ON THE TIMING AND EFFICIENCY OF CREATIVE DESTRUCTION*

RICARDO J. CABALLERO AND MOHAMAD L. HAMMOUR

We analyze the timing, pace, and efficiency of ongoing job reallocation that results from product and process innovation. There are strong reasons why an efficient economy ought to concentrate both job creation and destruction during recessions, when the opportunity cost of reallocation is lowest. Incomplete contracting between labor and capital can disrupt this synchronized pattern and decouple creation and destruction. Transactional difficulties also lead to technological "sclerosis," characterized by excessively slow renovation. Government incentives to production may alleviate high unemployment but exacerbate sclerosis. In contrast, creation incentives increase the pace of reallocation. An optimal combination of both policies restores economic efficiency.

I. INTRODUCTION

When technology, in its broadest sense, is embodied in capital, skills, and the organization of work, technical progress puts the economy in a state of incessant restructuring. Its productive structure must constantly adapt to innovations in products, techniques, modes of organization, and to the evolving competitiveness of world markets. Production units that embody new techniques must continually be created, while outdated units must be destroyed.

This process of growth through Schumpeterian "creative destruction" results in an on-going reallocation of factors of production from contracting production sites to expanding ones.[1] Ongoing creative destruction, thus, often entails distressing job

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1. Schumpeter [1942] develops the concept of creative destruction. Cox and Alm [1992] provide numerous illustrations of creative destruction at work in the U. S. economy. The early study by Salter [1960] of the distribution of productivity across plants provides rich microeconomic evidence supporting the renovation process and heterogeneous microeconomic structure implied by the embodied nature of technical progress. The idea that technical progress is associated with extensive factor reallocation finds strong support in recent studies of productivity growth using plant-level LRD data, such as Bartelsman and Dhrymes [1991] and

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losses, and can therefore result in a political response to protect those jobs. If job reallocation is an inescapable requisite of the progress in standards of living, policies that are overly protective of existing jobs may hinder the pace of renovation and lead to technological "sclerosis." But laissez-faire may be equally deficient. The massive job destruction that takes place in a recession, for example, may be a sign of chronically malfunctioning markets, rather than an aspect of the healthy recycling of jobs.

This paper aims at improving our understanding of the characteristics of an efficiently functioning creative destruction process, of the way malfunctioning markets can disrupt this process, and of appropriate policy responses to such disruptions. We show how contracting difficulties in the formation of production units can disrupt the timing and volatility of creative destruction over the cycle, and hamper the pace of renovation in the economy. We analyze the effect of government incentives to production and creation decisions, and show how an optimal combination of both types of policies can restore full efficiency.

Section II presents our basic model. Our economy experiences ongoing exogenous technical progress. Its productive structure embodies the best techniques available at the time of creation, and must continually be restructured to incorporate innovations. Capital and labor must combine to form new production units, but the transaction between them may suffer from an "appropriability" problem. Appropriability arises whenever investment exhibits some degree of *specificity* with respect to labor, and the difficulty of writing and enforcing complete long-term contracts renders the associated specific quasi rents ex post appropriable.[2] Those contracting difficulties in the formation of production units will prove highly detrimental, in general equilibrium, to the creative destruction process.

A simple example of appropriability is a firm's investment in an individual worker's job-specific human capital, whose quasi rents become ex post appropriable if they cannot be "bonded"

Baily, Hulten, and Campbell [1992]. A related question, which focuses on physical as opposed to human or organizational capital, is how much of output growth is associated with *capital-embodied* technological progress. This issue is addressed by Hulten [1992] and Greenwood, Herkowitz, and Krusell [1992].

2. Grout [1984] analyzes the effects of appropriability on investment and wages in a partial-equilibrium model of union-firm bargaining. The problem of appropriability plays a prominent role in the New Institutional Economics literature, where asset specificity has been identified as a central dimension of Coasian [1937] transaction description (e.g., Klein, Crawford, and Alchian [1978]; Williamson [1979, 1985].

away.[3] Another example is search costs, which constitute a sunk investment in the worker that, by its very nature, cannot be protected by ex ante contracting. One should not, however, interpret appropriability as relating only to investment that is specific at the *individual* worker level. Specificity generally refers to the degree to which the asset would decrease in value if it is put to its best alternative use. When workers form coalitions to negotiate with firms, assets may have to be used outside the firm or the industry to escape the scope of the union. The quasi rents from all firm- or industry-specific assets can then become appropriable. At the level of political interaction between labor and capital interest groups, legislation—such as the right to strike or job protection regulations—can be used to reinforce asset specificity by restraining firms' outside options. In this sense, the concept of appropriability can be considered as capturing a broad variety of impediments to well-functioning labor and capital markets.

Section III focuses on cyclical aspects of creative destruction. We introduce exogenous cyclical fluctuations into the marginal profitability of production, and contrast the cyclical response of an inefficient economy with its efficient counterpart in terms of *observable* characteristics of timing and volatility of creation, destruction, and unemployment. In our efficient economy the sole role of unemployment is to facilitate labor reallocation. An efficiently restructuring economy will concentrate reallocation in recessions, when the marginal profitability of production is low and, thus, the opportunity cost of unemployment is low. *Both* job destruction and creation rise in a recession to increase labor reallocation. We show that contracting inefficiencies—because they require "quantity" movements in hiring and unemployment to generate wage responsiveness—can disrupt this tightly synchronized pattern and *decouple* creation and destruction. Recessions are then characterized by lower job creation, much higher job destruction, and higher unemployment—much like what we observe.

Section IV turns to the effect of contracting difficulties on the pace of the creative destruction process. Under what conditions will the restructuring of the productive system be excessively

3. For a treatment of bonding in the presence of specific investment, see Mortensen [1978]. For a discussion of bonding schemes and their limitations in the context of the efficiency wage literature, see Katz [1986].

sluggish, and result in technological sclerosis? When will restructuring be, on the contrary, wastefully rapid, and result in what one might call technological "hyperkinesis"? In the presence of appropriability, employed workers become "insiders" who are able to improve their bargaining position with the firm by taking ex post advantage of the specificity of its investment with respect to them. We find that, irrespective of whether insiders are too weak or too strong, inefficiency in either direction always leads to sclerosis. If insiders are weak, they put little labor-cost pressure on outdated units to be scrapped. If insiders are strong, they discourage job creation, increase unemployment, and lead again to low labor-market pressures on wages in outdated units.

Section V analyzes policy. An institutional cure to transactional inefficiencies is often practically or politically infeasible, and may be undesirable on distributional grounds. With this in mind, we focus on the effect of aggregate government incentives to production and creation decisions. Expanding the economy through production incentives can reduce unemployment, but at the cost of exacerbating sclerosis. Could the latter effect more than offset the welfare benefits of the former, rendering desirable—as the pre-Keynesian "liquidationist" view has it—a contraction that "cleanses" the productive structure? We argue against this possibility, and show that, so long as more unemployment is undesirable, creating a contraction cannot be beneficial on the whole. Contrary to production incentives, creation subsidies have the opposite effect of alleviating sclerosis as they accelerate the pace of reallocation. We show that it is through an optimal dynamic combination of both types of policies that the economy can recover its full efficiency.

Relation to the Literature. Our paper is related to several strands in the literature. A rich body of research developed in the 1960s that analyzes steady-state creative destruction in vintage models of embodied technological progress (see, e.g., Johansen [1959], Solow [1960], Phelps [1963], and Sheshinski [1967]). More recent analyses of creative destruction in an endogenous-growth vein can be found in Aghion and Howitt [1992] and Grossman and Helpman [1991]. Our paper addresses the question of efficiency of the creative destruction process, and analyzes how market failures can disrupt the pace of reallocation and lead to distorted unemployment rates. In this last respect it is related to the work of Aghion and Howitt [1994], who study the effect of different rates of technical progress on steady-state unemployment.

An important dimension of our analysis concerns out-of-steady-state business cycle issues. Mortensen and Pissarides [1994] and Mortensen [1994] use a search unemployment framework to interpret the evidence on gross job flows over the cycle uncovered by Davis and Haltiwanger [1990, 1992] and Blanchard and Diamond [1990]. Although their focus on search costs in firm-worker bargaining leads to useful insights, we argue below that shifting the emphasis from search to other forms of specific investment provides a more promising interpretation of the facts.

Finally, our efficiency analysis of creative destruction over the cycle contributes to the literature on reorganizations [Davis and Haltiwanger 1990; Hall 1991; Cooper and Haltiwanger 1993; Aghion and Saint-Paul 1992; Galí and Hammour 1992; Saint-Paul 1993] and shakeouts [Caballero and Hammour 1994a; Stiglitz 1993; Bresnahan and Raff 1991, 1992] during recessions. We attempt to relate questions on the efficiency of reorganization over the cycle to observable characteristics of the data, and ask whether a recession that cleanses the productive structure can be beneficial on the whole.

II. A Renovating Economy

Our first step is to present the model we will be using to analyze creative destruction throughout the paper. We first describe the basic structure of our model economy. The next two subsections characterize, in turn, the efficient centrally planned outcome and the decentralized equilibrium. The last subsection asks under what conditions the decentralized economy is efficient.

A. The Economy

Productive Structure. The economy trades in two goods: a produced good whose aggregate output at time t is $Q(t)$, and a nonproduced good in fixed supply $\overline{M}$.[4] Its productive structure is made up of many "production units" that combine in fixed proportions a unit of capital, a unit of labor, and a unit of the nonproduced good as an intermediate input. Exogenous technical progress is embodied in production units and drives the continuous process of their creation and destruction. Abstracting away

4. As will become clear, the nonproduced good is an intermediate input in production. Its main role in our model is to introduce cyclical fluctuations in profit margins in the form of exogenous variations in the price of that good.

from "learning-curve" effects, we assume that a production unit embodies the leading technology at the time t when it was created and produces $A(t)$ units of output. The productivity frontier $A(t)$ grows exogenously at rate $\gamma > 0$.[5]

Each production unit corresponds to a "job." The creation rate of new production units corresponds to the gross hiring rate in the economy, and is denoted by $H(t)$. Production units in operation fail exogenously at rate δ, and are scrapped beyond a certain *endogenously* determined age. Both events free up a unit of labor.

If we denote by $\bar{a}(t)$ the age of the oldest unit in operation, it is clear from the above that aggregate employment $E(t)$ and output $Q(t)$ are determined by the distribution of production units aged between 0 and $\bar{a}(t)$:

$$E(t) = \int_0^{\bar{a}(t)} H(t-a)e^{-\delta a}da; \tag{1}$$

$$Q(t) = \int_0^{\bar{a}(t)} A(t-a)H(t-a)e^{-\delta a}da. \tag{2}$$

Creation Costs. Creating a production unit is costly. It requires acquiring and installing capital, searching for a worker, training him, and organizing his job. As we will show, the structure of creation costs is crucial for the responsiveness of creation, destruction, and unemployment to aggregate shocks, and for the degree of real wage rigidity.

The total cost, in terms of the produced good, of creating $H(t)$ production units at t is proportional to the leading productivity $A(t)$, and can be thought of in terms of forgone output. Because the distinction is important for our analysis, $C(H,U)$ is split into two components, investment $I(H)$ and search costs $S(H,U)H$:

$$C(H,U)A(t) = [I(H) + S(H,U)H]A(t),$$
$$I_H, I_{HH}, S_H \geq 0, \; S_U \leq 0.$$

Investment includes capital investment and installation as well as training and organizational costs. $I(H)$ is increasing and (weakly) convex in H. Convexity captures the idea that it may be expensive to create fast, either at the aggregate or the individual level, and provides a motive for "smoothing" creation.[6] The flow

5. It is not difficult to endogenize the growth rate γ, but, to keep the paper focused, we decided not to exploit this dimension. The steady-state effects of endogenizing growth are briefly discussed in footnote 31.

6. Convexity at the aggregate level may be derived from a concave production function for capital. It may also be derived from linear individual adjustment costs

search cost $S(H,U)$ is the expenditure required to expect one hire per unit time, and is (weakly) increasing in aggregate hires H and decreasing in aggregate unemployment U. It can be derived from a constant vacancy-posting cost and a matching function $H = H(U,V)$, $H_U,H_V > 0$, where V denotes aggregate vacancies.[7]

Throughout the paper we will be using the following functional form for creation costs:

$$(3)\qquad I(H) = c_0H + \tfrac{1}{2}c_1H^2,$$
$$S(H,U) = c_2\,(H/U)^{\eta/(1-\eta)},\qquad c_0,c_1,c_2 \geq 0,\qquad 0 \leq \eta < 1.$$

The quadratic specification for $I(H)$ yields a simple linear form for the marginal investment cost. The search cost specification can be derived from the constant returns Cobb-Douglas matching function $H = \xi U^{\eta}V^{1-\eta}$. For notational simplicity we henceforth denote the creation cost and its components by $C(t)$, $I(t)$, and $S(t)$.

Consumer-Workers. We close the model by introducing consumer-workers in the simplest way possible. There is a continuum of infinitely lived individuals indexed by $i \in [0,\bar{L}]$, each endowed with one unit of labor and shares over production units and the stock of nonproduced goods. Individual i's intertemporal utility at time t is given by

$$\int_t^{\infty} [Q_i^d(s) + p(s)A(s)M_i^d(s)]e^{-r(s-t)}ds.$$

Utility is linear in both $Q_i^d(s)$ and $M_i^d(s)$, i's consumption at s of the produced and nonproduced goods.[8] Linearity greatly simplifies the consumer's side of the model, since it implies risk neutrality and gives a constant interest rate equal to the subjective discount rate r. We assume $r > \gamma$ to guarantee finite utility. $p(s)$ is the marginal utility of the nonproduced good, normalized by the leading technology $A(s)$ (due, e.g., to technical progress in the

but a nondegenerate distribution of potential entrants (e.g., heterogeneous observable skills), as in Diamond [1994]. Convexity at the individual level may be derived from convex installation and training costs, assuming a fixed number of symmetric firms.

7. Let $\pi > 0$ denote the unit flow-cost of posting a vacancy. If we invert the matching function and write it as $V = V(H, U)$, then the unit flow-cost of hiring a worker is $S(H, U) = \pi V(H, U)/H$. The property $S_H > 0$ requires that the matching function be less than unit-elastic with respect to V; the property $S_U < 0$ only requires that the matching function be increasing in U.

8. It would have been easy to add a linear term to account for a positive value of leisure. In the equilibrium conditions below, the marginal value of leisure would have entered in exactly the same way as the price of the intermediate input. We chose to drop this term for simplicity.

utilization of the nonproduced good). Using the produced good as a numeraire, $p(s)$ also represents the price (normalized by $A(s)$) of the nonproduced good.

In order to introduce cyclical fluctuations in the marginal profitability of labor, we assume that $p(t)$ is an exogenous function of time. Throughout the paper we assume that the path $\{p(t)\}_{t \geq 0}$ is continuous and such that positive creation and destruction are taking place at all points in time. Because our main results do not depend on uncertainty, we assume that the path of $p(t)$ is known with certainty.

A few aggregate relationships will be useful. The two goods market equilibrium conditions are

$$Q(t) = Q^d(t) + C(t)A(t), \tag{4}$$

$$\overline{M} = M^d(t) + E(t), \tag{5}$$

where $Q^d \equiv \int_i Q_i^d di$, $M^d \equiv \int_i M_i^d di$, and, by fixed proportions, $E(t)$ is equal to the demand for intermediate inputs. Finally, aggregate unemployment is given by

$$U(t) \equiv \overline{L} - E(t). \tag{6}$$

B. The Central Planner Problem

We start by asking how a central planner would manage our economy, and derive the corresponding efficiency conditions. This analysis will help us characterize the efficient path of creative destruction, and will provide us with a benchmark for assessing the efficiency of the decentralized outcome.

Since utility is linear, the central planner always maximizes aggregate utility, whatever his distributional concerns may be. His problem is

$$\max_{\{H(t),\overline{a}(t)\}} \int_0^\infty [Q^d(t) + p(t)A(t)M^d(t)]e^{-rt}dt, \tag{7}$$

subject to (1), (2), (4)–(6), and the constraints $\overline{a}(t), H(t), U(t) \geq 0$, for all t, taking as given the path $\{p(t)\}_{t \geq 0}$ and the history $\{H(t)\}_{t<0}$ that determines the initial distribution of jobs.[9] In this problem the planner is assumed unable to improve the efficiency of matching in the labor market and takes the matching function and cost parameters as given.

9. The constraint $U(t) \leq \overline{L}$ need not be imposed explicitly because it is guaranteed by $H(t) \geq 0$.

The first-order conditions with respect to the scrapping age $\bar{a}(t)$ and creation $H(t)$, respectively, are

$$A(t - \bar{a}(t)) - (p(t) + \tilde{w}^E(t))A(t) = 0, \tag{8}$$

$$\tilde{c}^E(t)A(t) = \int_t^{t+T(t)} [A(t) - (p(s) + \tilde{w}^E(s))\,A(s)]e^{-(r+\delta)(s-t)}ds, \tag{9}$$

where

$$\tilde{w}^E(t) = -C_U(t) + \mu(t),\ \mu(t) \geq 0 \text{ with “=” if } U(t) > 0, \tag{10}$$

and

$$\tilde{c}^E(t) = C_H(t). \tag{11}$$

The marginal cost variables $\tilde{w}^E(t)$ and $\tilde{c}^E(t)$ play an important role in the comparison of the centrally planned with the decentralized outcome (the superscript E stands for “Efficient”). They refer, respectively, to the “shadow” wage of a worker and to the marginal creation cost of a job, normalized by $A(t)$. Equation (8) is an exit condition that requires the quasi rents from a job to be zero at the time of destruction: $A(t - \bar{a}(t))$ is the output of a production unit that has reached the exit age $\bar{a}(t)$ and $(p(t) + \tilde{w}^E(t))A(t)$ is its operating cost, equal to the cost of the unit of intermediate input and the unit of labor used. Equation (9) is an entry condition that equates the marginal creation cost $\tilde{c}^E(t)A(t)$ of a job created at t to the expected present value of quasi rents over its planned lifetime $T(t)$ ($A(t)$ being the job's output and $(p(s) + \tilde{w}^E(s))A(s)$ its operating cost at s).

If unemployment is positive, the shadow wage $\tilde{w}^E(t)$ in (10) is equal to the reduction $-C_U(t)$ in total search costs that would result if the worker were to remain unemployed. If unemployment is zero and the constraint $U(t) \geq 0$ is binding, the shadow wage is higher, equal to the value needed in (8) to reach full employment.

The only beneficial function unemployment plays in this efficient economy is to reduce the search costs of creation. Note that if $\lim_{U\searrow 0} C_U = \infty$ (which is the case with functional form (3) when $c_2 > 0$), then there is always a small enough positive value of U that satisfies (8), so it is always efficient to have some unemployment. On the other hand, if $C_U \equiv 0$ and unemployment does not facilitate the creation process (which is the case when $c_2 = 0$), then we have full employment $U = 0$ as long as $p(t)$ is small enough to guarantee a minimum of profitability.

An equilibrium for the centrally planned economy is a path $\{\bar{a}(t),H(t),U(t)\}_{t\geq 0}$ that satisfies the exit and entry equations (8)–(11) and

$$\bar{a}(t) = T(t - \bar{a}(t)), \tag{12}$$

$$U(t) = \bar{L} - \int_0^{\bar{a}(t)} H(t-a)e^{-\delta a}da, \tag{13}$$

given a history $\{H(t)\}_{t<0}$ that determines the initial distribution of jobs. Equation (12) gives the function $T(t)$ implicitly as a transformation of $\bar{a}(t)$, which holds as long as destruction is always taking place. It states that the age $\bar{a}(t)$ of the oldest job at t is equal to the maximum lifetime T that was planned for it at its time of creation $t - \bar{a}(t)$. Equation (13) gives unemployment as a function of the history of hiring, and follows immediately from (1) and (6).

C. Decentralized Equilibrium with Appropriability

We now turn to the determination of decentralized equilibrium in the presence of contracting difficulties. Abstracting away from internal labor markets and on-the-job search, we assume that all workers in new production units are hired from the unemployment pool, and all workers from destroyed production units return there. Firms can freely enter the labor market at any time to hire workers. To create a production unit at time t, a firm searches for a worker at the flow cost $S(t)$ described above.

Specific Investment and Appropriability. Firms must combine capital with labor to form new production units. When some of the required investment is specific to the production unit, an appropriability problem arises in the transaction between firm and worker. If a binding complete contract cannot be written and enforced before specific investment is sunk, the resulting specific quasi rents are potentially appropriable by the worker. Employed workers become insiders, who can take ex post advantage of the specific investment that would be lost if the relationship breaks up. If workers negotiate as part of a union or if they are protected by legislation, the effective specificity of investment may increase further.[10]

10. The "insider power" of unions is as much a problem of incomplete contracts as that of individual workers. Workers as a group may control organizational knowledge, for example, which is replicable if a few leave, but not if all of

To capture this appropriability problem, we introduce a parameter $\phi \in [0, 1]$ that captures the share of investment $I_H(t)A(t)$ which is specific and whose quasi rents cannot be protected by contract. To fix ideas, suppose that it costs a firm $1000 to create a job, $700 of which goes to nonspecific equipment and $300 to specific training for the worker. In the absence of binding contracts, the appropriability parameter would be $\phi = 0.3$. If the worker belongs to a union or is protected from dismissal by legislation, ϕ may effectively be higher.

To form a production unit, we think of the firm and the worker as entering into a self-enforcing agreement. The two parties recognize that investment creates specific quasi rents, which form an appropriable surplus $\Pi(t)$ that must be bargained over. We assume a generalized Nash-bargaining solution, with a share $\beta \in (0, 1)$ of the surplus going to the worker and $(1 - \beta)$ going to the firm.[11]

The surplus $\Pi(t)$ is equal to the value the production unit creates above what the firm and the worker can claim as their best alternatives. The firm can only recover $(1 - \phi)I_H(t)A(t)$ of its investment if it drops out of the match. The worker's outside alternative is to turn unemployed and search for another job. The flow opportunity cost of not doing so is the shadow wage $\tilde{w}^D(t)A(t)$ (the superscript D stands for "Decentralized"). With this in mind, the appropriable surplus can be written as

$$\text{(14)} \qquad \Pi(t) = \int_t^{t+T(t)} [A(t) - (p(s) + \tilde{w}^D(s))\, A(s)]e^{-(r+\delta)(s-t)}ds - (1 - \phi)I_H A(t).$$

The surplus is equal to the present value of value added over the maximum lifetime $T(t)$ of the production unit minus the worker's shadow wage, after subtracting the protected part of investment. The planned maximum lifetime is given by the exit condition,

them do so (e.g., Lindbeck and Snower [1986]). In this context, insider power arises if the firm cannot find a way to sign an ex ante contract with the group that protects it from opportunistic behavior. Insider power may also be due to legislation, such as job-protection or right-to-strike laws, and thus be the expression of appropriability operating at the political level and making long-term contracts even less enforceable.

11. Binmore, Rubinstein, and Wolinsky [1986] discuss the circumstances under which the axiomatic generalized-Nash bargaining solution can be given a game-theoretic foundation. Our specification of the two parties' "threat points" is consistent with a game-theoretic solution where the main consideration is an exogenous risk that the bargaining process may break down.

$$(15) \quad A(t) - [p(t + T(t)) + \tilde{w}^D(t + T(t))]A(t + T(t)) = 0,$$

which maximizes the value of a production unit. This condition states that exit is planned at the time $t + T(t)$ when value added from production no longer covers the worker's shadow wage.[12]

Equilibrium Conditions. We now turn to equilibrium conditions. On the worker side the equilibrium shadow wage $\tilde{w}^D(t)A(t)$ is equal to the expected utility flow received by an unemployed worker:

$$(16) \qquad \tilde{w}^D(t) = \frac{H(t)}{U(t)} \beta \Pi(t).$$

It is equal to the flow probability $H(t)/U(t)$ of finding a job times the gain from capturing the worker's share of the associated appropriable surplus. It is important to keep in mind that $\tilde{w}^D(t)A(t)$ measures an opportunity cost, while the *actual* flow of wage payments received by employed workers exceed the $\tilde{w}^D(t)A(t)$ by the worker's share of appropriable specific quasi rents.[13]

Turning to firms, the free entry of production units implies that, as long as entry is positive, the cost of creating a production unit is equal to the firm's share of the appropriable surplus plus the value of its protected investments.[14] Rearranging, we get

$$(17) \qquad (\phi I_H(t) + S(t))A(t) = (1 - \beta)\Pi(t).$$

The firm's share of the appropriable surplus must compensate it exactly for the unprotected investments it is called on to make. Note that search costs enter in the same way as the unprotected part $\phi I_H(t)$, and can therefore be considered a special case of full appropriability. This is because, by their very nature, investments in search cannot be protected with an ex ante contract. The above condition makes clear that, under free entry, a bargainable surplus is created if and only if there is an appropriability problem. Otherwise, the free-entry condition becomes $\Pi(t) = 0$, which by (14) is the standard condition that equates marginal creation costs to the present value of quasi rents.

12. By the same token, because we have assumed that *all* investments made at t embody technology $A(t)$, even nonspecific capital must be scrapped at $T(t)$ since the technology it embodies is no longer viable.

13. For a job created at t_0, the present value of *actual* wages $w^A(t)$ at t_0 is equal to $\beta\Pi(t_0)$. Calculating an exact path for those wages that supports the self-enforcing agreement requires further assumptions on how the firm recovers the protected part of its investment if it decides to break with the worker.

14. More formally, the free-entry condition is $(I_H(t) + S(t))\, A(t) = (1 - \beta)\Pi(t) + (1 - \phi)I_H A(t)$.

We can now formulate the conditions that govern equilibrium. Given a history $\{H(t)\}_{t<0}$ that determines the initial distribution of production units, an equilibrium for this economy is a path $\{\overline{a}(t),H(t),U(t)\}_{t\geq 0}$ that satisfies the system of equations,

$$A(t - \overline{a}(t)) - (p(t) + \tilde{w}^D(t))\,A(t) = 0, \tag{18}$$

$$\tilde{c}^D(t)A(t) = \int_t^{t+T(t)} [A(t) - (p(s) + \tilde{w}^D(s))\,A(s)]e^{-(r+\delta)(s-t)}ds, \tag{19}$$

where

$$\tilde{w}^D(t) = \frac{H(t)}{U(t)}\frac{\beta}{1-\beta}[\phi I_H(t) + S(t)], \tag{20}$$

and

$$\tilde{c}_D(t) = \left(1 + \frac{\beta}{1-\beta}\phi\right)I_H(t) + \frac{1}{1-\beta}\,S(t), \tag{21}$$

as well as equations (12)–(13) that define $T(t)$ and $U(t)$.

Equation (18) is an exit condition that uses (12) to restate (15) in terms of $\overline{a}(t)$. The shadow wage $\tilde{w}^D(t)A(t)$ in that equation is given by (20), which solves for (16) using (17). Equation (19) is a free-entry condition that restates (17) using (14). It is written in terms of the "effective" creation cost $\tilde{c}^D(t)A(t)$ given by (21), defined as the marginal cost that is *effectively* being set equal to the present value of a production unit. The decentralized equilibrium conditions (18)–(21) have the same structure as the first-order conditions (8)–(11) of the central planner problem, except that cost signals $\tilde{w}^D(t)$ and $\tilde{c}^D(t)$ are generally distorted.

Both cost signals depend on the parameters that determine the bargaining position of insiders. The shadow wage $\tilde{w}^D(t)A(t)$ is naturally increasing *in partial equilibrium* with the insider bargaining position parameters ϕ and β, because those parameters improve the value of the worker's outside alternative. The effective creation cost $\tilde{c}^D(t)A(t)$ is also increasing *in partial equilibrium* with ϕ and β. Intuitively, if firms must concede a large share of a production unit's value to insiders, their incentive to enter will be reduced, and they will act as if they faced an effectively higher entry cost.

The Nature of Unemployment. Equilibrium in this economy generally involves positive unemployment, whose nature is intimately tied to the problem of appropriabiilty. Looking at equation

(20), we see that a positive unemployment level U is always needed to sustain a given shadow wage $\tilde{w}^D$ in (18), as long as there is an appropriable surplus $\phi I_H + S > 0$. If there were no unemployment, workers would find it infinitely easy to find an alternative job, and their shadow wage $\tilde{w}^D$ would be infinite. That would deter any job creation, which is inconsistent with full employment. Unemployment thus acts as an equilibrium response of the economic system that restrains the bargaining position of insiders and preserves the profitability of investment. Note that unprotected specific investments $\phi I_H > 0$ give rise to positive unemployment even in the case when search costs are zero ($c_2 = 0$) and the centrally planned outcome requires full employment. Naturally, if there is no appropriability problem and $\phi I_H + S = 0$, the bargainable surplus is zero, and no unemployment is needed in equilibrium. In this case the economy will be in full employment, as long as $p(t)$ is small enough to guarantee a minimum of profitability—which we always assume.

D. Efficiency of the Decentralized Equilibrium

Cost signals in the decentralized economy are in general distorted, and the outcome will not generally be efficient. However, there are conditions on the economy's parameters under which the decentralized outcome will be socially efficient. Those conditions provide us with a very useful benchmark for analyzing market inefficiencies.

One can easily show that the following configuration for the bargaining parameters guarantees that $\tilde{w}^D = \tilde{w}^E$ and $\tilde{c}^D = \tilde{c}^E$, and thus that the decentralized outcome is efficient:[15]

$$(\phi, \beta) = (0, \eta).$$

The condition $\phi = 0$ ensures that the appropriability problem does not arise. The condition $\beta = \eta$ on the share parameter helps equate the private and social marginal costs of search, which are in general different because of the well-known "congestion" and "thick-market" externalities captured by the two arguments in the function $S(H,U)$.[16]

15. For a discussion of efficiency in search models, see Diamond [1982] and Hosios [1990].

16. Those two externalities operate as follows: a decision to create a job and search for a worker makes search costlier for others ($S_H \geq 0$); a decision to destroy a job and add a worker to the unemployment pool makes search cheaper for others ($S_U \leq 0$).

III. Creation, Destruction, and Unemployment: Timing and Volatility

In this section we focus on cyclical aspects of the process of creative destruction, and analyze its response to transitory fluctuations in profitability. We introduce business cycles in the form of exogenous cyclical fluctuations in the price $p(t)$ of intermediate inputs, which we interpret more broadly as capturing different factors that affect the profitability of production units. We contrast the cyclical response of an economy that suffers from incomplete contracting difficulties with an efficient economy in terms of *observable* characteristics of timing and volatility of creation, destruction, and unemployment. The discussion centers around the effect of two sets of parameters: parameters (ϕ,β) that characterize the bargaining position of insiders, and must be equal to $(0,\eta)$ for the economy to be efficient; and parameters (c_0,c_1,c_2) that characterize the structure of creation costs, where $c_0 + c_1H(t)$ is the marginal investment cost and $c_2\ (H/U)^{\eta/(1-\eta)}$ is the search cost.

Recessions in our efficient economy are times when restructuring is intensified, since the opportunity cost of the required unemployment is low. The creation and destruction margins will be tightly *synchronized* to avoid the waste of resources through excessive unemployment. They will be *positively* correlated, and a motive to smooth the cyclical response of creation will *also* imply a smoothing of destruction. This synchronized pattern is disrupted in the presence of contracting inefficiencies, and the creation and destruction margins can become *decoupled.* Instead of being times of intense reallocation, recessions are then times of high destruction, low creation, and wasteful unemployment. Furthermore, unlike the case of an efficient economy, a motive to smooth creation will tend to accentuate rather than smooth fluctuations in destruction—leading to possible *asymmetries* between the two margins.

Our analysis highlights the delicate nature of explanations of observed asymmetries in creation and destruction as resulting from constraints on one of the margins. As the discussion of the efficient economy makes clear, a smoothing motive on the creation margin does not necessarily lead, in general equilibrium, to greater volatility in destruction than in creation. To take another example that we do not formalize here, an option value of waiting to create does not necessarily decouple the response of creation from destruction in recessions, for, in the efficient economy, destruction would not take place if the economy is not ready to create. In both cases, additional general-equilibrium mechanisms must be at work that decouple creation from destruction. The one we put forward in this paper is the presence of incomplete contracting difficulties that impose a form of "rigidity" on real wages, and require "quantity" responses in unemployment and hiring over the cycle to induce a response in wages.[17]

A. Efficient Restructuring over the Cycle

We start by considering the response of an efficient economy—with $(\phi,\beta) = (0,\eta)$—to cyclical fluctuations in $p(t)$. The only role of unemployment in such an economy is to facilitate labor reallocation. Thus, if job creation entails only investment but no search costs ($c_2 = 0$), efficient equilibrium unemployment is zero. Aggregate shocks are entirely absorbed by fluctuations in the shadow wage, while all quantities, including labor market flows and stocks, remain unaffected.

Introducing search costs gives rise to unemployment, whose sole role is to facilitate reallocation. Figure I simulates the path of an efficient economy with linear investment costs and positive search costs ($c_0 > 0$, $c_1 = 0$, and $c_2 > 0$). Business cycles are generated by a deterministic sine-wave in $p(t)$.[18] We report the path of the "business cycle" variable $b(t) \equiv -(p(t) - p^*)$, which is positive in expansions and negative in recessions, where p^* is the average $p(t)$ over the cycle. Panel a shows one full business cycle in $b(t)$, with its trough in the middle of the diagram. Panels b–d present the path of output, creation and destruction, and unemployment.[19]

From the point of view of efficiency, the dynamics of those

17. Decoupling could also arise if the shock in $p(t)$ is large enough so that the economy hits a "corner," where value-added becomes negative—or falls below a certain reservation-value of leisure—for a lump of production units. Those units will therefore be destroyed irrespective of what happens on the creation margin. As mentioned in subsection II.C, we have ruled out such events by assumption. Another reason for decoupling is cyclical fluctuations in *voluntary* unemployment, resulting from intertemporal substitution in leisure. For an analysis of gross flows that stresses this aspect of unemployment, see Davis and Haltiwanger [1990].

18. The figure was generated with the following parameters: $r = 0.065$, $\gamma = 0.028$, $\delta = 0.05$, $\eta = 0.5$, and $\bar{L} = 1$. Creation cost parameters are $c_0 = 0.0790$, $c_1 = 0$, and $c_2 = 0.045$. The economy is efficient with bargaining-position parameters $\phi = 0$ and $\beta = \eta$. $p(t)$ follows a sine-wave of period 4 years, mean 0.321, and amplitude ± 0.044. The general simulation method used is the same as in Caballero and Hammour [1994a].

19. What may appear as "irregularities" in some of the figures are in fact the result of the "echo" effect of previous cycles on the age-distribution of jobs at the start of the current cycle.

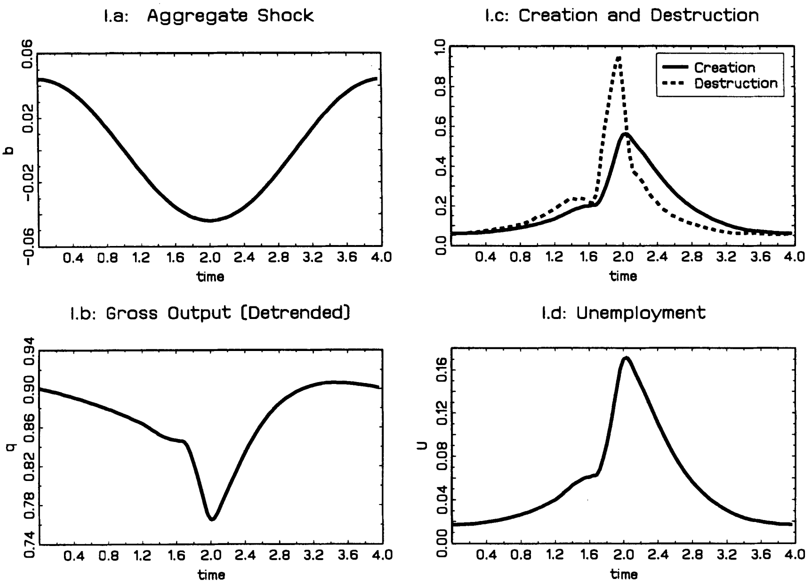


FIGURE I
Business Cycles in an Efficient Economy
Note that $c_0 > 0$, $c_1 = 0$, and $c_2 > 0$.

variables are driven by the fact that the *opportunity cost* of creating unemployment is lowest at the bottom of a recession, when production is least profitable. It is therefore efficient to concentrate the unemployment needed to facilitate reallocation near the trough of a recession, and intensify at that time the process of creative destruction.[20] As shown in the figure, recessions are characterized by a sharp increase in destruction that spills workers into unemployment, followed promptly by a large spurt of creation, which reaches its peak at the same time as unemployment. Sharp recessions in this economy are a preparation for strong recoveries. Creation, destruction, and unemployment are thus tightly synchronized and positively correlated.[21]

20. This point is emphasized by Davis [1987] and Davis and Haltiwanger [1990]. The literature contains several similar "opportunity cost" models of different types of investment activities during recessions: e.g., Hall [1991], Aghion and Saint-Paul [1994], and Galí and Hammour [1992].

21. Note in the figure that despite the symmetry of the driving force, the efficient economy's observed cyclical response is asymmetric. Recessions and recoveries are sharp and short-lived, while expansions are prolonged and fade away slowly before the onset of the next recession.

The strong intertemporal substitution incentive to concentrate reallocation near the bottom of a recession may be counteracted by an incentive to smooth the creation process. If marginal investment costs are now increasing ($c_1 > 0$), creation must be smoothed, as it becomes expensive to vary the intensity of creation over the cycle. Panel a in Figure II presents the path of creation and destruction in an efficient economy with both increasing marginal investment costs and search costs (c_0, c_1, $c_2 > 0$). Panel b will be discussed later.[22] Since the only purpose of destruction and unemployment in the efficient economy is subsequent creation, destruction and unemployment remain synchronized with creation, and are therefore also smoothed. This strong joint-smoothing behavior is another aspect of the coupling of creation and destruction in an efficient economy.

B. Inefficient Restructuring: Distorted Intertemporal Substitution

We now turn to the effect of incomplete-contracting difficulties on the economy's cyclical response. It is important to distinguish the implications due to the special nature of search, from those that arise more generally from specific investment. What distinguishes search costs from other forms of specific investment is that they are a decreasing function of unemployment (i.e., $\eta > 0$ in (3)). Absent this effect, the presence of search costs would not provide a role for unemployment in the efficient economy, and would be indistinguishable from more generic specific investments in the inefficient economy. We first concentrate on the effect of search-related inefficiencies ($\beta \neq \eta$) on the cyclicality of creative destruction, and assume no other appropriability problems ($\phi = 0$).

Figure III compares the same efficient economy as in Figure I ($c_1 > 0$, $c_1 = 0$, and $c_2 > 0$) with an inefficient economy identical in all respects except that $\beta \neq \eta$, so that search is inefficient.[23] Panel a compares the cyclical response of creation for the two economies, and panel b compares destruction. It is clear that both the efficient and inefficient economies concentrate creation and

22. The figure was generated with the same parameters as Figure I, except that the creation cost parameters are now $c_0 = 0.0790$, $c_1 = 0.75$, and $c_2 = 0.0113$; the $p(t)$ wave is of mean 0.422 and amplitude ± 0.064; and the appropriability parameter is $\phi = 0$ in panel (a) and $\phi = 1$ in panel (b).

23. The efficient case ($\beta = \eta$) corresponds to $\beta = 0.5$, and the inefficient case ($\beta < \eta$) to $\beta = 0.2$.

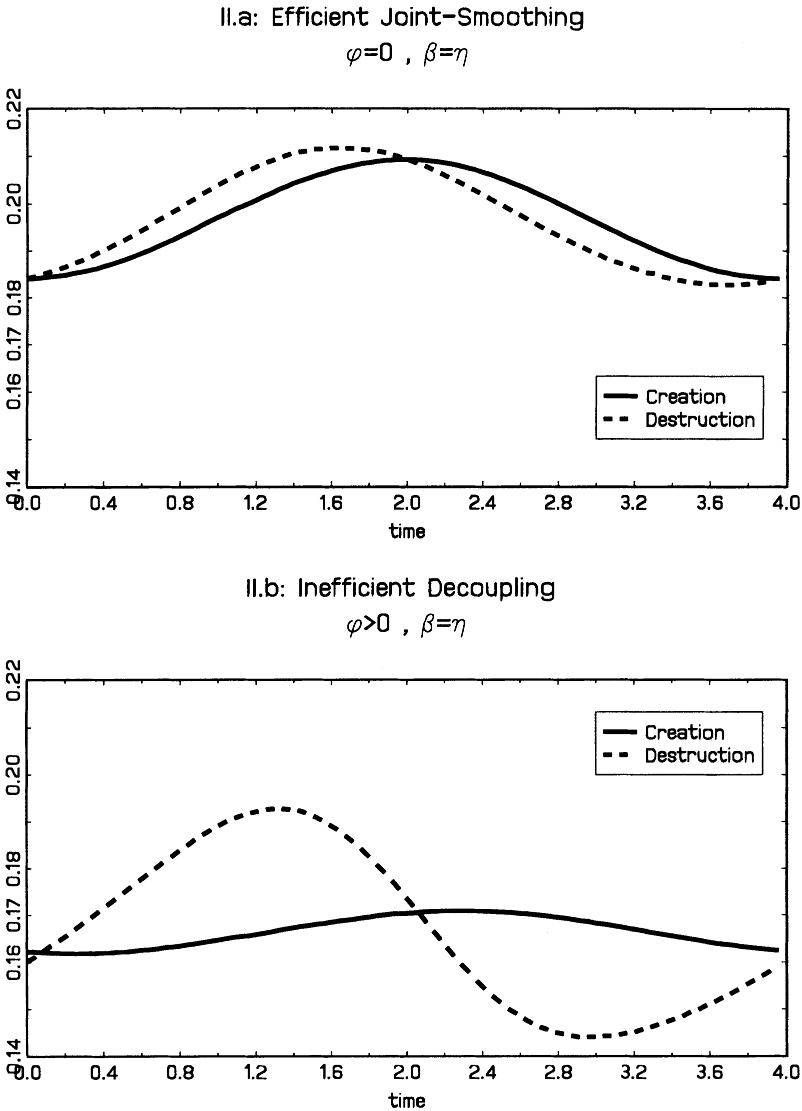


FIGURE II

Efficient and Inefficient Job Flows

Note that $c_0 > 0$, $c_1 > 0$, and $c_2 > 0$.

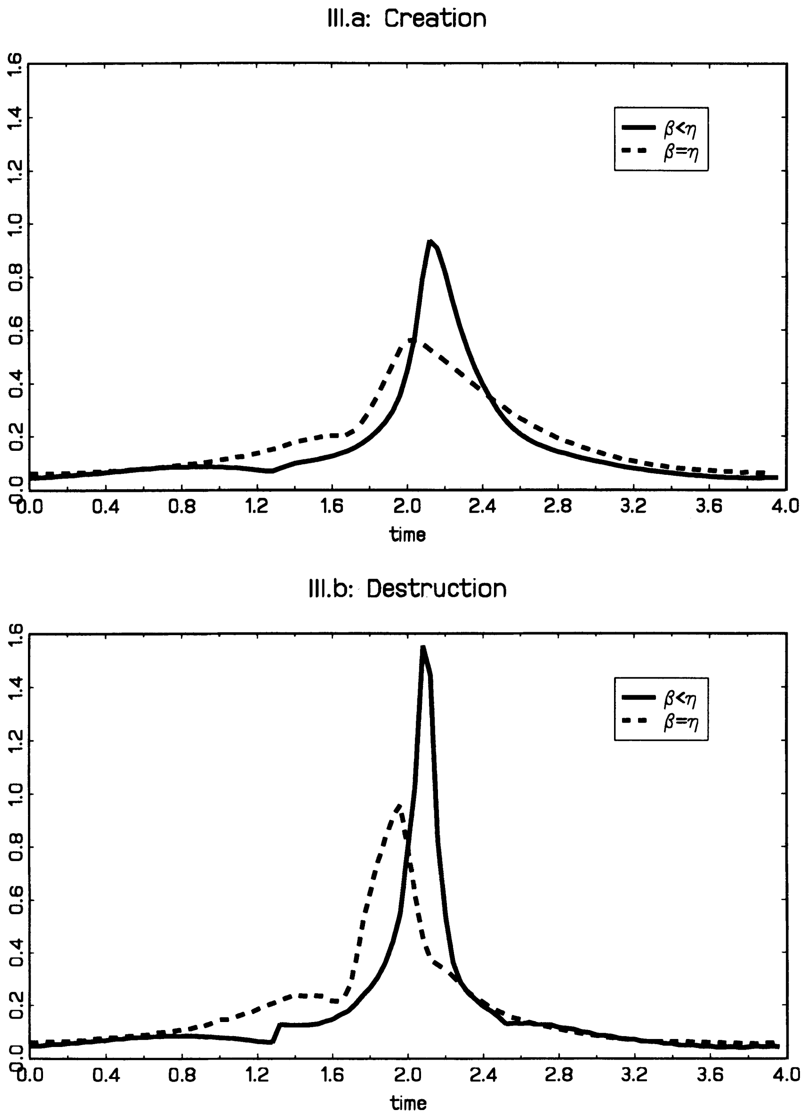


FIGURE III
Distorted Volatility

Note that $c_0 > 0$, $c_1 = 0$, and $c_2 > 0$.

destruction near the trough of a recession, but not to the same extent. The same intertemporal-substitution incentives are at work in both economies, but those incentives can be distorted in the inefficient case. When insiders are stronger than efficient ($\beta > \eta$), the economy will restructure less than efficiently during recessions. When insiders are weaker than efficient ($\beta < \eta$), the opposite will happen, and the economy will restructure excessively during recessions.[24]

To sum up, in search-based models of creative destruction, such as the one developed by Mortensen and Pissarides [1993, 1994], the economy's response to transitory aggregate fluctuations in profitability is driven by intertemporal-substitution incentives to concentrate *both* creation and destruction near the bottom of a recession. What search inefficiencies do is to disrupt the extent to which restructuring is concentrated in recessions.[25]

C. Inefficient Restructuring: Decoupling

The problem of appropriability has implications for the economy's cyclical response that go beyond, and can be more serious than the distorted intertemporal-substitution incentives related to search inefficiencies. Incomplete-contracting problems can derail the reallocation process over the cycle and *decouple* creation

24. The reason why stronger-than-efficient insiders lead to insufficient restructuring during recessions is that a large worker-share β of the bargainable surplus $\Pi(t)$ means that an excessively small share of that surplus will enter the free-entry condition (17). This muffles the effect of cyclical fluctuations on the entry condition and the related intertemporal-substitution incentive. Moreover, the shadow wage (20) is excessively responsive to H/U, and overly accommodates fluctuations in profitability.

25. The precise implication of intertemporal substitution is that creation and *unemployment* are positively correlated. Because destruction must peak *before* creation to generate high unemployment, the correlation between creation and destruction is a more delicate question that depends on precise timing and measurement issues.

Mortensen and Pissarides [1993] present simulation results that show a positive correlation between creation and destruction. Mortensen [1994] argues that this counterfactual implication can be reversed by adding on-the-job search. In a second paper Mortensen and Pissarides [1994] show that their model can also exhibit a negative correlation between creation and destruction.

The fragility of those results is closely connected to a timing issue. The authors assume that workers whose jobs are destroyed at time t only join the unemployment pool (and enter the matching function) at time $t + \Delta t$. Thus, a negative shock that increases destruction this period will only lead to high unemployment and cheap creation in the next period. This leads firms to delay creation this period until the next, giving rise to a *negative* contemporaneous correlation between creation and destruction, present even in an efficient economy. Notwithstanding, the synchronization between creation and destruction lies in the *positive* correlation Mortensen and Pissarides [1993] document between destruction at t and creation at $t + \Delta t$. The issue of how small Δt is relative to the sampling frequency becomes important.

and destruction, both in terms of synchronization and joint-smoothing. Recessions become times of wasteful unemployment, unassociated with greater reallocation activity.

Creation-Driven Recessions. The decoupling effect of appropriability on creation and destruction can be seen in its purest form by temporarily setting search costs to zero ($c_2 = 0$), so unemployment plays no role in facilitating reallocation. With zero search costs, recall that the efficient economy exhibits zero unemployment and no quantity responses to the cycle. Efficient "synchronization" in that case simply means that the constant rates of creation and destruction are *equal.* Contrary to the efficient economy, an economy with appropriable quasi rents (ϕ, $\beta > 0$) will generally exhibit positive unemployment. Moreover, in a recession such an economy will experience a rise in unemployment associated with decoupled creation and destruction.

Although appropriability problems generally break the synchronization between creation and destruction, this can happen in many ways. The rise in unemployment during recessions could be mostly associated with a fall in creation or an increase in destruction. An interesting feature of our economy is that whether it is creation or destruction that responds mostly to the business cycle depends on the structure of creation costs. In particular, we show that if c_1 is small, and there is little motive to smooth creation over the cycle, the economy will respond mostly on its creation margin. On the contrary, if c_1 is relatively large, then the economy will respond mostly on its destruction margin.

To see this most clearly, consider the extreme case where the parameter c_1 is zero, so that marginal creation costs are constant. We can show in this case that the economy responds to the cycle exclusively on its creation margin $H(t)$, while the scrapping age $\bar{a}(t)$ on the destruction margin remains constant. When $c_1 = 0$, there is a simple solution to equilibrium conditions (12)–(13) and (18)–(21). First, the free-entry condition (19) can be solved for a *constant* scrapping age $\bar{a}^*$, once we substitute in it exit condition (18) and take into account the definition of $T(t)$ in (12):

$$\left[1 + \frac{\beta}{1-\beta}\phi\right]c_0 = \int_0^{\bar{a}^*}\left[1 - e^{-\gamma(\bar{a}^*-a)}\right]e^{-(r+\delta)a}da.$$

Second, note that the constant scrapping age $\bar{a}^*$ can be maintained only if the profitability (18) of exiting $\bar{a}^*$-year old jobs remains unchanged over the cycle, which requires that the shadow wage fully absorb fluctuations in $p(t)$. Finally, by wage equation (20) the implied fluctuations in the shadow wage can be generated through appropriate fluctuations in hiring $H(t)$. In equilibrium, recessions are completely driven by a fall in creation $H(t)$, while the scrapping age $\bar{a}^*$ on the destruction margin does not respond.[26] The fall in creation in response to a negative profitability shock leads to a fall in shadow wages that fully "insulates" the profitability of existing jobs. The economy exhibits in this case a perfect "insulation" mechanism similar to that discussed in Caballero and Hammour [1994a].[27]

Destruction-Driven Recessions. As we increase the parameter c_1 away from zero and introduce an incentive to smooth creation over the cycle, the economy's cyclical responsiveness shifts from the creation to the destruction margin. A smoothing motive dampens the cyclical response of creation and its effect on $H(t)$ and $U(t)$, and therefore limits the extent to which shadow wages can fall to accommodate a negative profitability shock and insulate existing production units. By exit condition (18) this means that, in a recession, the scrapping age $\bar{a}(t)$ must fall and the rate of destruction must rise to accommodate part of the aggregate shock. To the extent this happens, recessions are *destruction-* rather than *creation*-driven, and lead to a cleansing of outdated production units.

Figure IV presents an example of the phenomenon discussed above, when aggregate investment costs are convex (c_0, $c_1 > 0$) and there are no search costs.[28] The business cycle variable $b(t)$ in panel a is similar to that in Figure I. In sharp contrast to the efficient cycle in Figure I, creation and destruction are decoupled and are now negatively correlated (panel c).

The stark difference between the efficient and inefficient cycles in Figures I and IV can be seen in Figure V, which displays the corresponding Beveridge curves in vacancies-unemployment

26. This does not mean that the rate of job destruction remains constant over time. Despite the constant scrapping age, destruction will vary as a result of the echo effect of past cyclical variations in hiring on the current age distribution of jobs.

27. In Caballero and Hammour [1994a] we model an industry that faces an exogenous consumption wage and downward-sloping demand for its good. Insulation there operates through the goods rather than the labor market via movements along the demand curve.

28. The figure was generated with the same parameters as in Figure I, except that the economy is now inefficient with $\phi = 1$ and $\beta = 0.5$; the creation cost parameters are $c_0 = 0.0790$, $c_1 = 1.00$, and $c_2 = 0$; and the $p(t)$ wave is of mean 0.456 and amplitude ± 0.071.

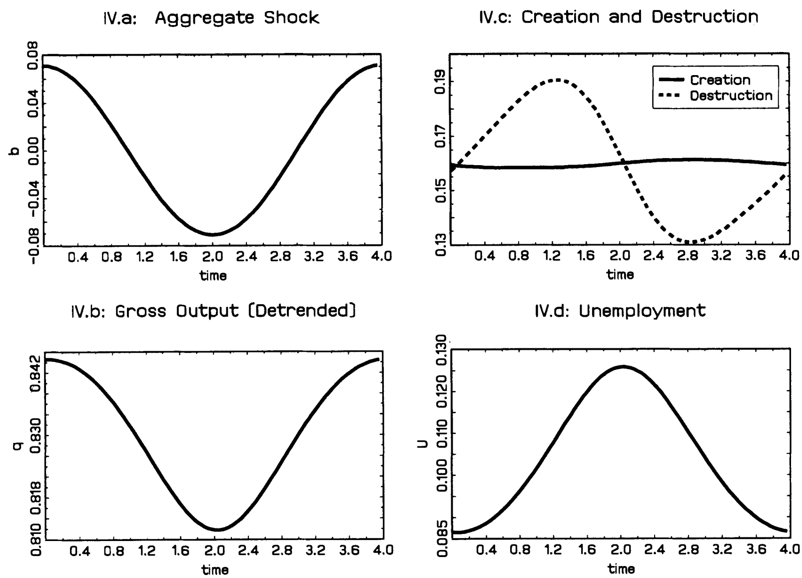
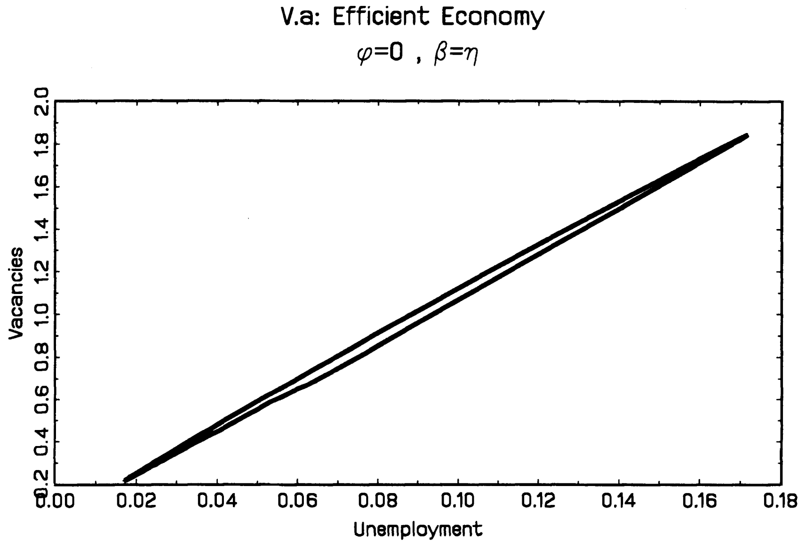


FIGURE IV
Business Cycles in an Inefficient Economy
Note that $c_0 > 0$, $c_1 > 0$, and $c_2 = 0$.

space.[29] The upper panel reveals the strong synchronizing incentives of unemployment acting as a reallocation device in an efficient economy. In this example, not only does creation rise as unemployment rises, which could be the direct result of higher unemployment in the matching function, but also creation efforts (vacancy posting) rise. Quite the opposite, the lower panel reveals the downward-sloping Beveridge curve associated with the decoupling of creation and destruction in an inefficient economy with appropriable specific quasi rents. Thus, depending upon the extent of contracting inefficiency, the same type of aggregate shock can lead to either an upward or a downward sloping Beveridge curve.[30]

29. In Figure V the unit by which vacancies are measured was fixed by choosing an arbitrary value for the free shift-parameter ξ in the matching function (see subsection II.A).

30. For evidence on the downward-sloping nature of the Beveridge curve for most OECD countries, see, e.g., Johnson and Layard [1986] or Layard, Nickell, and Jackman [1991].



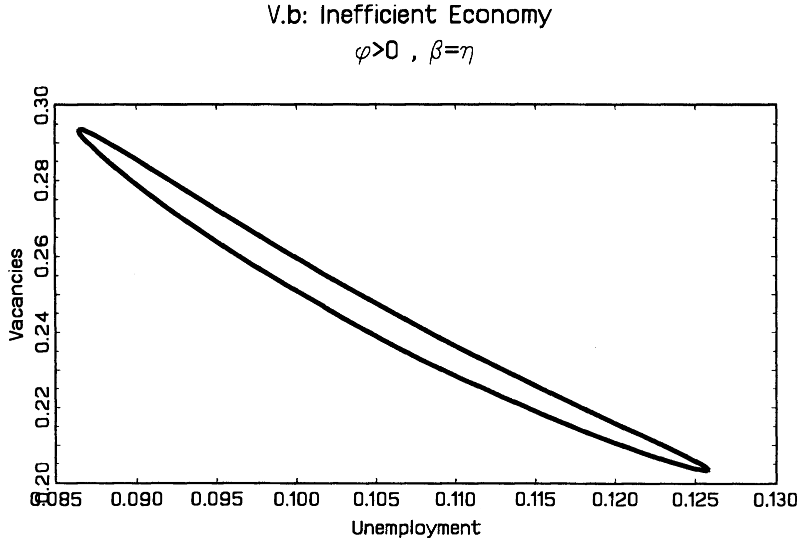


FIGURE V
Beveridge Curves

Appropriability decouples creation and destruction not only in terms of timing, but also in terms of amplitude. Recall from panel a of Figure II, which depicts the cyclical response of an efficient economy with c_0, c_1, $c_2 > 0$, that when there is a motive to smooth creation over the cycle, the efficient economy will also smooth destruction. This joint-smoothing behavior breaks down in the presence of appropriability. Panel b of Figure II presents the cyclical response of an economy identical to the efficient economy in panel a, except that it suffers from incomplete-contracting inefficiencies ($\phi > 0$). Incomplete contracting not only disrupts the precise timing of destruction followed by immediate creation, but also breaks their joint-smoothing pattern. By limiting the cyclical responsiveness of the shadow wage, the smoothing of creation exacerbates rather than dampens the volatility in destruction and leads to asymmetries in their volatilities. In this inefficient case, destruction is too volatile and occurs too early relative to creation, leading to an unnecessarily prolonged and volatile period of unemployment accumulation.

Covert and Overt Rigidity. The decoupling between creation and destruction is ultimately due to the fact that incomplete contracting induces a form of rigidity in shadow wages, which requires the quantity movements of lower creation and higher unemployment for wages to fall in a recession. Yet, the extent of those quantity effects may be such that they leave little trace of the underlying rigidity on the equilibrium path of the shadow wage. The extreme case of this arises when marginal creation costs are constant ($c_1 = 0$). In that case, we have seen that the cyclical response of the creation margin induces a one-to-one response in the shadow wage to fluctuations in $p(t)$, thus fully insulating the destruction margin. Although the shadow wage varies as much as it would in an efficient economy, it harbors a hidden form of rigidity in the form of the quantity movements required to induce this response. We call this a phenomenon of "covert" rigidity. When marginal creation costs are increasing instead ($c_1 > 0$), we have seen that the shadow wage does not respond one-to-one to fluctuations in $p(t)$, which causes a cyclical response on the destruction margin. In this case, the shadow wage exhibits a mixture of "covert" and "overt" rigidity.

IV. Market Failures: Unemployment and Sclerosis

In this section we turn to the effect of labor market inefficiencies on the pace of the creative destruction process. Under what conditions will the restructuring of the productive system be excessively slow, and result in technological sclerosis? When will restructuring be, on the contrary, wastefully rapid, and result in what one might call technological hyperkinesis? We find that, regardless of whether insiders are excessively weak or strong, inefficiency in either direction always leads to sclerosis.[31]

A. Weak and Strong Insiders

To study the pace of creative destruction, we consider the economy in steady state as a tool of analysis. Our results will, nevertheless, be instructive about the average pace of reallocation in a fluctuating economy and even about the effect of relatively low-frequency cycles.[32] In this subsection we derive an "equivalence" result that will be useful in the subsequent analysis. We show that there is a form of steady-state equivalence between the two insider bargaining-position parameters ϕ and β, which allows us to compensate insiders for a reduction in one parameter by increasing the other. We can thus divide the parameter space into two well-defined regions where insiders are too "weak" and too "strong" relative to the efficient configuration, even when one parameter indicates weakness and the other strength (e.g., $\beta < \eta$ and $\phi > 0$).

We use an asterisk to denote a variable in steady state. A steady state is an equilibrium path with constant $(\bar{a}^*, H^*, U^*)$, and requires a constant path for the exogenous variable p^*. The economy's equilibrium conditions (12)–(13) and (18)–(21) in steady state become

$$e^{-\gamma\bar{a}^*} - [p^* + \tilde{w}^{*D}] = 0, \tag{22}$$

$$\tilde{c}^{*D} = PV(\bar{a}^*), \tag{23}$$

$$U^* = \bar{L} - H^*[1 - e^{-\delta\bar{a}^*}]/\delta, \tag{24}$$

31. Our analysis takes the rate of technical progress as exogenously given. It is straightforward to endogenize γ by, for example, adding a competitive constant returns research sector whose flow revenues are proportional to the flow of newly created production units. Appropriability problems, by depressing turnover and exacerbating sclerosis, reduce the profitability of research activity and, therefore, the rate of productivity growth. A simple example with $c_0 = 1$, $c_1 = c_2 = 0$, and calibrated to yield more-or-less realistic numbers for productivity growth, shows that raising the appropriability parameter ϕ from 0 to 1/2, doubles the scrapping age, raises unemployment by 2–3 percentage points, and cuts creation and growth by half.

32. With increasing marginal creation costs, the average level of different quantities in a fluctuating economy may be different from their steady-state level. This is because, given the convexity of $C(H,U)$ in H, volatility in H makes creation more expensive on average.

where

$$(25)\qquad \tilde{w}^{*D} = \frac{H^*}{U^*}\frac{\beta}{1-\beta}[\phi I_H^* + S^*],$$

$$(26)\qquad \tilde{c}^{*D} = \left(1 + \frac{\beta}{1-\beta}\phi\right)I_H^* + \frac{1}{1-\beta}S^*,$$

$$(27)\qquad PV(\bar{a}^*) = \frac{1 - e^{-(r+\delta)\bar{a}^*}}{r+\delta} - \frac{e^{-\gamma\bar{a}^*} - e^{-(r+\delta)\bar{a}^*}}{r+\delta-\gamma}.$$

We can now state our equivalence result, which is proved formally in Appendix 1. Consider an economy with positive search costs ($c_2 > 0$). Consider any pair $(\phi_0,\beta_0) \in [0,1] \times (0,1)$, and the steady state $(\bar{a}_0^*, H_0^*, U_0^*)$ that corresponds to $(\phi,\beta) = (\phi_0,\beta_0)$. Then one can find a (weakly) decreasing function $f_0(\phi)$ over [0,1] such that, for any $\phi \in [0,1]$, the corresponding steady state to $(\phi,\beta) = (\phi, f_0(\phi))$ is $(\bar{a}_0^*, H_0^*, U_0^*)$. Naturally, we must have $f_0(\phi_0) = \beta_0$.

Another way to state the result is that any steady-state outcome $(\bar{a}_0^*, H_0^*, U_0^*)$ corresponds to a whole schedule $(\phi, f_0(\phi))$ of bargaining-position parameters. Quite intuitively, this schedule is decreasing because a rise in one bargaining parameter must be offset by a fall in the other, if we are to keep insider bargaining position and the steady-state outcome unchanged. It is in this sense that the parameters ϕ and β are equivalent *in steady state.*

This result allows us to divide the bargaining-position parameter space into two clearly delineated regions of excessively weak and strong insiders. In Figure VI we first draw the "efficient" schedule $(\phi, f^E(\phi))$ that corresponds to the efficient steady state. By the result in subsection II.D, this schedule crosses the β-axis at the point $(\phi,\beta) = (0,\eta)$. All equivalence schedules that start below this point correspond to weaker insiders than is efficient, and remain below the efficient schedule.[33] All schedules above correspond to stronger-than-efficient insiders, and remain above the efficient schedule. Thus, the efficient schedule divides the parameter space into two regions: a region below it where insiders are weak, and a region above it where they are strong.

B. Unemployment and Sclerosis

With the above classification of insider bargaining-position in steady state, we are ready to characterize the direction of inef-

33. Schedules cannot cross because each is drawn for a different steady-state equilibrium.

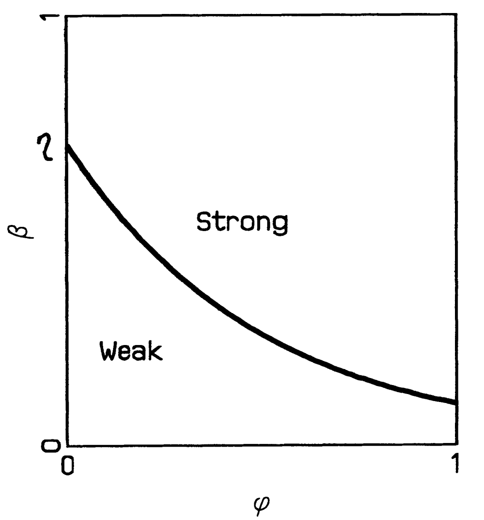


FIGURE VI
Strong and Weak Insiders

ficiency in the two regions. It is clear from (22)–(24) that $(U^*, \bar{a}^*)$ are sufficient statistics to describe a steady state, since H^* can then be obtained from unemployment equation (24). We will thus focus on those two variables. Steady-state results in our model are clearest when we assume that $c_1 = 0$ in (3). Because differentiating between c_1 and c_0 is much less interesting in steady state than over the cycle, we choose to assume that $c_1 = 0$ in presenting all steady-state results for the rest of this paper.

Under- and Overemployment. Given the equivalence result, we can choose to vary either β or ϕ to characterize steady state. Figure VII traces the curve in $(U^*, \bar{a}^*)$-space that is generated by increasing β (the arrows indicate the direction of movement as β increases).[34] The trough of the curve corresponds to the efficient value $\beta = f^E(\phi)$. It is clear that unemployment is increasing with β. In other words, the strong-insiders region is characterized by underemployment, and the weak-insiders region by overemployment. This is what one would expect, given that strong insiders take an excessively large share of quasi rents and discourage la-

34. The figure was generated with the following parameters: $r = 0.065$, $\gamma = 0.028$, $\delta = 0.15$, $\eta = 0.5$, $p^* = 0.390$, and $\bar{L} = 1$. The creation cost parameters are $c_0 = 0.399$, $c_1 = 0$, and $c_2 = 0.004$. The bargaining position parameters are $\phi = 0.3$ and $0.05 \leq \beta \leq 0.65$.

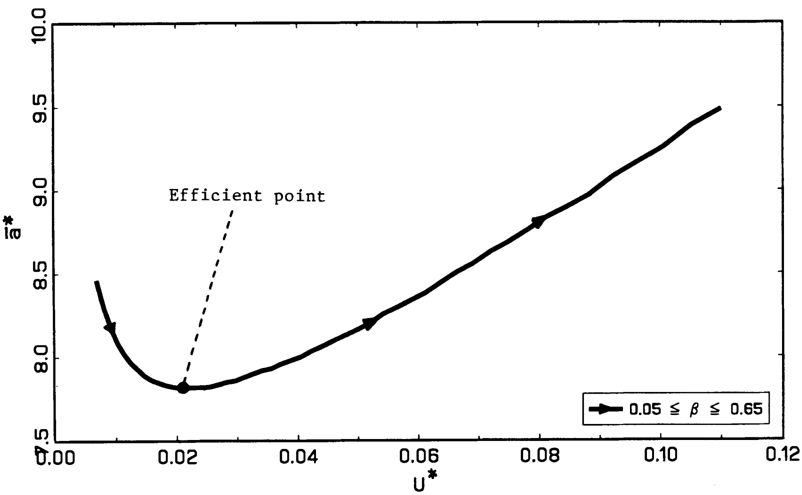


FIGURE VII
Effects of Increasing β in Steady State

bor demand, while weak insiders take an excessively small share and encourage labor demand. As discussed earlier, the economy offsets a stronger insider bargaining position with an endogenous rise in unemployment that weakens insiders' outside opportunities and restores adequate firm profitability.

More formally, Appendix 2 shows that $dU^*/d\beta > 0$ in the weak-insiders region and in the strong-insiders region near the efficient equivalence curve. Although we could not show formally that it is positive everywhere in the strong-insiders region, this was true in all the numerical examples we have tried. Moreover, Appendix 2 shows that $U^* \rightarrow \overline{L}$ as $\beta \rightarrow 1$.

Technological Sclerosis. If we turn to the scrapping age $\bar{a}^*$, we find in Figure VII that it is minimized at the efficient level of β. Thus, unlike what happens with unemployment, the economy exhibits the *same* direction of inefficiency for $\bar{a}^*$ in the weak- and strong-insiders regions. Appendix 2 shows formally that, in both regions, $\bar{a}^*$ is above its efficient value. Inefficiencies in both directions always lead to sluggish renovation and technological sclerosis. Sclerosis is thus a state of affairs that any policy program will most likely have to face.[35]

35. A related result can be found in the search literature. When job matchings are stochastic, the "reservation productivity" is maximized at the efficient parameter configuration (see Pissarides [1990], Ch. 7).

To get an intuition for this result, Appendix 3 shows that aggregate welfare in steady state can be written as follows:

$$W^*(t) = \left[K_0^* + \frac{p^*\overline{M} + \tilde{w}^{*D}\overline{L}}{r - \gamma}\right]A(t). \tag{28}$$

This expression splits welfare in terms of the *shadow* income flows attributable to different factors of production. The first term K_0^* corresponds to the present value of income that goes to the owners of the *initial* distribution of production units. The second term is the discounted value of shadow income that flows to the owners of the intermediate input ($p^*\overline{M}$) and to workers ($\tilde{w}^D\overline{L}$). Note that the shadow wage goes to both employed and unemployed workers, because the latter also receive an expected flow $\tilde{w}^{*D}$ based on the probability of finding a job (see equation (16)).

Now, we need to compare W^* across steady states that correspond to different configurations of (ϕ,β). The problem is that if we want to talk meaningfully about the parameters (ϕ,β) that maximize W^*, we need to start from the same initial distribution of jobs. But this means that we will not be generally starting in steady state. For this reason, despite the fact that our result is quite general, we limit our discussion to the limit-case where $(r - \gamma)$ goes to zero. In this undiscounted case, initial conditions do not matter, and we can ignore the term K_0^*.

In this case, equation (28) shows that the bargaining parameters that maximize welfare are the ones that maximize the shadow wage $\tilde{w}^{*D}$. But exit condition (22), which can be written as $\tilde{w}^{*D} = e^{-\gamma\bar{a}^*} - p^*$, implies that maximizing $\tilde{w}^{*D}$ amounts to minimizing $\bar{a}^*$. Thus, the efficient parameter configurations are the ones that minimize $\bar{a}^*$.

Intuitively, sclerosis in this economy—whether insiders are weak or strong—results from the undervaluation and misuse of labor as a factor of production. It is when labor has the highest shadow value that the pressure to exit is highest on outdated techniques and the pace of renovation is fastest. When insiders are weak, the reason for the undervaluation of labor is clear. When they are strong, their shadow wage should be high in partial equilibrium. But in general equilibrium, strong insiders discourage job creation, leading to increased unemployment and a depressed shadow wage of an unemployed worker.[36]

36. Note that this discussion is about shadow wages, not *actual* wage flows. In fact, one can show that—with continuous Nash bargaining—average wage payments are generally maximized in the interior of the strong-insiders region.

V. Policy

In this section we turn to government policy. What kind of policies can improve the pace and cyclical features of the creative destruction process? What would be the effect of those policies on unemployment and sclerosis? A simple answer is to recommend that governments implement institutional reform in the labor market to fix the problems at their root. However, there is often little the government can do when the problem is one of incomplete contracting at the microeconomic level. When appropriability operates through legislation, reform may either be politically infeasible or undesirable from a distributional or social point of view. In the absence of an institutional cure, we study two classes of macroeconomic policies—production and creation incentives—that can provide at least a partial cure for the economy's ills. As we will see, those two types of policies affect the economy's unemployment and sclerosis problems very differently, and could actually be combined optimally to bring the economy to its efficient outcome.

A. Production and Creation Incentives

At first sight, policies that directly encourage creation, e.g., an investment tax credit, and those that directly encourage production, e.g., a reduction in the corporate income tax, may appear equivalent. So long as their benefits are the same in present value terms, should they not affect investment in the same way? In the presence of two margins, this argument misses important differences in the way those policies affect destruction. Creation incentives directly affect the decision to invest, and, through more intense hiring in the labor market, indirectly prop up wage pressures on exiting jobs. Production incentives not only affect investment decisions, but also directly encourage firms to keep outdated production units longer in operation.[37]

We introduce production incentives in our model as a subsidy $i_p(t)$ that we subtract from a production unit's operating costs. We

Politically, labor may thus find it advantageous to push for an outcome where insiders have greater-than-efficient bargaining power.

37. In practice, distinguishing between production and creation incentives can be quite tricky. Consider an investment tax credit. Although it is primarily a creation incentive, it can act simultaneously as a production incentive if, through a Keynesian multiplier effect, it leads to an aggregate-demand expansion. As a second example, consider a tax holiday for new investments. It acts effectively as a creation incentive if it lasts less than a production unit's lifetime, but as a production incentive if it lasts more.

introduce creation incentives as a subsidy $i_c(t)A(t)$ paid for each production unit created, which we subtract from the unit's effective creation cost.[38] Decentralized equilibrium conditions (18)–(19) become

$$(29)\qquad A(t-\bar{a}(t)) - [p(t) + \tilde{w}^D(t) - i_p(t)]\,A(t) = 0;$$

$$(30)\qquad [\tilde{c}^D(t) - i_c(t)]\,A(t) = \int_t^{t+T(t)} [A(t) - (p(s) + \tilde{w}^D(s) - i_p(s))A(s)]\,e^{-(r+\delta)(s-t)}ds.$$

We analyze the effects of those policies on the economy's steady state in terms of the sufficient statistics $(U^*,\bar{a}^*)$.[39] Appendix 4 shows that an increase in the production incentive i_p^* increases the hiring intensity H^*/U^*, reduces unemployment U^*, but increases the scrapping age $\bar{a}^*$. The subsidy i_p^* to profit margins protects outdated production units by absorbing the cost pressures to destroy them, including those from increased hiring intensity. The impact of creation incentives is quite different. Appendix 4 shows that an increase in i_c^* raises the hiring intensity H^*/U^*, reduces the scrapping age $\bar{a}^*$, while its effect on unemployment U^* is ambiguous. A creation subsidy leads to greater hiring intensity, which increases wage pressures to destroy outdated production units. Its effect on unemployment depends on the degree to which higher destruction offsets the positive effect of increased creation on employment.

Figure VIII illustrates the steady-state effects of production and creation incentives. The solid and dashed lines represent the steady states that correspond to a range a values for i_p^* and i_c^*, respectively (subsidies are positive and taxes are negative). The two lines intersect at the point where $i_p^* = i_c^* = 0$. Arrows indicate the direction of movement along those lines when i_p^* and i_c^* are increased. The figure was generated with what we take to be a realistically small value for the search cost.[40] In this small-c_2 case, the two policies appear almost "orthogonal": production sub-

38. Depending on the way it is designed, the creation subsidy could be appropriable or not. Our formulation implicitly assumes the former.

39. As explained in subsection IV.B, all steady-state results in this section are presented under the simplifying assumption that $c_1 = 0$. Since differentiating between c_0 and c_1 is much less important in steady state than over the cycle, we assume that $c_1 = 0$ to present results in their clearest form.

40. The figure was generated with the same parameters as Figure VII. We chose to model a ϕ-inefficient economy with bargaining parameters $\beta = 0.5$ and $\phi = 0.3$. We calibrated p^* and the creation cost parameters c_0 and c_2 (we set $c_1 =$

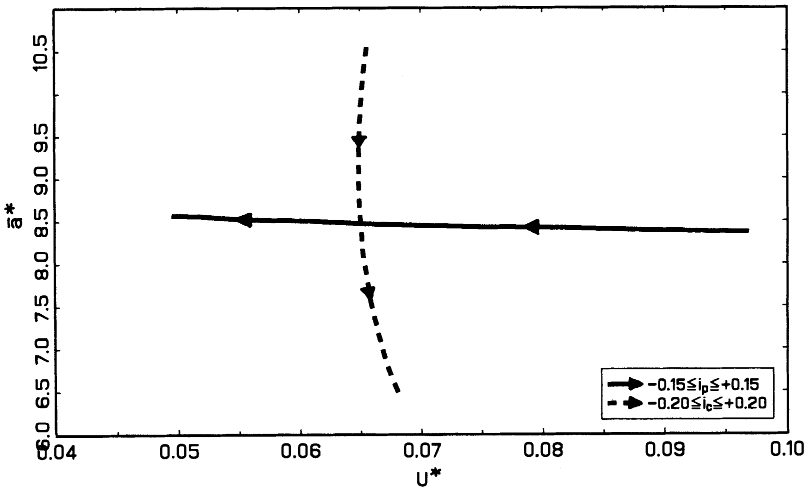


FIGURE VIII
Increases in Production and Creation Incentives

sidies are the appropriate tool to reduce steady-state unemployment with little effect on $\bar{a}^*$, while creation subsidies are the tool to reduce sclerosis with little effect on U^*.

How do those conclusions carry over to *temporary* increases in $i_p(t)$ and $i_c(t)$? Noting from (29)–(30) that the production subsidy $i_p(t)$ and the cyclical variable $p(t)$ enter profit margins in the same way (but with opposite signs), we can use our previous analysis of business cycles to analyze the effect of temporary production incentives. If we think of fluctuations as being driven by $i_p(t)$ rather than by $p(t)$, our previous analysis indicates that, similarly to what happens in steady state, a temporary increase in $i_p(t)$ will generally result in lower $U(t)$ and higher $\bar{a}(t)$. However, the steady-state result that the effect on $\bar{a}(t)$ is small when search costs are small does not generalize. We saw in subsection IV.C that, even when search costs are zero, recessions can reduce $\bar{a}(t)$ substantially and have a strong cleansing effect on the pro-

0 because it is not central for steady-state issues) so as to yield an unemployment rate $U^* = 0.065$, a hiring intensity of $H^*/U^* = 3$, and a search cost S^* equal to three weeks of the leading technology's quasi rents. Calibration was done with zero government incentives ($i_c^* = i_p^* = 0$). It is the last restriction on S^* that gives us the small value for c_2. The implied scrapping age for the calibrated economy is $\bar{a}^* = 8.47$ years.

ductive structure.[41] Similarly, the intuition for why permanent creation incentives decrease $\bar{a}(t)$ in steady state clearly carries over to temporary ones. It will still be the case that the resulting rise in hiring incentives will increase wage pressures on exiting production units.

B. Expansionary Policy, Liquidationism, and Accelerationism

Having characterized the effects of our two policy instruments, we can now assess them in terms of welfare. We concentrate on the strong-insiders region, where the economy suffers from high unemployment and technological sclerosis, and study the welfare effects of introducing a small production or creation incentive.

Production Incentives and the Liquidationist View of Recessions. In the strong-insiders region the welfare effect of expanding the economy through a production subsidy appears to be, at first sight, ambiguous. On the one hand, economic expansion can relieve the unemployment problem; on the other, it exacerbates the state of technological sclerosis. Could the second effect dominate the first and make the expansion undesirable on the whole? In this case, what the economy really needs would be a recession that cleanses its productive structure: an idea reminiscent of the pre-Keynesian liquidationist view (see, e.g., De Long [1990]).

To address this question, let us first look at the steady-state welfare effects of a small production subsidy di_p^* starting from $i_p^* = 0$. As discussed in subsection IV.B, a meaningful welfare comparison across steady states can only be undertaken in the limit case where $(r - \gamma)$ goes to zero, so that initial conditions do not matter. In this case, Appendix 3 shows that the change in the *flow* of steady-state welfare in response to policy can be expressed in terms of the response of the hiring intensity H^*/U^*:

$$d\omega^*|_{i_p=i_c=0} = (\tilde{w}^{*D} - \tilde{w}^{*S})U^*\frac{d(H^*/U^*)}{H^*/U^*}, \tag{31}$$

where $\omega^* A(t) \equiv \lim_{r \searrow \gamma}(r - \gamma)W^*(t)$, and $\tilde{w}^S \equiv -C_U$ represents the *social* shadow value of an unemployed worker. It is easy to see

41. The cleansing effect of recessions arises in the imperfect-insulation case $c_1 > 0$. A large c_1 is much less important for steady-state analysis. Although Figure VIII was generated with $c_1 = 0$, for example, we generated the same figure with a large c_1 and obtained qualitatively very similar results.

that, when insiders are strong, their decentralized-equilibrium shadow wage $\tilde{w}^D(t)$ is always greater than their social shadow wage $\tilde{w}^S(t)$.[42] Since a production incentive always increases H^*/U^*, equation (31) shows that a small production subsidy is always welfare-improving in the strong-insiders region.[43] Exit condition (29) gives a good intuition why the liquidationist view cannot hold here. The cleansing that results from depressing the economy amounts to moving a worker from a job at the destruction margin to the unemployment pool. Since the exiting worker produces $\tilde{w}^{*D}$ on the job but has a social value of only $\tilde{w}^{*S}$ in the unemployment pool, this produces a social loss of $(\tilde{w}^{*D} - \tilde{w}^{*S}) > 0$. This intuition carries over to temporary recessions as well, since the inequality $\tilde{w}^S(t) < \tilde{w}^D(t)$ also holds outside of steady state.[44]

Creation Incentives and "Accelerationist" policies. Let us now turn to the steady-state welfare effect of a small creation subsidy di_c^* starting from $i_c^* = 0$. In the strong-worker region this policy would provide a partial cure for sclerosis by reducing $\bar{a}^*$. Although its effect on unemployment is ambiguous, we know by equation (31) that, since it increases H^*/U^*, it must be welfare-improving.

Naturally, a creation subsidy can only be beneficial up to a point. When the subsidy becomes too large, the economy will suffer from a state of hyperkinesis with restructuring happening at an excessively fast and costly pace. Government intervention can thus give rise to a new phenomenon of excessively *low* $\bar{a}^*$, which we saw would otherwise not arise in our decentralized economy.[45]

42. Since we are comparing $\tilde{w}^S$ and $\tilde{w}^D$ for the *same* aggregate quantities, this statement corresponds to the simple partial-equilibrium result that the shadow wage is increasing in the bargaining position of insiders.

43. Conversely, one can show that, in the weak-insiders region, $(\tilde{w}^{*D} - \tilde{w}^{*S}) < 0$ and a small production *tax* is welfare-improving.

44. In the working-paper version [Caballero and Hammour 1994b, figure 10] we show the time path of the flow of welfare that corresponds to the business-cycle simulation in Figure II.b, assuming that the business cycle is driven by fluctuations in $i_p(t)$. Even though the source of fluctuations is a pure policy variable—which does not have the *direct* welfare-effect of $p(t)$—is it clear there that the flow of welfare is procyclical.

45. The case of Singapore as documented by Young [1992] seems to match well this pattern of government-induced high investment and excess restructuring. In the 1970s and 1980s aggregate investment in Singapore reached phenomenal levels as a share of GDP, peaking at 43 percent in 1984. High investment was to a great extent related to a combination of tax incentives and widespread government participation in the finance of local companies (financed primarily by labor-income taxation and forced saving). Not surprisingly, during the same pe-

C. Optimal Dynamic Policy

We have seen that production and creation subsidies affect the economy's creation and destruction margins differently. This raises the question whether a judicious combination of the two policies can correct the price signals that distort those two margins and restore full efficiency.

In fact, the solution to this problem is quite simple. We can restore efficiency if we use the creation subsidy to correct the distortion in the effective creation-cost signal, and the production subsidy to correct the shadow-wage signal. In other words, we need to set

(32)

$$\begin{cases} i_c(t) = \tilde{c}^D(t) - \tilde{c}^S(t) = \dfrac{\beta\phi}{1-\beta} I_H(t) + \dfrac{\beta - \eta}{(1-\eta)(1-\beta)} S(t); \\ i_p(t) = \tilde{w}^D(t) - \tilde{w}^S(t) = \dfrac{H(t)}{U(t)} i_c(t). \end{cases}$$

It is straightforward to verify that equilibrium conditions (29)–(30) for the decentralized economy subject to those subsidies are identical to equilibrium conditions (8)–(9) for the corresponding efficient economy.

Consider what this implies for a strong-insiders economy in steady state. Such an economy suffers from high unemployment and sclerosis. In terms of Figure VIII we need to move it in the southwest direction. This can be achieved through a combination of *positive* production and creation subsidies. The former mainly reduces unemployment (westward movement), and the latter mainly relieves sclerosis (southward movement). Thus, the presence of strong insiders requires that firms be compensated via a combination of creation and production subsidies. The opposite policies are required when insiders are weak.

In addition to the level effects above, equations (32) also allow us to solve for the cyclical aspect of optimal policy design. In order to isolate this cyclical dimension, we remove level effects

riod the economy was undergoing one of the world's highest rates of structural change in manufacturing, moving from one industry specialization to the next at a very fast pace. Young's assessment of the Singaporean economy is that it invested and restructured at excessively high rates. Compared with a laissez-faire economy like Hong Kong, it reached a similar growth rate but at a much higher cost.

by focusing on cases where (ϕ,β) lie along the efficient steady-state equivalence curve described in subsection IV.A.[46] Figure IX presents optimal dynamic policies for the economy simulated in Figure II. The business cycle variable $b(t)$ is shown in panel a, the optimal path of creation incentives in panel b, and the optimal path of production incentives in panel c. The last two panels present curves for different configurations of bargaining-position parameters (ϕ,β) along the efficient equivalence-curve. The efficient parameter configuration is $(\phi,\beta) = (0,1/2)$ (since $\eta = 1/2$), and calls for no government intervention. As the parameter configuration gives more weight to the appropriability parameter ϕ, optimal creation and production subsidies become increasingly countercyclical. As we have seen in subsection III.C, as the appropriability problem worsens, the shadow wage becomes increasingly rigid. Relative to the efficient economy, insiders become excessively strong during recessions, when wages do not fall enough and unemployment is too high, and excessively weak during expansions for the opposite reason. This explains why firms must be given incentives during recessions, and taxed during expansions.

VI. Conclusion

Economies are hardly static structures occasionally perturbed by aggregate shocks. Rather, they are dynamic, continuously restructuring objects, with large and sustained factor reallocation flows. Technological unemployment, as described by Schumpeter, is a natural result of the frictions indigenous to the process of reallocation. But it comes with no guarantee that unemployment is at the right level, that restructuring occurs at an adequate pace, or that the cyclical features of reallocation flows are efficient.

In this paper we have focused on the disruptive effects on creative destruction of incomplete contracting in the labor market, when investment exhibits some degree of specificity with respect to labor. We argued that the resulting problem of appropriability in the capital-labor relationship is a pervasive one, and permeates all levels at which capital and labor interact.

46. This guarantees that, in steady state, insiders are neither too strong nor too weak. It does not guarantee that the same is true *on average* in an economy with ongoing fluctuations. However, Figure IX shows that this difference is of minor importance.

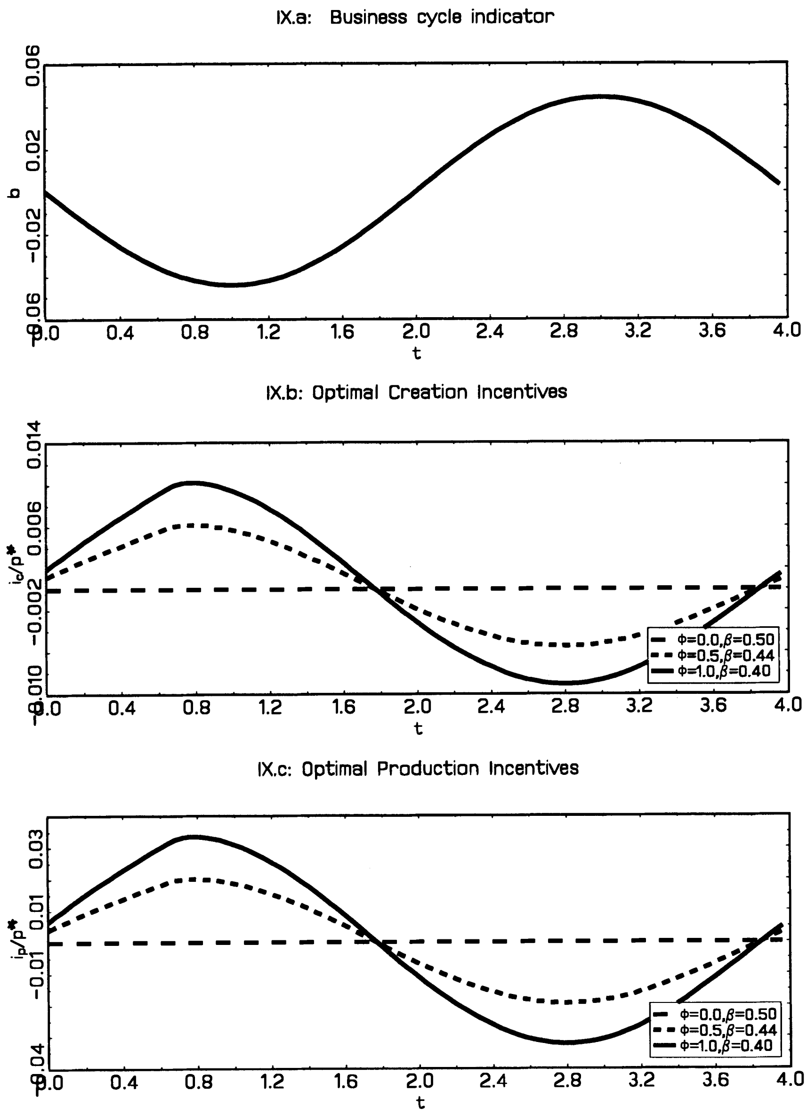


FIGURE IX
Optimal Countercylical Policies

Note that $c_0 > 0$, $c_1 > 0$, and $c_2 > 0$.

We found that appropriability problems systematically lead to technological sclerosis, whether insiders' bargaining position is strong or weak. The basic reason is that, in general equilibrium, those inefficiencies lead to a misuse and undervaluation of labor at the margin. If insiders are weak, labor costs on old techniques are relatively too low, leading firms to keep them for too long. If insiders are strong, they discourage job creation, leading in turn to less pressure for job destruction and to high unemployment.

With strong insiders, an effective policy response to sclerosis lies in the introduction of incentives to create which, by increasing the intensity of hiring in the labor market, prop up wage pressures to scrap old technology. But, as far as high unemployment is concerned, hiring incentives may not be an effective remedy precisely because they lead to increased scrapping. To partially reduce their effect on the destruction margin, creation incentives can be complemented by means of policies that encourage firms to keep their workers, although one has to be careful not to exacerbate the appropriability problem through such policies as the imposition of firing costs.

Incomplete contracting can also disrupt the cyclical response of creative destruction. In an efficient economy there are strong reasons to concentrate reallocation efforts in recessions, when the opportunity cost of generating the unemployment needed to facilitate reallocation is low. Recessions should be times of intense reallocation, when creation as well as destruction and unemployment are high. Appropriability problems, by introducing a form of wage rigidity, may derail the desired synchronization of job flows. Such decoupling is consistent with the evidence on gross labor flows documented by Davis and Haltiwanger [1990, 1992] and Blanchard and Diamond [1989]. Their evidence shows that the large increase in job destruction and unemployment during recessions is associated with low rather than high creation. Moreover, the apparent smoothing of creation over the cycle finds no counterpart in the behavior of destruction.

Paradoxically, the same appropriability problems that lead to technological sclerosis also lead to excessive destruction during recessions. Rather than being times of increased reallocation intensity, recessions become times of productivity cleansing. This does not mean that, because of sclerosis, we find a case for a revived liquidationist view of recessions as desirable. High destruction and increased unemployment are essentially wasteful in this context. When insiders are strong, their shadow wage in production is greater than their social shadow value, and the difference is lost when they are moved from production to unemployment. In the absence of an institutional cure for malfunctioning labor markets, cyclical policy may be called for. In the face of wage rigidity induced by appropriability problems, the provision of countercyclical incentives to firms may help improve the timing of labor-reallocation flows over the cycle.

APPENDIX 1: (ϕ,β)-EQUIVALENCE IN STEADY STATE

In this Appendix we prove the steady-state equivalence result between ϕ and β stated in subsection IV.A. For any steady state $(\bar{a}_0^*, H_0^*, U_0^*)$ we must determine the corresponding equivalence schedule $(\phi,\beta) = (\phi, f_0(\phi))$ along which the steady state remains unchanged. From equations (22)–(23) we know that for this to happen $\tilde{w}^{*D}$ and $\tilde{c}^{*D}$ must be constant along those schedules.

Now, replacing (25) in (26) yields $\tilde{c}^{*D} = I_H^* + S^* + \tilde{w}^{*D}U^*/H^*$. This means that a schedule $(\phi, f_0(\phi))$ that keeps $\tilde{w}^{*D}$ constant given $(\bar{a}_0^*, H_0^*, U_0^*)$ also keeps $\tilde{c}^{*D}$ constant. This schedule can be easily obtained by inverting (25) and solving for the wage in (22):

$$f_0(\phi) = \left[1 + \frac{H^*}{U^*}\left(\frac{\phi I_H^* + S^*}{b^* + e^{-\gamma\bar{a}^*}}\right)\right]^{-1}_{(\bar{a}^*, H^*, U^*) = (\bar{a}_0^*, H_0^*, U_0^*)}.$$

APPENDIX 2: THE WEAK- AND STRONG-INSIDERS REGIONS: CHARACTERIZATION

Here we analyze the steady-state effect of changing the bargaining position of insiders on (*i*) the flow probability $X^* \equiv H^*/U^*$ of the unemployed finding a job, (*ii*) the scrapping age $\bar{a}^*$, and (*iii*) unemployment U^*. Given the equivalence result in Appendix 1, we set without loss of generality $\phi = 0$ and vary β in the analysis.

Replacing $\tilde{w}^{*D}$ from (25) in exit condition (22) and differentiating yields

$$(33) \qquad -\gamma e^{-\gamma\bar{a}^*} d\bar{a}^* = \frac{\beta S^*}{(1-\beta)(1-\eta)}\, dX^* + \frac{X^* S^*}{(1-\beta)^2}\, d\beta.$$

Replacing $\tilde{c}^{*D}$ from (26) in free-entry condition (23) and differentiating yields

$$(34)\qquad PV'(\bar{a}^*)d\bar{a}^* = \frac{\eta}{1-\eta}\frac{S^*/X^*}{1-\beta}dX^* + \frac{S^*}{(1-\beta)^2}d\beta.$$

(*i*) Solving out for $d\bar{a}^*$ in (33)–(34), we get

$$\frac{dX^*}{d\beta} = -\frac{X^*(1-\eta)[PV'(\bar{a}^*)X^* + \gamma e^{-\gamma\bar{a}^*}]}{\eta(1-\beta)[(\beta/\eta)PV'(\bar{a}^*)X^* + \gamma e^{-\gamma\bar{a}^*}]},$$

which is strictly negative since $PV'(\bar{a}^*) > 0$.

(*ii*) Solving out for dX^* rather than $d\bar{a}^*$ in (33)–(34), we get

$$\frac{d\bar{a}^*}{d\beta} = \frac{S^*X^*(\beta-\eta)}{(1-\beta)^2[\beta X^*PV'(\bar{a}^*) + \eta\gamma e^{-\gamma\bar{a}^*}]}.$$

Thus, $\bar{a}^*$ decreases (respectively, increases) as insiders' bargaining position improves when insiders are weak (respectively, strong), reaching a minimum at the efficient point.

(*iii*) As for unemployment, differentiating (24) yields

$$\frac{dU^*}{d\beta} = -U^2\left[\frac{1-e^{-\delta\bar{a}^*}}{\delta}\frac{dX^*}{d\beta} + X^*e^{-\delta\bar{a}^*}\frac{d\bar{a}^*}{d\beta}\right].$$

This expression is clearly positive in the weak-insiders region, since both X^* and $\bar{a}^*$ decrease as the position of insiders improves. In the strong-insiders region this expression is more difficult to sign. All the numerical examples we have tried show U^* rising with β throughout the region, but we could not prove this in general. What we can show is that $dU^*/d\beta$ is positive near $\beta = \eta$ (because there $dX^*/d\beta > 0$ and $d\bar{a}^*/d\beta \approx 0$), and that $U^* \to \bar{L}$ as $\beta \to 1$ (because the effective creation cost goes to infinity while the present value of quasi rents is bounded from above by $1/(r + \delta) < \infty$).

APPENDIX 3: STEADY-STATE WELFARE

This appendix derives (*i*) expression (28) in subsection IV.B for steady-state welfare in terms of factor income streams and (*ii*) expression (31) in subsection V.B for the effect of policy on the steady-state flow of welfare in the limit case when $r \searrow \gamma$.

(*i*) Replacing the accounting identities (4) and (5) in the social planner's objective function (7) yields the following expression for welfare at time *t:*

$$(35)\quad W(t)=A(t)\int_t^{\infty}[q(s)-C(s)+p(s)(\overline{M}-E(s))]e^{-(r-\gamma)(s-t)}ds,$$

where $q(t) \equiv Q(t)/A(t)$. Adding and subtracting the shadow price signals net of government subsidies $(\tilde{w}^D(s) - i_p(s))E(s)$ and $(\tilde{c}^D(s) - i_c(s))H(s)$ introduced in (29)–(30), we get

$$\begin{aligned}(36)\quad W(t)/A(t) = &\int_t^{\infty}[q(s) - (p(s) + \tilde{w}^D(s) - i_p(s))E(s)\\ &- (\tilde{c}^D(s) - i_c(s) - i_c(s))H(s)]e^{-(r-\gamma)(s-t)}ds\\ &+ \int_t^{\infty}[(\tilde{c}^D(s) - i_c(s))H(s) - C(s)]\, e^{-(r-\gamma)(s-t)}ds\\ &+ \int_t^{\infty}[p(s)\overline{M} + (\tilde{w}^D(s) - i_p(s))E(s)]\, e^{-(r-\gamma)(s-t)}ds.\end{aligned}$$

First, we show that the first term in (36) is equal to the shadow quasi rents $K_0(t)$ attributable to the owners of the initial distribution of production units. To see this, note that expressions (1)–(2) for employment and output imply that

$$\begin{aligned}&\int_t^{\infty}[q(s) - (p(s) + \tilde{w}^D(s) - i_p(s))\, E(s)]e^{-(r-\gamma)(s-t)}ds\\ &= \int_t^{\infty}\int_0^{\bar{a}(s)}[e^{-\gamma a} - (p(s) + \tilde{w}^D(s) - i_p(s))]H(s-a)e^{-\delta a}da\; e^{-(r-\gamma)(s-t)}ds\\ &= \int_t^{t+T(t)}\int_{s-t}^{\bar{a}(s)}[e^{-\gamma a} - (p(s) + \tilde{w}^D(s) - i_p(s))]\, H(s-a)e^{-\delta a}da\; e^{-(r-\gamma)(s-t)}ds\\ &+ \int_t^{\infty}\int_0^{\min\{s-t,\bar{a}(s)\}}[e^{-\gamma a} - (p(s) + \tilde{w}^D(s) - i_p(s))]\\ &\qquad H(s-a)e^{-\delta a}da\, e^{-(r-\gamma)(s-t)}ds.\end{aligned}$$

The first term in the final expression is what we define as $K_0(t)$. By free-entry condition (30), the second term is equal to $\int_t^{\infty}[\tilde{c}^D(s) - i_c(s)]\, H(s)e^{-(r-\gamma)(s-t)}ds$, which proves our claim.

Second, using (3) and (20)–(21), it is easy to see that $C(s) = \tilde{c}^D(s)H(s) - \tilde{w}^D(s)U(s) - \frac{1}{2} I_{HH}(s)H(s)^2$. This implies that the second terms in (36) is equal to

$$\int_t^{\infty}[\tilde{w}^D(s)U(s) + \frac{1}{2}I_{HH}(s)H(s)^2 - i_c(s)H(s)]e^{-(r-\gamma)(s-t)}ds.$$

All of the above implies that, using (6), expression (36) can be rewritten as

$$\frac{W(t)}{A(t)} = K_0(t) + \int_t^{\infty}\left[p(s)\overline{M} + \tilde{w}^D(s)\overline{L} + \frac{1}{2}I_{HH}(s)H(s)^2 - i_p(s)E(s) - i_c(s)H(s)\right]e^{-(r-\gamma)(s-t)}ds.$$

Setting $I_{HH} \equiv 0$ (since we assume that $c_1 = 0$ in the main text) and $i_p \equiv i_c \equiv 0$, and solving in steady state yields (28).

(*ii*) Define the steady-state flow of welfare as $\omega^* A(t) \equiv \lim_{r\searrow\gamma} (r - \gamma)W^*(t)$. Using (6) in (35), this is equal to $\omega^* = q^* - C^* + p^*M - p^*(\overline{L} - U^*)$. Now steady-state equations (22)–(23) (after including the subsidies in (29)–(30)) can be thought of as determining the pair (H^*,U^*), with $\overline{a}^*$ implicitly determined by (24). With this in mind, we can write the effect of policies on the welfare flow as follows:

$$(37) \qquad d\omega^* = (q^*_{H^*} - C^*_{H^*})\, dH^* + (q^*_{U^*} + p^* - C^*_{U^*})dU^*.$$

Equations (29)–(24), together with exit condition (29) in steady state, imply that

$$q^*_{H^*} = \frac{q^* - (p^* + \tilde{w}^{*D} - i^*_p)E^*}{H^*} \text{ and } q^*_{U^*} = -\,(p^* + \tilde{w}^{*D} - i^*_p).$$

Using free-entry condition (30) in steady state with $r = \gamma$, we can rewrite the first expression as $q^*_{H^*} = \tilde{C}^{*D} - i^*_c$. Substituting in (37), we get

$$d\omega^* = (\tilde{c}^{*D} - i^*_c - \tilde{c}^{*S})dH^* - (\tilde{w}^{*D} - i^*_p - \tilde{w}^{*S})\, dU^*,$$

where $\tilde{c}^{*S} = C^*_H$ and $\tilde{w}^{*S} = -C^*_U$. This expression yields (31), since from (32), we have $\tilde{c}^{*D} - \tilde{c}^{*S} = (\tilde{w}^{*D} - \tilde{w}^{*S})/(H^*/U^*)$, which yields expression (31).

Appendix 4: Effects of Production and Creation Incentives

Appendix 4 derives the results presented in subsection V.A on the steady-state effects of production incentives i^*_p and creation incentives i^*_c on hiring intensity $X^* \equiv H^*/U^*$, unemployment U^*, and the scrapping age $\overline{a}^*$. The system of equations that determines the effect of policies on steady state is (22)–(27), where (22)–(23) are amended as follows to incorporate the subsidies i^*_p and i^*_c:

(38) $$e^{-\gamma\bar{a}^*} - [p^* + \tilde{w}^{*D} - i_p^*] = 0,$$

(39) $$\tilde{c}^{*D} - i_c^* = PV(\bar{a}^*).$$

As stated in subsection IV.B, our steady-state results are derived under the simplifying assumption $I_{HH}^* \equiv 0$.

Production Incentives. Differentiate (38) and (39) with respect to i_p^*, taking (25) and (26) into account, to obtain

(40) $$\frac{d\bar{a}^*}{di_p^*} = \frac{e^{\gamma\bar{a}^*}}{\gamma}\left[1 - \frac{\beta}{1-\beta}\left(\phi I_H^* + \frac{S^*}{1-\eta}\right)\frac{dX^*}{di_p^*}\right]$$

and

(41) $$\frac{dX^*}{di_p^*} = \frac{1-\eta}{\eta}\frac{X^*}{S^*}(1-\beta)PV'(\bar{a}^*)\frac{d\bar{a}^*}{di_p^*}.$$

Since we assume throughout the paper that $r > \gamma$, (27) yields

$$PV'(\bar{a}^*) = \frac{\gamma}{r+\delta-\gamma}(e^{-\gamma\bar{a}^*} - e^{-(r+\delta)\bar{a}^*}) > 0,$$

which implies by (41) that $\mathrm{sgn}(d\bar{a}^*/di_p^*) = \mathrm{sgn}(dX^*/di_p^*)$. But this condition is only consistent with (40) if

$$\frac{dX^*}{di_p^*} > 0 \text{ and } \frac{d\bar{a}^*}{di_p^*} > 0.$$

Using this result and differentiating equation (24) shows that unemployment decreases with the subsidy i_p^*:

$$\frac{dU^*}{di_p^*} = -U^{*2}\left\{(1 - e^{-\delta\bar{a}^*})\frac{dX^*}{di_p^*} + \delta X^* e^{-\delta\bar{a}^*}\frac{d\bar{a}^*}{di_p^*}\right\} < 0.$$

Creation Incentives. Replacing (25) in (38) and differentiating the resulting expression with respect to i_c^* yields

(42) $$\frac{d\bar{a}^*}{di_c^*} = -\frac{e^{\gamma\bar{a}^*}}{\gamma}\frac{\beta}{1-\beta}\left[\phi I_H^* + \frac{S^*}{1-\eta}\right]\frac{dX^*}{di_c^*}.$$

Substituting (26) in (23), differentiating with respect to i_c^*, and substituting $d\bar{a}^*/di_c^*$ from (42) yields

$$\frac{dX^*}{di_c^*} = (1 - \beta)\left[\frac{\eta}{1-\eta}\frac{S^*}{X^*} + \frac{e^{\gamma\bar{a}^*}}{\gamma}PV'(\bar{a}^*)\beta\left(\phi I_H^* + \frac{S^*}{1-\eta}\right)\right]^{-1} > 0.$$

This, in conjunction with (42), implies that

$$\frac{d\bar{a}^*}{di_c^*} < 0.$$

Finally, as illustrated in Figure VIII, the response of unemployment to creation incentives cannot be unambiguously signed.

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REFERENCES

Aghion, Philippe, and Peter Howitt, "A Model of Growth through Creative Destruction," *Econometrica,* LX (1992), 323–52.
Aghion, Philippe, and Peter Howitt, "Growth and Unemployment," *Review of Economic Studies,* LXI (1994), 477–94.
Aghion, Philippe, and Gilles Saint-Paul, "On the Virtue of Bad Times," typescript, 1991.
Baily, Martin Neil, Charles Hulten, and David Campbell, "Productivity Dynamics in Manufacturing Plants," *Brookings Papers on Economic Activity: Microeconomics* (1992), 187–267.
Bartelsman, Eric J., and Phoebus J. Dhrymes, "Productivity Dynamics: U. S. Manufacturing Plants, 1972–1986," Columbia University Department of Economics Discussion Paper No. 584, September 1991.
Binmore, Ken, Ariel Rubinstein, and Asher Wolinsky, "The Nash Bargaining Solution in Economic Modeling," *Rand Journal of Economics,* XVII (1986), 176–88.
Blanchard, Olivier, and Peter Diamond, "The Beveridge Curve," *Brookings Papers on Economic Activity* (1989), 85–155.
Blanchard, Olivier, and Peter Diamond, "The Cyclical Behavior of Gross Flows of Workers in the U.S.," *Brookings Papers on Economic Activity* (1990), 85–155.
Bresnahan, Timothy F., and Daniel M. G. Raff, "Intra-Industry Heterogeneity and the Great Depression: The American Motor Vehicles Industry, 1929–35," *Journal of Economic History,* LI (1991), 317–31.
Bresnahan, Timothy F., and Daniel M. G. Raff, "Technological Heterogeneity, Adjustment Costs, and the Dynamics of Plant-Shut-Down Behavior: The American Motor Vehicle Industry in the Time of the Great Depression," typescript, Stanford University, 1992.
Caballero, Ricardo J., and Mohamad L. Hammour, "The Cleansing Effect of Recessions," *American Economic Review,* LXXXIV (1994a), 1350–68.
Caballero, Ricardo J., and Mohamad L. Hammour, "On the Timing and Efficiency of Creative Destruction," NBER Working Paper No. 4768, June 1994b.
Coase, Ronald, "The Nature of the Firm," *Economica,* IV (1937), 386–405.
Cooper, Russell, and John Haltiwanger, "The Aggregate Implications of Machine Replacement: Theory and Evidence," *American Economic Review,* LXXXIII (1993), 360–82.
Cox, W. Michael, and Richard Alm, "The Churn," Federal Reserve Bank of Dallas, Annual Report, 5–18, 1992.
Davis, Steven J., "Fluctuations in the Pace of Labor Reallocation," *Carnegie-Rochester Conference Series on Public Policy,* XXVII (1987), 335–402.
Davis, Steven J., and John Haltiwanger, "Gross Job Creation and Destruction:

Microeconomic Evidence and Macroeconomic Implications," *NBER Macroeconomics Annual,* V (1990), 123–68.
Davis, Steven J., and John Haltiwanger, "Gross Job Creation, Gross Job Destruction, and Employment Reallocation," *Quarterly Journal of Economics,* CVII (1992), 819–64.
De Long, J. Bradford, "Liquidation Cycles: Old Fashioned Real Business Cycle Theory and the Great Depression," NBER Working Paper No. 3546, 1990.
Diamond, Peter, "Wage Determination and Efficiency in Search Equilibrium," *Review of Economic Studies,* XLIX (1982), 217–27.
——, *On Time* (Cambridge: Cambridge University Press, 1994).
Galí, Jordi, and Mohamad L. Hammour, "Long-Run Effects of Business Cycles," typescript, 1992.
Greenwood, Jeremy, Zvi Herkowitz, and Per Krusell, "Macroeconomic Implications of Investment-Specific Technological Change," typescript, Institute for International Economic Studies Seminar Paper No. 527, October 1992.
Grossman, Gene M., and Elhanan Helpman, *Innovation and Growth in the Global Economy* (Cambridge: MIT Press, 1991).
Grout, Paul A., "Investment and Wages in the Absence of Binding Contracts: A Nash Bargaining Approach," *Econometrica,* LII (1984), 449–60.
Hall, Robert E., "Labor Demand, Labor Supply, and Employment Volatility," *NBER Macroeconomics Annual,* VI (1991), 17–47.
Hosios, Arthur J., "On the Efficiency of Matching and Related Models of Search and Unemployment," *Review of Economic Studies,* LVII (1990), 279–98.
Hulten, Charles R., "Growth Accounting When Technical Change Is Embodied in Capital," *American Economic Review* LXXXII (1992), 964–80.
Johansen, Leif, "Substitution versus Fixed Production Coefficients in the Theory of Economic Growth: A Synthesis," *Econometrica,* XXVII (1959), 157–76.
Johnson, George, and Richard Layard, "The Natural Rate of Unemployment: Explanation and Policy," in Orley Ashenfelter and Richard Layard, eds., *Handbook of Labor Economics* (Amsterdam: North-Holland, 1986).
Katz, Lawrence F., "Efficiency Wage Theories: A Partial Evaluation," *NBER Macroeconomics Annual,* I (1986), 235–76.
Klein, Benjamin, Robert G. Crawford, and Armen A. Alchian, "Vertical Integration, Appropriable Rents, and the Competitive Contracting Process," *Journal of Law and Economics,* XXI (1978), 297–326.
Layard, Richard, Stephen Nickell, and Richard Jackman, *Unemployment: Macroeconomic Performance and the Labor Market* (Oxford: Oxford University Press, 1991).
Lindbeck, Assar, and Dennis Snower, "Wage Setting, Unemployment and Insider Outsider Relations," *American Economic Review,* LXXVI (1986), 235–39.
Mortensen, Dale, "Specific Capital and Labor Turnover," *Bell Journal of Economics,* IX (1978), 572–86.
——, "The Cyclical Behavior of Job and Worker Flows," *Journal of Economic Dynamics and Control,* XVIII (1994), 1121–42.
Mortensen, Dale, and Christopher Pissarides, "The Cyclical Behavior of Job Creation and Job Destruction," in J. C. Ours, G. A. Pfann, and G. Ridder, eds., *Labour Demand and Equilibrium Wage Formation* (Amsterdam: North-Holland, 1993).
Mortensen, Dale, and Christopher Pissarides, "Job Creation and Job Destruction in the Theory of Unemployment," *Review of Economic Studies,* LXI (1994), 397–416.
Phelps, Edmund S., "Substitution, Fixed Proportions, Growth and Distribution," *International Economic Review,* IV (1963), 265–88.
Pissarides, Christopher, *Equilibrium Unemployment Theory* (Oxford: Basil Blackwell, 1990).
Saint-Paul, Gilles, "Productivity Growth and the Structure of the Business Cycle," *European Economic Review,* XXXVII (1993), 861–83.
Salter, Wilfred E. G. *Productivity and Technical Change* (Cambridge: Cambridge University Press, 1960).
Schumpeter, Joseph A., *Capitalism, Socialism, and Democracy* (New York: Harper and Brothers, 1942).
Sheshinski, Eytan, "Balanced Growth and Stability in the Johansen Vintage Model," *Review of Economic Studies,* XXXIV (1967), 239–48.

Solow, Robert M., "Investment and Technological Progress," in K. J. Arrow, S. Karlin, and P. Suppes, eds., *Mathematical Methods in Social Sciences* (Stanford: Stanford University Press, 1960).
Stiglitz, Joseph, "Endogenous Growth and Cycles," NBER Working Paper No. 4286, March 1993.
Williamson, Oliver E., "Transaction-Cost Economics: The Governance of Contractual Relations," *Journal of Law and Economics,* XXII (1979), 233–61.
——, *The Economic Institutions of Capitalism* (New York: Free Press, 1985).
Young, Alwyn, "A Tale of Two Cities: Factor Accumulation and Technical Change in Hong Kong and Singapore," *NBER Macroeconomics Annual,* VII (1992), 13–53.