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Production Fluctuations and Fiscal Policy in an Economy with Aggregate and Idiosyncratic Shocks

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Ever since Lucas (1972), much of the work on the theory of business cycles has focused on asymmetric information as a culprit in aggravating fluctuations in real variables such as GNP and employment. In Lucas' own model, there are both aggregate shocks in the form of changes in the money supply and idiosyncratic shocks to individual firms' demand, but firms cannot tell these apart. When a firm observes, say, an increase in the demand for its output, it attaches positive probability to the possibility that there has been a real change in preferences. Thus, it may expand output, rather than simply raise its price as it would do if it knew for certain that the increase was due to inflation. Hence, the entangling of aggregate and idiosyncratic shocks implies that changes in the money supply have real effects: inflation induces a rise in GNP whereas deflation promotes recession.

One unattractive feature of this model is that it requires that changes in the money supply be unobservable, and such an assumption may be hard to swallow in an age where M1 through M4 are reported virtually continuously. Accordingly, various authors (e.g., Grossman and Weiss (1982)) have attempted to replace the money supply in Lucas' model with a macro variable that is more plausibly unobservable (such as the real interest rate).

Quite a different route was taken by Grossman, Hart, and Maskin (1983), who assumed that each firm knows when a macro shock occurs but not what its effect on other firms is. They showed that a shock that would have left GNP unaffected had information been symmetric will reduce GNP under such an asymmetry of information when agents are risk-averse. Risk aversion implies that firms will attempt to insure themselves against the effects of shocks. But since other agents (including insurers) cannot directly observe how a shock affects a given firm, the firm's insurance benefits must be contingent on an observable proxy, such as its level of output. Thus, a firm will have the incentive to reduce output below the first-best efficient level in order to prove that it has been adversely affected by a shock and thereby claim an insurance benefit. The overall result is a fall in GNP greater than would have occurred had information been symmetric.

In this paper we examine two models related to that of Grossman-Hart-Maskin. In the first (sections 1 and 2), we show that there is another way in which asymmetric information can aggravate fluctuations: through a mechanism resembling a Keynesian multiplier. In this model, firms have

private information about their production costs, and this causes underproduction in high-cost firms. We show that an initial small aggregate endowment shock will, through its impact on production, affect income and hence aggregate demand, thereby inducing a large ultimate shift in production. This multiplier arises from the incompleteness of insurance possibilities that asymmetric information entails. Equilibrium in this model can be quite inefficient, even relative to the informational constraints we impose. Hence, we consider how welfare might be improved through taxes and subsidies. We demonstrate that, perhaps surprisingly, the optimal fiscal policy tends to drive equilibrium output further away from the first-best level. Moreover, despite the presence of a "Keynesian" multiplier, such a policy may well not consist of subsidizing demand and production but rather of taxing them.

In our second model (sections 3 and 4), the asymmetry of information concerns the demand for firms' products. The impact of aggregate demand shocks on unemployment in this case has been studied by Grossman, Hart, and Maskin (1983), and we do not consider that issue here. However, we do analyze whether there is a role for government intervention. As in the production-shock case, we find that a government, possessing the same information as the market, can improve on the market allocation. The optimal intervention in this case consists of stabilizing demand: high-final-demand products are taxed and low-final-demand products are subsidized.

1 Shocks to Production

Consider a competitive economy with two goods: one produced (soap), the other unproduced (oil). Each agent is endowed with \bar{K} units of oil, where \bar{K} is a random variable common to all agents with support $[\underline{K}, \bar{K}]$.

An agent can produce either zero or one unit of soap, and the latter requires c units of oil. For each agent, the value of c is drawn independently from a distribution that places equal probability on c_L and c_H , where $c_L < c_H < \underline{K}$.¹ We assume that there are many agents, so that, from the law of large numbers, the population divides equally between c_L and c_H . An agent's cost parameter is not known *ex ante*, but it becomes private information to the agent by the time he must decide on production. Only an agent's output (or, equivalently, sales) of soap—and not his input of oil or profit—is observable to others.

All agents have the same Cobb-Douglas preferences:

$$\alpha \ln x + (1 - \alpha) \ln y,$$

where x is consumption of soap and y that of oil. So that we can solve explicitly for equilibrium, agents are assumed to be infinitely risk-averse. That is, if consumption is represented by the random variables \tilde{x} and \tilde{y} , an agent's von Neumann-Morgenstern utility is given by

$$\min[\alpha \ln \tilde{x} + (1 - \alpha) \ln \tilde{y}],$$

where the minimization is taken over the random variables' supports.

Because agents are risk-averse, they will wish to purchase insurance against the randomness they face. This is provided by risk-neutral, competitive insurance companies that pool risks by insuring a large number of producers (half of whom turn out to be low-cost). Since inputs are not observable, however, insurance will necessarily be incomplete. Note also that insurance companies are unable to provide insurance across aggregate states (i.e., across different values of \tilde{K}), because pooling is impossible in the case of aggregate uncertainty.

The timing is as follows. Before any random variable is realized, agents and insurers agree to insurance contracts. In exchange for a premium, an agent receives a benefit contingent on the realization of the "macro" variable \tilde{K} and the agent's (observable) output of soap. Next, \tilde{K} and agents' costs are realized, after which agents make their production decisions. Finally, agents receive their insurance benefits, and there is competitive trade in oil and soap.

Let $p(K)$ be the equilibrium price of soap in terms of oil if the realization of \tilde{K} is K (oil is the numeraire throughout). Let $b_1(K)$ and $b_0(K)$ be an agent's insurance benefit (net of premium) when $\tilde{K} = K$ and he, respectively, does and does not produce soap. For each realization of \tilde{K} , an agent has four conceivable production plans:

- (1) produce if $\tilde{c} = c_L$ and produce if $\tilde{c} = c_H$;
- (2) produce if $\tilde{c} = c_L$ and not produce if $\tilde{c} = c_H$;
- (3) produce if $\tilde{c} = c_H$ and not produce if $\tilde{c} = c_L$;
- (4) not produce if $\tilde{c} = c_H$ and not produce if $\tilde{c} = c_L$.

We will demonstrate that for a range of parameter values there is a unique equilibrium outcome in which all the c_L agents and a fraction $\lambda(K)$ of the c_H agents produce soap. Specifically, we have the following:

PROPOSITION 1 If the realization K satisfies

$$\frac{1}{2}(2c_H - c_L)(1 - \alpha) + \frac{1}{2}\alpha c_L < \alpha K < (1 - \alpha)(2c_H - c_L) + \frac{1}{2}\alpha c_L + \frac{1}{2}\alpha c_H, \quad (*)$$

then in any equilibrium $p(K) = 2c_H - c_L$ all c_L agents produce soap and so do a fraction $\lambda(K)$ of c_H agents, where

$$\lambda(K) = \frac{2K\alpha - (2c_H - c_L)(1 - \alpha) - \alpha c_L}{(2c_H - c_L)(1 - \alpha) + \alpha c_H} \quad (**)$$

To see why this proposition holds, note first that production plan 3 is impossible in equilibrium: A c_H agent produces soap in equilibrium if and only if

$$p(K) - c_H + b_1(K) \geq b_0(K). \quad (1)$$

Inequality (1) is the c_H agent's *incentive constraint*, which arises because the value of c is private information. But (1) continues to hold when c_H is replaced by c_L —a contradiction of plan 3.

Let $b(K)$ be the *ex ante* expected net insurance benefit that a given agent receives when $\bar{K} = K$.² In equilibrium, this will be allocated between $b_1(K)$ and $b_0(K)$ so as to maximize the agent's expected utility. If the agent adopts plan 2 in equilibrium, then, in view of his extreme risk aversion, his insurance contract solves

$$\max_{b_0(K), b_1(K)} \min \{b_0(K), p(K) - c_L + b_1(K)\} \quad (2)$$

subject to

$$\frac{1}{2}b_1(K) + \frac{1}{2}b_0(K) = b(K), \quad (3)$$

$$p(K) - c_L + b_1(K) \geq b_0(K), \quad (4)$$

and

$$b_0(K) \geq p(K) - c_H + b_1(K). \quad (5)$$

Here, (4) and (5) are the incentive constraints for c_L and c_H agents, respectively. It is readily seen that the maximized value of the agent's expected utility is

$$\frac{1}{2}(p(K) - c_L) + b(K). \quad (6)$$

If instead the agent adopts plan A, his payoff is

$$b(K) \quad (7)$$

regardless of c . From (6) and (7), plan 4 can be optimal only if $p(K) \leq c_L$, which we will soon see is impossible.

Finally, if the agent adopts plan 1 his expected payoff is

$$\min\{p(K) - c_H + b(K), p(K) - c_L + \frac{1}{2}b(K)\} - \frac{1}{2}(c_H + b(K)). \quad (8)$$

Formulas (6) and (8) imply that the agent prefers plan 1 to plan 2 if $p(K) > 2c_H - c_L$, that he prefers plan 2 to plan 1 if $p(K) < 2c_H - c_L$, and that he is indifferent between the two plans if $p(K) = 2c_H - c_L$.

Suppose, contrary to the proposition, that $p(K) > 2c_H - c_L$ in equilibrium. From the above analysis, all agents adopt plan 1. Hence, the per capita supply of soap is 1. Given the Cobb-Douglas preferences, per capita demand is

$$\frac{\alpha I}{p(K)}, \quad (9)$$

where I is per capita income. In view of the equal likelihood of c_H and c_L and our assumption that all agents adopt plan 1,

$$I = p(K) - \frac{1}{2}c_L - \frac{1}{2}c_H + K. \quad (10)$$

Now, in equilibrium, supply equals demand (i.e., (9) equals 1), and so

$$p(K) = \frac{2\alpha K - \alpha c_L - \alpha c_H}{2(1 - \alpha)},$$

which, from the right-hand inequality of (*), is less than $2c_H - c_L$. Hence, $p(K) > 2c_H - c_L$ is impossible.

Next suppose that $p(K) < 2c_H - c_L$. Let $\delta(K)$ be the fraction of agents adopting plan 2 (the rest adopt plan 4). Then per capita supply is $\frac{1}{2}\delta(K)$ and per capita demand is

$$\frac{\alpha(\frac{1}{2}p(K)\delta(K) - \frac{1}{2}\delta(K)c_L + K)}{p(K)} \quad (11)$$

Equating per capita demand and supply, we obtain

$$p(K) = \frac{\alpha(K - \frac{1}{2}\delta(K)c_L)}{\frac{1}{2}(1 - \alpha)\delta(K)} \quad (12)$$

The right-hand side of (12) is smallest when $\delta(K) = 1$, in which case we obtain

$$p(K) = \frac{\alpha(K - \frac{1}{2}c_L)}{\frac{1}{2}(1 - \alpha)}. \quad (13)$$

But from the left-hand inequality of (*), the right-hand side of (13) is bigger than $2c_H - c_L$, a contradiction.

We conclude that $p(K) = 2c_H - c_L$ after all. Hence, all agents adopt either plan 1 or plan 2. Let $\lambda(K)$ be the fraction adopting plan 1. Then $\lambda(K)$ adjusts to satisfy

$$\frac{\alpha((2c_H - c_L)\{[1 + \lambda(K)]/2\} - \frac{1}{2}c_L - \frac{1}{2}\lambda(K)c_H + K)}{2c_H - c_L} = \frac{1}{2} + \frac{1}{2}\lambda(K).$$

Solving for $\lambda(K)$, we obtain (**), establishing the proposition.

It is instructive to compare this equilibrium with the one that arises when there is no asymmetry of information, i.e., when insurers can observe the realizations of the agents' costs. In that case an agent can obtain perfect insurance against fluctuations in c (although not against those in K). Hence, incentive constraints such as (4) or (5) are no longer needed. We shall call equilibrium in the case of symmetric information *first-best*.

PROPOSITION 2 Given condition (*), there is a unique first-best equilibrium in which all the c_L agents produce, a fraction $\gamma(K)$ of the c_H agents produce, and the equilibrium price $p(K)$ satisfies

$$p(K) = \frac{\alpha(K - \frac{1}{2}c_L - \frac{1}{2}\gamma(K)c_H)}{[\frac{1}{2} + \frac{1}{2}\gamma(K)](1 - \alpha)}, \quad (14)$$

where, for all K ,

$$\begin{aligned} p(K) &\geq c_H, \\ \gamma(K) &= 1 \text{ if } p(K) > c_H. \end{aligned} \quad (15)$$

To verify the claim, note first that, with perfect insurance, an agent's expected payoff from production plan 1 is

$$p(K) - \frac{1}{2}(c_H + c_L) + b(K).$$

That from plan 2 is

$$\frac{1}{2}(p(K) - c_L) + b(K),$$

and that from plan 4 is $b(K)$. Hence, plan 1 is optimal provided $p(K) \geq c_H$, plan 2 is optimal when $c_H \geq p(K) \geq c_L$, and plan 4 is optimal when $p(K) \leq c_L$. Now, the right-hand side of (14) takes on a maximum

$$\frac{\alpha(K - \frac{1}{2}c_L)}{\frac{1}{2}(1 - \alpha)} \quad (16)$$

when $\gamma(K) = 0$. But (16) is strictly greater than c_H , in view of the left-hand inequality in (*). Hence, there always exists a unique $\gamma(K)$ in $(0, 1]$ satisfying (15). If we interpret $\gamma(K)$ as the fraction of agents adopting plan 1, it is clear from the above analysis that the behavior implicit in (14) and (15) is optimal. To see that there is no other equilibrium, suppose to the contrary that $p(K) < c_H$. Then no c_H agents will produce. Let $\delta(K)$ be the fraction of c_L agents who do. Then, from the equality between supply and demand, (12) holds, and we generate the same contradiction as that following (13).

Notice that the equilibrium price and production levels of proposition 2, which obtain when there is complete insurance, coincide with those that arise when no insurance at all is possible (i.e., when agents' production levels, as well as their input levels, are unobservable): It is easy to check that each of the production plans 1, 2, and 4 is optimal for the same range of prices in both cases.

One significant difference between the equilibria of propositions 1 and 2 is that, for the range of parameters defined by (*), the latter entails a uniformly *higher* production level. That is, for all K , $\gamma(K) > \lambda(K)$. To see this, note from (14) that

$$\gamma(K) = \frac{2\alpha K - \alpha c_L - (1 - \alpha)p(K)}{p(K)(1 - \alpha) + \alpha c_H} \quad (17)$$

The right-hand side of (17) is decreasing in p . Moreover, when $p = 2c_H - c_L$ it coincides with (**), the expression for $\lambda(K)$. But in the range (*) the equilibrium price $p(K)$ in proposition 2 is strictly less than $2c_H - c_L$. Hence, $\gamma(K) > \lambda(K)$.

2 Multipliers and Taxes

Another notable distinction is that the proposition 1 equilibrium exhibits something resembling a Keynesian multiplier, whereas that of proposition

2—like those of all conventional competitive models—does not. Suppose that in the equilibrium of proposition 1 there is a small “oil shock”—an increase ΔK . Because ΔK increases agents' endowments, its initial effect is to induce a rise in the demand for soap of

$$\frac{\alpha \Delta K}{2c_H - c_L} \quad (18)$$

given the Cobb-Douglas preferences and the equilibrium price $2c_H - c_L$. The equilibrium change in supply, however, is $\frac{1}{2}\lambda'(K)\Delta K$, which, from (**), equals

$$\frac{\alpha \Delta K}{(1 - \alpha)(2c_H - c_L) + \alpha c_H} \quad (19)$$

Now, because $2c_H - c_L > c_H$, (19) is bigger than (18). Thus, an initial shock to demand is magnified into an ultimately larger equilibrium response.

In the equilibrium of proposition 2, by contrast, an initial shock to demand $\alpha \Delta K/p$ (with the price held constant) results ultimately in the equilibrium change $\frac{1}{2}\gamma'(K)\Delta K$. Now, either $\gamma' = 0$ (when $p > c_H$), in which case there is no change in output at all, or else (when $p = c_H$) the change (from (17)) is

$$\frac{\alpha \Delta K}{c_H},$$

which is exactly the same as the initial shock. Either way there is no multiplier.

Thus, because proposition 2 pertains both to symmetric information with complete insurance and asymmetric information so extreme that no insurance is possible, we conclude that the existence of a multiplier depends not only on asymmetric information but also on incomplete insurance.

Notice that in the range (*) our model exhibits constant returns to scale (CRS) at the margin (i.e., starting from less than full production, output can be expanded a bit without affecting marginal cost). The conventional argument for why there is no multiplier in a competitive CRS economy is that when there is an increase in demand, firms are willing to meet that demand at the same prices. But because these firms are earning zero marginal profit on the extra output, the higher supply generates no additional income and

so the story stops there. This is precisely what occurs in the equilibrium of proposition 2. When $p(K) = c_H$, an increase in demand draws more c_H agents into production, but each of them earns $p(K) - c_H = 0$.

The situation is even worse if there are decreasing returns to scale at the margin. For an increase in demand to be met by producers, the price must rise. But if demand is downward sloping, this higher price works to dampen the initial demand increase. Thus with decreasing returns we ordinarily obtain a *divider* rather than a multiplier.

In the incomplete insurance model of proposition 1, however, marginal profit is *not* zero despite the constant returns. The equilibrium price (marginal revenue) is $2c_H - c_L$ but the marginal cost of additional output is only c_H . Hence, the marginal profit is $c_H - c_L > 0$. Thus, an increase in demand gives rise to an increase in profit, which generates more demand, and so on.

Let us compare this explanation for a multiplier with some others in the literature. First, with imperfect competition among firms it is no longer true that the marginal social surplus (the sum of consumer and producer surplus) of another unit of output is zero. Indeed, it is ordinarily positive, since firms equate marginal revenue rather than price with marginal cost. Hence, a small increase in demand will induce an increase in surplus, leading to a further rise in demand, and so on (Blanchard and Kiyotaki 1987; Hart 1982). Second, suppose that there are positive externalities in production, so that an increase in one firm's output increases the marginal profitability of other firms' production (Diamond 1982).³ Then, an increase in demand that leads one firm to increase its production will indirectly lead others to do so as well. Finally, consider a standard competitive model but suppose that, for some reason, prices are fixed at non-Walrasian levels (Benassy 1975; Grandmont and Laroque 1976). Assume, in particular, that firms cannot sell all they would like to at these prices. Then, once again, marginal social surplus will be positive (marginal profit is positive and marginal consumer surplus is zero), and so a rise in demand will generate further rounds of increases.

Suppose that the government of our incomplete-insurance economy contemplates taxing or subsidizing the sale of soap. (For simplicity, assume that sales of oil are unmonitorable, and so a tax or subsidy on oil is impossible. This is in keeping with our assumption that inputs of oil are unobservable.) There, in fact, exists a simple policy that the government can adopt to raise equilibrium soap production to the first-best level: It can

subsidize soap and finance the subsidy with a lump-sum tax. Suppose, for example, that the first-best level of soap per capita is 1 for oil level K^* and that the corresponding equilibrium price is p^* ($< 2c_H - c_L$). The government can induce this level of output in the incomplete-insurance economy by setting the consumer price of oil, q , equal to p^* , and setting the producer price, p , at a level above $2c_H - c_L$. With such a high producer price, all agents will choose to produce soap, so that the per capita output is 1. This means that per capita income is

$$K + p - \frac{1}{2}c_H - \frac{1}{2}c_L + (q - p) = K + q - \frac{1}{2}c_H - \frac{1}{2}c_L, \quad (20)$$

where the expression in parentheses on the left-hand side corresponds to the lump-sum tax needed to finance the discrepancy between consumer and producer prices. Note that when q is set at p^* the right-hand side of (20) is just first-best per capita income.

Thus, the subsidy policy works. Moreover, by virtue of its promotion of production (and GNP), it can be thought of as a form of Keynesian "pump-priming." Indeed, analogous policies improve welfare in all the other models we mentioned that exhibit multipliers. But a subsidy is not desirable in our model. Obviously the first-best equilibrium dominates the equilibrium of proposition 1. But we saw in the preceding section that the noninsurance equilibrium (which in turn is dominated by the proposition 1 equilibrium) also has first-best-level production, suggesting that such a level is not worthwhile *per se*; the available insurance opportunities matter, too.

Indeed, we now argue that the optimal tax policy involves setting a tax on soap sales, leading to a lower production level than in proposition 1. The rationale for such a tax is that it improves insurance. A c_H agent pays less than an equal share of this tax because, with his lower income, he buys less soap than his more fortunate c_L counterparts. But he gets an equal share of the receipts from the tax. Thus, he benefits overall.

More formally, consider raising the consumer price q slightly above the producer price $p = 2c_H - c_L$. The effect on a nonproducing c_H agent's utility is

$$\frac{d}{dq} \left[\alpha \ln \left(\frac{\alpha(K + b_0 + (q - p)x)}{q} \right) + (1 - \alpha) \ln((1 - \alpha)(K + b_0 + (q - p)x)) \right], \quad (21)$$

where x is per capita demand for soap. Rewriting (21), we obtain, at $q = p$,

$$\frac{\alpha p}{K + b_0} \left[\frac{px - (K + b_0)}{p^2} \right] + \frac{1 - \alpha}{K + b_0} x = \frac{1}{K + b_0} \left[x - \frac{\alpha(K + b_0)}{p} \right]. \quad (22)$$

Now, the demand for soap by the c_H agent, $\alpha(K + b_0)/p$, is less than per capita demand, x (since the agent's income is below average). Thus, the right hand side of (22) is positive, and so a tax on soap is desirable.⁴

Why is fiscal policy necessary at all—that is, why can't the market duplicate the government's actions?

A competitive insurer—just like the government—can in principle drive a wedge between the producer and consumer prices of soap, since we assume that it can monitor sales. However, it has no incentive to do so. Suppose a large number of other insurance companies are providing such a wedge—i.e., the consumer price is $q > 2c_H - c_L$, but producers pay a tax ($q - p$) to their insurance company and so the producer price is $p = 2c_H - c_L$ (this is as in the fiscal policy described above). Then the optimal contract for a remaining small insurance company involves *all* its producers (both high-cost and low-cost) producing soap, since the effective price of soap for this coalition is $q > 2c_H - c_L$ (see (8)). Of course, if all insurers offer such a contract, then the equilibrium price could not remain above $2c_H - c_L$. Thus, there is a pecuniary externality that the individual insurer ignores by virtue of its taking prices as given. A government internalizes this externality when it sets taxes for everyone, and therein lies its advantage. Indeed, if there were only one insurer for the whole economy, it too would internalize the externality (although then presumably we would have to worry about the exercise of monopoly power). But even in this case there would be nothing to stop a new small insurance company from setting up and eliminating the wedge.

Small insurers could nevertheless improve on the competitive outcome above if they were able to keep track of their clientele's soap *purchases* as well as sales. Thanks to its ability to monitor, an insurer could (and would) offer each of its customers the following contract: pay the consumer price q rather than the producer price p , and the difference will be distributed to all the insurance company's customers as a lump-sum subsidy. In other words, each insurance company and its customers would act as a miniature government-controlled society. The customers could not avoid the tax by buying from outside soap producers, since their purchases could be monitored.

Of course, the power to monitor an agent's soap purchases considerably exceeds what we were supposing that the government could do when we considered fiscal policy. In view of the linearity of prices, that policy allowed for trade to be completely anonymous (so that the government need not keep track of any given agent's transactions at all).

Another reason why the market cannot duplicate the government's actions can also be given. Suppose insurance companies can monitor only production and not sales (the previous analysis does not depend on the possibility of sales monitoring). On the other hand, assume that consumers purchase soap in a (large) number of "established" retail stores where sales *can* be monitored. Then it is feasible for the government to drive a wedge between the producer price p and the consumer price q of soap by imposing a tax at the retail level. However, an individual insurance company cannot implement such a wedge without getting the agreement of all retail stores to buy from the producers at the price p and sell to consumers at q —something that an individual retail store has no incentive to go along with (it is better for it to let other retail stores agree to the wedge and then undercut them by selling at just below q).

3 Shocks to Demand

We next turn to a model in which aggregate shocks affect a firm's demand, along the lines of Grossman, Hart, and Maskin 1983. Specifically, we consider an economy in which each of n agents uses a single input, which we will interpret as his own labor, to produce output. There are two types of output: goods 1 and 2. Whether he produces good 1 or 2, each agent has the same production function: $f(\ell)$, where $f' > 0$, $f'' < 0$, and $f'(0) = \infty$; that is, ℓ units of labor are transformed into $f(\ell)$ units of either good 1 or good 2. Also, each agent has the same utility function: $V(U(x_1, x_2) - R\ell)$. Here U is a homogeneous-of-degree-1, twice-differentiable, concave, increasing function that transforms consumption levels of the two goods x_1 and x_2 into "utils." R represents the (real) disutility of supplying labor, and V is a strictly concave von Neumann-Morgenstern utility function representing attitudes toward risk. (In contrast to previous sections, the agent is no longer infinitely risk-averse.) For simplicity, we assume

$$U(x_1, x_2) = 0 \text{ if } x_1 \text{ or } x_2 = 0,$$

$$U_1(0, x_2) = \infty \text{ if } x_2 > 0,$$

$$U_2(x_1, 0) = \infty \text{ if } x_1 > 0,$$

and

$$U_{12} > 0,$$

where subscripts denote partial derivatives with respect to the first or second argument. One implication of our assumption that labor disutility is constant is that there is no reason for a labor market to exist; an agent may just as well use his own labor as purchase it in the marketplace.

We suppose that the two goods are *ex ante* identical, but that, after an aggregate shock hits, one of them is in high demand. Without loss of generality, we take this to be good 2:

$$U_2(1, 1)/U_1(1, 1) > 1. \quad (***)$$

We further assume that agents are affected idiosyncratically by the shock: an agent cannot predict in advance whether he will end up producing good 1 or good 2; each possibility is equally likely. This assumption is a stylized representation of a situation where the impact of an aggregate demand shock on producers is uncertain. For an alternative formulation where agents produce intermediate goods, the demands for which are stochastically related to the demand for final output, see Grossman, Hart, and Maskin 1983.

As in our model of production shocks, we suppose that an agent cannot directly insure himself against demand shocks. This assumption reflects two more basic hypotheses: that (as before) an agent's profit is unobservable, and that it may be impossible to verify *ex post* whether the agent is producing good 1 or good 2.

Hence, a contract that makes insurance contingent on an agent's output is unenforceable. For simplicity, moreover, we rule out partial insurance contingent on the employment level by supposing that it too is unverifiable. (This is in contrast to the model of sections 1 and 2, where insurance could be conditional on output.)

We evaluate agents' expected payoffs *ex ante*: formally, at date 0 (the date when insurance contracts, had they been feasible, would have been written). At date 1, each agent finds out which good he produces and, acting as a price-taker in output markets, chooses how much labor to supply accordingly. Date-1 output prices then adjust so that date-1 output markets clear. At date-1, there will be equal numbers of agents in each

sector. Normalize so that $p_1 = 1$ and $p_2 = p$, where $p > 1$. Then an agent in sector 2 will solve the following problem at date 1: Choose x_1, x_2 , and ℓ to maximize $U(x_1, x_2) - R\ell$ subject to $x_1 + px_2 \leq pf(\ell)$. Necessary and sufficient conditions for a solution to this (in addition to the budget constraint) are

$$U_2(x_1, x_2)f'(\ell_2) = R$$

and (23)

$$U_1(x_1, x_2)pf'(\ell_2) = R.$$

Similarly, the conditions for an agent in sector 1 are

$$U_2(x'_1, x'_2)\frac{f'(\ell_1)}{p} = R$$

and (24)

$$U_1(x'_1, x'_2)f'(\ell_1) = R.$$

Since markets clear at date 1, we must also have

$$x_1 + x'_1 = f(\ell_1)$$

and (25)

$$x_2 + x'_2 = f(\ell_2).$$

Together, (23)–(25) plus the two budget constraints characterize the market equilibrium.

We can simplify these conditions as follows. Since U is homogeneous of degree 1, each individual will choose to consume goods 1 and 2 in the same proportions. Hence, as long as relative prices are such that these proportions are the same as those of aggregate production $(f(\ell_1), f(\ell_2))$, budget constraints will ensure that (25) is satisfied. Therefore, using the fact that U_i is homogeneous of degree 0, we may replace (23)–(25) by the following:

$$U_2(f(\ell_1), f(\ell_2))f'(\ell_2) = R,$$

$$U_1(f(\ell_1), f(\ell_2))f'(\ell_1) = R,$$

$$\frac{U_2(f(\ell_1), f(\ell_2))}{U_1(f(\ell_1), f(\ell_2))} = p.$$

(26)

It is easy to see from this that equilibrium exists and is unique. Let (ℓ_1^*, ℓ_2^*) be the unique maximizer of

$$U(f(\ell_1), f(\ell_2)) - R\ell_1 - R\ell_2,$$

and let

$$p^* = U_2((f(\ell_1^*), f(\ell_2^*))/U_1(f(\ell_1^*), f(\ell_2^*))).$$

Then $(\ell_1^*, \ell_2^*, p^*)$ satisfies (26) and hence constitutes an equilibrium. On the other hand, any solution to (26) solves

$$\text{Maximize } U(f(\ell_1), f(\ell_2)) - R\ell_1 - R\ell_2$$

and hence equals (ℓ_1^*, ℓ_2^*) ; and so p must equal p^* .

It is useful to compare the above outcome with what a central planner could achieve under perfect information (the "first best"). *Ex post*, the planner would choose a Pareto-optimal allocation; that is, he would maximize

$$U(x_1, x_2) - R\ell_2$$

subject to

$$U(x'_1, x'_2) - R\ell_1 \geq \bar{U},$$

$$x_1 + x'_1 = f(\ell_1),$$

$$x_2 + x'_2 = f(\ell_2).$$

This also leads to the maximization of net surplus

$$U(f(\ell_1), f(\ell_2)) - R\ell_1 - R\ell_2$$

and hence to

$$(\ell_1, \ell_2) = (\ell_1^*, \ell_2^*).$$

However, the planner would engage in *ex ante* risk sharing. In particular, the planner would arrange for unlucky sector-1 producers to receive a per capita lump-sum transfer T from lucky sector-2 producers, where T maximizes the expected *ex ante* utility of a typical producer; that is, T solves

$$\begin{aligned} \text{Maximize } \frac{1}{2}V & \left(U(f(\ell_1^*), f(\ell_2^*)) \left(\frac{p f(\ell_2^*) - T}{p f(\ell_2^*) + f(\ell_1^*)} \right) - R\ell_1 \right) \\ & + \frac{1}{2}V \left(U(f(\ell_1^*), f(\ell_2^*)) \left(\frac{f(\ell_1^*) + T}{p f(\ell_2^*) + f(\ell_1^*)} \right) - R\ell_1 \right). \end{aligned}$$

The solution of this equalizes the *ex post* "utils" of sector-1 and sector-2 producers; i.e., it satisfies

$$\begin{aligned} U(f(\ell_1^*), f(\ell_2^*)) \left(\frac{p f(\ell_2^*) - T}{p f(\ell_2^*) + f(\ell_1^*)} \right) - R\ell_2^* \\ = U(f(\ell_1^*), f(\ell_2^*)) \left(\frac{f(\ell_1^*) + T}{p f(\ell_2^*) + f(\ell_1^*)} \right) - R\ell_1^*. \quad (27) \end{aligned}$$

(From this it is easy to see that $T > 0$.) Of course, it is in some sense inappropriate to compare the outcome of a constrained market economy with what an omniscient planner can achieve. We now analyze the planner's problem under the assumption that he faces the same constraints as the market.

4 Optimal Fiscal Policy

Suppose that the government can subsidize or tax outputs *ex post*, and balance the budget through lump-sum transfers (as in section 2). Reasons similar to those in section 2 explain why an entrepreneur or an insurance company cannot duplicate what the government does. In particular, whereas the government can impose a tax on good 2 at the retail level, an insurance company would have to get the consent of all retailers to such an arrangement—and it would always pay an individual retailer to refuse to go along and undercut the other retailers.

As in section 2, we shall confine our attention to linear taxes and subsidies. As before, we will normalize the consumption price of good 1 to be 1 and denote the consumption price of good 2 by q . However, we now let producer prices deviate from these values to reflect taxes or subsidies—denote the producer prices of goods 1 and 2 by μ and π respectively.

A producer in sector 2 now maximizes

$$W(q)\pi f(\ell) - R\ell,$$

and a producer in sector 1 maximizes

$$\left. \begin{aligned} & R\ell_1 \\ & \frac{f(\ell_1^*) + T}{f(\ell_2^*) + f(\ell_1^*)} - R\ell_1 \end{aligned} \right\}.$$

of sector-1 and sector-2

$$\left. \begin{aligned} & \frac{f(\ell_1^*) + T}{f(\ell_2^*) + f(\ell_1^*)} - R\ell_1^* \end{aligned} \right\} \quad (27)$$

First, it is in some sense a trained market economy. We now analyze the plans under the same constraints as

tax outputs *ex post*, and (as in section 2). Reasons for entrepreneur or an insurance contract does. In particular, good 2 at the retail level, and the cost of all retailers to such an individual retailer to refuse to

transition to linear taxes and the option price of good 1 to good 2 by q . However, we now consider effect taxes or subsidies — and π respectively.

$$W(q)\mu f(\ell) - R\ell,$$

where

$$W(q) = \max\{U(x_1, x_2) | x_1 + qx_2 \leq 1\}.$$

This yields the first-order conditions

$$W(q)\pi f'(\ell) = R,$$

$$W(q)\mu f'(\ell) = R.$$

In market equilibrium,

$$U_2(f(\ell_1), f(\ell_2)) \frac{\pi}{q} f'(\ell_2) = R,$$

$$U_1(f(\ell_1), f(\ell_2)) \mu f'(\ell_1) = R, \quad (28)$$

$$\frac{U_2(f(\ell_1), f(\ell_2))}{U_1(f(\ell_1), f(\ell_2))} = q.$$

An optimal intervention policy is a choice of q, μ, π that solves

$$\text{Maximize } \frac{1}{2}V(\alpha U(f(\ell_1), f(\ell_2)) - R\ell_2) + \frac{1}{2}V((1 - \alpha)U(f(\ell_1), f(\ell_2)) - R\ell_1)$$

subject to (28) and

$$x = \frac{\pi f(\ell_2) - T}{\pi f(\ell_2) + \mu f(\ell_1) - 2T}, \quad (29)$$

$$T = \frac{1}{2}(\pi - q)f(\ell_2) + \frac{1}{2}(\mu - 1)f(\ell_1).$$

Here T is a lump-sum tax chosen to balance the government's budget, and α is sector 2's share of net revenue (and hence of total "utils" $U(f(\ell_1), f(\ell_2))$). Solving for T and using (28) and $U_1 f(\ell_1) + U_2 f(\ell_2) = U$, we obtain as the government's objective function

$$\frac{1}{2}V\left(\frac{1}{2}Rf(\ell_2) - \frac{1}{2}Rf(\ell_1) + \frac{1}{2}U - R\ell_2\right) + \frac{1}{2}V\left(-\frac{1}{2}Rf(\ell_2) + \frac{1}{2}Rf(\ell_1) + \frac{1}{2}U - R\ell_1\right),$$

where the control variables are ℓ_1 and ℓ_2 . The first-order conditions are

$$(V_2') \left(\frac{1}{2} R \left[\frac{(f'(\ell_2))^2 - f(\ell_2)f''(\ell_2)}{(f'(\ell_2))^2} \right] + \frac{1}{2} U_2 f'(\ell_2) - R \right) \\ + (V_1') \left(-\frac{1}{2} R \left[\frac{(f'(\ell_2))^2 - f(\ell_2)f''(\ell_2)}{(f'(\ell_2))^2} \right] + \frac{1}{2} U_2 f'(\ell_2) \right) = 0 \quad (30)$$

and

$$(V_2') \left(-\frac{1}{2} R \left[\frac{(f'(\ell_1))^2 - f(\ell_1)f''(\ell_1)}{(f'(\ell_1))^2} \right] + \frac{1}{2} U_1 f'(\ell_1) \right) \\ + (V_1') \left(\frac{1}{2} R \left[\frac{(f'(\ell_1))^2 - f(\ell_1)f''(\ell_1)}{(f'(\ell_1))^2} \right] + \frac{1}{2} U_1 f'(\ell_1) - R \right) = 0, \quad (31)$$

where

$$V_2' = V' \left(\frac{1}{2} \frac{R f(\ell_2)}{f'(\ell_2)} - \frac{1}{2} \frac{R f(\ell_1)}{f'(\ell_1)} + \frac{1}{2} U - R \ell_2 \right)$$

and

$$V_1' = V' \left(-\frac{1}{2} \frac{R f(\ell_2)}{f'(\ell_2)} + \frac{1}{2} \frac{R f(\ell_1)}{f'(\ell_1)} + \frac{1}{2} U - R \ell_1 \right).$$

It is easy to see that $\ell_2 > \ell_1$ in equilibrium (i.e., the high-demand sector produces more). Suppose not: $\ell_2 \leq \ell_1$. Then the argument of V_2' is smaller than the argument of V_1' and so $V_2' \geq V_1'$. It follows from (30) and (31) that

$$U_2 f'(\ell_2) \leq R,$$

$$U_1 f'(\ell_1) \geq R.$$

However, since good 2 is the high-demand good, $\ell_2 \leq \ell_1$ implies $U_2 > U_1$ (see (***)). Hence, $f'(\ell_2) < f'(\ell_1)$, contradicting $\ell_2 \leq \ell_1$.

Given $\ell_2 > \ell_1$, we must have $V_2' < V_1'$. It follows immediately from (30) and (31) that $U_2 f'(\ell_2) > R$ and $U_1 f'(\ell_1) < R$. Hence, by (28), $\pi < p$ and $\mu > 1$. We have established the following:

PROPOSITION 3 An optimal intervention policy involves setting

$$U_2 f'(\ell_2) > R,$$

$$U_1 f'(\ell_1) < R,$$

$$\pi < p,$$

and

$$\mu > 1.$$

That is, the profitable sector is taxed, and the unprofitable sector is subsidized, leading to underemployment in the former and overemployment in the latter.⁵

Note that $\ell_2 > \ell_1$, $U_2 f'(\ell_2) > R$, and $U_1 f'(\ell_1) < R$ collectively imply $U_2 > U_1$; and hence $p < 1$ from (28). That is, optimal policy stabilizes demand, but not completely. Also, if $f(\ell) = \ell^\beta$, where $0 < \beta < 1$, we can compare the equilibria with and without intervention. Under intervention

$$\frac{U_2 f'(\ell_2)}{U_1 f'(\ell_1)}$$

exceeds 1, its value under nonintervention (see (26)). Hence, ℓ_2/ℓ_1 falls as a result of intervention. It follows from (28) that p rises above p^0 , the equilibrium nonintervention relative price, and also that $\pi/\mu < p^0$. That is, if $f(\ell) = \ell^\beta$, we have

$$1 < \frac{\pi}{\mu} < p^0 < p \quad (32)$$

under an optimal intervention policy. In other words, the consumption relative price rises under intervention, while the production relative price falls.

Thus, as in section 2, we see that government policy can yield a Pareto improvement over the laissez-faire equilibrium even though the government has the same information that the market participants have.

Conclusions

A conclusion common to both models studied in this paper is that asymmetric-information economies exhibit externalities that cause the market outcome to be inefficient, even in a second-best sense. This conclusion has also been reached by others (see, e.g., Greenwald and Stiglitz 1984), but not in a macroeconomic setting. We have shown that in some cases the externality leads to a Keynesian-type multiplier (model 1), whereas in other cases optimal government policy bears some resemblance to a Keynesian stabilization policy (model 2).

There is an analogy between our results and those found in the literature on incomplete markets (for a recent review, see Geanakoplos 1990). Incomplete-market equilibria are also second-best suboptimal, and there is a role for government intervention. However, in most incomplete-market models the market structure is taken to be exogenous. In contrast, in the present paper we have derived the trading possibilities from primitive assumptions about which variables are observable and verifiable; in this sense, the market structure is endogenous.

Dedication

This paper is dedicated to Frank Hahn, whose insistence that every theorist has an obligation to consider a large macroeconomic issue—at least, occasionally!—has been a source of inspiration to us.

Notes

1. The second inequality ensures that high-cost producers have enough supplies of oil to produce soap even in the worst-endowment state.
2. Because all agents are *ex ante* identical and the insurers are risk-neutral and competitive, $b(K)$ will turn out to be zero for each K in equilibrium. But this fact plays no role in our analysis.
3. Actually, in Diamond's model the externality is created when an agent searches for a trading partner; this raises the marginal return to search by others. But we can interpret the effort one must exert to sell one's goods as part of the production process.
4. We are implicitly assuming here that only linear taxes are feasible.
5. We refer to "an" optimal intervention policy because there is no guarantee that it is unique. The characterization in proposition 3 applies to any optimal policy.

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