ANNALES D'ÉCONOMIE ET DE STATISTIQUE. – N° 37/38 — 1995

Market Power in Macroeconomic Models: New Developments

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ABSTRACT. – Earlier work on the market-power foundations of macroeconomics (*see* Silvestre, *Journal of Economic Literature*, 1993) adopted static or temporary equilibrium models. This paper surveys the more recent litterature, which is explicitly dynamic (models of overlapping generations, equilibrium fluctuations or neoclassical growth). The issues discussed include: (*a*) unemployment at low wages; (*b*) redistributive policies: (*c*) public expenditures (*d*) partial wage indexation, and (*e*) the equilibrium analysis of economic fluctuations.

Pouvoir de marché et modèles macroéconomiques : nouveaux développements

RÉSUMÉ. – Une étape antérieure de la littérature sur le pouvoir de marché comme fondement de l'analyse macroéconomique (*voir* Silvestre *Journal of Economic Literature,* 1993) adopta des modèles statiques ou d'équilibre temporaire. L'article présente un panorama des travaux les plus récents, qui sont explicitement dynamiques (modèles à générations imbriquées, de cycles ou de croissance néoclassique). Les principaux sujets discutés sont : (*a*) le chômage avec bas salaires; (*b*) la politique de redistribution; (*c*) la dépense publique; (*d*) l'indexation partielle des salaires, et (*e*) l'analyse des fluctuations économiques comme phénomènes d'équilibre.

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I thank Jean-Pascal BENASSY, Rodolphe DOS SANTOS FERREIRA, Jean-François FAGNART, Jang-Ting GUO, Kevin SALYER and an anonymous referee for comments, with the usual *caveat.*

1 Introduction

This text surveys some recent work on the market-power foundations of macroeconomics. Earlier efforts in the area, as represented in Huw DIXON and Neil RANKIN [1994], or in SILVESTRE [1993], built models that were static or that adopted the temporary equilibrium viewpoint. The more recent literature, on the contrary, is cast in infinite horizon, general equilibrium models that are explicitly dynamic. A first group of papers (Sections 2-4 below) adopts infinite overlapping generations models and addresses three topics. First, the possibility of unemployment at all wages, which had previously appeared in temporary equilibrium models. Second, the effects of a government policy that supplies public output or subsidizes old people, financed by taxes or money creation. Third, the rationality of partial wage indexation. A second group of papers (Section 5 below) attempts to understand economic fluctuations as equilibrium phenomena when sellers of output have market power. Their method is the introduction of price-setting behavior in neoclassical growth, overlapping generations of real business cycle models.

The Appendix is concerned with a conceptual issue that pervades the discussion of the macroeconomic implications of imperfect competititon, namely the presence of "macroeconomic", "demand" or "pecuniary" externalities. While the concepts of "strategic complementarities" (or "supermodularity") and of "coordination failure", also present in the literature, have well-defined meanings, "pecuniary externalities" do not: several seemingly unrelated notions coexist. I formalize one such notion and analyze its relation to economic efficiency.

2 Unemployment at all Wages

A competitive economy has positive wages as long as labor is a productive input for useful goods. But it was discovered in the eighties that labor could end up with a zero market price under noncompetitive conditions in the output market and perfect competition in the labor market. More precisely, Claude d'ASPREMONT, Rodolphe DOS SANTOS FERREIRA and Louis-André GÉRARD-VARET [1984, 1989 *a*, 1989 *b*, 1990], Pierre DEHEZ [1985] and SILVESTRE [1990] built general equilibirum models where the marginal revenue curve of firms with market power becomes negative at large enough levels of ouptut. Then the demand for labor is bounded from above by an amount that, when labor supply is fixed, may fall short of labor supply. Unemployment will, in that case, occur at any nonnegative wage, *i.e.*, it will occur no matter how the wage is determined. In particular, a competitive labor market would then turn useful labor into a free good in excess supply, a striking form of inefficiency. If labor supply is not fixed, then the labor market will be in equilibrium at a low wage on the elastic segment of the labor supply. The inefficiency is then less obvious but may be serious nevertheless [1].

The argument can be formalized as follows. Assume that preferences are homogeneous, so that the demand addressed to a market is $y\,(p)\,I$, where p is a suitably normalized price and *I* is the wealth of the buyers in that market. Assume that firms take *I* as exogenous, or, in the terminology of d'ASPREMONT, DOS SANTOS FERREIRA and GÉRARD-VARET, that there are no "Ford effects". If the market is supplied by *N* Cournotian firms, the following condition must be satisfied at any symmetric, positive production equilibrium:

$$\text{MARGINAL REVENUE} = p\left(1 - \frac{1}{N\,\eta}\right) = \text{MARGINAL COST.}$$

where $\eta = -y'\,.\,p/y > 0$ is the market elasticity of demand.

Suppose that $\left(1 - \dfrac{1}{N\,\eta}\right)$ becomes negative for low p (*i.e.*, large y). This means that, for low p, $\eta < \dfrac{1}{N}$: demand is relatively inelastic at low p (or the number of firms is relatively small). Because marginal cost is nonnegative, so must be marginal revenue. Thus, a negative marginal revenue at large output levels puts a bound on the demand for labor. If the bound is low enough relative to the availability of labor, then unemployment will result at any nonnegative wage. The result has implications for evaluating the effects of union activity. A strategy of wage maintenance with unemployment is justifiable when *laissez faire* would substantially lower the wage while failing to cure unemployment.

Christian SCHULTZ [1992] contested this result. He noted that the above mentioned models either are static or adopt the temporary equilibrium viewpoint. Temporary equilibrium models postulate exogenous price expectation functions. Static models do not, but the ones in this literature are isomorphic to temporary equilibrium models with rigid price expectations. Thus, Schultz argued, the models fail to show that the phenomenon of unemployment at all wages can occur when expectations are no longer given by an exogenous function but display perfect foresight *i.e.*, they must be point expectations that coincide with the actual future prices in a multiperiod equilibrium setting.

Schultz chose an overlapping generations model, where, in each period, output is supplied in a single sector by *N* Courtonian firms. Time periods are numbered 1, 2, ...; generation t lives for two periods: it is young at time t and old at time $t+1$. At time 1, there is an old generation, named generation 0, which is endowed with m_0 units of fiat money. People earn wages and receive profits when young, and can save for consumption when

1. See SILVESTRE [1993] for a discussion.

old. Money is the savings instrument. Because there is neither creation nor destruction of money in this model and, at equilibrium, money supply equals money demand, each generation reaches old age with m_0 units of money in its pocket.

Schultz's main result is that, if prices are perfectly foreseen, then there are low enough wages so that full employment obtains in each period. The result is partly driven by the assumption that old people, realizing that they are about to die and lacking any bequest motive, want to spend their whole money holdings in current consumption, no matter what the current price is. In other words, their price elasticity of demand, η^0, is unity. Now, the market elasticity η is a weighted average of the elasticity of the young, η^Y, weighted by their share in current demand γ, and that of the old, $\eta^0 = 1$, weighted by $(1-\gamma)$, [2] *i.e.*,

$$\eta = \gamma\eta^Y + (1-\gamma). \tag{1}$$

Schultz shows that, in his model, (1) implies that $\eta \geq \dfrac{3}{4}$ and, thus, $\eta > \dfrac{1}{N}$ for $N \geq 2$. Thus, the fact that the elasticity of demand by old people is always one makes marginal revenue positive for all p. Hence, unemployment will disappear at low enough wages.

In summary, Schultz offers an overlapping generations model where the phenomenon of unemployment at any wages cannot occur as long as prices are perfectly foreseen. But, does his result hold for all overlapping generations models with perfect foresight of prices? The answer is negative: d'Aspremont, Dos Santos Ferreira and Gérard-Varet [1991] present two departures from Schultz's model, each allowing for some forms of unemployment at all exogenously given wage sequences.

The phenomenon can take two forms in this world with an infinity of periods. A strong form is characterized by the fact that, given any wage sequence, the equilibrium price sequence tends to infinity while the employment sequence tends to zero. A weaker form consists of sequences that have unemployment in an infinite number of periods, perhaps accompanied by full employment also in an infinite number of periods.

The first departure assumes Ford effects, *i.e.*, a firm is aware of the influence that its actions have on the wealth of its customers, and, indirectly via income effects, on the demand that it faces. It turns out that, under this assumption, the elasticity of the aggregate demand is no longer given by (1), but, instead, writing ξ for the elasticity of intertemporal substitution in consumption, by:

$$\tilde{\eta} = \gamma\xi + (1-\gamma), \tag{2}$$

an expression which can take low values for low ξ (intertemporal complementarity) and high γ (propensity to consume).

2. One can identify γ with the propensity to consume.

D'ASPREMONT, DOS SANTOS FERREIRA and GÉRARD-VARET [1991] show that the strong form of unemployment at all wages (*i.e.*, prices tend to infinity and employment to zero) necessarily occurs when "$\tilde{\eta}(\lambda) \geq \frac{1}{N}$" implies "$\lambda < 1$", where λ is defined as the current price divided by the anticipated price for the following period. They have generalized this result to economies where, as discussed in the following section, the government may have active policies of money creation, public spending and intergenerational redistribution subject to a budget constraint.

The condition in the previous result is a strong one, since it implies that, at equilibrium, λ is always less than 1. If one relaxes this condition and admits both $\lambda > 1$ and $\lambda < 1$ (but not $\lambda = 1$) at equilibrium, and if one rules out stationary price sequences, then the weak form of the phenomenon appears: unemployment arises infinitely often for any given sequence of wages.

An alternative departure from Schultz's model is based on the observation that, in his paper, the demand elasticity of old people is unity not only because they spend all their wealth, but also because they spend it on a single good. If, on the contrary, old people buy from different sectors, and the elasticity of intersectorial substitution is less than one, then their demand elasticity in a given sector is also less than one.

More precisely, D'ASPREMONT, DOS SANTOS FERREIRA and GÉRARD-VARET [1991] consider an economy with *M* sectors, where $x = (x_1, ..., x_M)$ (resp. $\hat{x} = (\hat{x}_1, ..., \hat{x}_M)$) is the vector of present (resp. future) sectorial consumption. The utility function is of the form: $U(u(x), u(\hat{x}))$, where u is CES, with elasticity of substitution $\sigma > 0$, *i.e.*, σ can be called the intersectorial elasticity of substitution.

The possibility of the strong form of unemployment depends on two parameters: the intersectorial elasticity of substitution σ and the number of sectors *M*. Large values for $\sigma \left(\sigma > \frac{M^2}{M^2 - 1}\right)$ rule out this type of unemployment, whereas intersectorial complementarity $(\sigma < 1)$ and a large number of sectors (*M*) tend to favor it. The paper also discusses conditions under which the weaker form of unemployment occurs.

Summarizing, the results in D'ASPREMONT, DOS SANTOS FERREIRA and GÉRARD-VARET [1991] show that the phenomenon of unemployment at all wages, previously known to be possible in temporary equilibrium or static models, remains a possibility in an overlapping generations world where agents have perfect foresight of future prices. But, as suggested by SCHULTZ [1992], explicit models displaying the phenomenon are necessarily complex.

3 Market Power and Public Policy

The only function of the government in the overlapping generations model of the previous section consists in endowing generation 0 with m_0 units of fiat money, quantity of money which is kept constant thereafter. Some of the recent overlapping generation models, reviewed in this section, give a larger role to the government. The government may redistribute wealth, taxing young people and subsidizing old people, and it may demand and spend some of the output, perhaps providing public services. A maintained hypothesis is that, except for the initial injection of m_0 units of money in the economy, the government balances its budget in each period, *i.e.*, any excess of expenditure over taxes is financed by money creation.

3.1. **The Effectiveness of Fiscal Policy**

A first question is the efficacy of fiscal policy. The issue can be first discussed within a simple overlapping generations model due to Jean-Pascal BENASSY [1991 a, b, 1994], where the government supplies a public output. He considers an overlapping generations model where, at time t, the government supplies a public output in the constant amount g, which enters the utility function together with private output and leisure, *i.e.*, the utility function of generation t, $t \geqq 0$, is:

$$U\,(x_{tt},\, x_{t,\,t+1},\, \omega - L_t,\, g),$$

where x_{tt} is the consumption of the private output by generation t when young, $x_{t,\,t+1}$ is the consumption of the private output by generation t when old, ω is the endowment of leisure (when young) and L_t is the supply of labor (also when young). The technology is given by a production function, $f\,(L_t)$, and feasibility requires that $x_{tt} + x_{t-1,\,t} + g \leq f\,(L_t)$.

Because money is the savings instrument, the demand for money by a generation that expects to consume the amount $x_{t,\,t+1}$ when old at the price p_{t+1} is:

$$m_t^D = p_{t+1}\, x_{t,\,t+1}. \tag{3}$$

As before, the government gives the amount of money m_0 to generation 0: the 0-homogeneity of the system relative to nominal variables makes the magnitude of m_0 irrelevant for policy purposes, as long as it is positive. In addition, the government must finance any budget deficit by money creation, *i.e.*, for $t > 1$, the supply of money at $t+1$ is:

$$m_t^s = m_{t-1} + p_t\,(g - \tau), \tag{4}$$

where τ is the tax, in real terms, imposed on young people, and m_t is the amount of money in period t.

Attention is restricted to quasi-stationary equilibria, *i.e.*, those in which all real variables, except for the consumption of generation 0, are invariant through time. (Stationarity requires that, in addition, prices be constant). Thus, one writes $x_{tt} = x$ and $x_{t,\,t+1} = \hat{x}$, for $t > 0$. Because, at equilibrium, money supply equals money demand, (3) and (4) yield:

$$m_{t-1} = p_t\,\hat{x},$$
$$m_t = p_{t+1}\,\hat{x},$$
$$m_t = m'_{t-1} + p_t\,(g - \tau),$$

i.e., $p_{t+1}\,\hat{x} = p_t\,\hat{x} + p_t\,(g-\tau)$, which implies that:

$$\frac{p_t}{p_{t+1}} = \frac{m_{t-1}}{m_t} = \frac{\hat{x}}{\hat{x}+g-\tau} := \lambda, \tag{5}$$

constant through time. Naturally, if the government runs a current deficit $(g-\tau>0)$, then $\lambda<1$ and the constant real allocation is supported by an inflationary sequence of prices and an increasing money supply.

The market structure is monopolistically competitive à la DIXIT-STIGLITZ [1977] in both the output and the labor markets, and all price setters face demand curves with constant elasticity. Thus, the degree of market power (markup) is constant. In particular, firms (resp. workers) face demand curves with elasticity of η (resp. ϵ), a real number between one and ∞. The Lerner index (*price-marginal cost*)/*price* is $\dfrac{1}{\eta}$, and the *price*/*marginal cost* ratio or "markup" is $\dfrac{\eta}{\eta-1}$, to be written γ_η, a real number between one and ∞. [3] We view φ_η as an index of market power in the output market: perfect competition implies that $\varphi_\eta=1$. Similarly, we view $\varphi_\varepsilon = \dfrac{\varepsilon}{\varepsilon-1}$ as an index of market power in the labor market. The overall index of market power in the economy is indexed by $\varphi := \varphi_\eta\,\varphi_\varepsilon$.

BENASSY [1991 a, b, 1994] assumes a utility function of the form

$$U\,(x,\,\hat{x},\,\omega-L,\,g)$$

where x (resp. $\hat{x}$) is consumption at young (resp. old) age, $\omega-L$ is the amount of leisure, L is the amount of labor supplied and g is real government expenditure. The production function is denoted $f\,(L)$, with inverse $f^{-1}\,(y)$ written $\tilde{c}\,(y)$.

A reference case is provided by specializing U to the "Cobb-Douglas" form:

$$U\,(x,\,\hat{x},\,\omega-L,\,g) = x^\alpha\,\hat{x}^{1-\alpha}\,(\omega-L)^\beta + v\,(g).$$

It can be shown that, in this case, equilibrium output, employment and real wage in a balanced budget (no money creation), stationary equilibrium is determined by the equations:

$$p = \varphi_\eta\, w \tilde{c}'\,(y), \tag{6}$$

$$\frac{w}{p} = \varphi_\varepsilon\,\frac{\beta\,(y-g)}{\omega-L}, \tag{7}$$

$$L = \tilde{c}\,(y), \tag{8}$$

3. Alternatively, the word "markup" is sometimes applied to the ratio (price-marginal cost)/price, which is Lerner's index here.

where (7) implicitly defines the "supply-of-labor function": *i.e.*, the locus of pairs (labor supplied, real wage) compatible with utility maximization under the demand conditions faced by a worker [4]. Equilibrium output $\tilde{y}(g)$ is, in particular, determined by the equation:

$$\omega - \tilde{c}(y) - \varphi\,\tilde{c}'(y)\,\beta\,(y-g) = 0, \tag{9}$$

yielding the multiplier:

$$\frac{d\tilde{y}(g)}{dg} = \frac{\varphi\,\tilde{c}'\,\beta}{\tilde{c}' + \varphi\,\beta\,\tilde{c}' + \varphi\,\tilde{c}''\,(y-g)\,\beta}. \tag{10}$$

Note that, as long as marginal cost is nondecreasing ($\tilde{c}'' \geq 0$), the multiplier is positive, *i.e.*, government expenditure is effective in expanding output.

Benassy's market structure yields a constant degree of market power: the markup factors φ_η and φ_ε are determined by the parameters η and ε independently of the amount of government expenditure. But in many models fiscal policy does affect market power: the discussion in Section 2 above illustrates the way in which government policy may alter the elasticity of the demand curves faced by firms and, thus, the markup factor. Indeed, as analyzed by Hans Jørgen JACOBSEN and SCHULTZ [1994], and by D'ASPREMONT, DOS SANTOS FERREIRA and GÉRARD-VARET [1994 a], fiscal policy often operates by modifying demand elasticities.

JACOBSEN and SCHULTZ [1994] consider an overlapping generations model with perfect competition in the output market but with a particular type of imperfect competition in the labor market, namely Nash bargaining. Government expenditure is simply government consumption, which neither enters the utility function directly nor is a subsidy to old people. Moreover, it takes the form of a constant-elasticity function of the price, rather than a quantity fixed in real terms: a change in fiscal policy means a change in a multiplicative factor, leaving the elasticity unchanged, in the government demand function.

JACOBSEN and SCHULTZ's [1994] first result is that fiscal policy is effective (*i.e.*, can affect output) if and only if the elasticity of the demand for output by the government differs from that of the private sector. Thus, the only channel through which fiscal policy operates is the effect on demand elasticities. The second result is that perverse effects may well occur, *i.e.*, an upward shift in the demand function of the government may decrease output. This may occur when government demand is more inelastic than private demand: an increase in government demand then reduces the overall demand elasticity, resulting in reduced output.

4. Of course, only when $\varphi_\varepsilon = 1$ do workers take the real wage parametrically, and (7) does define a supply function in the ordinary, competitive sense of the word. The extension to the noncompetitive case goes back at least to Donald BUSHAW and Robert CLOWER [1957], who analyzed the "supply function of a monopolist".

3.2. **The Welfare Analysis of Policy**

BENASSY [1991 a, b, 1994] defines a "stationary first best" allocation as the quasi-stationary allocation that solves the problem:

$$\max U\,(x,\,\hat{x},\,\omega - L,\,g)\,\text{s. to}:\;\; x + \hat{x} + g = f\,(L).$$

He shows that such allocation, a welfare benchmark, can be decentralized as a Walrasian equilibrium, defined by competitive profit maximization, the price-taking budget constraint $p_t\, x_{tt} + p_{t+1}\, x_{t,\,t+1} = w_t\, L_t + \Pi_t - p_t\, \tau_t$ (where w_t is the wage rate and Π_t the profit income at t), and the policy parameters g, τ, where $g = \tau$ (zero deficit and money creation and, hence, no inflation or deflation). The marginal condition:

$$\frac{\partial U}{\partial g} = \frac{\partial U}{\partial x},$$

must hold, *i.e.*, the private and public forms of output, which are perfect substitutes in production, must have the same marginal utility.

A market-power equilibrium is then considered, where prices are higher than marginal costs (the firm has market power in the output market) and wages are higher than the marginal disutility of labor (the worker has market power in the labor market). An immediate consequence is that the marginal equalities defining the stationary first best allocation cannot be satisfied, no matter what the values of the policy parameters g and τ are. Thus, the welfare level of the stationary first best allocation cannot be attained.

The objective of the government is now to choose g and τ in order to maximize $U\,(x,\,\hat{x},\,\omega - L,\,g)$ subject to the conditions of a market-power equilibrium. Consider first the case where the government is further restricted to zero money creation, *i.e.*, $g = \tau$. Then the following result is obtained: as long as the level of employment at the market-power equilibrium increases with g, the government should choose g (and τ) so that, at the resulting equilibrium,

$$\frac{\partial U}{\partial g} < \frac{\partial U}{\partial x},$$

i.e., the supply of public output should exceed the quantity that a price-taking consumer would freely choose. The intuition for this surprising result is that a market-power equilibrium is characterized by underproduction. The direct marginal utility of public output may be low, but one should add the indirect effect through the increased use of the underutilized input.

The market-power world departs from the Walrasian one in another way. As just mentioned, zero money growth is optimal in the latter, but, typically, not in the former. In a market-power situation, the government will typically do better by ignoring, if it can, the equality $g = \tau$. BENASSY [1991 b] shows that, as long as both $\hat{x}$ and L are increasing in τ at the market power equilibrium, the government should choose $g < \tau$, *i.e.*, a budget surplus and, by (5), a permanent deflation. The last result conflicts with traditional Keynesianism, illustrating the fact that market-power models do not offer unconditional support for all Keynesian policy measures.

3.3. **Increasing Returns and Coordination Failures**

Consider expression (10) above. Note that, if all costs are variable, then the assumption that, for all y, $\tilde{c}''(y) \geq 0$ implies nonincreasing returns to scale, whereas $c''(y) < 0$, for all y, implies that returns to scale are increasing. Expression (10) indicates that, if returns to scales are strongly increasing, then the multiplier is negative, *i.e.*, fiscal policy is effective in a perverse way: the lower g, the better.

The intuition goes as follows. Equations (6-8) above can be rewritten as:

$$\frac{w}{p} = \frac{f'(L)}{\varphi_\eta}, \tag{11}$$

$$\frac{w}{p} = \varphi_\varepsilon \, \frac{\beta\,(f(L) - g)}{\omega - L}, \tag{12}$$

interpreted as the (indirect) "demand for labor function" and "supply of labor function", in the sense just mentioned, with the real wage as dependent variable. Note that the slope of the supply-of-labor function in (12) is positive, but that of the demand function depends on $f''(L)$, and is positive for increasing returns to scale ($f'' > 0$, or, equivalently, $\tilde{c}'' < 0$). With strongly increasing returns, the demand-for-labor function (with the real wage w/p on the vertical axis) becomes steeper than the supply of labor, reversing the usual comparative statics. Two observations. First, if this is occurs at an equilibrium, then it is likely that other equilibria exist. Second, the possibility of reversal under increasing returns to scale is fairly robust. It may also occur in the simplest, partial equilibrium models of an output market with a constant markup [5].

The multiplicity of equilibria and the reversal of the usual sign of the multiplier do occur in the alternative overlapping generations models due to Marco PAGANO [1990] and D'ASPREMONT, DOS SANTOS FERREIRA and GÉRARD-VARET [1994 a]. Pagano displays four distinctive features. First, it is a model of monopolistic competition on the circle, à la Steven SALOP [1979]; this makes his model comparable to the ones in Martin WEITZMAN [1982] and Robert SOLOW [1986]. Second, the saving instrument is physically productive capital. Third, government expenditures do not provide a desirable good. Instead, they redistribute wealth from the young to the old: such transfers reduce savings and, thus, the supply of capital.

5. Let $D(p)$ be a partial equilibrium demand function, and consider the model defined by (6) (w is now a parameter) and the equation: "$y - D(p) - g = 0$." The latter is a demand-for-output function, whereas (6) is a supply-of-output function in the previous sense. Equilibrium output is then determined by the equation "$y - D(\varphi_\eta \, w\tilde{c}'(y)) - g = 0$." We compute the multiplier:

$$\frac{dy}{dg} = \frac{1}{1 - D' \, \varphi_\eta \, w\tilde{c}''},$$

which could be negative for $\tilde{c}''$ negative and large, making the supply function downward sloping and steeper than the demand function.

Fourth, as did Richard STARTZ [1989], it postulates fixed costs and adopts the "long run view" according to which positive profits induce the entry of new firms: profits are then zero at a steady state. In addition, the labor market is competitive.

PAGANO [1990] shows that the locus of pairs (real wage, employment) consistent with equilibrium in the output and capital markets, and with the zero-profit condition is positively sloped. This locus can be interpreted as an "eventual-demand-for-labor curve", because it embodies all equilibrium conditions except the satisfaction of the labor supply. As before, increasing returns to scale play a role in having an upward sloping "demand for labor" curve, although the mechanism is no longer the behavior of marginal costs, but the presence of fixed costs and the zero-profit condition. The demand for labor curve may then have several intersections with the competitive supply-of-labor curve, which is also positively sloped. They correspond, in Pagano's model, to multiple, Pareto ranked equilibria.

The local analysis of the inferior equilibrium is then reminiscent of the previous discussion: the demand-for-labor curve is then (positively sloped and) steeper than the supply of labor, and the multiplier becomes negative. Pagano moreover analyzes possible transitions between equilibria and shows that fiscal policy may also have globally anti-Keynesian effects.

D'ASPREMONT, DOS SANTOS FERREIRA and GÉRARD-VARET [1994 *b*] extend some of the previously mentioned ideas within an overlapping generations model both with variable markups and (possibly) increasing returns to scale. Both leisure and government expenditures enter the utility functions, but now the utility function is linear in leisure, in government expenditures and in a CES subutility function defined on present and future consumption: the elasticity parameter is then interpreted as the elasticity of intertemporal substitution. Moreover, the labor market is competitive whereas Cournot oligopoly prevails in the output market. Returns to scale may be decreasing, constant or increasing.

Because utility is linear in leisure, while there is a bound on the amount of labor that a consumer may supply, the labor supply correspondence has a horizontal and a vertical segment. This may yield, under increasing returns, two stationary equilibria, one where the labor resource constraint is binding ("full employment") and another one where it is not. The two equilibria are Pareto ranked: the one with higher employment is Pareto superior to the other one.

As in PAGANO [1980] and JACOBSEN-SCHULTZ [1994], fiscal policy is effective by a mechanism that operates at least partly by affecting the elasticity of demand (and, thus, the degree of market power), and it may yield a perverse, negative "multiplier". The (somewhat surprising) precise conditions depend on both the returns to scale and on the elasticity of intertemporal substitution. In order to expand employment, fiscal policy must reduce the degree of market power when returns to scale are decreasing, but enhance market power under increasing returns. This is achieved by increasing expenditure under either decreasing returns to scale and intertemporal complementarity, or under increasing returns and substitutability. Otherwise, expanding employment requires a reduction of public expenditures.

3.4. **Expectations and the Effectiveness of Monetary Policy**

All the overlapping generations models considered so far assume perfect foresight, *i.e.*, price expectations are point expectations at the actual level of future prices. Neil RANKIN [1992, 1994] notes that this property is stronger than simply requiring that expectations be correct at equilibrium: for instance, some forms of adaptive expectations may correctly forecast future prices along a quasi-stationary equilibrium. Both papers analyze the impact of alternative expectational hypotheses on the effectiveness of policy in an overlapping generations model with an oligopolistic labor market and a perfectly competitive output market.

In RANKIN [1992] the government chooses a constant (positive or negative) rate of monetary growth. Money creation (resp. destruction) results in subsidies (resp. taxes), shared by contemporaneous old and young in fixed proportions. Starting from a benchmark stationary equilibrium (*i.e.*, zero monetary growth) with unemployment, will an increase in the rate of monetary growth increase employment? In other words, is money "superneutral"? The [1994] paper, in contrast, considers the effects of an once-and-for all creation of money, *i.e.*, it analyzes the "neutrality" of money.

Rankin's answer is that it depends on the form of expectations. He distinguishes between forward-looking expectations (perfect foresight or rational expectations) and several types of backward-looking expectations, given by alternative rules that take as arguments the information available at the moment. Many of the backward-looking rules make no forecasting errors along a quasi-stationary equilibrium. But perfect foresight expectations satisfy a stronger concept of rationality, namely, their forecasts are correct not only at equilibrium but also out of it. Rankin shows that, under perfect competition, this feature does not affect the responsiveness of total output to choices of the rate of monetary growth, as long as expectations remain correct at a quasi-stationary equilibrium. But under imperfect competition the distinction matters. For instance, monetary growth may have a positive effect on output under perfect foresight or under some forms of backward-looking expectations, but not under other forms. In particular, output is independent of the monetary growth rate under "monetarist" expectations, which have unit elasticity of expectations. It follows from Rankin's analysis that the presence of market power introduces new difficulties into the modelling of expectation formation.

4 Union Power and Partial Indexation

It is often understood that, if unions have market power and behave rationally, and if wage contracts are set before the realization of random shocks, then unions will choose full indexation, *i.e.*, real wages will be rigid throughout the realization of shocks. This view implicitly assumes that wage contracts can be contingent on all realizations of shocks. A recent paper by BENASSY [1993 b] shows that, if wages cannot be contingent on all shock realizations, but only on prices, then partial indexation maximizes the union's objective function. The result parallels earlier findings by Jo Anna GRAY [1976] that some form of partial indexation may be "optimal", in the sense of minimizing a loss function which depends on the deviations of actual output from the output obtained in a frictionless, competitive economy. In both cases, and in agreement with Stanley FISCHER [1977], the implication is that nominal rigidities may result from real shocks, and nominal shocks can affect real variables.

BENASSY's [1993 b] economy is formalized as an overlapping generations model with two types of consumers, firm owners and workers, who live for two periods. A consumer's utility is Cobb-Douglas in consumption when young and when old, but leisure does not enter the utility function. Firms behave as price and wage takers, and all consumers are price takers in the output market, but unions have monopoly power and can impose, before technology and monetary shocks are realized, a wage contract of the form:

$$\frac{w_t}{\overline{w}_t} = \left(\frac{p_t}{\overline{p_t}}\right)^{\rho}.$$

where p_t is the price of period t's output, w_t is period's t wage rate, $\overline{p_t}$ and $\overline{w}_t$ are base prices and wages and ρ is the indexation parameter. Nominal rigidity obtains when $\rho = 0$, real rigidity when $\rho = 1$, and intermediate forms of rigidity for values in between. Unions are free to choose the degree on indexation ρ.

Technology and monetary shocks are independently and normally distributed. The paper shows that, unless technology shocks are absent (*i.e.*, the variance of the technology shock is zero), then the degree of indexation chosen by the rational union is less than one. In words, the presence of technology shocks imposes a certain degree of nominal wage rigidity and enables nominal shocks to have real effects.

5 Equilibrium Fluctuations under Market Power in the Goods Market and Wage-Taking Behavior

A variety of models of equilibrium fluctuations with market power have flourished in recent years. They assume that firms have market power in the output market, but that the labor market is perfectly competitive. This contrasts with some of the models discussed in Sections 2-4 above, which often incorporate market power in the labor market.

Table 1 classifies some of the work into four cells. Each cell has a price-taking counterpart, and some of the cells advance research agendas

TABLE 1

Equilibrium Fluctuations under Market Power in the Output Market

		FLUCTUATIONS AROUND A STEADY STATE	FLUCTUATIONS INVOLVING SEVERAL STEADY STATES	
STOCHASTIC	SHOCKS TO FUNDAMENTALS	CELL I (RA) Beaudry-Devereux (1993) Cho (1990) Devereux et al (1993) Hairault-Portier (1993) Horstein (1993) Jeanne (1994) Rotemberg-Woodford (1992 a,b, forth)		EXOGENOUS FLUCTUATIONS
STOCHASTIC	NO SHOCKS TO FUNDAMENTALS	CELL II (RA) Benhabib-Farmer (1994) Farmer (1993) Farmer-Guo (1994 a,b) Galí (1994 a) Woodford (1991)	CELL III (OLG) Chatterjee et al (1994) Rivard (1994)	ENDOGENOUS FLUCTUATIONS
DETERMINISTIC		CELL IV (OLG) D'Aspremont et al (1994) Lloyd Braga (1994)	CELL V (RA) Galí (1993 a,b,1994 b) Galí-Zilibotti(1993)	ENDOGENOUS FLUCTUATIONS

initiated under price-taking assumptions. Cell I's price-taking counterpart is the standard real business cycle model, as in Finn KYDLAND and Edward PRESCOTT [1982], John LONG and Charles PLOSSER [1983] or Robert KING and PLOSSER [1984]. Cell II's price-taking counterparts are representative agent models displaying sunspot equilibria, with either money in the utility function (William BROCK [1974], Roger FARMER [1993], Ch. 10) or cash-in-advance constraints (FARMER [1993], Ch. 10). Cell III's price-taking counterparts are overlapping generations models with sunspot equilibria (as described in Pierre andré CHIAPPORI and Roger GUESNERIE, [1991], or John GEANAKOPLOS and Heraklis POLEMARCHAKIS, [1991]; see also FARMER and Michael WOODFORD, [1984, 1987], and FARMER [1993], Ch. 9, for formulations in the spirit of the work discussed here). Cell IV's price-taking counterparts are the deterministic overlapping generations models with complex dynamics, as in Jean-Michel GRANDMONT [1985]. Last, the price-taking counterpart of Cell *V* is neoclassical optimal growth theory, as pioneered by David CASS [1985] and Tjalling C. KOOPMANS [1965].

The label RA indicates "representative agent" models, *i.e.*, models where the consumption sector is an infinitely lived consumer (or many identical consumers), whereas OLG indicates an "overlapping generations" model, with an infinite number of consumers who live for two periods.

5.1. **Does Market Power in the Output Market Increase the Responsiveness to Shocks?**

The work in Cell I of Table 1 is, in part, motivated by the need to clarify the role of technology shocks in output fluctuations. It assumes universal wage taking, but firms have market power in the output market. Does market power increase, relative to price taking, the response of the economy to shocks?

Some preliminary "back of the envelope" computations in the simplest models may be useful. A convenient benchmark is Benassy's overlapping generations model discussed in Section 3.1 above. Recall that the overall degree of market power φ is there constant. In the "Cobb Douglas" case, and assuming an inverse production function of the form $\tilde{c}\,(y) = k + by$ (where k reflects a, possible zero, fixed cost), equation (9) becomes:

$$\omega - k - by - \varphi\, b\, \beta\,(y - g) = 0,$$

which can be explicitly solved to yield:

$$\hat{y}\,(g,\, b,\, \varphi) = \frac{\omega - k + b\,\beta\varphi\, g}{b\,\beta\varphi + b}.$$

The responsiveness of output to shifts in demand can be represented by the multiplier of government expenditure:

$$\frac{\partial \hat{y}}{\partial g} = \frac{\beta\varphi}{\beta\varphi + 1} > 0,$$

[in agreement with (10)], and the one relative to technology shifts by:

$$\frac{\partial \hat{y}}{\partial b} = -\frac{\omega - k}{[\beta\varphi + 1]\, b^2} < 0,$$

i.e., a positive demand shift increases equilibrium output.

Differentiating with respect to the degree of market power φ we obtain:

$$\frac{\partial^2\, \hat{y}}{\partial g\, \partial \varphi} = \frac{\beta}{[\beta\varphi + 1]^2} > 0,$$

i.e., market power *increases* the responsiveness of output to *demand* shifts (as in the early, static model by Huw DIXON [1987]), and:

$$\frac{\partial^2\, \hat{y}}{\partial b\, \partial \varphi} = \frac{\omega - k}{b^2}\,\frac{\beta}{[\beta\varphi + 1]^2} > 0,$$

i.e., market power *decreases* the responsiveness of output to *technology* shifts (a negative demand shock reduces output to a lesser extent at a higher degree of market power).

Two observations. First, the comparison depends on the fact that the model is properly formulated as a general equilibrium one, with the associated process of income formation and interactions with the labor market. Second, the constancy of the marginal real cost and the Cobb-Douglas demand make the example particularly simple. In general, the curvatures of the demand and marginal cost function matter and some of the results could be reversed if, for instance, the demand function were concave instead of convex.

5.2. Fluctuations around a Steady State due to Shocks to Fundamentals

The real business cycle approach (see KYDLAND and PRESCOTT [1982], LONG and PLOSSER [1983], KING and PLOSSER [1984], and, for a collection of recent work, the forthcoming book edited by Thomas COOLEY) constitutes a dominant research agenda in modern macroeconomics. The canonical real business cycle model postulates an economic environment where the first fundamental theorem of welfare economics holds.

The first cell of Table 1 builds upon the real business cycle, and maintains the assumption of infinitely lived, identical consumers that are always on their price-taking supply and demand curves. Contrary to the canonical real business cycle model, however, firms have market power, so that the markup φ is greater than one. As in traditional real business cycle analysis, the economy is subject to exogenous shocks: technological shocks (JANG-OK CHO [1990], Andreas HORSTEIN, [1993]), shocks in military purchases (Julio ROTEMBERG and WOODFORD, [1992 a]) or shocks in the price of energy (ROTEMBERG and WOODFORD [1992 b]). The reader is referred to Rotemberg and Woodford (forthcoming) for an excellent survey of this line of work.

CHO [1990] studies the volatility of output under various market structures: monopoly, Cournot oligopoly, monopolistic competition and perfect competition. He finds that output volatility increases with the degree of competition. In particular, technology shocks of a given size generate the observed volatility of US output data under either perfect competition or Cournot oligopoly with ten firms per market (and presumably also for monopolistic competition), but a substantially lower degree of output volatility under higher degrees of market power. Thus, the volatility of output and employment induced by technology shocks is lower as market power increases. The result fits well with the static benchmark of the previous section. But Cho's results on the response of output to demand shocks do not agree with those of the fixed markup case in Section 5.1 above: CHO ([1990], Table 3 and p. 35) finds that "introducing serially correlated government purchases, which is independent of the technology shock, stabilizes output fluctuations (even though the degree is slight)". CHO ([1990], p. 2) attempts to provide intuition by a simple partial equilibrium story. But, as noted in Section 5.1, the partial equilibrium intuition is unreliable.

HORSTEIN [1993] and ROTEMBERG and WOODFORD [1992 a, 1992 b, forthcoming] consider market structures with monopolistic competition and increasing returns to scale. HORSTEIN [1993] studies the impact of increasing returns to scale and market power (parametrized by a constant markup) on the measurement of productivity fluctuations by means of the Solow residual. The Solow residual is defined as the difference between the logarithm of output and those of the inputs, weighted by market shares. In general, as argued by Robert HALL [1986, 1988, 1990], the variation in the Solow residual can be expressed as the sum of three terms: productivity changes, a term that reflects the degree of increasing returns to scale and a term that reflects the discrepancy between prices and marginal costs. If, for instance, output y is given by the homogeneous production function $y = \theta\, F\,(K,\, L)$, where K is the capital input and L is the labor input, then the variation in the Solow residual, $\frac{\dot{y}}{y} - (1-q)\,\frac{\dot{K}}{K} - q\,\frac{\dot{L}}{L}$ (where q is labor's share in national product), can be written as

$$\frac{\dot{\theta}}{\theta} + \zeta\,\frac{\dot{K}}{K} + (\varphi - 1)\,q\,\frac{\dot{\left(L/K\right)}}{(L/K)},$$

where, denoting by F_K and F_L the partial derivatives of F, ζ is defined as $\frac{F_K\,K + F_L\,L - F}{F}$, zero under constant returns to scale and positive under increasing returns, and φ is the markup, which satisfies $\theta\,F_L = \varphi\,\frac{w}{p}$, $\left(\text{where } \frac{w}{p} \text{ is the real wage}\right)$. If returns to scale are constant $(\zeta = 0)$ and firms are price and wage takers $(\varphi = 1)$, then the variation in the Solow residual equals the change in productivity $\frac{\dot{\theta}}{\theta}$, but under increasing returns $(\zeta > 0)$ or market power $(\varphi > 1)$, the variation in the Solow residual exceeds the change in productivity. (For instance, an increase in the labor/capital ratio L/K will increase the Solow residual when $\varphi > 1$; the Solow residual will then be procyclical when so is L/K, even when productivity is unchanged.) HORSTEIN [1993] shows that the excess may be substantial [6].

He also analyzes the effect of market power and increasing returns on the volatility of output and employment in the presence of technology shocks. The benchmark computations of the previous section indicated that the response of output to technology shocks would be smaller under market power. Indeed, many authors believe that technology shocks cannot account for a large fraction of observed output fluctuations under market power (as CHO, [1990], mentioned above, or the recent paper by S. Rao AIYAGARI, [1994], which introduces a new methodology for calculating the contribution of technology shocks to the business cycle). But HORSTEIN [1993] finds the effect of market power on the contribution of technology shocks to output volatility somewhat ambiguous: it may be lower than under price taking and constant returns, but not by much. This suggests that productivity shocks

6. The Solow residual may also overestimate productivity changes under "labor hoarding", on which there is an extensive literature. See, e.g., Craig BURNSIDE, Martin EICHENBAUM and Sergio REBELO [1993], Steven GARBER [1989], Mark BILS and CHO [1994], Dale JORGENSON and Zvi GRILICHES [1967], David LEBOW [1992], Walter OI [1962], ROTEMBERG and Lawrence SUMMERS [1990] and SUMMERS [1986].

may account for a substantial fraction of the volatility of output even after taking into account market power and increasing returns. The volatility of employment under market power and increasing returns is, on the other hand, clearly below that of price taking and constant returns, which is already substantially low than that of the US data.

Similar questions are studied in ROTEMBERG and WOODFORD [forthcoming], with different models and methodology. They confirm HORSTEIN [1993] result in what concerns the volatility of employment: market power reduces the influence of technology shocks on employment, but not on output. In fact, market power increases the effect of a technology shock on output. Michael DEVEREUX, Allen HEAD and Beverly LAPHAM [1993] also find that market power (based on product differentiation in an economy with free entry) increases the volatility of output in response to technology shocks.

ROTEMBERG and WOODFORD [1992 *a*, forthcoming] consider the effects of government expenditures on output. As in the benchmark of Section 5.1 above, the multiplier is larger the higher the degree of market power.

Several of the models by ROTEMBERG and WOODFORD [1992 *a*, *b*, forthcoming] embody variable markups, which are exogenous in some formulations and endogenous in others, with alternative theories of markup determination, as analyzed in ROTEMBERG and WOODFORD [1991]. The latter include a "customer market" model for the determination of markups, as well as an implicit collusion model à la ROTEMBERG and Garth SALONER [1986]. They argue that calibrated models that incoporate market power (in particular, the model where variable markups support implicit collusion among oligopolistic firms) give a better account of the observed effects of shocks than perfectly competitive models.

The study of the cyclical variability of markups is combined with that of business formation in Franck PORTIER's [1994] empirical study of the French economy, where he finds procyclical business formation and countercyclical markup. His model also analyzes the transmission of technological and demand shocks in model where markups are variable and firms enter and exit the market.

Besides analyzing shocks in productivity or in demand, some work in Cell I also considers the effects of shocks in the stock of money in real business cycle models. The study was pioneered by Thomas Cooley and Gary Hansen [1989], but market power accompanies a certain degree of price stickiness in the more recent work. Jean-Olivier HAIRAULT and Franck PORTIER [1993] answer some empirical puzzles of the canonical real business cycle model. Both Paul BEAUDRY and DEVEREUX [1993], and Olivier JEANNE [1994], find a "liquidity effect", *i.e.*, a persistent decrease in the nominal interest rate caused by an increase in the stock of money. The effect is validated in some recent empirical results, but it is hard to reproduce in the canonical real business cycle model. Beaudry and Devereux also find that a positive monetary shock generates a hump-shaped response in output that agrees with many empirical observations.

Overall, the work in Cell I of Table 1 may be evaluated within the spirit of the real business cycle model as expressed by Jean-Pierre DANTHINE and John DONALDSON [1993, p. 3]. In their words:

"*In reality, the RBC methodology is, by nature, ideologically neutral, in the sense that it prefers the model or set of models that are best able to replicate the stylized facts, independent of the hypothesis underlying them.*"

The work earns high marks in this respect, in particular because it is able to explain anomalies concerning the Solow residuals. But the ability to mimic macroeconomic time series should not be the only criterion, if for nothing else because the choice of which series to mimic is judgemental. (Does the model try to mimic the unemployment time series?) There is something else, which one may call "empirical microfoundations", defined as being in touch with the empirical results in applied microeconomics (industrial organization, labor economics, consumer theory, and public economics). Admitting prices higher than marginal costs agrees with many empirical findings in industrial organization (Mark BILS, [1987], Timothy BRESHNAHAN, [1989], Ian DOMOWITZ *et al.*, [1988], HALL [1988], MATTHEW SHAPIRO, [1987]). But, as I will argue in Section 5.7 below, one can doubt that the real business cycle characterization of the labor market agrees with empirical research in labor economics.

5.3. **Sunspots around a Steady State**

The first fundamental theorem of welfare economics implies that, in the perfectly competitive, representative agent, canonical business cycle model, any equilibrium must maximize the expected utility of the representative agent and (under the strict concavity of the utility function), the solution to such maximization problem is unique. Thus, the equilibrium is globally (and, a fortiori, locally) unique. But in a world where some economic agents have market power, equilibria may not be locally unique, *i.e.*, it may happen that arbitrarily close to an equilibrium with self-fulfilling beliefs one can find another equilibrium, also with self-fulfilling beliefs. The model is then indeterminate.

Some variables may be subject to initial conditions in dynamic economic models, but the behavior of some others depends on the expectations by agents. This leads to forward looking dynamic model. The local behavior of a dynamical model in the neighborhood of a stationary solution characterizes the determinacy of equilibrium. If the forward-looking dynamic system has "too few" stable roots (*i.e.*, roots inside the unit circle), then many rational expectations equilibria exist in a neighborhood of the stationary solution (see Olivier BLANCHARD and Charles KAHN [1980] and GUESNERIE and WOODFORD [1992], FARMER [1993], or Jesse BENHABIB and Aldo RUSTICHINI [1994], for recent expositions). As just argued, the first fundamental theorem prevents the appearance of too few stable roots in the canonical real business cycle model, but departures from the model that yield nonoptimal equilibria may display indeterminacy. Examples of such departures are the introduction of money in the utility function or the imposition of cash-in-advance constraints (see BROCK [1974] and FARMER [1993], Ch. 10) or the assumption of growth externalities à la John CHIPMAN [1970] and Paul ROMER [1986] (see FARMER, [1993], Ch. 7).

Market power provides another departure from the canonical real business cycle model that allows for indeterminacy and for fluctuations due to self-fulfilling shifts in expectations. Consider, for instance, the representative agent models of BENHABIB and FARMER [1994] and FARMER and JANG-TING GUO [1994 *a*, *b*] in Cell II. The basic model has two interpretations (FARMER [1993], Ch. 7): either market power with increasing returns at the firm level, or price-taking behavior with external economies of scale à la Chipman-Romer. For some parameter values, which require a high degree of economies of scale (and market power in the first interpretation), the forward-dynamics, linearized system has too few roots inside the unit circle: sunspot equilibria and indeterminacy then occur.

Sunspot equilibria also appear in WOODFORD ([1991], which has both money in the utility function and market power) and Jordi GALI [1994 *a*]. Contrary to BENHABIB and FARMER [1994] and FARMER and GUO [1994 *a*, *b*], Galí assumes constant returns to scale. Firms have market power and sell to two markets: consumers (consumption demand) and other firms (investment demand). The elasticity of the demand faced by a firm, and thus, its markup, depends on the composition of demand, because consumption and investment demands have different elasticities. Again, this may lead to multiple rational expectations equilibria: in particular, to persistent fluctuations in the absence of shocks to the fundamentals and indeterminacy. This requires that the two demands have very different elasticities, *i.e.*, one must be rather high, and tthe other one rather low. (It does not matter much which one is high.) Again, indeterminacy obtains at relatively extreme parameter values.

5.4. **Fluctuations in Overlapping Generations Models**

D'ASPREMONT, DOS SANTOS FERREIRA and GÉRARD-VARET [1994 *b*], Satyajit CHATERJEE, Russell COOPER and B. RAVIKUMAR [1993] and Brian RIVARD [1994] construct overlapping generations models with market power which display multiple, Pareto ranked steady states [7]. The multiplicity allows for sunspot equilibria that randomize among allocations in the neighborhoods of each of the steady states. This in turn generates indeterminacy, because there are degrees of freedom in choosing the parameters of the randomization, say the entries of the transition matrix associated with a sunspot equilibrium (see, e.g., the proof of Theorem 3 in CHATTERJEE, COOPER and RAVIKUMAR, [1993]).

RIVARD [1994] presents a model of monopolistic competition à la BLANCHARD-KIYOTAKI [1987] and increasing returns, while CHATTERJEE, COOPER and RAVIKUMAR [1993] has two sectors, Cournot oligopoly in the output market and strategic complementarities in the entry of new firms. The latter model may display, depending of the parameter values: (*a*) sunspot equilibria that involve random movements from the neighborhood

7. They can be seen as the overlapping generations counterpart of the coordination problems present in the static models of BLANCHARD and NOBUHIRO KIYOTAKI [1987], COOPER and Andrew JOHN [1988], Walter HELLER [1986], KIYOTAKI [1988], see SILVESTRE [1993] for a survey. But it should be kept in mind that overlapping generations models may display Pareto ranked equilibria even under competitive conditions.

of a steady state to the neighborhood of another one, where the likelihood of changing states is small–*i.e.*, the off-diagonal elements of the Markov transition matrix are small; (*b*): sunspot equilibria in the neighborhood of the deterministic cycles with frequent switches between states (large off-diagonal elements of the transition matrix), and (*c*): deterministic cycles involving movements between the neighborhoods of two steady states–*i.e.*, the off-diagonal elements of the transition matrix are zero: the phenomenon actually fits in Cell V of Table 1. Equilibria of type (*a*) have interesting empirical implications as (i) persistence of output fluctuations; (ii) procyclical net business formation, which leads output, and (iii) countercyclical markups. As is well known, overlapping generations models without market power also can generate sunspot equilibria. But, as CHATTERJEE-COOPER-RAVIKUMAR [1993] and RIVARD [1994] emphasize, market power allows sunspot cycles to display persistent output fluctuations, and to occur without appealing to extreme elasticity parameters.

The papers CHATTERJEE-COOPER-RAVIKUMAR [1993] and RIVARD [1994] are located in Cell III of Table 1 because they consider stochastic equilibrium cycles. But overlapping generations models may also display deterministic equilibrium cycles, as the "Type (*c*) equilibria" mentioned in the previous paragraph, and some equilibria in the papers by D'ASPREMONT, DOS SANTOS FERREIRA and GÉRARD-VARET [1994 *b*] and Teresa LLOYD BRAGA [1994]. The latter are located in Cell IV of Table 1, although some of the fluctuations may actually involve several steady states.

LLOYD BRAGA [1994] considers an overlapping generations model with Cournot oligopoly in the output market and perfect competition in the labor market, and analyzes the behavior of the real wage along deterministic cycles. She argues that market power is needed to generate the observed absence of systematic cyclical behavior in the real wage.

D'ASPREMONT, DOS SANTOS FERREIRA and GÉRARD-VARET [1994 *b*] build an overlapping generations model with a perfectly competitive labor market and with "Cournotian monopolistic competition" in the output markets: the market structure is defined by several sectors and several firms in each sector. A firm's perceived demand curve is constructed by taking as given the quantities produced by other firms in the same sector and the prices charged by firms in other sectors. Consumers live for two periods, and intra-period utility is a CES function of the goods produced in all sectors: its parameters include an elasticity of intersectorial substitution. The formulation generalizes previous models with Cournot oligopoly (one sector) or monopolistic competition (one firm per sector) [8]. A first result, already indicated, is the presence of multiple Pareto ranked, stationary equilibria: it necessitates increasing returns to scale. The paper analyzes the conditions under which deterministic endogenous fluctuations may occur: this include complementarity in demand or increasing returns to scale with

8. The model is similar to the one in D'ASPREMONT, DOS SANTOS FERREIRA and GÉRARD-VARET [1994 *a*], but public expenditure does not enter the utility function.

enough variability in the elasticity of demand, and, hence, in the degree of market power.

5.5. **Deterministic Growth and Fluctuations**

The different elasticities of investment demand relative to consumption demand present in GALÍ [1994 a] may also be at the root of coordination problems in deterministic growth models, *i.e.*, they may generate multiple, Pareto ranked steady state equilibria, as well as multiple nonstationary equilibria. GALÍ [1993 a, b, 1994 b] considers a continuous time model that departs from the prototype of CASS [1965] and KOOPMANS [1965] by postulating monopolistic competition in the output market, where firms face investment demand and consumption demand. In the prototype (with constant labor supply) the equation "MARGINAL REVENUE PRODUCT OF CAPITAL = MARGINAL COST OF CAPITAL", or:

$$p\tilde{f}'(K) = r + \delta,$$

where p is the price of output, $\tilde{f}'(K)$ is the marginal physical product of capital, r is the interest rate and δ is the capital depreciation rate, has a unique solution that determines the unique, efficient steady state. Moreover, given an initial condition K_0, there is a unique solution path that converges to the steady state. Under market power, the equation becomes:

$$p\tilde{f}'(K) = \varphi(r + \delta),$$

where φ is, as before, the markup, equal to the ratio (price/marginal cost), or to $(\eta/\eta - 1)$, where η is the elasticity of the demand curve faced by a firm. The solution is still unique under a constant markup (although, evidently, the corresponding steady state will be inefficient), but if the markup is endogenous and variable, then the equation may have several solutions, which will correspond to different steady states.

In GALÍ [1993 *a*] firms face again demand from two sectors with different elasticities. If the elasticity of consumption demand is higher than that of investment demand, then the overall elasticity faced by firms (a weighted average of the two) is positively related to investment and the capital stock (*i.e.*, the markup factor is negatively related to investment), and the marginal revenue product of capital may be increasing in some range. The equation "MARGINAL REVENUE PRODUCT OF CAPITAL = MARGINAL COST OF CAPITAL" may have multiple solutions, corresponding to multiple steady states.

Figure 4 in GALÍ [1993 *a*] illustrates one possibility in the (capital, consumption) space. There are three steady states, High, Low and Medium. High and Low are saddlepoints, and Medium is a sink. Given an initial condition K_0 on capital, there may be a continuum of equilibrium paths, indexed by the arbitrarily chosen (within bounds) initial consumption: one path converges to High, and another one to Low (they are the stable branches of the saddles), where the remaining paths converge to Medium. Medium is a source for other values of the parameters. It may then happen that for some values of K_0 there is a unique path, which converges to either High or Low, whereas for intermediate values of K_0 there are multiple solutions, some converging to High and some to Low. The analysis has implications for explaining some stylized facts in development economics, in particular, the lack of convergence in output per capita among countries with similar initial conditions.

Alternative models in the same spirit are presented in GALÍ [1993 *b*] and in GALÍ and Fabrizio ZILIBOTTI [1993] both with increasing returns and entry. In GALÍ [1993 *b*] the positive relationship between elasticity and investment is based on a model of product differentiation in intermediate goods, where the variety of differentiated inputs is not constant, and where the elasticity of substitution among inputs increases with the variety of inputs available. The market structure in GALÍ and ZILIBOTTI [1993] is Cournotian with zero profits due to free entry (potential entrants are Bertrand, rather than Cournot, competitors): the elasticity of demand faced by a firm depends on the number of firms in its market. Both papers study the possibility of multiple steady states and the equilibrium dynamics.

5.6. **Determinacy and Beliefs**

The indeterminacy of models with self-fulfilling beliefs has motivated a position that treats beliefs as exogenous. One reads in FARMER [1993, p. 183].

> "*I will argue that exactly the same arguments that one might use to defend the assumption of fixed preferences can be applied to the assumption that beliefs are primitives of the model. In models where there are multiple rational expectations equilibria, we should think of the* belief function *as a primitive construct that tells us how agents predict the future. The rational expectations assumption, in this class of models, is a consistency principle that restricts the class of belief functions that are admissible to the modeler, and it plays the same role in models with multiple equilibria that the assumption of transitivity plays in the theory of rational choice. Since every belief function has a unique implication for the time-series behavior of the data, this assumption does not pose any new philosophical problems. The econometrician can in principle estimate the parameters of beliefs just as he can in principle estimate the parameters of the utility function*."

Indeed, Farmer performs some calibration exercises comparing a model of self-fulfilling beliefs, where the actual path of employment, prices,..., follows the realizations of a "sunspot" random variable (interpreted as a signal, unrelated to preferences or technology, on which agents base their forecasts) with a canonical real business cycle model random technology shocks [9]. Belief shocks are, in the first model, parallel to the technology shocks of the second one.

The problem with this view is that, as GUESNERIE and WOODFORD [1992] emphasize, it is of the essence of a rational expectations equilibrium

9. See Kevin SALYER [forthcoming] for another set of of comparisons suggesting that the real business cycle formulation is in fact the better alternative.

that beliefs be coordinated among individuals. Whereas the transitivity of preferences is a consistency condition at the level of the individual consumer, the rationality of expectations is a condition of coordination among individual views of the future. To illustrate, let agent i's forecast on future prices, $p_{i,\,t+1}$, be given by the belief function:

$$p_{i,\,t+1} = \psi_i\,(p_{t-1},\, p_t,\, \eta_{it},\, \eta_{i,\,t+1}),$$

where $\{\eta_{it}\}$ is the sequence of the "sunspot" random variables which agent i believes that influence prices. But beliefs must be coordinated in order to support an equilibrium, *i.e.*, they must satisfy rational expectation conditions, which in particular require that

$$\begin{aligned} \eta_{it} &= \eta_{ht}, \qquad \text{for all} \quad i,\, h,\, t, \\ \psi_i &= \psi_h, \qquad \text{for all} \quad i,\, h. \end{aligned}$$

The assumption that beliefs are data amounts to postulating a particular (random) coordination device, which selects one among the many, not isolated equilibria. The selection ends the indeterminacy, but is not clear why one should expect Nature to endow us with pre-coordinated beliefs. Perhaps we should accept indeterminacy as a sign of incompleteness and as a challenge to develop better models. As suggested by BENHABIB-RUSTICHINI [1994], they may have to incorporate both economic and noneconomic behavior.

5.7. **The Labor Market**

Models of equilibrium fluctuations under market power share a shortcoming with their price-taking counterparts, namely their formulation of the labor market. One can identify three aspects of the problem.

• Labor supply elasticities. There is an empirical problem, namely the wage-employment variability puzzle (DANTHINE and DONALDSON [1990], PRESCOTT, [1986]), *i.e.*, the relative variability of employment in time series data is much larger than in the magnitudes generated by typical real business cycle models. In order to generate figures that display some of the employment relative variability found in actual time series, traditional real business cycle models use large labor supply elasticities as calibration parameters.

So do some of the current models of equilibrium fluctuations under market power. But this leads to weak empirical microfoundations. Labor economists typically find low labor supply elasticities for men (see, e.g., John PENCAVEL [1986] and Robert TRIEST [1992]). Those of women are more confuse (see Mark KILLINGSWORTH and James HECKMAN [1986]). Indeed, recent developments in real business cycle research that include home production may capture some relevant aspects of the supply of labor by women (see Jeremy GREENWOOD *et al.*, forthcoming). But the magnitude of any effects of prices and wages on female labor supply are dwarfed, in the time series of the last few decades, by the dramatic changes in female participation rates.

• Female labor participation and supply. The most striking feature of female labor behavior is the dramatic increase in female labor participation rates, see Table 2.

TABLE 2

Female Civilian Labor Participation Rates (in percent) in the US.

1940	1950	1960	1970	1980
25.5	28.6	34.5	41.6	50.5

Source: M. R. Killingsworth and J. J. Heckman (1986, p. 104).

These figures are, in my view, hard to understand as the response of a consumer with unchanged preferences to variations in wages, prices or interest rates. Yet some of the real business cycle models attempt to mimic employment time series that span thirty or more years as the labor supply responses of a single, infinitely lived agent. This is, in my view, an example of flimsy empirical microfoundations. One should add that the objection does not fully apply to the demand for output, because there is less evidence of such a strong, systematic trend.

• Unemployment. An objective of the real business cycle program is the integration of growth theory with the theory of fluctuations. But a crucial time series to be explained by the analysis of fluctuations is the magnitude or rate of reported unemployment, not only the hours worked. By postulating Walrasian conditions in the labor market, traditional business cycle theory shuts itself off from explaining a basic component of economic fluctuations. So do the existing models of equilibrium fluctuations under market power. The static, general equilibrium models of market power (as discussed, e.g., by DIXON and RANKIN [1994] or SILVESTRE [1993]) or the stationary overlapping generations model discussed in Sections 2-4 above typically allow for market power in the labor market. Alternatively, as put forward by DANTHINE and DONALDSON [1990, 1993, forthcoming] and BENASSY [1993 *a*], one can incorporate a non-Walrasian labor market in an otherwise straightforward real business cycle model: DANTHINE and DONALDSON actually favor some form of efficiency wage model. These options seem more in line with observed unemployment time series than the Walrasian hypothesis.

5.8. **Equilibrium vs. Disequilibrium Fluctuations**

In the 60's and 70's growth theory and the theory of fluctuations were distinct in at least three basic aspects.

From the *conceptual* point of view, growth theory was based on the equilibrium method, in its two aspects of the equality of price-taking supply and demand and perfect foresight of future prices. This was to some extent justified by the fact that it contemplated potential output rather than actual output, and one can argue that any notion of potential output must, by its very nature, embody equilibrium conditions such as the full employment of physical and human capital. Fluctuation theory, on the contrary, was based on Walrasian disequilibrium with two regimes. A classical regime would rule when actual output was close to (perhaps above) potential output. But a demand-constrained, Keynesian regime would rule at low levels of output. Expected demand, rather than prices, would then determine investment in the short run. See James TOBIN [forthcoming] for a recent presentation.

The conceptual distinction had a *normative* counterpart. Growth theory indicated the long run efficiency of the system, whereas fluctuation theory showed that there were large welfare losses in the short run. Thus, it would be unwise for the public sector to engage in long term planning, but anticyclical measures were called for.

Last, the distinction had *empirical* implications. Actual time series on, say, output were understood as the sum of two series: a smoothed one, interpreted as potential output, and the residual, interpreted as cyclical deviations from potential output. The time series of the rate of deviation from potential output goes up and down with (but fluctuates at a greater amplitude than) the unemployment rate (see Arthur OKUN [1962] and TOBIN, forthcoming). The reader is referred to BLANCHARD and FISCHER [1989, Ch. 1] for a discussion of the alternative approaches to the decomposition of output series.

Modern dynamic research has, to a large extent, abandoned the distinction. The prototype is the macroeconomic real business cycle model of KYDLAND and PRESCOTT [1982] and KING and PLOSSER [1984], developed simultaneously with the study of complex equilibrium dynamics in microeconomics (see Michele BOLDRIN and WOODFORD, [1990], or GUESNERIE and WOODFORD, [1992], for recent surveys). Actual output series are understood as generated by price-taking behavior under market clearing and rational expectations. Moreover, the economy is devoid of public goods and externalities in the canonical form of the model. Thus, the first welfare theorem applies and equilibria are optimal. Fluctuations themselves are seen as optimal: one way of verbalizing the optimality of a business cycle with periods of high (booms) and low (depressions) activity is to compare it, on the one hand, with the day-night or weekdays-weekend activity cycles or even with the geographical patterns of economic activity: high in cities and low in the countryside. (The word is “agglomeration”: see HALL [1991], for an engaging presentation). The economic role of the government is reduced to distribution, and not even that in representative-agent models. There is no meaningful distinction between actual and potential output or welfare.

The recent dynamic models with market power equilibrium follow this methodology, but because the first fundamental theorem does not apply, leave in principle open the door for Pareto-improving government intervention. They are, in this respect, parallel to the static models discussed in SILVESTRE [1993]. As in there, coordination failures may occur and government intervention may induce a Pareto superior equilibrium. Dynamic equilibrium models with market power in the output markets and also in the labor markets (or with an efficiency-wage equilibrium in the labor market) may generate socially costly depressions where output and welfare are well below their potential levels.

Market power models may, in principle, display disequilibrium dynamics between several steady state equilibria, although this approach has not generated so far explicit dynamics or a substantial amount of empirically oriented work [10]. The view is based in the static coordination problem literature, as represented by, say, BLANCHARD and KIYOTAKI [1987], COOPER and JOHN [1988], HELLER [1986], KIYOTAKI [1988], and Alan MANNING [1990]. The models have Pareto ranked, static equilibria which can, of course, be interpreted as the steady states of a dynamic one, offering the following view of the business cycle.

There are two stable steady states, a high activity one and a low activity one. The economy finds itself, at some instant, in the high activity steady state. It returns to it after favorable shocks and after small unfavorable shocks. But large, unfavorable shocks put the system in a trajectory that leads to the low activity equilibrium. Similarly, if the economy is in the low activity equilibrium, then a large, favorable shock leads to the high activity one.

Note that, while in transition between steady states, the economy is out of equilibrium, *i.e.*, the conditions of the static, market power equilibrium are not satisfied: perhaps firms maximize relative to perceived demand functions which are incompatible with the process of income formation, or perhaps a firm takes as given actions of other firms which are not the best response against its own actions.

The allocation corresponding to the low activity equilibrium is Pareto dominated by the high activity one. Economic policy may, in principle, be effective both in preventing and in abandoning the low activity equilibrium. For instance, if the economy is stuck in the low activity equilibrium, then monetary expansion may be the favorable shock that leads towards recovery. As argued in Silvestre [1993], this effective role of monetary policy is, in theory, consistent with the neutrality principle, *i.e.*, with the assertion that the set of market-power equilibria is, in its projection on nonnominal coordinates, invariant with respect to monetary policy instruments.

6 Concluding Remarks

Dynamic equilibrium models with market power have, to some extent, responded to the stimulus of research conducted under the assumption of price-taking behavior. Some of the papers, as the ones in Sections 2-4 and in Cells III and IV of Table 1, adopt the overlapping generations model. They make precise important insights about the second-best role

10. There are examples of models that dynamize some sorts of coordination problems, see, e.g., Peter HOWITT and R. PRESTON MCAFEE [1988] for a dynamic analysis of search-based coordination problems.

of economic policy, the possibility of unemployment at all wages, the dependence of the effects of monetary policy on expectations, fluctuations and dynamic coordination problems. The models are somewhat removed from current macroeconomic practice by two related reasons: first, they are not empirically oriented and, second, while the overlapping generations model is certainly used in monetary economics, dynamic macroeconomics has by large adopted the representative agent view (or, at most, the assumption of a finite number of consumer types) [11]

A second class of papers, represented by Cells I, II and V of Table 1, are rooted in neoclassical growth theory, often following the methodology of the real business cycle model. Price taking (plus the absence of "imperfections") has a very strong implication here, namely, the validity of the First Fundamental Theorem of Welfare Economics: fluctuations are efficient in the canonical real business cycle model [12]. The market power approach views fluctuations as the result of equilibrium behavior, but, because agents have market power, equilibrium does not guarantee efficiency. In particular, recessions may involve large social costs and generate levels of output and welfare well below their potential.

Dynamic equilibrium models with market power represent an improvement over their price-taking counterparts because they may better replicate the stylized facts of macroeconomic time series. This work thus advances the real business cycle research agenda to the extent that it is basically pragmatic, aimed at better mimicking observed features of economic fluctuations. Moreover, and outside this agenda, the market power approach is more in line with empirical results in industrial organization and, thus, its empirical microfoundations are more solid. Normatively, this work presents a fundamental difference with its price-taking counterpart: recessions have social costs, and anticyclical policy may be welfare enhancing.

Deeper empirical microfoundations and more explicit welfare analysis are two directions where further progress is welcome. This includes modelling the labor market in a manner consistent with empirical labor market research, and a public sector that supplies useful goods and services in a second-best world. Once a realistic labor market is incorporated, the need to understand the fluctuations in the rate of unemployment can be brought to the forefront of research.

11. See, e.g., George McCandless with Neil Wallace [1991] for a macroeconomics textbook based exclusively on overlapping generations.

12. This contrasts with the overlapping generations model, where Walrasian equilibria may well be inefficient: see Geanakoplos and Polemarchakis [1991] for an interpretation of the inefficiency as due to the lack of market clearing "at infinity".

APPENDIX

A.1 Coordination Problems, Strategic Complementarities and Pecuniary Externalities

The literature on the market-power foundations of macroeconomics has emphasized the possibility of coordination problems, *i.e.*, of the presence of multiple, Pareto-ranked equilibria. The phenomenon is, in turn, often related to strategic complementarities or supermodularity in the interaction among economic agents (see, for instance, BLANCHARD and KIYOTAKI [1987], COOPER and JOHN [1988], HELLER [1986], KIYOTAKI [1988]). These concepts have a well-defined meaning and provide useful conceptual tools.

But, in addition, the literature often refers to a less precise concepts, namely that of "macroeconomic", "demand", or, more generally, "pecuniary externalities". Physical externalities (also called "real" and "direct") do have a clear meaning and an important role in economic analysis. A physical externality is present when the utility or production function of an economic agent includes as arguments the consumption or production vectors of other agents, firms or consumers. Most of urban economics and of environmental economics is indeed based on the presence of physical externalities. Moreover, modern growth theory often appeals to the positive externality caused by the creation of technological knowledge in the process of production, see CHIPMAN [1970] and ROMER [1986].

The conceptual obscurity appears when one considers externalities that are not physical but "pecuniary". If one reads, for instance, Peter BOHM [1987] or J. de V. GRAAFF [1987] in the *New Palgrave Dictionary*, one is left feeling that the term "pecuniary externalities" has never had a clear, generally accepted meaning.

For instance, a first, generalist, meaning identifies "pecuniary externalities" with economic interdependence through markets (see, for instance, Kenneth ARROW and Frank HAHN, 1971). JOHN [1988] in fact develops a suggestive taxonomy of externalities from this viewpoint.

Second, Tibor SCITOVSKY [1954] seems to use the term "pecuniary externality" in the sense of "coordination problem", *i.e.*, the presence of a laissez-faire equilibrium that is dominated by another one. For instance, HELLER and David STARRETT [1976] argue that, in Scitovsky's example, an equilibrium obtains, under incomplete markets, which is inferior to the equilibrium that corresponds to a complete set of markets. But the phrase "coordination problem" or "Pareto-ranked equilibria" seem preferable for this purpose.

A third notion, which is adopted in what follows, defines an externality to be present when *an individual could take an action that improves society's welfare but not her own benefit*. The concept presupposes a definition of what an individual action is, and how do individual benefits depend on actions. To be precise, let there be n individuals in society and let a_i denote an action (or strategy) by individual i, to be chosen among a set of a priori admissible actions. An individual's benefit depends not only on her action a_i, but also on the actions of the other agents: let it be represented by a real-valued function $b_i(a)$, where $a = (a_1, ..., a_n)$.

Moreover, one must have a notion of "improvement in society's welfare". Two notions have played an important role in economics:

(A) numerical, aggregate valuations of welfare changes, as in, e.g., the sum of consumer and producer surplus in cost-benefit analysis, or, more generally, a social welfare function;

(B) Pareto improvement, *i.e.*, an increase in b_i, for some i, achieved without decreasing b_j fo any j.

The analysis is conducted in terms of first order effects. To this end, I assume that a_i is a continuous, unidimensional variable, and that b is a differentiable, concave function. I focus on situations a^* where no individual can increase her benefit by moving away from a^*: a^* is then called a (Nash) equilibrium. Moreover, I take a^* to be interior. It follows that, at a^*, $\partial b_i / \partial a_i = 0$, for all i.

By definition, the presence of an externality so defined, *i.e.* of a situation where an individual could unilaterally take an action that benefits society, necessarily implies inefficiency. But what about the converse? Can all instances of inefficiency be traced to an externality? The discussion below shows that the answer is affirmative provided that society's welfare is measured by an aggregate, real valued function. But it is negative under the traditional Pareto criterion.

A.2 **The Case of an Aggregate Measure of Welfare**

Social welfare is now a real-valued, differentiable function $B(a)$ that has as ultimate arguments the actions of the individuals. One views *B* as an aggregate, numerical measure of social welfare. As an illustration, *B* may be the sum of producer and consumer surpluses. Alternatively, *B* can be a social welfare function $B(a) = \tilde{B}(b_1(a), ..., b_n(a))$, where $\tilde{B}$ has positive partial derivatives [13]. I assume that *B* is differentiable and concave.

Now efficiency is equivalent to the absence of externalities. More precisely, *if a^* is an inefficient equilibrium, then an externality is present at a^**. The argument is simple. If a^* is inefficient, then there is another tuple $\hat{a}$ with $B(a^*) < B(\hat{a})$. Because of differentiability and concavity, this implies that $\partial B / \partial a_i \neq 0$ for some i, at a^*, *i.e.*, individual i could improve

13. For instance, $B(a) = \Sigma_i b_i(a)$, *i.e.*, society's welfare is the sum of individual benefits; actually, the justification for using the sum of consumer and producer surplus is that, under some assumptions, the two sums coincide.

society's welfare by moving away from a^* [14]. But, by assumption, by doing so she cannot improve her benefit. Thus, an externality is present at a^*.

This argument parallels Arthur Pigou's [1920] discussion. He takes the "national dividend" as the measure of social welfare. My $\partial B / \partial a_i$ corresponds to his value of the marginal social net product, whereas $\partial b_i / \partial a_i$ is the value of the marginal individual net product. His view seems to be that is an inefficient equilibrium requires the divergence of the two values [15]. I show next that the view cannot be extended to the case where an improvement in society's welfare means a Pareto improvement.

A.3 **The Case of the Pareto Criterion**

The analysis is now more subtle. First note that any unilateral deviation from an equilibrium a^* will typically hurt the deviator and, thus, it will fail to yield a Pareto improvement. But, under differentiability, the cost to the deviator will be of second order of magnitude, because she is originally at a maximum. One can then neglect second-order effects and redefine both inefficiency and externality in terms of first-order changes. An equilibrium then displays a first-order externality if a deviation by an individual, say, individual i, yields nonnegative first order effects in the benefits of the other players with at least a positive effect. Similarly, an equilibrium is first-order inefficient if there is a direction along which the directional derivatives of the individual benefit functions are all nonnegative, and at least one is positive.

Formally, write the Jacobian matrix of b at a^*,

$$Db\left(a^*\right) = \begin{bmatrix} \dfrac{\partial b_1}{\partial a_1}, \ldots, \dfrac{\partial b_1}{\partial a_n} \\ \dfrac{\partial b_n}{\partial a_1}, \ldots, \dfrac{\partial b_n}{\partial a_n} \end{bmatrix},$$

evaluated at an equilibrium a^*. (The diagonal is zero.) Individual i *generates a first-order externality* if all the entries in the i-th column of $Db\left(a^*\right)$ have weakly the same sign (*i.e.*, some, but not all, may be zero, and the nonzero ones are either all positive or all negative), and an equilibrium a^* is *first order inefficient* if there is another tuple of actions $\hat{a}$ such that the directional derivatives of the individual benefit functions in the direction $\hat{a} - a^*$ have all the same sign (again weakly). Of course, the (column) vector of these directional derivatives is, in matrix notation, $Db\left(a^*\right)\left(\hat{a} - a^*\right)$.

Can one have first-order inefficiency without first-order externality? It is true that many economic examples of "macroeconomic externality" found in the literature (e.g., the "demand externality" of Blanchard and Kiyotaki, [1987]) display both inefficiency and externality. But they are simple models where an action by an individual changes everybody else's benefit in the same manner, *i.e.*, all entries in a given column have the same sign (weakly). Then either all these signs are zero, in which case there is neither first-order

14. I am assuming that a^* is not a boundary point.

15. See Louis Makowski and Joseph Ostroy [1993] for an interesting version of the first fundamental theorem of welfare economics that adopts Pigou's approach.

inefficiency nor first-order externality, or one such sign is nonzero, in which case one has both inefficiency and externality. But the answer is, in general, negative, as Examples 1 and 2 below show.

Example 1: Consider the matrix

$$Db(a^*) = \begin{bmatrix} 0 & -1 & 1 & 1 \\ -1 & 0 & 1 & 1 \\ 1 & 1 & 0 & -1 \\ 1 & 1 & -1 & 0 \end{bmatrix}.$$

An inefficiency occurs, because if all individuals increase their actions by ε (*i.e.*, i takes the action $a_i^* + \varepsilon$ instead of a_i^*), then everybody's benefit increases by $-\varepsilon + 2\varepsilon > 0$, and, thus, a^* is inefficient. Yet any unilateral move benefits some people and hurts others, and, thus, it does not benefit society in the Pareto sense. This example has a straightforward economic interpretation. Individuals are firms: one and two are in agriculture, and three and four are in industry. Their actions are the quantities produced. Expanding your output hurts other firms in your sector, but it benefits firms in other sectors. More generally, the example depicts opposing intragroup and intergroup effects.

Example 2. Consider the matrix

$$Db(a^*) = \begin{bmatrix} 0 & 1 & 1 & 1 \\ 1 & 0 & 1 & 1 \\ -1 & -1 & 0 & -1 \\ -1 & -1 & -1 & 0 \end{bmatrix},$$

and the following simultaneous moves: agents 1 and 2 move to $a^* - \varepsilon$, while agents 3 and 4 move to $a^* + \varepsilon$ (where $\varepsilon > 0$). Then the first-order changes in utility are $(0, 1, 1, 1) \cdot (-\varepsilon, -\varepsilon, \varepsilon, \varepsilon) = -\varepsilon + 2\varepsilon = \varepsilon$ for agent 1, $(1, 0, 1, 1) \cdot (-\varepsilon, -\varepsilon, \varepsilon, \varepsilon) = -\varepsilon + 2\varepsilon = \varepsilon$ for agent 2, $(-1, -1, 0, -1) . (-\varepsilon, -\varepsilon, \varepsilon, \varepsilon) = 2\varepsilon - \varepsilon = \varepsilon$ for agent 3 and $(-1, -1, -1, 0) . (-\varepsilon, -\varepsilon, \varepsilon, \varepsilon) = 2\varepsilon - \varepsilon = \varepsilon$, a first-order Pareto improvement. Yet any unilateral move benefits some people and hurts others.

The second example can be interpreted as follows. Let agents 1 and 2 be shareholders, let 2 and 3 be workers, and let the a's represent levels of productive activity (investment by shareholders or labor supply by workers). An increase in productive activity increases profits (which benefits shareholders) and reduces wages (which hurts workers).

The examples provide economically significant equilibria which are inefficient: a socially superior state can be reached by a simultaneous move, but unilateral moves are not socially desirable. The inefficiency is, in these cases, based on society's failure to induce cooperation or coordination, rather than on the individual's failure to internalize the social effects of her actions.

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