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Economics Letters 82 (2004) 139–145
economics letters
www.elsevier.com/locate/econbase

Inequality, market power, and product diversity

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Received 19 March 2003; accepted 26 June 2003

Abstract

We analyze a macroeconomic model of monopolistic competition in which consumers earn unequal incomes. When preferences are nonhomothetic, the distribution of income affects equilibrium markups and equilibrium product diversity.

Keywords: Inequality; Markups; Monopolistic competition

JEL classification: D30; D42; E25

1. Introduction

In this paper we analyze the role of the personal distribution of income for macroeconomic outcomes when firms have market power. While the recent macroeconomic literature has extensively studied the role of income inequality when *capital markets* are imperfect (see e.g. Bertola, 2000 for a recent survey) this literature has been almost entirely silent about the role of income distribution when there are imperfections in *product markets*.[1]

This question, however, is both theoretically interesting and empirically relevant. In the theoretical literature, any impact of inequality transmitted by product market power is typically ruled out by the

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[1] Macroeconomic models in which income distribution plays a role because it affects demand functions of monopolistic producers include Murphy et al. (1989), Falkinger (1994), Zweimüller (2000), and Saint-Paul (2002). However, none of these papers consider the role of income distribution for mark-ups and pricing decisions of monopolistic producers.

0165-1765/$ - see front matter
doi:10.1016/j.econlet.2003.06.003

assumption of homothetic preferences and/or a representative consumer. From an empirical point of view, numerous studies have shown that homothetic preferences are a hopelessly unrealistic description of actual consumer behavior (see e.g. Deaton and Muellbauer, 1980). Hence exploring the implications of nonhomothetic preferences sheds light on a neglected, but empirically relevant issue.

Our starting point is a variant of the popular model of Dixit and Stiglitz (1977) that has been widely applied to macroeconomic questions. We keep their assumption of symmetric preferences and technologies but allow for utility functions that are nonhomothetic.[2] Keeping the symmetry assumption highlights the role of consumer heterogeneity. Deviating from the homotheticity assumption makes the firms' market demand functions dependent on the distribution of income and allows us to study the role of income inequality for equilibrium product diversity and markups.

The paper is organized as follows. Section 2 describes the setup of the model and derives individual and market demand functions. In Section 3 we discuss existence and uniqueness of the general equilibrium and how this equilibrium is affected by changes in the distribution of resources across consumers.

2. The setup

2.1. Technology, preferences, and endowments

Consider an economy with a continuum of products indexed by j. All goods are produced with the same technology that requires a fixed setup of a units of labor to run a firm and one unit of labor to produce one unit of output. The labor market is competitive and the wage rate equals w. Hence the marginal cost of production is also equal to w, the same for all goods.

All consumers have the same preferences. Their objective function is defined over an infinite, continuous range of potentially producable products $j \in [0, \infty]$. From this set of differentiated goods an endogenous range N is produced in equilibrium. We assume *symmetry* and *separability* of the various products. Moreover, we denote by $v(c(j))$ the utility gained from consuming good j in quantity $c(j)$ and normalize the utility from not consuming a good to zero, $v(0)=0$. Then consumer's objective function can be written as

$$u(\{c(j)\}) = \int_0^N v(c(j))\mathrm{d}j$$

The function $v(\cdot)$ satisfies the usual assumptions $v'>0$ and $v''<0$. Furthermore we assume $v'(c)c/v(c)<1$ for all $c \geq 0$.[3]

[2] In their original work, Dixit and Stiglitz (1977) consider not only CES-preferences but also VES-preferences ("variable elasticity of substitution") over the differentiated products. In that part of their analysis, however, they make the implicit assumption that all consumers are identical. Distributional issues are not addressed.

[3] Concavity of the $v(\cdot)$-function and the normalization $v(0)=0$ imply that $v'(c)c/v(c) \leq 1$. The assumption in the text requires this latter inequality to hold strictly. This precludes degenerate equilibria.

There is a population of consumers of mass 1. Consumers are heterogenous with respect to their labor endowment θ. The endowment distribution has support over the interval $[\underline{\theta}, \bar{\theta}]$, $0 < \underline{\theta} < \bar{\theta} < \infty$ and cumulative density $F(\theta)$. Average endowment is normalized to unity.

2.2. Individual consumption and market demand

The optimal consumption of good j is given by the first order condition

$$v'(c(j)) = \lambda(\theta)p(j), \tag{1}$$

where $\lambda(\theta)$ is the marginal utility of income for a consumer with endowment θ. Eq. (1) implicitly defines the optimal demand for product j as a function of its price and the endowment level θ. For further use we denote the individual demand function by $c(p(j), \theta)$. By implicit differentiation of Eq. (1) it is straightforward to verify that the price elasticity of *individual* demand, which we denote by $\eta(\cdot)$, is given by

$$\eta(c(p(j), \theta)) \equiv -\frac{\partial c(p(j), \theta)}{\partial p(j)} \frac{p(j)}{c(p(j), \theta)} = -\frac{v'(c(p(j), \theta))}{c(p(j), \theta) \cdot v''(c(p(j), \theta))}. \tag{2}$$

Thus $\eta(\cdot)$ is determined by the curvature of the utility function $v(\cdot)$ and, in general, varies with consumption level c.

Market demand, which we denote by x, can be calculated by horizontal aggregation of individual demand curves. From Eq. (1), market demand for good j is

$$x(p(j)) \equiv \int_{\underline{\theta}}^{\bar{\theta}} c(p(j), \theta) \mathrm{d}F(\theta). \tag{3}$$

By symmetry, the above demand function depends on j only via the price $p(j)$, but is otherwise independent of j.

3. Equilibrium product diversity and markups

3.1. Equilibrium conditions

The equilibrium is characterized by symmetry.[4] Therefore we have $p(j) = p$, $c(p(j), \theta) = c(p, \theta)$, and $x(p(j)) = x(p)$.

[4] The assumption that ensures symmetric outcomes is $v'(c)c/v(c) < 1$ for all $c \geq 0$ which implies $v'(0) = \infty$. This means all consumers purchase all available products. To see that the assumption is sufficient, note that $v'(0) < \infty$ implies $\lim_{c \to 0} v'(c)c/v(c) = v'(0) \lim_{c \to 0} c/v(c) = 1$ where the latter equality follows from l'Hôpital's rule (with $v'(0) < \infty$, asymmetric equilibria would be possible in which poor consumers are excluded from certain markets; see Foellmi and Zweimüller, 2003).

Producers have monopoly power on their respective markets and set prizes to maximize profits. A single firm is small and cannot influence aggregate variables. Formally, each monopolist solves the problem $\max_p[p\, x(p) - w\, x(p)]$. The solution to this problem can be written in the familiar form

$$\frac{p-w}{p} = \frac{1}{\varepsilon(p)}, \text{ with } \varepsilon(p) = \int_{\underline{\theta}}^{\bar{\theta}} \frac{c(p,\theta)}{x(p)} \eta(c(p,\theta)) \mathrm{d}F(\theta) \tag{4}$$

where $\varepsilon(p)$ denotes the price elasticity of *market* demand. Eq. (4) states that profits are maximized where the relation between the profit margin (price minus marginal cost) and the price, the "Lerner index" is equal to the inverse of the price elasticity of demand. This price elasticity is a weighted sum of the *individual* price elasticities, the weights being individuals' relative consumption levels $c(p,\theta)/x(p)$.

There is *free entry* for firms. In equilibrium, the marginal firm just breaks even and, by symmetry, all other firms also make zero profits. In equilibrium we must have

$$(p-w)x = wa, \tag{5}$$

where a is the fixed labor input necessary to operate a firm, and $x = x(p)$ denotes market demand when firms charge the monopoly price.

The economy-wide *resource constraint* requires that labor demand cannot exceed labor supply which is equal to unity (a population of mass 1 that supplies on average 1 unit of labor). Aggregate labor demand in the production of final output equals xN (N is the mass of firms that breaks even) and aggregate labor demand necessary to cover the fixed cost is aN. A perfect labor market ensures that in equilibrium labor supply equals labor demand

$$1 = (x+a)N. \tag{6}$$

In equilibrium, the *distribution of income* is identical to the endowment distribution. Firms make zero profits, all income accrues from labor, and each household gets the same wage per labor unit. Consumers spend all income and spread expenditures equally across goods. Hence a consumer with labor endowment θ purchases exactly θx units on each variety

$$c(\theta,p) = \theta x. \tag{7}$$

3.2. Uniqueness versus multiplicity of equilibria

The above system of four equations can easily be reduced to a single equation with the degree of product diversity N as the unknown. Using Eqs. (5) and (6) we can write $(p-w)/p = aN$. The right-hand-side of Eq. (4) can be rewritten using Eqs. (7) and (6). Taken together this yields

$$aN = \left(\int_{\underline{\theta}}^{\bar{\theta}} \theta \eta \left(\theta \frac{1-aN}{N} \right) \mathrm{d}F(\theta) \right)^{-1} \qquad \text{where } N \in (0, 1/a) \tag{8}$$

The left-hand-side relates feasible values of product diversity N to values of the Lerner index $(p-w)/p$ that ensure zero profits (ZP-curve in Fig. 1). The right-hand-side relates values of N to values of $(p-w)/p$ that guarantee profit maximization (PM-curve in Fig. 1).

Proposition 1. *(a) There exists at least one equilibrium with $N \in, (0, 1/a)$. (b) When the price elasticity of individual demands $\eta(c) = -v'(c)/(cv''(c))$ is non-increasing in c, this equilibrium is unique. When $\eta(c)$ is non-monotonic in c there may (but need not) be multiple equilibria.*

Proof. (a) We argue graphically (Fig. 1). Both PM- and ZP-curves are continuous. The ZP-curve starts at the origin, slopes upward and stops at $(p-w)/p = 1$ when $N = 1/a$. The PM-curve starts at $(p-w)/p = 1/\varepsilon(\infty)$ when $N = 0$, and stops at $(p-w)/p = 1/\varepsilon(0)$ when $N = 1/a$. At least one intersection exists when $\varepsilon(\infty) < \infty$ and $\varepsilon(0) > 1$. To see that this is actually the case recall that $0 < v'(c)c/v(c) < 1$. Using l'Hôpital's rule we may write $0 < \lim_{c \to 0} v'(c)c/v(c) = \lim_{c \to 0}[v''(c)c + v'(c)]/v'(c) = \lim_{c \to 0}[1 + v''(c)c/v'(c)] = \lim_{c \to 0}[1 - 1/\eta(c)] < 1$ from which it follows that $1 < \eta(0) < \infty$. When for all consumers $c = 0$, we have $\varepsilon(0) = \eta(0) > 1$. By similar arguments, we have $1 < \eta(\infty) < \infty$. When for all consumers $c \to \infty$, we have $\varepsilon(\infty) = \eta(\infty) < \infty$.

(b) If $\eta(c) = -v'(c)/(cv''(c))$ *decreases* in c, it increases in N. Then the market price elasticity $\varepsilon(x) = \int_{\underline{\theta}}^{\bar{\theta}} \theta\eta\left(\theta \frac{1-aN}{N}\right) dF(\theta)$ also increases in N. Thus the PM-curve is downward sloping and we have a unique equilibrium (Fig. 1a). If $-v'(c)/(cv''(c))$ increases in c, the PM-curve is upward sloping. Then, the equilibrium is either unique (PM^A) or there may be multiple equilibria (PM^B) (Fig. 1b). □

The proposition says that the equilibrium is unique if a larger number of firms is associated with lower mark-ups (PM-curve is downward sloping). One might consider such a situation as "realistic" as it is consistent with the intuition that an increase in the number of competitors tends to cut profits margins. However, the proposition also says that there are utility functions where a larger number of competitors are associated with higher profit-margins. This is a necessary (but not sufficient) condition for multiple equilibria. The intuition for multiplicity is this: When many firms enter, production per good is low,

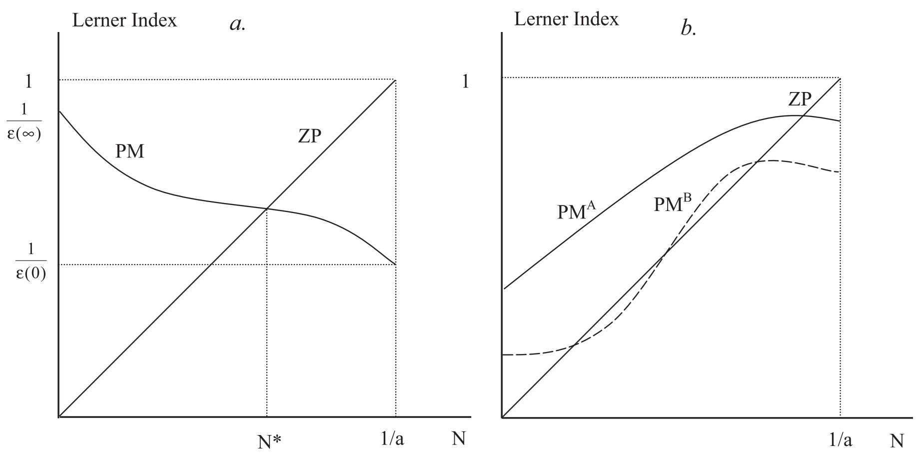

Fig. 1. Existence of an equilibrium (a, b).

elasticities of substitution are small and mark-ups are high, which supports an equilibrium with high entry. When few firms enter, elasticities of substitution are high and mark-ups are low. This in turn supports an equilibrium with a low number of firms.

3.3. The impact of inequality on product diversity and mark-ups

We now turn to our question of primary interest: How does inequality affect product diversity and mark-ups? The following proposition follows directly from our previous analysis.

Proposition 2. *Consider a unique equilibrium. When* $-v'(c)/v''(c)$ *is concave (convex) in c, a more unequal distribution of* θ *increases (decreases) product diversity and the mark-up, and decreases (increases) the real wage. Only when* $v'(c)/v''(c)$ *is affine-linear in c, macroeconomic aggregates are unaffected by the endowment distribution.*

Proof. Consider two distributions $F_0(\theta)$ and $F_1(\theta)$, such that $F_0(\theta)$ is less unequal than $F_1(\theta)$ (that is, $F_0(\theta)$ second order stochastically dominates (SSD) $F_1(\theta)$). Using Eq. (2) we rewrite $\theta\eta(\theta x) = -v'(\theta x)/(xv''(\theta x))$. When $-v'(c)/v''(c)$ is concave (convex), SSD implies $\int_{\underline{\theta}}^{\bar{\theta}} -v'(\theta x)/v''(\theta x)\mathrm{d}F_1(\theta) < (>) \int_{\underline{\theta}}^{\bar{\theta}} -v'(\theta x)/v''(\theta x)\mathrm{d}F_0(\theta)$. Concavity implies, for given x (and, by Eq. (6), for a given N), more inequality decreases the price elasticity of market demand and increases the Lerner index. In Fig. 1a, the PM-curve shifts up. In the new equilibrium, both product diversity and the Lerner index are higher. □

To understand the intuition, consider the effect of inequality on the shape of market demand functions. An *individual's* demand reaction to a price change is given by $\partial c(\theta)/\partial p = (1/p)[-v'(\theta x)/v''(\theta x)]$ (use Eq. (1)). The sensitivity of market demand to a price change is just the sum of these individual demand changes. When $-v'(\theta x)/v''(\theta x)$ is *concave*, an increase in inequality *decreases* the price sensitivity of market demand. Hence the price elasticity of the new market demand function is smaller. As a consequence, both equilibrium product diversity and the Lerner index increase.[5]

Obviously, when $-v'(\theta x)/v''(\theta x)$ is convex, analogous arguments lead to the conclusion that a mean preserving spread in the endowment distribution makes demand more sensitive to changes in prices. The price elasticity of the new market demand function is now larger. Thus, in the new equilibrium, mark-ups and product diversity are smaller, and the real wage is higher. Only in the special case, when the utility function $v(\cdot)$ is such that $-v'(c)/v''(c)$ is affine-linear in c, changes in the endowment distribution have no effect on aggregate outcomes. Only in that case, macroeconomic outcomes can be viewed as if they were generated by decisions of a representative consumer.[6]

[5] Note that the effect on the elasticity of the market demand depends on how changes in inequality affect the distribution of changes in individual demands. It is not relevant whether the rich or the poor have the higher demand elasticities: $\eta(\theta c)$ could be increasing, decreasing, or non-monotonic in θ.

[6] Utility functions that feature linearity of $-v'(\theta c)/v''(\theta c)$ belong to the HARA-class. In that case we have $v'(c) = (\beta c - \bar{c})^{-1/\beta}$ and $-v'(c)/v''(c) = \beta c - \bar{c}$ and the equilibrium (market) demand elasticity is $\beta - \bar{c}N/(1 - aN)$ which is independent of the distribution of income. In the even more special case when $\bar{c} = 0$, $v(\cdot)$ is a CES-utility function (Dixit-Stiglitz, 1977) where the Lerner index equals $aN = 1/\beta$.

Acknowledgements

We thank Josef Falkinger, Lars Ljungqvist, and Manuel Oechslin for valuable discussions.

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