Dundee Discussion Papers in Economics 234

Chen, Yu-Fu; Molana, Hassan; Montagna, Catia

Publication date:
2010

UNIVERSITY OF DUNDEE

Dundee Discussion Papers in Economics

sire

Environmental Degradation and the Limits to LOV

Yu-Fu Chen,
Hassan Molana &
Catia Montagna

Department of
Economic Studies,
University of
Dundee,
Dundee.
DD1 4HN

Working Paper
No. 234
Apr 2010
ISSN:1473-236X

Environmental Degradation and the Limits to LOV

Yu-Fu Chen	Hassan Molana	Catia Montagna
y.f.chen@dundee.ac.uk	h.h.molana@dundee.ac.uk	c.montagna@dundee.ac.uk

University of Dundee, Scotland, UK

Abstract

We show how consumers' environmental concerns may limit 'love of variety' (LOV) and be reflected in consumers decisions. We investigate how the impact of environmental degradation on LOV influences demand and optimal product variety, and how a pollution tax on firms might be used to improve upon the market outcome and increase welfare.

Keywords: Environmental degradation, love-of-variety, environmental policy

JEL classification: L1, Q2

Contacting Author: Catia Montagna, Economic Studies, School of Social and Environmental Sciences, University of Dundee, 3 Perth Road, Dundee, DD1 4HN, U.K.
tel: (+)44-(0)1382-384845; *fax*: (+)44-(0)1382-384691
e-mail: c.montagna@dundee.ac.uk

1. Introduction

In this paper, we modify the Dixit-Stiglitz framework of product differentiation to capture how environmental concerns can affect consumers' decisions via their 'love of variety' (LOV).

In the theoretical literature, it is generally assumed that product-variety is limited by the supply-side whilst the potential demand for variety is *unlimited*. As a result, standard welfare analyses point to market outcomes being characterized by a sub-optimal (under-) provision of varieties. However, if there are limits to LOV, the standard assumption may lead to an over-production of varieties relative to what is socially optimum. We contend that consumers' environmental concerns may be one of the factors limiting LOV, since the effects of product variety on welfare may not be independent of these concerns. Specifically, we argue that – to the extent that (excessive) availability of varieties affects (or is perceived to affect) pollution – the disutility from environmental degradation may manifest itself via a lower enjoyment of variety.[1] We propose to incorporate this effect by augmenting the standard Dixit and Stiglitz (1977) utility with a LOV parameter[2] that is a decreasing function of perceived environmental degradation.

One plausible implication of this modification is that the negative externality of pollution on consumers' utility is reflected in their demand for goods. In this, we depart from most of the existing theoretical literature[3] in which, whilst reducing utility, environmental degradation (typically modelled as an additive argument in the utility function; see, e.g., Stokey, 1998) does not affect demand functions – unless it influences consumers' budget constraints (e.g. via a tax).

We investigate how the impact of environmental degradation on LOV influences demand and optimal product variety, and how a pollution tax on firms might be used to improve upon the market outcome and increase welfare.

Section 2 outlines the model. Section 3 discusses the sub-optimality of market equilibrium and explains the role of policy. Section 4 concludes the paper.

2. The model

We consider a simple partial equilibrium monopolistic competition model with a mass N of symmetric firms. Each firm produces a variety indexed $i \in [0, N]$ of a horizontally differentiated good. Consumers' demand for each variety i is assumed to be

$$y(i) = N^{\lambda-1} \frac{E}{P}\left(\frac{p(i)}{P}\right)^{-\sigma}, \qquad (1)$$

[1] For instance, consumers may be increasingly conscious of the wastage (e.g., due to unnecessary replacements and high levels of obsolete stocks) associated with excessive variety (Tang and Yam, 1996). Anecdotally, the popularity of locally produced organic 'green grocery boxes' in the UK may be indicative of a willingness to sacrifice access to the greater variety offered by supermarkets.

[2] See Benassy (1996), Molana and Montagna (2000) and Montagna (2001) for further discussion and some applications of this modification.

[3] For informative reviews of different aspects of the environmental economics literature see e.g. Copeland and Taylor (2004) and Lahiri and Ono (2007).

where E and P denote respectively the total expenditure and the price index for the differentiated good, $p(i)$ is price of the variety, $\sigma>1$ is the elasticity of substitution between varieties and $0 \le \lambda \le 1$ is a parameter that captures the extent of LOV with $\lambda=0$ and $\lambda=1$ corresponding to the two extreme cases of 'no love' and 'maximum love'. It can be shown that the above demand function is consistent with CES price and quantity indices

$$P = N^{(\lambda-1)/(1-\sigma)} \left(\int_0^N p(i)^{1-\sigma} di \right)^{\frac{1}{1-\sigma}} \tag{2}$$

and

$$D = N^{-(\lambda-1)/(1-\sigma)} \left(\int_0^N y(i)^{1-1/\sigma} di \right)^{\frac{1}{1-1/\sigma}}, \tag{3}$$

and the budget constraint

$$E = \int_0^N p(i)y(i)di. \tag{4}$$

Using (1)-(3), we obtain

$$D = \frac{E}{P}, \tag{5}$$

which provides a measure of indirect utility.

Consider a situation where the extent to which consumers derive utility from the availability of product variety is affected by the (perceived) degree of environmental degradation due to the production of these varieties. We propose to incorporate this effect by letting the LOV parameter λ be a decreasing function of perceived pollution. For simplicity, we assume, without loss of generality, that each firm releases a constant amount of pollution (i.e. a firm's pollution is independent of its output level). Then, total pollution is proportional to the mass of firms N.[4] Hence, we let $\lambda = \lambda(N)$ with $\lambda' < 0$.[5]

Note, from (2), that the price index P attaches a weight of $N^{\lambda-1}$ to each $p(i)^{1-\sigma}$. With a constant and positive λ, P has the usual Dixit-Stiglitz property of being monotonically decreasing in N. The modification we propose, whereby consumers' concern for the environment affects (through its impact on λ) the weight attached to $p(i)^{1-\sigma}$, changes the above monotonicity property. Specifically, it can be easily verified that P reaches a minimum and starts rising once N arrives at a certain threshold. In turn, this implies that the indirect utility in (5) first

[4] It is plausible to assume that – for given levels of pollution emission per unit of output – *total* environmental degradation is increasing in the number of firms (e.g. via extra production plants, land usage, etc). For simplicity, in this model we do not consider output-related pollution.

[5] We can assume without loss of generality that the domain of $\lambda(N)$ is bounded in $[\underline{N}, \overline{N}]$ with $\lambda(\underline{N}) = 1$ and $\lambda(\overline{N}) = 0$.

increases and then falls in N. The intuition for this is that the *direct* effect of an increase in N is to reduce P and increase D (for a given λ). However, its *indirect* effect (via a reduction in λ, the extent to which consumers value extra variety) works towards an increase in P and a reduction in D. Thus, for a sufficiently small N, the net effect of an increase in N is to reduce P and increase utility: when N is small, the level of pollution is low and an expansion of product variety has the standard effect of increasing welfare. For a sufficiently large N, λ is small and the net effect of an increase in N is to increase P and reduce utility since now the indirect effect on D via a fall in λ dominates.

It is worth noting that this modification does not change any of the standard properties of the original framework: at the level of the individual consumer, taking N and hence λ as given, duality holds in that both maximizing (3) subject to (4) for a given E and minimising (4) subject to (3) with a given D yield the same result, i.e. the demand function in (1). The main implications of the above modification becomes apparent when we consider the aggregate market equilibrium.

3. Equilibrium and welfare analysis

Assuming that the market for each variety clears, that the production technology is the same across firms, and that marginal costs are constant, the profit of the representative firm i is $\pi(i) = \left(p(i) - \beta\right) y(i) - \alpha$, where β and α are the firm's marginal and fixed cost parameters, respectively. Maximisation of profit subject to (1) yields the constant mark-up pricing rule

$$p(i) = p = \frac{\beta}{1 - 1/\sigma}, \tag{6}$$

where p is the price of a variety under symmetry.

Allowing for the mass of firms N to be determined endogenously via free entry and exit, and using (6), the zero-profit condition $\pi(i) = 0$ implies that each firm's optimal output scale is

$$y(i) = y = \frac{\alpha}{p - \beta} = \frac{\alpha(\sigma - 1)}{\beta}, \tag{7}$$

which is constant and the same for all firms (as in the standard CES monopolistic competition framework). These imply that the price index in (2) can be written as

$$P = \frac{p}{N^{\lambda(N)/(\sigma-1)}}, \tag{2'}$$

which, for a given p, yields an inverse-U-shaped relationship between P and N as long as $\lambda' < 0$ and $\sigma > 1$.

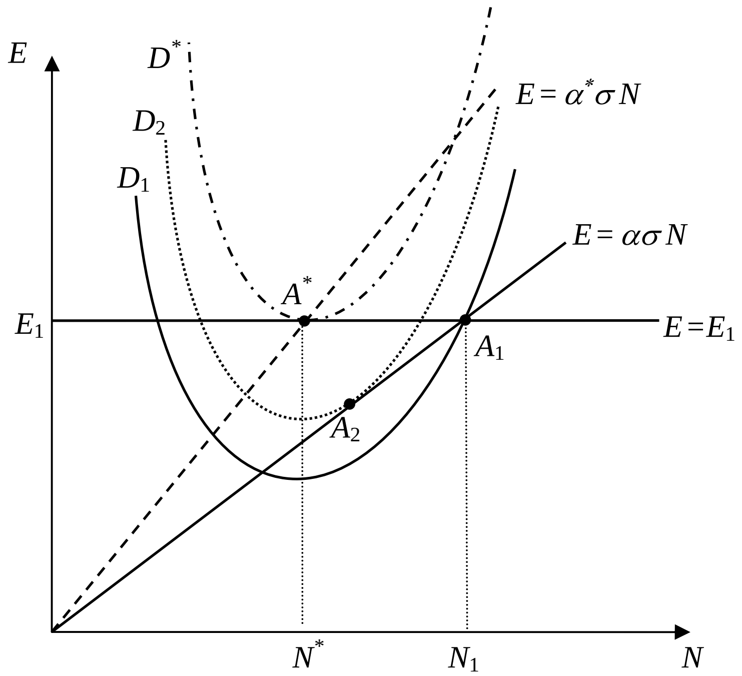
The market equilibrium condition, equating aggregate expenditure and revenue, implies

$$E = \alpha\sigma N, \tag{8}$$

which, for any given α, σ and E, determines the equilibrium mass of firms. This solution for N does not necessarily coincide with the optimal mass of varieties, N^*, that would maximise the indirect utility for a given E and hence satisfy dP/dN=0. We illustrate the main point in Figure 1 which depicts the demand and supply sides in (N, E) space. The demand side is illustrated by the inverse-U-shaped utility-indifference curves, D_1, D_2 and D^* which correspond to equation (5) for a given D and taking account of (2′), i.e. they are contours of $E/P = \bar{D}$ and have the same functional properties as P; higher contours correspond to higher utility levels and all contours reach a minimum at the same N=N^* which also minimises P. For any given level of aggregate expenditure (utility), maximum utility (minimum expenditure) is therefore achieved at N=N^*.

The supply side, for a given σ and α, is shown by the line $E = \alpha\sigma N$ which determines the mass of firms. With a predetermined aggregate expenditure, e.g. E=E_1, the market equilibrium solution occurs at point A_1 where the $\alpha\sigma N = E$ and $E = E_1$ lines intersect.

Figure 1: Market solution and the effect of optimal policy



In partial equilibrium, and in the absence of any policy intervention, the level of utility (welfare) is determined by the highest possible utility-indifference curve that passes through A_1, i.e. D_1. Because the $E = \alpha\sigma N$ line slopes upwards, with no policy intervention the mass of firms determined by the market equilibrium always exceeds the utility maximising one, N^*. This would hold even in general equilibrium where aggregate expenditure E is endogenously determined. To verify this, note that (as long as σ and α are fixed) the solution ought to satisfy $E = \alpha\sigma N$, hence the best possible outcome corresponds to that level of E at which the

$E = \alpha\sigma N$ line is tangent to the highest possible indifference curve, shown by D_2 at A_2. In this sense, therefore, there is always an *over-production* of varieties.

Clearly, in such a situation there is a role for policy since an intervention can improve welfare by affecting the mass of varieties and the pollution level. In the simple framework of the above model, a social planner could impose a lump-sum pollution charge on each firm that, by increasing the fixed cost α, would push the market outcome to coincide with the optimal number of varieties. The effect of this policy is shown in Figure 1 by the move from $\left(N_1, E_1\right)$ at A_1 to $\left(N^*, E_1\right)$ at A^* which is achieved by raising the initial fixed cost α to α^*; $\alpha^* - \alpha$ is the optimal lump-sum tax necessary to make the $E = \alpha\sigma N$ line cross the E=E_1 line at the point at which the latter is tangent to the highest possible indifference curve. This tax reduces the mass of firms to N^* and cuts the pollution level below that implied by the market solution, thus increasing welfare.

4. Conclusions

This paper modifies the CES Dixit-Stiglitz utility function to allow for consumers' environmental concerns to affect their love of variety. We show that consumers' awareness of the environmental impact of production can limit their demand for product variety and result in the market outcome being characterised by an overproduction of variety relative to what is socially optimal. A lump-sum tax on firms is then shown to be effective in correcting the sub-optimality of the market outcome by reducing entry of firms and limiting pollution.

References

Benassy, J.P., 1996. Taster for variety and optimum production patterns in monopolistic competition. Economics Letters 52, 41-47.

Copeland, B.R. and Taylor, M.S., 2004. Trade, growth and the environment. Journal of Economic Literature 42, 7-71.

Dixit, A.K. and Stiglitz, J.E., 1977. Monopolistic competition and optimum product diversity. American Economic Review 67, 297-308.

Lahiri, S. and Ono, Y., 2007. Relative emission standard versus tax under oligopoly: the role of free entry. Journal of Economics 91, 107-128.

Molana, H. and Montagna, C., 2000. Market structure, cost asymmetries, and fiscal policy effectiveness. Economics Letters 68, 101-107.

Montagna, C., 2001. Efficiency gaps, love of variety and international trade. Economica 68, 27-44.

Stokey, N.L., 1995. Are there limits to growth? International Economic Review 39, 1-31.

Tang, P.Y. and Yam, R.C.M., 1996. Product variety strategy – an environmental perspective. Integrated Manufacturing Systems, 7/6, 24-29.