Taste Heterogeneity, Elasticity of Substitution and Green Growth

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Overview of the Theoretical Results

- In the presence of consumers' taste heterogeneity, price elasticity of demand can be expressed as a function of
  - elasticity of substitution between goods for individual consumer and
  - dispersion of consumers' relative valuation of goods

Application to green growth theory:

- if the dispersion of consumers' tastes is large enough, technological progress in clean industries increases the consumption of dirty goods and and emissions.
- This is because green growth increases real income of all consumers, including those who do not value clean goods.
- for any given level of taste dispersion, aggregate elasticity of substitution between clean and dirty goods increases with the number of varieties of the clean good.

Related Literature

- Relating elasticity of substitution and elasticity of demand to taste heterogeneity of consumers
  - Hotelling (1929), Salop (1979), Perloff and Salop (1985), Anderson, de Palma and Thisse (1988, 1989)
- Interpretation of the Dixit and Stiglitz framework
  - Chamberlin (1950), Dixit and Stiglitz (1975, 1977,1979, 1993), Pettingel (1979), Yang and Heijdra (1993)
- Dependence of green growth on heterogeneity of taste and number of varieties
  - Acemoglu et al. (2012, 2014) , Aghion et al. (2014), Andree and Smulders (2014), Hassler et al. (2014)

Dixit and Stiglitz (1977)

- Representative consumer with preferences described by the CES utility function:

$$U = \left(\sum_{j=1}^{N_t} (x_j)^\rho \right)^{\frac{1}{\rho}}$$

- The demand faced by the producer given by:

$$Q_j = \frac{p_j^{-\frac{\rho}{1-\rho}}}{\sum_k p_k^{-\frac{\rho}{1-\rho}}} p_j^{-1} Y$$

- and price elasticity of demand is

$$\frac{dQ_j}{dp_{jt}} \frac{p_j}{Q_j} == -\frac{1}{1-\rho}$$

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$$\frac{dQ_j}{dp_{jt}} \frac{p_j}{Q_j} == -\frac{1}{1-\rho} (1 - \rho \phi_j)$$

Dixit and Stiglitz with Taste Heterogeneity

- Consumer with preferences described by the CES utility function:

$$U_i = \left(\sum_{j=1}^{N_t} (\theta_{ij} x_{ij})^{\rho} \right)^{\frac{1}{\rho}}$$

- x_{ij} is the quantity of product j consumed by individual i
    - θ_{ij} is the idiosyncratic taste parameter
    - Taste heterogeneity: each consumer might have different valuation of product j

The agent chooses optimal consumption basket, $\mathbf{x}$ given his income, y and set of prices $\mathbf{p}$

- The demand faced by the producer if $\rho < 1$ is given by:

$$Q_j = \int \int \ldots \int \frac{\left(\theta_{ij}/p_j\right)^{\frac{\rho}{1-\rho}}}{\sum_k \left(\theta_{ik}/p_k\right)^{\frac{\rho}{1-\rho}}} p_j^{-1} y g\left(\underline{\theta}\right) d\underline{\theta}$$

- and price elasticity of demand is

$$\frac{dQ_j}{dp_j}\frac{p_j}{Q_j} = -\frac{1}{1-\rho}\left(1-\rho\frac{\int\int\ldots\int \phi_{ij}^2 y g\left(\underline{\theta}\right) d\underline{\theta}}{\int\int\ldots\int \phi_{ij} y g\left(\underline{\theta}\right) d\underline{\theta}}\right) =$$

$$= -\frac{1}{1-\rho}\left(1-\rho\frac{E\left(\phi_j^2\right)}{E\left(\phi_j\right)}\right)$$

Meassure of taste heterogeneity

- Symetric equilibrium exists if the distribution of tastes is symmetric in the sense that $E(\psi_j) = E(\psi_k)$, $E\left(\psi_j^2\right) = E\left(\psi_k^2\right)$ and $Cov(\psi_j, \psi_k) = Cov(\psi_j, \psi_h)$ for any j, k and h and if all goods have the same supply curve.
- Let $\theta^{\frac{\rho}{1-\rho}} \sim Gamma\left(\frac{\mu}{D}, \frac{1}{D}\right)$, then, in symmetric equilibrium, $\phi = \psi = \frac{\theta^{\frac{\rho}{1-\rho}}}{\sum_k \theta^{\frac{\rho}{1-\rho}}} \sim Dirichlet\left(\frac{\mu}{D}, \frac{\mu}{D}, ..., \frac{\mu}{D}\right)$ and

$$\frac{E\left(\phi^2\right)}{E(\phi)} = \frac{\mu + D}{N\mu + D}$$

- At the point of symmetric equilibrium, the demand faced by firm is given by

$$log\left(Q_j\right) = -\frac{1}{1-\rho}\left(1-\rho D\left(\psi\right)-\frac{\rho}{N}\right) * log\left(p_j\right)$$

$$+\frac{\rho}{1-\rho}\left(\frac{-D\left(\psi\right)}{N-1}+\frac{1}{N}\right)\sum_{k\neq j}\log\left(p_k\right)+\log\left(\frac{y}{N}\right)$$

This is exactly the Walrasian demand of the *representative consumer* with $U = \left(\sum_{j=1}^{N_t}\left(x_j\right)^{\eta}\right)^{\frac{1}{\eta}}$ where $\eta = \rho\frac{1-\frac{1}{N}-D}{1-\frac{1}{N}-\rho D}$

Application: Green Growth

- Consumer i derive utility from two types of goods: clean and dirty:

$$u_i = \left(\theta_{ci} x_c^{\rho} + x_d^{\rho}\right)^{\frac{1}{\rho}}$$

- The clean and dirty goods produced with labour and the range of machines:

$$Q_j = l_j^{1-\alpha} \int_0^1 A_{vj}^{1-\alpha} z_{vj}^{\alpha} dv$$

- Machines supplied by monopolists charging the mark-up $\mu = \frac{1}{\alpha}$ over unit cost of production, φ
- Production of dirty good is associated with pollution (or CO2 emission), $P = \vartheta Q_d$

Emissions Path

$$P = \vartheta Q_d$$

In equilibrium

$$\frac{d\log(P)}{dt} = \frac{d\log(Q_d)}{d\log(A_c)}\frac{d\log(A_c)}{dt}$$

$$\frac{d\log(Q_d)}{d\log(A_c)} = \alpha - \frac{\rho}{1-\rho}(1-\alpha)\left(1 - \frac{E\left[\phi_{id}^2\right]}{E\left[\phi_{id}\right]}\right)$$

Variety of Clean Goods

- Suppose there is a variaty of clean goods and for individual consumer they are perfectly substitutable:

$$u_i = \left(\left(\sum_{k=1}^{n} \theta_{cik} x_{cik} \right)^{\rho} + x_{id}^{\rho} \right)^{\frac{1}{\rho}}$$

- Suppose also that θ_{cik} are iid with cdf given by $G(\theta)$.
- Each consumer chooses one favourite clean good. Let $\varphi_{ci} = \max_k \{\theta_{cik}\}$

Effect of variety on Emission Path

$$\frac{d\log(P)}{dt} = \left(\alpha - \frac{\rho}{1-\rho}(1-\alpha)\left(1 - \frac{E\left[\phi_{id}^2\right]}{E\left[\phi_{id}\right]}\right)\right)\frac{d\log(A_c)}{dt}$$

$$\frac{E\left[\phi_{id}^2\right]}{E\left[\phi_{id}\right]} = \frac{\int \phi_d^2 G(x)^{n-1} g(x)\,dx}{\int \phi_d G(x)^{n-1} g(x)\,dx}$$

which is a decreasing function of n, number of varieties of clean good.

Application to green growth theory:

- Elasticity of substitution between goods at the aggregate level can be expressed as a function of the dispersion of consumers' relative valuation of goods
- if the dispersion of consumers' tastes is large enough, technological progress in clean industries increases the consumption of dirty goods leading to more emissions
- for any given level of taste dispersion, aggregate elasticity of substitution between clean and dirty goods increases with the number of varieties of the clean good.

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