Taste for variety: the origins of variety expansion concept in NGT.

Anton Bondarev

11.04.2018

Introduction

- At the end of 1970-s the standard neoclassical growth theory dominated the Economics
- The new generation of endogenous theories emerged from the **taste-for-variety** concept
- These theories under the name of **New Growth Theory** still dominate the economic landscape

Overview

- The idea of taste for variety appeared in works of Dixit&Stiglitz (1977), (1980)
- These works have nothing to deal with technological change
- Rather they studied the effect of industrial structure on the welfare
- In their papers Dixit&Stiglitz argue that monopolistic power may be not that bad
- To justify the optimality of monopoly (and monopolistic competition) they introduce new factor of utility
- In their framework utility of consumers depends on the quantity of product and diversity of products

Utility function

The utility of representative consumer is a function of all the products he/she consumes:

$$u = U(x_0 + \{\sum_{1}^{n} x_i^{\rho}\}^{1/\rho}) \tag{1}$$

where x_0 is the numeraire and x_i are all other goods.

- n is the number of products being equal to the number of producers
- Thus increase in n will increase the utility of a consumer
- There is a non-obvious interplay between increase in consumption of existing goods and new good consumption.

Demand as function of variety

- It may be demonstrated that demand for each product in such a setting depends on the number of products n;
- Denote

$$y = \{\sum_{1}^{n} x_i^{\rho}\}^{1/\rho} \stackrel{!}{=} x n^{1+\beta}, q = \{\sum_{1}^{n} p_i^{-1/\beta}\}^{-\beta} \stackrel{!}{=} p n^{-\beta} \quad (2)$$

products and price indices, with $\beta = (1-\rho)/\rho$

- Demand for each product is

$$x_i = y\left[\frac{q}{p_i}\right]^{1/(1-\rho)} \stackrel{!}{=} \frac{s(q)}{pn} \quad (3)$$

- And the elasticity of the (log) demand is

$$\frac{\partial x_i}{\partial p_i} = \frac{-1}{1-\rho} = \frac{-(1+\beta)}{\beta} \quad (4)$$

Firms behaviour

- Assume every product is produced by only one firm;
- Thus number of products is the equilibrium number of firms
- Every firms being the monopolist in its product, sets the price from $MR = MC$ rule (and using demand elasticity):

$$p_i\left(1 - \frac{\beta}{1+\beta}\right) = c \tag{5}$$

where c is the common for all firms marginal cost.

- In equilibrium all varieties have the same price

$$p_e = c(1+\beta) = \frac{c}{\rho} \tag{6}$$

Market equilibrium

- The equilibrium is defined as
  - Equilibrium number of active firms, n_e under free entry
  - Equilibrium output for each such a firm, x_e.
- Conditions for these are:

$$n_e : \frac{s(p_e n_e^{-\beta})}{p_e n_e} = \frac{a}{\beta c}; \tag{7}$$

$$x_e = \frac{a}{\beta c}. \tag{8}$$

where $s(\bullet)$ is a function depending on the form of utility.

Conceptual findings

- Authors then compare the market equilibrium with the socially optimal one;
- With the constraint of nonnegative profits for all the firms market equilibrium is socially optimal
- Unconstrained social optimum has greater number of firms (variety)
- These results depend crucially on the assumption of constant (and similar) elasticity of substitution between sectors
- Resource allocation between sectors also depends on this elasticity
- **Monopolistic competition may be as good as the social optimum!**

Significance for further research

- The form of utility, being proposed in this work, began to be widely used
- First it have been applied to international trade models
- These further models already included technology
- The most important idea was that of new dimension in consumers utility
- This taste for variety allowed for justification of widening range of products as a source of growth
- This denoted the first deviation of economic thought from the "productivity" concept as the only source for growth
- However, later on these concepts have been reunified in NGT.

Overview

- The model of Romer (1990) is the first in the stream of NGT models which followed
- It exploits the concept of taste for varieties in a yet different way
- Includes specific **R&D** sector
- Uses the concept of human capital (although in a limited manner)
- Does not include growth of productivities
- The most important part of the model is the **dynamics of designs**, not knowledge.

Factors

- There are four production factors:
  - Capital, K
  - Labour, L
  - Human capital, H
  - The level of technology, A
- H measures the **rival** knowledge (education, learning-by-doing) used in production
- A represents the **non-rival** knowledge about technology
- This last is the number of designs of products known to the economy
- Both labour and human capital are assumed constant (essential!)

$$L = const; H = const. \tag{9}$$

Output

- There are three sectors in the economy:
  - Final goods production, Y
  - Production of intermediary inputs, x_i
  - Production of knowledge (designs), A.
- Final output is given by:

$$Y(H_Y, L, x) = H_Y^{\alpha} L^{\beta} \sum_{1}^{\infty} x_i^{1-\alpha-\beta} \tag{10}$$

- Intermediate durables are produced from final output:

$$K = \eta \sum_{1}^{\infty} x_i; \dot{K} = Y - C; \tag{11}$$

- Designs are produced by the stock of knowledge and human capital (knowledge spillovers):

$$\dot{A} = \delta H_A A. \tag{12}$$

Comments on the production of knowledge

- The equation for design dynamics assumes non-rival knowledge
- Each inventor j uses his/her own human capital, H_A^j, but common knowledge A
- Human capital in this model is fixed to yield one-dimensional dynamics
- There are upgrades with endogenous human capital also
- The level of A in fact determines the range of intermediary inputs being used
- Thus A influences both new designs production (in a non-excludable way) and final output (in an excludable way).

Intellectual property rights

- Every new design from A is patented by the inventor
- This patent is infinite in its length (essential!)
- Producers of intermediary inputs have to buy this patent
- Technology (intellectual property) is one of the production factors for investment goods
- Buying the design is the entry cost for intermediate producers
- Hence, intermediate producers set prices independent of the size of patent price for the design.

Intermediate producers: monopolistic competition

- After buying the design from inventor, producer of product i maximizes his/her profits:

$$\max_{x_i} p(x_i)x_i - r\eta x_i \rightarrow x_i^*, p^*(x_i); \tag{13}$$

- Prices are set by producers of durables
- For those durables, which are not yet invented ($i > A$) prices are **infinite**
- Every producer of good x_i acts as a **monopolist**
- The price for the design, P_A is competitive due to large number of potential producers (free entry condition).

Final producers: perfect competition

- Large number of firms acting at final product market Y
- At each given point in time they try to maximize profits:

$$\max_x \int_0^\infty [H_Y^\alpha L^\beta x(i)^{1-\alpha-\beta} - p(i)x(i)]di \tag{14}$$

- Yielding the inverse demand for durable i:

$$p(i) = (1-\alpha-\beta)H_Y^\alpha L^\beta x(i)^{-\alpha-\beta}; \tag{15}$$

- This demand is used by durables producers in setting up their monopoly price:

$$\bar{p}_i = r\eta/(1-\alpha-\beta). \tag{16}$$

- This monopoly price **is the same for all products** i.

Price of the design

- The decision upon the start of production of a durable i depends on the price of the design;
- Expected stream of profits should be equal the price of design:

$$\int_0^{\infty} e^{-\int_t^{\tau} r(s)ds} \pi(\tau)d\tau = P_A(t); \tag{17}$$

- As price of design is constant in equilibrium, differentiation yields a condition on price:

$$\pi(t) = r(t)P_A. \tag{18}$$

- At any time excess profit must be sufficient to cover costs of investments into the design.

Representative consumer

The household is solving the usual Ramsey-type problem:

$$\max_{C} \int_0^{\infty} e^{-\rho t} U(C) dt \tag{19}$$

with budget constraint:

$$L + H + \int_0^{\infty} \pi(i) di = Y - C - \dot{K} \tag{20}$$

yielding intertemporal optimization rule (Ramsey rule)

$$\dot{C}/C = (r - \rho)/\sigma. \tag{21}$$

Equlibrium definition

In this model the **equilibrium** is characterized by:

- Consumers making savings and consumption decisions taking interest rates as given
- Holders of human capital deciding whether to work in research or manufacturing, taking as given A, P_A and ω_A
- Final good producers choose labour, human capital and set of durables taking prices as given
- Durables producers set the price for durables taking as given interest rates and demand for durables
- New entrants into the durables market decide upon the entry taking price of the design, P_A, as given
- Supply for each good is equal to the demand (determination of prices).

Discussion of the model

- With fixed A and thus fixed durables the model resembles that of Solow
- All the durables are supplied at the same level, $\bar{x}$
- Then it is possible to obtain this $\bar{x}$:

$$K = \eta A\bar{x} \rightarrow \bar{x} = \frac{K}{\eta A}; \tag{22}$$

- The total output is given by

$$Y(H_A, L, x) = (H_Y A)^{\alpha}(LA)^{\beta} K^{1-\alpha-\beta} \eta^{\alpha+\beta-1}. \tag{23}$$

- The model behaves like the one with both capital and labour augmenting technical change A.

Nonconvexities

- This model exhibits nonconvex behaviour at various levels
- The nonconvexity in final output is the result of monopolistic competition as of Dixit&Stiglitz idea
- Nonconvexity in the output of designs, A, arises from knowledge spillovers
- In both cases the nonconvexity is the consequence of non-rival nature of A
- The key determinants of balanced growth path are knowledge spillovers present in the model and prices.

Balanced Growth Path: Inputs

- Alone the BGP main variables, A, K, Y, all grow at constant exponential rates
- For A to grow at a constant rate, the distribution of human capital, H_Y, H_A has to remain constant
- Rate of K/A should also remain constant alone BGP (**sectorial structure**)
- Implying $\bar{x}$ is also constant
- The wage paid for human capital, ω_H, grows as a proportion of A growth
- The rates of growth of capital and technology are proportional:

$$K(t)/\eta = \bar{x}A(t). \tag{24}$$

BGP: Price of the design

- Price for the design, P_A, is determined from the profit of durables producer:

$$P_A = \frac{1}{r}\pi; \tag{25}$$

- While the profit of each monopolist is constant, since $\bar{x}$ is constant:

$$\pi = (\alpha + \beta)\bar{p}\bar{x}; \tag{26}$$

- Hence the price of the design is defined as:

$$P_A = \frac{\alpha + \beta}{r}\bar{p}\bar{x} = \frac{\alpha + \beta}{r}(1 - \alpha - \beta)H_Y^{\alpha} L^{\beta} \bar{x}^{1-\alpha-\beta}. \tag{27}$$

notice the disappearance of time factor in interest rate

BGP: Wages and human capital

- In equilibrium wages paid in final goods sector and research sector should be the same:

$$\omega_H^Y = \omega_H^A = \omega_H; \tag{28}$$

- Thus the distribution of human capital has to be chosen as to satisfy

$$\omega_H = P_A \delta A = \alpha H_Y^{\alpha-1} L^{\beta} A \bar{x}^{1-\alpha-\beta}. \tag{29}$$

- Substitution of (27) into the last equation yields the fixed distribution of human capital alone BGP:

$$H_Y = 1 - H_A = \frac{1}{\delta} \frac{\alpha}{(1-\alpha-\beta)(\alpha+\beta)} r. \tag{30}$$

BGP: Growth rates

- If $\bar{x}$ is fixed, K and Y grow at the same rate and the proportion K/Y is fixed;
- Then the ration C/Y is also constant:

$$C/Y = 1 - \frac{\dot{K}}{Y} = 1 - \frac{\dot{K}}{K}\frac{K}{Y} = const; \tag{31}$$

- The common growth rate of all variables is a function of human capital:

$$g = \frac{\dot{C}}{C} = \frac{\dot{Y}}{Y} = \frac{\dot{K}}{K} = \frac{\dot{A}}{A} = \delta H_A. \tag{32}$$

BGP Final

- Taking into consideration Eq. (30), the growth rate is the function of interest rate and human capital:

$$g = \delta H - \frac{\alpha}{(1-\alpha-\beta)(\alpha+\beta)} r; \tag{33}$$

- Growth rate of consumption is related to the interest rate from household decision:

$$g = \frac{\dot{C}}{C} = (r-\rho)/r; \tag{34}$$

- This together with Eq.(33) defines the BGP growth rate as a function of technology parameters only:

$$g = \frac{\delta H - \frac{\alpha}{(1-\alpha-\beta)(\alpha+\beta)}}{\sigma \frac{\alpha}{(1-\alpha-\beta)(\alpha+\beta)} + 1} \tag{35}$$

Role of technology in the model

- The main drive of growth in the model is human capital in the research sector;
- This human capital generates the stream of inventions which are paid for by the patents for new designs;
- The research process itself is homogeneous;
- All the durables are essentially the same, hence the constant and similar $\bar{x}$;
- The interest rate determines, how much human capital is allocated to research;
- The large interest rate will threat the growth rates, since less resources will be devoted to research;
- **According to this model, financial markets, increasing financial returns, threaten technical change and growth**.

Social welfare

- It is possible to compare the decentralised equilibrium with the social planner optimum;
- This last is obtained from the optimal control type problem;
- It turns out, that monopolistic competition is sub-optimal;
- This happens because of a mark-up of a monopoly sector, which shifts the growth rate of the economy downwards;
- This result is in contrast with the earlier findings of Dixit&Stiglitz on optimality of monopoly for research.

Conclusions

- We browsed through models employing the concept of the **taste for variety**;
- This was identified as the new, additional to productivity, source of growth;
- It has been employed in studies of industrial organization (Dixit&Stiglitz);
- In international trade theory and specialisation phenomena;
- At last, it has been reconciled with productivity growth concept by P. Romer;
- This is considered to be the beginning of endogenous growth theory;
- It stressed the importance of human capital, interest rates and allocation of resources for growth;
- Still, **inventions** themselves are treated in a homogeneous way.

Literature

- Dixit A. and Stiglitz J. (1977) Monopolistic Competition and Optimum Product Diversity. *The American Economic Review, Vol. 67, No. 3*, pp. 297-308;
- Dasgupta P. and Stiglitz J. (1980) Uncertainty, Industrial Structure and Speed of R&D. *The Bell Journal of Economics, Vol. 11, No. 1*, pp. 1-28;
- Krugman P. (1979) A Model of Innovation, Technology Transfer, and the World Distribution of Income. *Journal of Political Economy, Vol. 87, No. 2*, pp. 253-266;
- Ethier W. (1982) National and International Returns to Scale in the Modern Theory of International Trade. *The American Economic Review, Vol. 72, No. 3*, pp. 389-405;
- Romer P. (1990) Endogenous Technological Change. *Journal of Political Economy, Vol. 98, No. 5, Part 2*, pp. S71-S102.

Next time

- We apply the concept of *horizontal innovations* to environmental field
- Discuss the role of knowledge accumulation and environmental feedback on the economy
- The model: Endogenous growth and natural resource scarcity by Barbier (1999)
- Based on the Romer's model with environmental module.