Specialization and Market Development as Engines of Growth

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Specialization and Market Development as Engines of Growth

Abstract

Purpose

We seek to explain the following stylized facts. 1) The share of household production in total output has fallen over time as the economy has grown. 2) Services as a percent of GDP have risen at the same time.

Design/methodology/approach

This paper constructs an original model of growth based on Adam Smith's notions of specialization and extent of the market. Growth depends on the specialization of labor in market production and learning-by-doing in transactions services. It is a model of sustained, but not infinite, growth.

Findings

The model can replicate the above stylized facts for reasonable parameterizations.

Originality/value

This paper shows that it is possible to build growth models that match the historic experience without relying in unbounded growth. Models like this may be very useful in understanding the processes that drive growth.

1. Introduction

The endogenous growth literature has focused on various endogenous mechanisms. Romer (1986) focused attention on aggregate increasing returns-to-scale. Lucas (1988) & Young (1993) explored learning-by-doing in the production process. Papers by Segerstrom et al (1990), Grossman & Helpman (1991), and Aghion & Howitt (1992) looked Schumpeterian incentives in R&D. These are but a few of the engines of growth that have been explored in this large and growing body of work.

Growth is not new, of course. It was one of the main focuses of Adam Smith's *Wealth of Nations*. Indeed, economic growth inspired the work of most of the classical economists. Two of Smith's famous concepts are that "extent of the market" drives growth opportunities, and that wealth is created by specialization and exchange. Modern researchers are certainly aware of Smith and the intuitive foundation of many of today's growth models is that growth is driven in by extent of the market in one fashion or another.

Less attention has been paid to the second concept, however – at least in economic growth. This could be because gains from specialization are usually bounded while other engines of growth are not. Since the historic growth experience is long-lived it is appealing to work with models that imply unbounded growth. Still, specialization and exchange are important components of observed economic development. The movement from individual autarky to perfect specialization is fundamentally a change in levels and not rates of growth and this imposes limits on growth. The transition need not be instantaneous, however. As long as specialization does not proceed too rapidly, it is a valid candidate for explaining at least part of observed growth. Any model using specialization as an engine of growth, therefore, must incorporate a reasonable impediment to specialization, which dissipates slowly over time.

The goal of this paper is to create an endogenous model of transitional growth that generates an evolving division of production between households and firms. This is not the first paper to propose a model where specialization plays an important role in growth.

Kim (1989) builds a static model where workers can invest in both the breadth and depth of human capital. As extent of the market expands, workers invest more in more depth and less in breadth of skill. As a result, matches between workers and the needs of the firms become better as market size expands.

Locay (1991) examines a model with an evolving division of production activities between the household and marketplace; his model is driven by scale economies in production and relies upon monitoring costs to provide home production with the advantage at small scales of output. In Locay's model the evolution of markets arises from an exogenous increase in population growth (and, therefore, increased factor supplies and demands).

Yang & Borland (1991) also develop a model which generates growth via specialization. They use identical agents and a large number of final goods. Growth is driven by both learning-by-doing and increasing returns-to-scale. The economy grows and the market expands as long as two key parameters are neither too small nor too large.

Ng & Yang (1997) build a model where costly experimentation leads to both productivity growth and increases in the division of labor.

Ades & Glaeser (1999) use two different datasets to show that the correlation between initial wealth is higher for closed economies than for open ones. Since in many contexts, openness to trade is a substitute for extent of the market, these results suggest that much growth is related to the size of the market, appropriately defined.

Fishman & Simhon (2002) consider a model where capital market imperfections limit the amount of specialization available to poor households. Increases in initial equality raise the amount of specialization and lead to higher growth.

Bartolini & Bonatti (2008) model the linkage between social capital, market activity, and growth. They show “that the economy tends to grow faster when it is relatively poorer in social capital and that perpetual growth can be consistent with the progressive erosion of social capital.[1]”

[1] Bartolini & Bonatti (2008) p. 917.

In contrast to these approaches, this paper offers a model in which aggregate economies of scale arise from the progressive specialization of labor within a chain of production. Market evolution is limited at each point in time by the presence of interfirm transaction/transportation costs that rise with the increasing thinness of markets in later stages of production – possibly due to greater product differentiation. The evolution of markets arises from declining transaction costs over time via learning-by-doing spillovers that permit increased aggregate labor productivity through more complete specialization. Hence, while learning-by-doing drives the dynamics of our model, it does so indirectly through transactions costs and not by direct increases in technical know-how.

We believe that technical progress and the engines of the papers cited above undoubtedly explain some or most of observed economic growth. However, without de-emphasizing these contributions, we wish to explore Adam Smith's simple, yet elegant notions of specialization and extent of the market in the context of aggregate economic growth. We wish to see if a carefully specified model can be simulated and replicate the historic growth experience. Specifically, we are looking for a history of sustained positive growth rates for hundreds of years.

2. The Model

We are attempting to build a model where increases in the extent of the market drive increases in specialization. These increases in specialization lower transactions costs and lead goods that were previously produced in households to be produced by firms and sold in markets. This feedback, while of finite duration, nonetheless generated long periods of sustained growth. We imagine a continuum of goods with raw materials at one end and final consumption goods at the other. Workers are able, if they so choose, to specialize in production at one point along this continuum. The gains from specialization are assumed to be inherent in the nature of market production as opposed to home production. Workers will generally provide some labor to the market and will buy goods at some limit of production beyond which the market does not provide any goods for sale. After purchasing these goods the workers take them home and transform them into final goods at home using the portion of their available labor they did not supply to the market.

Over time as the extent of the market expands, workers will provide more and more labor to the market and buy goods that are closer and closer to final goods. This means they will also spend less time engaged in home production.

Growth is driven by falling transactions costs which come from spillover effects. As people begin to purchase more goods, the cost of buying and selling goods falls toward some absolute lower bound.

2.1 Preliminaries

We assume a continuum of goods on the unit interval. Consumers have preferences which depend only on consumption of the final good. We also assume that they are each endowed with one unit of labor which they supply either to the labor market or home production. Since only consumption enters utility, workers have no demand for leisure time. Because goods are not storable and there is no capital, the dynamic problem which consumers solve can be viewed as a series of static problems. Consumers are homogeneous, with enough individuals to ensure competitive markets. We assume a population of infinitesimally small consumers with a size of measure one.

Production in this economy is closely related to that set forth in Swanson (1999) where workers in the market specialize in a particular range of related goods. However, in our model firms or individuals obtain goods from the immediately previous stage of production and apply labor to these goods to produce value-added. The outcome is goods which can then be passed on to the next stage of production. Production of an arbitrary good, i, is assumed to be Leontieff in production labor and materials (goods from the previous stage). The labor portion of production is linear with labor productivity varying by the production environment (indexed by s=h,m; h=home & m=market). For market production, some labor will also be used to transport goods to a location where production of the next stage good occurs. Home production is assumed to occur all in the same place and hence has no transaction costs. The production function for good i is

$$Y(i) = Min\left[L_s(i)/a_s, N_s(i)/c_s(i), M(i)\right] \tag{2.1}$$

Where:

$Y(i)$ is the output of production at stage i,

$L_S(i)$ is production labor in environment s used to produce good i,

a_S is the unit labor requirement in goods production for labor in environment s,

$N_S(i)$ is labor in environment s used to perform transaction services for good i,

$c_S(i)$ is the unit labor requirement in transaction services of good i for labor in environment s, and

$M(i)$ is the materials passed from the immediately preceding stage to stage i.

We assume that $a_h > a_m$, which guarantees that individuals are more productive in market production than in home production. This could be because there is an optimal firm size which is larger than the household.

We also assume that $c_h(i) = 0$ and $c_m(i) = c\tau(i)$. The details of $\tau(i)$ are discussed below.

2.2 Autarky Production

In autarky each individual takes free raw materials and passes them through all stages, adding value via household labor inputs at each stage, to final production of the final good. Each individual must choose the optimal level of labor for each stage of production. For simplicity we assume that there is no time element involved in the production and passing of goods from one stage to the next. Rather, production at all levels occurs within the same time period. Since we are focusing on growth over long periods of time this is a reasonable simplification.

Given the nature of production and the constraint that $Y(i) \geq M(i)$ (i.e. the materials passed to the next stage must be less than or equal to production), we can write the production function for final goods for an individual:

$$Y(1) = Min[Y(i)] = Min[L_h(i)/a_h]; \ 0 \leq i < 1 \tag{2.2}$$

The optimal choice of outputs for each level of production is described by $Y(i) = Y_a$. This gives the following labor constraint:

$$1 = \int_0^1 Y_a a_h di = Y_a a_h \tag{2.3}$$

Which gives final production & consumption of $Y_a = 1/a_h$.

2.3 Market Production

If individuals engage in household production they can costlessly move materials from one stage of production to the next. However, we assume that if firms engage in production they must pay a transaction cost of $c\tau(i)\ di$ units of labor per unit transported whenever goods are moved from one stage to the next. This gives the following competitive pricing formula:

$$\dot{P}(i) = c\tau(i) w\ di + a_m w\ di \tag{2.4}$$

$\dot{P}(i)$ shows the increase in the price of goods moving up the chain of production by a small increment in the neighborhood of i, w is the wage paid per unit of labor. We can normalize units so that w=1.

We assume that P(0)=0 since initial materials are free. We also assume that $c = a_m$.

Integrating eq. (2.4) gives the price of good i, $P(i)$:

$$P(i) = \int_0^1 [a_m + a_m \tau(i)] dj = a_m [i + T(i)];\ T(i) \equiv \int_0^i \tau(j) dj \tag{2.5}$$

Now consider the case where markets exist for all stages between 0 and J. In this case an individual could allocate some labor to the market, work for a firm and earn wages which he could use to purchase good J. He must then take good J and transform it via household production into the final good. The individual who does this faces the following budget constraint:

$$P(J)M(J) = w\left[1 - \int_J^1 L_h(i) di\right] \tag{2.6}$$

$L_h(i)$ is labor devoted to household production at stage i. Workers will be indifferent between producing any of the 0 to J market goods and supplying transaction services.

The individual takes his purchases of $M(J)$ and applies labor in the household to obtain $Y(1)$. As in the autarky case we will have $Y(i) = C$ but for all $i>J$.

2.4 Levels of Market Participation

The labor resource constraint can be written as:

$$(1-J)Ya_h + JYa_m + Ya_m T(J) = 1 \tag{2.7}$$

The first term is labor devoted to household production, the second term is the amount of labor allocated to market production and the third term is the amount allocated to transaction services. The last two of these terms are the per worker averages, the exact distribution for a given individual across these two activities is indeterminate.

We assume that the transaction cost of moving goods from one stage to the next increases with the stage. This can be rationalized by noting that goods at later stages are more differentiated than those at earlier stages. Differentiated goods will have thinner markets and higher transaction costs per unit. However, none of these costs apply to household production.

We make the following assumptions about the transportations costs over goods

- $0 < \tau(i)$ and finite for all $i<1$
- $\tau(i)$ is continuous & monotonically increasing in i
- $\tau(0) < a_h / a_m - 1$
- $\tau(1) > a_h / a_m - 1$

These assumptions assure that there exists a unique level J greater than zero and less than one that maximizes final consumption.

We define $C(J)$ as the level of final consumption for an individual who relies on market production for intermediate goods up to stage J. Since $C(J)$ is the same as Y we can rewrite it as:

$$C(J) = [(1-J)a_h + Ja_m + T(J)a_m]^{-1} \tag{2.8}$$

$C(J)$ will be maximized at the value of J^* defined by $\tau(J^*) = a_h/a_m\text{-}1$.

2.5 GDP & Real Consumption

We define a useful measure of economic activity and welfare. Gross national product, G, is the value of all goods and services purchased by households. This measure includes the value of all market production in the economy, but excludes the value of household production. All Individuals purchase an amount of good J equal to their final consumption level of $C(J)$ and value it at price $P(J)$. Thus, G can be written as:

$$G = \frac{a_m[J + T(J)]}{(1-J)a_h + Ja_m + a_m T(J)} \tag{2.9}$$

This is contrasted to total final consumption, C, which is the sum of final consumption goods consumed by all individuals, and is not price adjusted.

3. Changes in Transaction Costs over Time

As long as the relationship $\tau(i)$ is constant, the economy exhibits no growth. We now incorporate a simple form of learning-by-doing that leads to transitional growth. We assume that the transaction cost at stage i falls over time as a function of experience in the market.

We assume there is an upper and lower bound for the transaction cost at stage i. With no experience the transaction cost sits at the upper bound $\tau^U(i)$. With sufficient experience the cost is lowered to $\tau^L(i)$.

In addition to the assumptions made above, we also assume that $\tau^U(i) > \tau^L(i)$ for all i.

We assume that the relationship between the actual cost at time t, denoted $\tau(i,t)$ and these bounds is a function of experience base on past market transactions. We also assume that experience is a pure public good. If this were not the case then some individuals might choose to "invest" by overproducing now and making losses in exchange for speeding up learning-by-doing. Thus, the transactions cost associated with good i in period t is

$$\tau(i,t) = \tau^U(i) - f\{E(t)\}[\tau^U(i) - \tau^L(i)] \tag{3.1}$$

where $E(t)$ is a measure of the market experience accumulated as of period t.

We make the following assumptions:

- $f(0) = 0$

- $f(E)$ is continuous & monotonically increasing in E
- $\lim_{E \to \infty} f(E) = 1$

We also assume there are spillovers of experience in transacting a particular good to the cost of transacting of all other goods. Experience is proportional to the volume of all past market transactions. Hence, total new experience accruing in period *t* is,

$$\Delta E(t) = J(t)C(J(t)) \tag{3.2}$$

Total accrued experience since *t*=0 is:

$$E(t) = \sum_{s=0}^{t} \Delta E(s) \tag{3.3}$$

Assumptions about $\tau^U(i)$ and $\tau^L(i)$ guarantee that $0 < \tau(i,t)$ and finite for all *i*<1 and $\tau(0,t) < a_h / a_m - 1$ since $\tau(i,t)$ is a convex combination of $\tau^U(i)$ and $\tau^L(i)$. $\tau(i,t)$ is also continuous & monotonically increasing in *i* and, therefore, has all the properties of $\tau(i)$ listed in section 2. Hence, we can choose *J*(*t*) as described there. Figure 1 illustrates the evolution of $\tau(i,t)$ over time.

[Take in figure 1]

We can now set forth propositions about the behavior of the economy during its period of transitional growth.

Proposition 1: Some market production will occur at t=0 *and the set of goods so produced will grow but must stop short of some upper bound less than* 1.

Proof: *J*(0) is defined by $\tau^U(J(0)) = a_h / a_m - 1$ and $\tau^U(0) < a_h / a_m - 1$, so *J*(0)>0 and individuals will provide labor to the market for goods 0 through *J*(0). $\tau(i,t)$ falls over time, but it has a lower bound of $\tau^L(i)$. Since $\tau^L(1) > a_h / a_m - 1$ there is an upper bound on *J*(*t*) even as *t* goes to infinity. This upper bound, *J**, is defined by $\tau^L(J^*) = a_h / a_m - 1$.

Proposition 2: Our measures of GDP (Y) and consumption (C) will grow over time, but are also bounded from above.

Proof: Follows that from Proposition 1. The upper bounds are found by substituting J^* for J into eqs. (2.8) and (2.9).

4. Simulation Results

To simulate this model we approximate our continuous setup by constructing a discrete grid on i in the range [0,1] divided into N equally sized segments.

In order to check the robustness of our simulation results we need functional forms for $\tau^U(i)$, $\tau^L(i)$ & $f(E)$, that allow for flexibility in shape; subject to the assumptions made above.

First we specify functional forms for $\tau^U(i)$ and $\tau^L(i)$ as:

$$\tau^U(i) = \lambda^U c + \beta i + \delta i^2 + \lambda \tfrac{i}{1-i} \ ; \ c \equiv a_h / a_m - 1$$

$$\tau^L(i) = \mu \tau^U(i)$$

where $\beta > 0$, $\delta > 0$, $\gamma > 0$, $\lambda^U < 1$ & $\mu < 1$ are free parameters and c is the critical value for market participation. Note that $\lambda^U < 1$ implies that there is some participation in the first period of the simulation.

Next we specify $f(E)$ as a Poisson function,

$$f(E) = 1 - e^{-\kappa E}$$

κ>0 is a sensitivity parameter with higher values leading to faster reduction in transactions costs.

We begin our simulations by using a grid with N=10,000 and running a 1000-period simulation. We set $a_h = 1$ by a normalization. We also set $\lambda^U = .99$, which gives an initial extent of the market, $J(0)$, that is close to, but still greater than zero. Finally, to allow for similar long-run growth potential in both goods production and transaction costs we set $\mu = a_m$.

We choose the remaining parameters in the model, a_m, β, δ, γ, and κ, to generate a time series for GDP, that 1) exhibits substantial and smooth growth for a long span of periods, 2) a final state where the extent of the market (J) is large and growth has ended.

Table 1 presents parameter values that meet these criteria. Plots of relevant time series are given in figures 2 through 5.[2]

[Take in table 1]

Table 1 shows that it is possible to generate a sustained episode of reasonable growth rates with the model. Simulation 1, for example, generates an average annual growth rate of 1.42% over a 300-year period. Simulation 2 generates an average annual rate of half this size for a period of 600 years by reducing the sensitivity of transactions costs to experience. These simulations also show that the growth rate of final consumption is substantially lower than the growth rate of observed GDP. While GDP grows at average rates of 1.42% and 0.76%, final consumption grows at 0.33% and 0.15% respectively. Thus, in these parameterizations, much of the observed growth is due to the reorganization and reclassification of household production into market production.

[Take in figures 2 & 3]

There are two sources of growth in the model which feed back on each other. These are gains from market specialization and gains from lowered transactions costs. In simulations 1 and 2 the potential gains from both are the same, $\mu = a_m = 1/100$.

Simulation 3 shows how it is possible to generate reasonable growth rates relying almost exclusively on transactions cost reductions. We set $a_m = .98$, but keep $\mu = 1/100$. The resultant simulation generates an 600-year average growth rate of 0.73%. Figure 4 shows that growth in this case is steadily declining, rather than remaining roughly constant.

[Take in figure 4]

Simulation 4 shows that it difficult or impossible to generate long spans of growth based solely on gains from specialization. Here we set $\mu = .99$ and keep $a_m = 1/100$. In this case growth is very high at the beginning of the simulation, but rapidly drops to zero. The only way

[2] The jagged nature of the growth plots in the figures is due to the discrete nature of the grid for the chain of production. Growth occurs both because of a decrease in transaction costs and due to expansion of the market to include goods further along the chain. When both of these occur in a given period the observed rate of growth is relatively large. However, when movement along the chain does not occur, then only the 2nd effect is observed and growth is relatively low.

to generate sustained spells of growth that correspond to observed growth rates is by allowing for meaningful interactions between both sources.

[Take in figure 5]

5. Conclusions

This paper considers a model of transitional growth driven by the movement from individual autarky to specialization and exchange in the market. Abstracting from other sources of growth that are undoubtedly important, we show that this kind of transitional growth is capable of explaining a substantial portion of the historic growth experience. More specifically, we show that growth of more than 0.75%, or roughly one-half observed growth, can be sustained by this process for several centuries.

Our model is quite simple along many dimensions. Our model has undifferentiated labor and therefore cannot generate any inequality. Richer model with workers that have innate comparative advantages at producing one of the goods in the production chain can be used to generate inequality, however. Intuitively, at early stages of market development most workers will not be able to specialize and inequality will be low. As markets develop, inequality will rise as more and more workers will be able to devote larger portions of their available labor to their comparative advantage via market production. As the extent of the market approaches 100%, however, more and more workers will be able to specialize and inequality will tend to fall again.

In this model there is only one factor of production and both capital accumulation and technical progress are absent. It may be that incorporating specialization into a more realistic growth model would yield a better fit with the data than either model does alone. Growth in our model is driven by spillovers of market experience which lower the costs of buying and selling goods. It may be that incorporating exogenous technical progress or endogenous investment in transportation technology would be even more fruitful ways of driving specialization. We leave this for future research.

Table 1

Various Parameterizations and The Results They Generate

	Simulation 1	Simulation 2	Simulation 3	Simulation 4
span	100-400	100-700	100-700	100-700
parameters				
a_h	1	1	1	1
λ^U	0.99	0.99	0.99	0.9999
β	50	50	100	0
δ	50	50	0	0
γ	0.1	0.1	5.0	0.0005
κ	0.015	0.0075	0.006	0.002
μ	0.01	0.01	0.1	0.99
a_m	0.01	0.01	0.98	0.0001
descriptives				
Mean for gG	1.42%	0.76%	0.73%	0.03%
Mean for gC	0.33%	0.15%	0.09%	0.00%
J(1)	0.0002	0.0003	0.0001	0.1667
G(1)	0.505	0.510	0.000	0.667
C(1)	0.505	0.505	0.529	0.500
J(T)	0.9745	0.9745	0.7959	0.9391
G(T)	221.87	221.87	1283.63	1.44
C(T)	2.27	2.27	1.61	0.50

Figure 1
Evolution of Transaction Costs & Market Participation over Time

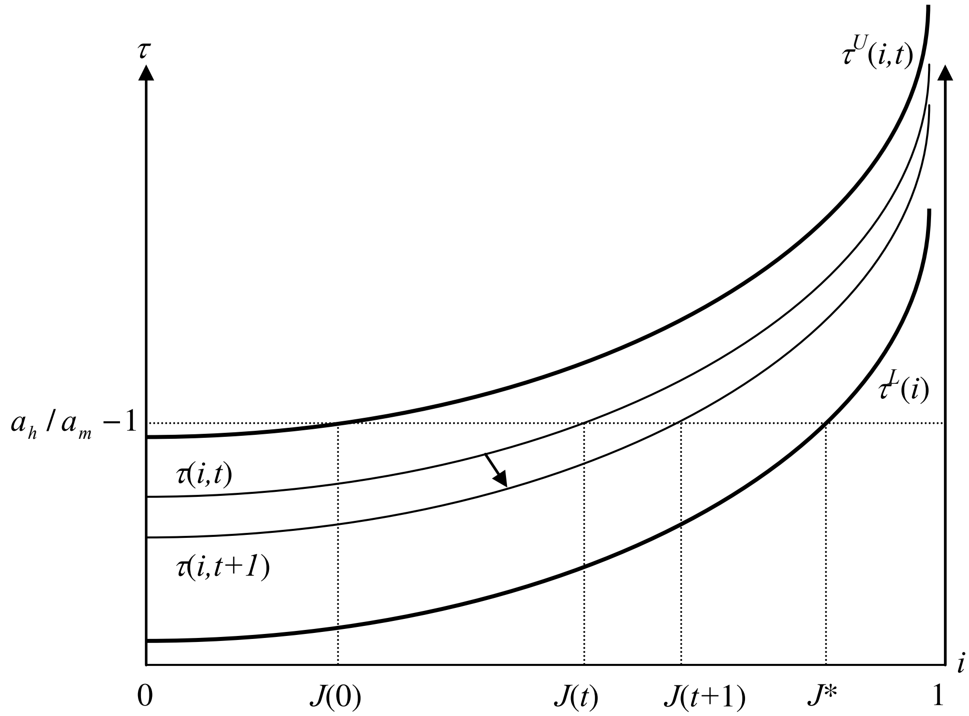
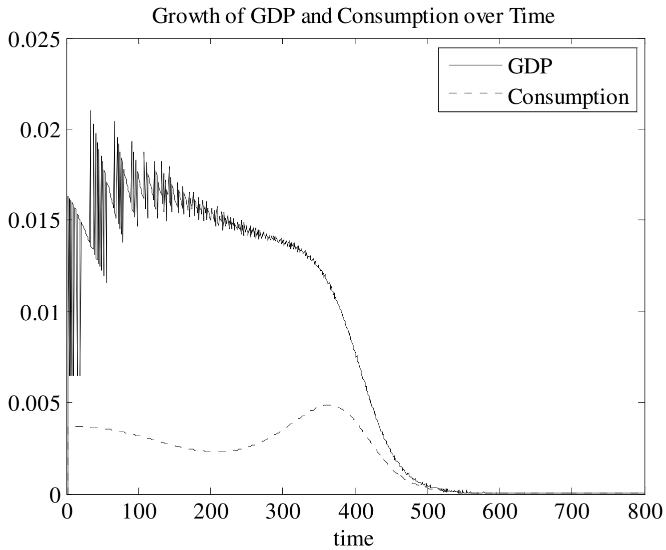


Figure 2
Simulation 1



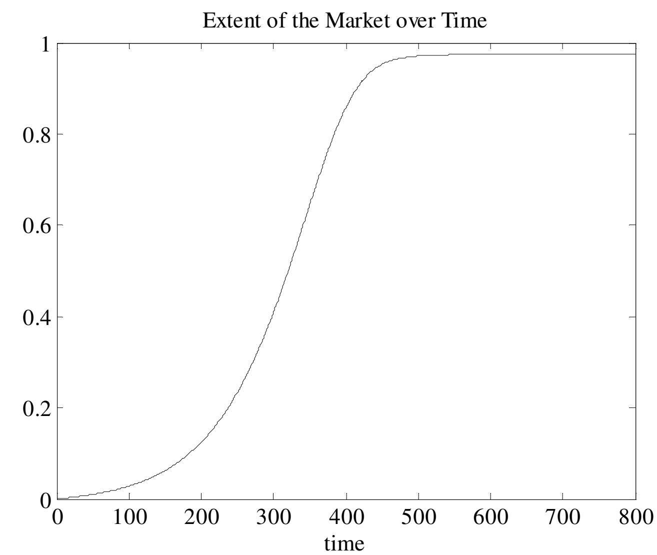
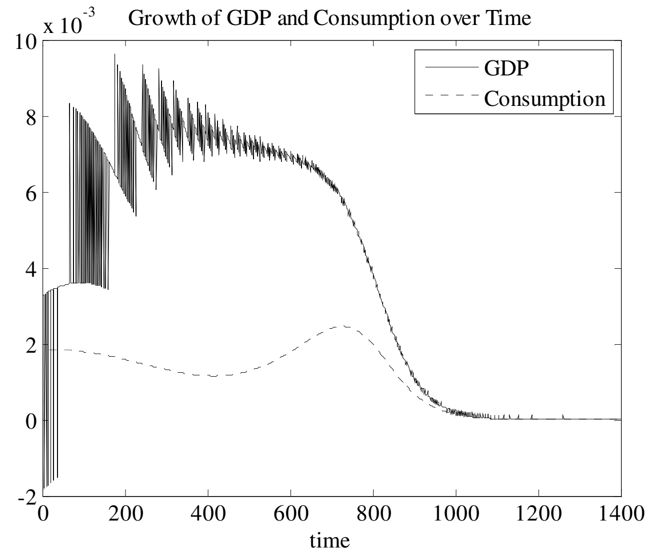


Figure 3
Simulation 2



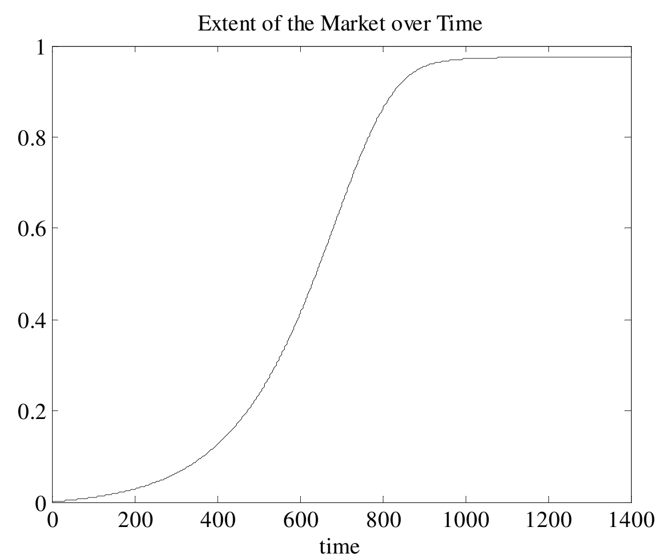
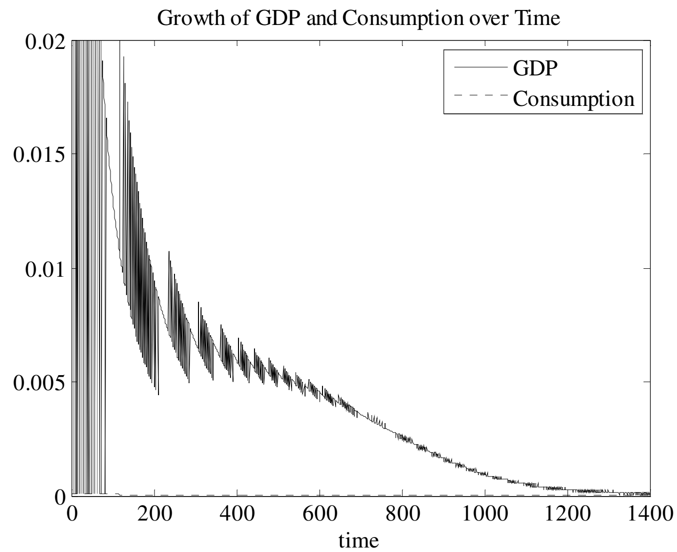


Figure 4
Simulation 3



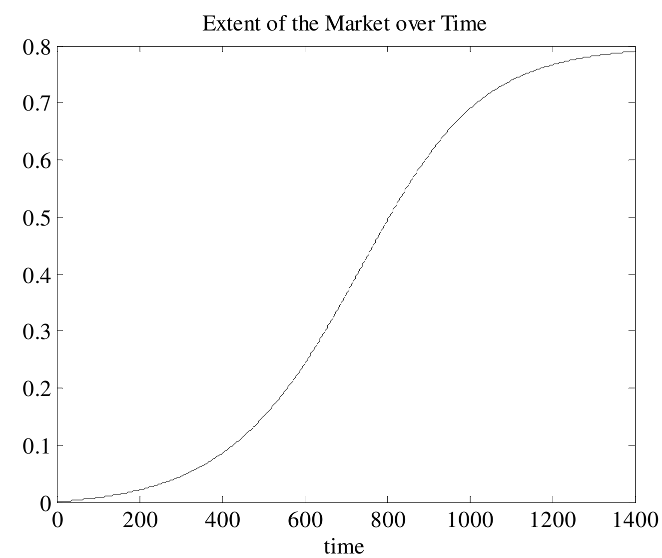
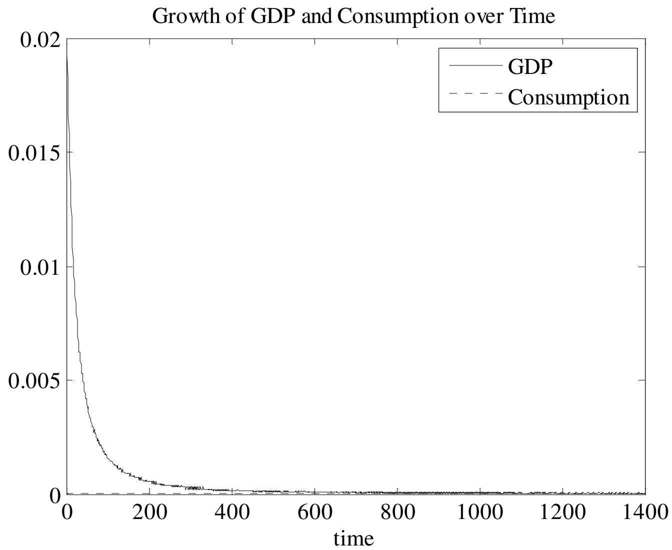
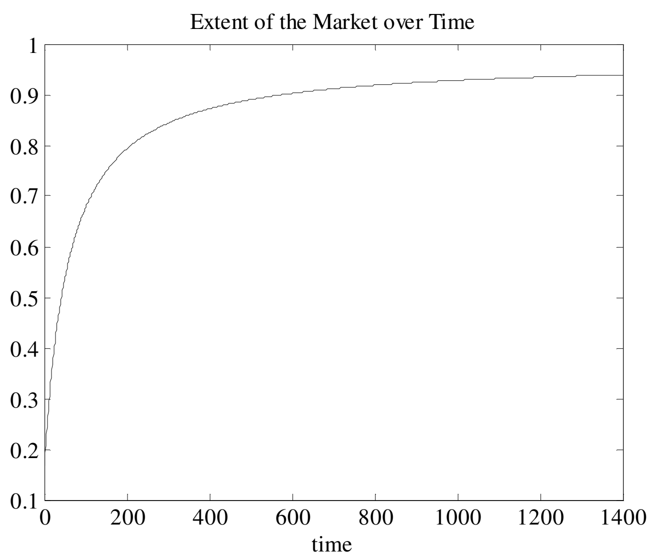


Figure 5
Simulation 4





References

Ades, A. and Glaeser, E. (1999), “Evidence on Growth, Increasing Returns, and the Extent of the Market”, *The Quarterly Journal of Economics*, Vol. X, pp. 1025-1045.

Aghion, P. and Howitt, P. (1992), "A Model of Growth through Creative Destruction", *Econometrica*, Vol. 60 No. 2, pp. 323-51.

Arrow, K. (1962),"The Economic Implications of Learning by Doing", *Review of Economic Studies*, Vol. 29, pp. 155-173.

Bartolini, S. and Bonatti, L. (2008), “Endogenous Growth, Decline in Social Capital and Expansion of Market Activities”, *Journal of Economic Behavior & Organization*, Vol. 67, pp. 917–926.

Devereux, J. & Locay, L. (1992), "Specialization, Household Production. and the Measurement of Economic Growth", *American Economic Review*, Vol. 82 No. 2, pp. 399-403.

Fishman, A. & Simhon, A. (2002), “The Division of Labor, Inequality and Growth”, *Journal of Economic Growth*, Vol. 7, pp. 117-136.

Grossman, G. and Helpman, E. (1991), "Quality Ladders in the Theory of Growth", *Review of Economic Studies*, Vol. 63, pp. 43-61.

Kim, S (1989), “Labor Specialization and the Extent of the Market”, *Journal of Political Economy*, Vol. 97 No. 31, pp. 692-705.

Locay, L (1990), "Economic Development and the Division of Production between Households and Markets", *Journal of Political Economy*, Vol. 98 No. 5, pp. 965-982.

Lucas, R. (1988), “On the Mechanics of Economic Development", *Journal of Monetary Economics*, Vol. 22 No. 1, pp. 3-42.

Ng, Y. & Yang, X. (1997), “Specialization, Information, and Growth: A Sequential Equilibrium Analysis”, *Review of Development Economics*, Vol. 1 No. 3, pp. 257-274.

Romer, P. (1986), "Increasing Returns and Long-Run Growth", *Journal of Political Economy*, Vol. 94 No. 5, pp. 1002-1037.

Solow, R. (1957), "Technical Change and the Aggregate Production Function", *Review of Economics and Statistics*, Vol. 39 No. 3, pp. 312-320.

Segerstrom, P., Anant, T. & Dinopoulos, E. (1990), “A Schumpeterian Model of the Product Life Cycle”, *American Economic Review*, Vol. 80, pp.1077-1091.

Summers, R. & Heston, A. (1991), "The Penn World Table (Mark 5): An Expanded Set of International Comparisons: 1950-1988", *Quarterly Journal of Economics*, Vol. 106 No. 425, pp. 327-368.

Swanson, C. (1999), "The Division of Labor and the Extent of the Market", *Economics Letters*, Vol. 62, pp. 135-138.

Yang, X. & Borland, J. (1991), "A Microeconomic Mechanism for Economic Growth", *Journal of Political Economy*, Vol. 99 No. 3, pp. 460-482.

Young, A (1993), "Invention and Bounded Learning by Doing", *Journal of Political* Economy, Vol. 101 No. 3, pp. 443-473.