Viability of Innovation Processes, Emergence and Stability of Market Structures

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Abstract

The paper is devoted at analyzing the co-ordination role that markets and organizations are called to play in order to make viable innovation processes. This analysis reveals that the viability of innovation processes cannot be dissociated from the way market structures emerge and evolve, and hence that there is not a 'new economy' problem referring to the specific character of certain technologies, namely, the information and communication technologies.

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1. Introduction

The recent contradictory performance of the so called 'new economy' has cast doubts on the alleged role of certain technologies as a major factor of economic growth. In this paper we intend to analyze the different aspects of the co-ordination role that markets and organizations are called to play in order to make viable the innovation process on which, rather than on the specific character of particular technologies, the growth of the economy actually depends. As a matter

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of fact, although there is strong evidence that technical and market conditions have deeply changed with the emergence of new technologies, it should also be clear that the new economy has to solve the same basic co-ordination problems than the old one.

Clearly, information and communication technologies tend to increase the capacity of the economy to deal with variety. "This has led to decreases in the cost of switching from one series to another, from one product to another" (E. Zuscovitch 1998, p. 252), that is, with reference to a neo-Austrian analytical framework (Hicks 1973), decreases in the *utilization* costs of a larger gamut of products and services. However "this tendency calls for a massive incorporation of science and technology in specific configurations to match this specified variety", which generally involves higher *construction* costs. "In the present era of increasing specification, producers need to master an ever-expanding body of knowledge in order to adjust products to the functional properties of different applications. While the costs of switching from one product to the other may have decreased, the characterization and design of a variety remain very expensive" (ibid. pp 252-3). In other words, economies of the new age, as those of the older era, are confronted to a biased technological progress in the sense that it is characterized by an increase in the construction costs, although more than compensated by a decrease in the utilization costs. Innovation results in a breaking up of the(time) structure of the existing productive capacity, associated with the appearance of co-ordination problems both at the firm level and at the industry level. As we shall see, in a restructuring process costs and proceeds are no longer synchronized, as with an established way of functioning of the economy, and hence also supply and demand are no longer equal at each moment of time and over time. Reactions to these imbalances result in fluctuations that maybe a threat to the viability of the innovation process

The way in which these co-ordination problems are dealt with is what actually determines the performance of the firms involved and hence the evolution of the process of innovation: and markets and organizations play a crucial role in this respect. The market itself, however, is affected by this process. The viability of innovation processes cannot be dissociated from the way market structures emerge and evolve.

The analysis carried out in this paper sketches out the evolution paths followed by an industry subject to technological shocks under alternative hypotheses as to the productive resources involved and the price regimes considered and as to the specific context where the innovation process is taking place, in order to test the viability of this process and the type of market structure emerging from it.

2. Innovation and Sunk Costs

According to the standard approach, technology is given in that it has an already defined specific character. Innovation is then reduced to a decision of adoption of new technologies to which are associated given results.

According to our approach - the sources of which are both Austrian and Marshallian - innovation is instead a process of development of the technology and at the same time of transformation of the productive structures of the economy. An innovative choice implies in fact the breaking up of the existing industrial structure and a modification of the market conditions, followed by a gradual reshaping. Thus the market as well (and, namely, competition) appears as an aspect of a restructuring process rather than as a state characterized by a given structure.

Innovation, in particular, comes down to a process of research and learning that results in the appearance of new productive options and new productive structures. In this sense it is a process of 'creation of technology', which, when (and if) successfully brought about, makes it possible to actually transform the potential increasing returns of technology into growth and monetary gains for the firms and the consumers.

The problem of technological change thus does not consist in the choice between given alternatives, it consists in making the innovation process possible. Accordingly, the economic aspect of this problem is no longer represented by the 'rationality' of a choice but by the 'viability' of the process through which a different alternative is brought about. This viability depends on how the co-ordination problems which necessarily arise in a process that is in the nature of a structural change are dealt with step by step; and this depends in turn on how the process of competition takes place.

Coordination is required in the first place to re-establish the harmony between construction and utilization, disturbed by the structural modification implied by a qualitative change, so as not to have too strong imbalances between costs and proceeds and between supply and demand of final output. As a matter of fact this is what the viability of the process of change undergone depends on in the end.

The co-ordination problem just mentioned consists mainly in dealing with the sunk costs associated with a restructuring of productive capacity. These are the costs of fixed capital or of R&D, advertising and the like, that is, they are the construction costs of a new productive capacity. The focus on sunk costs is common to the New Industrial Organization approach (NIO), but the role that we attribute to them is quite different.

In the NIO "a fascinating aspect of sunk costs is their commitment value" (Tirole 1988, p.314). This commitment refers to a multi-period context and represents a credible threat which is essential to the determination of market structure. However, the sunk costs depend in turn on market structure and are determined simultaneously with the latter. This is so because the sunk costs are determined once the market game which defines the market equilibrium is known. Everything is defined following a backward induction process which implies an analytically instantaneous determination of all the relevant magnitudes. A less extreme version of NIO is that of Sutton (1991,1998) who abandons the aim of identifying **a** unique equilibrium outcome in a given multi-period context. "Instead we admit some class of candidate models (each of which may have one or more equilibria) and ask whether anything can be said about the set of outcomes that can be supported as an equilibrium of any candidate model" (1998, pp.6-7) This set of outcomes must satisfy two conditions: the viability condition – which means that each firm covers its sunk cost over the multi-period domain – and the stability condition – which allows to preserve a certain structure of the market.

Although essentially different our treatment of sunk costs has some relation to Sutton's analysis. This concerns the focus on viability and its relation to market structure.

However, sunk costs, in our analysis, are the expression of a breaking of the intertemporal complementarity of the production process as the result of the attempt to carry out an innovation. Intertemporal complementarity is the main feature of a process of production where the relation between the phase of construction and that of utilization of productive capacity is stressed. When this complementarity is no longer assured costs are dissociated in time from proceeds and hence become 'sunk' costs. The characteristic of the sunk costs of the investment in a process which implies a structural change is that they will only be recovered when (and if) the process itself is actually established. This means not only to take into account the whole period of construction of the new productive capacity - which is likely to have a considerable length as, before construction in a proper sense, it implies experimenting, pilot plans, and so forth - but to go further beyond that point, until the stream of receipts from the new output has reached a certain size and the change has thus proved viable. In a context of gradual reshaping, costs depend not only on the current production but also on the length of construction of the new productive capacity, on the length of utilization of this capacity, and on the total volume of the output produced over the successive periods. And e.g. when productive capacities in excess will result in lower rates of utilization and/or in scrapping of production processes, then there are changes in production costs, and hence in viability conditions. These changes really express co-ordination failures that emerge as a consequence of a breaking in the intertemporal complementarity of production processes.

In this context the irreversibility of investment together with an incomplete information prevent any solution based on backward induction; hence investment decisions are not necessarily consistent with the working of the market. Market structure depends on the working of the co-ordination mechanisms and is actually the outcome of a process sketched out by the way sunk costs are sequentially dealt with. The viability of this process, and the resulting market structure considered, depend exactly on how we are able to deal with this sort of 'sunk' costs. Financial resources - and in particular the existence and the strength of financial constraints - play an essential role in this, as they determine the way in which investment decisions are actually carried out and hence whether the productive capacities brought about are consistent or less with the existing environment

Finally, an important difference with the NIO approach must be stressed. In this approach the market game that determines both the market structure and the associated sunk costs is in the nature of a choice. The focus is therefore on an incentive scheme which allows to make this choice.

On the contrary the problem we address has not the character of a choice. What matters is the viability of a process which builds up step by step and does not depend on a marked game solved beforehand. In this light the focus is on the conditions that make this process viable rather than on incentive schemes relevant for a choice

3. The role of competition

In the perspective adopted competition is no longer considered as a particular state of affairs. It is viewed as a process of trials and errors. A process of discovery of the market information, the information about the behaviour of competitors and customers. In other words, a co-ordination mechanism.

This is the idea of competition best suited to an innovation process portrayed as a change which takes place through distortions of productive capacity that imply the appearance of problems of co-ordination between supply and demand step by step. An orderly competition appears then as an equilibrating process that makes innovative choices viable. It is really successful when price and quantity adjustments are carried out which make it possible to obtain normal profits, that is when these adjustments do not result in a waste of productive resources. As such competition not only may co-exist with increasing returns but helps firms to capture them.

Thus viewed competition is a process which walks both on the leg of imperfect information and on that of the time dimension of production, and which is fed by the sequential interaction of competing firms.

The time dimension of production, together with the time dimension of decision processes, is the main problem concerning a firm which decides to set up a new productive capacity. As a matter of fact productive capacities must be built before they can be utilized. During the period of construction of an entirely new productive capacity, the innovative firm has to bear sunk costs that result in a temporary competitive disadvantage. But after that, after the end of the phase of construction, there will be a period during which the first mover will take advantage of its innovative choice, as he will be alone to possess the more efficient productive capacity. This will last until a competitor will have himself had time to get the superior capacity operative. The existence and the interaction of these different periods and of the lags associated with them, which are the expression of the time dimension of the production process and of the decision processes, are the main aspect of the process of change. In this process the end of the road is never reached, the market is never in 'perfect competition', but a strong competition may obtain that results in increasing returns.

In our analysis as well as in that of Nelson and Winter (1982), firms do not know *ex ante* whether it pays to innovate. "Indeed the answer to this question for any single firm depends on the choices made by other firms, and reality does not contain any provisions for firms to test their policies before adopting them. Thus there is little reason to expect equilibrium policy configurations to arise. Only the course of events over time will determine and reveal what strategies are the better ones" (Nelson and Winter ibid. p. 286).

4. The model

The course of the events over time resulting from innovative choices will be analyzed here by means of a model derived from that built by Amendola and Gaffard (1998), which makes it possible to exhibit the time structure of production processes and to analyze the sequential interaction of competing firms in a process of restructuring of productive capacities.

4.1. State and control variables

In the usual way the system is described by state variables and control variables.

The state variables are for each firm (i):
$x^i(t)$, the vector of production processes,
$m^i(t)$, the money proceeds from sales,
$h^i(t)$, the monetary idle balances,
$o^i(t)$, the stock of final output,
$\omega^i(t)$, the wage fund,
$\psi^i(t)$, the available human resources,
$d^i(t)$, the volume of final demand,
$\delta^i(t)$, the market share.

The control variables are:
$x^i(t)$, the rate of starts of production processes,
$u^i(t)$, the rate of scrapping of production processes,
$\tau^i(t)$, the rate of utilization of productive capacity,
$p^i(t)$, the price of final output,
$w^i(t)$, the wage rate,
$f^i(t)$, the external financial resources which depend on banking policy,
$\eta^i(t)$, the fraction of total real stocks actually put back on the market.

These are either determined exogenously in the simulations (the open-loop control variables) or according to feedback mechanisms (the close-loop control variables).

4.2. The structure of productive capacity

In each firm i production is carried out by means of processes of a Neo-Austrian type. An elementary process of production is defined by the input vector:

$$\mathbf{a}_j^i = \left[a_{jk}^i\right]; k = 1...n^c + n^u$$

whose elements represent the quantities of labour required in the successive periods of the phase of construction c (from 1 to n^c) and following it, of the phase of utilization u (from $n^c + 1$ to $n^c + n^u$) of the productive capacity of commodity (technology) j, so that:

$$\mathbf{a}_j^i = \left[\mathbf{a}_j^{ic}, \mathbf{a}_j^{iu}\right]$$

with $a_{jk}^i = a^{ic} \; \forall \; k = 1, ..., n^c$ and $a_{jk}^i = a^{iu} \; \forall \; k = n^c + 1, ..., \; n^c + n^u$, and by the output vector:

$$\mathbf{b}_j^i = \left[b_{jk}^i\right]$$

with $b_{jk}^i = 0 \; \forall \; k = 1, ..., n^c$and $b_{jk}^i = b^i \; \forall \; k = n^c + 1, ..., \; n^c + n^u$.

At each given moment t the productive capacity of a commodity j by a firm i is represented by the intensity vector:

$$\mathbf{x}_j^i(t) = \left[\mathbf{x}_j^{ic}(t), \mathbf{x}_j^{iu}(t)\right]$$

each element of which is a number of elementary production processes of a particular age, still in the construction phase or already in the utilization phase.

At each given moment of time the productive capacity of the firm i is given by the vectors:

$$\mathbf{x}^i(t) = \left[\mathbf{x}^{ic}(t), \mathbf{x}^{iu}(t)\right]$$

Whose elements are the number of processes in construction, $\mathbf{x}^{ic}(t)$, and in utilization, $\mathbf{x}^{iu}(t)$, referring to all the technologies in use - all the commodities ($\mathbf{x} = \sum_j \mathbf{x}$).

The productive capacity is subject to ageing and to modifications due to investment and scrapping. Scrapping of production processes $u(t)$ occurs when resource constraints are as stringent as not to allow all the processes inherited from the past to be carried on. An alternative to scrapping is a partial use of utilization processes, which, however, implies a cost, as we shall see when considering the rate of utilization of existing productive capacity.

4.3. Resources constraints

In each period the level of activity (both investment and current production) of each firm, which depends on its wage fund $\omega^i(t)$, is constrained by available financial resources or, alternatively, by available human resources.

The available financial resources $F^i(t)$ are:

$$F^i(t) = m^i(t-1) + h^i(t-1) + f^i(t)$$

where the internal financial resources are given by $m^i(t-1)$, the money proceeds from the sales of final output, and $h^i(t-1)$, the idle money balances involuntarily accumulated in the past and ready for use, and the external financial resources by $f^i(t)$.

External financial resources are such that:

$$f^i(t) = \min[k^i m^i(t-1), f_d^i(t)]$$

where k^i stands for the borrowing power of each firm, and $f_d^i(t)$ is the demand for external financing resulting from the production and investment decisions actually taken.

External financial constraints are formally exogenous in the model. Different financing scenarios which imply to consider the relation between external finance and the viability of innovation processes have been explored[1].

The available human resources at the industry level depend on a natural growth rate of population and on a wage elasticity:

$$\psi^i(t) = (1+g)^t L(0) w^i(t)^{\vartheta}$$

where g is the natural growth rate, w the industry average wage rate, and ϑ the wage elasticity of the labour supply.

A general human constraint may appear due an insufficient growth of the labour force. This constraint can be relaxed by each firm through the wage policy followed.

A competition among the firms exists on the labour market implying that each firm obtains a fraction of the labour supply ψ^i, which depends on the relative wage it pays to its workers:

$$\psi^i(t) = \phi^i(t)\psi(t)$$

with:

$$\phi^i(t) = \frac{\left[\phi^i(t-1) w^i(t-1)\right]^{\epsilon}}{\sum_i \left[\phi^i(t-1) w^i(t-1)\right]^{\epsilon}}$$

[1] An interpretative step forward can be made by inferring that when positive results of the simulations are associated with a specific value of k, such a value will express the opinion (and the decisions) of financial markets and/or of bankers.

With ϵ less than one, the distribution of the labour supply between firms is more or less constant while wages they paid are different. With ϵ greater than one, on the other hand, the firm which, at one moment, has the greater share of labour supply, benefits a kind of cumulative advantage, which implies that more and more workers prefer to be hire by this firm whatever the wage it pays.

When the human constraint is more stringent than the financial constraint money balances are involuntarily accumulated:

$$h^i(t) = \max\left[0, m^i(t-1) + h^i(t-1) - \omega^i(t)\right]$$

4.4. Money proceeds, real stocks and current production.

Within the sequential setting considered prices are fixed within each given period and can only change at the junction of one period to the next one. As a consequence money proceeds are given by:

$$m^i(t) = \min\left[p^i(t)d^i(t), p^i(t)s^i(t)\right]$$

Real stock changes $\Delta o^i(t)$ are substitutes for the price changes, which cannot take place within the period. Excess supply results in an accumulation of undesired stocks for the firm:

$$\Delta o^i(t) = o^i(t) - o^i(t-1)$$

$$o^i(t) = \max\left[0, s^i(t) - d^i(t)\right]$$

where $s^i(t)$ and $d^i(t)$ are current real supply and real demand (for the different and successive commodities or technologies), respectively.

Current final production by firm i is given by:

$$q^i(t) = s^i(t) - \eta o^i(t-1), 0 \leq \eta \leq 1,$$

The rate of utilization τ^i of the productive capacity inherited from the past is such that:

$$q^i(t) = \tau^i(t) \sum_{k=1}^{n^c+n^u} b^i_k x^i_k(t)$$

where $b^i_k = \sum_j b^i_{kj}$, and $x^i_k = \sum_j x^i_{kj}$

4.5. Aggregate demand and market shares

The aggregate market demand, D, is determined as follows:

$$D(t) = (1 + \hat{g})D(t-1)p(t)^{\theta}, \theta \leq 0$$

where $\hat{g}$ is a given exogenously determined growth rate, and θ the demand price elasticity

or, alternatively, by a logistic curve such that:

$$D(t) = D(t-1)\left[1 + \zeta_1(\zeta_2 - D(t-1)\right]$$

or, alternatively, by a stochastic process such that:

$$D(t) = D(t-1)\left[1 + G\right]\left[(1 - \xi_1) + \varepsilon\xi_2\right]$$

The average market price is given by:

$$p(t) = \frac{\sum_i p^i(t)s^i(t)}{\sum_i s^i(t)}$$

The market shares are:

$$d^i(t) = \delta^i(t)D(t)$$

with:

$$\delta^i(t) = \frac{\left(\frac{\delta^i(t-1)}{p^i(t-1)}\right)^{\beta}}{\sum_i \left(\frac{\delta^i(t-1)}{p^i(t-1)}\right)^{\beta}}$$

that is, a firm's market share depends on the relation of its price to the average market price in the preceding period.

With β less than one, more or less constant market shares obtain when the prices charged by the firms are different. This looks a Chamberlinian competition. With β greater than one, on the other hand, the firm which, at one moment, has the greater market share, has the cumulative advantage which result in the exit of some other firms. This looks like a situation characterized by increasing returns of adoption.

4.6. Investment, production and price decisions

The evolution path followed by each firm is actually determined by the behaviour of the decision variables, namely, the rate of starts of new production processes $x_1^i(t)$, the rate of utilization of productive capacity τ^i, the price of final output $p^i(t)$, the wage rate $w^i(t)$, the ratio k^i of the external financial resources $f^i(t)$ to the money proceeds from the sales of final output $m^i(t)$ (i.e.,the firm's borrowing power), and the rate of scrapping $u_k^i(t)$.

Each firm determines the rate of starts of production processes in such a way that the productive capacity available $n^c + 1$ periods later will match a final demand which is expected to be equal to the current one multiplied by a growth factor $1 + \gamma^i$:

$$x_1^i(t) = \max\left[0, \frac{d^i(t-1)(1+\gamma^i(t-1))^{n^c+1} - \bar{\tau}^i \sum_{k=2}^{n^u} b_{k+n^c}^i(t+n^c)x_{k+n^c}^i(t+n^c)}{\bar{\tau}^i b_{n^c+1}^i(t+n^c)}\right]$$

where $\gamma^i(t-1)$ is the growth rate of the final demand expected by the firm i at $t-1$ (which is determined as a weighted mean of the growth rates registered in the previous periods), and $\bar{\tau}^i$ is the desired rate of utilization of productive capacity .

Different investment behaviours may be considered by introducing more or less stringent limits to the variations of the *desired* rate of starts from one period to the next: limits which represent more or less aggressive investment behaviours. In fact, firms take investment decisions looking at the expected demand, but they also know that the volatility of investments is a threat to their survival. So the change in the rate of starts of new production processes (whether an increase or a decrease) from one period to the next is bounded, which sets a limit to the 'capacity competition' that would otherwise take place. This kind of competition depends on the fact that in a truly sequential context the firms do not know in advance the result of the market game. Thus, when they make investment decisions looking at the expected demand, they discount the increases in productivity resulting from their own innovations but not those realized by the competitors. This is likely to bring about productive capacities in excess with respect to the existing demand and pushes the competing firms to a 'capacity competition' aimed at stealing market shares from each other.

Each firm determines current production by fixing the current rate of utilization of its productive capacity, $\tau^i(t)$, so as to adjust its current supply to the expected final demand $\hat{d}$:

$$\tau^i(t) = \min\left[1, \frac{\hat{d}^i(t) - [o^i(t-1) - o^i_d(t)]}{\sum_{k=1}^{n^c+n^u} b^i_k x^i_k(t)}\right]$$

.

where $\hat{d}$ is such that:

$$p^i(t)\hat{d}^i(t) = \frac{m^i(t-1)^2}{m^i(t-2)}$$

.

that is, the expected final demand is made to depend on the past trend of money proceeds of the firm,

and o^i_d are the stocks that the firms desire to keep.

As the result of the production and investment decisions the actual wage fund is given by:

$$\omega^i(t) = w^i(t)\Lambda^i(t)$$

where Λ^i is the labour demand given by:

$$\Lambda^i(t) = \sum_{k=1}^{n^c+n^u} A^i_k(t)x^i_k(t)\rho^i_k(t)$$

where $\boldsymbol{\rho}^i$ is a vector which allows to take into account what are the consequences on the labour demand of a variation in the rate of utilization of the productive capacity:

$\boldsymbol{\rho}^i = \left[\rho^i_1, ..., \rho^i_{n^c}, ..., \rho^i_{n^c+n^u}\right]$,

with: $\rho^i_k = 1$ for all $1 \leq k \leq n^c$

and $\rho^i_k = \tau^i(t) + \zeta^i(1 - \tau^i(t))$ for all $n^c + 1 \leq k \leq n^c + n^u$

where ζ^i stands for the labour required to maintain a process of production idle.

The price charged by each firm is determined as follows:

$$p^i(t) = \frac{w^i(t) \sum_{k=1}^{n^c+n^u} a^i_{jk}\rho^i_k}{\bar{\tau}^i \sum_{n^c+1}^{n^c+n^u} b^i_{jk}(t)}$$

with $\rho_k^i(t) = 1$, $1 \leq k \leq n^c$ and $\rho_k^i(t) = \bar{\tau}^i(t) + (1 - \bar{\tau}^i(t))\zeta^i$, $n^c < k \leq n^c + n^u$.

That is, it is determined in such a way as to cover the cost of production when using the productive capacity which is the expression of the technology adopted, at the desired rate of utilization of this productive capacity. This price is determined step-by-step with reference to the new technology adopted each time, at the moment this first reaches the phase of utilization. This is how price competition is implemented by each firm.

This price can be adjusted as mentioned above in order to relax the financial resource constraint:

$$\breve{p}^i(t) = p^i(t) + \sigma^i \frac{[\tilde{x}_1^i(t-1) - \hat{x}_1^i(t-1)a_1^c w^i(t-1)]}{\hat{d}^i(t)}; 0 \leq \sigma^i \leq 1$$

where $\tilde{x}_1^i$ is the desired rate of starts, and $\hat{x}_1^i$ is the rate of start constrained by the available financial resources.

It can also (and alternatively) be adjusted in reaction to the market disequilibria perceived in the previous period:

$$\breve{p}^i(t) = p^i(t) + \chi^i \frac{[d^i(t-1) - s^i(t-1)]}{s^i(t-1)}, 0 \leq \chi^i \leq 1$$

Moreover changes in price from one period to the next are both upward and downward bounded.

The wage rate is endogenous to the model, being determined by the partially exogenous supply of labour and the endogenous demand for labour. Changes in the wage rate paid by each firm reflect the disequilibria arising on its labour market, that is:

$$w^i(t) = w^i(t-1)\left[1 + +\upsilon^i \frac{\Lambda^i(t-1) - \psi^i(t-1)}{\psi^i(t-1)}\right]$$

where υ^i is a reaction coefficient.

As already mentioned firms are wage makers on local labour markets. However competition between firms results in different but convergent wage rates charged by each of them.

4.7. Innovation, imitation, entry and exit processes

A firm can introduce a new technology by innovating or by imitating. Innovation means entering a process which should allow better performances than those of the firms that keep using older technologies. Imitation consists in copying the prevailing best practice. Innovations as well as imitations are generated by probability distributions that are independent from firm to firm but the same for all firms and over all periods.

The market structure evolves endogenously. On the one hand, as already mentioned, price variations stirred by cost variations result in changes in market shares. Any firm whose market share falls below a given threshold (e.g. 1%), whatever the reason (too high price or lack of resources), exits from the market. On the other hand, only one firm can enter the market in each period of time.

Entry is modelled as a random process, characterized by an independent random variable *newentry* that takes on the values one or zero according to whether a new firm does or does not enter. Effective entry occurs with the probability:

$$\Pr\{newentry\} = \varrho.\Gamma(t)$$

where Γ is a rate of industry excess demand calculated on a given number of previous periods.

The size of a new entrant is equal to a targeted market share (e.g. 50% of the existing excess demand at the industry level). This threshold may be considered as figuring the strength of the financial constraint that the new firm has to bear.

4.8. Firms' performance and market concentration

The performance of each firm is measured by its unit margins, whereby a unit margin is defined, in each period, as the ratio of the difference between the price (calculated as mentioned above) and the current unit cost of output - obtained by dividing the total cost of production of the amount of output obtained in that period by the same amount - to the price itself:

$$\mu^i(t) = \frac{p^i(t) - c^i(t)}{p^i(t)}$$

where:

$$c^i(t) = \frac{w^i(t)\Lambda^i(t)}{q^i(t)}$$

.

Unit margins on average equal to zero mean that firms realize normal profits. Unit margins will be instead necessarily negative at the beginning of any innovation process characterized by higher construction costs. This reveals the initial competitive disadvantage suffered by the innovative firm. On the other hand, negative unit margins may also reveal the existence of excess capacities, that is, of a lower degree of utilization of productive capacity with respect to the desired level, and viceversa.

The market concentration is measured by the Herfindahl index.

5. The simulation analysis

The above model allows to investigate some classical problems of industrial economics: the relation between competition and increasing returns;the entry-exit dynamics and the sources of shake-out processes; and so on.

In what follows, we shall focus on the conditions for innovation processes to allow to reap the benefits of technology, and on the evolution of market structures associated with these processes.

While standard models of oligopoly or monopolistic competition usually deal with the degree of competition and the characteristics of industrial structures as determined by given information and cost conditions, our model intends to deal with a dynamic process of rivalry such as determined by *changing* costs and information conditions. This process can result in a waste of productive resources and no real advantage for the customers or, alternatively, may allow firms and/or customers to benefit from increasing returns. It can likewise result in a strongly instable market structure or at the opposite in a fairly stable structure.

Within this framework, the character of the shocks that take place at each period does not really matter. These shocks always come down to a demand for new productive resources which will result in a productive structure functioning in such a way as to allow to reap the benefits of the change undergone only if the co-ordination problems raised by the shocks themselves are properly dealt with.

We shall consider a market in which two or more firms compete with each other by innovating , whether at the same time or sequentially, one after the other. Technological changes are 'forward biased' 'in a sense similar but not equal to the definition given by Hicks (1973),: that is, increasing construction (labour) costs are more than compensated by increasing output rates. At the beginning of the experiment the firms considered have an equal share of the market and face an aggregate final demand which is growing at a given rate (5%). There are no biases in the functioning of the product and the labour markets ($\beta = 1$ and $\epsilon = 1$). Prices are determined with regards to a structure of productive capacity (embodying the more recent technology) capable of sustaining a steady state (see the corresponding equation in the model). Cost changes, not automatically transferred on prices, have therefore an immediate effect on unit margins. Finally, there are free entry and exit conditions.

A strong external financial constraint (k=0.2) prevents 'capacity competition' between the incumbents from being too strong, and hence favours the profitable entry of new firms that are supposed to have the required funds, given the targeted market share exogenously determined. With a limited number of firms at the beginning (N=2 in our experiment), the following entry-exit process is characterized by a concentration index that decreases before it is stabilized, and a sort of oligopoly (a duopoly, as results from the behaviour of market shares) with a competitive fringe emerges which seems fairly stable. Prices and costs are diminishing, although through fluctuations, which means that productivity gains associated with the new technologies are really obtained. Nevertheless, unit margins remain negative first because, given an exponential growth of demand there is an exponential growth of investments in forward biased innovations, and because the entry of new firms amplifies this effect resulting in an excess of productive capacity with respect to the volume of final demand (simulation 1). The robustness of these results is attested by the synthesis carried out from multiple runs corresponding to different values of the variables randomly chosen, which shows an increase followed by a stabilization of the average number of firms existing on the market over time, and an increase followed by a decrease in the mean dispersion of market shares (simulation 2).

At the opposite, always with few original incumbents (N=2), a weak external financial constraint (k=1), by favouring investment on the part of the incumbent themselves, makes it difficult for new firms to enter and simultaneously results in a relatively strong instability in the market shares, which is associated with an increase of the concentration index. Costs and unit margins strongly fluctuate. There are actually no gains from innovations (simulation 3). If the initial market structure is large enough (N=10) a gap may appear that can be filled by new entrants, and a process of shake-out can be observed. The concentration index increases (simulation 5). These results are confirmed when we look at multiple runs. They show a large fluctuation in the number of firms over time, the amplitude of which is all the more important than the initial number of firms is higher as well as a strong increase in the mean dispersion of the market shares (simulations 4 and 6).

With a larger number of initial incumbents (N=50 in our experiment) the competition conditions dramatically change, and a strong external financial constraint is no longer suficient to stabilize the market and to allow to obtain the gains of technology. The initial atomistic structure appears as very instable. A selection process takes place, which has a cumulative character. As a matter of fact, any exit results in a reduction of the average market price (the exiting firms being of course the less competitive ones, that is, those charging higher prices) which makes marginal firms more fragile and can even push them out of the market. This effect is the stronger the higher the number of initial firms and hence the more contiguous their position. The concentration index increases. Costs and unit margins exhibit stronger fluctuations than in the previous case without a falling trend, which means that gains from innovations are not really obtained (simulation 7). The instability of the market structure appears as an obstacle to the viability of the innovation process. These results are confirmed when looking at multiple runs that reveal a decrease in the average number of firms and an increase in the mean dispersion of market shares (simulation 8).

A strong human resource constraint seems to have the same effect as a strong financial resource constraint, that is, it generally results in a viable innovation process associated with the emergence of a stable market structure. However this effect seems to be more general. With a small (N=2) or a not too large (N=10) number of initial incumbents and no financial resource constraint, after a phase characterized by numerous new entries, there are neither significant new entries nor significant exits: the process seems to converge towards an atomistic market structure. The costs are decreasing and the unit margins are increasing, which means that the innovation process is viable and its fruits will be shared between firms and customers (simulations 9 and 11). On the other hand the number of initial incumbents seems to have an influence on the degree of stability of the industry such as measured by the evolution of both market shares and the concentration index. This is confirmed by the fact that if we increase the original number of incumbents (N=50), although remaining viable, the innovation process is characterized by a strong shake-out (simulations 13 and 14).

This is true whether the wage reaction coefficient is equal to zero, or enough low (υ =0.05) (simulation 15), that is, when scarcity of the labour resource does not bring about strong increases in wages. These results are confirmed when we look at multiple runs. They show both a stabilization in the average number of firms existing on the market, and a stabilization of the mean dispersion of the market shares (simulations 10, 12, and 16). It is worth mentioning once again that things go better with a very few number of incumbents at the beginning. In particular the mean dispersion of market shares goes back to its initial value after a strong but quick fluctuation (simulation 10). However, when the wage reaction coefficient is high (υ=0.4), innovation processes are no longer viable. In other words, the positive effect of a labour shortage are more than outweighed by its effects on the price of labour. Strong fluctuations in wages result in strong fluctuations in costs and prices which provoke an extreme disorder in the structures of productive capacities (simulation 17 and 18).

6. Results and Comments

Innovation strategies carried out in a context of incomplete information will result in a breaking of the steady state. Problems of co-ordination over time within the firms and between firms will then arise which result in market disequilibria. Reactions to these disequilibria stimulate an out-of-equilibrium adjustment process. What happens then to the firms (to their cost performances and to their market shares) and hence what happens to the market structure, must be looked at as a process sketched out step by step by sequentially interacting disequilibria. What essentially matters is the deformation of the structure of productive capacity of the" different firms involved, which will be amplified or dampened according to the nature of the co-ordination mechanisms that prevails along the way. The conjecture that we are testing is that the ability to take really advantage of innovations essentially depends on the ability for each firm to maintain a structure of the productive capacity that sustains a quasi-steady state. And this depends in turn on the working of the market coordination mechanism.

The availability of productive resources (the financial and the human resource in our Neo-Austrian modeling) and the constraint that these may impose on production processes, and the equilibrating (or disequilibrating) role performed by price and wage regimes, are the essential elements of the co-ordination mechanism at work. There is a strong interaction between these elements. Changes in prices through which competition is usually seen to take place reflect changes in costs. The changes in costs result in the first place from the modifications in the structure of productive capacity due to the innovation process, whose viability in turn essentially depends on the prevailing resource constraints. On the other hand, the changes in costs also reflects an endogenous dynamics due to wage changes (and more generally to changes in prices of intermediary inputs). In turn changes in prices affect costs through changes in the market shares which modify the availability of resources and hence investment and the structure of productive capacity.

However, there is not an *ex ante* optimal co-ordination mode. It all depends on how the ingredients just mentioned get combined along the way. And this depends in turn on the specific context within which co-ordination has to be carried out (initial number of incumbent firms, entry and exit conditions, and the like).

It follows that the success (or less) of the introduction of new technologies and the emergence and evolution of given market structures does not depend on the properties of technology, but on the capacity to coordinate the activity of the different firms participating to the restructuring process involved, which results in a certain degree of stability of the market structures.

Thus technological advances do not determine the dynamics of the number of firms. On the contrary, this is actually identified only once a stabilization of the market structure signals that viability conditions have been fulfilled.Nevertheless, different market structures can emerge from the same kind of innovation process, depending on the effective working of the coordination mechanism.

The focus on coordination of innovation seen as an essentially economic process reveals that there is not a 'new economy' problem referring to the specific character of certain technologies, namely, the information and communication technologies. The true reason why these are reckoned to be a major factor of growth is that their supposed flexibility is believed to remove obstacles to the working of the market and eliminate the possibility of market failures (as the existence of increasing returns or the choice of non optimal scales of production) thus making possible to establish a full competition. We have shown on the contrary that, the more we let the market play in a sense near to the Walrasian equilibrium (by assuming full price flexibility, free entry, and the like) the less probable is to carry out a viable innovation process and to reap the benefits of technology.

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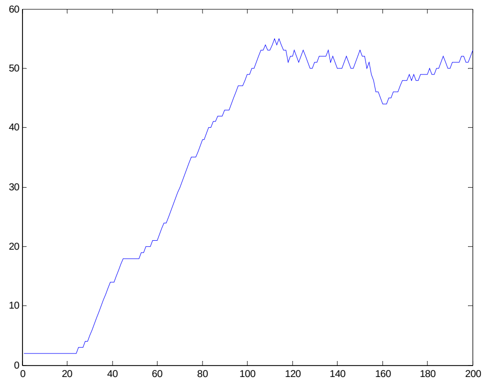
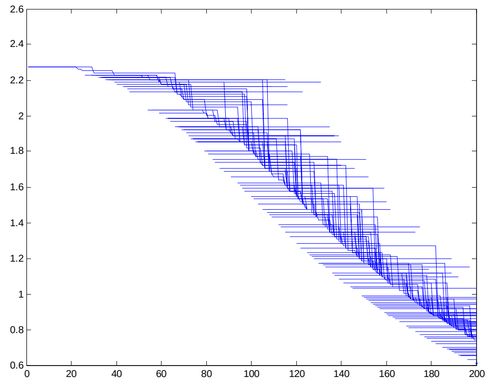
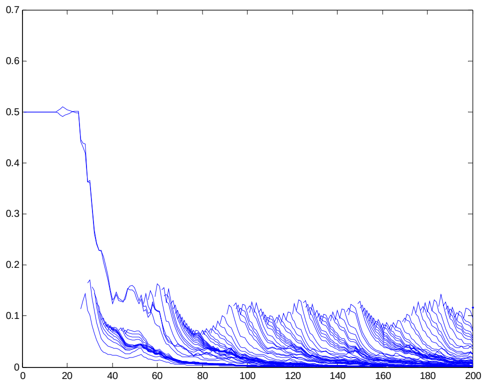
- Figures



Sim. 1: Number of Active Firms



Sim. 1: Prices



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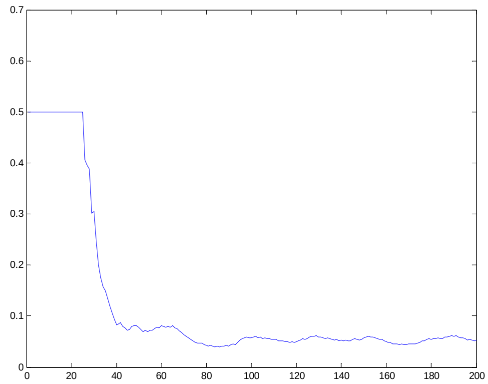
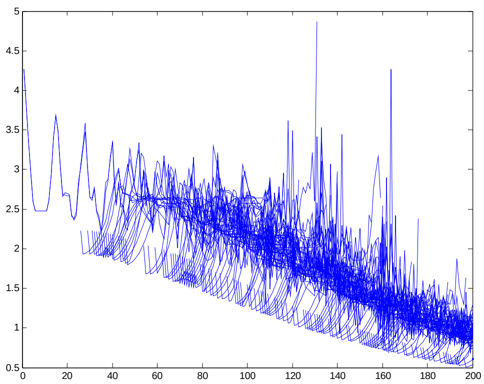


Sim. 1: Herfindahl Index



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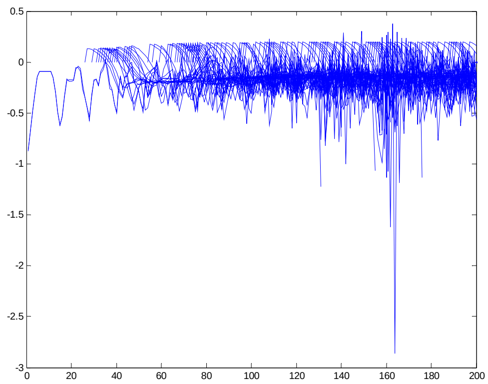

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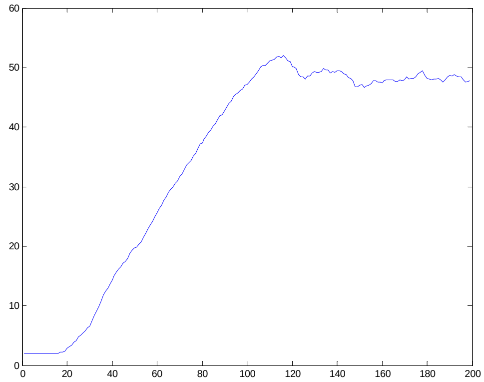

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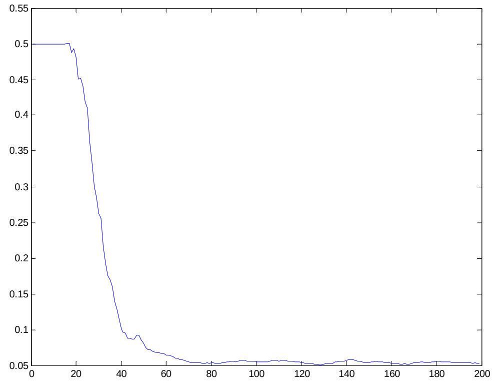

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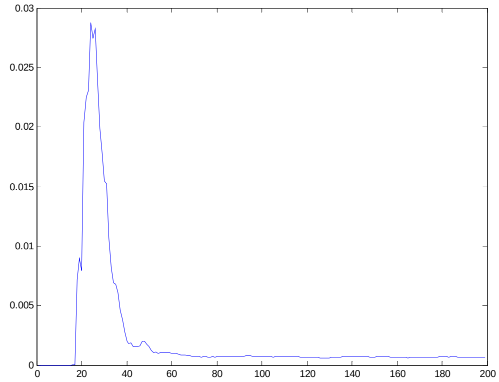
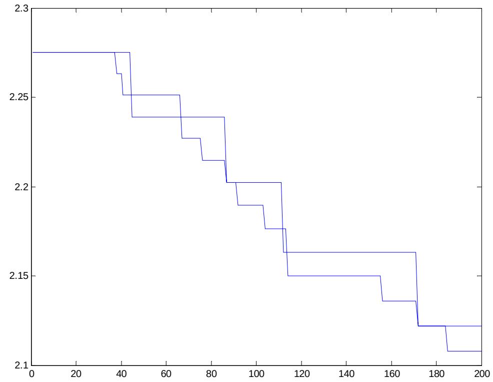


Sim. 2: Dispersion of Market Shares



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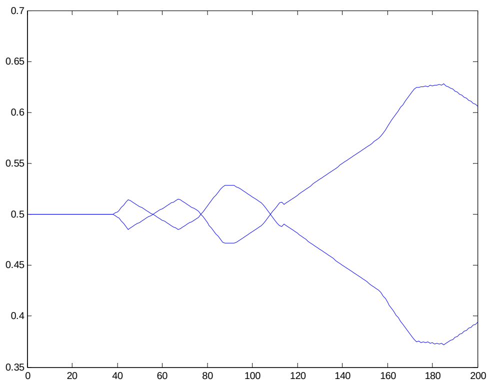

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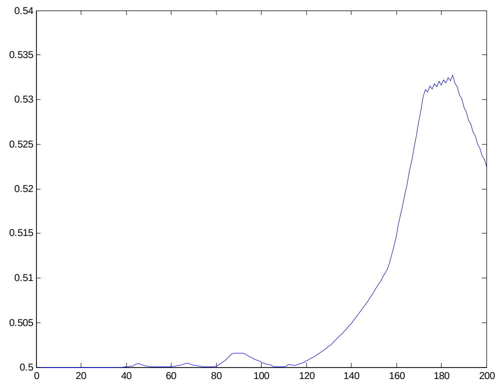

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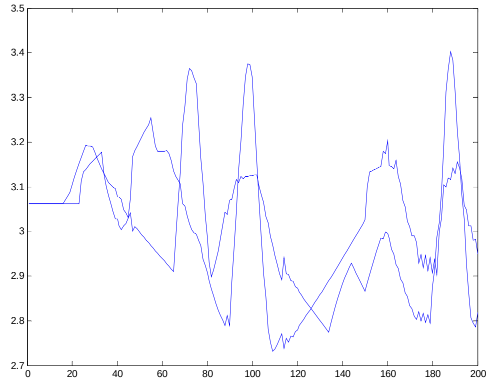
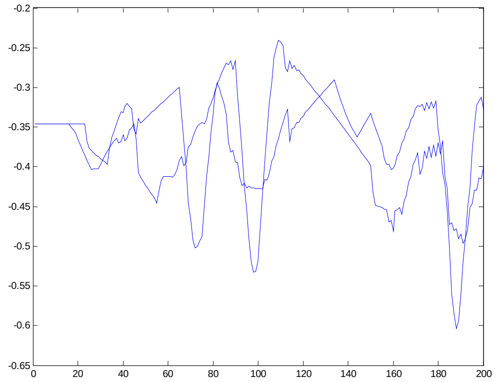


Sim. 3: Unit Cost



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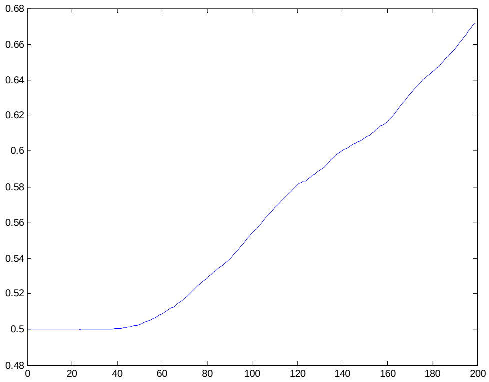

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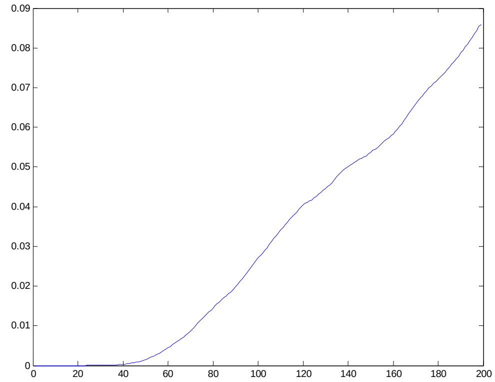

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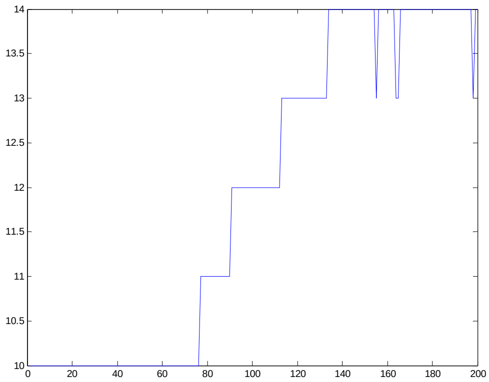

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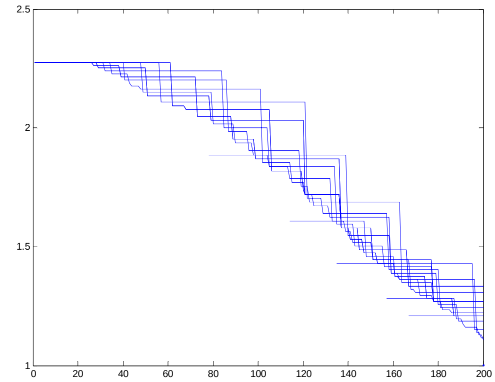

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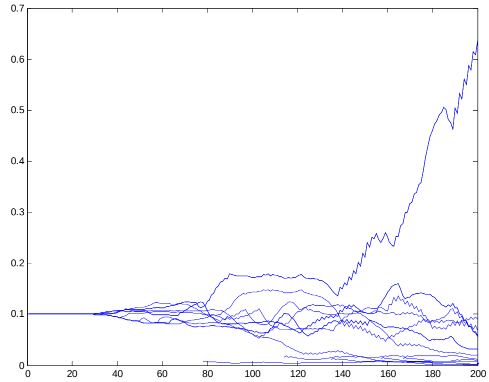

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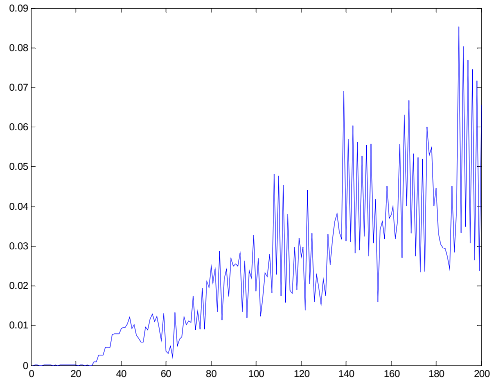
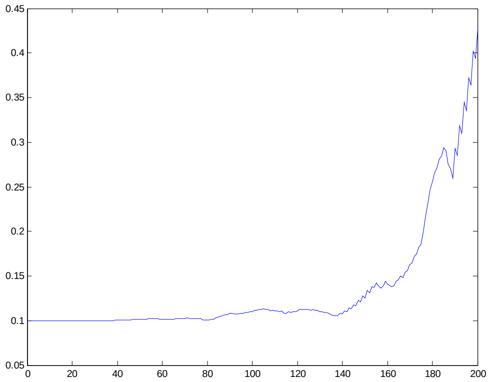


Sim. 5: Turbulence Index



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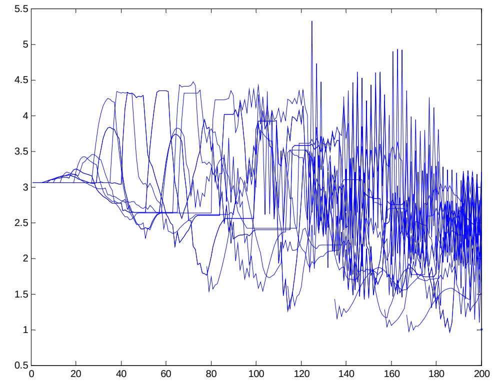

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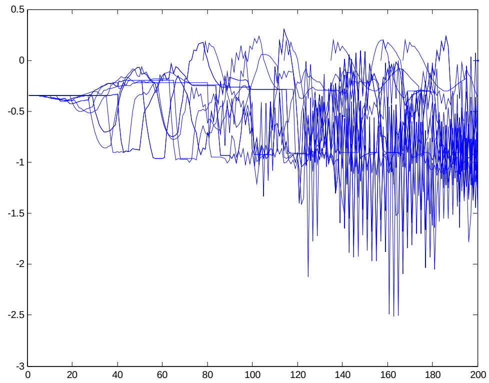

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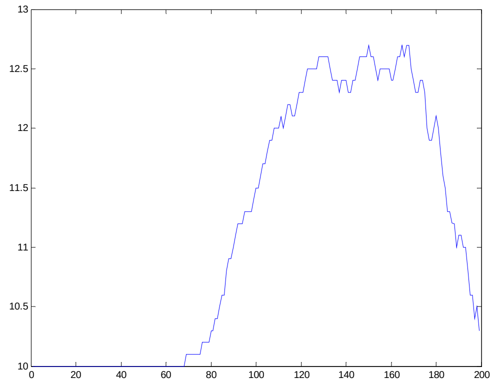

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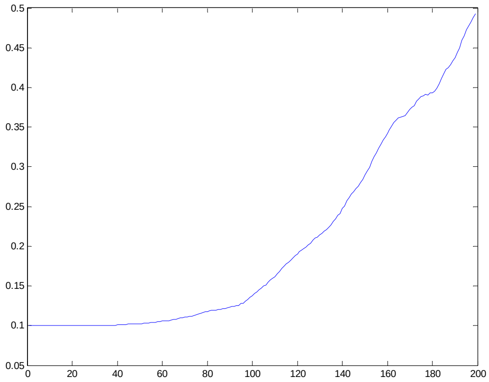

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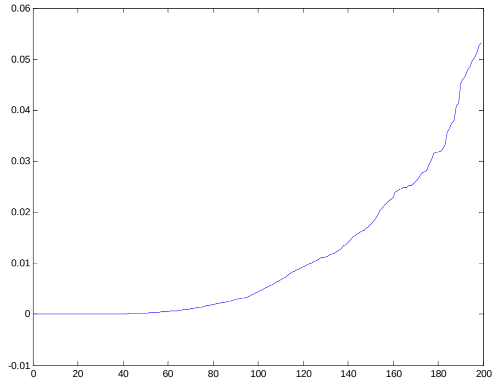

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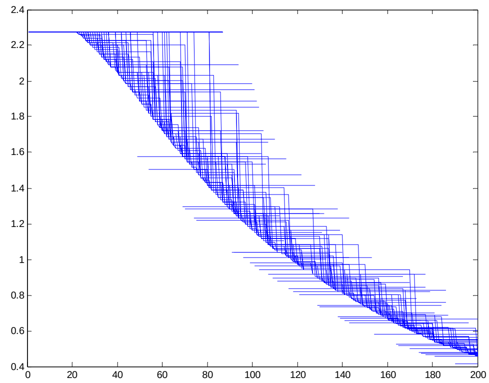

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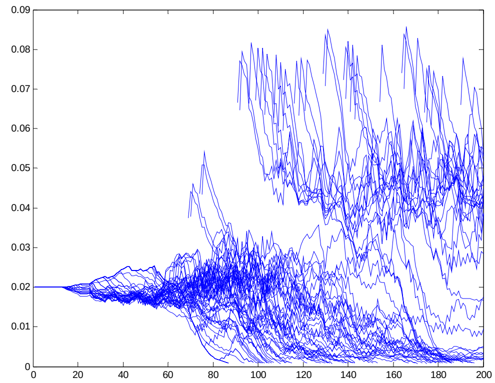

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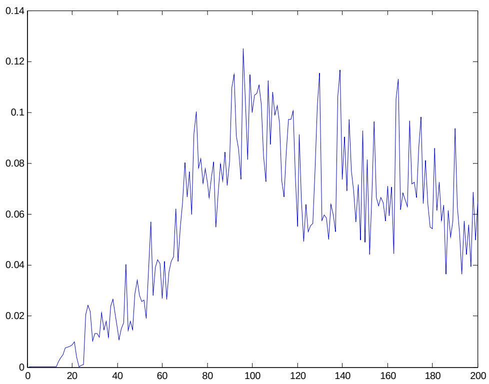
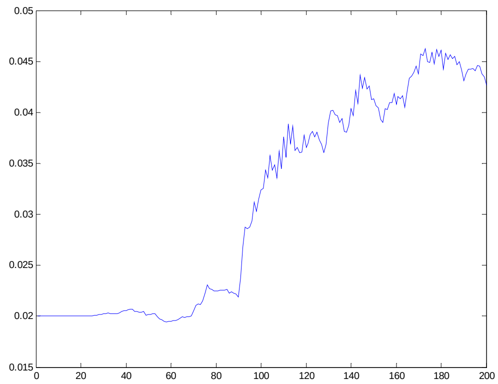


Sim. 7: Turbulence Index



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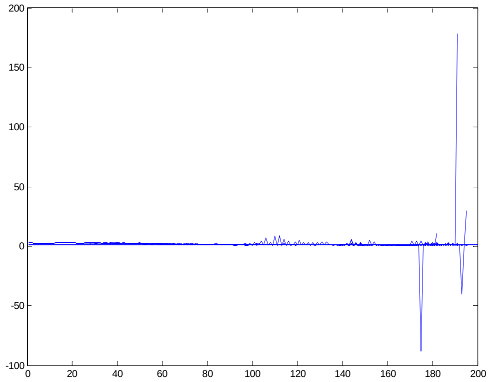

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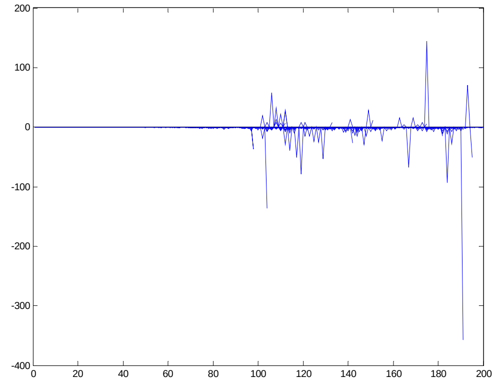

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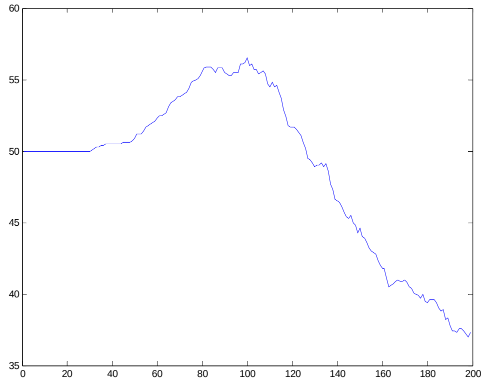
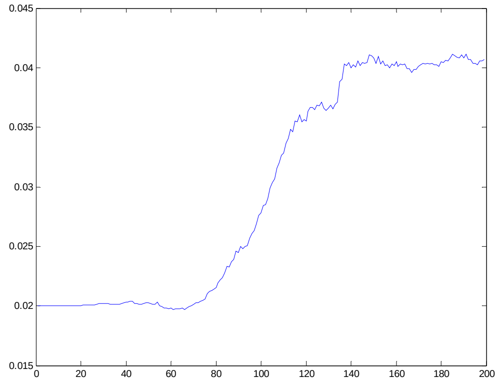


Sim. 8: Number of Active Firms



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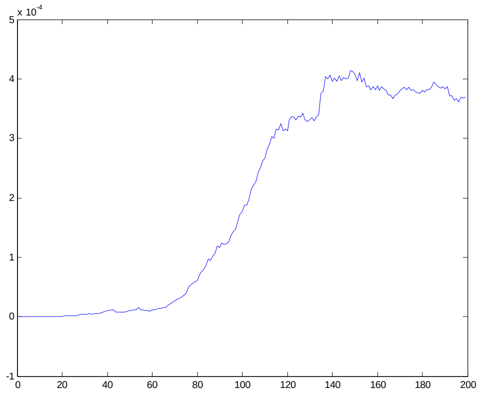

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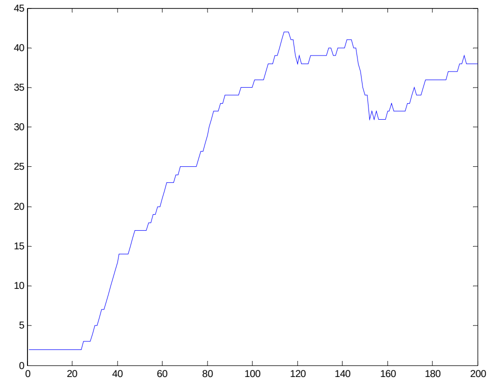

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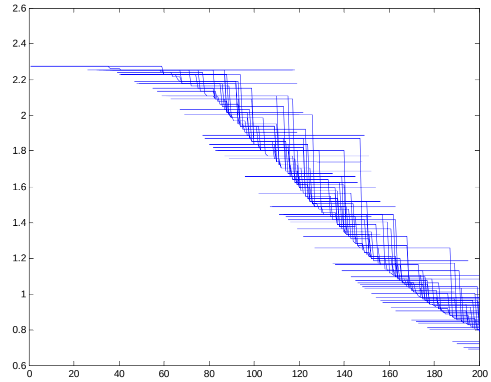

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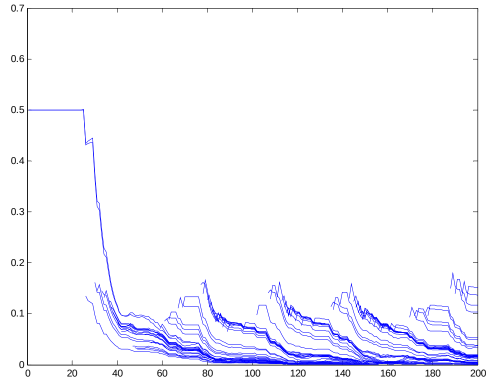

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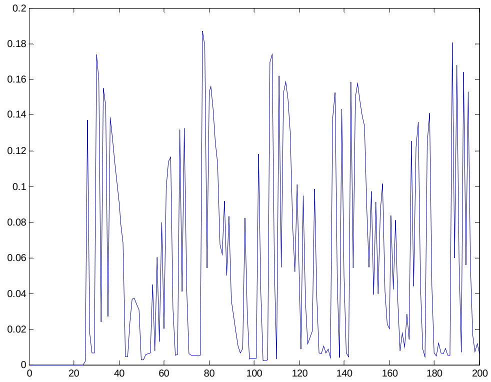

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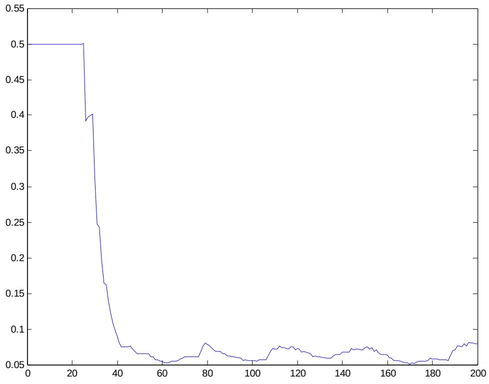

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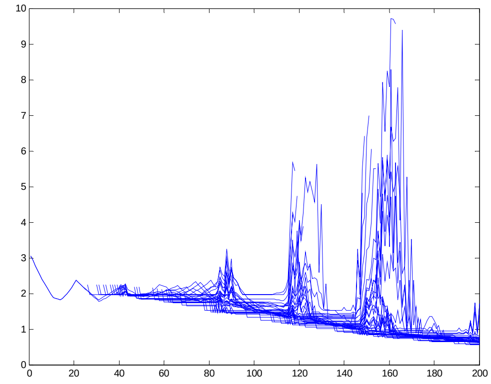

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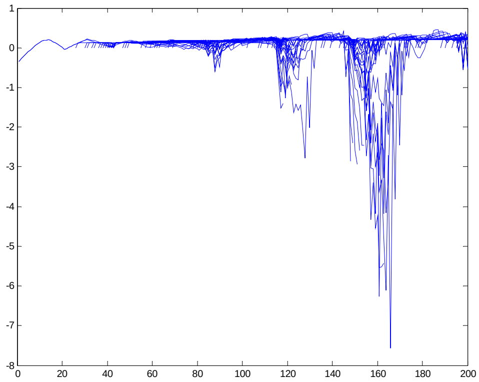
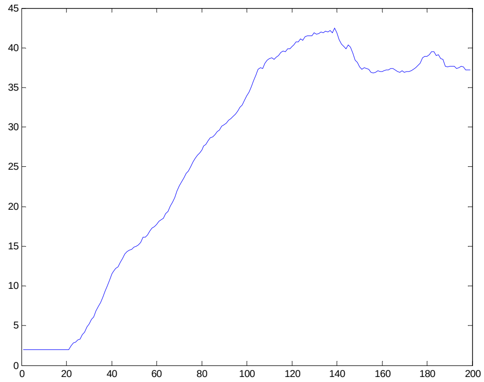


Sim. 9 : Unit Margin



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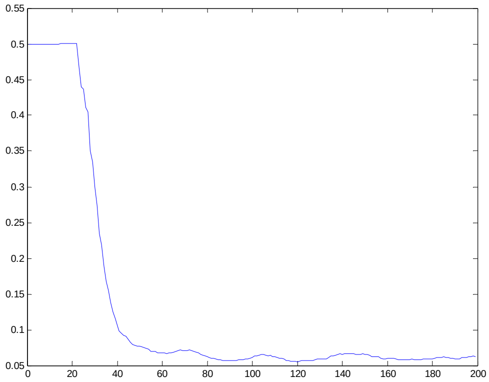
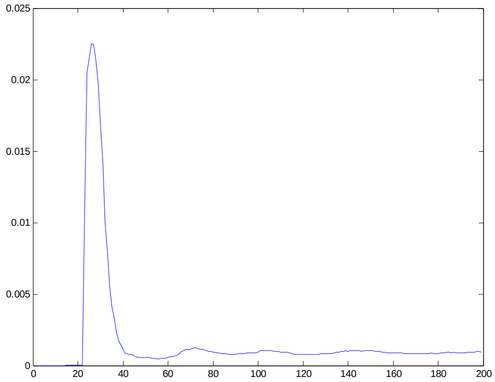


Sim. 10 : Herfindahl Index



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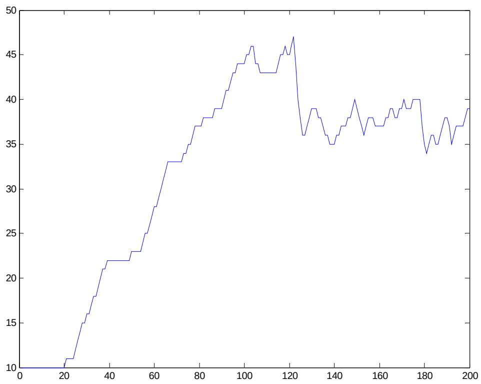
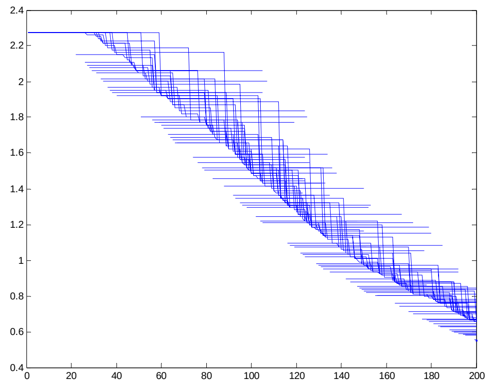
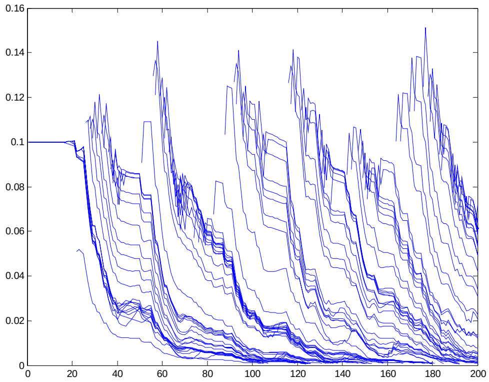


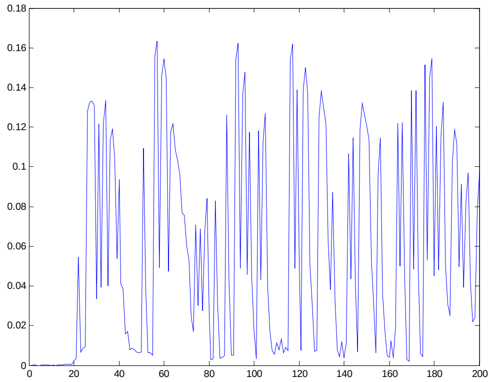
Sim. 11 : Number of Active Firms



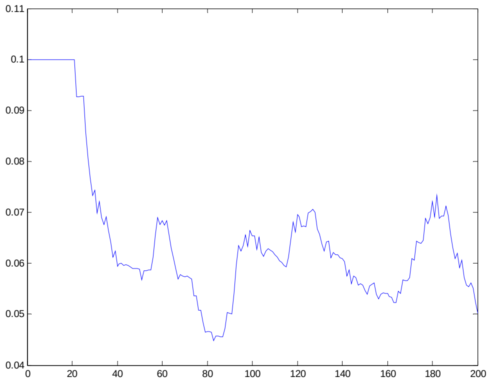
Sim. 11 : Prices



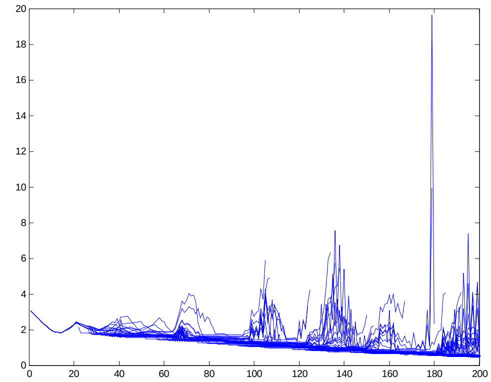
Sim. 11 : Market Shares



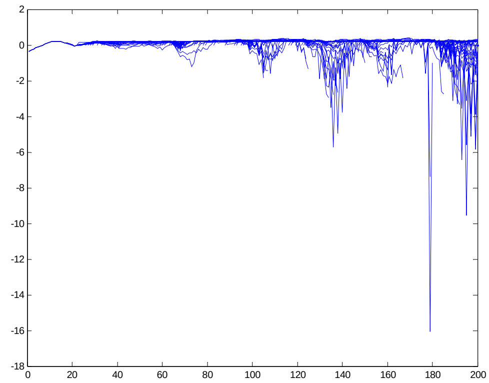
Sim. 11 : Turbulence Index



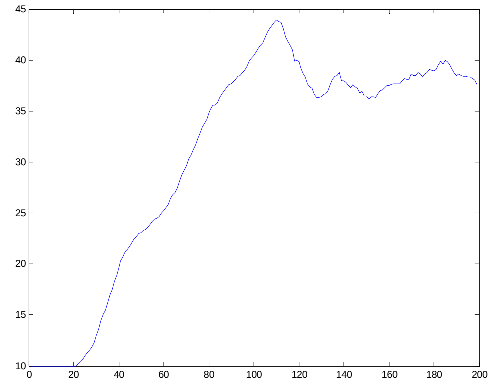
Sim. 11 : Herfindahl Index



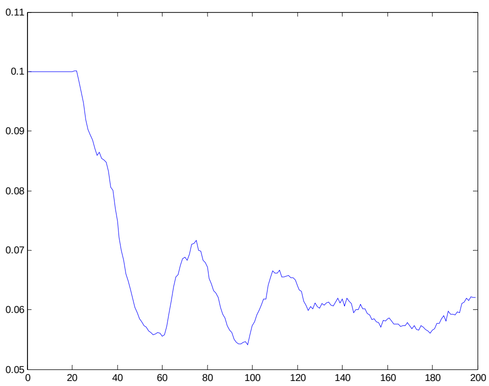
Sim. 11 : Unit Cost



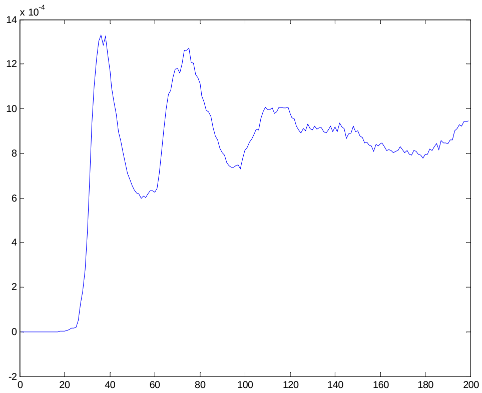
Sim. 11 : Unit Margin



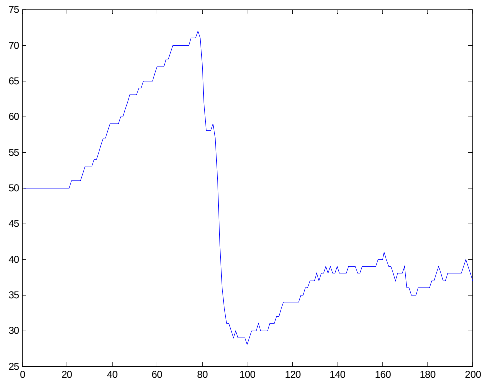
Sim. 12: Number of Active Firms



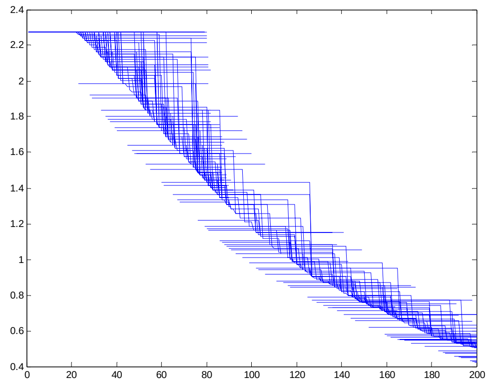
Sim. 12: Herfindahl Index



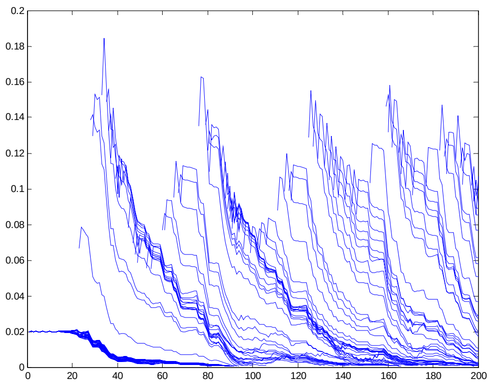
Sim. 12: Dispersion of Market Shares



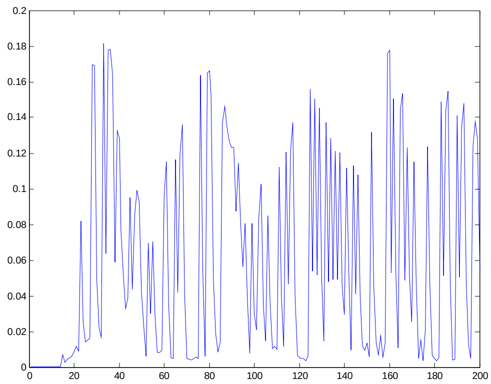
Sim. 13: Number of Active Firms



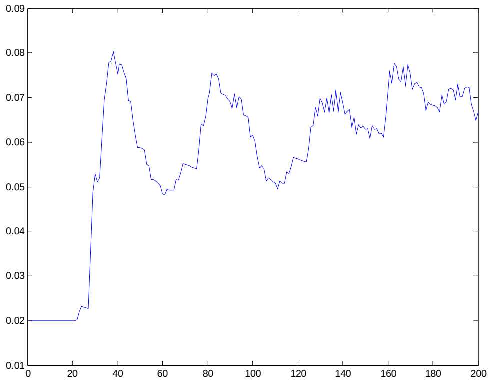
Sim. 13: Prices



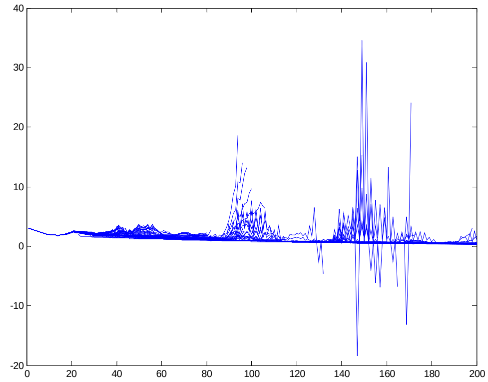
Sim. 13: Market Shares



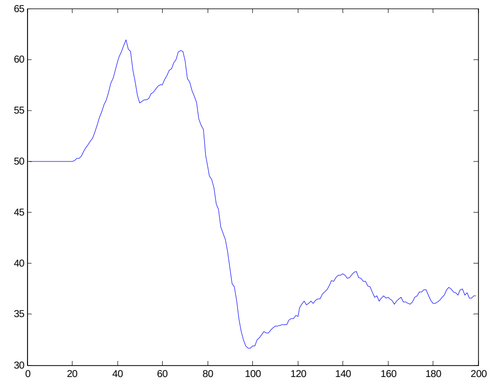
Sim. 13: Turbulence Index



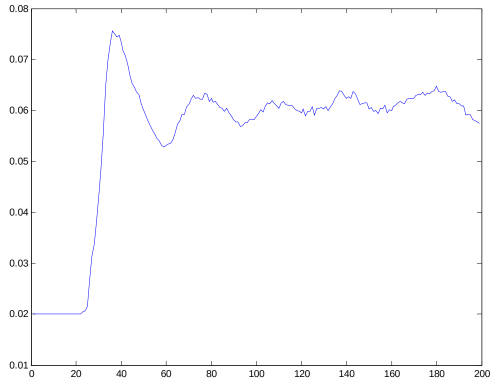
Sim. 13: Herfindahl Index



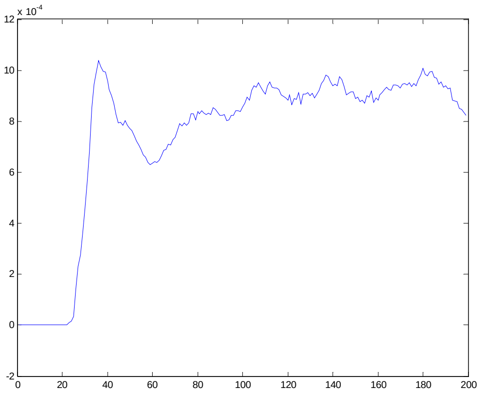
Sim. 13: Unit Costs



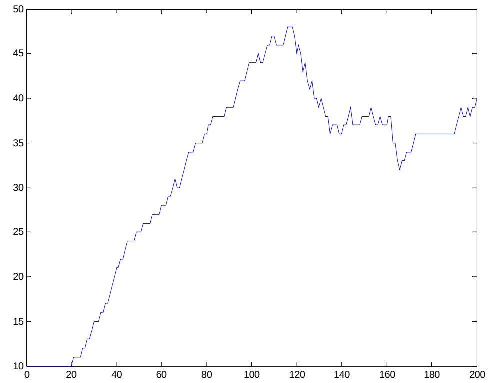
Sim. 14: Number of Actrive Firms



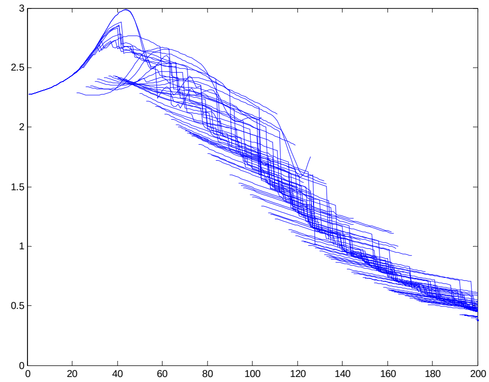
Sim. 14: Herfindahl Index



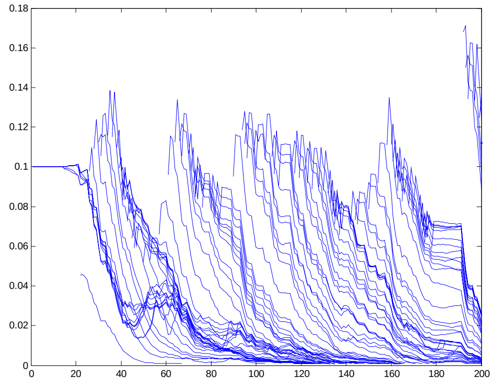
Sim. 14: Dispersion of Market Shares



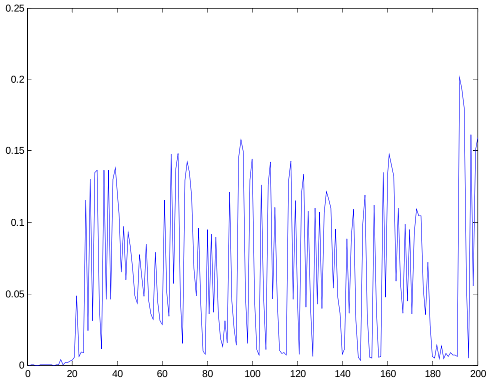
Sim. 15: Number of Active Firms



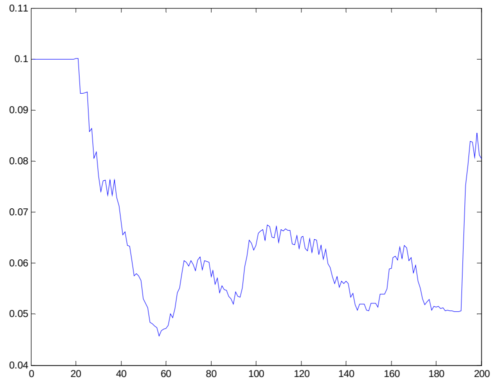
Sim. 15: Prices



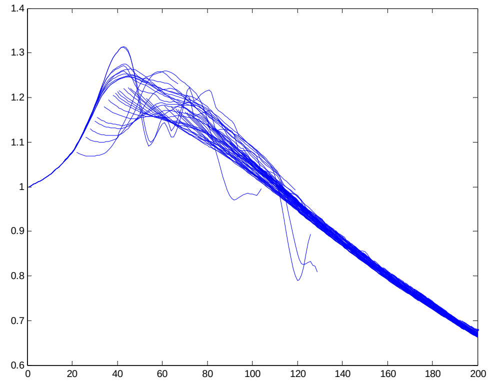
Sim. 15: Market Shares



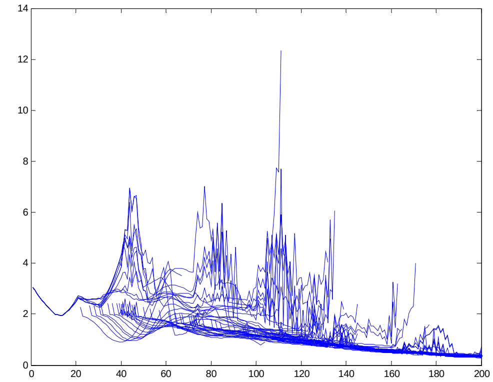
Sim. 15: Turbulence Index



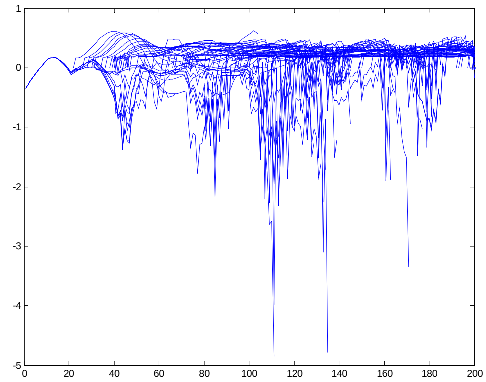
Sim. 15: Herfindahl Index



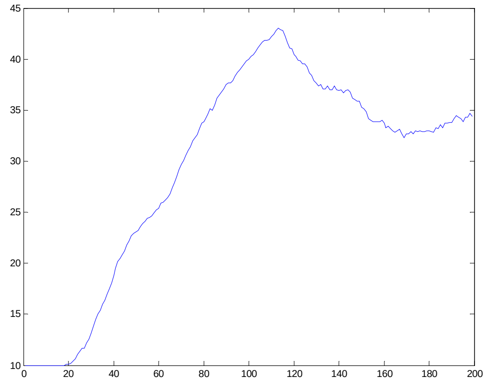
Sim. 15: Wage Rates



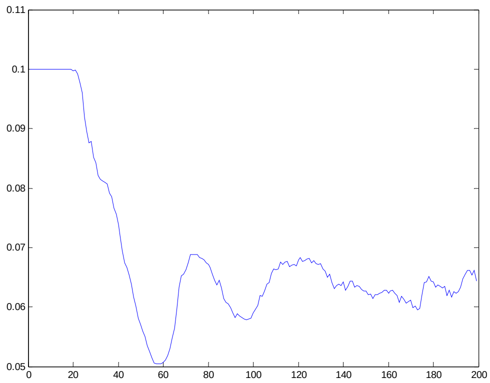
Sim. 15: Unit Cost



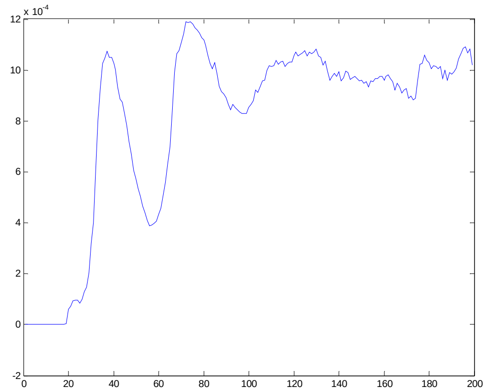
Sim. 15: Unit Margin



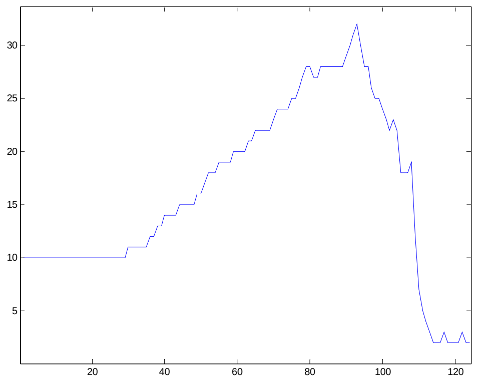
Sim. 16: Number of Active Firms



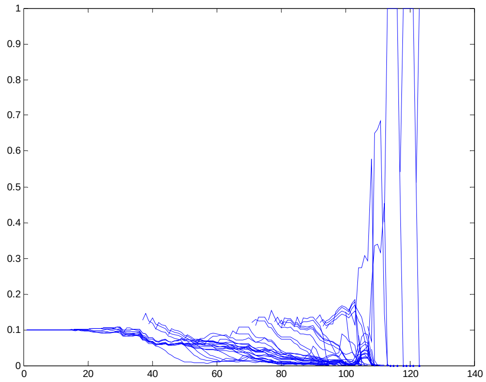
Sim. 16: Herfindahl Index



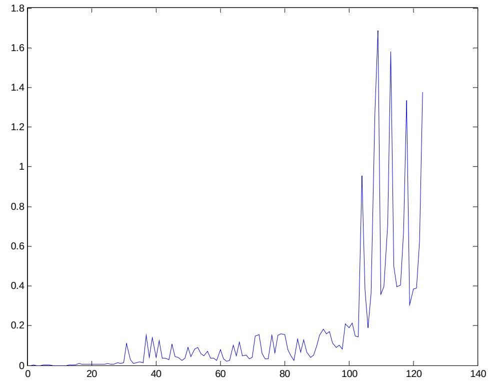
Sim. 16: Dispersion of Market Shares



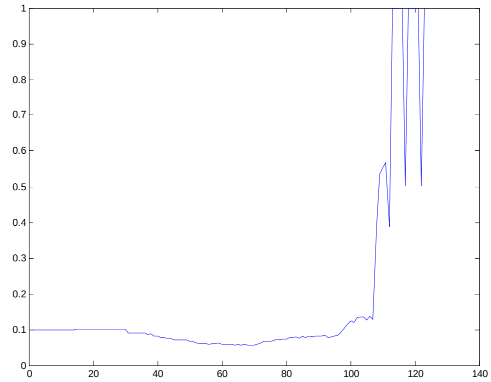
Sim. 17: Number of Active Firms



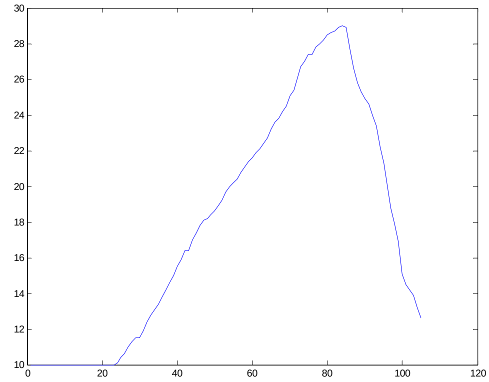
Sim. 17: Market Shares



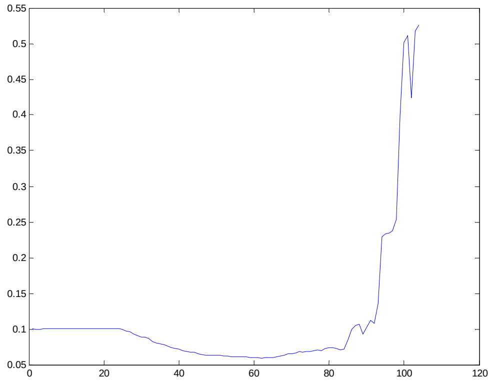
Sim. 17: Turbulence Index



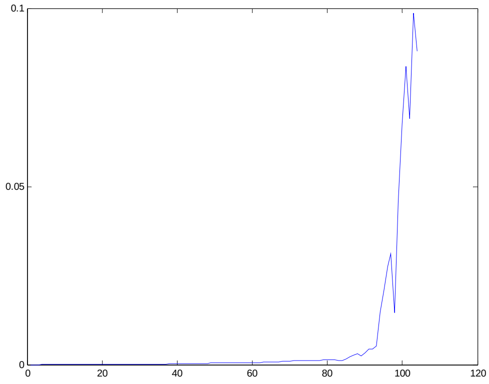
Sim. 17: Herfindahl Index



Sim. 18: Number of Active Firms



Sim. 18: Herfindahl Index



Sim. 18: Dispersion of Market Shares