Akdeniz İ.İ.B.F. Dergisi (21) 2011, 1-16

SELEKSIYON MEKANIZMASININ ENDÜSTRI DINAMIKLERI ÜZERINE ETKISI: BIR SIMÜLASYON ÇALIŞMASI

THE EFFECT OF SELECTION MECHANISM ON INDUSTRY DYNAMICS: A SIMULATION STUDY

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ABSTRACT

Entry and exit play an important role in efficient resource allocation and evolution for long term economic growth. Employing simulation techniques, this paper investigates the effects of entry and exit behavior on price dynamics, productivity dynamics, market structure and profitability of the industry. In the study, two types of entrants are considered; one is more productive than the incumbents and the other is less productive. The findings for both types of entrants are compared with the original Nelson and Winter (1982) model as well. Results of the paper suggest that adding up entry and exit dynamics into the model increases the profitability and narrows the gap between the best practice productivity level and the average productivity level. In addition, the difference between the productivity levels of the entrants does not affect the industry dynamics.

Anahtar Kelimeler: *Entry, Exit, Simulation, Industry Dynamics, Nelson-Winter*

ÖZET

Piyasaya giriş ve piyasadan çıkış kaynakların etkin dağılımında ve uzun dönem büyümesinde önemli rol oynamaktadır. Bu çalışmada, simülasyon teknikleri kullanılarak, piyasaya giriş ve piyasadan çıkış davranışının fiyat dinamikleri, üretkenlik dinamikleri, piyasa yapısı ve endüstri karlılığı üzerine etkisi incelenmiştir. Piyasaya giriş yapan firmalar iki tip olarak sınıflandırılmıştır. Birinci tipteki firmalar yerleşik firmalardan daha üretken, ikinci tiptekiler ise daha az üretkenlerdir. Bu iki tip giren firma için bulunan sonuçlar aynı zamanda Nelson ve Winter (1982) modeliyle de karşılaştırılmıştır. Çalışmanın sonuçlarına göre, giriş ve çıkış dinamiklerini modele eklemek endüstri karlılığını artırmakta ve en iyi üretkenlik seviyesi ile ortalama üretkenlik seviyesi arasındaki farkı azaltmaktadır. Buna ilaveten, giren firmaların üretkenlikleri arasındaki fark endüstri dinamiklerini etkilememektedir.

Key Words: *Piyasaya Giriş, Piyasadan Çıkış, Simülasyon, Endüstri Dinamikleri, Nelson-Winter*

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1. Introduction

The competitive selection mechanism does not only affect the market structure and performance but also growth and welfare. While entry forces incumbent firms to be more efficient, exit causes resources to be used in more productive areas. As a result, entry and exit increase the overall efficiency and so the welfare of the society. Moreover, since innovative entrepreneurship leads to gap-filling and input-completing activities, entry is particularly relevant for developing countries (Acs and Amoros, 2008).

The literature on entry was initiated with Bain (1949). After the recognition of the importance of entry, efforts were focused on quantifying barriers to entry (e.g., Mann (1966)). Orr (1974) used regression analysis in his paper to investigate the determinants of entry. Following Orr (1974), many studies tried to understand the entry behavior. In the literature, while some studies explain entry behavior by industry characteristics (MacDonald, 1986; Khemani and Shapiro, 1986; Acs and Audretsch, 1989; Rosenbaum and Lamort, 1992; Fotopoulos and Spence, 1998a, 1998b; Ilmakunnas and Topi, 1999; Hölz, 2002; Gunalp and Cilasun, 2006), others use individual and environmental characteristics of firms' founders (Foti and Vivarelli, 1994; Vivarelli, 2004). There are also post-entry studies which have a similar structure. For instance, Mata *et al.* (1995), and Weiss (1998) use industry characteristics to explain post entry behavior while Vivarelli (2004), Segura *et al.* (2005) use entrepreneurship ability to explain it. Some findings of these studies are as follows.: New firms are generally small (Geroski, 1995). Probability of survival of these firms is low and increase with start-up size. Surviving new firms maintain higher growth rates in order to close the gap between their start-up size and the size of incumbents implying that Gibrat's law does not hold for small new firms (Audretsch *et al.*, 1999; Santarelli and Vivarelli, 2002). In addition to entry and post entry studies, exit behavior is also investigated in the literature. Some examples of exit studies are Shapiro and Khemani (1987), Sleuwaegen and Dehandschutter (1991), Rosenbaum and Lamort (1992) and Fotopoulos and Spence (1998a, 1998b).

Following the path-breaking studies of Nelson and Winter (1978, 1982), industry dynamics are investigated using extension of their models. For instance, Silverberg, Dosi and Orsenigi (1988) and Possas et al. (2001) include "learning by doing" as a complement to search processes of the type initially suggested by Nelson and Winter (1982). How firms change R&D strategies on the basis of received feedback, is suggested by Silverberg and Verspagen (1994 a,b). Yildizoglu (2002) investigated the effects of alternative R&D strategies on industry performance. Silverberg and Lehnert (1993) emphasize the importance of dating of investment. Moreover, entry and exit also began to be analyzed in a Schumpeterian context by employing simulation approaches. Some of the studies that include entry and exit in their models are McCloughan (1995), Klepper (1996), Ballot and Taymaz (2001), Pajares, Lopez and Hernandez (2003) and Jacoby (2004).

The aim of this study is to investigate the effects of entry and exit on industry dynamics by employing an evolutionary micro-simulation model developed in Nelson and Winter (1982). We analyzed two entrant types; entrants that are more efficient than the incumbents and the entrants that are less efficient than the incumbents. Regarding the exit, we assumed that firms tend to exit if their loss is above their sunk costs. We have compared our results with the Nelson & Winter model.

We have found that, adding up entry-exit dynamics into the model of Nelson and Winter (1982) does not affect the market price and concentration of industry. However, productivity dynamics moves in just the opposite way, so that the gap between the best-practice productivity level and average productivity level narrows in both entry-exit models. In addition, particularly the exit of inefficient firms due to their smaller size increases the average profitability of incumbent firms. It has been also found that, the results of both entry models are very close to each other in spite of the differences in productivity of entrants.

The rest of the paper is organized as follows. The model is presented in the next section. In section 3 simulation results are given. Finally, the last section concludes the paper.

2. Model

Our model is based on Nelson and Winter (1982). They made precise Schumpeterian causation through an evolutionary synthesis including behavioral patterns and their transmission, creation of new behavioral patterns and different types of selection mechanisms. Some main assumptions of their model are as follows:

In the industry a number of firms produce a single homogenous product. Firms are rationally bounded, and their decisions are based on routines or rules. Firms have ability to imitate the rules of other firms and/or they could learn for themselves and could create novelty. The firm's processes of imitation and innovation are often characterized by significant degrees of cumulativeness and path-dependence, but they may also be determined by the exogenous movement of science. The interactions between the firms are typically made disequilibrium situations and the result is success and failures of firms and their underlying routines.

The basic set-up of the model is based on complex transition rule with stochastic change in capital productivity (A) and deterministic change of physical capital stock (K). Supply is found by adding up the output of firms.

In the short term the firm's A and K are given and production is determined by the firm's fixed capacity utilization role with

Q=AK (1)

where Q is the amount of output.

In the model, market always clears and hence the total supply is sold. The market price is simply given by

P = D / Q (2)

where P is the market price, D is the fixed demand and Q is the amount of output. Given this price, firms can calculate their profits. Capital depreciates with a rate of δ. The maximum investment is determined by profit and financial resources from banks. Desired investment is determined by the size of price relative to the unit costs. It considers the market share of the firm. Actual investment is the mimimum of desired investment and maximum investment. Using this investment, firms set the next period's capital stock. Capital productivity is determined by firm-specific knowledge that is improved by R&D that can be innovative and/or imitative. Innovation and imitation are the result of R&D activities that gives proportional probabilistic results in two steps. For the innovation, in the first step, whether or not the firm will have a succesfull result is determined, and in the second step, the productivity of the result is found. Hence innovation is a cumulative process and firms with higher productivities have better chance to attain even higher productivities. In the case of imitation, similar to innovation case, the first step determines the success of R&D investment. If this is the case, the firm obtains the best-practice in the industry in the second step. Thereafter, firm chooses whether to use the old technology, to imitate or to innovate by comparing the productivity levels.

In their model, Nelson and Winter (1982) did not analyse the entry and exit behavior, instead they only analysed the industry evolution by checking the behavior of incumbent firms. However, for a better understanding of industry evolution, entry and exit dynamics should also be analyzed. In this study we integrated entry and exit of firms into the Nelson & Winter model.

One of the "stylized facts" about entry is that, entrants are usually smaller than incumbents (Geroski, 1995; Bartelsman, Scarpetta and Schivardi, 2003). For instance, the size of new entrants in Turkey is around 25 percent of that of established firms (Taymaz and Köksal, 2004). Hence, we have modeled the start-up size of the entrants determined randomly between 20% and 50% of the established firms' size[1]. In the Nelson & Winter model, there are two types of firms; innovative firms and imitative firms. We have introduced entrants as the innovative type in order to be consistent with the theory (Acs and Audretsch, 1990).

In many entry studies, profit rate is found as an important determinant of entry decision (see for example, Ilmakunnas and Topi, 1999; Günalp and Cilasun, 2006). In this respect, in our model entry occurs when the industry average profit rate is higher than the specified threshold. We used linearly formed model to determine the relation between profit rate and number of entrants. In this study two possible entry scenarios are analyzed. In the first scenario, entrants are more productive than the established firms, and in the second scenario, entrants are less productive than the established firms. On the other hand, since the selection is very important for the industry evolution, exit is included to the model. The firms tend to exit if their losses are above their sunk costs for three consecutive periods since in case of an exit, they could not cover their sunk costs. This kind of a relationship between the sunk cost and exit is also evident from the data (Rosenbaum and Lamort, 1992; Fotopoulos and Spence, 1998a). We have measured sunk costs as a fixed percentage of firms' physical capital that is 5 percent. The model is summarized in the Appendix as Psuedo Code. We have analysed our results by comparing the two entry scenarios with each other and with the original Nelson & Winter model where there is no entry and exit dynamics. The analyses are based on price dynamics, productivity dynamics, market structure and profitability of the industry.

3. Simulation Results

Simulations are performed using software developed with Java. We have run 101 simulations over 500 periods for two alternative entrant types in order to reduce the stochastic effects[2]. The simulation results of the original Nelson & Winter model are given in Figures 1-4. According to the graphs, the market price is found to be declining in time. When we look at the productivity dynamics we see that there is a widening gap between the maximum productivity and the average productivity. The reason behind this might be that there will always be at least one innovating firm among those

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[1] We measured the firm size as the capital stock (K) of the firms. Therefore, the start-up size of the new firms is determined randomly between 20% and 50% of established firms' average capital stocks.

[2] The number of runs is determined by comparing the values of the variables of interest after alternative number of runs. We found that the values are very close to each other after 101 runs, therefore the results to be considered in the analysis are those generated when the number of simulation runs is 101.

that have the best-practice productivity level. Hence, one might expect a widening gap between the best-practice and the average productivity due to the widening gap between the average productivity of innovators as compared to imitators.

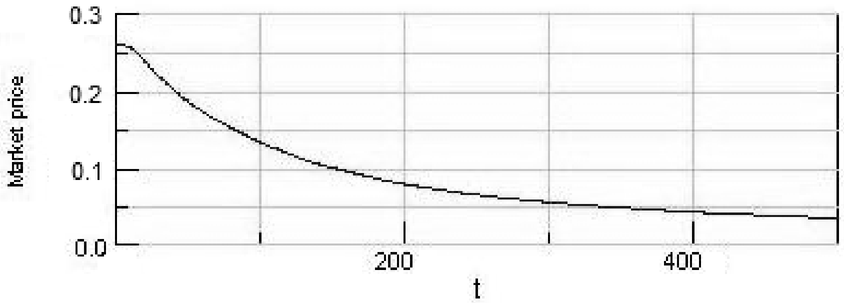

Figure 1. Price Dynamics for Nelson & Winter Model

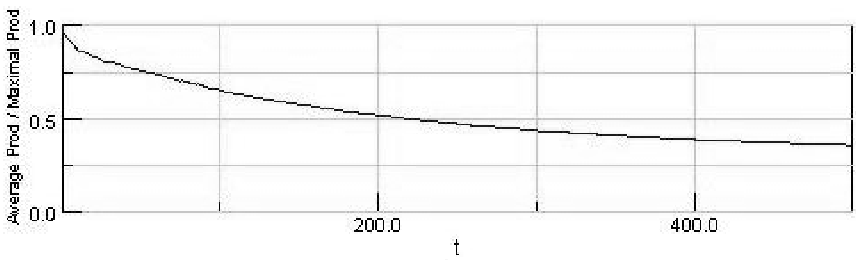

Figure 2. Productivity Dynamics for Nelson & Winter Model

The evolution of the market structure suggests that the industry becomes more concentrated (Figure 3). This result indicates that some firms begin to dominate the market. Neither type of the firms has a significant dominance on other type in terms of output but nevertheless imitators are somewhat better off[3]. Figure 4 displays the average profitability of imitators and innovators. It could be seen from the graph that imitators are on average more profitable than innovators[4].

3 We did not present some of our findings such as output levels of firms in order to keep the paper at a reasonable size. For interested readers we can supply the simulation algorithms and java codes.

4 It should be noted that there is scale differences between left (innovators) and right (immitators) sides of the profit rate plots (Figures 4, 8 and 12).

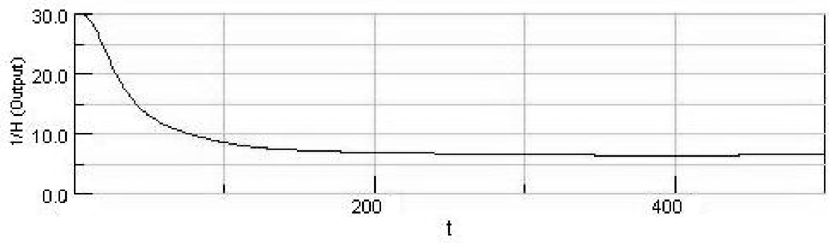

Figure 3. Concentration of Industry for Nelson & Winter Model

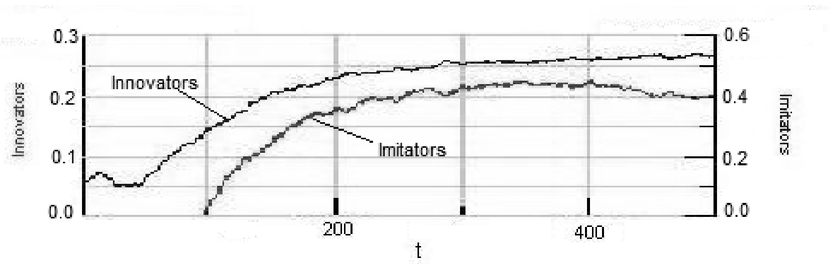

Figure 4. Average Profit Rate of Firms for Nelson & Winter Model

As it was mentioned before, we have analyzed the effects of two different types of entry. Figures 5-8 give the results of entry-exit model with more productive entrants than the established firms. Similar to the original model, the market price declines through time. However, different from the Nelson & Winter model, the productivity gap is narrowing, that is, the maximum productivity and the average productivity converges towards each other. The exit process leads to exit of inefficient firms. Therefore, at the end of the simulation, only the most productive 9 firms (5 innovative, 4 imitative) survives. In other word, exit process leads to this convergence.

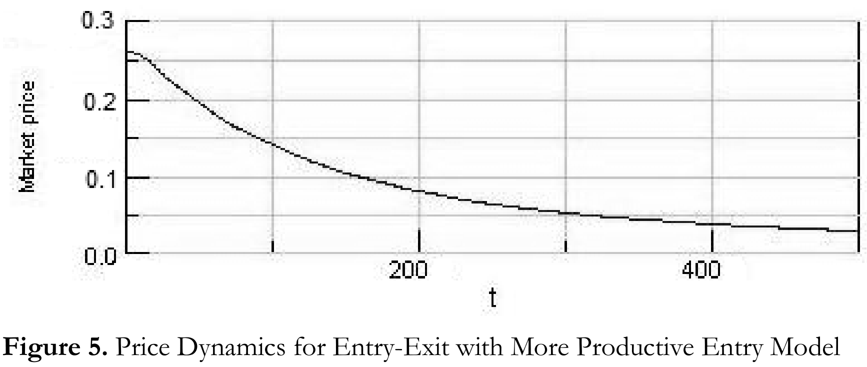

Figure 5. Price Dynamics for Entry-Exit with More Productive Entry Model

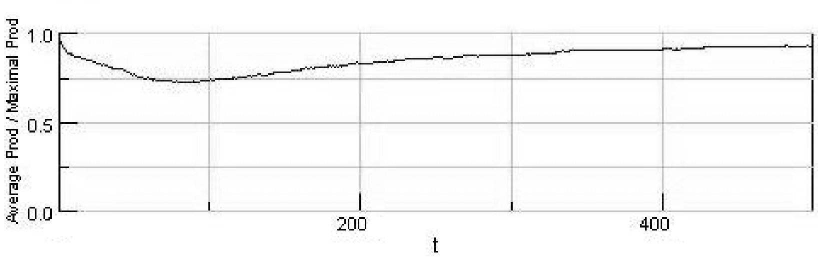

Figure 6. Productivity Dynamics for Entry-Exit with More Productive Entry Model

Concentration of the industry presents similar results to previous model. As expected, exit of less efficient firms lead to an increase in concentration (Figure 7). Since in this case the entrants are more productive, this time innovator firms are found to be somewhat better than imitators in terms of output levels. The profitability comparisons indicate that, profitability is higher in this model relative to the Nelson & Winter model. This was expected since the exit of firms could make survivors better off. On the other hand, imitators are on average more profitable in both models.

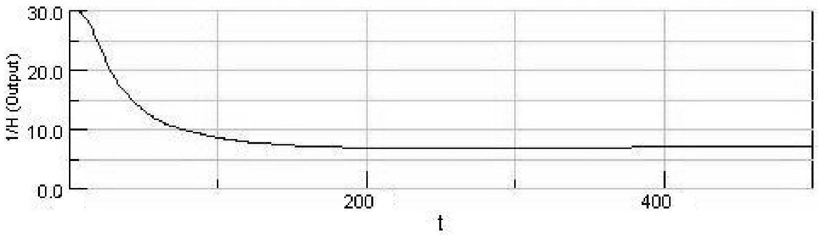

Figure 7. Concentration of Industry for Entry-Exit with More Productive Entry Model

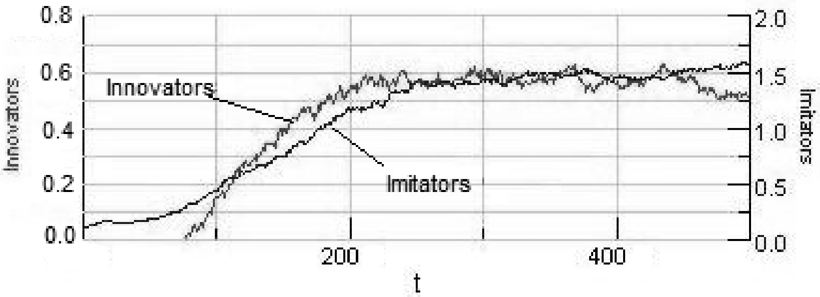

Figure 8. Average Profit Rate of Firms for Entry-Exit with More Productive Entry Model

Our second entry scenario is the entrance of firms with productivity levels below the average productivity levels of incumbents. The result of simulations of this model is very similar to the previous model since the exit process dominates the model (Figure 9-12). The inefficient firms leave the market in both models, therefore the productivity dynamics and concentration of the industry moves parallel. Market price also declines just as the previous models. The profitability of imitators is once again greater than that of innovators on average.

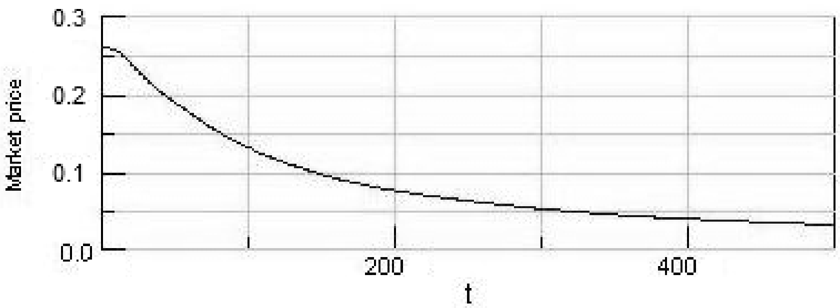

Figure 9. Price Dynamics for Entry-Exit with Less Productive Entry Model

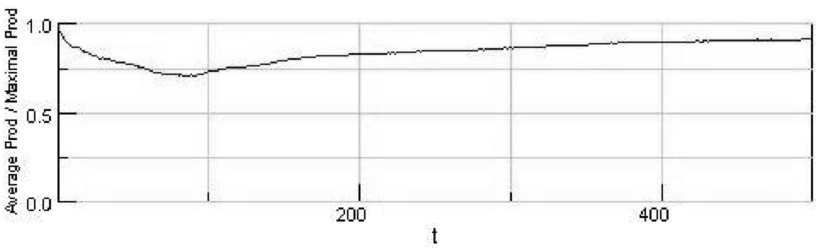

Figure 10. Productivity Dynamics for Entry-Exit with Less Productive Entry Model

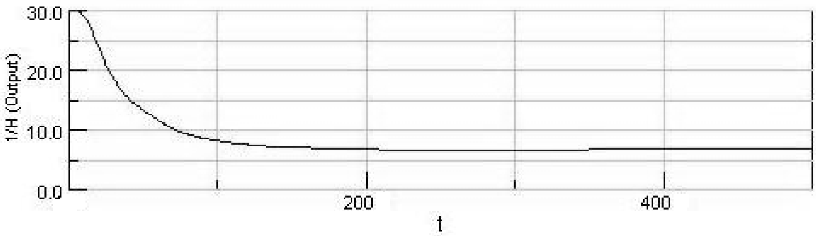

Figure 11. Concentration of Industry for Entry-Exit with Less Productive Entry Model

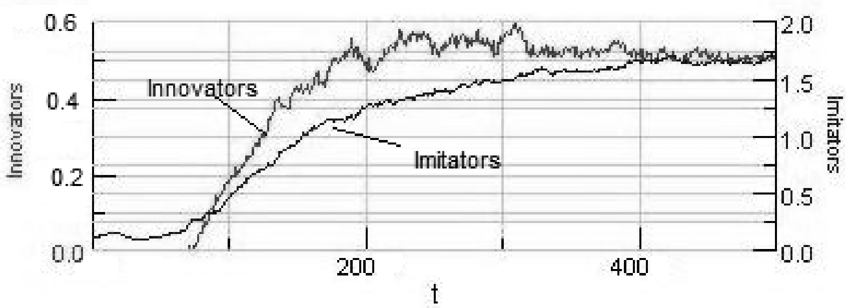

Figure 12. Average Profit Rate of Firms for Entry-Exit with Less Productive Entry Model

4. Conclusion:

In this study, we have analysed the effects of entry and exit process on industry dynamics in an evolutionary framework. Moreover, we have also checked the effects of different entry types with respect to the productivity differences. We have simulated 3 different models –the Nelson and Winter (1982)'s model, the entry-exit model with more productive entry, and the entry-exit model with less productive entry– and compared their results. Adding up the entry-exit dynamics into the Nelson & Winter model does not affect the market price and concentration of industry. However, the productivity dynamics move in just the opposite way. That is, while the gap between the best-practice productivity level and average productivity level narrows in both entry-exit models, it widens in the original Nelson & Winter model. In addition, particularly the exit of inefficient firms due to their smaller size increases the average profitability of both innovative and imitative firms. It has also been found that the results of both entry models are very close to each other in spite of the differences in the productivity of entrants.

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Appendix

Pseudo Code for Nelson-Winter Model with Entry and Exit Dynamics

```
for k=1:numofSim
% Initial values of variables
Cost: Capital cost
Dem : Demand coeff.
Eta : Demand elasticity
Prod0 : Initial prod.
Delta : Depreciation
P_in : Probability of innovation
P_im : Probability of imitation
Sigma_in : Dispersion
B : Bank
N_in : initial number of innovator firms
N_im : initial number of imitator firms
% Run the simulation for T periods
for t=1:T
Supply = IndSupply(Industry); % Calculate industry supply
P = demand(Supply); % Calculate industry demand
Statistics(Industry); % Calculate the statistics
for i=1:newN
% All firms imitate
end
for i=1:newN
if firm is innovative
%Innovative firms do innovate
end
% All the firms invest
end
% Exit dynamics
for i=1:newN
% Calculate the threshold of exit for each firm
```

```
% Threshold is the negative of 5% of firm Kapital
exitThreshold= - K(i) * 0.05;
if Profit if less than exitThreshold for the last 3 steps
Firm exits
end
end
Calculate the Kapital of entering firm (entryK)
It is a random amount between 20% and 50% of mean Kapital
of the existing firms
Calculate the Productivity of entering firm (entryProd)
It is a random amount between 0% and 50% of the mean
productivity of existing firms
Entry threshold of the Industry is set to 1.0
entryThreshold=1.0;
if Industry profit is higher than entryThreshold
Then (IndProf-entryThreshold)*5 number of innovator firms
will enter the industry
end
memorize the period results
end of periods
Calculate the mean of each simulation
End of simulation
```

Characteristics of Nelson-Winter Model

```
% Demand function is used to compute the market price
function x = demand(s)
x = Dem/(s^Eta);
% Computes the supply of the firm
function x = supply(k)
x = K*prod;
% Computes the profit rate on capital
function x = profit(k,Prix)
x = (Prix*prod-(cost+r_in+r_im));
% Computes the investment following the rule of Nelson and
```

```
Winter
    function K = invest(P, Supply, b)
    s=supply/Supply;
    margin=cost/(P*prod);
    invdes=delta+1-(margin*eta)/(eta-s);
    prf=profit(Industry,k,P);
    if(prf<0)
    loans=0;
    else
    loans=b*prf;
    end
    invmax=delta+prf+loans;
    ipos=min(invdes,invmax);
    inv=max(0.0,ipos);
    K=K*(1+inv-delta);
    % Imitation based on random numbers
    function prod = imitate(k,maxprod)
    tirage: random number between 0 and 1
    if ( tirage<=d_im*r_im*K )
    prod=maxprod;
    end
    % Innovation based on random numbers
    function prod = innovate(k)
    prd=0;
    tirage: random number between 0 and 1
    if ( tirage <= d_in*r_in*K )
    prd=(random number between 0 and 1)*sigma_in+prod;
    end
    if ( prd>prod )
    prod=prd;
    end
```