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A Simulation Study of Industry Dynamics

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A Simulation Study of Industry Dynamics

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Abstract

Entry and exit plays 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 by comparing the results with original Nelson and Winter (1982) model. In addition, two entry scenarios are analyzed and compared with each other, efficient entrants and inefficient entrants. 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.

JEL Codes: C15, L11

Keywords: simulation, industry dynamics, Nelson & Winter Model

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Endüstri Dinamikleri Üzerine Bir Simülasyon Çalışması

Seyit Mümin Cilasun ve Andaç Töre Şamiloğlu

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 Nelson ve Winter (1982) modeliyle karşılaştırılarak incelenecektir. Ayrıca, etkin ve etkin olmayan yeni firmaların girişlerine ilşikin senaryolar analiz edilecektir. 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.

JEL Kodları: C15, L11

Anahtar Kelimeler: simülasyon, endüstri dinamikleri, Nelson & Winter Modeli

A Simulation Study of Industry Dynamics

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1. Introduction

Entry and exit play an important role in influencing the market structure and performance. 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, Barnes and Haskel (2002) have shown that the entry of new firms, and especially the exit of low productivity units, makes important contribution to sectoral productivity growth in all countries.

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 a regression analysis in his paper to investigate the determinants of entry. The methodology of Orr was employed by many studies such as, MacDonald (1986), Khemani and Shapiro (1986), Acs and Audretsch (1989), Rosenbaum and Lamort (1992), Fotopoulos and Spence (1998a, 1998b) and Ilmakunnas and Topi (1999). Some examples of exit studies are Shapiro and Khemani (1987), Sleuwaegen and Dehandschutter (1991), Rosenbaum and Lamort (1992) and Fotopoulos and Spence'in (1998a, 1998b).

Following the path-breaking studies of Nelson and Winter (1978 and 1982), entry and exit began to be analyzed in an 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 *et al*. (2003) and Jacoby (2004).

This study presents an evolutionary micro-simulation model developed in the Nelson & Winter (1982) tradition for the analysis of entry and exit behavior and their effects on macro economic variables. We checked for two entry types, one is more efficient than the incumbents and the second is less efficient than the incumbents. The sizes of entrants are assumed to be 30 percent of the incumbents. Firms tend to exit if their loss is above their sunk costs. We have also compared our results with original Nelson & Winter model results. The

paper is organized as follows: Model is presented in the next section. In section three simulation results are given. Finally, forth section concludes the paper.

2. Model

We developed our model 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 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 given and production is determined by the firm's fixed capacity utilization role with Q=AK equation.

In the model market always clears hence total supply is sold. Market price is simply P=D/Q and given this price firms can calculate their profits. Capital productivity is determined by firm-specific knowledge. Innovation and imitation are the result of R&D activities that gives proportional probabilistic results in two steps. In the first step whether the firm will have a result is determined and in the second step the productivity of the result is found. In the case of imitation this result is best-practice technology and in the case of innovation the result is drawn from a normal distribution. And then firm chooses whether to use the old technology, to imitate or to innovate by comparing the productivity levels. Then by choosing maximum of desired and feasible investments firms decide the amount of investment and therefore the level of new capital stock will be determined.

In their model Nelson and Winter (1982) did not analyse the entry and exit behavior instead they only analyse 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 Nelson and Winter model presented in Yildizoglu's webpage.

On of the "stylized fact" about entry is that, entrants are usually smaller than incumbents (Geroski, 1995; Bartelsman et. al.). Hence, we have modeled the start-up size of the entrants determined randomly between 20% and 50% percent of the established firms' size. In 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.

Firms decide to enter if 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, 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 following periods since in case of an exit, the firms could not cover their sunk costs. We have measured sunk costs as a fixed percentage of firms' physical capital that is % 10 percent. We analyze our results by comparing two entry scenarios with each other and with original Nelson & Winter model that have no entry and exit dynamics. Analyses are based on price dynamics, productivity dynamics, market structure and profitability of the industry.

3. Simulation Results

We have run 101 simulations over 500 periods for two alternative entrant types in order to reduce the stochastic effects. The graphs of original Nelson & Winter model simulation results are given in Figure 1-4. According to the graphs, market price declines 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 that have the best-practice productivity level, hence, one might expect that a widening gap between best-practice and

average productivity due to the widening gap between the average productivity of innovators as compared to imitators.

Evolution of the market structure states that the industry becomes more concentrated (Figure 3). This result indicates that some firms began to dominate the market. Neither type of the firms has a significant dominance on other type in terms of output but still imitators are a little bit better off. Figure 4 reports the average profitability of imitators and innovators. It could be seen from the graph that imitators are on average more profitable than innovators.

As it was mentioned before, we have analyzed the effects of two different types of entry. Figure 5-8 gives the results of entry-exit model with more productive entrants than the average productivity level of established firms. Similar to the original Nelson & Winter model, market price declines through time. However, different from N & W model, the productivity gap is narrowing that is the maximum productivity and average productivity converges to 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) survived.

Concentration of the industry presents very close results between the two cases. In entry-exit case, exit of less efficient firms lead to an increase in concentration (Figure 7). Since the entrants are more productive, this time innovator firms are a little bit better than imitatives in terms of output levels. The profitability comparisons indicate that, profitability increase with respect to N & W 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.

Our second entry scenario is the entrance of the firms with productivity below the average productivity of the 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. Profitability of imitators is again greater than the innovators on average.

4. Conclusion:

In our study we have tried to analyse the effects of entry and exit process on industry dynamics. Moreover, we have also checked the effects of different entry types with respect to

the productivity differences. We have simulated 3 different models -Nelson & Winter (1982) model, entry-exit with more productive entry model and entry-exit with less productive entry model- and compared their results. Adding up entry-exit dynamics into Nelson and Winter (1982) model does not affect the market price and concentration of industry. However, productivity dynamics moved in just the opposite way that, the gap between the best-practice productivity level and average productivity level narrows in both entry-exit models. In addition, especially exit of inefficient firms due to their smaller size increases the average profitability of both innovative and imitative firms. It was also found the results of both entry models are very close to each other in spite of the differences in productivity of the entrants.

References

Acs, Z. J. and D. B. Audretsch, 1989, 'Small-Firm Entry in US Manufacturing', *Economica* **56** (222), 255-265.

Bain, J. S., 1949, 'A Note on Pricing in Monopoly and Oligopoly', *American Economic Review* **39** (2), 448-464.

Bain, J. S., 1956, *Barriers To New Competition*, Cambridge, MA: Harvard University Press.

Barnes, M. and J. Haskel, 2002, "Job Creation, Job Destruction and Small Firms: Evidence for the UK", *Queen Mary, University of London,* Working Paper 461.

Bartelsman, E., S. Scarpetta and F. Schivardi, 2003, 'Comparative Analysis of Firm Demoghrapichs and Survival: Micro-Level Evidence for the OECD Countries', *OECD Economics Department Working Papers*, no. 348. Paris, France: OECD.

Fotopoulos, G. and N. Spence, 1998a, 'Entry and Exit from Manufacturing Industries: Symmetry, Turbulence, and Simultaneity - Some Empirical Evidence from Greek Manufacturing Industries, 1982-1988', *Applied Economics* **30** (2), 245-262.

Fotopoulos, G. and N. Spence, 1998b, 'Accounting for Net Entry into Greek Manufacturing by Establishments of Varying Size', *Small Business Economics* **11** (2), 125-144.

Gérard, B. and E. Taymaz, 2001, 'Training Policies and Economic Growth in an Evolutionary Model.', *Structural Change and Economic Dynamics* **12**, 311-329.

Geroski, P. A., 1995, 'What Do We Know about Entry?', *International Journal of Industrial Organization* **13** (4), 421-440.

Ilmakunnas, P. and J. Topi, 1999, 'Microeconomic and Macroeconomic Influences on Entry and Exit of Firms', *Review of Industrial Organization* **15** (3), 283-301.

Jacoby, N., 2004, 'How Does The Firm Manage Internal Diversity? The Role of Internal Selection', *Organizations, Innovation and Complexity: New Perspectives on the Knowledge Economy Conference*

Khemani, R. S. and D. M. Shapiro, 1986, 'The Determinants of New Plant Entry in Canada', *Applied Economics* **18** (11), 1243-1257.

Klepper, S., 1996, 'Entry, Exit, Growth, and Innovation over the Product Life Cycle', *The American Economic Review*, **86** (3), 562-583.

McCloughan, P., 1995, 'Simulation of Concentration Development from Modified Gibrat Growth-Entry-Exit Processes', *The Journal of Industrial Economics*, **43** (4), 405-433.

Macdonald, J. M., 1986, 'Entry and Exit on the Competitive Fringe', *Southern Economic Journal* **52** (3), 640-652.

Mann, H. M., 1966, 'Seller Concentration, Barriers to Entry, and Rates of Return in Thirty Industries, 1950 1960', *Review of Economics and Statistics* **48** (3), 296-307.
Nelson, R.R. and Winter, S.G. 1978, "Forces generating and Limiting Concentration under Schumpeterian Competition", *Bell Journal of Economics*, 9: 524-548.

Nelson, R. R. and S. G. Winter, 1982, *An Evolutionary Theory of Economic Change*, Cambridge, MA: Harvard University Press.

Orr, D., 1974, 'The Determinants of Entry: A Study of the Canadian Manufacturing Industries', *Review of Economics and Statistics* **56** (1), 58-65.

Pajares, J., A. López and C. Hernández, 2003, 'Industry as an Organization of Agents: Innovation and R&D Management', *Journal of Artificial Societies and Social Simulation*, **6** (2). (http://jasss.soc.surrey.ac.uk/6/2/7.html)

Rosenbaum, D. I. and F. Lamort., 1992, 'Entry Barriers, Exit, and Sunk Costs: An Analysis', *Applied Economics* **24** (3), 297-304.

Shapiro, D. M. and R. S. Khemani, 1987, 'The Determinants of Entry and Exit Reconsidered', *International Journal of Industrial Organization* **5** (1), 15-26.

Sleuwaegen, L. ve W. Dehandschutter. "Entry and Exit in Belgian Manufacturing." in: *Entry and Market Contestability*. Ed.: P. A. Geroski ve J. Schwalbach. Oxford, UK: Basil Blackwell, 1991: 111-120.

Figure 1. Price Dynamics for Nelson & Winter Model

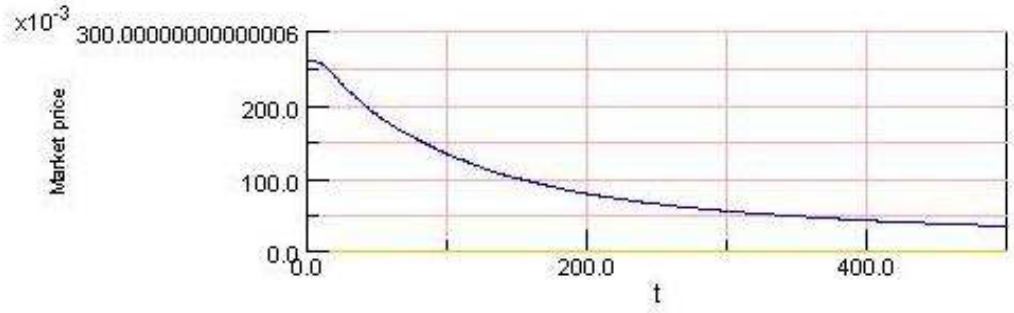

Figure 2. Productivity Dynamics for Nelson & Winter Model

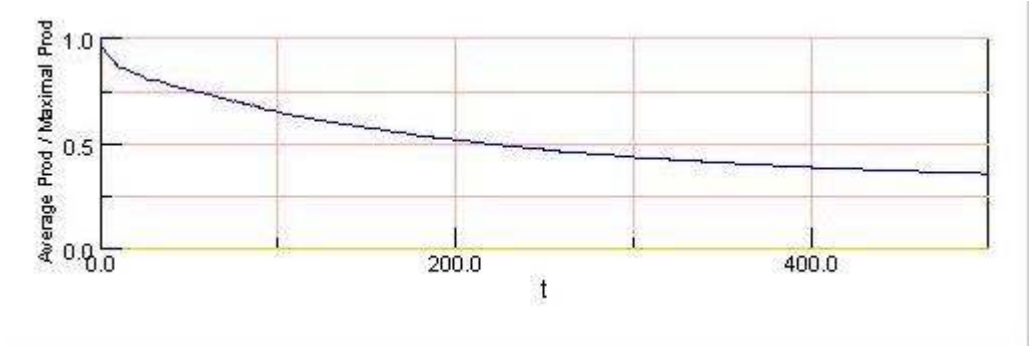

Figure 3. Concentration of Industry for Nelson & Winter Model

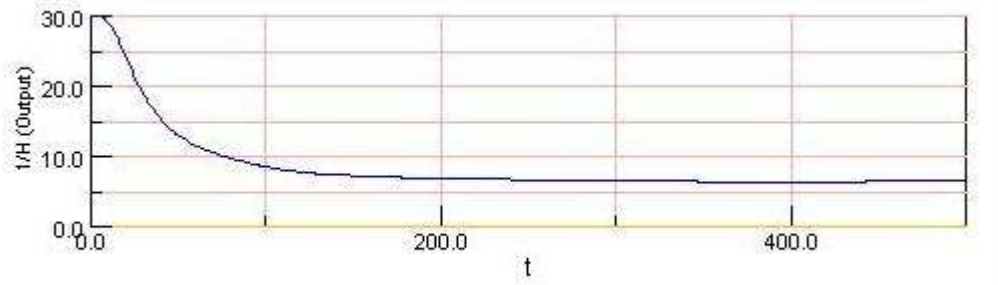

Figure 4. Average Profit Rate of Firms for Nelson & Winter Model

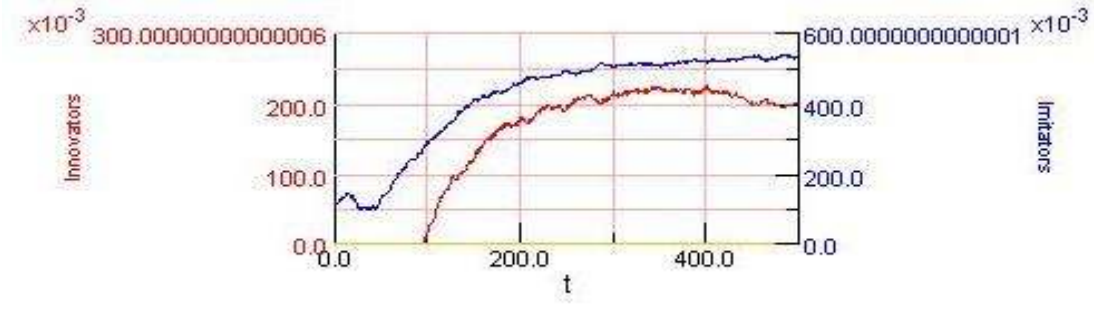

Figure 5. Price Dynamics for Entry-Exit with More Productive Entry Model

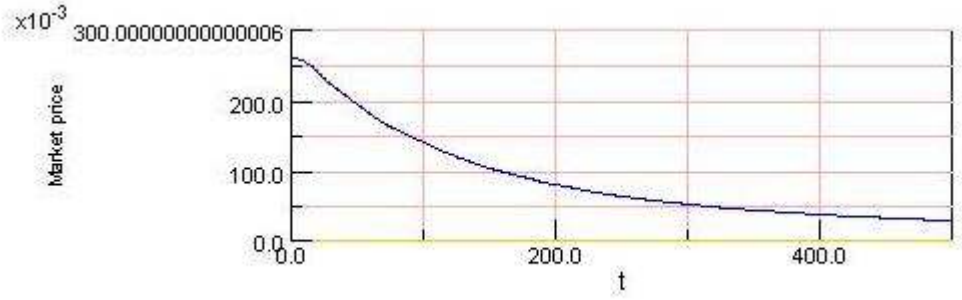

Figure 6. Productivity Dynamics for Entry-Exit with More Productive Entry Model

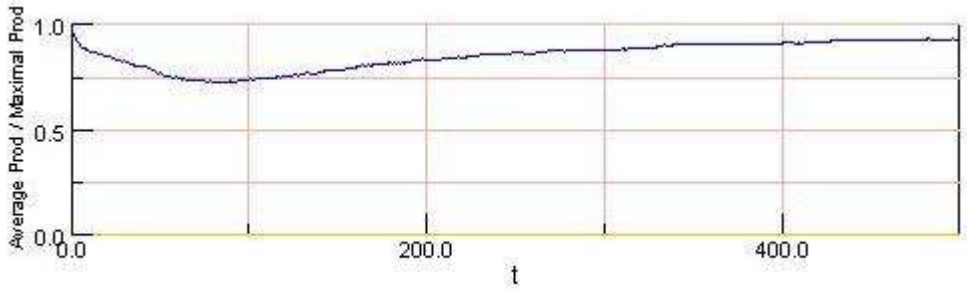

Figure 7. Concentration of Industry for Entry-Exit with More Productive Entry Model

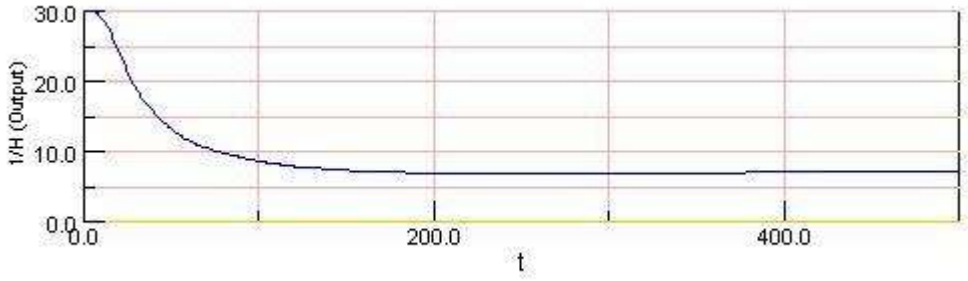

Figure 8. Average Profit Rate of Firms for Entry-Exit with More Productive Entry Model

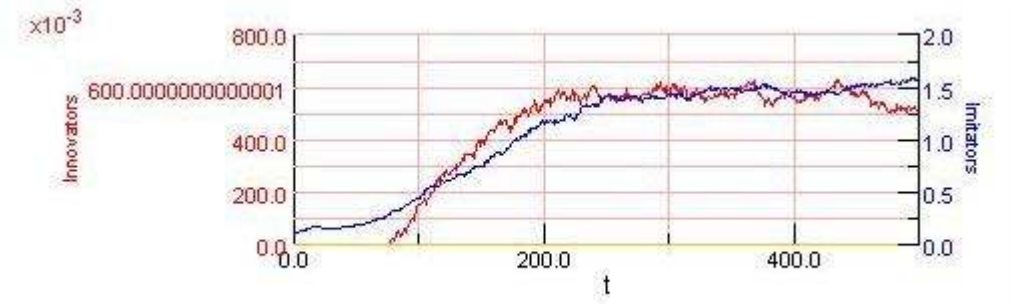

Figure 9. Price Dynamics for Entry-Exit with Less Productive Entry Model

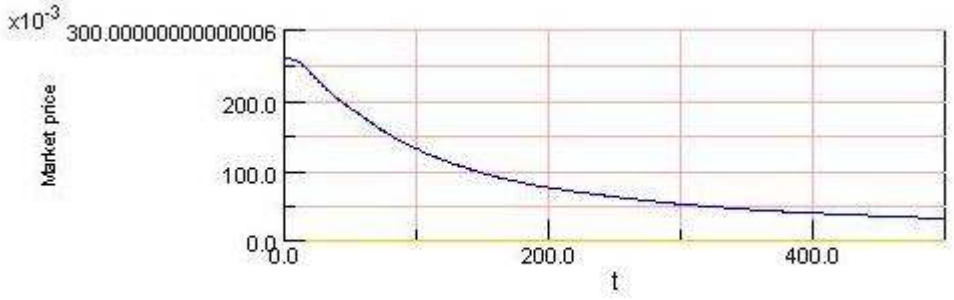

Figure 10. Productivity Dynamics for Entry-Exit with Less Productive Entry Model

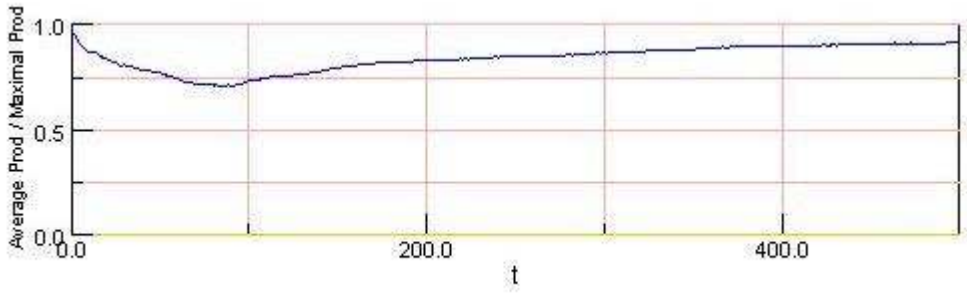

Figure 11. Concentration of Industry for Entry-Exit with Less Productive Entry Model

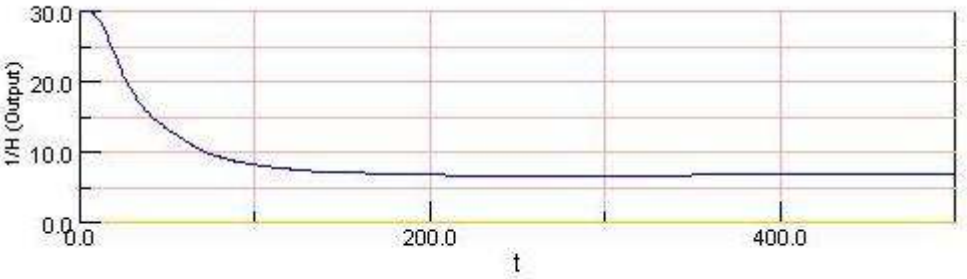

Figure 12. Average Profit Rate of Firms for Entry-Exit with Less Productive Entry Model