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Doctoral Thesis

Investment Strategies under Uncertainty

Theory and evidence of preemption in case of geographical market entrance

by

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In memory of my father

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Symbol Glossary

| | |
|--------------|---|
| a | Probability of investment |
| b | Positive root of variable in fundamental quadratic |
| b_x | Vector of regression coefficients |
| e | Infinitely small increment |
| m | Drift parameter of Brownian motion |
| p | Profit margin of firms |
| s | Variance parameter in Brownian motion |
| | |
| $a(t)$ | Jump in cumulative distribution function |
| b | Interest payment per unit time |
| dz | Increment of standard Wiener process |
| $D[Q(t)]$ | Inverse demand curve |
| D | Duopoly |
| E | Expectation operator |
| $EBIT$ | Earning before interest and tax |
| $f(t)$ | Density function |
| F | Follower |
| $F(t); G(t)$ | Cumulative distribution function |
| $h(t)$ | Hazard function |
| H | Partial likelihood function |
| I | Capital costs of investment |
| J | Joint investment |
| k | Level of asymmetry in firms' operating profitability |
| L | Leader |
| M | Monopoly |
| $P(t)$ | Profit curve of firms |
| $Q(t); n$ | Number of competitors |
| r | Risk adjusted discount rate |
| S | Firms' simple strategies |
| $S(t)$ | Survival function |
| t | Current time |
| T | Survival time |
| X_t | General notion for the state variable of a stochastic process |

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1 Introduction

Expansion investments of firms are the engine of the economic growth of nations.

In the last decades two types of expansion projects were key elements of the strategic management decisions and shaped the world's economic development significantly. On the one hand an increasing share of investment expenditures has been spent on the development of new technologies and products. On the other hand more and more firms focused on the acquisition of new markets and new customers and entered new geographical markets as part of the intensifying globalisation process.

The economic literature analysing the capital budgeting decisions of firms originally involves two different groups of theories¹. The first category applies *decision theoretic* principles and models the investment decision of individual firms in isolation. The second group applies *game theoretic models* and derives optimal investment strategy of investors with respect to the actions of their competitors

The application of option pricing for capital budgeting decisions started with Myers (1977)². Basic models for analysing the investments in real assets using continuous time real option frameworks were developed by Cukierman (1980)³, Bernanke (1983)⁴ Kester (1984), Brennan & Schwartz (1985)⁵ and by McDonald and Siegel (1986)⁶. The results of McDonald and Siegel revealed already an explicit expression for the option value of waiting to invest, with the investments depending on the model's parameters.

The practical application of basic real option models has been analysed in various ways by different authors, e.g. Trigeorgis and Mason (1987)⁷, Tirole (1988)⁸, Dixit and Pindyck (1996)⁹, Kulatilaka & Perotti (1998)¹⁰. However; most of these extensions regard the investment decision of firms in isolation, ignoring strategic interactions with rivals.

¹The categories originate from Huisman, K.J.M., 2001 Technology Investment: A Game Theoretical Real Option Approach. Kluwer Academic Publisher, Boston

²Myers, S.C., 1977 Determinants of Corporate Borrowing, Journal of Financial Economics

³Cukierman, A., 1980 The effects of Uncertainty on Investment under Risk Neutrality with Endogenous Information, Journal of Political Economy

⁴Bernanke, B.S., 1983, Irreversibility, Uncertainty, and Cyclical Investment, Quarterly Journal of Economics

⁵Brennan, M.J. & Schwartz, E.S., 1985 Evaluating Natural Resource Investment, Journal of Business

⁶McDonald, R. & Siegel, D., 1986 The Value of Waiting to Invest, Quarterly Journal of Economics

⁷Trigeorgis, L. & Mason, S.P., 1987 Valuing Managerial Flexibility, Midland Corporate Finance Journal 5

⁸Tirole, J., 1998 The Theory of Industrial Organisation, Cambridge, MA MIT Press

⁹Dixit, A.K., Pindyck, S.R., 1994 Investment Under Uncertainty, Princeton University Press

¹⁰Kulatilaka, N., Perotti, E. C., 1998 Strategic Growth Options, Management Science

Reinganum (1981)¹¹ and Fudenberg and Tirole (1985)¹² were among the first presenting how competition among rivals leads to preemption and rent equalization in case of new technology adoption. Smets (1991)¹³ developed one of the first real option models incorporating the strategic interaction of firms. The basic assumption, that the profit flow of one firm depends on the investment decision of his competitors, gave the result that the investment occurs sooner than the standard real option framework would suggest. Extending the basic model, Grenadier (1996)¹⁴ modelled the cycles in the real estate development industry, Lambrecht (2001)¹⁵ presented the impact of debt financing on market entry and exit decision of firms, while Kort, Huisman, Pawlina and Thijssen (2004)¹⁶ analysed the introduction of new technology in the case of two firms already competing with each other in a given market.

Despite the intensifying globalisation process of the last decades, a relatively small amount of research work has been devoted to the geographical market entry analysis of firms. Much of the strategic management literature analysed the impact of entry timing on the later performance of companies and only a limited amount of research has been dedicated to the understanding of factors which determine the entry decisions in new geographical markets.

On the other hand extensive research has already been carried out on the field of understanding the factors influencing technology investments and timing of product innovation and introduction. However a relatively small amount of analysis and research has been done to adapt these results to the geographical market entry decision of firms.¹⁷

In the late 80ties Eastern European countries opened up their borders and made it possible for foreign investors to enter new virtually untapped markets in Eastern Europe.

The general macroeconomic parameters of Eastern European countries varied significantly after the fall of the communist regimes (1989) both in absolute terms (e.g. population,

¹¹Reinganum, J., 1981 On the Diffusion of New Technology, Bell Journal of Economics

¹²Fudenberg, D., and Tirole, J., 1985 Preemption and Rent Equalization in the Adoption of New Technology, Review of Economic Studies

¹³Smets, F. 1991, Exporting versus FDI: The Effect of Uncertainty, Irreversibilities and Strategic Interactions, Working Paper Yale University

¹⁴Grenadier, S.R., 1996 The Strategic Exercise of Options: Development Cascades and Overbuilding in the Real Estate Markets, Journal of Finance

¹⁵Lambrecht, B.M., 2001 The Impact of Debt Financing on Entry and Exit in a Duopoly, The Review of Financial Studies

¹⁶Huisman, K.J.M., Kort, P.M., Pawlina, G. & Thijssen, J.J., 2004 Strategic Investment under Uncertainty: Merging Real Options with Game Theory, ZfB- Ergänzungsheft 3/2004

¹⁷Some examples for the few empirical analyses of firms' geographical market entry are the following studies: L. Fuentelsaz, J. Gomez and Y. Polo, F, 2000, Followers' entry timing: Evidence from the Spanish Banking Sector after Deregulation, Strategic Management Journal, presented an empirical analysis of the Spanish Banking system after deregulation and K. Gielens and M.G. Dekimpe, 2004, How to Size the Window of Opportunity: The Entry Strategy of Retail Firms into Transition Economies ERIM Report Series Research in Management analysed foreign retailers entry in Eastern Europe.

indebtedness, political risks) and in relative terms (e.g. economic growth, GDP per capita). However, each country represented new markets for those Western European companies which were eager to grow and were looking for new investment opportunities.

After reviewing the 15-year economic development of Eastern European countries, it is possible to analyse the market entry behaviour of foreign investors in order to understand the key factors of their success or failure. By doing this one should understand the drivers, which determined the timing of market entry and which differentiated the entrants from non-entrants and the early entrants from late entrants.

Interviews with corporate leaders of entrant companies from that period reveal the foreign companies' strategies relating to their Eastern European expansions. The following citations give a closer insight into the core of these strategies:

“We needed countries where we could be early entrants, countries that were stable, and countries with sufficient spending power per capita and with growth potential... This led us to identify the former Communist countries of Eastern Europe and a few overlooked emerging countries in Asia”¹⁸

“Dynamic growth is part of our strategy. Potential for growth in Central and Eastern Europe is much bigger because growth is amplified by the region's dynamic economic development and the amount of catching up that needs to be done in some banking markets.”¹⁹

“First of all, we entered neighbouring countries like Czechoslovakia, Hungary and Slovenia before expanding into the others. As a result we are something of a pioneer in those markets and we have been able to exploit our first-mover advantage.”²⁰

Browsing CEO interviews like the above citations from the last two decades show the following common strategy concept of successful entrant companies:

- Focus on extensive growth opportunities
- Early entry with the aim of benefiting from the first-mover's advantage

¹⁸Terry Leahy, CEO of British supermarket chain Tesco, June 2006 The grocers' global battlefield, Internet

¹⁹Interview with Walter Rothensteiner, 2005 CEO RZB Austria; Annual report RZB Group

²⁰Wolfgang Ruttendorfer, CEO OMV AG, March 2003 The Wall Street Transcript Publisher, Internet

- Targeting a carefully selected small number of countries
- Support of strong core business at home which financed the expansion

The aim of this thesis is to identify and measure the impact of factors, which influence the market entry decision of competing firms in order to analyse and understand firm's geographical market entry behaviour.

The next three chapters of this work present a theoretical framework for modelling market entry decisions in continuous-time under uncertainty. As in reality irreversibility of investment costs and management flexibility of optimising the entry timing are very important characteristics of the entry decision, an optimal stopping problem in continuous-time has been chosen as a general framework for the analysis. The impact of competition was added to the basic model by adapting the game theoretical approach with the aim of finding the equilibrium of the competing firms' strategies.

In chapter 5 the results of the theoretical models have been used in order to set up a hypothesis for a general empirical analysis and to test the significance of various identified factors assumed to influence the market entry decisions of firms. The empirical analysis was carried out using the data of Western European food retailers entering Eastern European countries after the fall of the communist regimes in the region. Grocery retailers have been chosen for testing the hypothesis of the theoretical results for two main reasons:

1. Western European retailers were eager to grow in that time period as most of them experienced maturing domestic markets with a growth rate of close to zero and a high concentration of top competitors.
2. The lack of major domestic players as incumbents in most of the Eastern European countries in the transitional period provided an excellent opportunity to research the entry behaviour of firms into new untapped markets.

With saturated home markets in the background and new opportunities in Eastern Europe it was inevitable that Western European retailers entered the Eastern European countries from the beginning of the 90s. However, entry strategies of the grocery retailers differed from each other in many aspects.

On the one hand certain Eastern European countries (e.g. Czech Republic, Poland and Hungary) were more attractive than others (e.g. Romania and Bulgaria). Foreign retailers showed up for example in Poland, in Hungary and in the Czech Republic from the beginning of the 90s while their number was already above ten by the end of the decade when retailers first started to consider Romania and Bulgaria as serious targets.

On the other hand competitors' interest towards the same country differed also significantly. Rewe and Tengelmann for example started their operation in Hungary and in the Czech Republic at the beginning of the 90s while considerable players of the industry like Tesco and Metro entered these markets only years later.

The fact that despite their growing international activities many retailers are struggling with competition and fail to survive in a more global industry recently motivated researchers and consultants to analyse the key factors for success of market entry strategies. AT Kearney for example stated, that right timing was essential of the success and many companies failed as they entered too soon or too late²¹. Retailers often appeared to be motivated to enter new markets by the fear of being left out by their competitors rather than by the chance of generating value in the new markets.

²¹Farra, F. and Bell, D.; 2006 Globalisation strategies: How to crack new markets, European Business Forum Issue 25, Internet

2 Theoretical Background of Investment Decisions under Uncertainty

2.1 Dynamic Net Present Value

“although India represents the next big market for growth, most global retailers are restricting themselves to keeping a watching brief on the country²²”

The right timing of an investment decision is a central problem in capital budgeting. Western European managers and investors faced more volatile markets in Eastern Europe than at home when they were considering to enter the markets of the region in the early 90s. Furthermore their market entry decisions, like every decision relating to foreign direct investments, had two very important characteristics:

1. The investment costs (at least partially such as rental costs, marketing costs, staff recruitment costs etc...) were irreversible, or sunk costs.
2. The investment decision was not a “now or never” decision, it depended on the management and could be freely delayed.

By watching and analysing missteps and successes in the globalisation process of large grocery retailers A.T Kearney²³ identified the early entry as one of main strategic lessons of market entrance pointing out that generally there is only a five to six-year window of opportunity to enter an emerging market. A.T. Kearney reflected the importance of *time and timing* in the following strategic advice: “Think ahead by several years and choose the timing of entry carefully.”²⁴

²²Davis,G., 2006 The grocers’ global battlefield, Internet

²³Farra, F., A.T. Kearney and D. Bell, 2006 Globalisation strategies: How to crack new markets, European Business Forum issue 25

²⁴Farra, F. and Bell, D.,2006 Globalisation strategies: How to crack new markets, European Business Forum Issue 25, Internet

Timing decision of investments can not be supported by the simple *static NPV* (net present value) calculations²⁵. These decisions need to be modelled by the application of an optimal stopping problem in a continuous-time model, where continuation means *waiting* and stopping equals *investing*.

The model developed by McDonald and Siegel (1986)²⁶ analyses the optimal timing decision of investment project assuming sunk investment costs and a project value which follows a geometrical Brownian motion. The remarkable result of these authors' continuous-time model shows the existence of an excess value of waiting compared to the *static NPV* results. This value needs to be compensated in addition to the investment costs at the time when the investment decision is made.²⁷ Consequently the investment trigger occurs at a higher level of project value than suggested by the *static NPV* rule.

Based on these results the *dynamic NPV* of investment opportunities involve the following value components for the investors:

$$\text{Dynamic NPV} = \text{Static NPV (intrinsic value)} + \text{Opportunity costs of waiting (time value)}$$

In cases where uncertainty is high, the opportunity costs of waiting increases. This implicates that the ability to change the investment strategy may represent a significant value component since it allows for investors to maximise the time value of investments. Driven by the changes in the investment environment investors typically face the following decisions with significant time value: (i) timing of the entry/exit decisions (ii) extension/reduction of the invested capital. Professional investors and managers have long intuited the additional value of decisional flexibility. Empirical studies show that the actual investment behaviour of firms differs from the general NPV rule. As a result firms are more cautious both in exit and entry decisions and therefore absorb operating losses or require an excess return before making their final decision.²⁸

²⁵A more detailed critic of the *static NPV* method can be found in Chapter One of Dixit, A.K., Pindyck, S.R., 1994 *Investment Under Uncertainty*, Princeton University Press

²⁶McDonald, R. and Siegel, D. 1986 The Value of Waiting to Invest, *Quarterly Journal of Economics*

²⁷A formal deduction of the time value of investment decisions is presented in Chapter 3 under the analysis of market entry in a monopoly economy.

²⁸Several empirical studies showed that firms generally invest in projects where the expected return incorporates extra return above the theoretically required rate. On the other hand it was also observed that firms are willing to stay in business and absorb operating losses. This contradicts the general exit rule based on which exit should happen in case the variable costs are no longer recovered. (One example for these studies is Bulan, L. Mayer, C. Somerville, C.T. *Irreversible Investment, Real Option and Competition: Evidence from Real Estate Development*, Wharton School Samuel Zell & Robert Lurie Real Estate Center, University of Pennsylvania)

2.2 Strategic Value

“...everybody wants to be in the top three in a country. If you are seventh, eighth or ninth, then you're not in the game.”²⁹

Can investors in a competitive environment maximise the opportunity costs of waiting when making investment decisions? What kind of impact has the competition on foreign direct investments? Do some firms have competitive advantage in a “market entry game”? If yes, what are the factors that the competitive advantage depends on?

These are typical questions which arise after browsing interviews with corporate leaders who managed successful market entry in Eastern European markets.

There are situations, where competitors jointly held investment opportunities. Foreign direct investments generally belong to such situations. As these opportunities are non-exclusive by nature, the intensity of competition may force market players to invest earlier than others at a date which occurs before maximising the time value of waiting.

To decide on the correct investment strategy in cases of non-exclusive ownership of investment opportunities not only the parameters of the investment project itself are to be considered carefully but also the number of competitors and their relative strength to each other. The evaluation of such situations consists therefore of an additional step: after the project value has been determined, it should be allocated to its owners based on a certain procedure.

As a result of the allocation procedure the value of investment opportunities being held jointly by competitors can be split up to the following value components:

Strategic value of investments = Dynamic NPV value ± Strategic premium

²⁹Roberts, B., global retail analyst, 2006 The grocers' global battlefield, Internet

The *strategic premium* results from the impact of one firm's action on its rivals' optimal response. The investment decision has therefore not only a direct influence on the firm's own profit but it also has an indirect strategic effect via the competitor's reaction.

The *strategic premium* can be positive or negative. Its sign depends on whether confrontation or cooperation features in the firms' behaviour toward each other.

If firms compete in the traditional sense, one firm's gain is generally the other's loss (zero-sum games). In these situations the negative externality of the firm's action implies contrarian reaction of the counterparts.

However, there are situations where the response is complementary and both parties gain if they coordinate their actions. In these games one firm's behaviour has positive externality on the payoff function of his counterpart and the partners intend to cooperate in order to create a larger total pie.

If the investment creates shared benefits for the competitors then the strategic value of early investment is negative. However, if the competitive reactions are contrarian, then the early investment deters the competitors and the strategic value is positive. This also means that positive strategic value generally reduces the time value of waiting as the firm should act before his counterpart in order to get the leading role. Market entry games are generally competitors' race for market shares and as such require confrontation of the players.

If the competitor's investment decisions are contingent upon each other's action, then the application of game theory becomes necessary for valuing the strategy of different investors. One firm may preempt his competitors by entering a new market earlier than other firms. This is a simple case of strategic games, where competitive strategy can be analysed by a combination of *dynamic NPV valuation method* and industrial organisational *game theoretic* concept.

3 *Standard Theoretical Market Entry Models*

3.1 *Overview*

This chapter presents valuation models combining the *dynamic NPV valuation* with *game theory* for the measurement of the strategic value of market entrance. The standard models measure basically the impacts of host market demand potential and competition among potential entrants on the market entry equilibrium.

The basic structure and assumptions of the standard duopoly model follow the analysis of Dixit and Pindyck³⁰ (1996). These authors presented the valuation of market entrance in a duopoly case with identical firms and analysed the effects of strategic interaction of the firms on the time value of the market entry based on the model of Smets (1991)³¹. The continuous-time equilibrium analysis in the case of endogenously given Leader and Follower roles is based on the paper of Huisman, Kort, and Pawlina³². These authors extended the closed loop equilibrium analysis of Fudenberg and Tirole³³ with application of mixed strategies in continuous time and completed the real option analysis of investment in new technologies

In this thesis the equilibrium analysis of the existing literature is extended in three various ways in the next chapter:

- In the first extension it is analysed how the existence of Follower's entry barrier impacts the equilibrium outcome of the standard case. In this model competitors remain equal, but the stake of being the first investor increases.
- In the second extension the equilibrium outcome of unequal competitors with asymmetric operational profitability or with asymmetric financial strength is examined. The aim of this analysis is to find out how one firm's comparative strength distorts the standard equilibrium results and to identify the best strategy which the unequal firms should follow respectively.

³⁰Dixit, A.K., Pindyck, R.S., 1996 Investment under Uncertainty, Princeton University Press

³¹Smets, F., 1991 Exporting versus FDI: The Effect of Uncertainty, Irreversibilities and Strategic Interactions, Working Paper, Yale University

³²Huisman, K.J.M., Kort, P.M. and Pawlina, G., 2004 Strategic Investment under Uncertainty: Merging Real Options with Game Theory, ZfB-Ergänzungsheft 3/2004

³³Fudenberg, D., Tirol, J., 1985 Preemption and rent equalization in the adoption of new technology, The Review of Economic Studies

- In the third extension the market entry equilibrium outcome is extended for the case of more than two competing firms.

The case of Follower entry barrier requires a limited extension of the standard model. The presentation of a similar case has not been found in the existing literature.

The impact of asymmetry on firm's investment decision is rarely analysed in economic literature.

Huisman (2001)³⁴, Pawlina and Kort (2006)³⁵ presented how asymmetric investment costs influence the technology innovation of firms, which already compete on a market. The results of these authors present a slightly different case to the geographical market entry decision of firms for two reasons. First, their analysis is based on the assumption that the introduction of new technology can cannibalise the profit of existing products in these markets. Second, in case of geographical market entry, firm specific asymmetry occurs in operational or financial strength rather than in the investment costs³⁶.

Lambrecht (2001)³⁷ presented how debt financing affects the survival probability of competitors and influences the order of market entry and exits. However, his analysis also incorporates the existence of incumbent firm(s) and represents therefore a different approach.

Market entry models with more than two competing firms have been very limitedly researched in the existing literature. Lambrecht (2001)³⁸ and Fudenberg and Tirole (1985)³⁹ presented some incomplete results with more than two competing firms without exact and complete deduction of the equilibria.

³⁴Huisman, K.J.M., 2001 *Technology Investment: A Game Theoretical Real Option Approach*. Kluwer Academic Publisher, Boston

³⁵Pawlina, G., and Kort, P.M., 2006 *Real Options in an Asymmetric Duopoly: Who benefits from your Competitive Disadvantage?*, *Journal of Economics and Management Strategy*, Volume 15

³⁶The assumption of different investment costs of firms in these authors' model is different to the case of Follower entry barrier, where additional investment costs are not firm specific but relate to the Follower role.

³⁷Lambrecht, B.M., 2001 *The Impact of Debt Financing on Entry and Exit in a Duopoly*, *The Review of Financial Studies*

³⁸Lambrecht, B.M., 2001 *The Impact of Debt Financing on Entry and Exit in a Duopoly*, *The Review of Financial Studies*

³⁹Fudenberg, D., Tirol, J., 1985 *Preemption and rent equalization in the adoption of new technology*, *The Review of Economic Studies*

The basic structure of the theoretical models is as follows:

1. In the first stage the value of market entrance for a single firm in case of a monopoly economy is presented. This is a benchmark case with a sole timing decision, where the impact of host market demand potential on the firm's optimal entry strategy is analysed within a *dynamic NPV* valuation framework.
2. In the second stage the model is extended to a duopoly economy in order to add the impact of competition to the analysis. Assuming rational and identical firms in the first step, those equilibria are examined which are supported by symmetric strategies.

The symmetric duopoly model is extended in the next step and the impacts of the following types of asymmetry are examined with respect of the timing of market entry and the determination of the Leader and the Follower roles:

- Follower's entry barrier (e.g. higher investment costs of the second entrant in the form of additional marketing expenses)
- asymmetric operational profitability of the competitors (e.g. different fixed costs of operation)
- asymmetric capital costs of the competitors (e.g. different financial leverage)

The aim of the duopoly analysis is to examine how the competition and the differences among competitors distort the optimal market entry date supported by the results of the *dynamic NPV* valuation in monopoly economy.

3. In the third stage the duopoly model is extended to the oligopoly case, with more than two competing firms.

The results of the theoretical models are used to understand the entry pattern and behaviour of Western European retailers into the Eastern European markets. The aim of the analysis is to set up a hypothesis on how general macroeconomic factors of the host markets (which are common to all firms) and how competition with firm specific factors influence the market entry strategies of foreign investors.

3.2 Market Entry in a Monopoly Economy

3.2.1 Assumptions

At this stage of the analysis the investment decision of a monopoly, which has the opportunity to enter a new market with sunk costs of $I > 0$ is considered. It is assumed that the firm is value maximising, risk neutral and finances its market entry entirely with equity.

The profit curve $P(t)$ presents the firm's profit at time t and can be calculated as the profit margin multiplied by the sales volume. The sales volume depends on the level of host market demand potential. It is represented by a downward-sloping inverse demand curve, which is assumed to be subject to continuous macroeconomic shocks. The profit curve of the firm can be written by the following function:

$$(1) P(t) = pX_t D[Q(t)], \text{ in which}$$

$$(2) dX = mXdt + sXdz ,$$

$$(3) X_0 = x, \text{ and } x > 0$$

where dz follows a standard Wiener process, m is the instantaneous conditional expected percentage change in X_t per unit time ($r > m > 0$) and $s > 0$ is the instantaneous conditional standard deviation per unit time. The positive drift m in the Wiener process reflects the assumption of continuous macroeconomic growth on the market.

$D[Q(t)]$ represents a downward-sloping inverse demand curve, where Q equals the number of competitors on the market. In case of assuming a monopoly economy $Q = 1$ holds⁴⁰.

$p \geq 0$ presents the profit margin the firm can realise on one unit of output in absolute monetary terms⁴¹. For simplicity it is assumed that risk in X_t has a correlation of one with the overall market risk noted as r_m .

⁴⁰ $D[Q(t)]$ is a strictly positive constant

⁴¹For the reason of simplicity the staggered impact of fixed or quasi fixed operational costs is ignored in the model.

3.2.2 Valuation Model

Upon market entrance the monopoly firm receives the monopoly profit, which can be written according to the previously defined profit curve as

$$(4) P(t) = pX_t D[1]$$

3.2.2.1 Market Entry Trigger

Before the optimal market entry date, the Monopoly waits with the market entrance. As the investment opportunity yields no current cash flow under waiting the total return is expected in the form of capital gains equalling r_m per unit time. The Monopoly chooses the optimal entry date by maximising the value of his investment. The date of market entry occurs therefore if the Monopoly's return on investments per unit time equals the expected amount of capital gain on the market entry per unit time. This non-arbitrage equilibrium requirement is formally expressed by the following Bellman equation:

$$(5) r_m M(X_t) dt = E[dM(X_t)]$$

Applying Itô's lemma for expressing the capital gain by the instantaneous change in the present value of the Monopoly's investment and calculating the expectation's operator the following homogeneous linear equation of second order is obtained:

$$(6) 0 = \frac{1}{2} \sigma^2 X_t^2 M''(X_t) + mX_t M'(X_t) - r_m M(X_t)$$

It is assumed that $m < r_m$. This implies the existence of trigger value at X_{t_M} , where the Monopoly gives up the strategy of waiting and enters the market. This trigger occurs when t exceeds t_M . Therefore the following two boundary conditions are imposed in order to define the optimal market entry date:

The “*value matching*” condition reflects that upon market entrance the value of waiting (time value of the investment) equals zero. This means, that the entry’s payoff equals the present value of the perpetual monopoly profit minus the sunk investment costs as expressed below:

$$(7) M(X_{t_M}) = \frac{pD(1)}{(r_m - m)} X_{t_M} - I$$

The “*smooth pasting*” condition ensures that the first derivatives or slopes of the functions expressing waiting and investing match at X_{t_M} so that t_M is the sole trigger date, which maximises the value of the Monopoly’s market entry⁴². This condition is expressed in the following equation.

$$(8) M'(X_{t_M}) = \frac{pD(1)}{(r_m - m)}$$

As an additional boundary condition the equation $M(0)=0$ can be posed. This condition ensures that zero is the absorbing barrier of the monopolistic profit and if X_t ever reaches zero it will remain there forever.

Solving the equilibrium differential equation (6) subject to the above boundary conditions gives the following optimal entry threshold for the Monopoly firm:

$$(9) X_{t_M} = \frac{b}{b-1} \frac{(r_m - m)}{pD(1)} I$$

where

$$(10) b = \frac{\frac{1}{2}S^2 - m + \sqrt{\left[\frac{1}{2}S^2 - m\right]^2 + 2S^2 r_m}}{S^2} > 1 \text{ holds.}$$

⁴² In case these slopes were different, another optimal entry date would exist either to the right or to the left of X_{t_M} . A more detailed description of the smooth pasting condition can be found in Chapter 4 of Dixit, A.K., Pindyck, R.S., 1996 Investment under Uncertainty, Princeton University Press.

3.2.2.2 Value Function

Based on the results of the optimal market entry threshold, the value function of the Monopoly's market entry can be expressed depending on actual level of host market maturity.

If $X_t \in [X_{t_M}; \infty)$, then the Monopoly will invest immediately and get the *static NPV* value of the market entry expressed by the value matching condition in *equation (7)*:

$$(11) \frac{pD(1)}{(r_m - m)} X_t - I.$$

If $X_t \in [0; X_{t_M})$, then the Monopoly will wait with the investment until the optimal entry trigger X_{t_M} , where he receives the net present value of $\frac{pD(1)}{(r_m - m)} X_{t_M} - I$ for the market entrance. The expected value of the Monopoly entry before the optimal entry threshold can be therefore expressed by discounting the net present value of market entrance at t_M to the actual date t as expressed below:

$$(12) E[e^{-r_m(t_M-t)} \left(\frac{X_{t_M} pD(1)}{r_m - m} - I \right)],$$

where t_M denotes the random first time the process reaches the optimal level of X_{t_M} starting from X_t and $E[e^{-r_m(t_M-t)}]$ represents the discount factor for a stochastic period of $(t_M - t)$.

Replacing the value of the discount factor⁴³ into *equation (12)* the value function of the Monopoly's market entrance takes the following form:

$$(13) \left(\frac{X_t}{X_{t_M}} \right)^b \left(\frac{X_{t_M} pD(1)}{r_m - m} - I \right)$$

⁴³ Detailed deduction is presented by Dixit, A.K., Pindyck, R.S., 1996 Investment under Uncertainty, Princeton University Press page 315-316

Combining the results of *equation (11)* and *equation (13)* the value function of the Monopoly market entry can be written as follows:

$$(14) M(X_t) = \begin{cases} \left[\frac{pD(1)}{(r_m - m)} X_{t_M} - I \right] \left[\frac{X_t}{X_{t_M}} \right]^b & \text{if } X_t \in [0; X_{t_M}) \\ \frac{pD(1)}{(r_m - m)} X_t - I & \text{if } X_t \in [X_{t_M}; \infty) \end{cases}$$

3.2.3 Conclusion:

In this section the geographical market entry of one firm in isolation without the impact of competition has been examined. Resolving an optimal stopping problem in continuous time the following entry strategy of the Monopoly has been obtained:

3.2.3.1 Market Entry Strategies

If the demand potential on the host market is below the critical level of X_{t_M} the *dynamic NPV* value of the Monopoly's market entry has significant time-value and the Monopoly waits with the investment.

If the demand potential on the host market has reached the critical level of X_{t_M} the time-value of further waiting evaporates and an immediate investment occurs. The value of market entrance equals the *static NPV* of the future perpetual monopoly profit cash flows minus the up front investment costs.

Rewriting the formula of the optimal investment trigger of the firm in *equation (9)* and substituting $V = \frac{b}{b-1}$ the following modified investment rule is obtained:⁴⁴

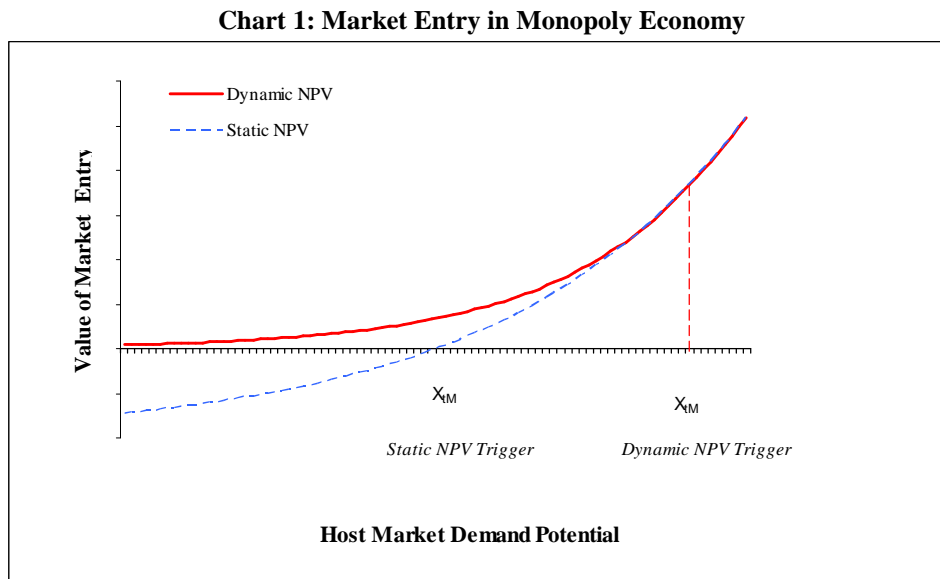
$$(15) \frac{pD(1)}{(r_m - m)} X_{t_M} = \mathbb{I}$$

Since $V > 1$ holds⁴⁵, the *dynamic NPV* valuation analysis requires a higher investment trigger than that of the traditional *static NPV* formula. This mark-up is due to the lost flexibility of further waiting, which is given up with the investment and the value of which should therefore be compensated by the future cash flows.

⁴⁴Similar analysis can be found in Dixit, A.K., Pindyck, R.S., 1996 Investment under Uncertainty

⁴⁵Equation $V > 1$ holds based on *equation (10)*.

The following chart presents the value function of the Monopoly market entrance defined by equation (14):



In the absence of competition the value of the market entry comprises of the traditional *static NPV (intrinsic value)* of the investment project and of the *waiting premium (time value)*. The waiting premium expresses the value of the decisional flexibility, which value component the Monopoly can maximise.

3.2.3.2 Impact of Common Economic Indicators of the Host Market

“We needed countries that were stable, and countries with sufficient spending power per capita and with growth potential... This led us to identify the former Communist countries of Eastern Europe and a few overlooked emerging countries in Asia”⁴⁶

The results of the Monopoly market entry model reveal that common economic factors of the host market influence the timing of investors’ arrival.

Increase in host market volatility (expressed by s) deters foreign investors’ arrival since the value of waiting goes to indefinite with uncertainty. Hence, attractive growth opportunities of the target markets (noted by m) have the reverse impact on the time value of investment and accelerate the market entry of foreign companies⁴⁷.

The time value of geographical market entry is significantly driven by common economic indicators of the host market. The results indicate that those Eastern European countries which provided more economic stability and higher growth in demand potential have become earlier attractive targets for foreign investments.

Eastern European countries showed strong differences in macroeconomic performance indicators such as *real GDP growth, annual inflation, foreign debt level and development of legal system*. Unfortunately such statistical figures are not completely available in the Eurostat⁴⁸ database as many Eastern European countries did not report for the period between 1989 and 1994. In order to limit the potential distortion impact of these variables to the test results, only those countries were selected which were candidates of the European Union expansion in the period of analysis. This method ensured that a relative homogenous group of Eastern European countries in terms of these common economic indicators was created.

⁴⁶Leahy, T., CEO of British supermarket chain Tesco, 2006 June The grocers’ global battlefield, Internet

⁴⁷Expressions of the optimal market entry date in *equations (9) and (10)* show the following limit values of V

to the common economic factors of the host market: $\lim_{s \rightarrow \infty} V = \infty$ and $\lim_{m \rightarrow r_m} V = 0$. The third

variable in β represents the discount rate of future cash flows. For simplicity reasons the model assumes that discount rate has a correlation of one with the host market demand potential (X_t) .

⁴⁸Eurostat (epp.eurostat.ec.europa.eu) is the central statistical office of the EU

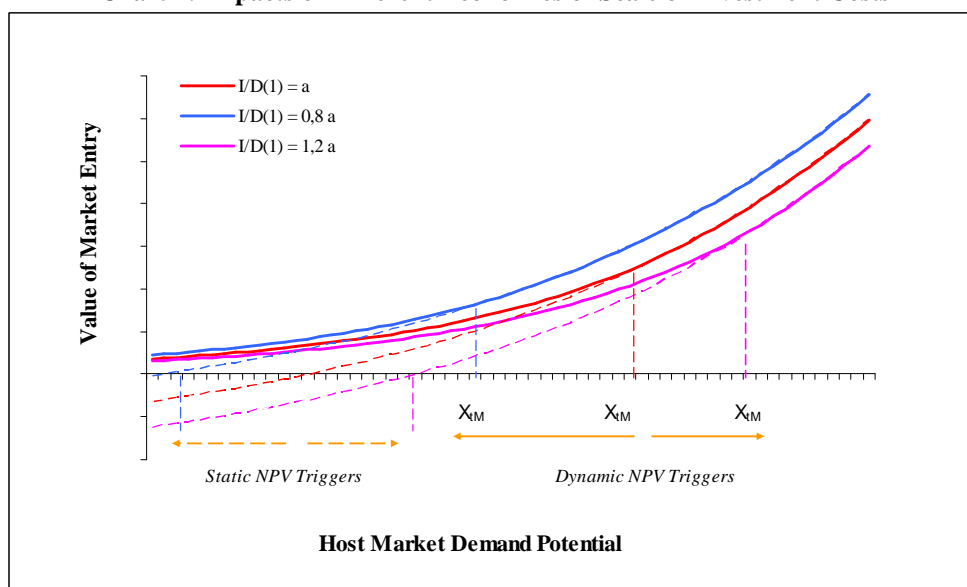
3.2.3.3 *Impact of Economies of Scale of Investment Costs*

"What's important is not to lose any local economies of scale. That's why it's important to be number one in a country and not just build (aggregate) sales across countries."⁴⁹

The result of *equation (9)* shows, that assuming constant investment costs per unit of output $\left[\frac{I}{D(Q)} \right]$, the timing of the market entry does not depend on the absolute size of the Monopoly's market and X_{t_M} remains unchanged. This means, that independently from the absolute market size, investors enter new markets at the same level of demand potential per capita.

However, if the investment costs per unit of output are different, then markets with larger absolute demand potential representing higher economies of scale of investment costs become more attractive. In that case, depending on the absolute market size, investors' market entry in countries with higher absolute level of demand potential occurs earlier than entry in countries with lower absolute level of demand potential.

Chart 2: Impacts of Different Economies of Scale of Investment Costs



⁴⁹Leahy, T., CEO of British supermarket chain Tesco, 2006 June The grocers' global battlefield, Internet

As the lower investment costs per unit of output increase the intrinsic value of the market entry, the investors' preference for markets with higher demand potential is in line with the results of both *the static and the dynamic NPV* analysis.

However, one should observe that the *dynamic NPV* analysis requires a higher compensation ($V > 1$) and consequently further delay of entry in countries with lower level of absolute demand potential. This results from the fact that not only the intrinsic value but also the time value component of the *dynamic NPV* correlates positively with the level of investment costs per unit of output.

Decreasing economies of scale of investment costs driven by fixed costs of foreign market entry such as those relating to cost of administration, logistics, marketing, personnel etc... implicate that investments in Eastern European countries with higher absolute level of demand potential occurred earlier.

The impact of absolute level of demand potential on the timing of market entry of foreign investors can be measured by separating the explanatory variables *average GDP (or purchasing power) per capita* and *average number of inhabitants* in the empirical tests⁵⁰.

Due to the rapid economic development of the region *average GDP per capita* generally increased but varied significantly both across years in a given country and across countries in Eastern Europe. As the time value of investment evaporates with increase in host market demand potential, the level of GDP per capita can provide an explanation why first investment of foreign retailers occurred in Hungary and in the Czech Republic, which showed significantly high GDP per capita compared to other countries at the beginning of the 90s.

During the analysed period *average number of inhabitants* of the Eastern European countries did not change dramatically but showed significant differences across countries. The relatively large population of Poland and Romania can explain that foreign retailers entered these countries at a relative low level of average GDP per capita compared to Hungary and to the Czech Republic.

⁵⁰The multiple of these two explanatory variables is assumed to reflect the absolute level of host market demand potential.

3.3 Market Entry in a Duopoly Economy

3.3.1 Assumptions

In duopoly analysis identical firms with exogenously assigned Leader and Follower roles are considered in the first step.

Since the number of firms is two the market demand function is described by $D[Q(t)]$ where $Q \in \{0;1;2\}$. The firm which moves first into the new market is the Leader, while the other firm, which moves later, is called as Follower. Both firms are assumed to have complete information with respect to all model parameters (including their rival's). The discounted profit stream of the Leader, investing at time t , is given by $L(X_t)$, while the same for the Follower is denoted by $F(X_t)$. It is assumed that $L(X_t) \geq F(X_t)$ for $\forall X_t$, which means, that the market entry of the Leader has no positive externalities on the Follower's market entry. If both firms enter the market at the same time t then a joint investment occurs and the discounted profit stream for both firms equals $J(X_t)$.

Following the standard calculation procedures of dynamic games first the value of the Follower is determined by working backward in building up the model. In case of exogenously given roles investors' strategies are the sole function of host market demand potential and investors can not react to each others' action. Assuming that the Leader has already entered the new market, the Follower faces a sole timing decision to maximise the value of duopoly profit stream. After having determined the Follower's entry date, the analysis can concentrate on the value of the Leader, who should optimise his market entry conditional on the Follower's strategy. The aim of this analysis is to find the optimal investment rule of the firms depending on the level of demand potential on the host market with the value-maximising investment threshold level of the Leader noted by X_{t_L} and of the Follower noted by X_{t_F} . This is a benchmark strategy which is used to analyse the impact of possible strategic interaction of the firms.

In the next stage of the analysis the Leader and the Follower roles are determined endogenously with the application of game theoretical analysis. In this section the perfect equilibrium is defined by closed-loop entry strategies of the firms, which allow investors to react both to the host market development and to each other's action.

3.3.2 Valuation Model

In case of the exogenously given Leader and Follower roles neither firm takes into account that they could influence the other's entry date. In this situation the Follower enters the market only after the Leader by definition and both firms precommit themselves to the entry date, which maximises the value of their investments. Based on this procedure the optimal strategy of the firms will define the *open loop equilibrium* of the market entry game of symmetric duopoly firms.

3.3.2.1 Value Function of the Follower

As the Follower maximises the value of his market entry after the Leader's entrance, he faces almost the same entry decision as the Monopolist. The significant difference between the Monopolist's and the Duopolist Follower's entry choice is that the duopoly profit per unit time of $pX_t D(2)$ is below the Monopolist's profit per unit time of $pX_t D(1)$, due to the downward-sloping inverse demand curve⁵¹. Based on the above argument the Follower's value function and optimal entry date can be expressed by replacing the monopoly profit with the duopoly profit in *equations (9) and (14)* as presented below:

$$(16) F(X_t) = \begin{cases} \left[\frac{pD(2)}{(r_m - m)} X_{t_F} - I \right] \left[\frac{X_t}{X_{t_F}} \right]^b & \text{if } X_t \in [0; X_{t_F}) \\ \frac{pD(2)}{(r_m - m)} X_t - I & \text{if } X_t \in [X_{t_F}; \infty) \end{cases}$$

$$(17) X_{t_F} = \frac{b}{b-1} \frac{(r_m - m)}{pD(2)} I$$

where $F(X_t) < M(X_t)$ and $X_{t_F} > X_{t_M}$ since $D(2) < D(1)$

⁵¹Both investors invest the same amount of investment costs noted by I .

3.3.2.2 Immediate Joint Market Entry

Since firms are assumed to be symmetrical, in case of immediate joint market entrance both firms pay the same investment costs and receive the same duopoly profit per unit time.

The payoff values of the firms' immediate joint investment equals therefore the *static NPV* of the Follower's market entry, which can be expressed based on *equation (16)* as follows:

$$(18) J(X_t) = \frac{pD(2)}{(r-m)} X_t - I \text{ for } \forall X_t \in [X_0; \infty)$$

It needs to be observed that the Follower's value function includes the time value of potential waiting as premium compared to the value of immediate joint entry. Therefore applying the results of *equations (16)* and *(18)* the following relations hold:

$$(19) \begin{aligned} J(X_t) &< F(X_t) && \text{for } \forall X_t \in [X_0; X_{t_f}) \\ J(X_t) &= F(X_t) && \text{for } \forall X_t \in [X_f; \infty) \end{aligned}$$

3.3.2.3 Market Entry Strategies of the Follower

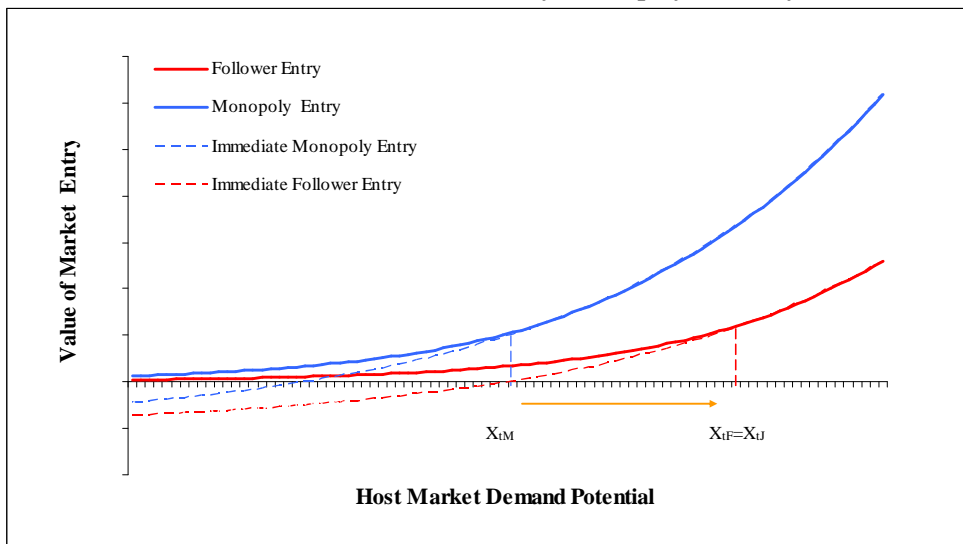
Before the optimal investment trigger X_{t_f} the market entry opportunity incorporates significant time value of delay, therefore the strategy of the Follower is to wait with his entry. The host market demand potential is not sufficiently large for providing the expected return on investment costs for two firms and the Follower invests after the Leader by definition.

The Follower enters the market immediately as soon as the demand potential of the host market reached the optimal investment threshold of X_{t_f} , where two investors can generate enough profit for covering their investment and waiting costs. At that point in time the time value of waiting with the market entrance evaporates and the value of the Follower's investment equals the *static NPV* of the perpetual duopoly profits and investment costs.

Given the same investment costs, the Follower's investment trigger occurs later than that of the Monopoly since the Follower's future market share (future profit) is smaller.

The following chart presents the value functions and the optimal market entry thresholds of the Monopolist and the Follower Duopolist:

Chart 3: Follower Market Entry in Duopoly Economy



3.3.2.4 Value Function of the Leader

Once the Leader entered the market at t_L he receives the monopoly profit of $P(t) = X_t pD[1]$, until the Follower's optimal entry date at t_F . Following the Follower's arrival both firms receive the same perpetual duopoly profit of $P(t) = pX_t D[2]$. Depending on the initial level of host market demand potential the Leader's value function can be derived based on the present value of the following expected future cash flows:

If $X_t \in [X_{t_F}; \infty)$, then the Leader invests immediately as the demand potential of the host market is large enough to provide the expected return on investment for the Duopolist competitors. In that case the Leader invests immediately with the Follower and both firms get the *static NPV* value of the perpetual duopoly profit and investment costs as expressed below:

$$(20) \frac{pD(2)}{(r_m - m)} X_t - I.$$

If $X_t \in [X_{t_L}; X_{t_F})$, then the demand potential of the host market provides the expected return on investment for only one firm. Therefore the Leader invests immediately and gets the monopoly profit until a stochastic expiration date of t_F , where the Follower enters the market. The expected present value of Leader's profit flow can be formally expressed as follows:

$$(21) E \left[\int_t^{t_F} e^{-r_m t} X_t pD(1) dt \right] + E \left[e^{-r_m (t_F - t_L)} \int_{t_F}^{\infty} e^{-r_m t} X_t pD(2) \right] - I$$

For technical convenience⁵² the above profit flow can be stripped further as the perpetual dividend rate of the Monopoly profit starting from the date of the Leader's market entrance minus the perpetual mark-up rate between the monopoly profit and the duopoly profit which the Leader loses from the date of the Follower's market entrance⁵³.

⁵² The deduction of the Leader value function presented in this section differs slightly from those provided in the existing literature. The method applied was chosen to provide a more detailed economic interpretation rather than a simple mathematical procedure.

⁵³ This substitution can be formally expressed as $pX_t D(2) = pX_t D(1) - [pX_t D(1) - pX_t D(2)]$

Based on that idea and after replacing the results of the discount factor to the stochastic arrival date of the Follower from *equation (13)* the expression of *equation (21)* can be rewritten as follows:

$$(22) \quad E \left[\int_t^{\infty} e^{-r_m t} X_t p D(1) dt \right] - E \left[e^{-r_m (t_F - t)} \int_{t_F}^{\infty} e^{-r_m t} X_t p (D(1) - D(2)) \right] - I = \\ \frac{X_t p D(1)}{r_m - m} - \left(\frac{X_t}{X_{t_F}} \right)^b \frac{X_{t_F} p (D(1) - D(2))}{r_m - m} - I$$

To compare the above results with the value function of the Follower, the last expression in *equation (22)* should be rearranged as follows:

$$(23) \quad F(X_t) + \frac{pD(1)}{(r_m - m)} X_t \left[1 - \left(\frac{X_t}{X_{t_F}} \right)^{b-1} \right] - I \left[1 - \left(\frac{X_t}{X_{t_F}} \right)^b \right]$$

If $X_t \in [0; X_{t_L}]$, then the demand potential on the host market is not sufficient for providing the expected return on the investment of the Leader. In that case the immediate market entry is not optimal for the Leader as it incorporates significant time value of waiting. Therefore the value of the Leader's market entry can be expressed as the discounted value of the Leader entry at the stochastic optimal entry trigger date of t_L .

This is formally expressed as follows:

$$(24) \quad E \left[e^{-r_m (t_L - t)} \left[E \left(\int_{t_L}^{\infty} e^{-r t} X_t p D(1) dt \right) - E \left[e^{-r_m (t_F - t_L)} \int_{t_F}^{\infty} e^{-r_m t} X_t p (D(1) - D(2)) \right] - I \right] \right] = \\ \left(\frac{X_t}{X_{t_L}} \right)^b \left(\frac{p[D(1) - D(2)]}{(r_m - m)} X_L \left[1 - \left(\frac{X_L}{X_{t_F}} \right)^{b-1} \right] + \frac{pD(2)}{(r_m - m)} X_L - I \right)$$

3.3.2.5 Exogenous Market Entry Trigger of the Leader

Equation (23) shows, that the Leader enters the market before the Follower only if the present value of the monopoly profits received additionally until the date of the Follower's arrival compensates the lost time value of the up front investment costs⁵⁴.

Following this decision rule the optimal entry date of the Leader can be obtained by maximising the excess value of the Leader compared to the Follower value with respect to X_{t_L} . The excess value of the Leader based on equation (23) is denoted as follows:

$$(25) \quad \Phi_{L/F}(X_t) = \frac{pD(1)}{(r_m - m)} X_t \left[1 - \left(\frac{X_t}{X_{t_F}} \right)^{b-1} \right] - I \left[1 - \left(\frac{X_t}{X_{t_F}} \right)^b \right]$$

Since before his market entrance the Leader realises his additional profit in the form of capital gain, the value function of the excess profit must satisfy the following non arbitrage requirement (Bellman equation):

$$(26) \quad r_m \Phi_{L/F}(X_t) = E(d\Phi_{L/F}(X_t))$$

The solution of the above presented optimal stopping problem must take the following general form:

$$(27) \quad \Phi_{L/F}(X_t) = A_1 X_t^{b_1},$$

In addition $\Phi_{L/F}(X_t)$ must satisfy the following boundary conditions, which holds at the optimal entry date of the Leader noted by X_{t_L} :

⁵⁴This is equivalent with the requirement that $L(X_t) > F(X_t)$ or $\frac{pD(1)}{(r_m - m)} X_t \left[1 - \left(\frac{X_t}{X_{t_F}} \right)^{b-1} \right] > I \left[1 - \left(\frac{X_t}{X_{t_F}} \right)^b \right]$, which is obtained based on equation (23). The first component reflects the present value of the restricted monopoly profits and the second component shows the lost time value of earlier investment costs.

The “*value matching*” condition requires that at the optimal entry date of the Leader the additionally received monopoly profit per unit time compensates the loss on time value of early investment costs per unit time. This can be formally expressed as follows:

$$(28) \quad A_1 X_L^b = \frac{pD(1)}{(r_m - m)} X_{t_L} \left[1 - \left(\frac{X_{t_L}}{X_{t_F}} \right)^{b-1} \right] - I \left[1 - \left(\frac{X_{t_L}}{X_{t_F}} \right)^b \right]$$

The “*smooth pasting*” condition requires furthermore that at optimal entry date of X_{t_L} these two value components change their value to the same extent with the instantaneous change in X_t . This requirement excludes the existence of additional optimal investment date(s) either to the right or to the left of the optimum and can be formally expressed as presented below:

$$(29) \quad A_1 b X_L^{b-1} = \frac{pD(1)}{(r_m - m)} - \frac{pD(1)}{(r_m - m)} b \left(\frac{X_{t_L}}{X_{t_F}} \right)^{b-1} + \frac{I}{X_{t_F}} b \left(\frac{X_{t_L}}{X_{t_F}} \right)^{b-1}$$

while zero as absorbing barrier remains and $\Phi_{L/F}(0) = 0$ holds.

After multiplying *equation (29)* by $\frac{X_{t_L}}{b}$ and deducting it from *equation (28)*, the optimal investment trigger for the Leader is obtained as follows:

$$(30) \quad X_{t_L} = \frac{b}{b-1} \frac{r-m}{pD(1)} I = X_{t_M}$$

Based on the results of *equations (20), (22), (24) and (30)* the value function of the Leader in case of exogenously given roles can be written as below:

$$(31) \quad L(X_t) \begin{cases} \left[\frac{p[D(1)-D(2)]}{(r_m - m)} X_{t_L} \left[1 - \left(\frac{X_{t_L}}{X_{t_F}} \right)^{b-1} \right] + \frac{pD(2)}{(r_m - m)} X_{t_L} - I \right] \left[\frac{X_t}{X_{t_L}} \right]^b & \text{if } X_t \in [0; X_{t_L}) \\ \frac{p[D(1)-D(2)]}{(r_m - m)} X_t \left[1 - \left(\frac{X_t}{X_{t_F}} \right)^{b-1} \right] + \frac{pD(2)}{(r_m - m)} X_t - I & \text{if } X_t \in [X_{t_L}; X_{t_F}) \\ \frac{pD(2)}{(r_m - m)} X_t - I & \text{if } X_t \in [X_{t_F}; \infty) \end{cases}$$

where $X_{t_L} = \frac{b}{b-1} \frac{r-m}{pD(1)} I$

3.3.2.6 Exogenous Market Entry Strategies of the Leader

The result of *equation (30)* shows, that despite the lower profit flow of the Duopolist Leader the optimal investment thresholds of both the Duopolist Leader and the Monopolist occur at the same level of demand potential of the host market.

The reason for the irrelevance of future competitor's arrival in the optimal timing of Leader's market entrance in case of exogenously given firm roles can be explained backwards as follows:⁵⁵

The Duopolist firms invest immediately if the initial level of host market maturity reaches at least the level of optimal entry for the duopoly profit, which occurs at $X_{t_J} = X_{t_F} > X_{t_L}$. As the duopoly profit is below that of the monopoly profit by definition, the Monopoly will also immediately enter the host market at that level of initial demand potential⁵⁶.

In case of entry before X_{t_F} the additionally received monopoly profit should compensate the loss of time value of the up-front investment costs per each unit time. These costs and benefits per unit time are exactly the same for both the Monopolist and the Leader Duopolist. Consequently compared to the joint entry date of the Duopolist firms, the market entry of both the Duopolist Leader and the Monopolist occurs with exactly the same units of time earlier.

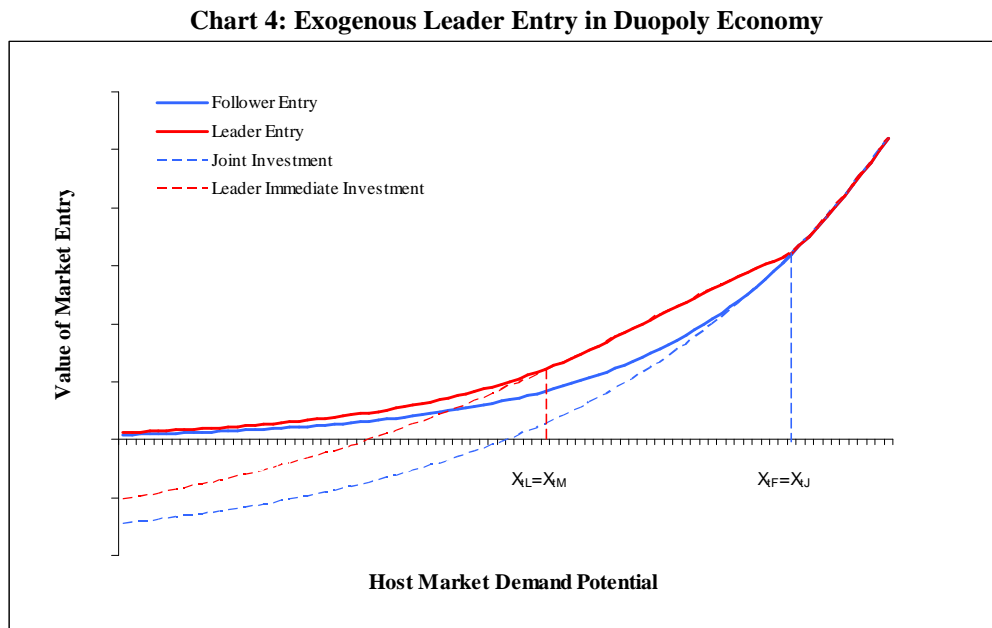
In case of exogenously given roles the Leader can maximise his entry value by ignoring the action of the Follower⁵⁷ as a result of which his optimal entry date is determined by common economic indicators of the host market in the same way as the Monopoly's market entry trigger.

⁵⁵The decision problem of the optimal Leader's market entry can be also formulated as follows: *With how many units of time does the investment/market entrance of the Duopolist Leader and the Monopolist occur earlier than that of the Duopolist Follower?*

⁵⁶Investment costs are assumed to be the same for both the Monopolist and for the Duopolist investors.

⁵⁷The Follower invests only after the Leader (or jointly at the same joint investment threshold) by definition.

The chart below presents the value functions of the Leader and the Follower in case of exogenously given Leader and Follower roles:



Based on the above analysis the open loop equilibrium of market entry in a duopoly economy with exogenously given Leader and Follower roles is given by the investment of the Leader at the optimal Monopoly market entry trigger noted by $X_{t_L} = X_{t_M}$ and the investment of the Follower at the optimal immediate joint entry trigger of the firms noted by $X_{t_J} = X_{t_F} > X_{t_L}$. As the Leader's entry date does not influence the Follower's profit flow the entry timing of the Follower and that of the Joint investment coincide at $X_{t_F} = X_{t_J}$. This result presents a correction of the optimal entry thresholds given by Dixit and Pindyck, 1994 on page 314⁵⁸. These authors' result of $X_{t_F} < X_{t_J}$ (or $Y_2 < Y_3$ based on their notation) can only hold if the Leader's action has an impact on the Follower's payoff. This situation occurs for example in case of assuming the existence of Follower's entry barrier (e.g. additional marketing costs in case of late arrival). The market entry equilibrium in this special case will be examined in the next chapter under the extension of the standard valuation model.⁵⁹

⁵⁸Dixit, A.K., and Pindyck, R.S., 1994 Investment under Uncertainty (Princeton University Press)

⁵⁹Another example, where the results of Dixit and Pindyck hold, has been presented by K. J. M. Huisman in the analysis of technology investments. Huisman examined the situation where both firms are already competing on the market and assumed that the introduction of a new technology by one of the competitors decreases the profit flow of his counterpart. As in this case the Follower is interested in recapturing his market share, Huisman received the same equilibrium results as Dixit and Pindyck.

3.3.2.7 Endogenous Market Entry Trigger of the Leader

As it is not realistic to assume that competing firms commit themselves to the Leader or to the Follower roles before entering a new market, in the next step of the analysis the Leader and the Follower roles are given endogenously.

Searching for the optimal entry date of the Leader (X_{t_L}), it was assumed, that the Leader brings its entry date forward in time as long as the compensation of increase in the present value of the additionally received monopoly profit per unit time is greater than or at least equals the increase of the present value of the investment costs per unit time.

Based on that assumption the sum of additionally received net present values per unit time which the Leader receives if $X_t \in [X_{t_L}; X_{t_F}]$ should be positive by definition. This also means, that the Leader's value exceeds the Follower's value at the optimal Leader investment trigger of X_{t_L} , which can be proved formally by the following calculations:

Denote the difference in the Duopolist firms' investment payoffs at X_{t_L} by the following expression:

$$(32) \quad \Phi_{L/F}(X_{t_L}) = L(X_{t_L}) - F(X_{t_L})$$

Replacing the results of the equations (31) and (16) into equation (32) the following result is obtained:

$$(33) \quad \Phi_{L/F}(X_{t_L}) = I \frac{b}{b-1} \left[1 - \left(\frac{D(2)}{D(1)} \right)^{b-1} \right] - I \left[1 - \left(\frac{D(2)}{D(1)} \right)^b \right] > 0^{60}$$

The assumption of endogenously given Leader and Follower roles implicates, that the firm's investment decision is determined by profit maximising economic considerations. As the

⁶⁰Expression under equation (33) exceeds zero because the followings results hold:

$$\Phi_{L/F}(X_{t_L}) = 0 \quad \text{if} \quad \frac{D(2)}{D(1)} = 1 \quad \text{while}$$

$$\frac{\partial \Phi_{L/F}(X_{t_L})}{\partial \frac{D(2)}{D(1)}} = -bI \left(\frac{D(2)}{D(1)} \right)^{b-2} + bI \left(\frac{D(2)}{D(1)} \right)^{b-1} < 0 \quad \text{for} \quad \frac{D(2)}{D(1)} \in (0;1)$$

Leader's value function exceeds the Follower's value function at X_{t_L} , there is no reason to believe that either firm will give up the Leader role for the Follower position. Consequently in order to opt for the Leader role, one firm will have the incentive to "ε-pre-empt" his counterpart at the optimal Leader entry date and invest at time $X_{t_{L2}} = X_{t_L} - e$ where $e > 0$.

The best reaction of the competitor firm to that strategy would be to invest at $X_{t_{L3}} = X_{t_L} - 2e$. Hence the preemption game continues as long as the Leader's extra profit is eliminated and the process stops if $\Phi_{L/F}(X_{t_p}) = 0$ holds. This requirement implies the following results at the optimal endogenous entry date of the Leader Duopolist:

$$(34) L(X_{t_p}) = F(X_{t_p}) \text{ and } X_{t_p} < X_{t_L} \quad ^{61}$$

As at X_{t_p} the values of the Leader and the Follower market entries are equal, the result of the preemption game is called as *rent equalisation*. This result presents the strategic impact of competition which drives each firm to pre-empt his rival up until the point where the Leader's market entry has no extra profit and the Leader investment strategy provides the same profit as the Follower's payoffs.

⁶¹The preemption point X_{t_p} represents the point in time, where the net present value of the monopoly profits cumulated from X_{t_L} up until X_{t_F} is eliminated completely. Because of the value matching condition of *equation (28)* the Leader's additional monopoly profit does not compensate the lost time value of investment costs per unit time before X_{t_L} as a result of which the Leader loses from its value in the preemption game with each unit of time of earlier investment than X_{t_L} .

Based on the above the Leader value function in the case of endogenously given roles needs to be modified as follows:

$$(35) \quad L(X_t) \begin{cases} \left[\frac{p[D(1)-D(2)]}{(r_m - m)} X_{t_p} \left[1 - \left(\frac{X_{t_p}}{X_{t_f}} \right)^{b-1} \right] + \frac{pD(2)}{(r_m - m)} X_{t_p} - I \right] \left[\frac{X_t}{X_{t_p}} \right]^b & \text{if } X_t \in [0; X_{t_p}) \\ \frac{p[D(1)-D(2)]}{(r_m - m)} X_t \left[1 - \left(\frac{X_t}{X_{t_f}} \right)^{b-1} \right] + \frac{pD(2)}{(r_m - m)} X_t - I & \text{if } X_t \in [X_{t_p}; X_{t_f}) \\ \frac{pD(2)}{(r_m - m)} X_t - I & \text{if } X_t \in [X_{t_f}; \infty) \end{cases}$$

where X_{t_p} is given by the solution of the following equation:

$$(36) \quad \frac{pD(1)}{(r_m - m)} X_{t_p} \left[1 - \left(\frac{X_{t_p}}{X_{t_f}} \right)^{b-1} \right] = I \left[1 - \left(\frac{X_{t_p}}{X_{t_f}} \right)^b \right]$$

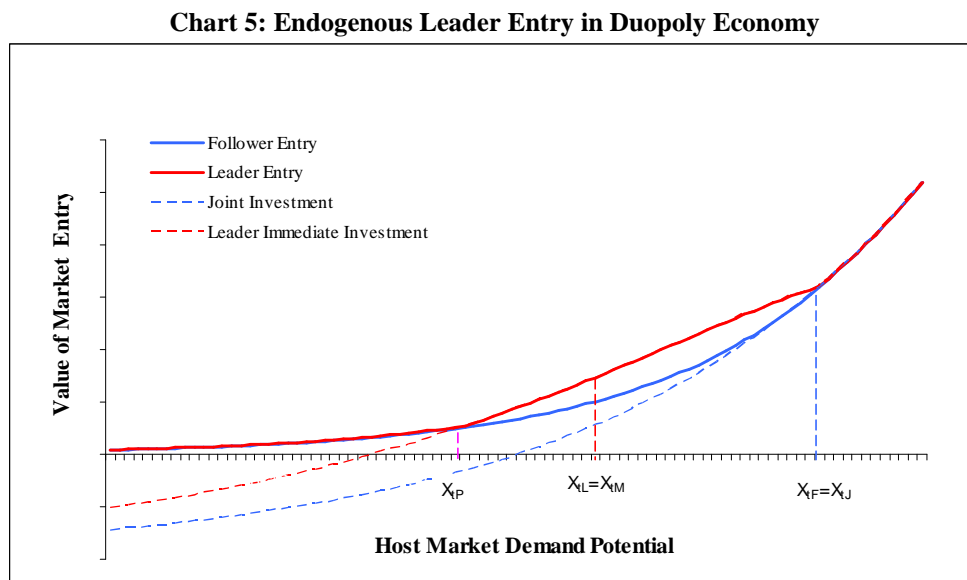
and the below presented results hold:

$$(37) \quad L(X_t) = F(X_t) \quad \text{for } \forall X_t \in [0; X_{t_p}] \text{ and for } \forall X_t \in [X_{t_f}; \infty)$$

$$L(X_t) > F(X_t) \quad \text{for } \forall X_t \in (X_{t_p}; X_{t_f})$$

3.3.2.8 *Endogenous Market Entry Strategies of the Leader*

The following chart presents the market entry value function of the Leader, the Follower and the Joint (immediate) investment in case of endogenously given roles and symmetric firms:



Because of the optimisation criteria of the Follower’s value function, the values of an immediate joint investment are either below the Follower’s strategy payouts (for $\forall X_t \in [0; X_{t_F})$) or equal the Follower’s strategy payouts (for $\forall X_t \in [X_{t_F}; \infty)$).⁶²

If $X_t \in [X_{t_L}; X_{t_F})$ then the excess Monopoly profit compensates the loss in time value of up front investment costs per each unit time and makes it possible for one of the competitors to enter the market earlier than the joint investment threshold. The Leader value exceeds the Follower value at the Leader’s optimal investment threshold of X_{t_L} as a result of which both firms want to get the Leader role and try to ε *pre-empt* each other. This competition for obtaining the Leader role accelerates the Leader’s entry beyond the optimal trigger of X_{t_L} .

⁶²The Follower value function includes the time value of the joint investment, which additional value evaporates at the optimal joint entry date by definition.

Since the Monopoly profit does not compensate the loss in time value of the up-front investment costs per unit time before the optimal Leader investment trigger, the Leader loses from its value by each unit time in case of an entry before X_{t_L} . Finally the preemption process stops at the intersection point of the Leader and the Follower value functions noted by X_{t_p} , at which point the value of the Leader's excess profit generated by the mark-up dividend rate of $D(1) - D(2)$ per unit time has been completely eliminated. At this trigger the two roles provide the same value of market entrance as a result of which the impact of the competition is referred to as rent equalisation in the literature.

Before X_{t_p} the *dynamic NPV* value of the market entry has positive time value even for the Leader. Before that date the immediate investment is therefore not optimal and both investors wait until the host market demand potential reaches X_{t_p} .

The results of the theoretical market entry model in a duopoly economy explain the staggered pattern of foreign retailers' market entry behaviour in Eastern Europe, which was characterised by certain time lag(s) in foreign investors' arrival within a given country. This entry behaviour is the result of two opposing impacts of competition on foreign investors' entry:

On the one hand *expected level of competition* accelerated the market entry of investors driven by the preemption process. This strategic impact of competition motivated first retailer(s) to invest soon in Eastern Europe.

On the other hand, however, increase in *actual level of competition* deterred further investments until the host market demand potential reached a higher level. This effect implies that once foreign retailer(s) entered the Eastern European markets successfully their competitors had to wait until the demand potential increased significantly.

Based on the above it is vital to separate the two opposing impacts of competition and measure the impact of its expected and its actual level separately in the empirical tests.

3.3.3 *Equilibrium Strategies*

The previous section described how the first mover advantage of the Leader intensifies the competition between the firms and eliminates the time value of waiting by the threat of preemptive market entrance.

Since it is only optimal for one firm to enter the market before the optimal joint entry date, the preemption game leads to the coordination problem between the firms on deciding which one of them will invest first. This section presents the solution of this coordination problem with the application of game theory.

As both firms are assumed to be identical in the standard model, there is no reason to assume that firms behave differently in case of endogenously given roles. This symmetry of the firms implicates that the equilibrium must be determined by symmetric strategies and symmetric mixed strategies must be applied for the solution of the firms' coordination problem at X_{t_p} ⁶³.

⁶³The market entry game of Duopolist firms is played at $X_t \in [X_p; X_F)$ if neither of the competitors has invested up until X_t . If $X_t \in (X_p; X_F)$ this situation occurs either by mistake or in case the game starts at $X_t > X_p$. Outside the interval of $X_t \in [X_p; X_F)$ the firms' strategies are obvious: below X_p both firms wait with the investment and above X_F both firms invest simultaneously.

3.3.3.1 Timing Games in District-Time

In the first step the preemption equilibrium is analysed in district time for $X_t \in [X_P; X_F]$. Applying mixed strategies and assuming that *firm i* invests with probability α_i and *firm j* invests with probability α_j , the value of *firm i* at X_t can be expressed based on his payoff matrix as follows:

$$(38) V_i = \max_{\alpha_i} [a_i(1-a_j)L(X_t) + (1-a_i)a_jF(X_t) + a_i a_j J(X_t) + (1-a_i)(1-a_j)V_i]$$

Due to the symmetry of the firms, *firm j* has exactly the same value at this point as expressed below:

$$(39) V_j = \max_{\alpha_j} [a_j(1-a_i)L(X_t) + (1-a_j)a_iF(X_t) + a_j a_i J(X_t) + (1-a_j)(1-a_i)V_j]$$

Applying the first order conditions for both firms' value function and assuming symmetric strategies (which means that $\alpha_j = \alpha_i = \alpha$), the probability of the market entrance in discrete time is obtained as follows:

$$(40) \alpha = \frac{L(X_t) - F(X_t)}{L(X_t) - J(X_t)}, \text{ where } \alpha \in [0;1] \text{ holds.}$$

This result reveals that each firm's incentive for investment (the probability of market entry) is determined by the ratio of benefits resulting from preemption to the range of total possible outcome of the game.

Replacing $\alpha_j = \alpha_i = \alpha$ into equations (38) and (39), the values of firms *i* and *j* are expressed respectively as follows:

$$(41) V_{i/j} = \frac{1-\alpha}{2-\alpha} L(X_t) + \frac{1-\alpha}{2-\alpha} F(X_t) + \frac{\alpha}{2-\alpha} J(X_t)$$

Equation (41) expresses the value of market entry by the sum of all potential strategies weighted by the respective probabilities for the occurrence.

Since the firms are identical, being the Leader occurs with the same probability of $\frac{1-a}{2-a}$ as being the Follower, while the remaining probability of $\frac{a}{2-a}$ is distributed to the occurrence of suboptimal Joint Investment.

The result presented in *equation (40)* shows that rent equalisation eliminates the probability of suboptimal joint investment at the preemption point since α goes to zero if $L(X_t) = F(X_t)$. At this single point of host market demand potential investors even with endogenously defined roles may coordinate their strategy and agree on which company enters the new market first. Hence, there will be no incentive to deviate from the agreed strategy on either part, since both the Leader and the Follower roles provide the same payoffs at this point.⁶⁴

If $X_t \in (X_{t_p}; X_{t_f})$ then the probability of simultaneous investment is always positive and is increasing with the firms' incentive to invest and to become the Leader (noted by a). This result shows that risk neutral players are willing to risk as much as the expected value of their investment equals the expected value of the Follower's strategy payoff in order to get the lucrative Leader role.

For cases of $X_t \in [0; X_p)$ and $X_t \in [X_f; \infty)$ the firms do not adopt mixed strategies as the optimisation problem is straightforward to solve. In the first case investment is never optimal, therefore $a = 0$, while in the second case both firms invests for sure and $a = 1$ holds.

⁶⁴As such coordination agreements are generally illegal the most possible outcome may be that both firms wait with their investment one unit of time until the host market reaches a higher market maturity.

Investors may apply mixed strategies individually by randomly deciding on every market entry. In each case, investors' decisions should follow a truly random pattern and the probability of investing or remaining outside should remain independent in every new investment opportunity from any history of decisions.⁶⁵

Although it may be assumed that managers make investment decisions by intuitively considering the benefit of surprise in their strategies, it is hardly realistic to believe that corporate leaders play the market entry games based on strict probability calculations. However, it needs to be observed that the application of mixed strategies requires random appearance of decision outcomes over the group of investors and as a consequence it allows for individual investors to choose pure strategies. Although investors may be indifferent between the pure strategies of investing or waiting, it is easy to assume that individual factors determine which actions are chosen by which firm. The application of mixed strategies can therefore be regarded as the realised outcome of investment decisions of various firms, which results can be statistically observed and analysed ex-post based on the trend of continuously increasing number of foreign retailers' entry in the Eastern European countries during the analysed period.

⁶⁵Foreign retailers can theoretically apply individual random decisions of geographical market entry by adapting the following procedures:

Market entry into a particular country needs to be considered without respect to prior market entry into other country/countries of the region and without respect to the outcome of previous market entry/entries. If more than one country reaches the necessary demand potential for the market entrance at the same time, retailers need to select from these countries based on the investment probability of the mixed strategy (e.g. investing in one randomly selected country out of three). However, investors must understand that applying mixed strategies gives the best possible expected value of the investments on average and incorporates outcomes of occasional low payoffs.

3.3.3.2 Timing Games in Continuous-Time

One player's mixed strategy in continuous-time is generally represented by a non-decreasing, right-continuous cumulative distribution function noted as $G_i(t) \in [0;1]$, which expresses the probability that *firm i* has invested by time t ⁶⁶. Applying this representation for equation (41) the expected value of *firm i* can be expressed as follows:

$$(42) \quad V_i(G_i; G_j) = \int_0^{\infty} (L(X_t)(1 - G_j(t))dG_i(t) + F(X_t)(1 - G_i(t))dG_j(t)) + \sum_0^{\infty} a_i(t)a_j(t)J(X_t),$$

where the following notations have been applied:

$1 - G_{i/j}(t)$ expresses the probability, that *firm i/j* has not invested up until time t .

$dG_{i/j}(t)$ represents the probability density function of *firm i/j* investment strategy and its value expresses the probability that *firm i* invests at time t in the infinitely small interval of $[t; t + e]$.

$a_{i/j}(t)$ measures the size of jump in the firms' cumulative distribution function of $G_{i/j}$ at time t and is calculated as $a_{i/j}(t) = G_{i/j}(t) - G_{i/j}(t^-)$ where $G_{i/j}(t^-)$ represents the left hand limit of $G_i(t)$ ⁶⁷. Its value expresses the probability with which *firm i/j* invests at exactly time t .

⁶⁶Following the representation of Thijssen, J.J.J., Huisman, K.J.M. and Kort, P.M., 2002 Symmetric Equilibrium Strategies in Game Theoretic Real Option Models, Discussion Paper CentER on page 8, the cumulative distribution function of *firm i* is independent from the strategy of his competitor.

⁶⁷The cumulative distribution function is right continuous by definition.

Fudenberg and Tirole argued (1985)⁶⁸ that in continuous time the symmetric mixed strategy of the firms can not be represented by a single distribution function as expressed by *equation (42)* since this representation can not capture the limit of discrete time equilibria with short time intervals. This can be proved by the following example:

Let Δt be defined as the length of period of the game so that for some constant N the equation $t = N\Delta t$ holds.

Applying the game's payoff matrix, the probability that at least one investor has entered the new market by *time* t can be expressed as follows:

$$(43) \quad 1 - ((1 - a_i)(1 - a_j))^N$$

As Δt converges to zero in continuous time, the probability that at least one player has entered the market at any positive t time (even at the start) converges to 1⁶⁹. As a consequence the game stops with probability 1 at the beginning of the time interval noted by $t_0 \in [X_{t_p}; X_{t_f})$. Applying the continuous time representation of the market entry strategies the cumulative distribution function of the firm, which invests at the beginning of the time interval, jumps to 1 at $t_0 \in [X_{t_p}; X_{t_f})$. However, this outcome represents a contradiction to the limit value of one firm's investment probability at $t_0 \in [X_{t_p}; X_{t_f})$ in discrete time shown under *equation (41)*⁷⁰. In discrete time investors can always adjust the probability of market entrance making the competitor indifferent to investment.

Based on the above, the application of strategy space in continuous-time as presented under *equation (42)* can not capture the discrete time limits of *equation (41)* and leads to missing coordination between the players.

⁶⁸Fudenberg, D. and Tirole, J., 1985 Preemption and Rent Equalization in Adoption of New Technology Review of Economic Studies

⁶⁹ $\lim_{N \rightarrow \infty} ((1 - a_i)(1 - a_j))^N = 0$ since $(1 - a_i) < 1$ and $(1 - a_j) < 1$

⁷⁰As pointed out by Fudenberg and Tirole the continuous time representation of preemption game strategies links the atom of size *one* in continuous time to the same size in discrete time. However, in discrete time the atom at the beginning of the period does not represent the probability of investing with probability *one* at exactly $t_0 \in [X_{t_p}; X_{t_f})$ but it refers rather to an "interval of atoms" expressing the probability of investing after $t_0 \in [X_{t_p}; X_{t_f})$.

In order to capture the discrete time limits of the game in continuous time the strategy space should be enlarged by an additional function noted by $a_i(t)$ to coordinate the firms' investment decisions.

As a result the market entry game in continuous time needs to be split respectively into

- (i) a *timing game*, which defines the optimal investment date and
- (ii) a *coordination game*, which defines the incentive of the players to invest (the probability of market entry). This game is played as soon as it is optimal for only one firm to invest ⁷¹. The outcome of this second game distributes the Leader and the Follower roles to the firms and creates the dependence of one firm value from the other's strategy.

The first game is played in continuous time and strategies are therefore given by a cumulative distribution function. The second game represents a repeated game in discrete time, in which the firms play fixed mixed strategies of investing or waiting until at least one firm invests.

⁷¹This situation occurs in the range of $X_t \in [X_{t_p}; X_{t_f})$.

The following game theoretic analysis is based on the perfect equilibrium concept of Fudenberg and Tirole (1985) which approach was extended by Thijssen, Huisman, Kort, Pawlina (2004)⁷² to stochastic games.

Definition of Firm's Extended Strategy Space:

As the market entry game is separated into a continuous timing game and into a discrete coordination game the simple strategy for *firm i/j* should be represented at $t \in [t_0; \infty)$ by the following pair of real-valued functions

$$(44) S^{t_0}(t; w) = \left(G_{i/j}^{t_0}(t; w); a_{i/j}^{t_0}(t; w) \right) \text{ where:}$$

1. $G_{i/j}^{t_0}(\cdot; w)$ is non-decreasing and right-continuous cumulative distribution function with left limits and denotes the probability that *firm i/j* has invested by time t
2. $a_{i/j}^{t_0}(\cdot; w)$ is right-differentiable and right-continuous function with left limits and coordinates the firms investment decision in the interval of $[t; t + dt]$ by expressing the probability that *firm i/j* enters the market if investment by at least one firm is optimal⁷³

The firms should coordinate their continuous strategies in order to ensure, that the investment of at least one firm occurs at $X_t \in [X_{t_p}; X_{t_f})$. The coordination requires the consistency between the cumulative distribution function and the discrete value function. This consistency is guaranteed by requiring that the increase in either firm's incentive to invest needs to indicate a jump in the cumulative distribution function of both firms. The size of the jump should reflect the increased probability of market entrance of the firms either in the form of Leader or in the form of joint investment according to the payoff matrix of the market entry game.

⁷²Thijssen, J.J.J., Huisman, K.J.M., Kort, P.M., 2002 Symmetric Equilibrium Strategies in Game Theoretic Real Option Models, Discussion Paper CentER

⁷³In order to determine the firms' roles in the limiting case where $a_{i/j} = 0$ the following additional technical conditions are required: $a_i^{t_0}(t; w) = 0$ and $t = \inf(u \geq t_0 | a_i^{t_0}(u; w) > 0)$, then $a_i^{t_0}(t; w)$ has positive right derivative at w .

This requirement is named as *a-consistency* of the strategies and is formally expressed as follows:

$$(45) \quad a_{i/j}^{t_0}(t;s) - a_{i/j}^{t_0}(t^-;s) \neq 0 \Rightarrow G_{i/j}^{t_0}(t;s) - G_{i/j}^{t_0}(t^-;s) = (1 - G_{i/j}^{t_0}(t^-;s)) \frac{a_{i/j}^{t_0}(t;s)}{a_{i/j}^{t_0}(t;s) + a_{j/i}^{t_0}(t;s) - a_{i/j}^{t_0}(t;s)a_{j/i}^{t_0}(t;s)}$$

It is assumed that playing the game costs no time and if both firms choose the option of not entering the market, the game will be repeated. The simple strategy space is defined as all possible strategy combination of the firms denoted as follows:

$$(46) \quad S^s(t_0;w) = \prod_{i/j} S_i^s(t_0;w)$$

Firms' Expected Payoff in the Extended Strategy Space

Let $t_i(t)$ be the earliest point in time at which *firm i* enters the market in the subgame starting at t_0 expressed as:

$$(47) \quad t_i = \begin{cases} \infty & \text{if } a_i(t; w) = 0 \quad \forall t \geq t_0 \\ \inf(t > t_0 | a_i(t; w) > 0) & \text{otherwise} \end{cases}$$

In order to ensure that at least one of the firms has invested for sure by a certain time $t(t)$ in the subgame starting at time t_0 the following notation is introduced:

$$(48) \quad t(t) = \min(t_i(t); t_j(t)),$$

Based on the above definitions of the strategy space the expected payoff for *firm i* in the subgame starting at time t can be expressed as follows:

$$(49) \quad V_i(t; (G_i, a_i); (G_j, a_j)) = \int_{s=t}^{t(t)^-} (L(X_s)(1 - G_j(s))dG_i(s) + F(X_s)(1 - G_i(s))dG_j(s)) + \sum_{s < t(t)} a_i(s)a_j(s)J(X_s) + (1 - G_j^-(t(t)))(1 - G_i^-(t(t)))W^i(t(t), (G_i, a_i); (G_j, a_j))$$

where

$t(t)^- = \lim_{u \rightarrow s} t(u)$ and expresses the left hand limit of $t(t)$ and

$W^i(t(t), (G_i, a_i); (G_j, a_j))$ is given by the following equations:

If $t_j(t) \neq t_i(t)$ then⁷⁴

$$(50) W^i(t(t), (G_i, a_i); (G_j, a_j)) = \begin{cases} \frac{1-G_j(t)}{1-G_j^-(t)} L(t) + \frac{a_j(t)}{1-G_j^-(t)} ((1-a_i(t))F(X_t) + a_i(t)J(X_t)) & \text{if } t_j(t) > t_i(t) \\ \frac{1-G_i(t)}{1-G_i^-(t)} F(X_t) + \frac{a_i(t)}{1-G_i^-(t)} ((1-a_j(t))L(X_t) + a_j(t)J(X_t)) & \text{if } t_j(t) < t_i(t) \end{cases}$$

and

If $t_j(t) = t_i(t)$ then⁷⁵

$$(51) W^i(t(t), (G_i, a_i); (G_j, a_j)) = \begin{cases} J(t) & \text{if } a_i = a_j = 1 \\ \frac{a_i(t)(1-a_j(t))L(X_t) + a_j(t)(1-a_i(t))F(X_t) + a_i(t)a_j(t)J(X_t)}{a_i(t) + a_j(t) - a_i(t)a_j(t)} & \text{if } 0 < a_i + a_j < 2 \end{cases}$$

The first two components of *equation (49)* appear in *equation (42)*. They express the expected value of *firm i* up until at least when it is optimal for one firm to invest in the subgame. The expected value equals the sum of probabilities of either obtaining the Leader role, or becoming the Follower or realising the expected value of joint investment.

The expression $(1 - G_j^-(t(t)))(1 - G_i^-(t(t)))$ represents the probability that neither of the firms have invested⁷⁶ by $t(t)$. In that case at least one firm's cumulative distribution function jumps to one in order to ensure that the game continues.

⁷⁴This situation occurs in case of asymmetric firms

⁷⁵It holds if firms are symmetric or in those subgames of asymmetric firms which are starting at $X_t \in [X_{t_{P_{A_1}}}, X_{t_{P_{A_2}}}]$, where both firms have incentive to become the Leader (see later at the market entry analysis of asymmetric firms in Chapter 4.2)

⁷⁶This occurs if both firms have chosen the option of remaining outside by coincidence.

If $t_j(t) > t_i(t) = t$ or $t_i(t) > t_j(t) = t$ then *firm i/j* invests with probability $a_{i/j}$ at each period while *firm j/i* enters the market with probability $\frac{a_{j/i}(t)}{1 - G_{j/i}^-(t)}$ at the first instance and with probability zero thereafter. This corresponds to a situation in which *firm j/i* plays an isolated jump of size $a_{j/i}(t)$ at time t and *firm i/j* adapts continuously with $a_{i/j}(t)$ ⁷⁷.

If $t_j(t) = t_i(t) = t$, then both firms consider the market entrance in each period. In that case the probabilities of getting the Leader/Follower roles or realising Joint investments are calculated from discrete time limits with constant probabilities of investment expressed by $a_{i/j}(t)$. The result is the same as presented by *equation (41)* under the discrete time.

If $t_j(t) = t_i(t) = 0$, then the firms' payoff is obtained by a first-order Taylor expansion.

⁷⁷In that case it is not optimal for *firm j/i* to invest until $t_{j/i}(t)$, therefore *firm j/i* can not coordinate his strategy.

Nash Equilibrium in the Extended Strategy Space

In equilibrium each firm looks for a strategy given by $S^{t_0}(t; w) = (G_i^{t_0}(t; w); a_i^{t_0}(t; w))_{i/j}$ which maximises its value expressed as $V_{i/j}(t; (G_{i/j}, a_{i/j}); (G_{j/i}, a_{j/i}))$ by holding the strategy of his counterpart fixed (Nash equilibrium).

In looking for the Nash equilibrium of market entry games firms should respond optimally to the exogenous move in host market demand potential, to the outcome of competitors' mixed strategies and to all possible deviations of rivals from the equilibrium strategy. This requirement means the application of closed loop strategies by definition.

In order to give the best reaction to all of the above described random outcomes at the end of each period, the firm's closed loop strategy should reflect that in stochastic case the probability of having invested up until *time* v depends only on the level of demand potential at *time* v and remains independent of that fact whether the market entry game started at *time* t or at *time* u . (The probability of investment at time t is independent of the length of subgame). This requirement is formally expressed below:

$$(52) \quad \forall_{0 \leq t \leq u \leq v} \quad G_i^t(v) = G_i^u(v)^{78}$$

$$(53) \quad \forall_{0 \leq t \leq u \leq v} \quad a_i^t(v) = a_i^u(v) = a_i(v)$$

A tuple of firms' closed loop strategies defines a subgame perfect equilibrium if it represents a Nash equilibrium in every possible subgame starting at $t \in [0; \infty)$. As in case of market entry games firms can observe and respond to their opponent's action at the end of each period, the application of closed loop strategies generally means subgame perfection.

⁷⁸Fudenberg and Tirole requires $\forall_{0 \leq t \leq u \leq v} \quad G_i^t(v) = G_i^t(u) + (1 - G_i^t(u))G_i^u(v)$ in their intertemporal consistency definition, requiring that the probability of having invested before *time* v starting at *time* t equals the probability of having invested before *time* u starting at *time* t plus the probability of having invested before *time* v starting at *time* u conditionally of not having invested before *time* u . Thijssen, J.J.J., Hismann, K.J.M. and Kort, P.M. pointed out that this is not a sensible requirement in the stochastic case.

3.3.3.3 Subgame Perfect Nash Equilibrium in Continuous Time

The value of the distribution function $G_i(\cdot; s)$ in case of geographical market entrance of symmetric firms is calculated as follows:

If $X_t \in [X_P; X_F)$ than the value of $G_i(\cdot; s)$ should reflect the probability that *firm i* invests. In that case, depending on the other firm's action, *firm i* either becomes the Leader by probability $\frac{1-a}{2-a}$ or realises joint market entrance with *firm j* by probability $\frac{a}{2-a}$.

Replacing the result of *equation (40)* for the expression of a , the value of $G_i(\cdot; s)$ is obtained by adding the probabilities of these possible outcomes.

Based on the above results a symmetric subgame perfect equilibrium is given by the tuple of closed-loop strategies $s_{0 \leq t < \infty}^{-t} \in ((G_i^t, a_i^t), (G_j^t, a_j^t))_{0 \leq t < \infty}$ where $t \geq 0$ and

$$(54) \quad G_{i/j}(t) = \begin{cases} 0 & \text{if } t < t_P \\ \frac{L(X_t) - J(X_t)}{L(X_t) - 2J(X_t) + F(X_t)} & \text{if } t_P \leq t < t_F \\ 1 & \text{if } t > t_F \end{cases}$$

$$(55) \quad a_{i/j}(t) = \begin{cases} 0 & \text{if } t < t_P \\ \frac{L(X_t) - F(X_t)}{L(X_t) - J(X_t)} & \text{if } t_P \leq t < t_F \\ 1 & \text{if } t > t_F \end{cases}$$

To prove that the above strategies yield Nash equilibrium in any subgame starting at $t \in (T_p; T_F)$ ⁷⁹ the following equation should hold:

$$(56) \quad G_{i/j} \left((1 - a_{j/t}) L_{i/j}(X_t) + a_{j/t} J_{i/j}(X_t) \right) + (1 - G_{i/j}) a_{j/t} F_{i/j}(X_t) = F_{i/j}(X_t)$$

The left side of *equation (56)* expresses the value of one firm making an isolated jump with a given probability. In that case, depending on his rival moves, the firm receives either the Leader's role or the payoff of the joint investment. With the remaining probability of not making the jump, the firm becomes the Follower if the other firm invests⁸⁰. The right hand side of *equation (56)* expresses the firm value in case of not making the jump for sure.

By replacing the values of $G_{i/j}$ and $a_{i/j}^t(t)$ given by *equations (54) and (55)* one can show that *equation (56)* holds. This implies that in each subgame of $t \in (T_p; T_F)$ following the strategies given by *equations (54) and (55)* makes firms indifferent between all possible choices⁸¹.

⁷⁹Outside this interval the Nash equilibrium prevails.

⁸⁰Based on the original assumption the game is repeated if neither firm has invested while repeating the game costs no time.

⁸¹A more formal proof that the under *equations (54) and (55)* given tuple of closed-loop strategies $s_{0 \leq t < \infty}^{-t} \in \left((G_i^t, a_i^t), (G_j^t, a_j^t) \right)_{0 \leq t < \infty}$ represent subgame perfect equilibrium is given in Thijssen, J.J.J., Huisman, K.J.M. and Kort, P.M., 2002 Symmetric Equilibrium Strategies in Game Theoretic Real Option Models, CentrER discussion paper

3.3.4 Conclusion

The fear of rival's preemption will not allow the firms in duopoly economy to maximise the time value of market entrance created by uncertainty.

There are two critical values of the host market demand potential which split the types of equilibrium and the optimal strategies of the symmetric firms in a duopoly economy.

1. For $\forall X_t \in [X_{t_F}, \infty)$ the absolute market demand is large enough for both competitors to enter the market simultaneously and therefore a Joint Entrance occurs.

2. For $\forall X_t \in [0, X_{t_p})$ the absolute market demand potential is so low that neither firm invests.

In this interval the value of entering the market is the same for the Leader and for the Follower and incorporates significant time value so that both firms wait until the market development reaches the preemption point.

3. For $\forall X_t \in (X_{t_p}, X_{t_F})$ being the Leader is the best strategy to follow, since the following relations hold:

- Above X_{t_p} and before X_{t_F} the present value of the monopoly profit opportunity overcompensates the lost time value of the investment costs, and consequently the Leader's strategy dominates the Follower's strategy.
- The Joint Investment is not Nash optimal since entering the market to get the duopoly profit includes time value before X_{t_F} . Driven by this time value both the Leader and the Follower strategies dominate the strategy of Joint Investment.

As both firms are motivated to become the Leader, the symmetric probability of getting the Leader or the Follower role is below one half and the mistake of Joint Investment at each $X_t \in (X_p, X_F)$ occurs with positive probability. Moreover it should be noted that based on the results of *equations (40) and (41)* the probability of

suboptimal joint investment increases with the mark-up in the Leader's value as the incentive to get the Leader role increases for both firms.

Based on the above, if $X_t \in (X_{t_p}, X_{t_f})$, then sequential market entry equilibrium occurs, where one firm becomes the Leader with the probability of *maximum one half* and the other enters the market as Follower with the *same probability* at X_{t_f} . With the remaining probability both firms invest and Joint market entrance occurs, which outcome does not represent the Pareto Optimum for either firm. However, the probability of this suboptimal outcome is positive since its value reflects the maximum risk which risk neutral players undertake in order to receive at least the expected value of the Follower role.

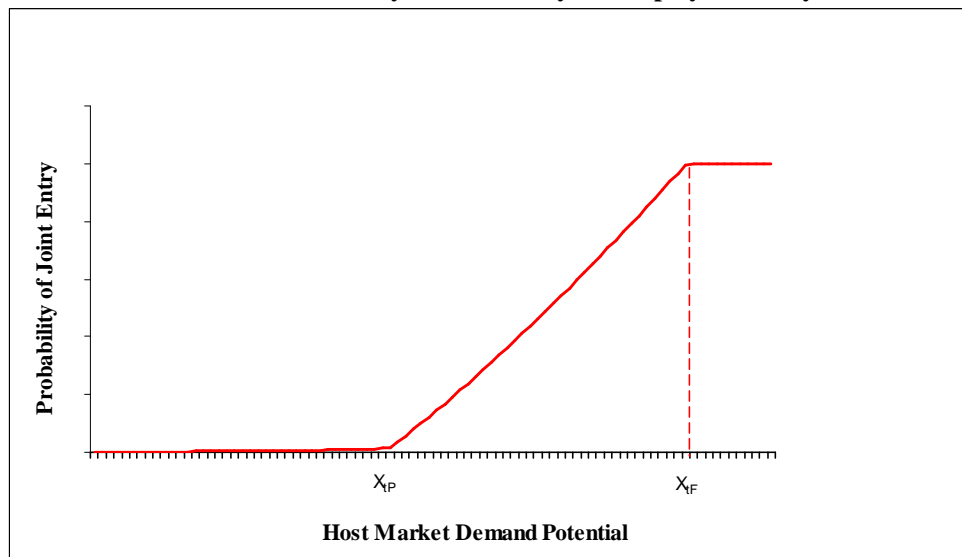
4. $X_{t_p} \in (0, X_{t_f})$ represents a unique point, at which the values of the Leader and the Follower roles are equal. Replacing $L(X_t) = F(X_t)$ into *equation (40)* it is obtained that α equals to zero at X_{t_p} . Based on *equation (41)* this result implies that the probability of joint investment goes to zero and the probability of becoming the Leader or Follower increases to one half at X_{t_p} . Driven by the rent equalization, there is no incentive for becoming the Leader at X_{t_p} as a result of which firms may distribute the Leader and Follower roles among themselves⁸² and neither firm has the incentive to deviate from the distributed strategy⁸³.

⁸²Dixit, A.K. and Pindyck, R.S. state that the probability of joint investment goes to zero in the interval between the preemption point and the Follower's entry date (p.313 *Investment under Uncertainty*, Princeton University Press, 1994). As pointed out by Huisman, K.J.M. this claim is only correct at the preemption point but not in the whole interval (p.179 *Technology Investments: A Game Theoretical Real Options Approach*, Kluwer Academic Publishers, 2001)

⁸³Although distributing the roles presents a Nash equilibrium at the preemption point, such agreements are generally illegal.

The following chart presents the development of the probability of Joint investments over the whole interval of host market's demand potential:

Chart 6: Probability of Joint Entry in Duopoly Economy



As the incentive of investment depends on the additional benefit of the Leader role, it is expected that the more lucrative investment opportunities the individual Eastern European countries provided, the more investors entered these countries simultaneously.

Poland showed the highest foreign retailer entry rate compared to the same level of demand potential in the analysed period. Moreover, the jump in the rate of foreign retailers' entry proved also to be the highest over the years. Retail analysts pointed out that the retail market in Poland was saturated early by the second half of the 90s forcing a cut-throat competition among retailers. Based on the obtained theoretical pattern of joint entry rate this was due to the fact that Poland provided the highest absolute level of host market demand potential driven by his relative high level of GDP per capita and by his largest population in the region (38 million inhabitants). This high level of host demand potential increased the probability of suboptimal (early) joint retailers' entry.

4 Extension of the Standard Theoretical Market Entry Models

4.1 Entry barrier of the Follower in Duopoly Economy

“...(retailers) cannot afford to wait before entering these new (developing) markets because it could cost them too much money at a later date. The early movers will have settled in and staked their claims on the prime retail estate.”⁸⁴

4.1.1 Assumptions

The existing market entry models can be extended in various ways. One interesting extension is obtained by assuming that entering the market as a Follower requires higher investment costs (e.g. intensive marketing activity) than investing first or jointly at the same time with the competitor.

That case does not assume asymmetry between the competing firms. It assumes that being the second investor in the new market incorporates the disadvantage of an additional entry barrier.

The importance of established customers relationships with the first mover⁸⁵ in the success of a business in a new market is the reason why the market entry equilibrium in that special case has been chosen for analysis.

⁸⁴The grocers' global battlefield, 2006 Internet

⁸⁵In the case of the retail industry, advantage of established customer relationships may result from the acquisition of the prime store locations.

4.1.2 Valuation Model

4.1.2.1 Value of the Follower

The Follower enters the market either jointly with his competitor or alone after the Leader's entry. Introducing an entry barrier for the late-entry, the Follower's investment can be presented by the following two functions.

In the case of *joint investment* of the competitors, the Follower has no extra entry costs, and therefore the Joint Investment function of the standard model can be applied.

$$(57) \quad J(X_t) = \frac{pD(2)}{(r-m)} X_t - I \quad \text{if } X_t \in [X_0; \infty)$$

However, in the case of *sequential entry* the Follower has additional entry costs and therefore *equation (16)* should be rewritten by replacing I with kI , where $k > 1$ holds:

$$(58) \quad F_b(X_t) = \begin{cases} \left[\frac{pD(2)}{(r_m - m)} X_{F_b} - kI \right] \left[\frac{X_t}{X_{F_b}} \right]^b & \text{if } X_t \in [0; X_{F_b}) \\ \frac{pD(2)}{(r_m - m)} X_t - kI & \text{if } X_t \in [X_{F_b}; \infty) \end{cases}$$

4.1.2.2 Follower Entry Trigger

The additional investment costs impact both *dynamic NPV* components of the Follower value. On the one hand, they reduce the intrinsic value of the Follower's entry (*static NPV value*), while on the other hand they increase the time value of waiting (*dynamic NPV component*). Due to these impacts the entry decision of the Follower requires a higher level of host market demand potential at the date of investment.

Compared to the standard Duopoly model, the Follower entry barrier moves the Follower value function downwards and consequently a later Follower's investment trigger noted as $X_{t_{F_b}}$ occurs.

These results can formally be obtained by comparing *equation (16)* with *equation (58)* as follows:

$$(59) F_b(X_t) < F(X_t) \quad \text{for } \forall X_t \in [0; \infty) \text{ since } k > 1 \text{ and}$$

$$(60) X_{t_{F_b}} = \frac{b}{b-1} \frac{(r_m - m)}{pD(2)} kI = X_{t_{F=t_j}} + \frac{b}{(b-1)} \frac{(r_m - m)}{pD(2)} (k-1)I > X_{t_F}$$

since $k > 1$ holds

The above results show that the additional entry costs in form of competitive disadvantage of the Follower deter the Follower entry making the competition in the new market after the Leader entry softer.

4.1.2.3 Optimal Joint Entry Threshold

In the standard model the Joint Investment value function merged into the Follower's value function at X_{t_F} , where the time value of immediate joint entry evaporated. Moving the Follower's value function of the standard model downwards implies that the new Follower value function will cross the unchanged Joint investment value function at a single point of $X_{t_{Jb}}$, which occurs earlier than $X_{t_F} = X_{t_J}$.⁸⁶

This new intersection point of optimal joint investment can be obtained by setting *equation (57)* equal to *equation (58)*. The results are presented below:

$$(61) \quad \frac{pD(2)}{(r-m)} X_{t_{Jb}} \left[1 - \left(\frac{X_{t_{Jb}}}{X_{t_{Fb}}} \right)^{b-1} \right] + (kI - I) \left(\frac{X_{t_{Jb}}}{X_{t_{Fb}}} \right)^b = I \left[1 - \left(\frac{X_{t_{Jb}}}{X_{t_{Fb}}} \right)^b \right]$$

⁸⁶Define $\Phi_{J_b/F_b}(X_t) = \frac{pD(2)}{(r-m)} X_t \left[1 - \left(\frac{X_t}{X_{t_{Fb}}} \right)^{b-1} \right] + kI \left(\frac{X_t}{X_{t_{Fb}}} \right)^b - I$ based on *equation (61)*.

$\Phi_{J_b/F_b}(X_{t_{Jb}}) = 0$ holds by definition. Based on *equation (60)* $\frac{\partial \Phi_{J_b/F_b}(X_t)}{X_t} > 0$ holds since $b > 1$.

Applying these results one can show that $X_{t_{Jb}} < X_{t_F}$ by proving that $\Phi_{J_b/F_b}(X_{t_F}) > 0$.

After replacing X_{t_F} the following result is obtained:

$\Phi_{J_b/F_b}(X_{t_F}) = \frac{pD(2)}{(r-m)} X_{t_F} - \frac{pD(2)}{(r-m)} X_{t_F} \left(\frac{X_{t_F}}{X_{t_{Fb}}} \right)^{b-1} + kI \left(\frac{X_{t_F}}{X_{t_{Fb}}} \right)^b - I > 0$ since the below equations hold:

$\Phi_{J_b/F_b}(X_{t_F}) = \frac{pD(2)}{(r-m)} X_{t_F} - \frac{pD(2)}{(r-m)} X_{t_F} \left(\frac{X_{t_F}}{X_{t_{Fb}}} \right)^{b-1} + kI \left(\frac{X_{t_F}}{X_{t_{Fb}}} \right)^b - I > 0$ as $k > 1$ while

$\frac{\partial \Phi_{J_b/F_b}(X_{t_F})}{\partial X_{t_{Fb}}} > 0$ and $X_{t_{Fb}} > X_{t_F}$

Equation (61) expresses the following strategic value component of joint market entrance in the case of Follower's entry barrier:

Compared to the standard model the optimal joint entry date occurs earlier at $X_{t_{Jb}}$. At this lower level of host market demand potential the lost time value of earlier occurring normal investment costs is compensated by the present value of duopoly profits received in the restricted period between $X_{t_{Jb}}$ and $X_{t_{Fb}}$ increased with the present value of the saved additional entry costs.

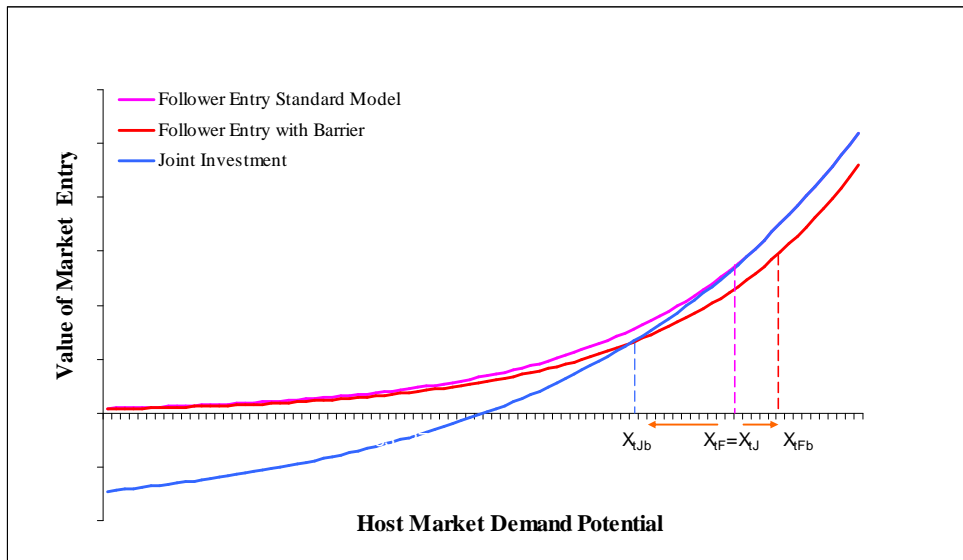
Compared to the standard model, the present value of saved additional entry costs, regarded as additional income of the Follower, make an earlier Joint entry at $X_{t_{Jb}}$ possible. This is a strategic value component, which is created by the opportunity of escaping from the additional entry costs, and which enhances the competition by reducing the time value of Joint market entry.

As a result, in the absence of Leader entry the Follower's entry barrier leads to an earlier optimal Joint Investment trigger than the standard model.

4.1.2.4 Market Entry Strategies of the Follower

The following chart presents the value functions of the Follower and the Joint entry in the case of Follower’s entry barrier:

Chart 7: Follower Entry with Barrier



The present value of the saved additional entry costs starts to compensate the lost time value of an immediate entry at $X_{t_{Jb}}$. To the right of $X_{t_{Jb}}$ the Joint Investment function is above, while to the left is below the downward shifted Follower’s function. This gives the following strategic instruction to the Follower:

If the market maturity is below $X_{t_{Jb}}$, the Follower should wait and not enter the market.

If the Leader entrance did not occur before $X_{t_{Jb}}$ the Follower should invest with probability one at this point in order to avoid the higher investment costs implied by a potential Leader entry.

If the Leader entrance occurred before $X_{t_{Jb}}$ the Follower should wait with his entrance until an extended date of $X_{t_{Fb}}$, where the market starts to compensate the higher entry costs. The Follower entry barrier accelerates the optimal Joint investment while it deters the optimal Follower entry compared to the results of the standard model. These results are formally summarised by the following equations:

$$(62) X_{t_{Jb}} < X_{t_J} = X_{t_F} < X_{t_{Fb}}$$

4.1.2.5 Value of the Leader

The Leader receives the same payouts as the Follower in the case of a Joint entry. However, if the joint investment does not occur, the extended date of the Follower's entry presents longer monopoly profit tenure and consequently more valuable first mover advantage for the Leader. It needs to be observed that the more valuable first mover advantage allows for more loss in the time value of investment costs as compensation in the preemption game. As a consequence, compared to the standard model, the preemption point occurs earlier in time at a lower level of host market demand potential if the Follower entry barrier exists. Driven by the extended period of the monopoly profit, the value function of the Leader expressed by *equation (35)* moves upwards and an earlier date of Leader's entry occurs at $X_{t_{Fb}}$. These results are obtained by replacing $X_{t_{Fb}} > X_{t_F}$ into *equation (35)* as presented below:

$$(63) L_b(X_t) \begin{cases} \left[\frac{p[D(1)-D(2)]}{(r_m - m)} X_{t_{Fb}} \left[1 - \left(\frac{X_t}{X_{t_{Fb}}} \right)^{b-1} \right] + \frac{pD(2)}{(r_m - m)} X_{t_{Fb}} - I \right] \left[\frac{X_t}{X_{t_{Fb}}} \right]^b & \text{if } X_t \in [0; X_{t_{Fb}}) \\ \frac{p[D(1)-D(2)]}{(r_m - m)} X_t \left[1 - \left(\frac{X_t}{X_{t_{Fb}}} \right)^{b-1} \right] + \frac{pD(2)}{(r_m - m)} X_t - I & \text{if } X_t \in [X_{t_{Fb}}; X_{t_{Fb}}) \\ \frac{pD(2)}{(r_m - m)} X_t - I & \text{if } X_t \in [X_{t_{Fb}}; \infty) \end{cases}$$

where $X_{t_{Fb}}$ is given by the solution of the below presented equation:

$$(64) \frac{pD(1)}{(r_m - m)} X_{t_{Fb}} \left[1 - \left(\frac{X_{t_{Fb}}}{X_{t_{Fb}}} \right)^{b-1} \right] = I \left[1 - \left(\frac{X_{t_{Fb}}}{X_{t_{Fb}}} \right)^b \right] \text{ and the following results hold:}$$

$$(65) X_{t_{Fb}} < X_{t_F} \text{ }^{87} \text{ and}$$

$$(66) L_b(X_t) > L(X_t) \text{ }^{88}$$

⁸⁷Replacing $X_{t_{Fb}} = X_{t_F}$ in the *equation (64)* and applying equations (36) and (60) the following result is obtained:

$$\left(1 - \left(\frac{1}{k} \right)^b \right) \left(\frac{X_{t_F}}{X_{t_F}} \right)^b \left(\frac{b}{b-1} \frac{D(1)}{D(2)} I - I \right) > 0 \text{ since } b > 1, k > 1 \text{ and } D(1) > D(2)$$

⁸⁸*Equation (66)* holds since $\frac{\partial L(X_t)}{\partial X_{t_F}} > 0 \quad \forall X_t \in [0; \infty)$ and $X_{t_{Fb}} > X_{t_F}$

4.1.2.6 *Market Entry Strategy of the Leader*

Based on the transformed value functions of the Duopolist firms the following two potential Nash equilibria occur in the case of the Follower entry barrier:

1. The first equilibrium (and the earlier one) occurs at $X_{t_{Fb}} < X_{t_p}$, which represents the crossing point of the new Leader and new Follower value functions. This investment trigger is the new preemption point, with exactly the same features as the preemption point of the standard model. As the additional investment costs of the Follower imply longer monopoly profit tenure of the Leader, the first mover advantage of the Leader increases and the new preemption point occurs earlier at a lower level of host market demand potential than in the standard model. At this point *sequential equilibrium occurs*, where one of the firms becomes the Leader with the probability of one half, while the other firm delays his market entry until $X_{t_{Fb}}$.

2. The second equilibrium occurs at the matching point of the new Follower's value function and the Joint investment value function at $X_{t_{Jb}}$. If neither of the competitors has invested up until this point, then a *simultaneous joint market entrance* occurs with probability one at $X_{t_{Jb}}$ as each firm has the intention to enter the market immediately in order to avoid the additional costs of the Follower entry barrier.

Compared to the standard model the additional entry costs enhance competition and both the joint entry trigger and the preemption threshold also occur earlier at a lower level of host market demand potential.

Based on the above the symmetric subgame perfect equilibrium in the case of Follower's entry barrier is given by the tuple of following closed-loop strategies $s_{0 \leq t < \infty}^{-t} \in ((G_i^t, a_i^t), (G_j^t, a_j^t))_{0 \leq t < \infty}$ where $t \geq 0$ and

$$(67) \quad G_{i/j}(t) = \begin{cases} 0 & \text{if } t < t_{P_b} \\ \frac{L(X_t) - J(X_t)}{L(X_t) - 2J(X_t) + F(X_t)} & \text{if } t_{P_b} \leq t < t_{J_b} \\ 1 & \text{if } t \geq t_{J_b} \end{cases}$$

$$(68) \quad a_{i/j}(t) = \begin{cases} 0 & \text{if } t < t_{P_b} \\ \frac{L(X_t) - F(X_t)}{L(X_t) - J(X_t)} & \text{if } t_{P_b} \leq t < t_{J_b} \\ 1 & \text{if } t \geq t_{J_b} \end{cases}$$

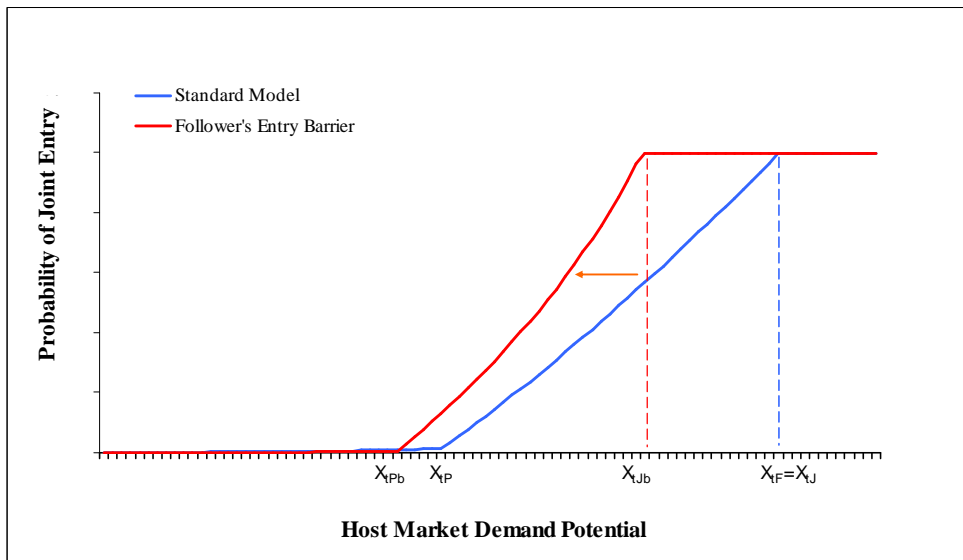
where $t_{P_b} < t_P$ and $t_{J_b} < t_J$

It should be also observed that compared to the standard model the firm's incentive to become the Leader becomes stronger for $\forall X_t \in \left(X_{t_{Pb}} ; X_{t_{Jb}} \right)$. This is due to the increased value of first mover advantage expressed by the ratio of $\frac{L_b(X_t) - F_b(X_t)}{L_b(X_t) - J(X_t)}$ ⁸⁹.

As both firms become greedier to obtain the Leader role both invest with higher probability if $X_t \in \left(X_{t_{Pb}} ; X_{t_{Jb}} \right)$. As a consequence the failure of suboptimal Joint entry increases compared to the results of the standard model.

Applying the results of *equation (55)* and *equation (68)* the below chart presents the higher probability of suboptimal joint investment in the whole interval of host market demand potential:

Chart 8: Probability of Joint Entry with Follower Entry Barrier



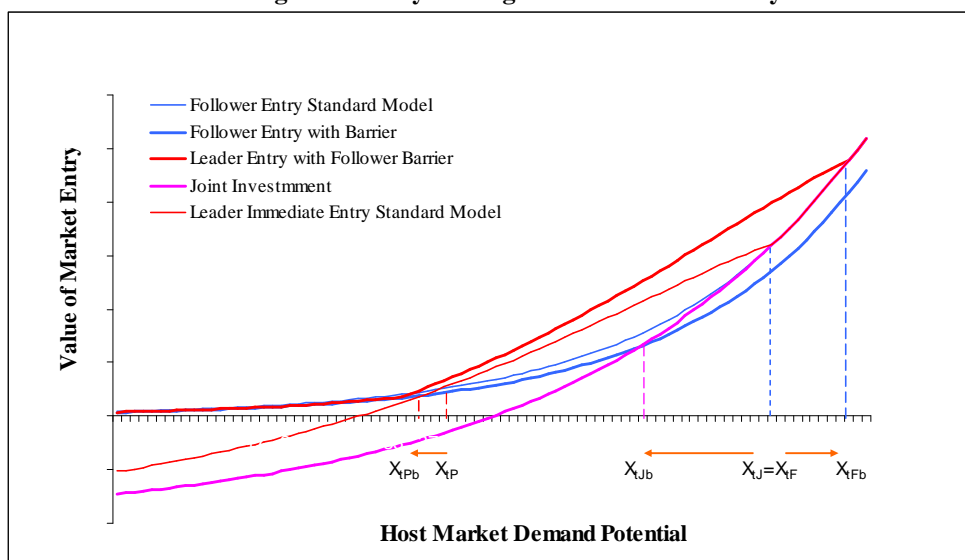
⁸⁹If $X_t \in \left(X_{t_{Pb}} ; X_{t_{Jb}} \right)$ the following equation holds $\frac{L_b(X_t) - F_b(X_t)}{L_b(X_t) - J(X_t)} > \frac{L(X_t) - F(X_t)}{L(X_t) - J(X_t)}$ since based on *equations (59) and (66)* $L_b(X_t) > L(X_t)$ and $F_b(X_t) < F(X_t)$.

4.1.3 Conclusion

The more intense competition driven by the more valuable first-mover-advantage accelerates the market entrance of the firms implying that (i) both the preemptive and the joint market entry equilibria occur earlier than in the standard model while (ii) the failure of suboptimal early joint entrance increases.

As the chart below presents the entry barrier of the Follower increases the competition between the firms and further reduces the time value of waiting compared to the standard model.

Chart 9: Endogenous Entry Strategies with Follower Entry Barrier



However, if the Leader's entry was successful, then the Follower's entry barrier has the opposite impact on the competition. The Follower entry occurs later at $X_{t_{Fb}} > X_{t_F}$ creating a longer tenure of monopolistic economy.

Existence of the Follower's entry barrier intensifies the strategic impact of competition. In those Eastern European countries where access to prime retail locations was limited (e.g, due to higher customer concentration) first foreign retailers must have arrived at an earlier stage of host market demand potential and late entrants must have invested with increased time lag.

As the empirical measurement of the existence of Follower entry barrier is very limited, this result has not been chosen to be tested explicitly. However, the impact of Follower's entry barrier is in line with the strategic impact of competition, therefore its possible existence is not expected to imply any distortion of the empirical test results.

4.2 *Asymmetric Firms in Duopoly Economy*

“If you are going to be a serious international player, you have to be one of the top two companies in a number of countries, which has sizable cash implications.” “In some ways we were disadvantaged, because other players had established a strong position in certain countries. But we had a very strong cash flow from the UK business, which gave us a strong start.”⁹⁰

4.2.1 *Assumptions*

The previous models ignore the fact that competitors may differ from each other and may have unequal power to fight with each other. Asymmetry among competitors arises basically from differences in their operational and/or in their financial performance while such inequalities may have a significant impact on the investment strategy of the firms.

Operational efficiency (*fitness*)⁹¹ is the result of higher profitability and is driven either by costs efficiency or by a better product/service portfolio.

Financial competitive advantage (*fatness*)⁹² arises either from different capital structure (different financial leverage) or from unequal access to the capital markets. In both cases the cost of capital for the liquidity-constrained firm is higher than that of his competitor, who has better access to credit lines or to cash reserves.

The next sections examine the impacts of asymmetry in the firms’ fitness and fatness on the market entry equilibria.

⁹⁰Reid, D., deputy chairman of Tesco, 2002 The McKinsey Quarterly, Number 3

⁹¹Expression originates from Lambrecht, 2001 The Impact of Debt Financing on Entry and Exit in a Duopoly, The Review of Financial Studies

⁹²Expression originates from Lambrecht, 2001 The Impact of Debt Financing on Entry and Exit in a Duopoly, The Review of Financial Studies

4.2.2 Impact of Fitness on the Market Entry Equilibrium

Introducing asymmetry in the operational profitability of the firms implies that the market entrance has different value for the competitors.

Assume that the operational profitability of *firm A* denoted by π_A is lower than that of his competitor *firm B* denoted by π_B .

$$(69) p_B = kp_A, \text{ where } k \in (1; \infty)$$

4.2.2.1 Value of the Follower

Following the same procedure as that of the standard model, in the first step the Follower's investment thresholds and value functions are calculated separately for the two firms.

Substituting *equation (69)* into *equation (17)* shows that the Follower investment trigger of the weaker firm occurs later than that of his stronger counterpart:

$$(70) X_{F_A} = \frac{b}{b-1} \frac{(r_m - m)}{p_A D(2)} I > \frac{b}{b-1} \frac{(r_m - m)}{kp_A D(2)} I = X_{F_B} \text{ since } k \in (1; \infty)$$

As *equation (16)* is strictly positively increasing in the value of the profitability ratio π , the Follower's value function of the stronger firm will always exceed that of the weaker firm and the following equation holds:

$$(71) F_B(X_t) > F_A(X_t) \text{ for all } X_t \in [0; \infty)$$

4.2.2.2 Value of the Leader

Based on *equations (69) and (70)*, the Leader value functions of the two firms can be obtained in the next step.

Each firm regards the Follower investment trigger of his counterpart as the potential end of his monopoly investment tenure. The stronger firm has a longer monopoly profit period than his weaker counterpart since $X_{t_{FA}}$ occurs later than $X_{t_{FB}}$. The present value of the higher monopoly profit per unit time realised during a longer monopoly investment tenure provides higher compensation for the up front investment costs of the stronger firm. The incremental benefit of the Leader role makes an earlier market entry of the stronger firm possible both in the case of exogenously and in the case of endogenously given roles.

As the Leader value function presented by *equation (35)* strictly positively increases in the input parameters of X_{t_F} and π ⁹³, the Leader value of the stronger firm always exceeds that of his weaker counterpart and the following equation holds:

$$(72) \quad L_B(X_t) > L_A(X_t) \text{ for all } X_t \in [0; \infty)$$

In the next step of the analysis the preemption point of the Leader needs to be determined in order to find the optimal Leader market entry date assuming endogenous roles.

Each firm determines his preemption point at the level of host market demand potential where the expected value of the Leader and the Follower investment strategies are the same and investors are indifferent to choosing the roles. Based on that criterion the following equations hold at the firms' preemption points respectively:

$$(73) \quad L_B(X_{t_{PB}}) = F_B(X_{t_{PB}}) \text{ and}$$

$$(74) \quad L_A(X_{t_{PA}}) = F_A(X_{t_{PA}})$$

⁹³Based on *equation (35)* the following results hold:

$$\frac{\partial L(X_t)}{\partial p} > 0 \text{ and } \frac{\partial L(X_t)}{\partial X_F} > 0 \text{ since } b > 1, D(1) > D(2) \text{ and } X_{t_F} > X_{t_P}$$

Based on the requirements of *equation (73) and (74)* and applying the results of *equations (71) and (72)* the following results are obtained at the preemption points of the two competing firms:

$$(75) L_B(X_{t_{PB}}) = F_B(X_{t_{PB}}) > F_A(X_{t_{PB}}) = L_A(X_{t_{PB}}), \text{ and}$$

$$(76) L_A(X_{t_{PA}}) = F_A(X_{t_{PA}}) < F_B(X_{t_{PA}}) < L_B(X_{t_{PA}})$$

As the Leader payoff of the stronger firm exceeds the Leader and the Follower value of the weaker firm at both firms' preemption points, the rent equalisation between asymmetric competitors never occurs.

4.2.2.3 Strict Dominance

Depending on the level of the asymmetry in the firms' profitability the stronger firm's Follower entry date occurs earlier than that of his competitor. The Leader market entry strategy provides additional monopoly profit flow for the weaker firm up until the early Follower arrival of his stronger competitor. However, opting for the Leader strategy the weaker firm gives up the time value of investment cost compared to his own Follower entry date. As a result the present value of the additional monopoly profit flow received by the weaker firm may not compensate the lost time value of his early entry costs if the asymmetry between the firms' profitability exceeds a certain level and the lag between the two firms' Follower entry thresholds becomes to large.

In these situations the weaker firm can not increase his value by opting for the Leader strategy and his Leader value function melts down into his Follower value function. As a consequence the stronger firm will strictly dominate his weaker counterpart and can optimise his investment date by ignoring the move of his competitor. (This represents the same situation as if the Leader and Follower roles were defined exogenously.) The weaker firm enters the market as Leader only if his Leader role provides higher present value than his Follower role. Let denote this investment decision criterion by the following function:

$$(77) \Phi_{L_A/F_A}(X_t) = L_A(X_t) - F_A(X_t) > 0 \quad \text{for } \forall X_t \in [X_{t_{LA}}; X_{t_{FB}})$$

Applying the results of *equations (16) and (35)* the value of the above function can be expressed as follows⁹⁴:

$$(78) \Phi_{L_A/F_A}(X_t) = \left(\frac{p_A(D(1) - D(2))}{(r_m - m)} X_t \right) \left[1 - \left(\frac{X_t}{X_{t_{FB}}} \right)^{b-1} \right] + \frac{p_A D(2)}{r - m} X_t - I - \left(\frac{p_A D(2)}{r - m} X_{t_{FA}} - I \right) \left(\frac{X_t}{X_{t_{FA}}} \right)^b$$

$$\text{for } \forall X_t \in [X_{t_{LA}}; X_{t_{FB}})$$

⁹⁴The deduction of critical k value for the case of asymmetry in investment costs is presented by Huisman, K.J.M., 2001 *Technology Investment: A Game Theoretical Real Option Approach*, Kluwer Academic Publishers, Boston.

The standard duopoly model with symmetric competitors showed how the present value of the restricted monopoly profits compensates the lost time value of the earlier investment costs in the case of Leader entry.

As the Follower entry thresholds of the asymmetric firms are different, the additional profit flow of the weaker firm's Leader role consists of the following two components:

- (i) monopoly profit flow up until the arrival of the stronger competitor for $\forall X_t \in [X_{t_{LA}}; X_{t_{FB}})$
and
- (ii) duopoly profit flow in the remaining period of $X_t \in [X_{t_{FB}}; X_{t_{FA}})$ until the weaker firm's own Follower threshold.

The weaker firm has no incentive to invest as Leader if the *equation (77)* does not hold. This means that the critical level of asymmetry noted as k^* should meet the following condition:

$$(79) \quad \Phi_{LA/FA}(X_t) = 0 \quad \text{for } \forall X_t \in [X_{t_{LA}}; X_{t_{FB}})$$

Substituting *equations (69) and (70)* into *equation (78)* gives the following expression for *equation (78)*:

$$(80) \quad \left(\frac{p_B D(1)}{k(r_m - m)} X_t \left[1 - \left(\frac{X_t}{X_{t_{FB}}} \right)^{b-1} \right] + \frac{p_B D(2)}{k(r_m - m)} X_t \left(\frac{X_t}{X_{t_{FB}}} \right)^{b-1} - \frac{p_B D(2)}{k(r_m - m)} X_t \left(\frac{X_t}{kX_{t_{FB}}} \right)^{b-1} - I \left[1 - \left(\frac{X_t}{kX_{t_{FB}}} \right)^b \right] \right) = 0$$

for $\forall X_t \in [X_{t_{LA}}; X_{t_{FB}})$

As the Leader value function of the weaker firm should be tangent to his Follower's value function the first derivative of *equation (80)* by X_t should also equal zero. This can be formally expressed as follows:

$$(81) \quad \frac{\partial \Phi_{LA/FA}(X_t)}{\partial X_t} = 0 \quad \text{which can be rewritten after substitution to the following form:}$$

$$(82) \quad \frac{p_B D(1)}{k^*(r_m - m)} - \frac{p_B D(1)}{k^*(r_m - m)} b \left(\frac{X_t}{X_{t_{FB}}} \right)^{b-1} + \frac{p_B D(2)}{k^*(r_m - m)} b \left(\frac{X_t}{X_{t_{FB}}} \right)^{b-1} - \frac{p_B D(2)}{k(r_m - m)} b \left(\frac{X_t}{kX_{t_{FB}}} \right)^{b-1} + bIk^* X_{FB} \left(\frac{X_t}{k^* X_{t_{FB}}} \right)^{b-1} = 0$$

After multiplying both sides of *equation (82)* by $\frac{X_t}{b}$ and subtracting it from *equation (80)* the following expression is obtained for X_t .

$$(83) \quad X_t = \frac{b}{b-1} \frac{k^*(r-m)}{p_B D(1)} I$$

Finally substituting the results of *equations (83)* and *(70)* into *equation (80)* the following value is calculated for the critical level of asymmetry noted as k^* :

$$(84) \quad k^* = \frac{D(1)}{D(2)} \left(\frac{\left(1 - \left(\frac{D(2)}{D(1)} \right)^b \right)^{\frac{1}{b-1}}}{b \left(1 - \left(\frac{D(2)}{D(1)} \right) \right)} \right) > 1^{95}$$

One firm strictly dominates its rival if the asymmetry between the competitors' profitability equals or exceeds the above defined critical level of k^* .

⁹⁵One can see that $k^* > 1$ holds, by rearranging *equation (84)* into the following form:

$$k^* \left(\frac{D(2)}{D(1)} \right) = (b-1) \left(\frac{D(2)}{D(1)} \right)^b - b \left(\frac{D(2)}{D(1)} \right)^{b-1} + 1 > 0 \quad \text{where } \frac{D(2)}{D(1)} \in (0;1)$$

The above equation holds since,

$$\lim_{\frac{D(2)}{D(1)} \rightarrow 1} k^* \left(\frac{D(2)}{D(1)} \right) = 0 \quad \text{and}$$

$$\frac{\partial k^* \left(\frac{D(2)}{D(1)} \right)}{\partial \frac{D(2)}{D(1)}} = (b-1)b \left(\frac{D(2)}{D(1)} \right)^{b-1} - (b-1)b \left(\frac{D(2)}{D(1)} \right)^{b-2} < 0$$

Equation (84) shows that the value of k^* depends not only on the level of incremental benefit of becoming the monopolist but also on common economic indicators of the host market, which both firms have in common such as volatility (s), profit growth (m) and discount rate (r)⁹⁶.

As the level of critical asymmetry is quite a complicated function of these common economic indicators extensive numerical simulations have been chosen to analyse these factors' impact instead of the analytical solution. The simulations indicate the following results⁹⁷:

$$(85) \quad \frac{\partial k^*}{\partial s} < 0; \quad \frac{\partial k^*}{\partial m} < 0 \quad \text{and} \quad \frac{\partial k^*}{\partial r} > 0.$$

These results show that the critical level of asymmetry is mitigated or strengthened by common economic factors depending on how the present value of the excess profit flow of an earlier entry can compensate the lost time value of early investment costs:

- Increase in *host market volatility favours the weaker firm*. As uncertainty increases the time value of waiting, the optimal entry triggers of the weaker firm (both Leader and Follower entry dates) occur at a higher level of market demand potential. In this interval the weaker firm gains higher monopoly and duopoly profit per unit time for the earlier entry, while the loss time value of his investment costs per unit time are independent from the level of market maturity and remain therefore unchanged.
- *Higher discount rate is to the relative advantage of the stronger firm*. Higher discount rate reduces the present value of additional monopoly and duopoly profits and increases the time value of investment costs.
- *Higher profit growth of the host market benefits the weaker firm*. Higher profit growth increases the present value of the restricted monopoly and duopoly profits, while time value of investment costs remains unchanged.

⁹⁶The common economic indicators drive the level of k^* since $b = \frac{\frac{1}{2}s^2 - m + \sqrt{\left[\frac{1}{2}s^2 - m\right]^2 + 2s^2r}}{s^2}$.

⁹⁷Similar procedures can be found in Lambrecht, 2001 The Impact of Debt Financing on Entry and Exit in a Duopoly, The Review of Financial Studies.

The charts below present the sensitivity of k^* values for the change in common economic factors:

Chart 10: k^* Sensitivity

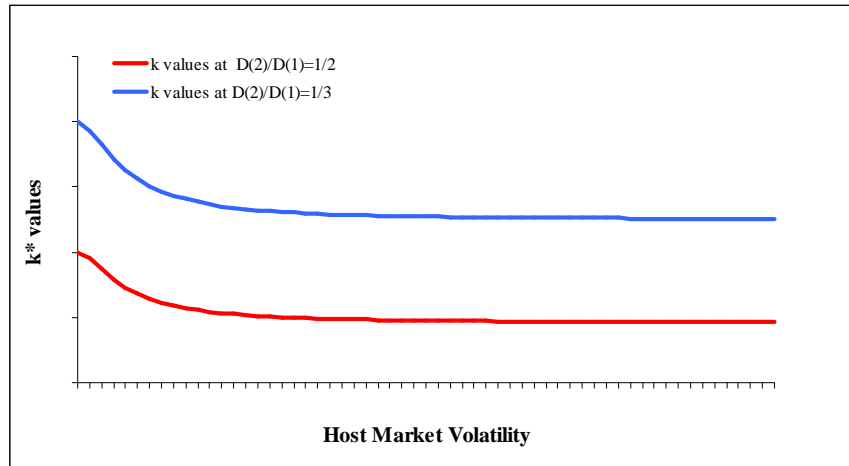


Chart 11: k^* Sensitivity

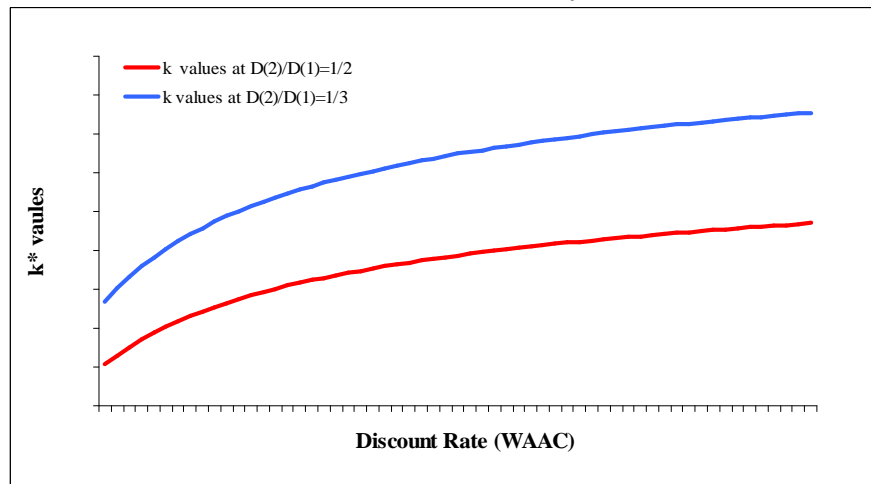
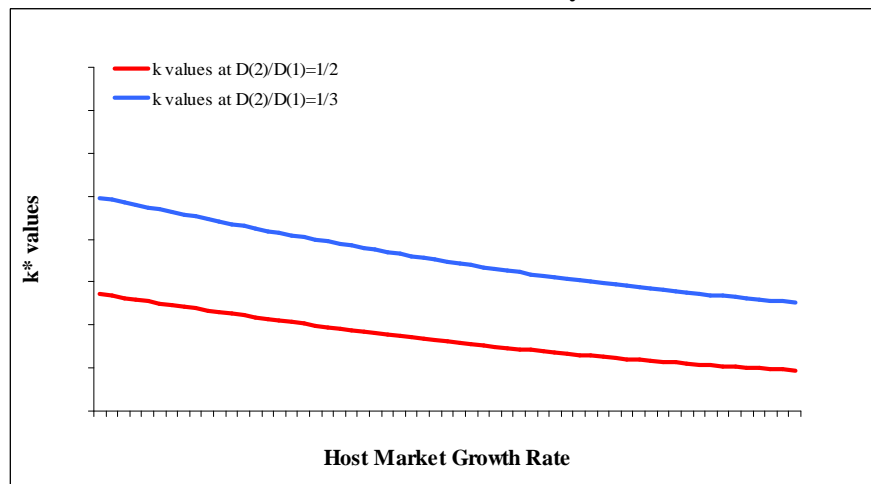


Chart 12: k^* Sensitivity



4.2.2.4 Market Entry Strategies in Strict Dominance

If the level of asymmetry equals or exceeds a critical level of k^* then the weaker firm has no intention to become the Leader and his Leader value function melts down into his Follower value function.

As a result the stronger firm strictly dominates his weaker competitor and a sequential equilibrium occurs where the weaker firm enters the market with probability one only at

$$X_{F_A} = \frac{b}{b-1} \frac{(r_m - m)}{p_A D(2)} I \text{ and the stronger firm can simply maximize his investment opportunity}$$

by investing with probability one at the optimal Leader threshold of $X_{L_B} = \frac{b}{b-1} \frac{(r_m - m)}{p_B D(1)} I$.

These closed loop strategies of the firms if $k \geq k^*$ are given below:

$$G_A(t) = \begin{cases} 0 & \text{if } t < t_{F_A} \\ 1 & \text{if } t \geq t_{F_A} \end{cases}$$

$$a_A(t) = \begin{cases} 0 & \text{if } t < t_{F_A} \\ 1 & \text{if } t \geq t_{F_A} \end{cases}$$

(86)

$$G_B(t) = \begin{cases} 0 & \text{if } t < t_{L_B} \\ 1 & \text{if } t \geq t_{L_B} \end{cases}$$

$$a_B(t) = \begin{cases} 0 & \text{if } t < t_{L_B} \\ 1 & \text{if } t \geq t_{L_B} \end{cases}$$

4.2.2.5 Market entry Strategies in Lack of Strict Dominance

If the level of asymmetry is below the critical level of k^* then the equilibrium depends on the initial level of host market demand potential.

For $\forall X_t \in [X_{t_{FA}}; \infty)$ the market maturity has reached the level where both firms enter the market *simultaneously* with probability one. This implies the following closed loop strategy sets of the firms:

$$\begin{aligned}
 G_A(t) &= 1 \\
 a_A(t) &= 1 \\
 (87) \quad G_B(t) &= 1 \\
 a_B(t) &= 1
 \end{aligned}$$

For $\forall X_t \in [X_{t_{PA}}; X_{t_{FA}})$ one should observe that the weaker firm has only incentive to preempt his stronger competitor in a restricted period and not in the whole interval. Between the Follower entry threshold of the stronger firm and his own Follower entry trigger, the weaker firm receives the duopoly profits, which do not compensate the time value of his earlier investment costs by definition. (This compensation occurs first at his optimal Follower entry trigger.) Therefore there exists a period before the optimal Follower trigger of the weaker firm where his Leader value function is below his Follower value function. Consequently the weaker firm's Leader and Follower value functions have two intersection points (noted as $X_{t_{PA}} = X_{t_{PA1}}$ and $X_{t_{PA2}}$ where $X_{t_{PA1}} < X_{t_{PA2}}$ holds) which separate the market entry equilibria of asymmetric firms as follows.

For $\forall X_t \in [X_{t_{PA_2}}; X_{t_{FA}})$ the stronger firm B enters the market for sure, since the joint market entrance has positive time value for the weaker firm up until $X_{t_{FA}}$ by definition. As a result *sequential* equilibrium occurs where the stronger firm invests immediately and becomes the Leader with probability one and the weaker firm enters the market with the same probability as Follower at $X_{t_{FA}}$. The closed loop strategy sets are obtained as follows:

$$(88) \quad \begin{aligned} G_A(t) &= \begin{cases} 0 & \text{if } t < t_{FA} \\ 1 & \text{if } t \geq t_{FA} \end{cases} \\ a_A(t) &= \begin{cases} 0 & \text{if } t < t_{FA} \\ 1 & \text{if } t \geq t_{FA} \end{cases} \\ G_B(t) &= 1 \\ a_B(t) &= 1 \end{aligned}$$

For $\forall X_t \in [X_{t_{PA_1}}; X_{t_{PA_2}})$ both firms intend to be the Leader and try to preempt his competitor. The value of the market entrance for the two asymmetric firms can be expressed therefore as follows:

$$(89) \quad \begin{aligned} V_A &= \max_{a_A} [a_A(1-a_B)L_A(X_t) + (1-a_A)a_B F_A(X_t) + a_A a_B J_A(X_t) + (1-a_A)(1-a_B)V_A] \\ V_B &= \max_{a_B} [a_B(1-a_A)L_B(X_t) + (1-a_B)a_A F_B(X_t) + a_A a_B J_B(X_t) + (1-a_A)(1-a_B)V_B] \end{aligned}$$

Equations (86) can be rewritten as below:

$$(90) \quad \begin{aligned} V_A &= \frac{a_A(1-a_B)}{a_A + a_B - a_A a_B} L_A(X_t) + \frac{(1-a_A)a_B}{a_A + a_B - a_A a_B} F_A(X_t) + \frac{+a_A a_B}{a_A + a_B - a_A a_B} J_A(X_t) \\ V_B &= \frac{a_B(1-a_A)}{a_A + a_B - a_A a_B} L_B(X_t) + \frac{(1-a_B)a_A}{a_A + a_B - a_A a_B} F_B(X_t) + \frac{+a_A a_B}{a_A + a_B - a_A a_B} J_B(X_t) \end{aligned}$$

Applying the first order conditions the following solutions are obtained for a_A and a_B :

$$a_A = \frac{L_B(X_t) - F_B(X_t)}{L_B(X_t) - J_B(X_t)}$$

(91)

$$a_B = \frac{L_A(X_t) - F_A(X_t)}{L_A(X_t) - J_A(X_t)}$$

where based on *equations (71) and (72)* $a_B < a_A$ holds⁹⁸.

The above results reveal how one firm's competitive advantage depends on the comparative strength of his competitor. Although both firms intend to enter the market, one firm's incentive to invest in the new market (expressed by $a_{A/B}$ respectively) depends on the payoffs of his counterpart, which reflect the competitor's ability to react to one firm's action.

In the race for the Leader role, the increase in the incremental benefit of one firm's potential Leader position should enhance the incentive of the other firm to challenge his counterpart. As a result the weaker firm needs to have a more aggressive investment strategy and should increase the probability of his market entrance in line with the incremental benefit of his stronger competitor in order to keep his opponent despite his comparative strength indifferent to opting for the Leader/Follower investment strategies.

Based on the previous calculations the asymmetric firms closed loop strategy sets for $\forall X_t \in [X_{t_{P_{A1}}}; X_{t_{P_{A2}}}]$ are as follows:

$$G_A(t) = \frac{a_A(t)}{a_A(t) + a_B(t) - a_A(t)a_B(t)}$$

$$a_A(t) = \frac{L_B(X_t) - F_B(X_t)}{L_B(X_t) - J_B(X_t)}$$

(92)

$$G_B(t) = \frac{a_B(t)}{a_A(t) + a_B(t) - a_A(t)a_B(t)}$$

$$a_B(t) = \frac{L_A(X_t) - F_A(X_t)}{L_A(X_t) - J_A(X_t)}$$

For $\forall X_t \in [0; X_{t_{PA_1}})$ the stronger firm will always preempt his competitor, since the weaker firm has an incentive to become the Leader only at $X_{t_{PA_1}}$.

This preemption occurs either

- (i) immediately before $X_{t_{PA_1}}$ (*e*-preemption) or
- (ii) at $X_{t_{LB}}$, if the optimal Leader threshold of the stronger firm is before the preemption point of the weaker firm⁹⁹.

Based on the above the closed loop equilibrium strategies are given as follows:

If $X_{t_{LB}} < X_{t_{PA_1}}$, then

$$\begin{aligned}
 G_A(t) &= \begin{cases} 0 & \text{if } t < t_{FA} \\ 1 & \text{if } t \geq t_{FA} \end{cases} \\
 a_A(t) &= \begin{cases} 0 & \text{if } t < t_{FA} \\ 1 & \text{if } t \geq t_{FA} \end{cases} \\
 (93)
 \end{aligned}$$

$$\begin{aligned}
 G_B(t) &= \begin{cases} 0 & \text{if } t < t_{LB} \\ 1 & \text{if } t \geq t_{LB} \end{cases} \\
 a_B(t) &= \begin{cases} 0 & \text{if } t < t_{LB} \\ 1 & \text{if } t \geq t_{LB} \end{cases}
 \end{aligned}$$

⁹⁸The joint investment function based on *equation (18)* is strictly positively increasing in $\pi \left(\frac{\partial J(X_t)}{\partial p} > 0 \right)$,

therefore $J_B(X_t) > J_A(X_t)$ also holds.

⁹⁹In that case the asymmetry between the firms makes it possible for the stronger firm to ignore the action of his competitor so that the stronger firm can act as a Leader with exogenously given role. However, compared to the situation of strong dominance preemption games between the firms may occur in certain subgames, which are starting at $X_t \in [X_{t_{PA_1}}; X_{t_{PA_2}})$.

If $X_{t_{LB}} \geq X_{t_{PA}}$ then

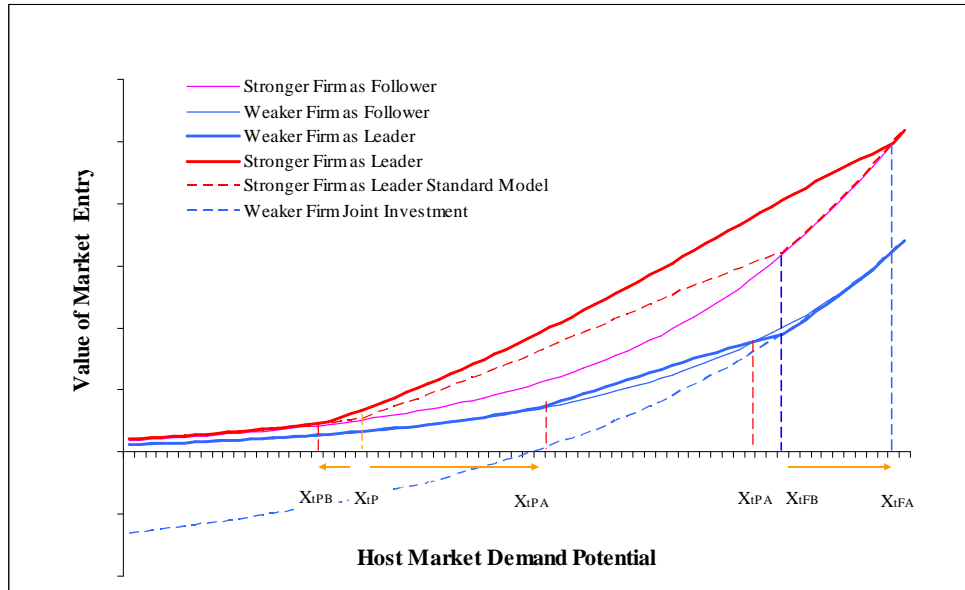
$$(94) \quad \begin{aligned} G_A(t) &= \begin{cases} 0 & \text{if } t < t_{FA} \\ 1 & \text{if } t \geq t_{FA} \end{cases} \\ a_A(t) &= \begin{cases} 0 & \text{if } t < t_{FA} \\ 1 & \text{if } t \geq t_{FA} \end{cases} \end{aligned}$$

$$\begin{aligned} G_B(t) &= \begin{cases} 0 & \text{if } t < t_{PA} \\ 1 & \text{if } t \geq t_{PA} \end{cases} \\ a_B(t) &= \begin{cases} 0 & \text{if } t < t_{PA} \\ 1 & \text{if } t \geq t_{PA} \end{cases} \end{aligned}$$

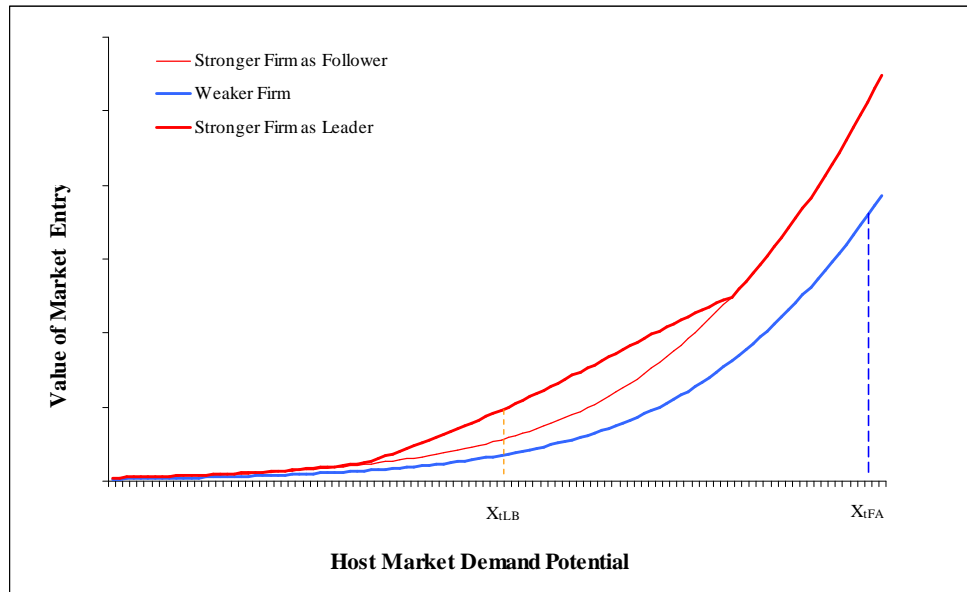
4.2.2.6 Conclusion

As the following chart shows, in the case of asymmetric firms, the weaker firm's monopoly investment tenure depends on his stronger competitor's Follower investment threshold, which occurs sooner than his own Follower entry.

Chart 13: Asymmetric Firms below the Critical k^* Level



If the asymmetry of the firms exceeds a certain level, then the weaker firm can not pre-empt his competitor and his Leader value function melts down into his Follower value function. Consequently, the weaker firm will only invest at his Follower investment trigger and the stronger firm can maximise the time value of his Leader entry by investing at this optimal Leader threshold. As a result competition will have no impact on the market entry timing of firms.

Chart 14: Asymmetric Firms above the Critical k^* Level


If the asymmetry of firms is below the critical level then the market entry equilibria depends on the initial value of the host market demand potential.

If $X_{t_0} \in [0; X_{P_{A_1}})$, then the preemption point of the weaker firm $X_{P_{A_1}}$, can not be regarded as a real preemption point, since the Leader market entrance of the weaker firm does not represent a subgame perfect Nash equilibrium. The Leader value function of the stronger firm always exceeds his competitor's Leader value function therefore the stronger firm has an incentive to ε pre-empt his weaker counterpart. As a consequence sequential equilibrium occurs, where the stronger firm becomes the Leader and the weaker firm will be the Follower.

If $X_{t_0} \in [X_{P_{A_2}}; \infty)$, then the weaker firm has no incentive to be Leader since his monopoly profit tenure is too short to compensate the lost time value of his investment costs. The Leader value function of the weaker firm is therefore below of his Follower value function and a sequential equilibrium occurs, where the stronger firm enters the market immediately and the weaker firm invests at his Follower's entry trigger.

However, if $X_{t_0} \in [X_{P_{A_1}}; X_{P_{A_2}}]$, then both firms want to be the Leader and enter the market with positive probability. Following the same steps as in the standard model for the determination of endogenously given Leader and Follower roles and introducing α_i for the

notation of the probability that the firm $i \in \{A; B\}$ invests, the following equilibria can be obtained:

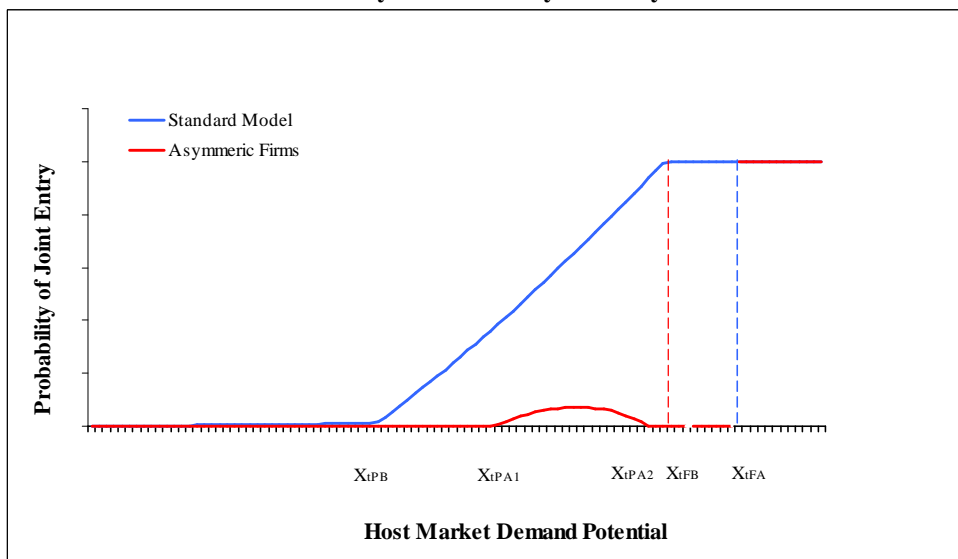
- Firm A enters the market as the Leader with the probability of $\frac{a_A(1-a_B)}{a_A+a_B-a_Aa_B}$ at X_{t_0} , and firm B invests as Follower at X_{F_B} .
- Firm B enters the market as the Leader with the probability of $\frac{a_B(1-a_A)}{a_B+a_A-a_Ba_A}$ at X_{t_0} , and firm A invests as Follower at X_{F_A} .
- both firms invest at X_{t_0} with the probability of $\frac{a_Ba_A}{a_B+a_A-a_Ba_A}$

where based on equation (91) the probability that firm A/B invests can be expressed as

$$a_{A/B} = \frac{L_{B/A}(X_t) - F_{B/A}(X_t)}{L_{B/A}(X_t) - J_{B/A}(X_t)}$$

Although both firms opt for the Leader role in this interval, the larger is the asymmetry between the firms, the higher is the probability that the stronger firm wins the market entry game and the lower is the probability of suboptimal joint investment.

Chart 15: Probability of Joint Entry with Asymmetric Firms



4.2.3 Impact of Fatness on the Market Entry Equilibrium

Fatness or financial competitive advantage may occur in the case of one firm's lower financial leverage and/or in the case of one firm's better access to cheaper credit lines.

Suspending the assumption that the market entry of firms is entirely financed with equity and introducing b for the notation of interest payment per unit of time, the firm's profit curve can be rewritten as follows¹⁰⁰:

$$(95) \quad P(t) = p_{EBIT} D[Q(t)]X_t - b$$

Assuming, that *firm B* has cheaper debt financing or lower financial leverage than *firm A* leads to the following relation between the discounted values of the firms' profit per unit time:

$$(96) \quad \frac{p_{EBIT_A} D[Q(t)]X_t - b_A}{r_A - m} < \frac{p_{EBIT_B} D[Q(t)]X_t - b_B}{r_B - m}, \text{ since}$$

$$b_A > b_B \text{ and}$$

$$r_B < r_A \text{ as the levered discount rate is lower for } \textit{firm B} \text{ than for } \textit{firm A}.$$

As *equation (96)* is equivalent to *equation (69)*, the asymmetry in *fatness* has the same impact on the market entry equilibrium as the asymmetry in *fitness* and makes the competition between firms softer.

¹⁰⁰For simplicity reasons the impact of taxation is ignored in the analysis.

4.2.3.1 Impact of Risk Aversion

As risk averse investors discount the values of the same uncertain profit curve with higher discount rate than their risk neutral counterparts, the same results as presented in the previous sections are obtained if one of the competitors is assumed to be more risk averse than the other.

The earlier the market entry happens, the larger is the portion of the uncertain future growth in the present value of the investment. As risk averse investors punish the uncertainty with a higher discount rate, the time value of their market entry is higher and their entry date postpones.

Consequently, the more risk averse the investors are, the more latecomers they will be by nature and the softer the market entry competition will be.

4.2.4 Conclusion

In the case of asymmetric competitors, depending on the initial level of the market maturity and the level of asymmetry between the firms the following types of equilibria may occur:

1. Pre-emptive equilibrium occurs if the asymmetry is below a certain critical level and the initial level of host market demand potential is in the preemption interval of the weaker firm. In that case both firms have the incentive of becoming the Leader at the same time, resulting in the same preemption game as that of the standard model. However, contrary to the standard model, the stronger firm's chances of becoming the Leader proportionally increase with the level of asymmetry among the firms' profitability.
2. Sequential equilibrium occurs, when the difference in the cost asymmetry is so significant that one firm strictly dominates the other or the market entry game starts either before or after the intersection points of the weaker firm's Leader and Follower value functions. In these cases the stronger firm's competitive advantage is large enough to deter the weaker firm from entering the market as Leader. Because of the asymmetry, the stronger firm is not forced by the competition to enter the market at his preemption point and therefore the rent equalisation of the firms never occurs.
3. Simultaneous equilibrium occurs only if the initial level of market maturity is above the Follower investment trigger of the weaker firm. In that case the market demand is large enough for two firms to enter the market jointly.

Unlike as in the case of the Follower's entry barrier, asymmetry between the rivals always mitigates the competition in the market entry process. The softer competition does not force the stronger firm to enter the market at his preemption point and as a consequence the rent equalisation between the firms does not occur.

Comparative strength of Western European retailers in terms of operational and/or financial profitability must have increased the probability that "fitter" and/or "fatter" retailers entered the Eastern European countries earlier than their weaker competitors. Retailer giants such as e.g. REWE, Tesco, Metro, Schwarz Group, Tengelmann invested in significantly more Eastern European countries than their counterparts with smaller home market shares during the analysed period.

4.3 *Market Entry in an Oligopoly Economy with More than Two Competing Firms*

*"We are seeing a shake-out of underperforming companies in certain countries because everybody wants to be in the top three in a country. If you are seventh, eighth or ninth, then you're not in the game."*¹⁰¹

4.3.1 *Assumptions*

Extending the standard market entry model of duopoly economy is straightforward to the case where $n > 2$ firms enter the same new market.

The first arriving firm receives the monopoly profit until the entrance of the second firm. After the second arrival both firms acting on the new market realise the duopoly profit up until the investment of the third competitor and with every additional entry each firm gets continuously decreasing profit shares.

The analysis presented in this section assumes the subsequent arrival of firms. The same results hold in the case of optimal joint investment of $j \in [2; n]$ firms at the optimal entry date of the $i^{\text{th}} \mid i \in [j; n]$ arriving firm if $k = i - j$ competitor(s) entered the market before. These optimal joint entries of firms occur by coincidence if the demand potential of the host market starts at $X_t \in [X_{t_{P_i}}; X_{t_{P_{i+1}}}]$.

¹⁰¹Roberts, B., global retail analyst, 2006 The grocers' global battlefield, Internet

4.3.2 Symmetric Firms

4.3.2.1 Value Functions

The entry threshold of the firms is calculated backwards by the determination of the market entry threshold of the latest arrival. The firm, which arrives finally, receives the smallest market share of $D(n)$. His entry trigger can be obtained by applying the Follower's value function as follows.

$$(97) F_n(X_t) \begin{cases} \left[\frac{pD(n)}{(r_m - m)} X_{t_{F_n}} - I \right] \left[\frac{X_t}{X_{t_{F_n}}} \right] & \text{if } X_t \in [0; X_{t_{F_n}}) \\ \frac{pD(n)}{(r_m - m)} X_t - I & \text{if } X_t \in [X_{t_{F_n}}; \infty) \end{cases}$$

where

$$(98) X_{t_{F_n}} = \frac{b}{b-1} \frac{(r_m - m)I}{D(n)} \text{ holds.}$$

Fixing the entry date of the final rival, the entry triggers of all previously arriving firms can be calculated repeatedly with the Leader value function. Since the firms receive a periodically decreasing profit share with the subsequent arrival of the remaining competitors, the Leader value function needs to be slightly modified with regard to the staggered decreasing profit flow as follows:

$$(99) \quad L_i(X_t) \begin{cases} \left[\sum_{j=i}^{n-1} \left(\frac{p(D(j) - D(j+1))}{(r_m - m)} X_{t_{P_j}} \left(1 - \left(\frac{X_{t_{P_j}}}{X_{t_{P_{j+1}}}} \right)^{b-1} \right) \right) + \frac{pD(n)X_{t_{P_n}} - I}{(r_m - m)} \right] \left(\frac{X_t}{X_{t_{P_i}}} \right)^b \\ \text{if } X_t \in [0; X_{t_{P_i}}) \\ \\ \sum_{j=i}^{n-1} \left(\frac{p(D(j) - D(j+1))X_t}{(r_m - m)} \left(1 - \left(\frac{X_t}{X_{t_{P_{j+1}}}} \right)^{b-1} \right) \right) + \frac{pD(n)X_t - I}{(r_m - m)} \\ \text{if } X_t \in [X_{t_{P_i}}; X_{t_{P_{i+1}}}) \\ \\ \sum_{j=i+1}^{n-1} \left(\frac{p(D(j) - D(j+1))X_t}{(r_m - m)} \left(1 - \left(\frac{X_t}{X_{t_{P_{j+1}}}} \right)^{b-1} \right) \right) + \frac{pD(n)X_t - I}{(r_m - m)} \\ \text{if } X_t \in [X_{t_{P_{i+1}}}; X_{t_{P_{i+2}}}) \\ \\ \mathbf{M} \\ \\ \frac{p(D(n) - D(n-1))X_t}{(r_m - m)} \left(1 - \left(\frac{X_t}{X_{t_{P_n}}} \right)^{b-1} \right) + \frac{pD(n)X_t - I}{(r_m - m)} \\ \text{if } X_t \in [X_{t_{P_{n-1}}}; X_{t_{P_n}}) \\ \\ \frac{pD(n)}{(r_m - m)} X_t - I \\ \text{if } X_t \in [X_{t_{P_n}}; \infty) \end{cases}$$

where $L_i(X_t)$ denotes the Leader value of the firm which enters the new market in which already $i-1 \in [0; n-1)$ competitors have already invested and $P_i \in [0; \infty)$ denotes his preemption date (or the earliest joint entry date for $i \in [0; n)$ firms).

4.3.2.2 Optimal Entry Triggers

Following the same argument as presented in the analysis of duopoly economy one firm is motivated to enter a new market where already $i-1 \in [0; n-1)$ of his competitors are active as long as the accumulated present value of the restricted profit flow of $pD(i)$ per unit time exceeds or at least compensates the time value of the earlier investment costs.

The firm receives the restricted profit flow of $pD(i)$ per unit time up until the arrival of an additional competitor. This occurs at the optimal joint entry date for $i+1 \in [1; n+1)$ firms noted by $X_{t_{P_{i+1}}}$. The firm loses the time value of investment costs also compared to $X_{t_{P_{i+1}}}$, since $X_{t_{P_{i+1}}}$ represents the firm's next optimal entry date if $i \in [1; n)$ firms have already invested.

Driven by the macroeconomic growth rate in the Wiener process of the profit curve, the compensation for the time value of investment costs decreases continuously with each unit of time going back from $X_{t_{P_{i+1}}}$.¹⁰²

Based on the above the optimal entry date for the $i^{\text{th}} | i \in [1; n)$ arriving competitor noted by $X_{t_{P_i}}$ is determined by the equilibrium where the investor is indifferent between investing or waiting until the next optimal entry trigger at $X_{t_{P_{i+1}}}$. This equilibrium requirement can be formally expressed as follows:

$$(100) \quad \frac{pD(i)}{(r_m - m)} X_{t_{P_i}} \left[1 - \left(\frac{X_{t_{P_i}}}{X_{t_{P_{i+1}}}} \right)^{b-1} \right] = I \left[1 - \left(\frac{X_{t_{P_i}}}{X_{t_{P_{i+1}}}} \right)^b \right] \text{ where}$$

$$(101) \quad X_{t_{P_n} = t_{P_n}} = \frac{b}{b-1} \frac{(r_m - m)I}{D(n)}$$

¹⁰²The time value of investment costs remains unchanged per each unit time due to the assumptions of flat market yield curve and fixed investment costs. This ensures that the compensation will not occur beyond a certain timeframe going back from $X_{t_{P_{i+1}}}$ and a new preemption point of $X_{t_{P_i}}$ is obtained as soon as the net present value of the earlier market entry has been completely eliminated. This requirement is formally expressed by equation (100).

4.3.2.3 Example: Oligopoly Economy with Three Competing Firms

Applying the previously presented procedure the value functions of the individual investors determine the following optimal entry dates of the firms if three identical firms compete for entering a host market.

First, the third (latest) entry is determined by applying the Follower value function of equation (97) as presented below:

$$(102) F_3(X_t) \begin{cases} \left[\frac{pD(3)}{(r_m - m)} X_{t_{F_3=t_{F_3}}} - I \right] \left[\frac{X_t}{X_{t_{F_3=t_{F_3}}}} \right] & \text{if } X_t \in [0; X_{t_{F_3=t_{F_3}}}) \\ \frac{pD(3)}{(r_m - m)} X_t - I & \text{if } X_t \in [X_{t_{F_3=t_{F_3}}}; \infty) \end{cases}$$

The third firm simply maximises the time value of his investment as no further entry is expected. His optimal entry date is obtained as follows:

$$(103) X_{t_{F_3=t_{F_3}}} = \frac{b}{b-1} \frac{(r_m - m)I}{D(3)}$$

Fixing the optimal entry date of the third investor, the value function of the second investor with the restricted period of excess duopoly profit stream can be obtained by applying the Leader value function as presented by *equation (99)*:

$$(104) \quad L_2(X_t) \begin{cases} \left[\frac{p(D(2) - D(3))X_{t_{p_2}}}{(r_m - m)} \left(1 - \left(\frac{X_{t_{p_2}}}{X_{t_{F_3}}} \right)^{b-1} \right) + \frac{pD(3)X_{t_{p_2}}}{(r_m - m)} - I \right] \left[\frac{X_t}{X_{t_{p_2}}} \right] \\ \text{if } X_t \in [0; X_{t_{p_2}}) \\ \\ \frac{p(D(2) - D(3))X_t}{(r_m - m)} \left(1 - \left(\frac{X_t}{X_{t_{F_3}}} \right)^{b-1} \right) + \frac{pD(3)X_t}{(r_m - m)} - I \\ \text{if } X_t \in [X_{t_{p_2}}; X_{t_{F_3}}) \\ \\ \frac{pD(3)}{(r_m - m)} X_t - I \\ \text{if } X_t \in [X_{t_{p_3}=t_{F_3}}; \infty) \end{cases}$$

Applying the equilibrium requirement expressed under *equation (100)* the preemption point of the second investor denoted by $X_{t_{p_2}}$ is given by the solution of the following equation¹⁰³:

$$(105) \quad \frac{pD(2)}{(r_m - m)} X_{t_{p_2}} \left[1 - \left(\frac{X_{t_{p_2}}}{X_{t_{p_3}=t_{F_3}}} \right)^{b-1} \right] = I \left[1 - \left(\frac{X_{t_{p_2}}}{X_{t_{p_3}=t_{F_3}}} \right)^b \right]$$

¹⁰³Due to the competition between the last two investors the second entrant can accelerate his investment compared to the third arrival as long as the present value of the restricted duopoly profits compensates the time value of early investment costs. The preemption point occurs if the excess profit of early investment has been completely eliminated.

Finally, with respect to the optimal arrival date of the second and third arrivals, the value function of the first investor with a restricted excess monopoly and duopoly profit period can be obtained based on *equation (99)* as follows:

$$(106) \quad L_1(X_t) \left\{ \begin{array}{l} \left[\frac{p(D(1) - D(2))X_{t_{F_1}}}{(r_m - m)} \left(1 - \left(\frac{X_{t_{F_1}}}{X_{t_{F_2}}} \right)^{b-1} \right) + \frac{p(D(2) - D(3))X_{t_{F_1}}}{(r_m - m)} \left(1 - \left(\frac{X_{t_{F_1}}}{X_{t_{F_3}}} \right)^{b-1} \right) + \frac{pD(3)X_{t_{F_1}} - I}{(r_m - m)} \right] \left(\frac{X_t}{X_{t_{F_1}}} \right)^b \\ \text{if } X_t \in [0; X_{t_{F_1}}) \\ \\ \frac{p(D(1) - D(2))X_t}{(r_m - m)} \left(1 - \left(\frac{X_t}{X_{t_{F_2}}} \right)^{b-1} \right) + \frac{p(D(2) - D(3))X_t}{(r_m - m)} \left(1 - \left(\frac{X_t}{X_{t_{F_3}=t_{F_3}}} \right)^{b-1} \right) + \frac{pD(3)X_t - I}{(r_m - m)} \\ \text{if } X_t \in [X_{t_{F_1}}; X_{t_{F_2}}) \\ \\ \frac{p(D(2) - D(3))X_t}{(r_m - m)} \left(1 - \left(\frac{X_t}{X_{t_{F_3}=t_{F_3}}} \right)^{b-1} \right) + \frac{pD(3)X_t - I}{(r_m - m)} \\ \text{if } X_t \in [X_{t_{F_2}}; X_{t_{F_3}=t_{F_3}}) \\ \\ \frac{pD(3)}{(r_m - m)} X_t - I \\ \text{if } X_t \in [X_{t_{F_3}=t_{F_3}}; \infty) \end{array} \right.$$

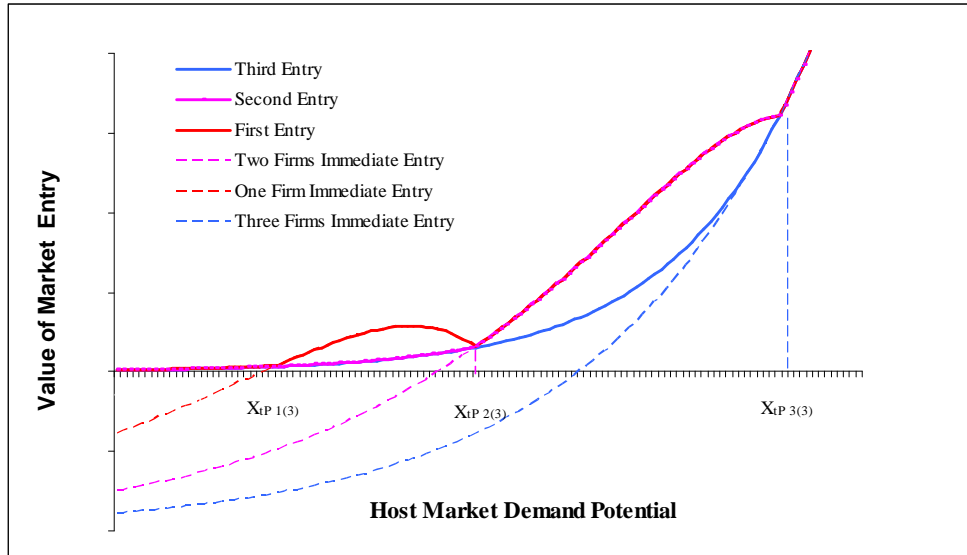
The preemption point for the first entry denoted by $X_{t_{F_1}}$ occurs at the solution of the following equation¹⁰⁴:

$$(107) \quad \frac{pD(1)}{(r_m - m)} X_{t_{F_1}} \left[1 - \left(\frac{X_{t_{F_1}}}{X_{t_{F_2}}} \right)^{b-1} \right] = I \left[1 - \left(\frac{X_{t_{F_1}}}{X_{t_{F_2}}} \right)^b \right]$$

¹⁰⁴Compared to the preemption point of the second entrance the first entry can be accelerated as long as the present value of the restricted monopoly profits compensates the time value of investment costs.

The picture below depicts the value functions and optimal market entry dates of three identical firms in oligopoly economy based on the results as presented under *equations (102) (104) and (106)*:

Chart 16: Oligopoly Economy with Three Identical Firms



4.3.2.4 Comparative Analysis

Two opposing impacts drive the optimal entry date of the firms in oligopoly economy.

1. On the one hand driven by the preemption process of endogenously given roles, the optimal entry date for the $(n-1)^{th}$ arrival in the case of n competing firms (representing the endogenous joint entry date of $n-1$ competitors) occurs earlier than the optimal last arrival in the case of $n-1$ competing firms (representing the exogenous joint entry date of $n-1$ firms). This is due to the same strategic impact of competition (preemption process) as presented under the comparative analysis of endogenous Leader versus Monopoly market entry.
2. On the other hand however, one should observe that this strategic impact implicates a shorter profit tenure with $pD(n-2)$ profit flow per unit time for the first $n-2$ entrants in the case of an economy with n competitors compared to the case of $n-1$ competing firms. Driven by the positive drift in the Wiener process of the profit curve, the wedge between the optimal exogenously and endogenously defined entry dates of the $(n-1)^{th}$ investor represents an investment period for the $(n-2)^{th}$ arriving firm where the present value of his profit flow exceeds the time value of his investment costs per each unit time¹⁰⁵. This accumulated net present value of investment makes possible that compared to the endogenously defined entry dates of the $(n-1)^{th}$ investor the firm which is arriving as number $(n-2)$ on the new market can further accelerate his entry if he faces only one additional competitor (case of $n-1$ firms) rather than two remaining competitors (case of n firms).¹⁰⁶

The following section compares the occurrence of optimal entry dates of the first and second investors between the duopoly case and the oligopoly case with three firms. The aim of the analysis is to present the effects of these two opposing impacts on the optimal entry dates.

¹⁰⁵ The formal proof is presented in the next section.

¹⁰⁶ In case of exogenously given firm roles the optimal entry date of each investor will coincide independently from the number of competitors (in the absence of competitions all firms can simply maximize the time value of investments costs).

4.3.2.5 Optimal Entry Triggers

Driven by the strategic impact of competition the entry thresholds of the second investor in oligopoly economy with three identical competitors will occur earlier than the optimal Follower entry date of the duopoly model.

This can be formally proved by seeing that the second investor of an oligopoly with three competitors is not indifferent between investing and waiting at the optimal Follower threshold of the duopoly case noted by X_{t_F} .

Define the function $\Phi_1(X_t)$ based on *equation (105)* as follows:

$$(108) \quad \Phi_1(X_t) = \frac{pD(2)}{(r_m - m)} X_t \left[1 - \left(\frac{X_t}{X_{t_{F_3}}} \right)^{b-1} \right] - I \left[1 - \left(\frac{X_t}{X_{t_{F_3}}} \right)^b \right]$$

Replacing the value of $X_t = X_{t_F}$ based on *equation (17)* into the above equation and applying the results of *equation (98)* for the value of $X_{t_{F_3}}$ the following results are obtained:

$$(109) \quad \Phi_1(X_{t_F}) = \frac{b}{b-1} I \left[1 - \left(\frac{D(3)}{D(2)} \right)^{b-1} \right] - I \left[1 - \left(\frac{D(3)}{D(2)} \right)^b \right] > 0$$

Since $\frac{\partial \Phi_1(X_{t_F})}{\partial \frac{D(3)}{D(2)}} < 0$; $b > 1$ and $\frac{D(3)}{D(2)} \in (0;1)$ hold.

The result of *equation (109)* shows that the investment has a positive value for the arrival of the second of three competitors at the optimal Duopoly Follower entry date. This positive value of investment implicates that the second investor can further accelerate his market entry beyond X_{t_F} to preempt the third competitor and $X_{t_{F_2}} < X_{t_F}$ holds.

Due to this strategic impact of competition between the third and the second investors, the first investor faces shorter monopoly profit tenure with lower compensation for the time value of his investment costs in the case of three competing firms compared to the case of two competitors.

The first investor's profit flow per unit time noted by $pD(1)$ overcompensates the time value of investment costs if $X_t \in [X_{t_M}; \infty]$. Therefore the wedge between $X_{t_{P_2}}$ and X_{t_F} implies that the first investor loses positive net present value of investment in the case of facing two rather than one competitor if $X_{t_M} \leq X_{t_{P_2}}$ holds.

Based on *equation (105)* the present value of the restricted duopoly profit of the second arriving firm at the Monopoly entry is obtained as follows.

$$(110) \quad \Phi_2(X_{t_M}) = \frac{pD(2)}{(r_m - m)} X_{t_M} \left[1 - \left(\frac{X_{t_M}}{X_{t_{F_3}}} \right)^{b-1} \right] - I \left[1 - \left(\frac{X_{t_M}}{X_{t_{F_3}}} \right)^b \right]$$

Since the compensation of the early entry for the restricted duopoly profit flow starts at $X_{t_{P_2}}$ by definition, one can show that $X_{t_M} < X_{t_{P_2}}$ holds by proving that $\Phi_2(X_{t_M}) < 0$.

Replacing the values of X_{t_M} and $X_{t_{F_3}}$ based on *equations (9)* and *(103)* into *equation (110)* the following result is obtained:

$$(111) \quad \Phi_2(X_{t_M}) = \frac{b}{b-1} I \frac{D(2)}{D(1)} \left[1 - \left(\frac{D(3)}{D(1)} \right)^{b-1} \right] - I \left[1 - \left(\frac{D(3)}{D(1)} \right)^b \right] < 0 \text{ since}$$

$$\frac{\partial \Phi_2(X_{t_M})}{\partial \frac{D(3)}{D(1)}} > 0; \text{ as } b > 1, \frac{D(2)}{D(1)} \in (0;1) \text{ and } \frac{D(3)}{D(1)} \in (0;1) \text{ hold.}$$

The result of *equation (111)* implicates that due to the earlier arrival of the second firm the monopoly investment tenure is less valuable if the first investor faces two competitors rather than one. As a consequence the first arriving firm in an oligopoly economy with three competitors can not afford to accelerate his entry up until the Leader preemption point of the duopoly economy and $X_{t_p} < X_{t_{p_1}}$ will hold.

This result can be formally proved as follows:

Define the function $\Phi_3(X_t)$ based on *equation (107)* as follows:

$$(112) \quad \Phi_3(X_t) = \frac{pD(1)}{(r_m - m)} X_t \left[1 - \left(\frac{X_t}{X_{t_{p_2}}} \right)^{b-1} \right] - I \left[1 - \left(\frac{X_t}{X_{t_{p_2}}} \right)^b \right]$$

Replacing the value of the Leader preemption point in duopoly economy based on *equation (36)* into the above equation the following result is obtained:

$$(113) \quad \Phi_3(X_{t_p}) = \frac{D(1)}{r_m - m} X_{t_p} \left(\frac{X_{t_p}}{X_{t_F}} \right)^{b-1} - \frac{D(1)}{r_m - m} X_{t_p} \left(\frac{X_{t_p}}{X_{t_{p_2}}} \right)^{b-1} - \left(\frac{X_{t_p}}{X_{t_F}} \right)^b I + \left(\frac{X_{t_p}}{X_{t_{p_2}}} \right)^b I < 0$$

Since $\frac{\partial \Phi_3(X_{t_p})}{\partial X_{t_{p_2}}} > 0$ ¹⁰⁷ and $\Phi_3(X_{t_p}) = 0$ at replacing $X_{t_{p_2}} = X_{t_F}$ ¹⁰⁸ where $X_{t_p} < X_{t_F}$ holds

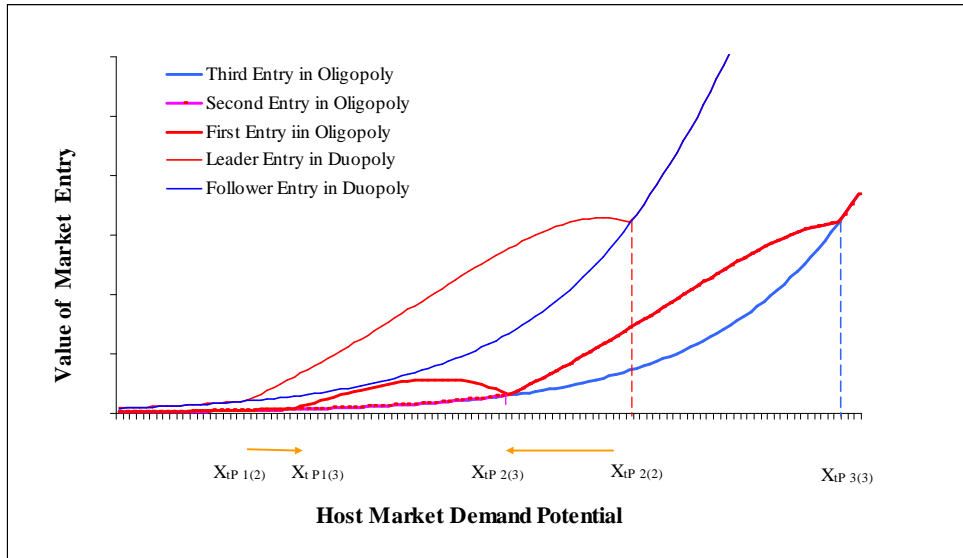
¹⁰⁷ After replacing the result of *equation (9)* the following equation is obtained:

$$\frac{\partial \Phi_3(X_{t_p})}{\partial X_{t_{p_2}}} = (b-1) \frac{D(1)}{r_m - m} (X_{t_p})^b X_{t_{p_2}} (X_{t_{p_2}})^{-b-1} - (b-1) \frac{D(1)}{r_m - m} (X_{t_p})^b X_{t_M} (X_{t_{p_2}})^{-b-1} > 0 \text{ since } X_{t_M} < X_{t_{p_2}}$$

¹⁰⁸ $\frac{X_{t_p} D(1)}{r_m - m} \left(\frac{X_{t_p}}{X_{t_F}} \right)^{b-1} - \frac{X_{t_p} D(1)}{r_m - m} \left(\frac{X_{t_p}}{X_{t_F}} \right)^{b-1} - \left(\frac{X_{t_p}}{X_{t_F}} \right)^b I + \left(\frac{X_{t_p}}{X_{t_F}} \right)^b I = 0$

The below chart presents the effect of competition in the case of three identical firms of an Oligopoly economy versus two identical firms of a Duopoly economy:

Chart 17: Comparative Analysis with Duopoly and Oligopoly Economies



4.3.2.6 Optimal Entry Strategies

The increase in the number of competitors impacts not only the optimal entry dates of the investors but it also influences the probability of becoming the Leader role at the individual preemption points respectively.

At the first preemption point noted by X_{t_1} one firm's value is obtained by the following equation:

$$(114) \quad V_i = \max_{a_i} \left[\begin{array}{l} a_i(1-a_j)(1-a_k)L(X_t) + \\ (1-a_i)a_j(1-a_k)F(X_t) + (1-a_i)(1-a_j)a_kF(X_t) + (1-a_i)a_ja_kF(X_t) + \\ a_ia_ja_kJ_3(X_t) + a_ia_j(1-a_k)J_2(X_t) + a_i(1-a_j)a_kJ_2(X_t) + \\ (1-a_i)(1-a_j)(1-a_k)V_i \end{array} \right]$$

where $J_2(X_t)$ denotes the payoffs if two firms and $J_3(X_t)$ denotes the payoffs if three firms enter the market simultaneously at the same time and $a_{i/j/k}$ presents the probability that firm $i/j/k$ chooses the option of market entrance.

Applying the first order condition on the above equation and substituting $a_i = a_j = a_k = a$ for symmetric firms the following expression is obtained for the value of one firm's market entrance at the beginning of the game:

$$(115) \quad V_{i/j/k} = \frac{1-2a+a^2}{3-3a+a^2}L(X_t) + \frac{2-3a+a^2}{3-3a+a^2}F(X_t) + \frac{2a-2a^2}{3-3a+a^2}J_2(X_t) + \frac{a^2}{3-3a+a^2}J_3(X_t)$$

Driven by the rent equalisation, risk neutral investors will be indifferent between waiting and investing at every preemption point. Consequently the incentive for the market entrance noted by a goes to zero at X_{t_1} and each firm will become the Leader with the probability of $\frac{1}{3}$

and the Follower with the probability of $\frac{2}{3}$.

Compared to the duopoly case, where the probability of the Leader and the Follower roles equalled to $\frac{1}{2}$, the results of *equation (115)* indicate that the increased number of competitors decreases the chances for one firm to become the Leader and enhances the probability of becoming the Follower.

At the second preemption point noted by X_{t_p} three outcomes are possible¹⁰⁹.

1. The *simplest one* is the case where two firms already entered the market before that point. As the market entry for an additional third competitor is not optimal, the remaining firm waits until the market maturity reaches the optimal investment threshold for a third competitor.
2. According to the *second alternative*, one firm has already invested before this trigger. In that case the roles of second and third entrant will be distributed between the remaining two firms based on the same calculation procedure as the Leader and Follower roles were allocated in the duopoly analysis.
3. The *last possible outcome* is that neither firm has invested up until that threshold¹¹⁰. This implicates that it will be optimal for two firms to invest simultaneously and the remaining third should enter the market at the next Follower threshold. The problem with this situation is that continuity may disappear in some subgames as the following examples show¹¹¹:

Firm i will be in the lucky pair of companies with the following probability:

$$(116) \quad a_i a_j (1 - a_k) L(X_t) + a_i (1 - a_j) a_k L(X_t)$$

¹⁰⁹The sub optimal outcome of the game where all three firms already entered the market before this optimal trigger is not analysed as it is out of importance.

¹¹⁰This happens if the game starts at this point of host market demand potential.

¹¹¹Similar explanation can be obtained from Fudenberg, D. and Tirole, J., 1985 Preemption and Rent equalization in the Adaption of New Technology, Review of Economic Studies. However, these authors' argument is not detailed in the same way.

However, with a remaining probability of $a_i(1-a_j)(1-a_k)L(X_t)$ *firm i* may have entered the market before neither of his competitors made his own entry decision. In that case the market entry game is repeated for the remaining two firms and with probability $a_j a_k$ the suboptimal triple joint entry may occur in this second round. If this outcome happens *firm i* should leave his optimal entry path for the suboptimal joint entry.

The same type of discontinuity happens in all cases where one firm has already made his entry decision without the commitment of at least one of his competitors. In the case of analysing *firm i*'s entry decision these remaining probabilities are as follows:

$$(117) \quad (1-a_i)a_j(1-a_k)F(X_t) + (1-a_i)(1-a_j)a_k F(X_t),$$

4.3.3 *Asymmetric Firms*

In the case of more than two asymmetric competitors the order of the market entrance among the firms should be determined by applying the following procedure:

Step 1: The latest investment triggers of two randomly selected firms are calculated. The firm with the earlier last investment threshold will be removed from the list and the algorithm will be repeated by $n - 1$ times. At the end of this procedure the weakest firm is identified and is taken out from the sample. Applying this algorithm iteratively one can obtain the order of the market entrance in the oligopoly backwards.

Step 2: In the next step the entry threshold of the firms needs to be determined. The process should start backwards with the determination of the market entry threshold of the weakest competitor. As the weakest firm arrives finally he receives the smallest market share of $D(n)$. After the entry trigger of the weakest firm has been obtained with the Follower value function, applying the Leader value function repeatedly, the entry trigger of the next weakest firm can be calculated as long as the first entry date is obtained.

However, it should be noted that in the case of asymmetric firms the market entry game has different continuations depending on which firm has entered the market first and with unequal continuation payoffs different firms have different strategic value of investing first.¹¹²

¹¹²A more detailed explanation can be obtained from Fudenberg, D. and Tirole, J. 1985 Preemption and Rent equalization in the Adaption of New Technology, Review of Economic Studies. Fudenberg and Tirole concluded that preemption need not enforce rent equalisation in case of more than two asymmetric firms. It should be noted that this is already the case with two asymmetric firms as presented in the previous chapter.

4.3.4 Conclusion

Generally two opposing impacts influence the optimal market entry date of investors if the competition intensifies due to the increase in the number of potential entrants.

On the one hand one additional competitor accelerates the entry of the next to last $(n-1)^{th}$ firm driven by the preemption process. However, on the other hand the early $(n-1)^{th}$ arrival implicates shorter $D(n-2)$ profit tenure for the previously arrived firms deterring the optimal $(n-2)^{th}$ preemption point. This process continues iteratively¹¹³ up until the investment of the first firm. Since the investment costs are assumed to be fixed and unchanged the positive drift in the Wiener process of the profit flow distributes a continuously decreasing weight to each impact going backwards. As a consequence the market entry date of the first investor in the case of $n \geq 3$ competing firms occurs between the first entry date of the cases with $n-2$ and $n-1$ competitors.

This means that the earliest first market entry date occurs in duopoly economy and each additional competitor delays the first market entrance compared to the Duopolist Leader preemption point. However, one needs to observe that one additional competitor accelerates the first market entry if the number of competing firms excluding him is odd and has the reverse impact if it is even.

It needs to be further observed that in the case of more than two competitors continuation may disappear in some subgames of the market entry game as a result of which no closed loop market entry strategy set exists. Moreover the chance of obtaining the Leader role decreases with the increase in the number of competitors and risk neutral players should risk more to get the expected value of the Follower strategy. This implicates that the increase in the number of competitors further deters the geographic market entrance in the case the investors are risk adverse.

¹¹³The extended $(n-2)^{th}$ preemption date represents a longer $D(n-3)$ profit tenure intensifying the competition and accelerating the $(n-3)^{th}$ arrival etc...

The theoretical results indicate, that Western European retailers deterred their investment decision in the Eastern European countries in those years when the number of competitors expected to invest in the near future exceeded a certain level. In the middle of the 90s foreign retailers entered jointly in great numbers especially in Poland and the Czech Republic as these countries presented the highest level of host market demand potential. It is therefore important to test a possible dual impact of *expected level of competition* in order to avoid distortion of the empirical test results and parameterise the empirical model properly.

5 Empirical Evidence for the Strategic Value of Investment

5.1 Introduction

Retail industry has become increasingly global in the recent decades. In the 90s Western European retailers were suffering from saturated home markets, cut-throat competition and restrictive legislation. Moreover, the combined home market share of the top five grocery retailers exceeded 70%, indicating a high concentration rate among the players. As a not surprising consequence the fierce market share races on the home markets pushed Western retailers to go globally and to search for new markets abroad ¹¹⁴.

In 2003 the top 30 food retailers have extended their operation in 85 different countries increasing their market presence by several times of the 15 countries which their operation covered a decade earlier¹¹⁵. Although two of three retailers failed to meet their financial targets after entering a developing country, going global remained a key element in the retailers' growth strategy.

Following the market opening of the former communist countries in Eastern Europe a significant growth opportunity with untapped market potential has been opened up for Western European retailers. However, entry patterns to Eastern Europe as target market varied substantially across firms and host markets. On the one hand, some target markets like Poland, Czech Republic and Hungary were more popular and attracted more foreign retailers with earlier investment than others (e.g. Romania, Bulgaria). On the other hand, some competitors preferred an earlier entry into the same countries compared to their rivals (e.g. REWE showed up generally earlier than Metro in the Eastern European countries).

This chapter presents the result of an empirical study examining the market entry behaviour of Western European retailers in Eastern Europe after the fall of the communist regimes in these

¹¹⁴A.T. Kearney for example argued that the industry is becoming increasingly global as (i) the size of middle and upper middle income groups is growing in most countries; (ii) retailers dramatically increased their global coverage, and (iii) the time period necessary for the developing markets to move from the traditional to modern retail shortened significantly. (Farra, F., A.T. Kearney and Bell, D., Globalisation strategies: How to crack new markets, EFB issue 25)

countries.¹¹⁶ The aim of the empirical analysis is to test the results of the theoretical models set up in the previous chapters. The focus of the tests is to analyse the length of time to the occurrence of an event (the market entry of Western European retailers) and to test the impact of some selected economic indicators and the intensity of competition on the duration of waiting.

The database used in this study was mainly provided by planetretail.net and the empirical tests have been carried out by the statistical software STATA/SE 8.0 for Windows.

¹¹⁵ A.T. Kearney, 2003 Global Retail Development Index, Internet

¹¹⁶ Gielens, K. and Dekimpe, M.G., 2004 How to Seize a Window of Opportunity: The Entry Strategy of Retail Firms into Transitional Economies, ERIM Report Series Research in Management present a very similar empirical study on entry patterns of Western European retailer into Eastern Europe including the analysis of speed and size of entry. The reason for choosing the same field of research was to extend and to change at some places the authors' model specification in order to better reflect the results of the theoretical models and to focus on a deeper analysis of the "speed of entry". Changes have been made in various stages of the empirical testing. These are noted at the place of their relevance.

5.2 Hypotheses

The aim of the empirical test is to measure and analyse the speed of market entry of top Western European grocery retailers in the Eastern European countries. The analysis focuses on the measurement of each value component of the market entrance including:

1. the *static* or intrinsic value *component*,
2. the *dynamic* or time value component and
3. the *strategic value component*

The empirical test measures the impact of common macroeconomic indicators and the effect of competition on the timing of foreign firms' arrival.

5.2.1 Explanatory Variables

5.2.1.1 Host Market's Attractiveness

Host market attractiveness is measured by the demand potential (X_t) and is assumed to accelerate the market entrance by increasing the intrinsic value of the investment (results of Chapter 3.2).

The demand potential is measured by the following macroeconomic indicators as continuous explanatory variables¹¹⁷ in the empirical tests:

1. *GDP per capita in PPS* (Purchasing Power Standards)¹¹⁸ has been selected to define the average host market demand potential at *time t*. The volume index of GDP per capita in PPS is expressed in relation to the European Union average. This eliminates the differences in price levels between countries allowing for meaningful cross country comparison rather than for temporal comparison.¹¹⁹

In order to measure the impact of increase in GDP per capita significantly, the scale of increase in the variable was set to thousand \$.

Based on the above the explanatory variable of GDP per capita has been imputed as expressed below:

¹¹⁷Gielens, K. and Dekimpe, M.G. regarded all their explanatory variables as time-varying variables and assumed that the change in variable accumulates the impact on hazard of investment over time. However, it should be noted that explanatory variables, like GDP per capita, change their value over time since they are assumed to follow a stochastic process. Because of the nature of the stochastic processes these variables should be regarded as continuous variables, the value of which may change independent of their absolute level and the change in their value does not necessarily accumulate the hazard of investment over time. (GDP per capita for example decreased in almost all Eastern European countries over a short period of time in the 90s during the 16-year period of analysis.)

¹¹⁸ Figures were nominated in USD

¹¹⁹ Gielens, K. and Dekimpe, M.G. measured home market attractiveness by Retail sales expectation at time *t* and by economic distance variables (like lag of GNP per capita of the host market compared to the home market of the retailer). In their study all explanatory variables were mean centered within counties in order to eliminate the impact of differences in the mean levels between countries. This analysis does not apply the mean centering approach and measures the impact of differences between the general macroeconomic indicators of the individual host countries.

$$GDP_t = \frac{(GDP \text{ per Capita})_t}{1000}$$

2. *Average number of inhabitants* has been added to the explanatory variables of the model in order to assess the potential impact of economies of scale of the investment costs on the timing of market entry.

In order to measure the impact of this explanatory variable significantly, the scale of increase in the variable was set to 10 million.

Based on the above the explanatory variable of average number of inhabitants has been imputed as follows:

$$INHAB_t = \frac{INHAB_t}{10.000.000}$$

The following table summarizes the descriptive statistics of variables relating to the host market attractiveness in the dataset¹²⁰.

Table 1: Host Market Attractiveness

| Variable | Obs | Mean | Std. Dev. | Min | Max |
|----------|-----|----------|-----------|--------|---------|
| gdp | 365 | 13.46414 | 4.52219 | 5.49 | 20.606 |
| inhab | 366 | 15.60154 | 11.39191 | 5.3051 | 38.6497 |

The minimum level of GDP per capita has been recorded in Romania in 1990 while its maximum level has been reached in the Czech Republic in 2005. The largest country in terms of inhabitants is Poland, which country represents *ceteris paribus* more than seven-times higher demand potential than the smallest country Slovakia.

The large range in both variables measuring the host market's attractiveness shows that the target countries at risk differed significantly from each other in terms of host market demand potential during the analysed period.

¹²⁰GDP per capita in PPS has not been recorded by Eurostat for Hungary in year 1990 and for Slovakia in years 1990 and 1991.

5.2.1.2 *Competitive Presence*

The theoretic market entry models in duopoly economy showed that the evolution of rivalry in the new market significantly influences the speed of market entry.

Competition showed an adverse impact on the timing of the market entrance since

1. its *anticipated level* accelerated the Leader's market entrance for $\forall X_t \in [X_{t_p}; X_{t_L}]$ and motivated the Leader to preempt his potential competitor,
2. its *actual level* deterred all potential Follower entries since as soon as the Leader's market entry happened, the Follower's arrival has been delayed up until $X_{t_f} > X_{t_L}$.

To assess the adverse impacts of both preemption and delay of competitors' entry the explanatory variables of actual and potential rivalry has been separated in the empirical test.¹²¹

1. *Actual competitive presence* at time t has been measured by the ratio between the number of past entries by the end of the prior year and the number of competitors at risk.

$$ACTCOMPET_t = \frac{\sum_{i=0}^{t-1} \text{number of entrants}_i}{\text{number of firms}}$$

¹²¹Gielens, K. and Dekimpe, M.G. modeled both explanatory variables with converted U shape by assuming that both actual and expected competitive actions have two opposing forces of imitation and deterrence. However, based on the results of the theoretic market entry models, it is to observe that the dual impact of competition is already modeled by the opposing forces of potential and actual rivalries on the new market. Following that argumentation the separation of the two variables with the assumption of linear form is reasonable.

2. *Anticipated competitive presence* at time t has been measured by the ratio of observed entry at time $t + 1$ to the number of major competitors.¹²²

$$EXPCOMPET_t = \frac{\text{number of entrants}_{t+1}}{\text{number of firms}}$$

The following table summarises the descriptive statistics of the variables measuring the competitive presence in the dataset:

Table 2: Competitive Presence

| Variable | Obs | Mean | Std. Dev. | Min | Max |
|-----------|-----|----------|-----------|-----|----------|
| actcompet | 366 | 14.53014 | 7.010595 | 0 | 27.86885 |
| expcompet | 366 | .3583266 | 1.314038 | 0 | 8.196721 |

The highest levels of both anticipated and actual competition have been recorded in Poland in 1995 and in 2005 respectively. Poland representing the country with the largest demand potential was the most attractive target for western European retailers.

The high volatility of both variables measuring competitive presence indicates that the level of competition in the host markets varied significantly across countries during the analysed period.

¹²² Calculation method follows the same procedure as presented by Gielens, K. and Dekimpe, M.G..

5.2.1.3 Firms' Resources

The analysis of asymmetric firms (Chapter 4.2) showed that “*fitter*” and “*fatter*” competitors have a better chance to preempt their rivals either by entering the market earlier than their competitors or by obtaining the Leader role with higher probability in the preemption game.

Unfortunately consolidated balance sheet and profit and loss account data are not completely available for all retailers at risk for the whole analysed period.¹²³

To measure the impact of potential asymmetry among competitors the indicator variable of the retailers' rank, calculated on the basis of the average market share of retailer in Western Europe in the period from 1999 to 2005 has been selected¹²⁴.

$$RANK_t = \text{Average rank}_{1999-2005}$$

Selecting retailers' rank as the explanatory variable of asymmetry among firms is based on the assumptions that

- retailers with larger home market share may have better access to credit lines and cash reserves, generating a higher “fatness” as competitive advantage
- retailers with larger home market share may operate more effectively (higher “fitness”) since they may profit from the benefits of economies of scale of fixed operating costs (e.g. logistic network, headquarters etc...) and may have better bargaining position against suppliers.

¹²³Complete financial datasets for each year under analysis has been available only for the publicly listed retailers on the list, which represent ca. 20% of the selected retailers. (Analyse MAJOR Databases from EUROPEAN SOURCES, Bureau van Dijk Electronic Publishing)

¹²⁴Gielens, K. and Dekimpe, M.G. captured the firms' resources through the variable of consolidated deflated sales, which variable is the nominator of the quotient of grocery market share. However, imputing retailers' ranks as indicator variables was considered to make a better possible comparison than the continuous covariate of consolidated deflated sales.

5.2.2 *Expected Shape of Covariates:*

Based on the results of the theoretical market entry models the following hypotheses have been set up for the empirical tests.

Hypothesis 1:

The market entry model of the Monopoly showed that the increase of host market demand potential decreases the time value of waiting and accelerates investments.

The explanatory variable GDP_t is expected therefore to have a *positive* impact on the speed of market entry.

Hypothesis 2

The comparative analysis on the impact of economies of scale of investment costs revealed that market entries into host markets offering better economies of scale of fixed investment costs (e.g. into countries with larger population) occur earlier.

The explanatory variable $INHAB_t$ is expected therefore to have a *positive* impact on the speed of entry.

Hypothesis 3:

The equilibrium analysis of endogenously given roles in Duopoly and in Oligopoly economies revealed that the expected entrance of rival firm(s) decreases the time value of waiting until the point of rent equalisation.

The explanatory variable $EXPCOMPET_t$ is expected to have therefore a *positive* impact on the speed of market entry.

Hypothesis 4:

The model results of the Duopoly and Oligopoly analysis showed that the Leader's entry delays the arrival of the Follower(s).

Consequently the explanatory variable $ACTCOMPET_t$ is expected to have a *negative* effect on the speed of market entry.

Hypothesis 5:

The equilibrium analysis of asymmetric firms showed that differences in firm-specific factors such as operating profit and indebtedness influence the sequence of firm's arrival favouring stronger ("fitter" and "fatter") firms.

As it is assumed that firm's home market share has a positive correlation with his operational and financial strength, the explanatory variable $RANK_t$ is expected to have a *negative* effect on the speed of market entry and firms with higher rank (equivalent to lower market share in Western Europe) arrived later.

5.3 *Description of the Dataset Used*

5.3.1 *Data of the Target Countries (Countries at Risk)*

5.3.1.1 *Selection Criteria*

Those Eastern European countries have been selected as potential target markets of Western European retailers which met the following criteria¹²⁵:

1. Only Eastern European countries with potential of being subject to the *EU expansion* have been considered for the analysis. The reason for adapting that criterion was to eliminate the impact of significant political and economic risks in the dataset.¹²⁶
2. *Croatia* has been dropped out from the list because of its involvement in the Balkan war, which had a significant extraordinary impact on its general market development in the period under analysis.
3. From the remaining ten potential target countries only those have been kept on the final list where incumbent grocery retailers did not possess significant market shares. The presence of strong incumbents would distort the entry timing analysis of foreign retailers and could not give comparable results with those target markets which were untapped. Based on this criterion the following countries have been ignored in the final selection¹²⁷:

¹²⁵Gielens, K. and Dekimpe, M.G. traced back the entry records in the following 11 Central and Eastern European countries: Bulgaria, Czech Republic, Eastland, Hungary, Latvia, Lithuania, Poland, Romania, Russia, Slovenia and Slovakia.

¹²⁶Applying that criterion, Russia has been excluded from the set of target countries identified by Gielens, K. and Dekimpe, M.G.

¹²⁷The presence of significant incumbent(s) has not been considered as a selection criterion in the analysis of Gielens, K. and Dekimpe, M.G.. As a consequence, these authors included the Baltic States and Slovenia as potential targets, assuming that they provided the same opportunity for foreign retailers as the other selected countries without incumbents.

- *Slovenia*, where *Mercator* (the Slovenian retail chain) owned more than a third of the grocery retail market
- The Baltic states, *Lithuania, Latvia and Estonia*, where local retailers' market share (e.g. the market share of the Lithuanian *VP Market* and the Estonian *ETK*) exceeded 50% on the home markets

5.3.1.2 Information Dataset

For each selected Eastern European country the electronic database of planetretail.net covered the following information on active retailers:

- retail format,
- retail banner,
- retail banner sales (nominated in €million),
- grocery retail banner sales (nominated in €million)
- number of stores and
- total sales area (Sq.m.)

Unfortunately information for the period between 1989 and 1998 has not been recorded completely in the electronic database and had to be researched manually from diverse planetretail.net resources and from the internet. Because of this procedure, some of the information covering the period of 1989-1998 may not be fully complete.

Macroeconomic indicators of the selected Eastern European countries have been downloaded from the public website of Eurostat, the central statistical office of the EU. The following macroeconomic indicators have been applied in the model:

- GDP per capita based on PPS¹²⁸ and nominated in \$.
- Number of inhabitants

¹²⁸Gross Domestic Product (GDP) measures the economic activity of the host country. It is defined as the value of goods and services produced less the value of any goods and services used in their creation. The volume in Purchasing Power Standard (PPS) is expressed in relation to the European Union (EU-25) average set to equal 100%. This method eliminates the impact of price level differences between countries and makes a meaningful cross country comparison of GDP possible.

5.3.2 Data of the Potential Entrants (Retailers at Risk)

5.3.2.1 Selection Criteria

Western European Grocery retailers have been regarded as potential entrants if they had at least 0.1% grocery retail market share in Western Europe based on their total consolidated net grocery sales.

The rank of Western European grocery retailers was recorded from 1999 to 2005 in the planetretail.net database. As the rank of top retailers did not change significantly in the period from 1999 to 2005, it was assumed that the list of retailers having at least 0.1% market share on average in the period from 1999-2005 could be used as proxy of retailers at risk for the whole period under analysis.

Based on the above presented selection criteria the following 61 Western European retailers have been identified as potential entrants¹²⁹:

Table 3: Top Western European Grocery Retailers

| Rank | Name | Nationality | Grocery Market Share (%) (Average 1990-2005) | Rank | Name | Nationality | Grocery Market Share (%) (Average 1990-2005) |
|------|-------------------|-------------|---|------|--------------------|-------------|---|
| 1 | Carrefour | Fr | 7,01% | 32 | Dansk Supermarked | DK | 0,48% |
| 2 | Tesco | GB | 4,06% | 33 | SOK | SE | 0,46% |
| 3 | Rewe | D | 3,95% | 34 | El Corte Inglés | ES | 0,46% |
| 4 | Metro Group | D | 3,62% | 35 | Dagrofa | DK | 0,43% |
| 5 | Edeka | D | 3,48% | 36 | Co-operative Group | GB | 0,42% |
| 6 | ITM (Intermarche) | Fr | 3,39% | 37 | Esselunga | I | 0,39% |
| 7 | Aldi | D | 3,24% | 38 | Colruyt | B | 0,37% |
| 8 | Schwarz Group | D | 3,09% | 39 | Jerónimo Martins | PT | 0,36% |
| 9 | Ahold | NL | 2,71% | 40 | Reitan | Norv | 0,34% |
| 10 | Auchan | Fr | 2,57% | 41 | Dohle | D | 0,33% |
| 11 | Casino | Fr | 2,38% | 42 | Norma | D | 0,29% |
| 12 | Sainsbury | GB | 2,31% | 43 | Globus | D | 0,29% |
| 13 | leclerc | Fr | 2,02% | 44 | Caprabo | ES | 0,22% |
| 14 | Système U | Fr | 1,38% | 45 | Bartels-Langness | D | 0,22% |
| 15 | Tengelmann | D | 1,33% | 46 | BWG | Ire | 0,21% |
| 16 | Lekkerland | D | 1,11% | 47 | Modelo Continente | PT | 0,19% |
| 17 | Migros | CH | 1,06% | 48 | Finiper | I | 0,18% |
| 18 | Morrison | GB | 0,99% | 49 | Costcutter | GB | 0,16% |
| 19 | Somerfield | GB | 0,83% | 50 | Sligro | NL | 0,16% |
| 20 | Louis Delhaize | Fr | 0,79% | 51 | Lombardini | I | 0,15% |
| 21 | Mercadona | ES | 0,73% | 52 | Tradeka | Fi | 0,15% |
| 22 | Conad | I | 0,65% | 53 | Unide | ES | 0,14% |
| 23 | SPAR (Austria) | D | 0,64% | 54 | SuperBest | DK | 0,14% |
| 24 | NorgesGruppen | Norv | 0,64% | 55 | Denner | CH | 0,14% |
| 25 | Marks & Spencer | GB | 0,63% | 56 | Stonehouse | GB | 0,13% |
| 26 | Schlecker | D | 0,63% | 57 | Baugur | GB | 0,13% |
| 27 | Axel Johnson | SE | 0,60% | 58 | Sperwer | NL | 0,13% |
| 28 | Kesko | Fi | 0,59% | 59 | Eurospin | I | 0,12% |
| 29 | Delhaize Group | B | 0,55% | 60 | Bennet | I | 0,11% |
| 30 | Eroski | ES | 0,53% | 61 | Gadisa | ES | 0,11% |
| 31 | Musgrave | Ire | 0,49% | | | | |

¹²⁹Gielens, K. and Dekimpe, M.G. identified 75 grocery retailers as potential entrants based on their consolidated food sales figures in 1991. (Planetretail.net could not replicate this dataset because data were recorded in a different system before 1999.) As retailers at risk should define the group at risk during the whole period of the analysis time, the selection criteria presented above was considered to better reflect the risk set.

5.3.2.2 *Information Dataset*

The dataset of the selected retailers includes the following information, obtained from various sources:

- the nationality of the retailers (*Source: Internet research*)
- the year of entry in each of the selected six Eastern European countries, if the market entry happened (*Source: planetretail.net & Internet research*)
- the retail format, which was selected for the market entrance (*Source: planetretail.net*)
- the rank of the retailer based on his Grocery Market Share (%) in Western Europe (*Source: planetretail.net*)¹³⁰

¹³⁰As only Western European retailers have been included in the risk set, grocery retailers with other nationalities (e.g. Wall-Mart) have been eliminated from the list.

5.3.3 Summary

The dataset of the empirical test includes the entry behaviour of 61 grocery retailers into 6 Eastern European countries from 1989 until 2005, resulting in 366 potential retailer-market entry combinations.

The timing of market entry is captured in number of years elapsed between 1989 and the year of entry. If the market entry did not happen until 2005, which represents the last year of observation, the retailer-market entry combination was right censored.

Of the 61 retailers included in the sample 23 entered into one or more countries with the total number of recorded entry amounting to 60. This result represents a total hit rate of 16.6% compared to the potential retailer market entry combinations.

The following table summarises the entry statistics:

Table 4: Number of Market Entries in Eastern Europe

| Year of entry | Bulgaria | Czech Republic | Hungary | Poland | Romania | Slovakia | Total entry |
|--------------------|----------|----------------|----------|-----------|----------|----------|-------------|
| 1989 | | | 1 | | | | 1 |
| 1990 | | | | | | | 0 |
| 1991 | | 3 | 1 | | | | 4 |
| 1992 | | 3 | 2 | 1 | | | 6 |
| 1993 | | | | 1 | | 2 | 3 |
| 1994 | | | 2 | 1 | | | 3 |
| 1995 | | | | 3 | | | 3 |
| 1996 | | 2 | | 5 | 1 | 1 | 9 |
| 1997 | | 2 | | 4 | | | 6 |
| 1998 | | 2 | 2 | 1 | 1 | | 6 |
| 1999 | 1 | | | | | 1 | 2 |
| 2000 | 1 | | | | 1 | 4 | 6 |
| 2001 | 1 | | | 1 | 2 | 1 | 5 |
| 2002 | | | | | 2 | | 2 |
| 2003 | | | | | | | 0 |
| 2004 | 1 | | 1 | | | | 2 |
| 2005 | 0 | 0 | 0 | 0 | 2 | 0 | 2 |
| Total entry | 4 | 12 | 9 | 17 | 9 | 9 | 60 |

5.4 Model Specification

5.4.1 Survival Analysis

Duration models, also called survival analysis, are statistical tests applied in the cases where the timing of a certain event is analyzed. Although the initial application of these models were in the field of medicine and engineering, more recently they have also been used in the research of economic and political sciences¹³¹.

5.4.2 Basic Assumptions

The *survival time*, noted by T , measures the years from 1989 until the market entrance of foreign retailers in one of the selected host countries of Eastern Europe. This survival time is considered to be a nonnegative random variable, where $f(t)$ denotes the density function of T and

$$(1) F(t) = \Pr(T \leq t) = \int_0^t f(x) dx \text{ denotes its cumulative distribution function.}$$

The probability that a foreign retailer has not entered an Eastern European country up until T is given by the following *survival function*:

¹³¹Some examples for empirical studies applying survival analysis in economic related research are the following articles:

Gropp, R., Vesala, J. and Vulpes, G., 2002 Equity and Bond Market Signals as leading Indicators of Bank Fragility, European Central Bank Working Paper Series No. 150

Sabuhoro, J. B. and Gervais, Y., 2004 Factors Determining the Success of Failure of Canadian Establishment on Foreign Markets: A Survival Analysis Approach, Business and Trade Statistics Field Research Paper;

Box-Steffensmeister, J.M. and Zorn, C. J.W., 1998 Duration Models and Proportional Hazards in Political Science, Paper prepared for presentation at the Annual Meeting of the Midwest Political Science Association

$$(2) S(T) = \Pr(T > t) = \int_t^{\infty} f(x) dx = 1 - F(t)$$

The *hazard function* noted by $h(t)$ and also called as the conditional failure rate, presents the instantaneous rate of “failure” defined as the entry of a certain retailer in one of the selected countries with the unit of $\frac{1}{t}$. It calculates the limiting probability that the failure event occurs in a given time interval, condition upon the retailer having survived (having not entered the host market) to the beginning of that interval.

$$(3) h(t|T_{i-1}, \dots, T_0) = \lim_{\Delta t \rightarrow 0} \frac{\Pr(t \leq T < t + \Delta t | T > t)}{\Delta t} = \frac{f(t)}{S(t)}$$

The *proportional hazard models* assume that the hazard functions of individuals in the sample are proportional. This means that there exists a base line hazard $h_0(t)$, which is modified multiplicatively by covariates so that the hazard function up until T for any individual in the sample can be written as follows:

$$(4) h_i(t, x, \mathbf{b}_x, h_0) = h_0(t)q(x, \mathbf{b}),$$

where $h_0(t)$ represents the hazard function assuming $q(x, \mathbf{b}_x) = 1$. The multiple noted by $q(x, \mathbf{b}_x)$ is driven by the vector of time-varying covariates of retailer’s and host markets’ characteristics (x) and the vector of their coefficients (\mathbf{b}_x).

Depending on the nature of covariates and on the form of the survival function, survival analysis can be modelled in the following three forms:

- Nonparametric analysis is applied, if the covariates are qualitative in nature (e.g. retailer rank)
- Semiparametric analysis is used, if the covariates are quantitative but there exists no assumption regarding the shape of the survival function
- Parametric analysis is chosen, if the covariates are quantitative and the shape of the survival function can be estimated¹³²

As the analysed dataset of the chosen empirical study is relatively small (366 observations), the functional form of the underlying hazard could not have been estimated and was left unspecified. Consequently the semi parametric modelling has been chosen for the empirical tests.

¹³²The advantage of the semi-parametric estimation is the absence of a distribution function regarding the retailer's entry dates. The parametric approaches assume a parametric model for T and estimate the unknown parameters for the survivor and the hazard functions such as exponential, gamma, Weibull, lognormal, Pareto distribution and so on. For example in the Weibull model, a baseline hazard function, noted by $h_0(t)$ is given parametrically by the function of It^{a-1} .

5.4.3 Model Specification with Cox Proportional Hazard Model

The semi parametric Cox Proportional Hazard Model¹³³ is the most commonly used regression model for survival analysis, since the model does not require any assumption on the distribution of the underlying data.

Based on the Cox model the entry rate at *time t* for *retailer* $i \in [1; I]$ in *country* $j \in [1; J]$ is given by the following hazard function:

$$(5) \ h_{i,j}(t|X_{i,j}) = h_0(t)e^{[b_x X_{i,j}(t)]}$$

where

$X_{i,j}(t)$ represents a vector of time-varying covariates of retailers and of host markets, which are assumed to influence the timing of market entry,

$h_0(t)$ is the baseline hazard rate and

b_x notes the vector of regression coefficients to be estimated in the model.

The main flexibility of the Cox Proportional Hazard Model is that the model makes no assumption on the shape of hazard over time. It only assumes that the shape remains unchanged. Because of that the baseline hazard $h_0(t)$ is not parameterised and is left unestimated.

¹³³ Cox, D. R., 1976 Regression models and life-tables, Journal of Royal Statistical Society, Series B 34

The entry of one of the Western European retailers at risk in one of the Eastern European countries at risk defines the event at hazard. This definition represents a total risk set of $K = I \times J$ potential market entrance since events at hazard and the calculation of the regression coefficients b_x is based on the following partial likelihood function¹³⁴:

$$(6) H = \prod_{k=1}^K \left[\frac{e^{[b_x X_{i;k}(t_{i;k})]}}{\sum_{k=1}^K Y_k e^{[b_x X_k(t_k)]}} \right]^{c_{i;j}}$$

where

$c_{i;j}$ equals one for the observations where the market entry has happened and zero for censored observations and

$\sum_{k=1}^K Y_k$ denotes the set of potential market entrance at risk.

Formula (6) is used both for data with and without ties. The observations are tied if they happened at the same time. As the numbers of failures in the risk group were small relative to the size of the group itself, ties were handled by the Breslow approximation method¹³⁵.

According to the Breslow method each event time contributes one factor to the likelihood function, however for tied events all events in the tie appear with the same denominator¹³⁶.

¹³⁴Gielens, K. and Dekimpe, M.G. applied the stratified Cox proportional approach by assuming that not all observations are independent but only those which occur within a given country. Their risk set was therefore defined on a country-by-country basis. Contrary to their approach, the risk set in this analysis is defined on the basis of potential market entry combinations of potential entry in selected host countries. This means that one retailer at risk defines six potential market entries at risk. As the entry statistic of retailers showed that retailers at risk were large enough to finance entries in more countries at almost the same time simultaneously, it was assumed that the market entry of a retailer in one country does not impact the probability of his market entry in another country.

¹³⁵Breslow, N.E., 1974 Covariance analysis of censored survival data, *Biometrics* 30

¹³⁶The Breslow approximation method for ties is also the approach which STATA applies automatically.

5.4.3.1 Summary

Based on the hypothesis set up on the result of the theoretical models the hazard function of the Cox model is assumed to have the following functional form:

$$(7) \ h_{i;k}(t|X_{i;k}) = h_0(t|X_{i;k}) e^{[a(GDP_t) + b(INHAB_t) + c(EXPCOMPET_t) - d(ACTCOMPET_t) - e(RANK_t)]}$$

5.5 Results and Explanations

In this section the Cox Proportional Hazard model is tested with the model specifications presented under *equation (7)*. In this section presented tables generally contain the exponentiated coefficients rather than the coefficients themselves for presentation purposes.

5.5.1 Test Process

In the first step of the testing process the model has been imputed without measuring the impact of asymmetry among competitors in order to test the results of the standard market entry model in duopoly economy presented in the first part of this work.

Based on this the following hazard function estimate is tested in the first step:

$$(8) h_{i;k}(t|X_{i;k}) = h_0(t|X_{i;k}) e^{[a(GDP_i)+b(INHAB_i)+c(EXPCOMPET_i)-d(ACTCOMPET_i)]}$$

The results of parameter estimates with their relating z values are set out in the table below:

Table 5: Results Standard Duopoly Model I

| Cox regression -- Breslow method for ties | | | | | | |
|---|------------|-----------|-------|-------|----------------------|----------|
| No. of subjects = | 365 | | | | Number of obs = | 365 |
| No. of failures = | 59 | | | | | |
| Time at risk = | 5366 | | | | | |
| | | | | | LR chi2(4) = | 157.67 |
| Log likelihood = | -264.67001 | | | | Prob > chi2 = | 0.0000 |
| ----- | | | | | | |
| _t | Haz. Ratio | Std. Err. | z | P> z | [95% Conf. Interval] | |
| ----- | | | | | | |
| gdp | 1.064731 | .0785217 | 0.85 | 0.395 | .9214371 | 1.230309 |
| inhab | 1.077049 | .0237647 | 3.36 | 0.001 | 1.031464 | 1.124649 |
| actcompet | .7639555 | .0384449 | -5.35 | 0.000 | .6922018 | .8431473 |
| expcompet | 1.224156 | .0966934 | 2.56 | 0.010 | 1.048581 | 1.429129 |
| ----- | | | | | | |

The table shows that all coefficients are significant at 1% significance level except for the coefficient of the explanatory variable GDP per capita. However, based on the results of the theoretical models it does not seem to be a realistic outcome, that the increase in host market

demand potential has no significant impact on the incentive of one retailer to enter a new Eastern European market. As a consequence the nature of GDP per capita as explanatory variable has been analysed carefully in the next step of the analysis.

It should be observed that according to the standard model the explanatory variable of actual competitive presence correlates positively with the level of host market demand potential. The reason for the correlation is that the increase in host market demand potential accelerates the Leader(s)'s entry. As actual competition is assumed to deter further entries, the explanatory variable GDP per capita has not only a direct positive but it also needs to have an indirect negative impact on the speed of entry at the same time.

In order to handle the dual impact of GDP per capita properly in the empirical test the following new explanatory variable has been created to replace the original variable GDP_t in the further analysis:

$$AVERAGEMARKETSHARE_t = \frac{GDP_t}{\sum_{i=0}^{t-1} \text{number of entrance}_i + 1} \quad 137$$

The change in variable $AVERAGEMARKETSHARE_t$ expresses properly the staggered impact of GDP per capita by reflecting the balance between the increase in host market demand potential and in the intensity of competition.

The increase in GDP per capita is expected to have a positive impact on the event at hazard only in the cases where its growth is ahead of the increase in competition, providing excess host market demand for new entries. The level of actual competition in the denominator of the variable expresses the inverse impact and decreases the speed of entry in the cases where the development of host market demand potential does not keep pace with the increase in actual competition.

¹³⁷The number of competitors already present in the given market has been increased by one in order to differentiate between markets without entry and markets with one Western European retailer. The ratio of $AVERAGEMARKETSHARE_t$ expresses in this way one unit of potential host market demand potential which an additional retailer could obtain if he enters the market. GDP per capita has been not multiplied by the number of inhabitants as the impact of this variable is measured separately.

Based on the previous argumentation the hazard function is tested in the following modified functional form:

$$(9) h_{i;k}(t|X_{i;k}) = h_0(t|X_{i;k}) e^{[a(AVERAGEMARKETSHARE_t)+b(INHAB_t)+c(EXPCOMPET_t)-d(ACTCOMPET_t)]}$$

The table below presents the results of parameter estimates with their relating z values after replacing variable GDP_t with the new variable $AVERAGEMARKETSHARE_t$:

Table 6: Results Standard Duopoly Model II

| Cox regression -- Breslow method for ties | | | | | | |
|---|------------|-----------|-------|-----------------|----------------------|----------|
| No. of subjects = | 365 | | | Number of obs = | 365 | |
| No. of failures = | 59 | | | | | |
| Time at risk = | 5366 | | | | | |
| Log likelihood = | -256.42884 | | | LR chi2(4) = | 174.15 | |
| | | | | Prob > chi2 = | 0.0000 | |
| ----- | | | | | | |
| _t | Haz. Ratio | Std. Err. | z | P> z | [95% Conf. Interval] | |
| ----- | | | | | | |
| inhab | 1.065782 | .0170851 | 3.97 | 0.000 | 1.032816 | 1.0998 |
| actcompet | .8395233 | .0254191 | -5.78 | 0.000 | .7911522 | .8908518 |
| averagemar~e | 1.426851 | .1173163 | 4.32 | 0.000 | 1.214486 | 1.67635 |
| expcompet | 1.336678 | .0967753 | 4.01 | 0.000 | 1.159845 | 1.540471 |
| ----- | | | | | | |

The results show that the new variable reflecting the staggered impact of host market demand potential became significant at 1% significance level. Moreover the estimates of coefficients and their z-values give strong evidence that the selected variables significantly differ from zero and influence strongly the speed of market entrance, while the signals of their coefficients agree to the model specification of *equation (9)*.

The analysis of oligopoly economy showed, that the positive strategic impact of competition softens with the increase in the number of competitors in certain cases. Moreover it was also observed that the increase in the number of potential entrants decreases the probability of getting the Leader role and mitigates the firms' incentive to invest.

To test the complete strategic impact of competition empirically the explanatory variable of $EXPCOMPET_t$ can be parameterised with quadratic relationship to allow for a potential converted U shape. Accordingly the following new explanatory variable has been added to the model in the next step of the analysis:

$$EXPCOMPET2_t = (EXPCOMPET_t)^2$$

Adding this new explanatory variable to the model the hazard function has been tested in the following modified functional form:

$$(10) h_{i;k}(t|X_{i;k}) = h_0(t|X_{i;k}) e^{[a(AVERAGEMARKETSHARE_t)+b(INHAB_t)+c(EXPCOMPET_t)-e(EXPCOMPET_t)^2-d(ACTCOMPET_t)]}$$

The table below sets out the results obtained by allowing for quadratic relationship for the intensity of expected competition as an explanatory variable:

Table 7: Results Oligopoly Model

| Cox regression -- Breslow method for ties | | | | | | |
|---|------------|-----------|-------|-----------------|----------------------|----------|
| No. of subjects = | 365 | | | Number of obs = | 365 | |
| No. of failures = | 59 | | | | | |
| Time at risk = | 5366 | | | | | |
| Log likelihood = | -251.95203 | | | LR chi2(5) = | 183.10 | |
| | | | | Prob > chi2 = | 0.0000 | |
| ----- | | | | | | |
| _t | Haz. Ratio | Std. Err. | z | P> z | [95% Conf. Interval] | |
| ----- | | | | | | |
| inhab | 1.060262 | .0164879 | 3.76 | 0.000 | 1.028434 | 1.093076 |
| actcompet | .857566 | .0263637 | -5.00 | 0.000 | .8074201 | .9108263 |
| averagemar~e | 1.3677 | .1140029 | 3.76 | 0.000 | 1.161556 | 1.61043 |
| expcompet | 2.344534 | .4740438 | 4.21 | 0.000 | 1.577434 | 3.484672 |
| expcompet2 | .9247124 | .0246219 | -2.94 | 0.003 | .877692 | .9742519 |
| ----- | | | | | | |

The results reveal that all variables have been proved to be significant at 1% significance level. Moreover the result of the likelihood ratio test shows that the addition of the quadratic explanatory variable has improved the goodness-of-fit of the model significantly. Since the

exponentiated coefficient of the explanatory variable $EXPCOMPET2_t$ is below one, the quadratic relationship has been proved to have a converted U shape.

To better understand the quadratic impact of expected competition, the exponentiated coefficients have been replaced by the coefficients themselves in the following table:

Table 8: Results Oligopoly Model (exp. coefficients)

| Cox regression -- Breslow method for ties | | | | | | |
|---|------------|-----------|-------|-----------------|----------------------|-----------|
| No. of subjects = | 365 | | | Number of obs = | 365 | |
| No. of failures = | 59 | | | | | |
| Time at risk = | 5366 | | | | | |
| Log likelihood = | -251.95203 | | | LR chi2(5) = | 183.10 | |
| | | | | Prob > chi2 = | 0.0000 | |
| ----- | | | | | | |
| _t | Coef. | Std. Err. | z | P> z | [95% Conf. Interval] | |
| ----- | | | | | | |
| inhab | .0585164 | .0155508 | 3.76 | 0.000 | .0280374 | .0889954 |
| actcompet | -.1536571 | .0307424 | -5.00 | 0.000 | -.2139111 | -.093403 |
| averagemar~e | .3131307 | .0833537 | 3.76 | 0.000 | .1497605 | .476501 |
| expcompet | .8520865 | .2021911 | 4.21 | 0.000 | .4557992 | 1.248374 |
| expcompet2 | -.0782725 | .0266266 | -2.94 | 0.003 | -.1304596 | -.0260854 |
| ----- | | | | | | |

The maximum point at which the impact of expected competition changes direction from being incentive to being deterring can be estimated based on the coefficients of the explanatory variables $EXPCOMPET_t$ and $EXPCOMPET2_t$. The quadratic function has its maximum at $x = \frac{-c}{2e}$ where e represents the coefficient of the quadratic term and c denotes the coefficient of the linear term as presented in *equation (10)*.

Replacing the coefficients' results presented in *table (8)* into that formula the maximum of the quadratic function is obtained at 5.5% of the total retailers at risk. This result means that if the number of retailers expected to invest in one of the given countries under analysis in the next year was above 3¹³⁸, then the hazard of Western European retailers' market entry into that country in the given year started to decrease. This is very close to the result of the theoretical analysis which showed that the earliest first market entry occurs in a duopoly economy¹³⁹.

Having parameterised the standard market entry model with explanatory variables of *Host market attractiveness* and of *Competitive presence*, the explanatory variable of retailer rank

¹³⁸This result has been calculated as the 5,5% of the 61 retailers at risk.

¹³⁹It needs to be observed that the explanatory variable $EXPCOMPET_t$ measures the impact of competition not only on the first arrival but for all investors' entries.

$RANK_i$ is added to the model for measuring the impact of *Firms' resources* in the final step of the analysis. The hazard function has been tested in the following functional form:

$$(11) h_{i;k}(t|X_{i;k}) = h_0(t|X_{i;k}) e^{[a(AVERAGEMARKETSHARE_i)+b(INHAB_i)+c(EXPCOMPET_i)-e(EXPCOMPET_i)^2-d(ACTCOMPET_i)-f(RANK_i)]}$$

The following tables set out the results of parameter estimates with their relating z values for the complete model first with exponentiated coefficients then with the coefficients themselves:

Table 9: Results Oligopoly Model with Asymmetric Firms

Cox regression -- Breslow method for ties

| | | | |
|-------------------|------------|-----------------|--------|
| No. of subjects = | 365 | Number of obs = | 365 |
| No. of failures = | 59 | | |
| Time at risk = | 5366 | | |
| Log likelihood = | -245.83024 | LR chi2(6) = | 195.35 |
| | | Prob > chi2 = | 0.0000 |

| _t | Haz. Ratio | Std. Err. | z | P> z | [95% Conf. Interval] |
|--------------|------------|-----------|-------|-------|----------------------|
| inhab | 1.054918 | .0164994 | 3.42 | 0.001 | 1.02307 1.087757 |
| actcompet | .8701946 | .0270592 | -4.47 | 0.000 | .8187434 .9248792 |
| averagemar~e | 1.298364 | .106709 | 3.18 | 0.001 | 1.105194 1.525297 |
| expcompet | 2.118235 | .4214959 | 3.77 | 0.000 | 1.434162 3.1286 |
| expcompet2 | .9341985 | .024727 | -2.57 | 0.010 | .8869701 .9839417 |
| retailerrank | .9675024 | .0096987 | -3.30 | 0.001 | .9486788 .9866996 |

Table 10: Results Oligopoly Model with Asymmetric Firms (exp. coefficients)

Cox regression -- Breslow method for ties

| | | | |
|-------------------|------------|-----------------|--------|
| No. of subjects = | 365 | Number of obs = | 365 |
| No. of failures = | 59 | | |
| Time at risk = | 5366 | | |
| Log likelihood = | -245.83024 | LR chi2(6) = | 195.35 |
| | | Prob > chi2 = | 0.0000 |

| _t | Coef. | Std. Err. | z | P> z | [95% Conf. Interval] |
|--------------|-----------|-----------|-------|-------|----------------------|
| inhab | .0534631 | .0156405 | 3.42 | 0.001 | .0228083 .0841179 |
| actcompet | -.1390384 | .0310956 | -4.47 | 0.000 | -.1999846 -.0780922 |
| averagemar~e | .261105 | .0821873 | 3.18 | 0.001 | .1000209 .422189 |
| expcompet | .7505833 | .1989844 | 3.77 | 0.000 | .360581 1.140586 |
| expcompet2 | -.0680663 | .0264687 | -2.57 | 0.010 | -.119944 -.0161886 |
| retailerrank | -.0330373 | .0100245 | -3.30 | 0.001 | -.052685 -.0133897 |

As the tables present, all parameters are significant at 1% of significance level and the results of the likelihood ratio test assure that the addition of the explanatory variable *RANK_t* improved the goodness-of-fit of the model.

In accordance with the expectations, weaker firms proved to arrive significantly later as the probability of entering the Eastern European markets decreased by 3.3% with the increase of the grocery retailer's rank on the Western European market.

5.5.2 Summary of the Results

The final results of the empirical test analysing the entry behaviour of 61 selected Western European retailers into 6 identified Eastern European target countries are to be interpreted *ceteris paribus* as follows:

- The number of foreign retailers' entry in the Eastern European countries per year increased by 5.5 % on average with every 10 million more inhabitants of the host country.
- Increase of the GDP per capita by USD 1,000 (without any further grocery retailer's entry) accelerated the annual rate of foreign retailer's arrival by 29.8%.¹⁴⁰
- The total impact of actual competitive presence on the speed of market entry consists of the following two components.
 1. One more additional active retailer in the host markets decreased the annual entry rate of foreign retailers by 2.1%. This result was calculated by dividing the 13% decrease in variable $ACTCOMPET_t$ by 6.1 which is the equivalent value of 1% increase in the retailers' number.
 2. In addition to this impact the increase in actual competition by one more active retailer on the host market reduced the entry rate by a further 23% through the variable of $AVERAGEMARKETSHARE_t$ assuming no change in the GDP per capital figures¹⁴¹.

Based on these results one more competitor on the host market reduced the rate of foreign retailers' entry per year by 25.1% on average in the analysed period.

- Up until 3 additional retailers expected to arrive in the next year the probability of an additional retailer's entry in the given year increased. In the case of more than 3 expected additional entrants this probability decreased at an increasing rate.

¹⁴⁰It should be noted that USD 1,000 increase in the GDP per capita presents a significant jump in the explanatory variable as its mean was USD 13,464 across countries in the period under analysis.

¹⁴¹The impact has been obtained by calculating the reciprocal value of the exponentiated coefficients of $AVERAGEMARKETSHARE_t$.

- Retailers possessing larger market share in Western Europe appeared sooner in Eastern Europe by 3.3% higher probability on average compared to competitors with one rank behind.

The historical entry pattern of Western European retailers in Eastern Europe reflects the existence of a three to four-year period of opportunity for retailers' entry.

Czech Republic and Hungary were the first target countries of Western European retailers mainly due to their relative high level of GDP per capita at the beginning of the 90s. (In 1991 and 1992 GDP per capita was above USD 8,000 in Hungary and above USD 11,000 in the Czech Republic, while GDP per capita in the other countries of the region were around USD 6,000 or below.) Moreover, reflecting the strong impact of GDP per capita on foreign retailers' entry rate, even Hungary and the Czech Republic showed significant differences in foreign retailers' entry rate during these years; 3 retailers per year invested in the Czech Republic compared to 1 to 2 retailer entries per year in Hungary.

In terms of GDP per capita Poland showed approximately 3-year time lag compared to Hungary during the 90s. However, in the middle of the 90s the number of Western European retailers entering Poland per year was approximately two-times the number of retailers entering Hungary 3 years before. This significant difference was mainly driven by the nearly four-times higher population of Poland which not only presented a higher absolute demand potential but also increased threat of preemptive competitors' entry for foreign retailers.

By the end of the 90s the most prosperous retail markets in the region (Poland, Czech Republic and Hungary) were all saturated, resulting that late entrants were either unable to capture significant market share or were forced to leave. (Edeka for example entered the Czech Republic in 2000 and exited in 2004.) However, Bulgaria and Romania represented further investment opportunities for foreign retailers since GDP per capita in these countries was still below USD 10,000 in 2005 and the number of foreign retailers' presence showed a relative low level to the region's other countries compared at the same level of demand potential.

Although Eastern European retail markets opened to all foreign investors simultaneously, not all of them grabbed the opportunities to the same extent. Retailers' relative strength to each other proved to be a significant driver of geographical market entry. Leading market players in Western Europe (Carrefour, Tesco, REWE and Metro Group) entered almost all Eastern

European countries, while none of the retailers with a home market share rank of above 30 entered more than three countries out of six.

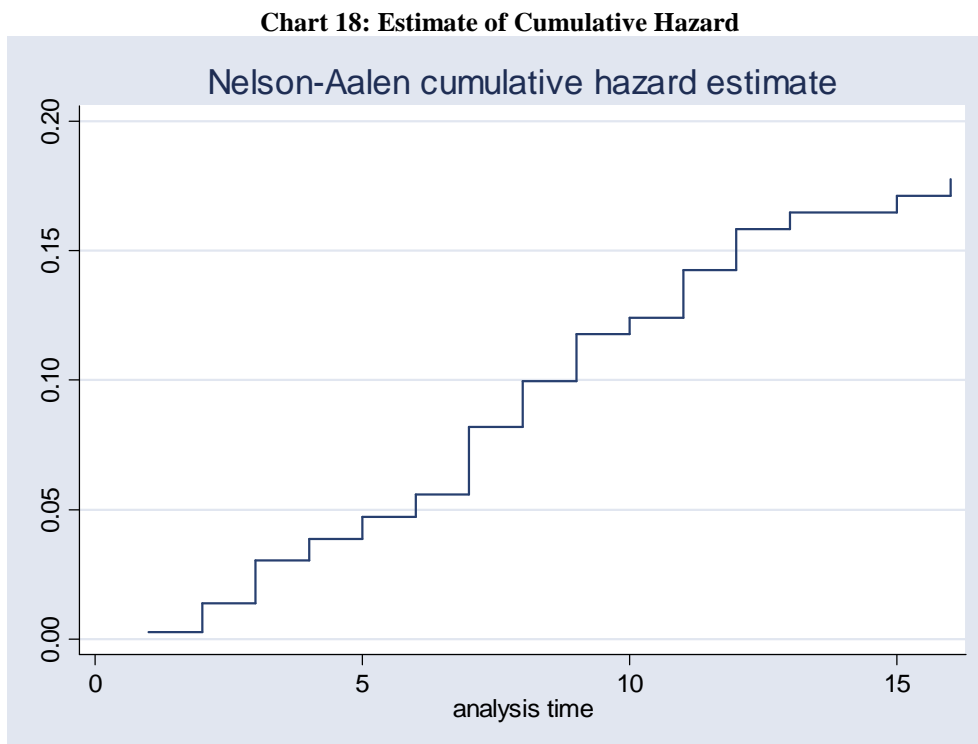
The results of the empirical tests verified the hypotheses, which were set up on the basis of equilibrium outcomes obtained from the theoretical market entry models.

The results show that driven by the development of demand potential on the host markets and by the intensity of competition, foreign retailers had a limited period of time - defined as the “window of opportunity” - to carry out their market entry. Western European retailers needed to use these strategically important years in Eastern Europe to preempt their competitors and to get the strategic first-mover-advantage on the new markets.

5.5.3 Robustness of the Results

5.5.3.1 Estimate of the Cumulative Hazard

The final results are presented by graphing the estimate of the cumulative hazard function for the 16-year period under analysis applying the Nelson¹⁴² and Aalen¹⁴³ estimator. The Nelson-Aalen estimator has been chosen to test the model since it has a better small sample property than the Kaplan-Meier¹⁴⁴ estimator.



The above graph shows visually how the hazard of entry in one of the Eastern European countries of one of the selected Western European retailers at risk has grown on average over the 16-year period under analysis from 1989 until 2005.

¹⁴²Nelson, W., 1972 Theory and application of hazard plotting for censored failure data, *Technometrics* 14

¹⁴³Aalen, O.O., 1978 Nonparametric inference for the family of counting processes; *Annals of Statistics* 6

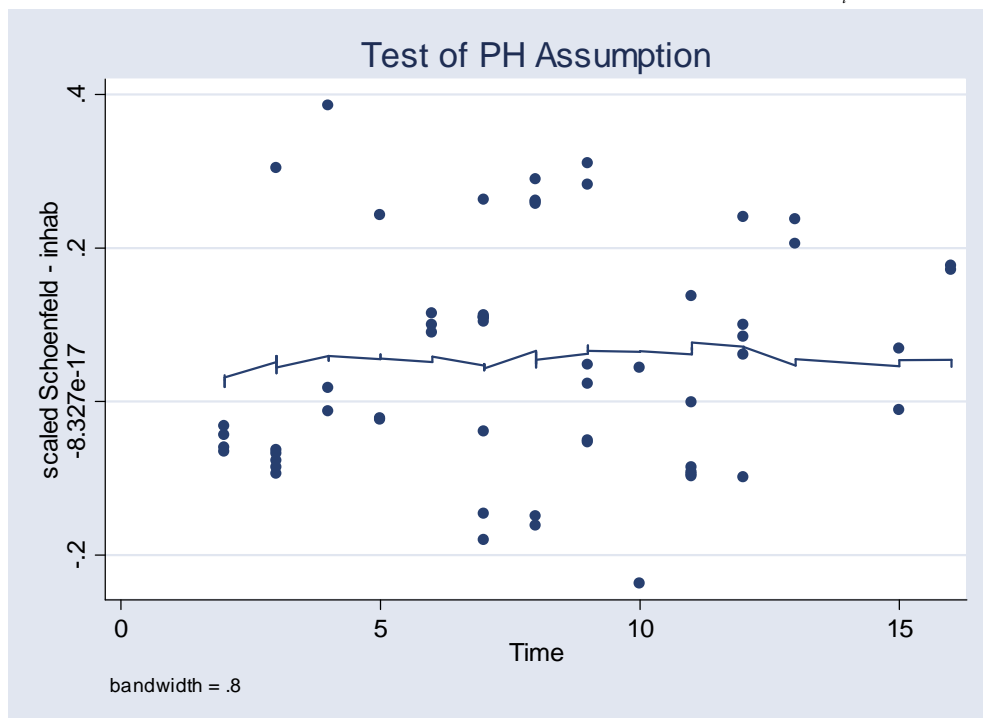
¹⁴⁴Kaplan, E.L. and Meier, P., 1958 Nonparametric estimation from incomplete observations, *Journal of American Statistical Association* 53

5.5.3.2 *Functional Form of Covariates*

The functional forms of the covariates have been tested by the use of martingale residuals¹⁴⁵. A smooth plot of martingale residuals versus the covariate itself indicates the proper functional form of the covariate¹⁴⁶.

As the following charts present this criterion is fulfilled for the covariate of every variable included in the final model.

Chart 19: Proportional Hazard Assumption Variable *INHAB_t*



¹⁴⁵Martingale residuals are simply calculated as the difference between the observed number of market entry in the dataset and the number of market entry, which the model predicts based on its functional form and estimated coefficients.

¹⁴⁶It can be shown that martingale residuals have a linear relationship with the functional form of the covariate, where the linear constant depends on the number of censored observations. Consequently a smooth plot of martingale residuals versus the single covariate indicates the proper functional form of the covariate vector.

Chart 20: Proportional Hazard Assumption Variable $AVERAGEMARKETSHARE_t$

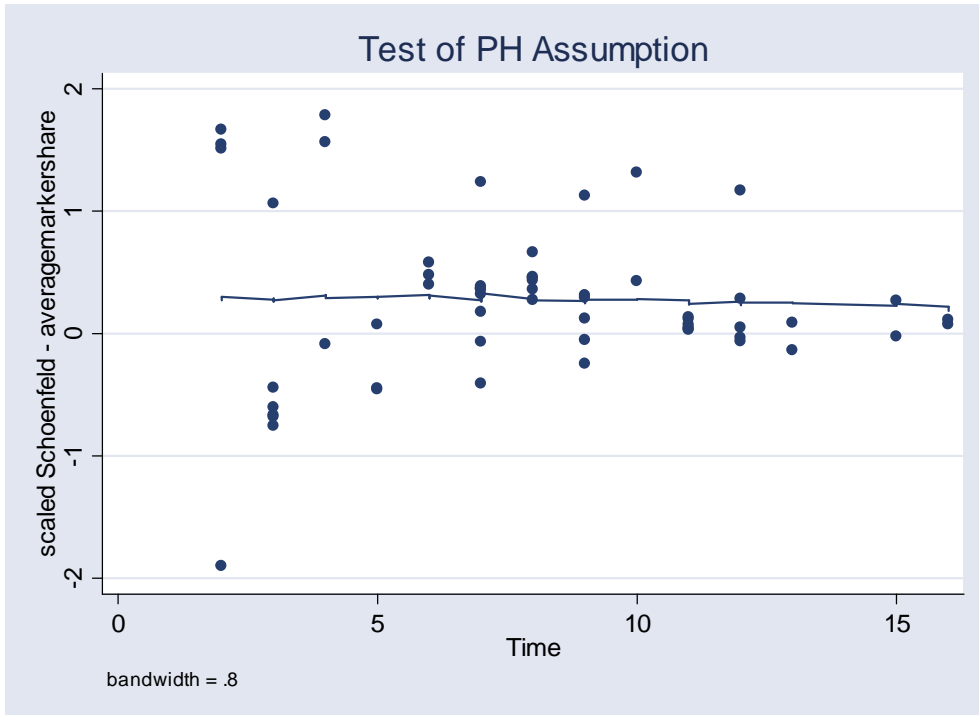


Chart 21: Proportional Hazard Assumption Variable $ACTCOMPET_t$

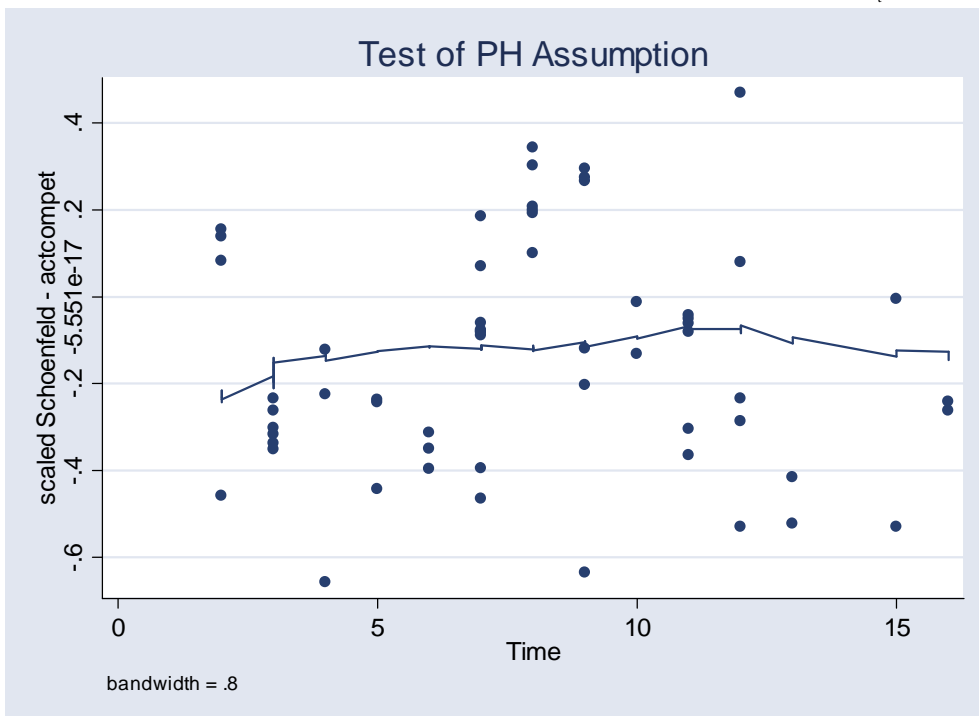


Chart 22: Proportional Hazard Assumption Variable $EXPCOMPET_t$

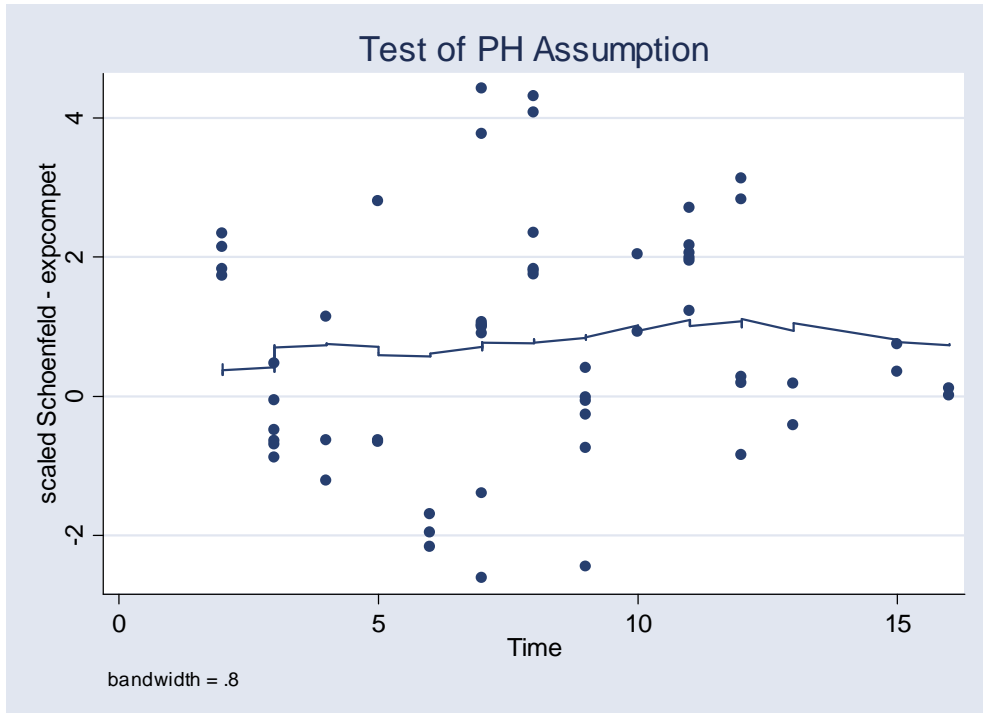


Chart 23: Proportional Hazard Assumption Variable $EXPCOMPET_{2t}$

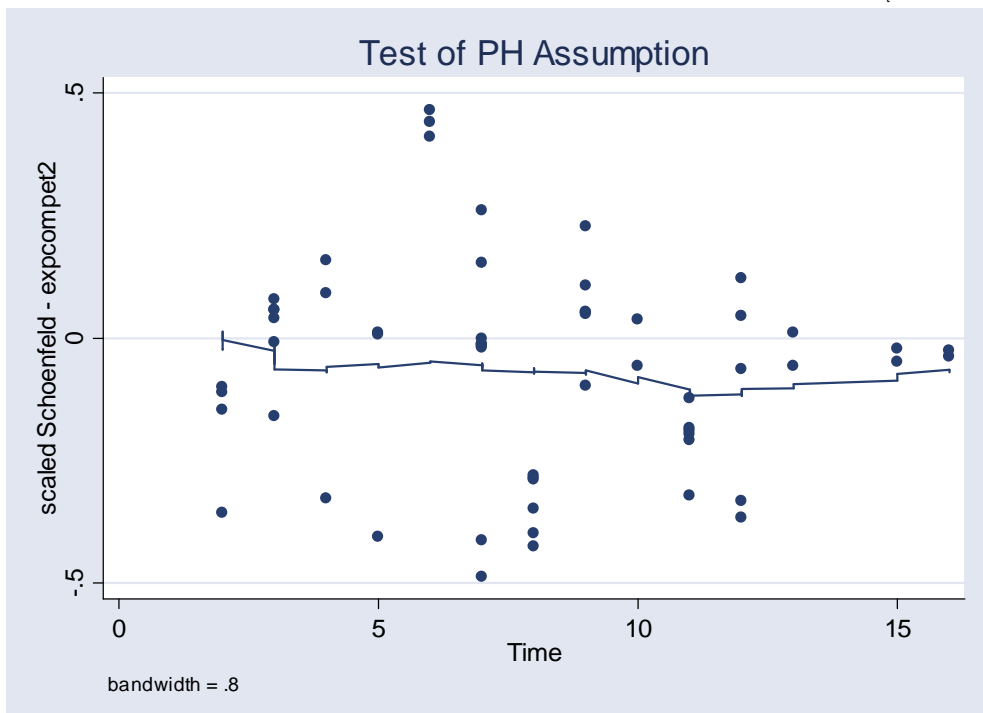
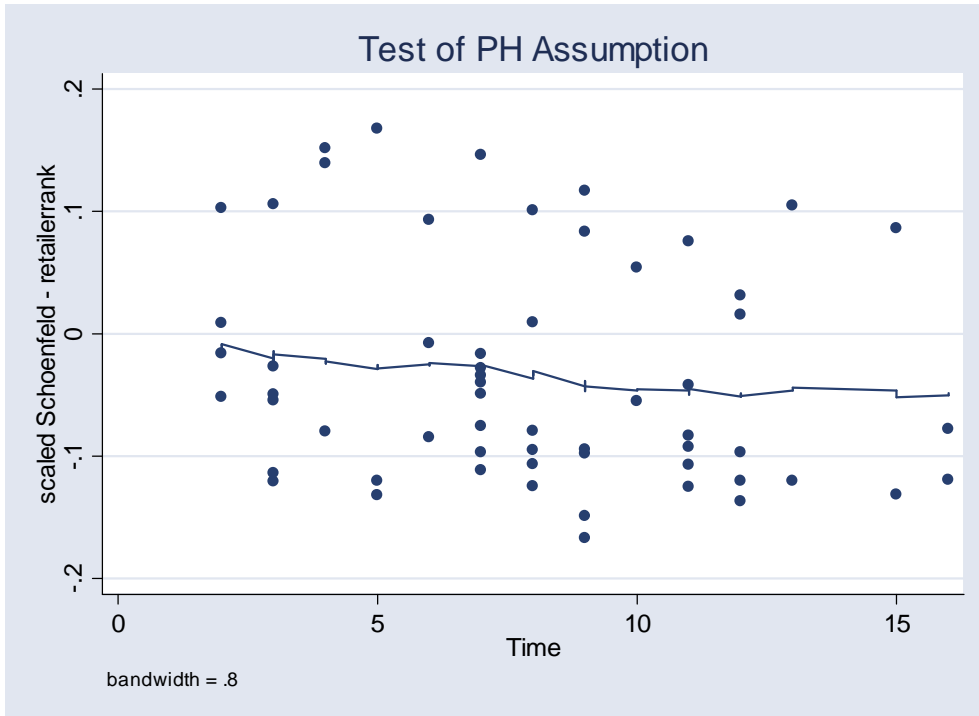


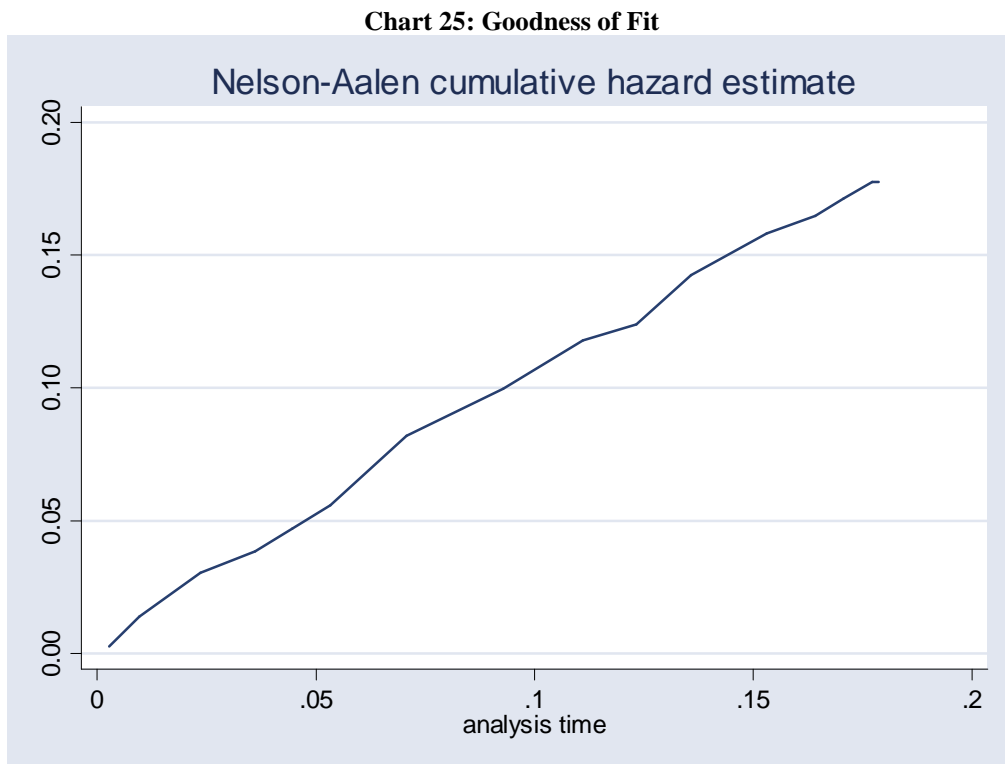
Chart 24: Proportional Hazard Assumption Variable $RANK_t$



5.5.3.3 Goodness of Fit

The overall model fit has been tested by using the Cox-Snell (1968) residuals¹⁴⁷. If the Cox regression model fits the data, then the Cox-Snell residuals have a standard exponential distribution with hazard function equal to one for all t and the cumulative hazard of the Cox-Snell residual forms a straight 45° line.

As presented by the chart below, the Cox model fits the data properly:



¹⁴⁷The Cox-Snell residuals are defined for the i^{th} observation as follows:

$CS_{r_i} = \hat{H}_o(t_i)e^{x_i \hat{b}_x}$, where both $\hat{H}_o(t_i)$ and \hat{b}_x are obtained from the Cox model with the estimated values of coefficients in the tested functional form. STATA predicts the Cox-Snell residuals from saved martingale residuals.

Cox, D.R. and Snell, E.J., 1968 A general definition of residuals (with discussion) Journal of the Royal Statistical Society, Series B 30

6 *Conclusions*

This work has examined the impact of host market uncertainty and competition on firm's market entry decisions. Both the theoretical and the empirical results showed that real world investment opportunities force investors to make their decision as part of a strategic equilibrium with their competitors, which do not allow one investor to formulate the investment strategy in isolation.

The theoretic models presented that market entrance might be carried out sequentially or simultaneously, depending on the underlying market conditions of the host market and on the relative strength of investors to each other.

The standard duopoly model presented the impact of competition and common economic factors on the market entry of firms and showed that the threat of preemption accelerates the market entry and forces rent equalisation.

The extension of the standard model investigated how the entry barrier of a late arrival, or the asymmetry among competitors affect the equilibrium outcome of the standard model. It was found that while the entry barrier of the Follower makes the competition among the firms tougher, the comparative strength of one firm always weakens the competition and eliminates the rent equalisation. Both the theoretical and the empirical analysis proved that stronger firms have better chances to enter earlier and become the Leader on new markets. However, the theoretical results indicate that common economic factors such as host market's volatility or growth potential can mitigate the competitive advantage of the stronger firm providing a chance for the weaker competitor to catch-up in the race for new markets.

As the likelihood of successful entry increases with the competitive advantage of one firm, it is not surprising that early entrants prefer host markets with close location and similar cultural features. This explains why "national regions" of Western retailers emerged in the early stage of the internationalisation of the Eastern European grocery retail sales market as a result of which German retailers invested relative quickly in Poland, Czech Republic and Hungary; French retailers rushed into Romania among the first investors, while the British giant Tesco arrived relatively late in all Eastern European markets¹⁴⁸.

¹⁴⁸Gielens, K. and Dekimpe, M.G. concluded that Western European retailers monitored especially their home market rivals as a result of which moves made by one firm's home rivals were more carefully followed than actions of rivals with other nationality. The results of the theoretic market entry model with asymmetric competitors reveal that firms should look for opportunities where they can benefit the most from their comparative advantage. This result may deliver a better explanation for the observed behavior.

The extension of the standard duopoly model to the case of oligopoly economy showed that the increase in the number of potential market entrants can mitigate the positive strategic impact of competition in some cases and delays the occurrence of first investments compared to the duopoly case. This result may be of importance in the cases of privatisation processes advising that the number of selected bidders needs to be kept small if the seller wants private investments to occur as soon as possible in a certain sector/geographic market¹⁴⁹.

This work could be extended in various ways. One very interesting extension could be to introduce incomplete information into the model, assuming that firms only know their own profit realisation but they have no information (or limited information) on their opponent's capabilities. Another interesting field of further research could be to measure how exactly the change in common macroeconomic factors of the host market substitutes for the comparative disadvantage of one firm. Lambrecht (2001) for example concluded that these factors may change the order of debt financed firm's market exit.

As the globalisation process becomes more intensive, the race for investment opportunities including those of entering new markets becomes tougher. This process, like competition by nature, favours stronger firms and projects that investors will face stronger competition even in their home markets in the future. It is therefore vital for the investors to understand all aspects of market entry games, in order to remain successful players in these strategic investments.

This was also one of the strategic lessons, which Sun Tzu emphasised to be worth consideration on the "*Art of war*" more than 2500 years ago:

"What the ancients called a clever fighter is one who not only wins, but excels in winning with ease. ... (and) who looks below the surface of things wins with ease."

¹⁴⁹Furthermore it is also advised to select even number of bidders in such processes based on the results of Chapter 4.3.

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