Global Firm Behavior in an Uncertain World

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Preface

Writing a thesis is a challenge which is not only mastered by oneself but also with the help of friends and colleagues. I would like to use this space to thank those people and institutions that had a considerable contribution to my achievements. First of all I would like to express my sincere gratitude to my supervisor Wilhelm Kohler. Besides his advice and mentoring he gave me the privilege to write this dissertation. Furthermore, he gave me the opportunity to become an ardent lecturer in international economics. From our common early days on at his chair he encouraged me to participate in international conferences, workshops and seminars which enabled me to establish my own scientific network and to improve my proceeding on my academic path. In 2007, I applied for the Danish International Economics Workshop with the intention to present my first results to a group of experts among which was Horst Raff. He is definitely one of the leading researchers in the field of international firm behavior and I feel grateful for having him as my second adviser.

I am profoundly indebted to Davide Sala with whom I spent long nights with fruitful discussions. With his outstanding knowledge in economics he has supported me without respite. He is not only a colleague but has become an invaluable friend.

Special thanks go to Philipp Schröder, who invited me for several research visits to Aarhus University in Denmark. During these stays I was able to establish new joint works which resulted in some chapters of my thesis. Furthermore, I would like to thank the members of the economic department in Aarhus for accommodating me in a very gentle way. I will not forget some experiences with Sebastian Buhai and other colleagues.

I am grateful to Sanne Hiller with whom I challenged numerical simulations both in Tübingen and Aarhus resulting in a joint project.
There have been numerous people at our chair in Tübingen who supported me in my work. I would like to thank Gabriel Felbermayr for pushing me into the direction of stochastic models. I am grateful to Inga Heiland and Ina Jäkel for their support as research assistants in several projects. Special thanks go to Gisela Zunker-Rapp and Marcel Smolka who supported me in particular during my last year while I was completing my thesis.

Finally, I wish to express my greatest thanks to my family and Julia, for their never ending support in various forms which cannot be formulated in words.

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CHAPTER 1

Motivation and General Comments

Global economic integration has been increasingly influenced by international trade and foreign direct investments in the past two decades. According to UNCTAD data (2008), since then domestic companies have steadily increased their exports and foreign plant shares (horizontal FDI) to access new markets. Besides this persistent growth, two additional striking developments can be identified in empirical data. Since the early 1980s the growth of FDI inflows has exceeded that of exports on average in every year until 2000. Within this period worldwide real GDP increased by 2.5% and global exports rose by 5.6% per year. In contrast global inflows of FDI increased by 17.7% (Navaretti and Venables, 2004). The major share of FDI originated in and were attracted by developed countries. However, this last development has changed its nature since 2003, as global FDI inflows have maintained their growth only because developing countries have started to attract relatively more FDI inflows whereas developed countries have experienced a reduction in their inflow growth rates (UNCTAD-Statistics, 2008).

Given the increasing importance of exports and FDI, economic theories focusing on these two elements of international economics have gained impetus. The first influential strand of explanation was the *Ownership*, *Location* and *Internalization Advantage* framework developed by John Dunning (1977, 1981) and attracting notice to the multinational enterprise (MNE).

Accordingly, international integration is not only realized through international trade and migration but furthermore shaped by transnational firms which may choose between serving a foreign country through exports and also via a foreign plant (FDI). As a consequence, modern trade models have started to depart from sector based analyses – common in Ricardo and Heckscher-Ohlin models – integrating MNEs into general equilibrium theory. Influential contributions in this strand of literature have been presented by Ethier (1986), Helpman (1984, 1985), Markusen (1995, 1998), and Fujita, Krugman and Venables (1999).

A first fundamental result stemming from these theoretical contributions is the common establishment of specific cost assumptions for exporting firms and foreign affiliate companies (representing FDI). In 1993 Lael Brainard formulated the so called *proximity-concentration trade-off* which according to Peter Neary (2006) represents the central plank in analyzing exporting firms and horizontal FDI. In a cross-sectional analysis Brainard (1997) provides empirical support for her cost structure hypothesis and concludes:

The proximity-concentration hypothesis predicts that firms should expand horizontally across borders whenever the advantage of access to the destination market outweigh the advantages from production scale economies.

The recent availability of more disaggregated data on international trade and FDI (see e.g. Roberts and Tybout, 1997; Bernard, Jensen, Redding, and Shoot, 2007) fostered a deeper microeconomic analysis of the described international integration. The latest advances both theoretically and empirically within this strand of literature are based on the seminal work of Marc Melitz (2003) which has been extended by Helpman et al. (2004) in order to explain observed patterns of internationalization - export or FDI - emphasizing firm heterogeneity. This so called *New New Trade Theory* is in line with empirical observations accenting that differences in firm productivity lead to a firm distribution within an industry, in which not all firms export or become foreign direct investors. More recently, this framework has been extended by Nocke and Yeaple (2007), in order to explain the prevalence of the greenfield variety of FDI relative to its counterpart, viz. mergers and acquisition. In a nutshell these type of models combine the proximity-concentration trade-off framework with a specific productivity assumption: Firms do not know their productivity performance until they incur the costs of an initial investment after which productivity stays constant through time. Once companies are involved into one of three possible investment strategies (domestic, exporting firm, or foreign direct investor), they finally realize whether they are productive enough to survive. In Helpman et al. the most productive firms become foreign direct investors, less productive ones export and the least productive ones serve only the domestic market conditional on surviving. The strong utilization of the New New Trade Theory lies among other things in successfully explaining the observed patterns of exporting and FDI strategies across firms at any one point in time.

Besides the successes of the described framework, there are also relevant shortcomings. While in general, the mentioned models present aggregate steady state equilibria, they neglect completely more complex dynamics and timing of entry into and exit from alternative internationalization strategies. Furthermore, they do not account for possible dynamics of switching between alternative market serving modes, e.g. starting with export and changing later into FDI across time. In contrast with only a few exceptions (e.g. Irarrazabal and Opromolla, 2009) the models insinuate that firms exhibit constant productivity throughout their entire lifetime once they found their optimal serving strategy and as a consequence they never change their serving mode.

These criticisms of missing dynamic aspects and transition adjustments are not only motivated theoretically but also based on empirical observations, in particular on how e.g. firm productivity evolves over time. There is ample empirical evidence (see e.g. Faggio et al., 2007) that firm productivity changes over time and since its evolution is not deterministic one can conclude that it is associated with uncertainty. More generally, from a microeconomic perspective firms are exposed to continuous shocks through time which can arise from uncertain demand in a new market, uncertain cost developments, political risk influencing a country's applied tariff policy, or just from uncertain productivity growth. Confronted with such potential repeated shocks over time, firms can be expected to react by means of forward looking intertemporal optimization. As a consequence, such a firm behavior should result in an endogenous market entry time differing for exporters and FDI. Furthermore, these type of continuous shocks should force firms to change their initially chosen market serving mode e.g. switching from exporting into FDI, if an unfavorable development appears.

In contrast to recent trade theories, modern finance models analyze firm behavior by accounting for continuous uncertainty and furthermore, fixed cost which are at least in part irreversible.

Within this so called *Real Option Theory*, pioneerd by Dixit and Pindyck (1994), it is possible to determine the optimal market entry time of a firm and also its switching behavior across different market entry strategies.

The combination of New New Trade Theory assumptions with the Real Option Theory allows to close idiosyncratic shortcomings of each approach. While the international economic approach to export and FDI turns out to be rich in modeling production and trade, it basically ignores timing and uncertainty dynamics. Conversely, while timing and uncertainty are key factors in pure finance models of investment, they are short on issues of proximity, trade and trade policy. Therefore, the unification of the chosen theories offers a promising way towards a more realistic modeling of timing aspects of multinational enterprises' internationalization process.
Indeed, a core contribution of this dissertation is the development of a dynamic theoretical model which combines the proximity-concentration trade-off framework with continuous uncertainty. The analytical complexity of the presented stochastic model is high and therefore, comes along with the necessity to simplify. In particular, results are derived in a partial equilibrium approach and for a large part assuming away Melitz-type heterogeneity among firms. Still, it is to emphasize that the basic model retains all ingredients of the proximity-concentration trade-off framework featured by most of the existing theories of trade and FDI. The new elements of the presented models are inter-temporal optimizations by firms in continuous time, assuming that their productivity follows a Geometric Brownian motion.

In a first step, a stochastic model is developed which analyzes the first time market entry decision of a representative firm (export or FDI) confronted with a stochastic productivity growth and sunk entry costs. Based on this basic model a more complex world is analyzed in which a representative firm can switch between different internationalization strategies back and forth. Due to the complexity of the equilibrium conditions the second model requires numerical simulations, as it negates closed form solutions.

After the development of a stochastic trade model, the possibility for further analyses of dynamic issues arises. In the presence of uncertainty over time, multinational enterprises are not only confronted with a choice problem between exporting and FDI. Differently, besides the described types of uncertainty as e.g. in productivity, exchange rates et cetera, a firm may also be confronted with a country specific risk concerning applied tariff rates. Indeed, empirical data suggests that the overhang between applied and bound tariffs differ across countries and time. However, there is no theoretical trade model which explains the timing of entry into the export market in dependence on risk of the trade policy path in a firm's destination market, reduction in risk via tariff bindings, and firms' fixed entry costs. By extending the initially developed model it is possible to provide a theoretical explanation for the effects of tariff overhangs on multinational firms paving the ground for empirical analyses in the future.

Finally, a last type of uncertainty firms may be confronted with, is the performance of managers who govern a company. Do newly hired managers with export experience increase the likeliness that a domestic company starts to export? In how far is the talent of a manager influential for the internationalization process of a firm? This type of uncertainty is again both theoretically and empirically barely considered in international economics. One reason for such a shortcoming is simply the lack of appropriate data as it requires detailed data on the employee level.
General intuition suggests, the implementation of manager behavior into the international firm context might provide further insights. Therefore, in a last step the previously developed dynamic model is modified in order to provide a motivation for an empirical analysis based on a newly composed Danish employer-employee dataset.

Overall the underlying thesis contributes to the international trade literature in several dimensions. Methodologically, a stochastic partial equilibrium model is developed merging concepts from international economics and finance theory. The basic model and its derivatives allow for the analysis of a firm's internationalization process, in particular the determination of the optimal serving mode, timing of the foreign market entry and the impact of different types of uncertainty on its behavior over time. An outstanding last feature of the presented models is the possibility to derive testable hypothesis which is demonstrated in the last contribution of this thesis.

Structure

This thesis represents a combination of essays dealing with the internationalization process of firms, both theoretically and empirically. Its four main chapters (2 to 5) are intended for separate publications and for this reason they should be regarded as self-contained studies. Together they span a range of related issues analyzed in the tradition of neoclassical international economics. During the last three years all models have been presented on several conferences and have been extended upon significant comments. The thesis is structured as follows.

Chapter 2 presents a theoretical model which combines the proximity-concentration trade-off framework with the real option methodology and sheds light on the effects of productivity growth. Three theoretical scenarios - no growth, determinist growth, and uncertain productivity growth - are considered based on a Geometric Brownian motion. One result of the dynamic setting is that firms may never enter a new foreign market as exporter, since in view of the FDI strategy, a positive value of waiting dominates until FDI turns out to be profitable. Uncertainty is identified as a compounding force for the described effect as it increases the likeliness of a first time market entry through FDI. The result is in line with empirical evidence. Furthermore, cumulative distribution functions for the market entry time are analytically derived which is a novelty in the trade literature and of crucial interest for empirical research in the future as they allow for a quantitative assessment of firm dynamics.

Chapter 3 is based on a joint work with Sanne Hiller from Aarhus University and represents an extension of the initial model. We analyze theoretically whether firms maintain their chosen market serving mode over time if they are confronted with dynamic elements such as uncertain productivity growth. Furthermore, we determine crucial elements which are responsible for market serving mode discontinuity. Due to highly non-linear functions the analysis relies on numerical simulations, as the model negates a closed form solution. We find that an uncertain productivity growth generates hysteresis, and hence confirm a general real option result. Market serving mode discontinuity hinges on this region of inactivity (hysteresis) and is decisively influenced by four dimensions: country specific competition, irreversible fixed costs, productivity growth and volatility. Higher fixed costs and volatility increase the likeliness of serving mode continuity whereas a higher degree of competition and productivity growth raises the probability of serving mode switching. Our final contribution is the derivation of testable predictions.

Chapter 4 is a joint work with Philipp Schröder and Davide Sala, both researchers at Aarhus University. In the underlying essay we also venture an application of my basic model to a dynamic tariff analysis. WTO negotiations deal predominantly with bound – besides applied – tariff rates. But, how can reductions in tariffs ceilings, i.e. tariff rates that no exporter may ever actually be confronted with, generate market access? The answer to this question relates to the effects of tariff bindings on the risk that exporters face in destination markets. The presented theoretical model formalizes the underlying interaction of risk, fixed export costs and firms' market entry decisions; doing so we highlight the important role of bound tariffs at the extensive margin of trade. We find, that bound tariffs are more effective with higher risk destination markets, that a large binding overhang may still command substantial market access, and that reductions in bound tariffs generate effective market access even when bound rates are above current and long-term applied rates.

Chapter 5 is co-authored by Davide Sala and is primarily an empirical contributions. Our major objective is the analysis of the impact of management characteristics on firms' entry decision into export markets over time. We first motivate our empirical strategy by presenting a theoretical partial equilibrium model which is again based on my basic model but accounts for management characteristics as an input factor. Applying an empirical strategy suggested by Chamberlain (1980) we are able to affirm the robustness of firm productivity and fixed costs as explaining variables for export decisions. Unobserved heterogeneity turns out to be systematically related to management characteristics, in particular management knowhow. By reducing the sample only to firms which enter the export market during the considered period, the type of management promotion (internal promotion opposed to e.g. external promotion) is identified to increase the likeliness of exporting.

Finally, chapter 6 summarizes the general results.

CHAPTER 2

Uncertain Productivity Growth and the Choice between FDI and Export

2.1 Introduction

The explanation of international economic integration has been a core field of economic research for decades. Development and welfare disparities between countries (regions) have been analyzed empirically and theoretically, whereas in both disciplines trade has been considered as the balancing force between unbalanced economic entities. Until the late 70s two major theoretical frameworks have dominated the analysis of international trade in goods. According to the Ricardian models (see e.g. Dornbusch et al., 1977), countries are involved into trade due to differences in their production technologies, and through trade in goods, they can improve their welfare state (gains from trade). The second influential explanation for observed goods flows has been the Heckscher-Ohlin framework according to which countries trade due to different relative endowments (see e.g. Heckscher and Ohlin, 1991). Within these commonly accepted and widespread models, international trade is motivated by comparative advantages either in technologies or in relative factor endowments. However, in none of these concepts the firm as

I would like to thank Wilhelm Kohler for repeated discussions on several issues. Furthermore, I am profoundly indebted to Davide Sala, who provided invaluable comments. Thanks are due to Philipp Schröder for inviting me to Denmark, where I developed my basic ideas further. I have benefited from comments of participants on the CESifo Summer Institute Conference "Operating Uncertainty Using Real Options". In particular, I thank Giuseppe Bertola and Thomas Gries. I am grateful for CESifo's financial sponsorship.

a microeconomic entity plays a role, since differences are analyzed on the basis of sectors. This negligence of firm behavior both empirically and theoretically can be partly explained by the simple unavailability of appropriate data at the time of the model creation.

However, with the 1970s the perception of global economic integration has started to change. Besides the steady growth of international trade flows (averagely 5.6%), economists recognized the extraordinary surge in global investment behavior of multinational enterprises. Starting in the late 1970s foreign direct investments (FDI) have shown an average annual growth rate of 17.7% until 2000 (Navaretti and Venables, 2004). The rising awareness of multinational investment behavior incited a dogmatic change in the theoretical explanation of international economic integration. The first seminal work which introduces firm behavior into the trade context has been presented by Krugman (1979). In his so-called *New-Trade Theory*, firms are modeled in a Dixit-Stiglitz framework and represent the source of international trade due to increasing returns to scale technologies. Within this first generation of monopolistic competition models, firm heterogeneity does not play a role since the major objective has been the explanation of intra-industry trade as such, which was not explicable within the classical models (Krugman, 1980). In the Krugman Model all firms export once trade is introduced.

Sensitized by the New-Trade theory and due to the increasing availability of commensurate data about international firm behavior, a broad range of various theoretical and empirical analyses with a stronger focus on multinational enterprises emerged in the 1980s. Besides the attempt to explain more complex export patterns, FDI started to be implemented into the new theoretical frameworks. Among them are Horstman and Markusen (1987), Markusen and Venables (1998, 2000), Brainard (1993), Helpman (1984, 1985), Ethier and Markusen (1996), and Ehtier (1986). A common ground within these models is the elaboration of the relationship between fixed and variable costs as one fundamental determinant, whether a firm starts to export or becomes a foreign direct investor (horizontal FDI). One specific assumption about the cost structure of firms and the resulting international firm behavior has been summarized as the *proximity-concentration trade-off framework* (Brainard 1993, 1997). Within this framework, firms are considered to be confronted with higher fixed costs in the FDI mode relative to the export mode, if they intend to enter a new market. Due to the fixed costs, firms possess increasing returns to scale in both market entry strategies. Simultaneously the export mode is assumed to exhibit higher variable costs relative to the FDI strategy since transport costs and other barriers add to the domestic production costs. As a result, the extent of scale effects in the two entry modes differ with respect to the state variables (quantity, goods price, productivity etc.). A strong significance of the proximity-concentration trade-off framework has been depicted empirically by Brainard (1997) for 27 countries on the industry level. Since then, the proximity-concentration hypothesis, as it is also referred to, has been established as a workhorse which explains export and FDI patterns.

The latest theoretical breakthrough in explaining the international firm behavior has been achieved by the so called *New New Trade Theories*, based on the seminal work of Melitz (2003), which was extended by Helpman et al. in 2004. Since empirical studies from the 1990s (Bernhard and Jensen, 1995; Doms and Jensen, 1998) and subsequently point out that differences in firm productivity lead to a firm distribution within an industry, in which not all firms export or become foreign direct investors (Greenaway and Kneller, 2007), the New Trade Theory appears to be limited for deeper explanation. Helpman et al. (2004) give consideration to these new empirical insights by introducing firm heterogeneity within an industry. The authors overcome the limitation of the standard monopolistic competition models (symmetric firms within a sector) by introducing the proximity-concentration hypothesis and by implementing productivity uncertainty. Figure 2.1 demonstrates the common result of this literature strand in which the

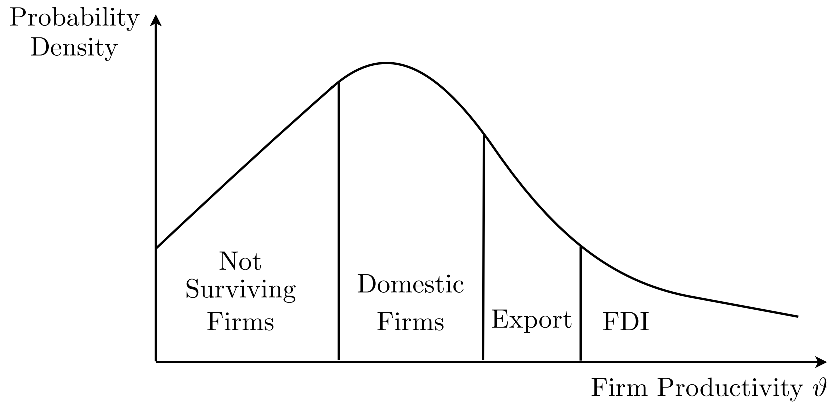


Figure 2.1: Firm Distribution and Productivity

most productive firms within a sector will be foreign direct investors, less productive ones will export and the least productive ones will serve only the home market conditional on survival. The sector-specific firm distribution is a result of a lottery in which firms experience their final productivity level after paying the market entry costs. The model has been tested in various empirical works (Girma et al., 2005; Wagner, 2006), and its core predictions are well reflected in the data (Helpman, 2006). Helpman et al. (2004) e.g. analyze U.S. exports and affiliate data based on a Pareto distribution for ex ante uncertainty, covering 38 countries and 52 manufacturing sectors and are able to identify the significance of the relationship between productivity and the mode of serving a new foreign market. The New New Trade Theory emphasizes that the firm distribution within an industry is not a random sample. In steady-state, productivity turns out to be an appropriate variable to explain the selection effects within an industry. However, within this new workhorse theory it is difficult to derive transition predictions, especially on how the firms select their market entry mode. Helpman et al. (2004) introduce productivity uncertainty as a one-time shock effect which determines the final firm distribution.

On the other hand, from a microeconomic perspective, firms base their market entry decision on intertemporal profit maximization. Within this optimization calculus, productivity uncertainty is not considered as a one time exogenous phenomenon but as a continuous aspect.

Faggio et al. (2007) e.g. present empirical data about the development of total factor productivity (TFP) for different sectors and for the whole economy in the U.K., starting in 1984. The authors show that besides a steady growth of TFP in the last decade, furthermore productivity dispersion in different sectors has increased. Bloom et al. 2007 show additionally that firm productivity exhibits a steady but volatile growth over time.

Given these insights, decision makers posses at least an expectation about their intertemporal productivity development in their home and foreign country. Based on historical experiences or on market analysis they anticipate a specific development of prospective productivity and decide on an appropriate market entry mode. Indeed, in the long run the self-selection within a sector will be based on survival arguments which can be modeled by a static productivity uncertainty as in Helpman et al. (2004). Still, the question remains whether it is appropriate to neglect the continuous volatile motion of firm productivity, especially if first time market entry modes are modeled.

In contrast to trade models, modern finance theory analyzes investment behavior by combining continuous uncertainty with fixed costs in an intertemporal framework (McDonald and Siegel, 1986; Pindyck, 1991). This strand of literature is known as the *real option approach* and has been extended among others by Dixit and Pindyck (1994). Although the theoretical framework turns out to be relatively complex, the approach is increasingly used by decision makers to assess enterprise strategies, especially in investment related questions (Leslie and Michaels, 1997). To shed light on the question whether continuous productivity uncertainty has a different impact on the export and FDI decision of an investor, the real option approach represents therefore a promising and appropriate framework.

The following model combines the proximity-concentration trade-off framework with an uncertain productivity growth (Geometric Brownian motion) to analyze the first time foreign market entry strategy of an investor who can choose between export and FDI. In order to work out the specific differences between a static and dynamic theoretical framework the analysis is conducted in three progressive steps. Starting from a framework without productivity growth, conditions for the optimal market entry mode are derived. In a second step productivity is assumed to grow deterministically, which leads to a broader set of choices for the investor as he can postpone his investment decision. Finally, productivity growth is modeled as a stochastic process accounting for the most realistic scenario.

Results of the model support the New New Trade Theory findings, as continuous uncertainty provides implicitly the same market entry patterns. Confronted with continuous risk, a firm will enter a new foreign market through exports at lower productivity levels relative to the FDI mode. Additionally, the model allows a deeper understanding of the chosen market entry mode under continuous productivity uncertainty.

2.2 Theoretical Framework

Several assumptions are introduced in order to elaborate essential effects of uncertain productivity growth on the choice of the optimal market entry mode.[1]

Consider a risk neutral investor who can serve a new foreign market with a specific product brand X_i either through exports, produced in the home country or through a new foreign affiliate plant (horizontal FDI), located in the destination country. These two market entry modes represent investment strategies which are substituting channels to sell X_i on the new market. The final decision on how to enter the foreign market is based on the comparison of the export investment value V_E with the alternative FDI strategy value V_F. The investment horizon is assumed to be

[1] The term uncertainty will be used in an interchangeable manner with the term risk. In a concise way, risk refers to a known probability distribution whereas uncertainty is referring to events in which the numerical probabilities cannot be specified. In this paper I do not follow this distinction.

infinite and market entry can be postponed without any negative effects on revenues.

2.2.1 Demand Side

The destination country's utility function is assumed to be given by

$$U_t(Q_t, Y_t) = Q_t^{\gamma} Y_t^{1-\gamma} \tag{2.1}$$
$$\text{with} \quad Q_t = \left(\sum_{i=1}^{n_t} X_{i_t}^{\rho} \right)^{\frac{1}{\rho}}, \quad 0 < \rho < 1, \quad 0 < \gamma < 1,$$

where Q_t represents a differentiated product with n_t varieties. X_{i_t} is the consumed amount of brand i only produced by the considered investor. ρ represents the degree of substitution between any two brands of Q_t. Y_t is a homogeneous composite good, freely traded and therefore, used as numeraire good with a normalized fixed world market price, equal to unity. The foreign household maximizes utility subject to the budget constraint

$$\sum_{i=1}^{n_t} X_{i_t} p_{i_t} + Y_t \leqq \xi_t \tag{2.2}$$

where ξ_t represents the foreign country's total expenditure and p_{i_t} the price of variety i in t. The demand function of variety i is then derived as

$$X_{i_t} = \frac{p_{i_t}^{-\eta}}{P_t^{-\eta}} \cdot \frac{\gamma \xi_t}{P_t} \tag{2.3}$$
$$\text{with} \quad \eta = \frac{1}{1-\rho}, \quad P_t = \left(\sum_{j_t}^{n_t} p_{j_t}^{1-\eta} \right)^{\frac{1}{1-\eta}},$$

where P_t denotes the foreign country's price index and η the elasticity substitution. The investor insinuates that the expenditure share $\gamma\xi$ spent on Q and the price index P do not change over time. Therefore, equation (2.3) represents the investor's perceived demand function and the inverse demand for the relevant variety X_i can be written as

$$p_t = Z X_t^{-\frac{1}{\eta}} \tag{2.4}$$
$$\text{with} \quad Z = P^{\frac{\eta-1}{\eta}} (\gamma\xi)^{\frac{1}{\eta}},$$

where the considered variety's subscript i is omitted, as the investor intends to serve the foreign market only with this distinctive brand. Furthermore, there is no strategic interaction among firms. Depending on the country specific elasticity of substitution, the investor possesses a varying degree of market power. The mark-up of price over marginal costs

$$\frac{p}{w} = Z\left(\frac{\eta}{\eta - 1}\right) \tag{2.5}$$

with w as the equilibrium wage rate, results from the investor's profit maximization problem as a monopolist. Defining ν as the inverse of the mark-up with

$$\nu = \frac{\eta - 1}{\eta}$$

the inverse demand function can be reformulated as

$$p = ZX^{\nu - 1}. \tag{2.6}$$

In a country, where ν is close to 0, the elasticity of demand is close to 1 which represents a scenario where the investor has a high monopoly power, since the substitutability between the varieties of good Q_t is very low ($\rho \rightarrow 0$). In contrast, for a country with ν close to 1, the elasticity of demand approaches infinity and the substitutability between the varieties of Q_t is very high ($\rho \rightarrow 1$). In such a country the investor is confronted with a perfectly competitive environment. As a result of this modified notation, ν can be used as a country specific competition measure for a variety X.

2.2.2 Production Side

In both, the home and foreign country, the investor is confronted with a production technology characterized by the Cobb-Douglas function

$$X_t(L_t) = \vartheta_t L_t^{\theta} \tag{2.7}$$

$$\text{with} \quad 0 < \theta < 1 \quad \text{and} \quad \vartheta_t > 0,$$

where X_t denotes the periodical output and labor L_t the only input factor. ϑ_t represents a productivity parameter and is referred to as the firm embedded productivity, because it is specific to the idiosyncratic firm independently of its location. In both market entry strategies the investor is confronted with fixed costs which are assumed to be sunk once invested. If the foreign market is served through exports, fixed costs I_E accrue. They include costs for the domestic production extension and expenses for a new foreign distribution and service network. In case of a FDI market entry mode fixed costs I_F must be covered which include the same distribution and service network costs as the export mode. However, due to the required new plant in the FDI mode, its fixed costs are assumed to be always higher than the export fixed costs I_E.[2] Given these irreversible fixed costs, both investment strategies exhibit increasing returns to scale.

Additionally, exports are subject to iceberg transport costs described by the transport technology

$$\lambda(\tau) = \tau - 1 \quad \text{with} \quad \tau > 1. \tag{2.8}$$

The extra domestic output X_{DE_t}, which is produced only for the new foreign market, shrinks during the transportation process by the constant factor $(\tau - 1)$. The residual output X_{E_t} which is finally sold in the destination country results as

$$X_{E_t} = \frac{X_{DE_t}}{\tau}. \tag{2.9}$$

Transport costs are avoided if the investor decides to serve the foreign market through a new affiliate. The wage rate w is determined in the homogeneous good industry Y, where the foreign country exhibits a lower wage rate than the investor's home country due to a less efficient production technology. The resulting fixed and variable cost structure with

$$\frac{I_E}{I_F} < 1 \quad \text{and} \quad \frac{w_F}{w_E \tau^{\frac{1}{\theta}}} < 1 \tag{2.10}$$

is the *proximity-concentration trade-off* assumption, which is fundamental in recent trade models dealing with international market entry strategies and represents the first crucial pillar in the

[2] A switching strategy from the export to the FDI mode, which would be associated with a different fixed cost structure, is assumed to be not possible. In a dynamic framework such an extension necessitates numerical methods (Dixit and Pindyck, 1994).

underlying model (Brainard, 1997, Helpman et al., 2004, and Yeaple, 2008).

2.2.3 The Evolution of Productivity

The major objective within the established theoretical framework is the analysis of firm-embedded productivity, introduced as ϑ_t, and its impact on the optimal market entry mode under different scenarios. Therefore, a more accurate coverage of possible productivity developments is necessary. From a theoretical point of view productivity can evolve in three different manners over time.

1. ϑ stays constant over time (no productivity growth).
2. ϑ constantly increases over time (deterministic productivity growth).
3. ϑ exhibits a volatile productivity increase over time (stochastic productivity growth).

Analytically, these productivity evolutions can be easily modeled by using the following Geometric Brownian motion denoted in differential notation as

$$d\vartheta_t = \alpha\vartheta_t dt + \sigma\vartheta_t dz_t, \tag{2.11}$$

where the parameters α and σ are assumed to be time invariant and represent the growth rate and extent of volatility, respectively. dz_t is the increment of a standard Brownian motion z_t with

$$dz_t = \epsilon_t\sqrt{dt} \quad \text{and} \quad \epsilon_t \sim N(0,1) \tag{2.12}$$

where ϵ_t is assumed to be a Gaussian random variable. Therefore, the expected value and the variance of the standard Wiener process' increment result as $\mathbb{E}(dz_t) = 0$ and $\mathbb{V}(dz_t) = dt$.
Figure 2.2 illustratively depicts the realizations of the above mentioned productivity paths. The increasing dashed line exhibits a yearly growth rate of 6% and no volatility as $\mathbb{E}(dz_t) = 0$. In such a case after 5 years, productivity can be expected to be 33% higher than initially. For a volatile productivity growth with $\sigma > 0$, it is no longer possible to predict a unique path. The dotted trajectories represent 2 potential developments for a scenario with $\sigma = 4\%$ out of infinite possibilities. The simplest case is depicted by the horizontal curve which represents a scenario

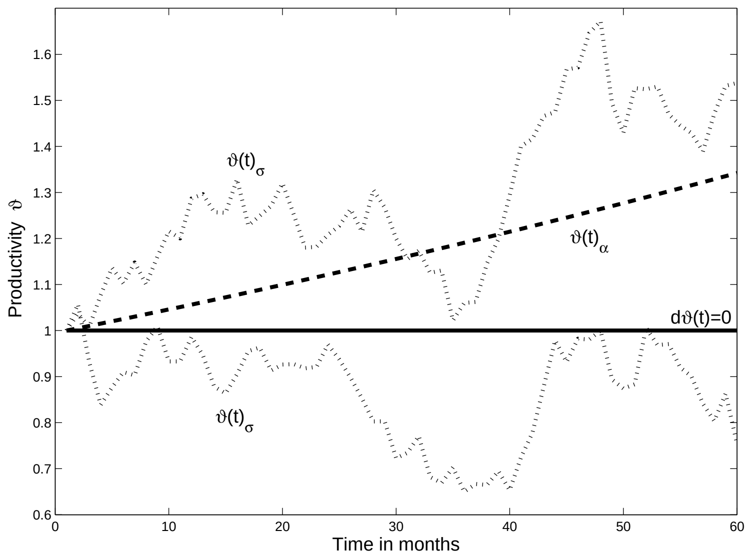


Figure 2.2: Exemplary Productivity Paths

without growth.[3]

Due to its coverage of all possible productivity developments, the Geometric Brownian motion in equation (2.11) represents the second pillar in this model. By combining the established proximity-concentration trade-off framework with the Geometric Brownian motion in productivity, the succeeding analysis examines the optimal first time market entry strategy of an international investor in all these scenarios separately.

2.3 The Optimal Market Entry Mode

In order to elaborate uncertainty effects of productivity growth on the choice between FDI and export, the analysis starts with the simplest scenario with no productivity changes over time. Successively, the complexity of the analysis is increased by introducing a deterministic growth case and finally by considering the most realistic scenario represented by equation (2.11). This stepwise approach permits an identification of the additional effects associated with extensions.

[3] The chosen values are illustrative examples. Faggio et al. (2007) e.g. present empirical data about productivity developments for different sectors in the U.K.

2.3.1 FDI or Export without Productivity Growth

In a scenario without any productivity growth equation (2.11) reduces to $d\vartheta_t = 0$ and the investor will determine the optimal market entry mode based on the current state of observations, as there are no expected productivity changes in the future. Empirically, it is difficult to identify such an industry or variety in the long run but in some sectors like in the textile industry, technology has reached its marginal productivity frontier temporarily, and one can assume nearly zero growth rates, at least in the short run. From a theoretical point of view, this scenario only represents a starting point for further analysis.

In the export mode the investor's expected periodical profits (cash-flows) Π_E are derived from the following maximization problem

$$\Pi_E = \max_L \; p\; X_E - w_E L \quad \text{s.t.} \quad X_E = \frac{X_{DE}}{\tau} \quad \text{s.t.} \quad X_{DE} = \vartheta L^{\theta} \quad \text{s.t.} \quad p = Z {X_E}^{(\nu-1)}. \tag{2.13}$$

Optimal periodical labor demand L_E^* and output X_E^* result as

$$L_E^* = \left(\frac{\vartheta^{\nu} Z \nu \theta}{w_E \tau^{\nu}}\right)^{\frac{1}{1-\nu\theta}} \quad \text{and} \quad X_E^* = \vartheta^{\frac{1}{1-\nu\theta}} \left(\frac{Z\nu\theta}{w_E \tau^{\frac{1}{\theta}}}\right)^{\frac{\theta}{1-\nu\theta}} \tag{2.14}$$

where the investor's domestic output which is foreseen for the export market amounts to

$$X_{DE}^* = \vartheta^{\frac{1}{1-\nu\theta}} \left(\frac{Z\nu\theta}{w_E \tau^{\nu}}\right)^{\frac{\theta}{1-\nu\theta}}. \tag{2.15}$$

Finally, the optimal expected periodical export cash-flows are given as

$$\Pi_E(\vartheta) = M_E \vartheta_E^{\kappa} \tag{2.16}$$

$$\text{with} \quad M_E = Z^{\frac{1}{1-\nu\theta}} \left(\frac{\nu\theta}{w_E \tau^{\frac{1}{\theta}}}\right)^{\frac{\nu\theta}{1-\nu\theta}} (1-\nu\theta) \quad \text{and} \quad \kappa = \frac{\nu}{1-\nu\theta}.$$

Transport costs do not accrue in the FDI mode ($\tau = 1$) and expected periodical profits result as[4]

$$\Pi_F(\vartheta) = M_F \vartheta^{\kappa} \tag{2.17}$$
$$\text{with} \quad M_F = Z^{\frac{1}{1-\nu\theta}} \left(\frac{\nu\theta}{w_F}\right)^{\frac{\nu\theta}{1-\nu\theta}} (1-\nu\theta) \quad \text{and} \quad \kappa = \frac{\nu}{1-\nu\theta}.$$

Cash-flows in both entry modes can be linear, convex, or concave in ϑ depending on κ. The following analysis focuses on cases in which the cash-flows are linear or convex in ϑ since this is a common assumption in recent trade models (Helpman, 2006).[5]

In order to choose the optimal market entry mode, the investor compares both market entry strategies' net present investment values which are associated with the earlier explained fixed costs. The opportunity costs in this certain scenario are equal to the riskless interest rate r and therefore, net present values of the export and FDI mode result as

$$V_E(\vartheta) - I_E = \frac{M_E \vartheta^{\kappa}}{r} - I_E \tag{2.18}$$
$$V_F(\vartheta) - I_F = \frac{M_F \vartheta^{\kappa}}{r} - I_F. \tag{2.19}$$

Figure 2.3 depicts the export strategy's investment value as a continuous line and the FDI mode's value as a dotted line.[6] The two curves' relative position to each other is not random but enforced by the proximity-concentration trade-off assumption. As the fixed costs in the export mode are assumed to be lower than in the FDI mode (comparative fixed cost advantage), for $\vartheta = 0$ the net investment value $V_E - I_E$ will always be higher than $V_F - I_F$. Furthermore, due to the higher variable costs in the export mode a gain in productivity leads to a higher marginal increase in the FDI investment value (comparative variable cost advantage). Differently expressed, the slope of $V_F - I_F$ will always be steeper than the slope of $V_E - I_E$. As a result, the export value function crosses the FDI value function always from above as depict in figure 2.3. In the underlying example, an investor will serve the new foreign market through FDI if the prevailing productivity level is larger than ϑ_{Fc1} and for a productivity level between ϑ_{Ec} and ϑ_{Fc} exporting

4 The optimal labor demand and output in the FDI mode are $L_F^* \left(\frac{Z\vartheta^{\nu}\nu\theta}{w_F}\right)^{\frac{1}{1-\nu\theta}}$ and $X_F^* = \left(\frac{Z\nu\theta\vartheta^{\frac{1}{\theta}}}{w_F}\right)^{\frac{\theta}{1-\nu\theta}}$.

5 Cash-flows will be always linear or convex in ϑ for $\kappa \geq 1$.

6 The domestic investment value V_D of the plant which serves the investor's home market is neglected. Implicitly, it is assumed that V_D is not affected by the new foreign market entry.

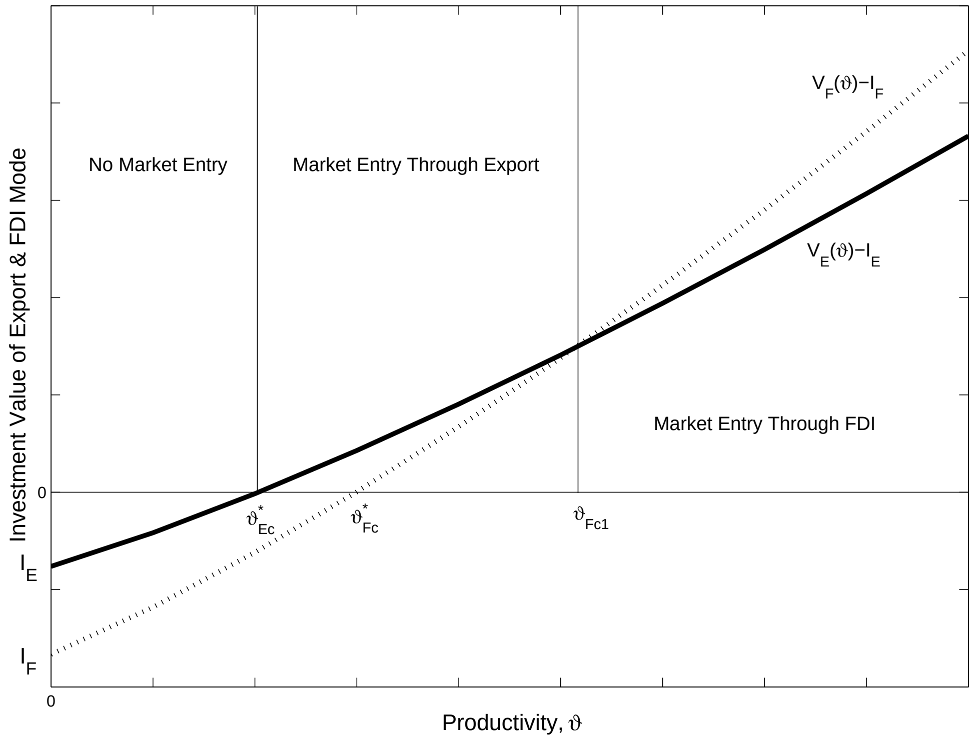


Figure 2.3: Investment Values within the Proximity-Concentration Trade-Off

turns out to be the optimal market entry strategy. For the remaining productivity range, market entry implies losses in both modes and is therefore discarded.

A decisive aspect whether the FDI strategy dominates the export mode or vice versa depends on the rank of the productivity cut-offs which result from equation (2.18) and (2.19) as

$$\vartheta^*_{Ec} = \sqrt[\kappa]{\frac{I_E r}{M_E}} \quad \text{and} \quad \vartheta^*_{Fc} = \sqrt[\kappa]{\frac{I_F r}{M_F}}. \tag{2.20}$$

Figure 2.3 illustratively depicts a case in which the intersection between the two value functions takes place above the horizontal-axes. However, for a cost structure with export fixed costs I_E close to FDI fixed costs, the two value functions may intersect on or below the horizontal axes. In such a case, only the FDI strategy provides relevant zero or positive net present values and it would represent the upper envelope function in figure 2.3. Simultaneously, its cut-off productivity level ϑ^*_{Fc} will be always equal to or below ϑ^*_{Ec}. Consequently, for such cost constellations FDI represents the only and optimal market entry strategy conditional on positive net present values.

It is possible to derive a concise condition which describes the ordinal rank between the two productivity cut-offs. Appendix 2.7.2 proofs that

$$\frac{\vartheta^*_{Ec}}{\vartheta^*_{Fc}} \lesseqgtr 1 \quad \text{if} \quad \frac{I_E}{I_F} \lesseqgtr \left(\frac{w_F}{w_E \tau^{\frac{1}{\theta}}}\right)^{\frac{\nu\theta}{1-\nu\theta}} . \tag{2.21}$$

Within the assumed relative cost structure, relation (2.21) states that the export mode's productivity cut-off ϑ^*_{Ec} is smaller (equal, bigger) than the FDI productivity cut-off ϑ^*_{Fc} if its fixed cost advantage is bigger (equal, smaller) than the FDI mode's variable cost advantage. Since

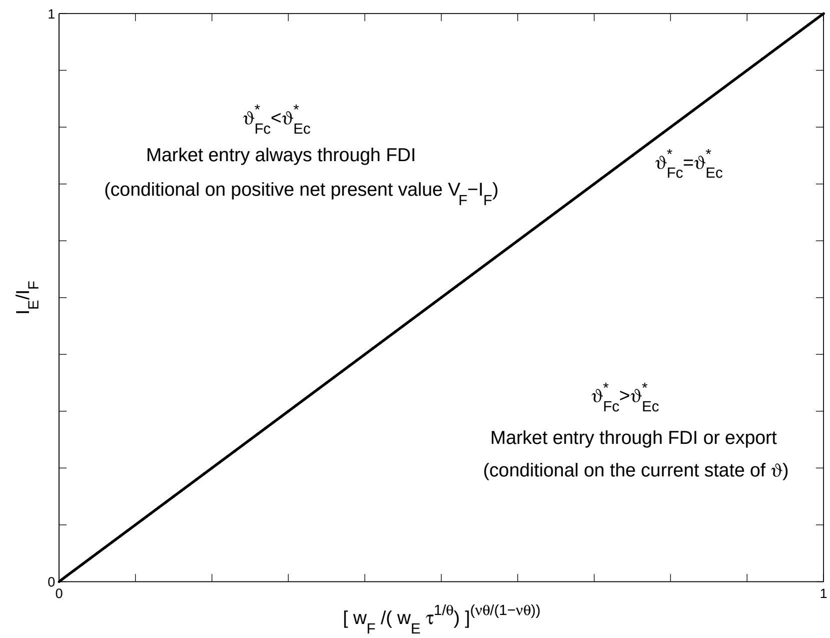


Figure 2.4: Relative Cost Constellations within the Proximity-Concentration Trade-Off

within the proximity-concentration trade-off framework relative fixed costs $\frac{I_E}{I_F}$ and relative variable costs $\left(\frac{w_F}{w_E \tau^{\frac{1}{\theta}}}\right)^{\frac{\nu\theta}{1-\nu\theta}}$ never exceed unity, it is possible to depict all relevant cost patterns in a unit relative cost box. The diagonal curve in Figure 2.4 represents all relative cost constellations for the FDI and export mode which exhibit a comparative fixed cost advantage equal to the comparative variable cost advantage, given the technology concavity θ and the country specific degree of competition ν. Therefore, any relative cost structure on or above the diagonal line leads to a FDI productivity cut-off ϑ^*_{Fc} being equal to or bigger than ϑ^*_{Ec}. In both cases the FDI mode's net present value function would represent the upper envelope in figure 2.3 and the investor serves the market through a foreign plant, conditional on a positive net present value.

Any relative cost constellation below the diagonal curve in figure 2.4 leads to a cut-off rank with ϑ^*_{Ec} always lower than ϑ^*_{Fc} which would be represented by an upper envelope function in figure 2.3 consisting of both, the FDI and export mode's net present value functions. Therefore, in such a case the optimal market entry strategy depends on the current observed productivity state ϑ and can be either FDI or exporting. The investor will choose the export mode if the observed current productivity level ϑ lies in-between the two productivity cut-offs $\vartheta^*_{Ec}, \vartheta_{Fc1}$ and fulfills the following condition

$$\vartheta_{Fc1} > \vartheta > \sqrt[\kappa]{\left(\frac{I_E - I_F}{M_E - M_F}\right) r} > \vartheta^*_{Ec}. \quad (2.22)$$

An essential result in the underlying scenario with no growth and no uncertainty is that 50% of all possible relative cost structures (upper left corner in figure 2.4) unambiguously entail FDI as the optimal market entry strategy, conditional on positive net present values. Furthermore, the export mode never becomes a unique dominant strategy as the lower left corner in figure 2.4 can lead to both export and FDI.

Result 1:
Given $I_E < I_F$ and $w_F < w_E \tau^{\frac{1}{\theta}}$, for more than 50% of all possible relative cost constellations within the proximity-concentration trade-off framework, FDI represents the unique optimal market entry mode.

The upper horizontal margin in figure 2.4 typifies relative cost constellation for which the fixed costs in both market entry modes are equal, but the variable costs are always lower in the FDI mode. Therefore, the investor will always opt for FDI. Analogously, for all cost constellations positioned on the right vertical margin in figure 2.4 both market entry modes exhibit equal total variable costs. Due to the lower fixed costs in the export strategy, in such cases the investor will always enter the market as exporter. Finally, the upper right corner in figure 2.4 represents a cost constellation for which the fixed cost advantage of the FDI mode is equal to the variable cost advantage of the export mode and therefore, the investor is indifferent between the two market entry strategies.

2.3.2 FDI or Export with Productivity Growth

A more realistic scenario for productivity development can be modeled as

$$d\vartheta_t = \alpha\vartheta_t dt \tag{2.23}$$

with α representing the productivity growth rate. Given the initial exponential cash-flows in equation (2.16) and (2.17) it is necessary to adjust the growth rate for cases in which $\kappa > 1$. The adjusted growth rate for convex profit flows results as

$$\alpha' = \frac{d\vartheta^\kappa}{\vartheta^\kappa} = \alpha\kappa. \tag{2.24}$$

Still, without any risk, the appropriate discount rate is equal to the riskless interest rate r. Consequently, for both strategies the gross value of their periodical cash-flows is determined by

$$V_i(t,T) = \int_{t+(T-t)}^{\infty} M_i\vartheta^\kappa(s)e^{-r(s-t)}ds \tag{2.25}$$

$$\text{with} \quad \vartheta^\kappa(s) = \vartheta_t^\kappa e^{\alpha' s} \quad \text{and} \quad i \in \{E,F\}. \tag{2.26}$$

T represents the time at which periodical profits start to flow and t the time at which the cash-flows are evaluated, with ϑ_0 representing the current productivity state. Therefore, the gross present value of growing periodical cash-flows (t=0) is given by[7]

$$V_i(0,T) = \frac{M_i\vartheta_0^\kappa}{\delta_c'}e^{-(r-\alpha')T} \quad \text{with} \quad \delta_c' = r - \alpha'. \tag{2.27}$$

In contrast to the previous scenario an investor is not only confronted with the choice problem between exporting and FDI. Additionally, a timing problem arises where the following net pay-offs $F_i(\vartheta)$ are optimized.

$$F_i(\vartheta) = \max_T \left(\frac{M_i\vartheta^\kappa}{r-\alpha'}e^{-(r-\alpha')T} - I_i e^{-rT} \right), \quad \text{with} \quad \vartheta = \vartheta_0, \quad i \in \{E,F\}. \tag{2.28}$$

Equation (2.28) clearly illustrates the unequal total discount rates of the cash-flows and the fixed costs. For $\alpha = 0$ which represent the previous scenario, there is no reason to postpone

[7] A meaningful economic interpretation for the investment values result for $r - \alpha' > 0$. Appendix 2.7.1 shows that under this condition $\beta_c > \kappa > 1$ with $\beta_c = \frac{r}{\alpha}$.

or delay an investment. The investment takes place if the discounted profit flows are equal or bigger than the discounted fixed costs in t (Marshallian rule). The corresponding investment rule results as

$$F_i(\vartheta) = \max[V_i(0,T) - I_i, 0]. \tag{2.29}$$

On the other hand for a growth rate $\alpha > 0$ the investor has an incentive to postpone the project in order to maximize his pay-off, although the current gross value of the cash-flow streams may be bigger than the current fixed costs. Solving the maximization problem in (2.28) provides the optimal investment times for both market entry modes:

$$T_i^* = \max\left(\frac{1}{\alpha'} \ln\left[\frac{rI_i}{M_i\vartheta^\kappa}\right], 0\right) \quad \text{with} \quad i \in \{E, F\}. \tag{2.30}$$

For periodical profit flows not too much larger than the user cost of capital rI_i, both investment strategies will be postponed into the future since $T_i^* > 0$. Due to the proximity-concentration trade-off assumption the optimal market entry time of exporting clearly differs from the optimal market entry time of the FDI strategy. For the sake of a better comparability between the different scenarios it is useful to determine the optimal productivity cut-offs ϑ_i^* in both investment strategies. By setting the optimal investment time T_i^* equal to zero it is possible to derive the investment rule and the optimal cut-off productivity ϑ_i^* which triggers market entry at $t = 0$, respectively. An instantaneous investment in both modes results if

$$rI_i = (r - \alpha')\frac{M_i\vartheta^\kappa}{(r - \alpha')} = M_i\vartheta^\kappa \quad \text{with} \quad i \in \{E, F\} \tag{2.31}$$

which states that the investor will execute one of the two investment alternatives if the corresponding cash-flows $M_i\vartheta^\kappa$ cover their cost of capital use rI_i. This optimality condition is known as the Jorgensonian investment rule (Jorgenson, 1963) and slightly differs from the generally applied Marshallian rule, which compares the absolute fixed costs with the gross investment values. By contrast Jorgenson's rule represents a marginal concept and in the presence of productivity growth, it leads to an investment rule where fixed costs need not only to be covered by the gross present value $V_i(\vartheta)$ but by relatively higher values.

Reshaping equation (2.31) provides

$$V_i(\vartheta) = \frac{M_i \vartheta^{\kappa}}{(r - \alpha')} = \left(\frac{r}{r - \alpha'}\right) I_i \quad \text{with} \quad \frac{r}{r - \alpha'} > 1 \tag{2.32}$$

where the wedge in front of the fixed costs is bigger than one, if $\alpha > 0$. Therefore, in absence of productivity growth (earlier scenario) the derived condition coincides with the Marshallian investment rule and no timing problem occurs. On the other hand, for positive productivity growth rates the investor will postpone his market entry decision (export or FDI) into the future T_i^* although the net payoffs are positive.

For a market entry in T_i^* the net present values of both investment modes result as

$$F_i(\vartheta) = \frac{\alpha' I_i}{r - \alpha'} \left(\frac{r - \alpha'}{r}\right)^{\frac{r}{\alpha'}} \left(\frac{M_i \vartheta^{\kappa}}{r - \alpha'}\right)^{\frac{r}{\alpha'}} I_i^{-\frac{r}{\alpha'}} \tag{2.33}$$

and are referred to as the option values. Clearly, for $\alpha = 0$ these value functions become worthless. Given the two possible investment times ($t_i = 0, T_i^*$) for each market entry strategy the investor will compare the net investment value $V_i(\vartheta) - I_i$ with its corresponding option value $F_i(\vartheta)$. By defining

$$A_{i_c} = \frac{\alpha' I_i}{r - \alpha'} \left(\frac{r - \alpha'}{r}\right)^{\frac{r}{\alpha'}} \left(\frac{M_i}{r - \alpha'}\right)^{\frac{r}{\alpha'}} I_i^{-\frac{r}{\alpha'}} \quad \text{and} \quad \beta_c = \frac{r}{\alpha}$$

the two value functions which determine each market entry mode's optimal timing, result as

$$F_i(\vartheta) = A_{i_c} \vartheta^{\beta_c} \qquad \text{for} \quad \vartheta_i < \vartheta_i^* \quad \text{postpone investment to } T_i^* \tag{2.34}$$

$$V_i(\vartheta) - I_i \qquad \text{for} \quad \vartheta_i > \vartheta_i^* \quad \text{invest today } (t = 0) \tag{2.35}$$

with $\quad i \in \{E, F\}$,

where the cut-off productivity levels are represented by ϑ_i^*.

The existence of productivity growth ($\alpha > 0$) has two new effects on the market entry choice of the investor. Equation (2.27) demonstrates that the gross present value of both investments increases in α. In comparison to the previous scenario, the investor is confronted with lower productivity cut-offs as the net present value functions increase. However, simultaneously growth in productivity generates an option value represented by (2.33) which eliminates this effect completely, as the investments are postponed. A graphical illustration visualizes the different adjustments very clearly. The two continuous curves in figure 2.5 represent the net present in-

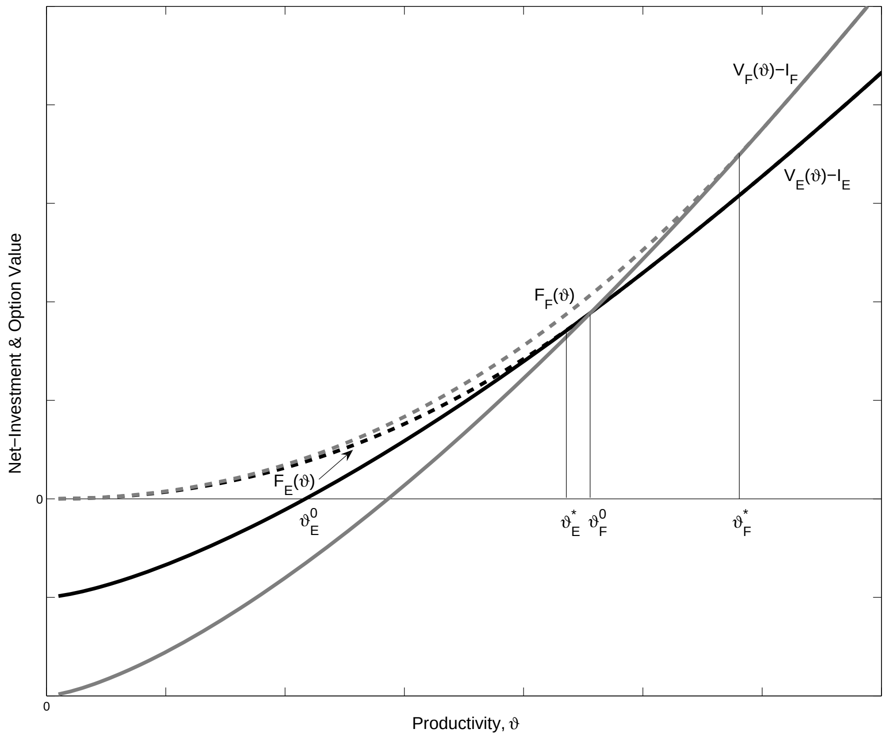


Figure 2.5: Value Functions of Exporting and FDI

vestment values for both market entry strategies in the presence of productivity growth, whereas the dashed lines represent the corresponding option values. If the investor decides on the market entry problem by applying the Marshallian rule, the optimal investment strategy is derived in the same manner as in a scenario without growth. In such a case for current productivity levels higher than ϑ_F^0, FDI represents the optimal mode. Exporting is chosen for current productivity levels between ϑ_E^0 and ϑ_F^0. These cut-offs are all lower than those in scenario one as explained and would cause an earlier market entry in both strategies. However, for the determination of the optimal productivity cut-offs the investor additionally accounts for the option values as there is a timing problem. In contrast to scenario one, these optimal cut-offs result at the tangency point between the net present investment value function and the respective option value. At these points for each market entry mode, the net investment value equals its option value, respectively, and the investor does no longer postpone his investment decision. Rearranging the earlier derived Jorgensonian investment rule provides the productivity cut-offs for both market entry modes as

$$\vartheta_E^* = \sqrt[\kappa]{\frac{\beta_c}{\beta_c - \kappa}\frac{I_E\ \delta_c'}{M_E}} \qquad \text{and} \qquad \vartheta_F^* = \sqrt[\kappa]{\frac{\beta_c}{\beta_c - \kappa}\frac{I_F\ \delta_c'}{M_F}} \qquad \text{with} \quad \delta_c' = r - \alpha'. \tag{2.36}$$

The difference between the interest rate r and the productivity growth rate α' represents the real opportunity cost rate δ_c. For a low productivity growth rate the opportunity costs of delaying each investment are high, whereas a high growth rate affects δ_c' negatively.

In the illustrative example in figure 2.5 exporting is in principle profitable for a current productivity level between ϑ_E^0 and ϑ_E^* if it is started instantaneously (t=0) but by starting in T_E^* the net present profits represented by the option value $F_E(\vartheta)$ are higher. Therefore, exporting is postponed until the current productivity level reaches ϑ_E^* at which the investor is indifferent between postponing and investing into the export platform. Consequently, as long as there is a positive difference between the option value $F_i(\vartheta)$ and the net present value $V_i(\vartheta) - I_i$ there exists a value of waiting and the market entry is postponed into T_i^*. Due to the same reasoning, for productivity levels between ϑ_F^0 and ϑ_F^*, the investor postpones his FDI investment decision into T_F^*, although an immediate market entry would provide profits. Graphically expressed, it is the upper envelope function in figure 2.5 which determines the final optimal market entry mode.

Generally, the determination of the optimal market entry mode necessitates the consideration of two aspects. First, the investor needs again to determine the ordinal rank between the two productivity cut-offs.

Appendix 2.7.3 shows that the cut-offs' rank depends on the different cost structures with

$$\frac{\vartheta_E^*}{\vartheta_F^*} \lesseqgtr 1 \quad \text{if} \quad \frac{I_E}{I_F} \lesseqgtr \left(\frac{w_F}{w_E \tau^{\frac{1}{\theta}}}\right)^{\frac{\nu\theta}{1-\nu\theta}}, \tag{2.37}$$

which is the same result as in scenario one.

The conclusion from this equivalent results is that the introduction of growth into the proximity-concentration trade-off framework does not change the relationship between the productivity cut-offs compared to the previous scenario. Figure 2.6 depicts the earlier introduced relative unit cost box within the proximity-concentration trade-off framework. The rank of the productivity cut-offs for all possible relative cost constellations is the same as in figure 2.4.

In order to derive the optimal market entry strategy, it is necessary to determine how the two investment modes' option values behave for different cost-constellations. Appendix 2.7.4 shows that

$$\frac{F_E}{F_F} \lesseqgtr 1 \quad \text{if} \quad \left(\frac{w_F}{w_E \tau^{\frac{1}{\theta}}}\right)^{\frac{\nu\theta}{1-\nu\theta}} \gtreqless \frac{I_E}{I_F}\left(\frac{I_E}{I_F}\right)^{-\frac{\kappa}{\beta_c}} \tag{2.38}$$

$$\text{with} \quad \beta_c = \frac{r}{\alpha}.$$

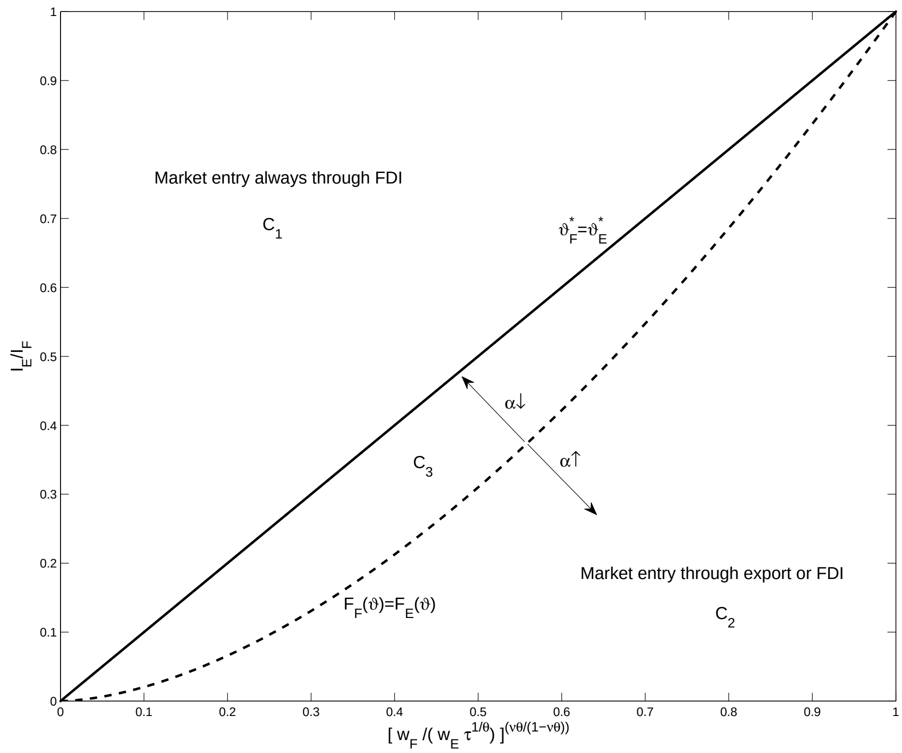


Figure 2.6: Relative Cost Constellations and Productivity Growth

Relation (2.38) is almost equal to the first condition in relation (2.37) except the second term on the right hand side which depends on the growth rate α. Therefore, it can be drawn as dashed line in the previous relative unit cost box. Within the proximity-concentration trade-off framework, for all relative cost constellations on the dash line, the two market entry strategies' option functions coincide. Respectively, any cost structure above the line will exhibit a FDI option value $F_F(\vartheta)$ which is always bigger than the export option value $F_E(\vartheta)$. The opposite holds for cost constellations below the dashed line. Based on the two conditions (2.37) and (2.38) it is possible to derive the optimal market entry modes for different cost constellations presented in figure 2.6.

Relative Cost Structures in Area C_1:

All relative cost patterns above the diagonal line, declared as area C_1, will lead to a FDI productivity cut-off ϑ_F^* which is always smaller than the export cut-off ϑ_E^*. Simultaneously, the FDI mode's option function will always be higher than the export mode's one with

$$F_F(\vartheta) > F_E(\vartheta) \quad \text{and} \quad \vartheta_F^* < \vartheta_E^*. \tag{2.39}$$

Therefore, in figure 2.5 the upper envelope function is always represented either through the FDI's option or net present value function. Consequently, for all these cost constellations an investor will unambiguously serve the foreign market through FDI, conditional on market entry.

Relative Cost Structures in Area C_2:

For cost constellations in area C_2 the relation between the two option functions and productivity cut-offs is given by

$$F_F(\vartheta) < F_E(\vartheta) \quad \text{and} \quad \vartheta_F^* > \vartheta_E^*. \tag{2.40}$$

For these cost patterns figure 2.5 would map an upper envelope function consisting of all four available value functions. Depending on the current state of the productivity level the investor enters the market either through exports or FDI. Therefore, area C_2 does not lead to an unambiguous market entry strategy.

Relative Cost Structures in Area C_3:

Relative cost structures between the diagonal line and above the dash line are declared as area C_3 and lead to a formation of the option value functions and productivity cut-offs with

$$F_F(\vartheta) > F_E(\vartheta) \quad \text{and} \quad \vartheta_F^* < \vartheta_E^*. \tag{2.41}$$

For these constellations the investor is in principle willed to enter the new foreign market through exports at lower productivity levels relative to the FDI mode. However, as the option value of the FDI mode is always higher than the two export value functions, exporting is always neglected for the sake of FDI. Figure 2.5 illustratively represents such a cost constellation and appendix 2.7.5 proofs that area C_3 will always lead to a market entry through FDI, since

$$\left.\frac{F_F(\vartheta)}{V_E(\vartheta)}\right|_{\vartheta>\vartheta_E^*} > 1 \tag{2.42}$$

for

$$\left(\frac{w_F}{w_E\tau^{\frac{1}{\theta}}}\right)^{\frac{\nu\theta}{1-\nu\theta}} > \frac{I_E}{I_F}\left(\frac{I_E}{I_F}\right)^{(-\frac{\kappa}{\beta_c})}. \tag{2.43}$$

Area C_3 evolves for positive growth rates and its extent depends on the size of α. Condition (2.38) shows for a decreasing α the exponent $\frac{\kappa}{\beta_c}$ approaches zero. Consequently, area C_3 diminishes until the dashed line in figure 2.5 coincides with the diagonal curve. This result represents the relative unit cost box for scenario one with $\alpha = 0$ and confirms the consistency of the framework. On the contrary, an increase in α enlarges area C_3 as the dashed curve in figure 2.5 becomes more convex. The economic intuition for this adjustments follows from condition (2.38). An increase in productivity growth reduces the comparative fixed cost advantage of the export mode and implicitly increases the comparative variable cost advantage of the FDI strategy. Differently expressed, a rise in α increases the FDI mode's option value stronger than the export option value. Consequently, as area C_1 and C_3 unambiguously enforce market entry through FDI it can be concluded that within the proximity-concentration trade-off framework a rise in α increases the range of cost patterns which result in FDI.

Result 2:
For $I_E < I_F$ and $w_E\tau^{\frac{1}{\theta}} > w_F$ the availability of productivity growth increases the range of relative cost constellation which enforce FDI as the optimal market entry strategy. The higher the growth rate α the larger the share of cost patterns which lead to FDI (far more than 50%).

Even though the underlying framework only considers a representative firm, the last result has crucial implications for sectoral first time market entry investments. Accordingly, sectors with higher productivity growth should exhibit a higher share of FDI as first time entry mode, since the range of relative cost constellations which promote FDI is relatively larger.

2.3.3 FDI or Export with Uncertain Productivity Growth

Although the introduction of productivity growth accounts for empirically important effects still one crucial aspect is neglected. Productivity growth is not a deterministic phenomenon but represents a continuously volatile process over time (Baily et al., 2001). As a consequence of this stochastic characteristic, the investor is no longer confronted with a simple choice problem between two types of market entry over time. Additionally, he has to adjust his expectations to the prevailing continuous productivity uncertainty. A natural and convenient way to extend the previous settings, in order to account for productivity uncertainty, is the introduction of a Geometric Brownian motion represented by (2.11) whose solution is derived in appendix 2.7.6 as

$$\vartheta_t = \vartheta_0 \; e^{\int_0^T (\alpha - \frac{1}{2}\sigma^2)dt + \int_0^T \sigma dz_t}. \tag{2.44}$$

Within this final framework the investor assesses any uncertain investment with respect to the capital market where an appropriate return (including a risk-premium) is derived. In order to evaluate the appropriate investment return for both market entry modes it is assumed that there exists an asset on a complete capital market which is perfectly correlated with the latter Geometric Brownian motion.[8] Furthermore, this replication asset is assumed to pay no dividends and therefore, its complete return can be attributed to its capital gain. With reference to the capital asset pricing model (CAPM) the risk adjusted expected return μ of such an investment is derived from

$$\mu_i = r + \frac{(r_M - r)}{\sigma_M} \upsilon_{cM} \sigma_i \tag{2.45}$$

where υ_{cM} specifies the correlation between the spanned asset and the market portfolio. r_M and σ_M represent the expected return and the volatility of the latter one. Within this framework the market price of risk is measured as $\frac{r_M - r}{\sigma_M}$ and is referred to as the *Sharpe ratio* (Sharpe, 1964). Based on the linear relationship in equation (2.45) it is possible to derive an appropriate risk-adjusted expected rate of return for any degree of uncertainty described by σ.

Once the adjusted expected return μ is known, it is possible to derive the risk-adjusted oppor-

[8] Within the option theory such a procedure is referred to as asset spanning or asset replication (Schwartz and Trigeorgis, 2004)

tunity costs in order to evaluate the export and FDI strategy under uncertainty. In equilibrium, the difference between the risk-adjusted return μ and the deterministic growth rate α represents the rate of opportunity costs with

$$\delta_u = \mu - \alpha. \tag{2.46}$$

For a positive δ_u, an investment exhibits an expected capital gain rate α which is lower than the risk-adjusted rate of return μ. Therefore, by delaying the investment the investor incurs an opportunity cost rate of δ_u. Consequently, for a high opportunity cost rate the immediate execution of the respective investment is more likely because the corresponding option value will be low, due to a low α.

Since in the underlying framework the cash-flows $M_i\vartheta_i$ increase exponentially in ϑ for $\kappa > 1$, it is necessary to determine the corresponding risk-adjusted growth rate α'_u, which is derived in appendix 2.7.7 as

$$\alpha'_u = \alpha\kappa + \frac{1}{2}\kappa(\kappa - 1)\sigma^2. \tag{2.47}$$

Therefore, for both market entry modes the expected value of the cash-flows at time t can be calculated by

$$\mathbb{E}(M_i\vartheta_t^\kappa) = M_i\vartheta_0^\kappa e^{\alpha\kappa + \frac{1}{2}\kappa(\kappa-1)\sigma^2} \qquad \text{with} \quad i \in \{E, F\}. \tag{2.48}$$

Equation (2.48) shows that for linear periodical cash-cash flows ($\kappa = 1$) in ϑ, the expected value is independent of the parameter σ. The investor expects the same profits as in the previous deterministic case. However, for $\kappa > 1$ the expected profit-flows increase and are bigger the higher the uncertainty in the productivity development becomes. This disproportionate expectation is driven by Jensen's inequality and has a positive impact on the current gross investment value in both market entry modes. Given the risk-adjusted growth rate α'_u the risk-adjusted total rate of return results as (see appendix 2.7.8)

$$\mu'_u = r + \kappa(\mu - r) \tag{2.49}$$

and the risk-adjusted discount rate can be derived as

$$\delta'_u = r - (r - \delta_u)\kappa - \frac{1}{2}\kappa(\kappa - 1)\sigma^2. \tag{2.50}$$

Finally, the net present investment values of both market entry modes associated with uncertain productivity growth result as

$$V_{i_u}(\vartheta) - I_i = \int_0^{\infty} M_i \vartheta^{\kappa} e^{\alpha'_u t} e^{-\mu' t} dt - I_i \tag{2.51}$$

$$V_{i_u}(\vartheta) - I_i = \frac{M_{i_u}\vartheta^{\kappa}}{r - (r - \delta_u)\kappa - \frac{1}{2}\kappa(\kappa - 1)\sigma^2} - I_i \tag{2.52}$$

$$\text{with} \quad \vartheta = \vartheta_0 \quad \text{and} \quad i \in \{E, F\}.$$

For $\kappa = 1$ and $\sigma = 0$ the two net present value functions increase linearly in ϑ and they exactly behave as in the deterministic scenario, because the opportunity cost rates are equal ($\delta'_u = \delta'_c$).[9] However, driven by Jensen's inequality, both expected present investment values are higher than in the previous scenario ($V_{i_u}(\vartheta) > V_i(\vartheta)$) if the cash-flows are convex in ϑ and if the productivity growth is accompanied by uncertainty ($\sigma > 0$). Formally, the additional term $\frac{1}{2}\kappa(\kappa - 1)\sigma^2$ accounts for these additional expected gains in the investment values.

In figure 2.5 the two net present value functions shift to the north if productivity growth is associated with uncertainty. Consequently, the intersection points between the horizontal axis and the export and FDI investment value functions appear at lower productivity levels with $\vartheta^0_{E_u}$ and $\vartheta^0_{F_u}$ representing the critical thresholds for positive values respectively for both market entry modes.

However, as in the previous scenario both market entry modes are associated with a timing problem as the periodical cash-flows rise over time whereas the fixed costs I_i are unchanged and appear only in the first investment period. Therefore, in order to assess whether there exits a value of waiting, it is necessary to determine the option values of both investment strategies. Appendix 2.7.10 derives the general functional form of the option values for both market entry

[9] Equation (2.51) provides reasonable values if the interest rate r is strictly bigger than α (see Appendix 2.7.9).

strategies as

$$F_{i_u}(\vartheta) = A_{i1_u}\vartheta^{\beta_{1_u}} + A_{i2_u}\vartheta^{\beta_{2_u}} \quad (2.53)$$

with

$$\beta_{1_u} = \frac{1}{2} - \frac{r-\delta_u}{\sigma^2} + \sqrt{\left[\frac{r-\delta_u}{\sigma^2} - \frac{1}{2}\right]^2 + \frac{2r}{\sigma^2}} > 1 \quad (2.54)$$

$$\beta_{2_u} = \frac{1}{2} - \frac{r-\delta_u}{\sigma^2} - \sqrt{\left[\frac{r-\delta_u}{\sigma^2} - \frac{1}{2}\right]^2 + \frac{2r}{\sigma^2}} < 0. \quad (2.55)$$

The optimal cut-offs $\vartheta^*_{i_u}$ and the two unknown A_{ij_u} can be determined by defining appropriate *boundary conditions.* If the current productivity level ϑ approaches zero, the option value of an uncertain investment should also tend to zero, as the probability of a sufficient increase in the future is low. Therefore, the first boundary condition states

$$F_{i_u}(0) = 0. \quad (2.56)$$

If the productivity level reaches the optimal cut-off level, the investor is indifferent between delaying the uncertain investment (keeping the option alive) and executing the project by investing the sunk costs I_i. As a consequence, the second condition is the *matching condition* which captures the indifference at $\vartheta^*_{i_u}$ with

$$F_{i_u}(\vartheta^*_{i_u}) = V_i(\vartheta^*_{i_u}) - I_i. \quad (2.57)$$

Finally, in order to find an optimal threshold value for ϑ the two functions need to be tangent in the optimum. Tangency can be accounted for by imposing the *smooth pasting condition* with

$$\frac{\partial F(\vartheta^*_{i_u})}{\partial \vartheta} = \frac{\partial V(\vartheta^*_{i_u})}{\partial \vartheta}. \quad (2.58)$$

The first boundary condition necessitates that $A_{i2_u} = 0$ as β_{2_u} is negative. Therefore, the option functions for both market entry modes are reduced to

$$F_{i_u}(\vartheta) = A_{i_u}\vartheta^{\beta_u} \quad (2.59)$$

$$\text{with} \quad \beta_u = \beta_{1_u} \quad \text{and} \quad i \in \{E, F\}.$$

By using the remaining two conditions (see Appendix 2.7.11) the option value functions result as

$$F_{i_u}(\vartheta) = A_{i_u}\vartheta^{\beta_u} \tag{2.60}$$
$$= M_i^{\frac{\beta_u}{\kappa}} I_i^{1-\frac{\beta_u}{\kappa}} \Omega\ \vartheta^{\beta_u}$$
$$\text{with} \quad \Omega = \frac{1}{\delta'_u}\left(\frac{\beta_u \delta'_u}{\beta_u - \kappa}\right)^{1-\frac{\beta_u}{\kappa}} - \delta'_u \left(\frac{\beta_u \delta'_u}{\beta_u - \kappa}\right)^{-\frac{\beta_u}{\kappa}} \quad \text{and} \quad i \in \{E, F\}. \tag{2.61}$$

Finally, the cut-off productivity level for each market entry mode is derived as

$$\vartheta^*_{Eu} = \sqrt[\kappa]{\frac{\beta_u}{\beta_u - \kappa}\frac{I_E \delta'_u}{M_E}} \quad \text{and} \quad \vartheta^*_{Fu} = \sqrt[\kappa]{\frac{\beta_u}{\beta_u - \kappa}\frac{I_F \delta'_u}{M_F}}. \tag{2.62}$$

These two equilibrium productivity levels differ from the previous cut-offs under certainty only in the magnitude of the two parameters δ'_u and β_u, which are affected by the productivity uncertainty σ.[10] The magnitude of β_u is derived form the fundamental quadratic equation

$$\Psi = \frac{1}{2}\sigma^2 \beta_u(\beta_u - 1) + (r - \delta_u)\beta_u - r = 0. \tag{2.63}$$

and as proven in appendix 2.7.12 decreases in σ

$$\frac{\partial \beta_u}{\partial \sigma} < 0. \tag{2.64}$$

The risk-adjusted discount rate δ'_u turns out to be the negative expression of Ψ. For reasonable results δ'_u needs to be strictly positive. Therefore, κ must lie between the two roots and consequently, this last requirement necessitates that

$$\beta_u > \kappa > 0. \tag{2.65}$$

Based on these two relationships it is possible to analyze the underlying market entry problem as in the previous scenarios. The ordinal rank between the two productivity cut-offs is independent of the growth rate α'_u and the extent of uncertainty σ. It is only influenced by the comparative

[10] For $\sigma = 0$ the opportunity cost rate $\mu - \alpha = \delta_u = r - \alpha = \delta_c$.

fixed cost and marginal cost advantage with

$$\frac{\vartheta_E^*}{\vartheta_F^*} \lesseqgtr 1 \quad \text{if} \quad \frac{I_E}{I_F} \lesseqgtr \left(\frac{w_F}{w_E \tau^{\frac{1}{\theta}}}\right)^{\frac{\nu\theta}{1-\nu\theta}}. \tag{2.66}$$

Therefore, for all relative cost constellations in figure 2.7, which are above the dotted line, the

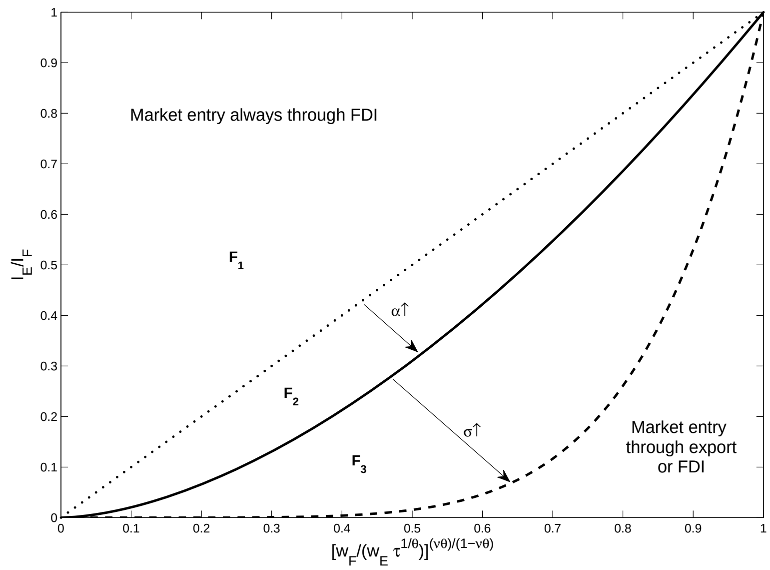


Figure 2.7: Relative Cost Constellations & Uncertain Productivity Growth

cut-off level for the FDI mode will always be lower than the export threshold. The opposite holds for cost patterns below the diagonal curve. The intuition behind this result is that uncertainty influences both entry cut-offs proportionally and does not distort the relationship which has been derived in the deterministic case. However, for the final entry decision it is the option values which determine the optimal market entry mode for given cost constellations.
It is possible to describe the relationship between the two option value functions by

$$\frac{F_E(\vartheta)}{F_F(\vartheta)} \lesseqgtr 1 \quad \text{if} \quad \left(\frac{w_F}{w_E \tau^{\frac{1}{\theta}}}\right)^{\frac{\nu\theta}{1-\nu\theta}} \gtreqless \frac{I_E}{I_F}\left(\frac{I_E}{I_F}\right)^{-\frac{\kappa}{\beta_u}}, \tag{2.67}$$

which is equal to the relationship in the previous scenario except the exponent β_u which is risk sensitive. According to the fundamental equation (2.63) for $\sigma = 0$

$$\beta_u = \frac{r}{r - \delta_c} = \frac{r}{\alpha} = \beta_c, \tag{2.68}$$

which proves the consistency of the model as the result is equivalent to the previous certain case. In figure 2.7 the areas F_1 and F_2 are equal to the areas C_1 and C_3 in figure 2.6 since they represent the deterministic case. By taking the two relationships (2.64) and (2.65) into account the risk driven adjustments of the option values and of equation (2.67) are straightforward. With an increase in productivity uncertainty, β_u decreases and becomes smaller than β_c. Graphically, the continuous line in figure 2.7 which represents relationship (2.67) becomes more convex as depicted by the dashed line. As a consequence, the range of relative cost constellations which enforce FDI over time increases by the area F_3. Differently expressed, a volatile growth in productivity broadens the range of cost constellations favoring FDI as the first time market entry strategy compared with a deterministic growth development. Uncertainty therefore acts as a compound force for the derived deterministic growth effects.

Result 3:
For $I_E < I_F$ and $w_E \tau^{\frac{1}{\theta}} > w_F$ the range of relative cost constellations which enforce FDI as the optimal market entry mode is strictly bigger if productivity growth $d\vartheta_t$ is associated with uncertainty. For $\sigma \rightarrow \infty$, FDI becomes the only relevant market entry mode.

2.4 The Timing Effects of Uncertainty

The increasing dominance of the FDI mode as the optimal first time market entry strategy due to an increase in σ implies according to the common real option theory an increase in the market entry time (Dixit and Pindyck, 1994).[11] However, in contrast to the previous deterministic case it is no longer possible to quantify the exact market entry time T_i^* for both market entry modes as the investor's decision is based on a stochastic process. But, it is possible to calculate the expected first time entry $\mathbb{E}(T_i^*)$, if the initial productivity level ϑ_0 and the cut-off productivity ϑ_i^* are known. The corresponding time T_i^* at which the stochastic process reaches its trigger value ϑ_i^* represents the *first passage time.*

By using the Girsanov theorem[12] it is possible to derive the probability density function of T_i^*

[11] Dixit and Pindyck (1994) assume in their illustrative examples that the risk adjusted return rate is invariant in σ which is the case for linear profit functions. In such cases, there is a positive relationship between the first time market entry T_i^* and σ.

[12] A detailed derivation is offered by Karatzas and Shreve (1991, p.196) or by Karlin and Taylor (1975, p.363).

as

$$f(T_i^*, \vartheta_0, \vartheta_i^*) = \frac{\ln\left(\frac{\vartheta_i^*}{\vartheta_0}\right)}{\sqrt{2\pi\sigma^2 T_i^{*3}}}\, e^{-\frac{\left(\ln\left(\frac{\vartheta_i^*}{\vartheta_0}\right) - (\alpha - \frac{1}{2}\sigma^2)T_i^*\right)^2}{2\sigma^2 T_i^*}} \tag{2.69}$$

$$\text{with} \quad \vartheta_i^* > \vartheta_0$$

which is also referred to as the *Inverse Gaussian distribution.*[13] The Laplace transform of T_i^* is then given by (see Ross, 1996; Proposition 8.4.1)

$$\mathbb{E}\left(e^{-\lambda T_i^*}\right) = \int_0^\infty e^{-\lambda T_i^*} f(T_i^*) dT_i^* = e^{-\left(\sqrt{(\alpha - \frac{1}{2}\sigma^2)^2 + 2\sigma^2\lambda} - (\alpha - \frac{1}{2}\sigma^2)\right)\frac{\ln\left(\frac{\vartheta_i^*}{\vartheta_0}\right)}{\sigma^2}}. \tag{2.70}$$

and can be used to determine the expected time before market entry as

$$\mathbb{E}(T_i^*) = \int_0^\infty T_i^* f(T_i^*) dT_i^* = -\lim_{\lambda \to 0} \frac{\partial \mathbb{E}(e^{-\lambda T_i^*})}{\partial \lambda} = \frac{\ln\left(\frac{\vartheta_i^*}{\vartheta_0}\right)}{\alpha - \frac{1}{2}\sigma^2}. \tag{2.71}$$

More precisely, the expected time before market entry results in both modes as (see Karatzas and Shreve, 1991)

$$\mathbb{E}(T_i^*(\vartheta = \vartheta_i^*)) = \begin{cases} \frac{1}{\alpha - \frac{1}{2}\sigma^2} \ln\left(\frac{\vartheta_i^*}{\vartheta_0}\right) & \text{if} \quad \alpha > \frac{1}{2}\sigma^2 \\ \\ \infty & \text{if} \quad \alpha \leq \frac{1}{2}\sigma^2 \end{cases} \tag{2.72}$$

$$\text{with} \quad \vartheta_i^* > \vartheta_0 \quad \text{and} \quad i \in \{E, F\}.$$

Equation (2.72) shows that for $\sigma \in (0, \sqrt{2\alpha})$ there exists a finite market entry time. However, if productivity growth α is lower than $\frac{1}{2}\sigma^2$ or equal to zero, market entry might not be realized since $\mathbb{E}(T_i^*)$ diverges.[14]

Within the proximity-concentration trade-off framework it is again possible to derive a relationship between relative fixed and variable costs which determines whether the expected market

[13] The name "*inverse gaussian distribution*" stems form the inverse relationship between the cumulant generating functions of these distributions and those of Gaussian distributions.

[14] A detailed discussion about the peculiarities of the inverse gaussian distribution can be found in Johnson, Kotz, and Balakrishnan (1995) or Dixit (1993).

entry time in the export mode is smaller (equal to, higher) than in the FDI mode.
It follows from equation (2.72) that

$$\mathbb{E}(T_E^*) \lesseqgtr \mathbb{E}(T_F^*) \quad \text{if} \quad \frac{\vartheta_E^*}{\vartheta_F^*} \lesseqgtr 1 \tag{2.73}$$

which equals relation (2.66) and which is fulfilled, if

$$\frac{I_E}{I_F} \lesseqgtr \left(\frac{w_F}{w_E \tau^{\frac{1}{\theta}}} \right)^{\frac{\nu\theta}{1-\nu\theta}} .$$

Combining this result with the previous outcomes summarized in figure 2.7 it can be seen that for all relative cost constellations above the diagonal line (area F_1 with $\vartheta_E^* > \vartheta_F^*$), the FDI mode's expected market entry time $\mathbb{E}(T_F^*)$ is always less than in the export mode. Simultaneously, FDI turns out to be the optimal entry strategy due to its higher option value. Inversely, for all relative cost patterns below the diagonal line, the optimal FDI productivity cut-off strictly exceeds the export cut-off. Therefore, if the new foreign market is served through exports, its expected market entry will appear earlier with respect to the FDI mode. However, for all cost constellations represented through the areas F_1 and F_2, which are driven by α and σ, the FDI option value is strictly superior to the export option value and consequently the investor is likely to serve the market through FDI in $\mathbb{E}(T_F^*)$, which is strictly higher than $\mathbb{E}(T_E^*)$, as illustrated by (2.73). Due to the abolition of such a profitable export strategy for the sake of a more profitable future FDI investment, a potential earlier expected market entry is prolonged by $\Delta\mathbb{E}(T^*) = \mathbb{E}(T_F^*) - \mathbb{E}(T_E^*)$. Since the prolongation of the expected market entry is caused by the negligence of a less profitable export mode over time, I refer to this first timing effect as *prolongation of market entry time by negligence.*[15]

Result 4:

For $I_E < I_F$ and $w_E \tau^{\frac{1}{\theta}} > w_F$ with $\alpha > 0$ and $\sigma > 0$, there exists a range of relative cost constellations which leads to a prolongation of the expected market entry time by $\Delta\mathbb{E}(T^*) = \mathbb{E}(T_F^*) - \mathbb{E}(T_E^*)$, due to the negligence of a profitable export mode in $T_E^* < T_F^*$.

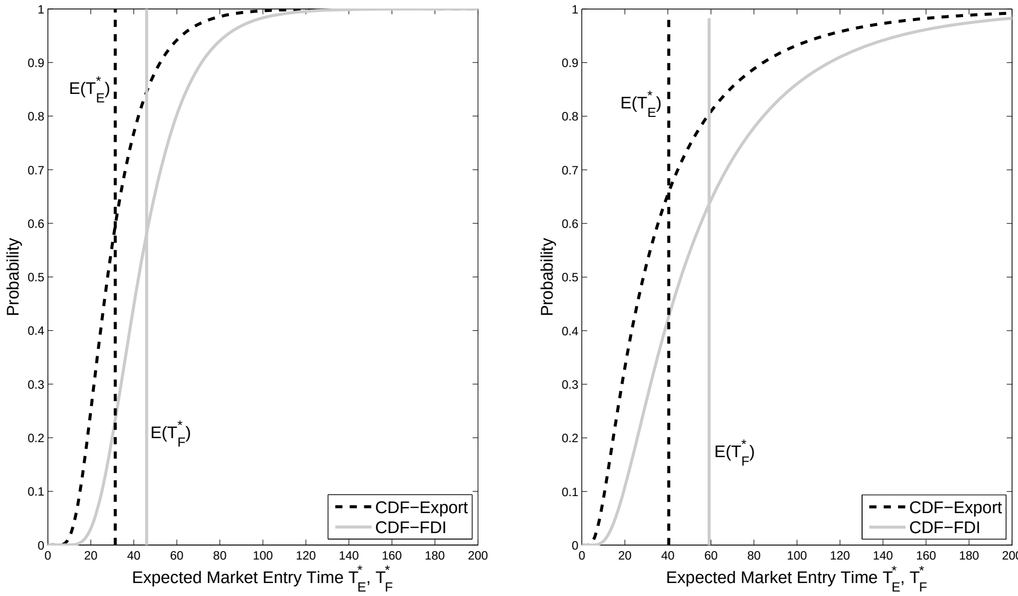
By integrating the probability density function (2.69) it is possible to derive the corresponding

[15] This result is based on the assumption that the initial productivity level ϑ_0 is smaller than ϑ_i^* with $i = \{E, F\}$. For all cost constellations below the diagonal line in figure 2.7, the optimal market entry mode will also depend on the current productivity level ϑ_0. If e.g. the current productivity level is above both cut-off productivity levels and therefore enforcing FDI, there is no timing issue and no prolongation of entry time by negligence.

cumulative distribution functions as

$$G(T_i^*, \vartheta_0, \vartheta_i^*) = N\left(-\frac{\ln\left(\frac{\vartheta_i^*}{\vartheta_0}\right) + (\alpha - \frac{1}{2}\sigma^2)T_i^*}{\sigma\sqrt{T_i^*}}\right) + e^{\left(\frac{2(\alpha-\frac{1}{2}\sigma^2)\ln\left(\frac{\vartheta_i^*}{\vartheta_0}\right)}{\sigma^2}\right)} N\left(-\frac{\ln\left(\frac{\vartheta_i^*}{\vartheta_0}\right) - (\alpha - \frac{1}{2}\sigma^2)t}{\sigma\sqrt{t}}\right) \tag{2.74}$$

with $\vartheta_0 < \vartheta_i^*$ and $i \in \{E, F\}$.



(a) $\vartheta_E^* < \vartheta_F^*, \alpha = 0.04, \vartheta_0 = 1, \sigma = 0.1$, but $F_F(\vartheta) > F_E(\vartheta)$ with $\kappa = 1$

(b) $\vartheta_E^* < \vartheta_F^*, \alpha = 0.04, \vartheta_0 = 1, \sigma = 0.16$, but $F_F(\vartheta) > F_E(\vartheta)$ with $\kappa = 1$

Figure 2.8: Cumulative Distribution Functions of T_i^*.

Panel a) in figure 2.8 represents the cumulative distribution functions of both investment strategies for a relative cost constellation which leads to a productivity cut-off ranking with $\vartheta_E^* < \vartheta_F^*$. The vertical dashed line represents the export mode's expected market entry time and the s-shaped curve its cumulative distribution function. The continuous curves represent the FDI mode. In the underlying example the export mode exhibits a first-order stochastic dominance over the FDI strategy. Differently expressed, for any market entry time T_i^*, the probability of market entry through exports will always be higher than in the FDI case. However, for the chosen relative cost pattern, the FDI mode exhibits a higher option value (see figure 2.7, areas F_2, F_3) and therefore the investor will neglect the export market entry for the sake of the

FDI mode. The distance between $\mathbb{E}(T_F^*)$ and $\mathbb{E}(T_E^*)$ in figure 2.8 represents the prolongation of market entry by negligence. Inversely, it can be concluded that for relative cost patterns which lead to a productivity cut-off ranking with $\vartheta_F^* < \vartheta_E^*$, the FDI mode has a first-order stochastic dominance over the export mode and there will be no market entry prolongation.

By considering the partial derivative of equation (2.71) with respect to σ it is possible to assess the impact of a volatility change in productivity on the expected market entry time. The differential results as

$$\frac{\partial \mathbb{E}(T_i^*)}{\partial \sigma} = \sigma \frac{1}{\left(\alpha - \frac{1}{2}\right)^2} \ln\left(\frac{\vartheta_i^*}{\vartheta_0}\right) + \frac{1}{\left(\alpha - \frac{1}{2}\sigma^2\right)} \frac{1}{\vartheta_i^*} \frac{\partial \vartheta_i^*}{\partial \sigma} \tag{2.75}$$
$$\text{with} \quad \frac{\vartheta_i^*}{\vartheta_0} > 1 \quad \text{and} \quad \alpha > \frac{1}{2}\sigma^2.$$

Thus, whether a change in uncertainty results in a positive or negative effect on the expected market entry time, decisively depends on the partial differential on the right hand side of equation (2.75). A change in uncertainty affects the optimal productivity levels ϑ_i^* through two channels. The first effect of an increase in σ is a rise in the option value of each market entry mode which is captured by

$$\frac{\partial\left(\frac{\beta_u}{\beta_u - \kappa}\right)}{\partial \sigma} > 0 \quad \text{for} \quad \kappa \geq 1. \tag{2.76}$$

The intuition for this monotonic positive effect is that an increase in uncertainty, incentivises the postponement of the investment decision into the future (higher ϑ_i^*) in order to gain additional information on the productivity development.

The second effect is a change in the expected investment value $V_i(\vartheta)$ which itself depends on the adjusted discount rate δ_u'.

For linear periodical cash-flows ($\kappa = 1$) the discount rate becomes independent of σ with

$$\frac{\partial \delta_u'}{\partial \sigma} = 0. \tag{2.77}$$

Summing up theses two effects, in this particular case both market entry modes' expected market entry time strictly increases in σ. Furthermore, since the productivity cut-offs of both entry modes additionally depend on the respective variable and fixed costs, the extent of their expected market entry time adjustments differs due to different cost structures. An increase in σ leads e.g. to a stronger rise in the FDI mode's expected market entry time

$$\frac{\partial \mathbb{E}(T_F^*)}{\partial \sigma} > \frac{\partial \mathbb{E}(T_E^*)}{\partial \sigma} > 0 \tag{2.78}$$

if

$$\frac{I_E}{M_E} < \frac{I_F}{M_F}, \tag{2.79}$$

which is the case for all relative cost patterns below the diagonal line in figure 2.7. Figure 2.8 represents such a relative cost constellation where panel b) differs from panel a) only in σ. As a result of the uncertainty increase, the expected market entry time is prolonged in both modes. However, the change in the FDI mode turns out to be higher than in the export mode with

$$\Delta \mathbb{E}(T_F^*) > \Delta \mathbb{E}(T_E^*). \tag{2.80}$$

Finally, three crucial effects can be identified within the proximity-concentration trade-off framework, associated with an increase in σ:

- An increase in the expected market entry times in both modes.
- An increase in the range of relative cost constellations in figure 2.7 favoring FDI as the optimal market entry mode.
- A higher increase in the expected market entry time in the FDI mode.

As a consequence, market entry through FDI becomes more likely, but the likeliness of market entry per period decreases due to postponement.

Result 5:
For $I_E < I_F$ and $w_E \tau^{\frac{1}{\theta}} > w_F$ with $\kappa = 1$, a rise in productivity volatility σ increases the likelihood of first time market entry through FDI but prolongs the expected market entry time $\mathbb{E}(T_F^*)$. The probability of first time market entry in T decreases.

These comparative static findings are compliant with the general real option literature according to which uncertainty monotonically increases the market entry time (Dixit and Pindyck, 1994). However, the described relationship turns out to be idiosyncratic to linear profit functions, as proven in appendix 2.7.13. For convex profit functions ($\kappa > 1$) an increase in productivity uncertainty does not only affect the optimal cut-off level negatively (increase in ϑ_i^*) but additionally exhibits a countervailing effect. In such a case, the expected profits of both market entry modes rise, due to Jensen's inequality which reduces the optimal cut-off levels ϑ_i^*. This positive adjustment is captured by the partial differential of the adjusted discount rate

$$\frac{\partial \delta_u'}{\partial \sigma} = \sigma\kappa - \sigma\kappa^2 < 0. \tag{2.81}$$

which is monotonically decreasing in σ. The intuition for this effect is that an investor can expect higher profits associated with productivity changes and as a consequence the adjusted discount rate increases the costs of waiting if σ increases. Therefore, for $\kappa > 1$ the total impact of uncertainty on the expected market entry time depends on the modulus of the two effects. For

$$\left| \frac{\partial \left(\frac{\beta_u}{\beta_u - \kappa} \right)}{\partial \sigma} \right| > \left| \frac{\partial \delta_u'}{\partial \sigma} \right|, \tag{2.82}$$

the expected market entry time also increases in σ for $\kappa > 1$, however

$$\left. \frac{\partial \mathbb{E}(T_i^*)}{\partial \sigma} \right|_{\kappa=1} > \left. \frac{\partial \mathbb{E}(T_i^*)}{\partial \sigma} \right|_{\kappa>1} \tag{2.83}$$

due to the negative effect in δ_u'.

For specific parameter values, Jensen's inequality dominates the total effect of an increase in uncertainty and for such cases the expected market entry time can decrease. Plotting the expected market entry time with respect to σ results therefore, in a u-shaped function (figure 2.9).

Differently expressed, for low levels of uncertainty the expected market entry time in both modes decrease whereas for high levels of uncertainty, a shift in σ increases $\mathbb{E}(T_i^*)$. Figure 2.9 shows that for high productivity growth rates α the likeliness of a decrease in the expected market entry time is higher than in cases with low growth rates. Technically, the range of values in which $\mathbb{E}(T_i^*)$ decreases in σ becomes bigger the higher the growth rate is ($\sigma_0 < \sigma_1$, in figure 2.9). The intuition for this result is that companies associated with high growth rates may appreciate a certain extent of productivity uncertainty and enter the market earlier. Whereas,

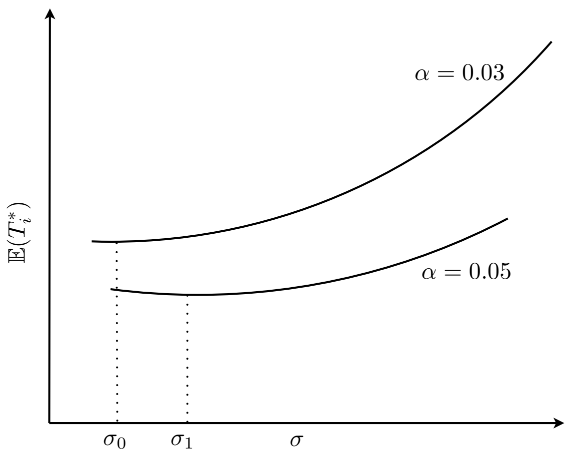


Figure 2.9: Expected Market Entry Time Pattern

firms confronted with low growth rates tend to dislike uncertainty and postpone their investment decision further into the future the higher the volatility.

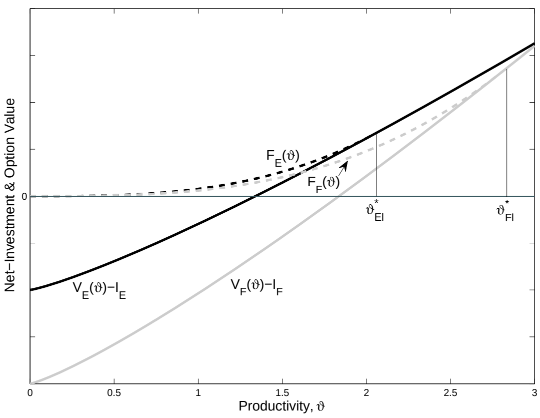
Finally, within the proximity-concentration trade-off framework, a reduction of the expected market entry time due to an increase in σ is still accompanied by a rise in the range of relative cost constellations in figure 2.7 which enforce FDI as the optimal entry strategy. Additionally, one can conclude that for a firm associated with a high productivity growth rate, a rise in uncertainty may lead to an earlier market entry.

Result 6:

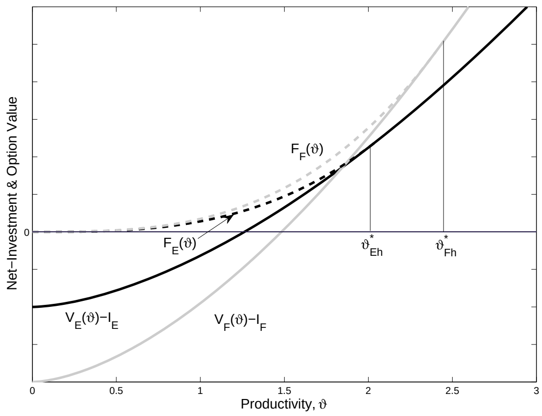
For $I_E < I_F$ and $w_E \tau^{\frac{1}{\theta}} > w_F$ with $\kappa > 1$, a rise in productivity volatility σ increases the likelihood of first time market entry through FDI. There exists a range of uncertainty $0 < \sigma < \sigma_0$ in which the market entry is pre-poned. For these parameter constellations the likeliness of market entry per period increases.

2.5 The Degree of Competition and Comparative Statics

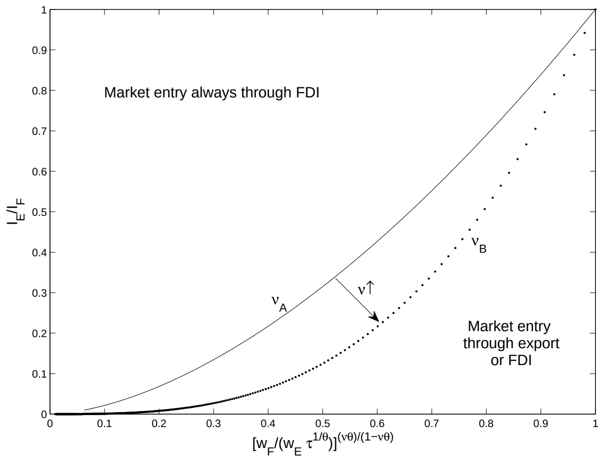
A crucial aspect for an investor's first time market entry decision is the degree of competition in the potential destination country. Within the established framework we can measure the extent of competition by considering the inverse of the country specific mark-up ν. Demand turns out to be flat if ν approaches one. In such a case, the investor holds a low degree of market power as the substitutability between the differentiated goods X_i is high.



(a) Country A (Low Competition)
$\nu_A = 0.75$



(b) Country B (High Competition)
$\nu_B = 0.9$



(c) Degree of Competition & Relative Cost Patterns

Figure 2.10: Competition Effects

Figure 2.10 depicts the export and FDI value functions in two different countries. The investor is confronted with exactly the same cost patterns in both foreign markets.[16] The only difference appears in the degree of competition, with country A exhibiting a lower competition between the differentiated goods X_i than country B ($\nu_A < \nu_B$). In the low competition case, the given relative cost pattern leads to an export productivity cut-off ϑ^*_{El} which is lower than the FDI cut-off. Simultaneously, given the degree of competition, the upper envelope function in panel a) turns out to be dominated by the option and investment value function of the export mode. Assuming that the initial productivity level ϑ_0 is below ϑ^*_{El}, the investor will definitely serve

[16] In both markets the investor is confronted with the following cost structure: $\frac{I_E}{I_F} = 2, \tau = 1.3, \theta = 0.5, \frac{w_F}{w_E} = 1, r = 0.06, \alpha = 0.02, \sigma = 0.01$.

the low competition country via exports. Based on these equilibrium results it can be concluded that the prevailing relative cost pattern must lie below the continuous line in panel c) as it depicts the only range of relative cost constellations for which the export mode represents a relevant entry mode.

Panel b) in figure 2.10 illustrates that a higher degree of competition on the alternative foreign market turns out to be accompanied by two adjustments. The first effect of an increased competition, is a decrease in both productivity cut-offs ϑ_i^*. Due to the particular cost assumptions within the proximity-concentration trade-off framework the FDI mode's cut-off reduction turns out to be bigger than in the export mode with

$$\frac{\partial \vartheta_F^*}{\partial \nu} < \frac{\partial \vartheta_E^*}{\partial \nu} < 0. \tag{2.84}$$

Compliant with the general economic intuition, an investor enters the more competitive market depicted in panel b) at lower productivity levels and therefore, implicitly at an earlier expected time. However, there exists a second effect which arises in the presence of higher competition. All value functions in panel b) increase in their convexity but the rise in the FDI mode's option value turns out to be stronger than in the export mode with

$$\frac{\partial F_F(\vartheta)}{\partial \nu} > \frac{\partial F_E(\vartheta)}{\partial \nu} > 0. \tag{2.85}$$

As a consequence of the disproportionate increase of the FDI mode's option and investment values the upper envelope in panel b) is only composed of FDI related functions. Panel c) represents in a further way the stronger increase of the FDI mode's option value. The dotted curve represents all relative cost constellations in country B for which the option values of both market entry modes are equal. The continuous line represents the same relationship but corresponds to country A. Technically, a rise in the degree of competition increases the range of relative cost patterns in panel c) which enforce first time market entry through FDI. In the underlying example the investor will serve country B through a foreign plant due to the higher competition. The intuition for this second effect is as follows. Besides an earlier market entry, a higher degree of competition necessitates a higher productivity in order to survive in the market. Since the marginal costs in the FDI mode are lower than in the export mode and since their impact on the profits dominate in the long run, FDI turns out to become more likely the higher the degree of competition.

Result 7:
For $I_E < I_F$, $w_E \tau^{\frac{1}{\theta}} > w_F$ and $\beta > \kappa > 0$, a rise in the degree of competition (rise in ν) decreases the expected market entry time $\mathbb{E}(T_i^*)$ and, also the optimal cut-offs ϑ_i^*. Simultaneously, the likeliness of market entry through FDI increases.

Finally, table 2.1 summarizes the effects of remaining parameters.

	Probability FDI Mode	Probability Export Mode	ϑ_E^*	ϑ_F^*	$\mathbb{E}(T_E^*)$	$\mathbb{E}(T_F^*)$
Transport Costs: $\tau \uparrow$	$\uparrow$	$\downarrow$	$\uparrow$	-	$\uparrow$	-
Variable Costs (Home): $w_E \uparrow$	$\uparrow$	$\downarrow$	$\uparrow$	-	$\uparrow$	-
Variable Costs (Foreign): $w_F \uparrow$	$\downarrow$	$\uparrow$	-	$\uparrow$	-	$\uparrow$
Fixed costs (Export): $I_E \uparrow$	$\uparrow$	$\downarrow$	$\uparrow$	-	$\uparrow$	-
Fixed costs (FDI): $I_F \uparrow$	$\downarrow$	$\uparrow$	-	$\uparrow$	-	$\uparrow$

Table 2.1: Summary of Comparative Statics

All adjustments which appear due to marginal changes in these parameters can be derived from figure 2.7. An increase e.g. in transport costs τ leads to a reallocation in the relative cost space to the left which is dominated by cost constellations enforcing FDI as the optimal first time market entry mode.

Since the derived graph includes both, the parameters of dynamic aspects and static costs, it is a convenient tool to visualize the effects of uncertain productivity growth within the proximity-concentration trade-off framework and their impact on the optimal market entry mode.

2.6 Conclusion

Whether firms serve a new foreign market through exports or horizontal FDI has become a frontier research field in international economics. Major contributions have been conducted under the umbrella of the New New Trade Theory where the seminal work by Helpman et al. (2004) paved the way for different analyses. In the tradition of international economics these models are framed as static general equilibrium models and perform empirically very well (Helpman, 2006). A major result within this strand of literature is that firms serving a foreign market through export tend to be less productive than those entering the market through horizontal FDI. Furthermore, a higher productivity dispersion within a sector seems to increase the share of FDI entrants.

One neglected aspect within these models are dynamic elements, in particular the fact that productivity growth is a continuous stochastic variable. The question e.g. whether volatile productivity growth might have a selection effect on market entry modes over time can not be answered. On the other hand from a firm perspective, productivity is a dynamic decision variable accounted for by decision takers. CEOs of multinational enterprises have certain expectations on their companies' productivity development and try to optimize their market entry modes intertemporally. Empirically, a boost in FDI could be observed especially in the mid 1980 and 1990 (UNCTAD, 2008) associated with disproportional growth in firm productivity due to information technology (IT) improvements. Given these observations and the lack of dynamic models accounting for timing effects, the underlying model elaborates market entry choice of a multinational firm. By combining the proximity-concentration trade-off framework with the real option methodology several results are derived which contribute to the existing literature. Within the assumed specific costs patterns productivity growth turns out to favor FDI as the optimal market entry strategy. The higher the productivity growth rate is the more likely is a firm to enter the new foreign market as a foreign direct investor. Since productivity growth is a volatile process (Baily et al. 2001) the model accounts for uncertainty. A riskier productivity growth turns out to increase the likeliness of market entry through FDI even further. This result coincides with the New New Trade Theory findings where sectors with a higher productivity distortion exhibit higher FDI shares. Finally the model offers the possibility to quantify the first time market entry time given an uncertain growth rate. The crucial result of the model is that both productivity growth and uncertainty increase the likeliness of market entry as foreign direct investor.

2.7 Appendix

2.7.1 Parameter Constraints

The gross investment value for each market entry mode is given by

$$V_i(\vartheta) = \frac{M_i \vartheta^{\kappa}}{(r - \alpha')} \quad \text{if} \quad T = t = 0. \tag{2.86}$$

Define

$$\delta_c' = r - \alpha' \tag{2.87}$$

as the adjusted discount rate. The cash-flows can be restated as

$$V_i(\vartheta) = \frac{M_i \vartheta^{\kappa}}{\delta_c'}. \tag{2.88}$$

A meaningful interpretation of equation (2.88) is only prevailing for

$$\delta_c' > 0 \tag{2.89}$$

which is equal to

$$r - \alpha\kappa > 0 \tag{2.90}$$

$$\frac{r}{\alpha} > \kappa \quad \text{with} \quad \beta_c = \frac{r}{\alpha}. \tag{2.91}$$

Therefore,

$$\beta_c > \kappa \geq 1 \tag{2.92}$$

since we assume linear or convex profit flows with $\kappa \geq 1$.

2.7.2 Productivity Cut-Offs under Certainty

Given the productivity cut-offs

$$\vartheta_{Ec}^* = \sqrt[\kappa]{\frac{I_E r}{M_E}} \quad \text{and} \quad \vartheta_{Fc}^* = \sqrt[\kappa]{\frac{I_F r}{M_F}} \tag{2.93}$$

it is possible to derive the condition under which

$$\frac{\vartheta_E^*}{\vartheta_F^*} \lesseqqgtr 1. \tag{2.94}$$

Substituting the productivity cut-offs in (2.94) provides

$$\frac{M_F}{M_E}\frac{I_E}{I_F} \lesseqqgtr 1 \qquad \text{if} \qquad \frac{M_F}{M_E} \lesseqgtr \frac{I_F}{I_E} \tag{2.95}$$

with

$$M_F = Z^{\frac{1}{1-\nu\theta}} \left(\frac{\nu\theta}{w_F}\right)^{\frac{\nu\theta}{1-\nu\theta}} (1-\nu\theta) \tag{2.96}$$

$$M_F = Z^{\frac{1}{1-\nu\theta}} \left(\frac{\nu\theta}{w_E \tau^{\frac{1}{\theta}}}\right)^{\frac{\nu\theta}{1-\nu\theta}} (1-\nu\theta). \tag{2.97}$$

Therefore, we can write

$$\frac{M_F}{M_E} = \left(\frac{\frac{\nu\theta}{w_F}}{\frac{\nu\theta}{w_E \tau^{\frac{1}{\theta}}}}\right)^{\frac{\nu\theta}{1-\nu\theta}}. \tag{2.98}$$

As a result, condition (2.94) can be stated as

$$\frac{\vartheta_{Ec}^*}{\vartheta_{Fc}^*} \lesseqqgtr 1 \quad \text{if} \quad \frac{I_E}{I_F} \lesseqqgtr \left(\frac{w_F}{w_E \tau^{\frac{1}{\theta}}}\right)^{\frac{\nu\theta}{1-\nu\theta}}. \tag{2.99}$$

2.7.3 Productivity Cut-Offs with Growth

Given the two productivity cut-offs

$$\vartheta_E^* = \sqrt[\kappa]{\frac{\beta_c}{\beta_c-\kappa}\frac{I_E}{M_E}(r-\alpha')} \qquad \text{and} \qquad \vartheta_F^* = \sqrt[\kappa]{\frac{\beta_c}{\beta_c-\kappa}\frac{I_F}{M_F}(r-\alpha')} \tag{2.100}$$

it is possible to derive the condition under which

$$\frac{\vartheta_E^*}{\vartheta_F^*} \lesseqqgtr 1. \tag{2.101}$$

Substituting the productivity cut-offs into (2.101) provides

$$\frac{M_F}{M_E}\frac{I_E}{I_F} \lesseqgtr 1 \qquad \text{if} \qquad \frac{M_F}{M_E} \lesseqgtr \frac{I_F}{I_E} \tag{2.102}$$

which is equal to the result in appendix 2.7.2 and therefore

$$\frac{\vartheta_E^*}{\vartheta_F^*} \lesseqgtr 1 \quad \text{if} \quad \frac{I_E}{I_F} \lesseqgtr \left(\frac{w_F}{w_E \tau^{\frac{1}{\theta}}}\right)^{\frac{\nu\theta}{1-\nu\theta}}. \tag{2.103}$$

2.7.4 The Relationship between the Export and FDI Option Function

Within the proximity-concentration trade-off assumption the corresponding option functions are derived as

$$F_E(\vartheta) = A_E \vartheta^{\beta_c} = \kappa(\beta_c - \kappa)^{\frac{\beta_c}{\kappa}-1} I_E^{\left(1-\frac{\beta_c}{\kappa}\right)} (r-\alpha')^{-\frac{\beta_c}{\kappa}} M_E^{\frac{\beta_c}{\kappa}} \beta_c^{-\frac{\beta_c}{\kappa}} \vartheta^{\beta_c} \tag{2.104}$$

$$F_F(\vartheta) = A_F \vartheta^{\beta_c} = \kappa(\beta_c - \kappa)^{\frac{\beta_c}{\kappa}-1} I_F^{\left(1-\frac{\beta_c}{\kappa}\right)} (r-\alpha')^{-\frac{\beta_c}{\kappa}} M_F^{\frac{\beta_c}{\kappa}} \beta_c^{-\frac{\beta_c}{\kappa}} \vartheta^{\beta_c}. \tag{2.105}$$

The option function of the export mode is bigger or smaller than in the FDI mode

$$\frac{F_E}{F_F} \lesseqgtr 1 \tag{2.106}$$

if

$$\frac{I_E}{I_F}\left(\frac{I_E}{I_F}\right)^{-\frac{\beta_c}{\kappa}} \lesseqgtr \left(\frac{M_E}{M_F}\right)^{-\frac{\beta_c}{\kappa}} \tag{2.107}$$

$$\frac{I_E}{I_F}\left(\frac{I_E}{I_F}\right)^{-\frac{\kappa}{\beta_c}} \lesseqgtr \frac{M_E}{M_F} = \left(\frac{w_F}{w_E \tau^{\frac{1}{\theta}}}\right)^{\frac{\nu\theta}{1-\nu\theta}}. \tag{2.108}$$

Therefore, we can state

$$\frac{F_E}{F_F} \lesseqgtr 1 \tag{2.109}$$

if

$$\left(\frac{w_F}{w_E \tau^{\frac{1}{\theta}}}\right)^{\frac{\nu\theta}{1-\nu\theta}} \gtreqless \frac{I_E}{I_F}\left(\frac{I_E}{I_F}\right)^{-\frac{\kappa}{\beta_c}} \tag{2.110}$$

$$\text{with} \quad \beta_c = \frac{r}{\alpha}.$$

Obviously, if $\alpha \uparrow$, $\beta_c \downarrow$ and $\frac{\kappa}{\beta_c}$ increases. For $\alpha \downarrow$, $\beta_c \uparrow$ and $\frac{\kappa}{\beta_c}$ approaches zero.

2.7.5 The Optimal Strategy in Area C_1

For all productivity levels with $\vartheta > \vartheta_E^*$, area C_3 unambiguously leads to FDI if the upper envelope in figure 2.5 is represented through $F_F(\vartheta)$. Within the proximity-concentration trade-off framework

$$\left.\frac{F_F(\vartheta)}{V_E(\vartheta)}\right|_{\vartheta > \vartheta_E^*} > 1 \tag{2.111}$$

if

$$\left(\frac{w_F}{w_E \tau^{\frac{1}{\theta}}}\right)^{\frac{\nu\theta}{1-\nu\theta}} > \frac{I_E}{I_F}\left(\frac{I_E}{I_F}\right)^{(-\frac{\kappa}{\beta})}. \tag{2.112}$$

Proof:

For cost structures in area C_3

$$\vartheta_E^* < \vartheta_F^* \tag{2.113}$$

and any investment strategy is postponed for $\vartheta < \vartheta_E^*$.
Furthermore, in ϑ_E* we have

$$F_E(\vartheta_E^*) = V_E(\vartheta_E^*) \tag{2.114}$$

and

$$\frac{\partial F_E(\vartheta_E^*)}{\partial \vartheta} = \frac{\partial V_E(\vartheta_E^*)}{\partial \vartheta}. \tag{2.115}$$

The two option value functions $F_E(\vartheta)$ and $F_F(\vartheta)$ are strictly convex in ϑ whereas the net present value functions are convex (strictly convex for $\kappa > 1$).
For any productivity level with $\vartheta > \vartheta_E*$ the option value of FDI will be higher than the value

function of exporting

$$\frac{F_F(\vartheta_E^*)}{V_E(\vartheta_E^*)} > 1 \tag{2.116}$$

if

$$\frac{\frac{\partial F_F(\vartheta_E^*)}{\partial \vartheta}}{\frac{\partial V_E(\vartheta_E^*)}{\partial \vartheta}} > 1 \quad \text{and} \quad \frac{\frac{\partial^2 F_F(\vartheta_E^*)}{\partial \vartheta^2}}{\frac{\partial^2 V_E(\vartheta_E^*)}{\partial \vartheta^2}} > 1. \tag{2.117}$$

Due to the convexity of all four value functions, the two inequalities in (2.117) hold for

$$\left(\frac{w_F}{w_E \tau^{\frac{1}{\theta}}}\right)^{\frac{\nu\theta}{1-\nu\theta}} > \frac{I_E}{I_F}\left(\frac{I_E}{I_F}\right)^{(-\frac{\kappa}{\beta})}. \tag{2.118}$$

Relative cost patterns in area C_3 always fulfill inequality (2.118).

2.7.6 Solution of a Geometric Brownian Motion

Consider a stochastic process described by

$$d\vartheta_t = \alpha\vartheta_t dt + \sigma\vartheta_t dz_t \quad \text{or} \quad \frac{d\vartheta_t}{\vartheta_t} = \alpha dt + \sigma dz_t. \tag{2.119}$$

By defining

$$\ln \vartheta_t = y_t \tag{2.120}$$

we receive an exponential process which is represented by

$$\vartheta_t = e_t^y. \tag{2.121}$$

A process described by equation (2.119) is called *Geometric Brownian Motion* and its solution can be derived by using Ito's lemma.

$$dy_t = \frac{\partial y_t}{\partial \vartheta_t} d\vartheta_t + \frac{1}{2}\frac{\partial^2 y_t}{\partial \vartheta_t^2}(d\vartheta_t)^2. \tag{2.122}$$

With

$$\frac{\partial y_t}{\partial \vartheta_t} = \frac{1}{\vartheta_t} \qquad \frac{\partial^2 y_t}{\partial \vartheta_t^2} = -\frac{1}{\vartheta_t^2} \qquad \text{and} \qquad (d\vartheta_t)^2 = \sigma^2 \vartheta_t^2 \; dt$$

we receive

$$dy_t = \frac{1}{\vartheta_t}(\alpha \vartheta_t \; dt + \sigma \vartheta_t dz_t) - \frac{1}{\vartheta_t^2}\frac{1}{2}\sigma^2 \vartheta^2 dt \tag{2.123}$$

$$= (\alpha - \frac{1}{2}\sigma^2)dt + \sigma dz_t. \tag{2.124}$$

The solution of the Geometric Brownian motion in equation (2.119) is therefore given by

$$\vartheta_t = e^{y_0 + \int_0^T (\alpha - \frac{1}{2}\sigma^2)dt + \int_0^T \sigma dz_t} \tag{2.125}$$

and with $e^{y_0} = \vartheta_0$ it can be rewritten as

$$\vartheta_t = \vartheta_0 \; e^{\int_0^T (\alpha - \frac{1}{2}\sigma^2)dt + \int_0^T \sigma dz_t}. \tag{2.126}$$

As $\ln(\vartheta_t)$ is a concave function, the change over time in $d\ln(\vartheta_t)$ is smaller than the change in $\frac{d\vartheta_t}{\vartheta_t}$. The ordinary Brownian motion dy_t follows a process with the drift $(\alpha - \frac{1}{2}\sigma^2)$ which is smaller than the drift of the Geometric Brownian motion. The difference of $\frac{1}{2}\sigma^2$ results from Jensen's inequality according to which $\mathbb{E}(\ln(\vartheta)) < \ln(\mathbb{E}(\vartheta))$. Consequently ϑ_t is lognormally distributed with

$$\vartheta_t \sim \text{lognormal}\left(\vartheta_0 + \alpha - \frac{1}{2}\sigma^2, \sigma\sqrt{t}\right).$$

2.7.7 The Adjusted Expected Growth Rate

Given the stochastic process in equation (2.11) and the cash-flows in (2.16) and (2.17), define

$$f(\vartheta_t) = \vartheta_t^\kappa \qquad \text{and} \qquad \kappa \ln \vartheta_t = \kappa y_t \tag{2.127}$$

where y_t represents an arithmetic Brownian Motion. Therefore the exponential function $f(\vartheta_t)$ can be expressed as

$$\vartheta_t^{\kappa} = e^{\kappa y_t}. \tag{2.128}$$

The solution of y_t has been derived in appendix 2.7.6 as

$$y_t = y_0 + \int_0^t (\alpha - \frac{1}{2}\sigma^2) ds + \int_0^t \sigma dz_s. \tag{2.129}$$

Therefore, the expected value of the exponential function $f(\vartheta_t)$ can be expressed as

$$\mathbb{E}(x_t^{\kappa}) = e^{\kappa y_0} e^{(\alpha - \frac{1}{2}\sigma^2)t\kappa} e^{\int_0^t \sigma dz_t}. \tag{2.130}$$

The last term in equation (2.130) still includes a random variable. By defining a moment generating function it is possible to evaluate its expected value.

Moment Generating Function

Consider a normally distributed random variable Z_t with

$$Z_t \sim N(m, \chi^2). \tag{2.131}$$

We can write

$$\mathbb{E}(e^{\kappa Z_t}) = \int_{-\infty}^{\infty} \frac{1}{\chi\sqrt{2\pi}} e^{\left(-\frac{(Z_t - m)^2}{2\chi^2}\right)} e^{\kappa Z_t} dz_t \tag{2.132}$$

$$= e^{\left(m\kappa + \frac{\chi^2\kappa^2}{2}\right)}. \tag{2.133}$$

In the underlying case $m = 0$ and $\chi = 1$. Furthermore the random variable in the Brownian motion is related to $\sqrt{t}$ with

$$dz_t = \epsilon_t \sqrt{t} \tag{2.134}$$

which leads to

$$\mathbb{E}(e^{\kappa\sigma Z_t}) = e^{\frac{\kappa^2\sigma^2 t}{2}}. \tag{2.135}$$

Therefore, applying this result to equation (2.130), the expected value of the exponential function $f(\vartheta_t)$ is given by

$$\mathbb{E}(\vartheta^\kappa) = e^{\kappa y_0} e^{(\alpha-\frac{1}{2}\sigma^2)t\kappa} e^{\frac{\kappa^2\sigma^2}{2}t}. \tag{2.136}$$

Using equation (2.128) the expected value results as

$$\mathbb{E}(\vartheta_t^\kappa) = \vartheta_0^\kappa e^{[\alpha\kappa+\frac{1}{2}\kappa\sigma^2(\kappa-1)]t}. \tag{2.137}$$

Finally, the expected cash-flows result as

$$\mathbb{E}(\Pi_i(\vartheta_t)) = M_i \vartheta_0^\kappa e^{[\alpha\kappa+\frac{1}{2}\kappa\sigma^2(\kappa-1)]t}. \tag{2.138}$$

The adjusted growth rate for convex profits with $\kappa > 1$ is then given by

$$\alpha' = \alpha\kappa + \frac{1}{2}\kappa\sigma^2(\kappa - 1). \tag{2.139}$$

2.7.8 Adjusted Expected Total Return and Discount Rate

In order to determine the risk adjusted present investment value, it is necessary to derive the expected rate of total return for the exponential cash-flows. Applying Ito's lemma we can write

$$\begin{aligned} \frac{d\vartheta_t^\kappa}{\vartheta_t^\kappa} &= \frac{\kappa\vartheta_t^{\kappa-1}d\vartheta_t + \frac{1}{2}\kappa(\kappa-1)\vartheta_t^{\kappa-2}\sigma^2\vartheta_t^2 dt}{\vartheta_t^\kappa} && (2.140) \\ &= \frac{\kappa\vartheta_t^{\kappa-1}(\vartheta_t\alpha dt + \vartheta_t\sigma dz_t) + \frac{1}{2}\kappa(\kappa-1)\vartheta_t^{\kappa-2}\sigma^2\vartheta_t^2 dt}{\vartheta_t^\kappa} \\ &= \kappa(\alpha dt + \sigma dz_t) + \frac{1}{2}\kappa(\kappa-1)\sigma^2 dt \\ \frac{d\vartheta_t^\kappa}{\vartheta_t^\kappa} &= (\alpha\kappa + \frac{1}{2}\kappa(\kappa-1)\sigma^2)dt + \kappa\sigma dz_t. && (2.141) \end{aligned}$$

The first part of this equation simply represents the adjusted growth rate of the exponential Brownian motion. For such a transformed Geometric Brownian motion it is straight forward that κ fulfills the following quadratic equation

$$\frac{1}{2}\sigma^2\kappa(\kappa-1)+(r-\delta_u)\kappa-r=0 \tag{2.142}$$

which can be reshaped to

$$\frac{1}{2}\sigma^2\kappa(\kappa-1)=r-(r-\delta_u)\kappa. \tag{2.143}$$

Substitution into equation (2.141) provides

$$\frac{d\vartheta_t^\kappa}{\vartheta_t^\kappa}=(\kappa\alpha+r-(r-\delta_u)\kappa)dt+\kappa\sigma dz_t. \tag{2.144}$$

The total expected return rate for an uncertain investment with linear cash-flows in ϑ driven by (2.11) is composed of the expected growth rate α and the remaining opportunity costs δ_u. Therefore, α can be substituted by $(\mu-\delta_u)$ which leads to

$$\mathbb{E}\left(\frac{d\vartheta_t^\kappa}{\vartheta_t^\kappa}\right)=(\mu\kappa+r-r\kappa)dt+\kappa\sigma dz_t. \tag{2.145}$$

The risk-adjusted expected rate of return for exponential cash-flows results as

$$\mu_u'=r+\kappa(\mu-r) \tag{2.146}$$

since $\mathbb{E}(\kappa\sigma dz_t)=0$. Furthermore, the risk-adjusted opportunity cost rate δ_u' is easily derived as

$$\delta_u'=\mu_u'-\alpha_u' \tag{2.147}$$

$$=r-(r-\delta_u)\kappa-\frac{1}{2}\kappa\sigma^2(\kappa-1). \tag{2.148}$$

Obviously, for $\kappa=1$ the adjusted opportunity cost rate δ_u' equals δ_u.

2.7.9 Parameter Constraints

Given the risk-adjusted discount rate δ_u' it is necessary to define $r>0$ in order to ensure a convergence of the expected present investment values. The adjusted discount rate δ_u' represents a quadratic function in κ and exhibits two root solutions for

$$\Phi(\kappa) = r - \kappa\alpha + \frac{1}{2}\kappa(\kappa - 1)\sigma^2 \qquad \text{where} \qquad \Phi(0) = r. \tag{2.149}$$

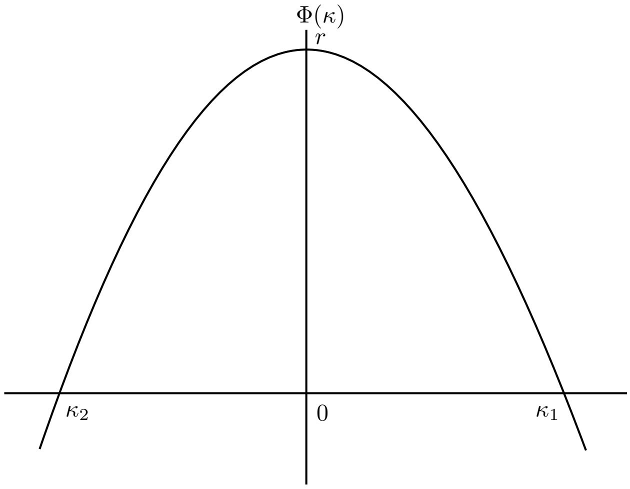


Figure 2.11: Quadratic Equation

For a reasonable result, κ must lie between $\kappa_2 < \kappa < \kappa_1$ and for convergence, it is necessary that
$r > \alpha \quad (\Phi(\kappa) > 0)$.

2.7.10 The Option Value of an Investment

There are several methods to derive the option value of an uncertain investment. A convenient approach can be applied if the present value V_i of an uncertain investment is derivable by the asset spanning method. In such a case the option value $F_i(\vartheta)$ and the critical threshold value ϑ_i^* for an investment that is characterized by productivity uncertainty as in equation (2.44) can be easily determined by constructing a riskless portfolio and by using the gross investment value $V_i(\vartheta)$ as a boundary condition. The replicated riskless portfolio is constructed by holding one unit of the option $F_i(\vartheta)$ and short selling of $n = \frac{\partial F_i(\vartheta)}{\partial \vartheta}$ units of an asset which comprises the same risk return patterns as equation (2.44). The short positions will require a payment of $\frac{\partial F_i(\vartheta)}{\partial \vartheta}\vartheta\delta_u$ for each incremental period dt. As explained earlier it is assumed that the asset used for replication pays no dividend and therefore, its expected return rate is μ and results only from its capital gain. This constructed portfolio is riskless and as a consequence it must provide a riskless return of $r\left(F_i(\vartheta) - \frac{\partial F_i(\vartheta)}{\partial \vartheta}\right)dt$, where r represents the riskless interest rate. The resulting arbitrage condition can be written as

$$dF_i(\vartheta) - \frac{\partial F_i(\vartheta)}{\partial \vartheta}d\vartheta - \delta_u \frac{\partial F_i(\vartheta)}{\partial \vartheta}\vartheta dt = r\left(F_i(\vartheta) - \frac{\partial F_i(\vartheta)}{\partial \vartheta}\right)dt. \tag{2.150}$$

$dF_i(\vartheta)$ can be reformulated by using Ito's lemma with

$$dF_i(\vartheta) = \frac{\partial F_i(\vartheta)}{\partial \vartheta}d\vartheta + \frac{1}{2}\frac{\partial^2 F_i(\vartheta)}{\partial \vartheta^2}\sigma^2\vartheta^2 dt \tag{2.151}$$

and we get a homogeneous linear differential equation of second order

$$\frac{1}{2}\sigma^2\vartheta^2\frac{\partial^2 F_i(\vartheta)}{\partial \vartheta^2} + (r - \delta_u)\vartheta\frac{\partial F_i(\vartheta)}{\partial \vartheta} - rF_i(\vartheta) = 0. \tag{2.152}$$

The solution of the homogeneous differential function is a linear combination of any two linearly independent solutions, as

$$A_i\vartheta^{\beta_u}. \tag{2.153}$$

Substituting this guess solution into the differential equation leads to the quadratic equation

$$\frac{1}{2}\sigma^2\beta_u(\beta_u - 1)A_i\vartheta_u^\beta + (r - \delta_u)\beta_u A_i\vartheta_u^\beta - rA_i\vartheta_u^\beta = 0 \tag{2.154}$$

$$\frac{1}{2}\sigma^2\beta_u(\beta_u - 1) + (r - \delta_u)\beta_u - r = 0. \tag{2.155}$$

The resulting two solutions for β_u are

$$\beta_{u1} = \frac{1}{2} - \frac{r - \delta_u}{\sigma^2} + \sqrt{\left[\frac{r - \delta_u}{\sigma^2} - \frac{1}{2}\right]^2 + \frac{2r}{\sigma^2}} > 1 \tag{2.156}$$

$$\beta_{u2} = \frac{1}{2} - \frac{r - \delta_u}{\sigma^2} - \sqrt{\left[\frac{r - \delta_u}{\sigma^2} - \frac{1}{2}\right]^2 + \frac{2r}{\sigma^2}} < 0 \tag{2.157}$$

and the final solution for the quadratic equation is

$$F_i(\vartheta) = A_{i1}\vartheta^{\beta_{u1}} + A_{i2}\vartheta^{\beta_{u2}}. \tag{2.158}$$

2.7.11 Cut-Offs under Uncertainty

Applying the matching and smooth pasting conditions on the option function we receive for the export case

$$A_E \vartheta^{*\beta_u} = \frac{M_E \vartheta^{*\kappa}}{\delta'_u} - I_E \qquad \text{(matching condition)} \tag{2.159}$$

and

$$\beta A_E \vartheta^{*\beta_u - 1} = \kappa \frac{M_E \vartheta^{*\kappa - 1}}{\delta'_u} \qquad \text{(smooth pasting condition).} \tag{2.160}$$

Respectively, it is possible to solve for the optimal export cut-off

$$A_E = \frac{M_E \vartheta^{*\kappa - \beta_u}}{\delta'_u} - I \vartheta^{*-\beta_u} \tag{2.161}$$

$$\frac{(\beta_u - \kappa)\vartheta^{*\kappa}}{\delta'_u} = \frac{I_E \beta_u}{M_E} \tag{2.162}$$

$$\vartheta^{*\kappa} = \left(\frac{\beta_u}{\beta_u - \kappa}\right) \frac{I_E \delta'_u}{M_E} \tag{2.163}$$

and the optimal productivity cut-off

$$\vartheta^*_E = \sqrt[\kappa]{\frac{\beta_u}{\beta_u - \kappa} \frac{I_E \delta'_u}{M_E}}. \tag{2.164}$$

Once the optimal cut-off is know it is possible to derive

$$A_E = \frac{M_E \vartheta_E^{*\kappa - \beta_u} - \delta'_u I_E \vartheta_E^{*-\beta_u}}{\delta'_u} \tag{2.165}$$

Substituting ϑ_E^* leads to

$$A_E = \frac{M_E \left(\frac{\beta_u I_E \delta_u'}{(\beta_u-\kappa)M_E}\right)^{\frac{\kappa-\beta_u}{\kappa}} - \delta_u' I_E \left(\frac{\beta_u I_E \delta_u'}{(\beta_u-\kappa)M_E}\right)^{-\frac{\beta_u}{\kappa}}}{\delta_u'} \tag{2.166}$$

$$= \frac{M_E \left(\frac{1}{M_E}\right)^{1-\frac{\beta_u}{\kappa}} I^{1-\frac{\beta_u}{\kappa}} \left(\frac{\beta_u \delta_u'}{\beta_u-\kappa}\right)^{1-\frac{\beta_u}{\kappa}} - \delta_u' I_E^{1-\frac{\beta_u}{\kappa}} \left(\frac{1}{M_E}\right)^{-\frac{\beta_u}{\kappa}} \left(\frac{\beta_u \delta_u'}{\beta_u-\kappa}\right)^{-\frac{\beta_u}{\kappa}}}{\delta_u'} \tag{2.167}$$

$$= M_E^{\frac{\beta_u}{\kappa}} I_E^{1-\frac{\beta_u}{\kappa}} \underbrace{\frac{1}{\delta_u'}\left(\frac{\beta_u \delta_u'}{\beta_u - \kappa}\right)^{1-\frac{\beta_u}{\kappa}} - \delta_u' \left(\frac{\beta_u \delta_u'}{\beta_u - \kappa}\right)^{-\frac{\beta_u}{\kappa}}}_{\Omega} \tag{2.168}$$

$$A_E = M_E^{\frac{\beta_u}{\kappa}} I_E^{1-\frac{\beta_u}{\kappa}} \Omega. \tag{2.169}$$

In the case of market entry through foreign direct investment we have

$$A_F = M_F^{\frac{\beta_u}{\kappa}} I_F^{1-\frac{\beta_u}{\kappa}} \Omega. \tag{2.170}$$

The optimal cut-off productivity levels for both entry alternatives result as

$$\vartheta_E^* = \sqrt[\kappa]{\frac{\beta_u}{\beta_u - \kappa} \frac{I_E \delta_u'}{M_E}} \quad \text{and} \quad \vartheta_F^* = \sqrt[\kappa]{\frac{\beta_u}{\beta_u - \kappa} \frac{I_F \delta_u'}{M_F}}. \tag{2.171}$$

2.7.12 Fundamental Quadratic Equation

The fundamental quadratic equation has been derived in appendix 2.7.10 as

$$\Psi = \frac{1}{2}\sigma^2 \beta_u(\beta_u - 1) + (r - \delta_u)\beta_u - r = 0 \tag{2.172}$$

and can be depicted as in figure 2.12.

Consider the total differential

$$\frac{\partial \Psi}{\partial \beta_u}\frac{\partial \beta_u}{\partial \sigma} + \frac{\partial \Psi}{\partial \sigma} = 0 \tag{2.173}$$

which can be evaluated at $\beta_u = \beta_{1_u}$. Obviously the quadratic equation Ψ increases in β_u with

$$\frac{\partial \Psi}{\partial \beta_u} > 0. \tag{2.174}$$

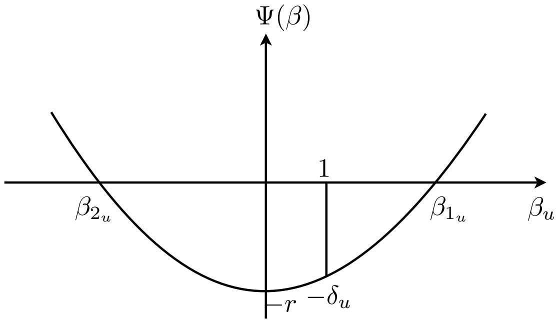


Figure 2.12: Fundamental Quadratic Equation

The derivative of Ψ with respect to β_u results as

$$\frac{\partial \Psi}{\partial \sigma} = \sigma \beta_u (\beta_u - 1) \tag{2.175}$$

which is always positive for $\beta_u > 1$ and $\sigma > 0$. Therefore, the exponents $\beta_u = \beta_{1_u}$ decreases in σ with

$$\frac{\partial \beta_u}{\partial \sigma} < 0. \tag{2.176}$$

Consequently, for $\beta_u > \kappa > 0$

$$\frac{\partial \left(\frac{\beta_u}{\beta_u - \kappa} \right)}{\partial \sigma} > 0. \tag{2.177}$$

2.7.13 Expected Market Entry Time

It has been shown that

$$\frac{\partial \beta_u}{\partial \sigma} < 0. \tag{2.178}$$

and for $\beta_u > \kappa > 0$

$$\frac{\partial \left(\frac{\beta_u}{\beta_u - \kappa} \right)}{\partial \sigma} > 0. \tag{2.179}$$

For $\kappa = 1$, which leads to linear cash-flow functions in ϑ, the adjusted discount rate δ_u equals δ_c and is independent of σ. In such a case

$$\frac{\partial \delta_u}{\partial \sigma} = 0 \tag{2.180}$$

and given the productivity cut-offs

$$\vartheta_i^* = \sqrt[\kappa]{\frac{\beta_u \; I_i \delta_u'}{\beta_u - \kappa \; M_i}} \tag{2.181}$$

within the proximity-concentration trade-off framework ϑ_i^* monotonically increases in σ, with

$$\frac{\partial \vartheta_i^*}{\partial \sigma} > 0 \qquad \text{and} \quad i \in \{E, F\}. \tag{2.182}$$

Therefore, in both market entry modes the expected market entry time also increases strictly in σ, with

$$\begin{aligned} \frac{\partial \mathbb{E}(T_i^*)}{\partial \sigma} &= \sigma \frac{1}{\left(\alpha - \frac{1}{2}\right)^2} \ln\left(\frac{\vartheta_i^*}{\vartheta_0}\right) + \frac{1}{\left(\alpha - \frac{1}{2}\sigma^2\right)} \frac{1}{\vartheta_i^*} \frac{\partial \vartheta_i^*}{\partial \sigma} \\ \text{and} \quad \frac{\vartheta_i^*}{\vartheta_0} &> 1, \quad \alpha > \frac{1}{2}\sigma^2. \end{aligned} \tag{2.183}$$

For relative cost patterns with

$$\frac{I_E}{M_E} < \frac{I_F}{M_F} \tag{2.184}$$

wich is equivalent to

$$\frac{I_E}{I_F} < \left(\frac{w_F}{w_E \tau^{\frac{1}{\theta}}}\right)^{\frac{\nu\theta}{1-\nu\theta}} \tag{2.185}$$

an increase in σ leads to a stronger shift in the FDI mode's expected market entry mode

$$\frac{\partial \mathbb{E}(T_F^*)}{\partial \sigma} > \frac{\partial \mathbb{E}(T_E^*)}{\partial \sigma}. \tag{2.186}$$

For parameter constellations which exhibit $\kappa > 1$, the periodical cash-flows are convex in ϑ and the impact of a volatility change on productivity growth is twofold. Besides a positive effect of uncertainty on the option value, which is expressed by

$$\frac{\partial\left(\frac{\beta_u}{\beta_u-\kappa}\right)}{\partial\sigma} > 0 \tag{2.187}$$

in equation (2.62) there exits a negative counter effect driven by Jensen's inequality. More precisely, if σ increases, the expected value of both market entry modes increases, which is analytically expressed by a reduction in the risk adjusted discount rate δ'_u, with

$$\frac{\partial\delta'_u}{\partial\sigma} = \sigma\kappa - \sigma\kappa^2 < 0. \tag{2.188}$$

For

$$\left|\frac{\partial\left(\frac{\beta_u}{\beta_u-\kappa}\right)}{\partial\sigma}\right| > \left|\frac{\partial\delta'_u}{\partial\sigma}\right| \tag{2.189}$$

the expected market entry time also increases in σ for $\kappa > 1$, however

$$\left.\frac{\partial\mathbb{E}(T_i^*)}{\partial\sigma}\right|_{\kappa=1} > \left.\frac{\partial\mathbb{E}(T_i^*)}{\partial\sigma}\right|_{\kappa>1} \tag{2.190}$$

due to the negative effect in δ'_u. The increase in the FDI mode's expected market entry mode will again be higher than in the export mode, if condition (2.185) is fulfilled.

There are parameter constellations for which the effect of Jensen's inequality dominates over the uncertainty effect, with

$$\left|\frac{\partial\left(\frac{\beta_u}{\beta_u-\kappa}\right)}{\partial\sigma}\right| < \left|\frac{\partial\delta'_u}{\partial\sigma}\right|. \tag{2.191}$$

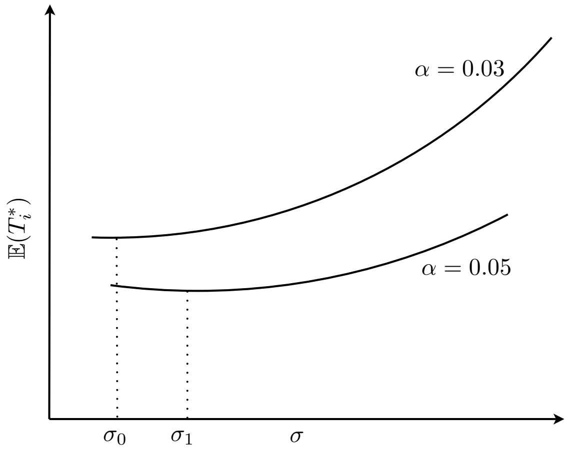


Figure 2.13: Expected Market Entry Time Pattern

In such cases uncertainty leads to a reduction of the expected market entry time in both market entry modes. A detailed analysis can be found in Wong (2007), where he proves a u-shaped pattern of the optimal expected market entry time in σ.

Figure 2.13 exemplarily depicts a parameter sample in which an increase of σ in $(0, \sigma_0)$ reduces the expected entry time, whereas in the remaining range market entry is prolonged.

CHAPTER 3

The Discontinuity of Foreign Market Serving Modes

3.1 Introduction

The importance of Foreign Direct Investment (FDI) and International Trade has risen over the last two decades. Domestic companies have steadily increased their exports to foreign markets and expanded their foreign plant shares as a means of foreign market access (UNCTAD 2008). These developments have led to an increased research effort in understanding firm behavior on international markets (see Greenaway and Kneller (2007) for a recent survey). Since the seminal work of Melitz (2003) on export behavior and industry dynamics, the triad productivity, economies of scale, and selection are considered to be the major forces behind international enterprise behavior.

Accounting for firm heterogeneity, Melitz (2003)'s New New Trade Theory lays the basis to explain firms' sorting into exporter status. Helpman et al. (2004) introduce Foreign Direct Investment into this framework where in equilibrium the most productive firms tend to serve foreign markets via FDI, less productive firms become exporters, and low-productivity firms

This paper is a joint work with Sanne Hiller form Aarhus University. The concept was developed jointly whereas theoretical analysis, conducting numerical simulations, and writing were shared equally. The paper was presented on the spring meeting of young economists in Istanbul and on the Danish International Economics Workshop 2009. We thank participants for helpful comments.

tend to restrict their activity to the domestic market (for empirical evidence see for example Wagner (2006) or Mayer and Ottaviano (2007), Oberhofer and Pfaffermayr (2008)). The resulting sorting pattern in these models is rooted in the cost structure: The export activity brings about higher variable cost due to transportation and relatively low fixed cost of market entry. Differently, firms which serve the foreign market as a foreign direct investor commonly face lower variable cost, but considerably higher fixed costs arising from the replication of production facilities abroad or information cost on the institutional environment. This cost structure depicts the proximity-concentration trade-off as introduced by Brainard (1993): Whether the company decides to serve the foreign market via FDI or as an exporter crucially hinges on the trade-off between scale advantages for home production, and the benefits from proximity when producing abroad. The theoretical prediction of the New New Trade Theory on firm distribution turns out to be well reflected in the data (Helpman, 2006) which explains the strong impetus within this strand of literature.

However, there are empirical developments which are out of the scope of these static general equilibrium models. Helpman et al. (2004) derive in their setting a final firm distribution within an industry by combining the proximity-concentration trade-off framework with firm productivity heterogeneity. Here, a one time lottery draw assigns the level of productivity to the firm.

Clearly, this framework suffices for the objective to explain the different types of foreign market serving modes at a specific time. But it turns out to be insufficient for transition analysis.

Presume for a moment, that a firm has found it optimal to serve a new foreign market as an exporter. Still, once having chosen to serve a market via exports does not at all imply persistence of the exporter status of the individual firm. Indeed, we are able to show that e.g. within the Danish manufacturing sector there exists a significant number of firms which interrupt their foreign market activities by exiting. Furthermore, there are firms which exhibit a high switching between serving only the domestic market and foreign destinations amounting to up to three times within eight years. Similar observations are presented by Wagner (2008) for a sample of German manufacturing firms between 1995 and 2004. The author is able to show that the number of export market entries is of similar magnitude as the exits for a given year. The availability of such foreign market activities of firms allows the hypothesis that there are dynamic factors such as exchange rate volatility or demand uncertainty which may influence a firm's market serving mode both positively and negatively over time. Referring to the importance of firm productivity in the New New Trade Theory, an exporter might learn by exporting and by this token experience an increase in productivity (Clerides et al. (1998)). Exhibiting this increased productivity, the firm might then consider serving the market no longer as an exporter, but its optimal strategy might turn out to be foreign direct investment. In a similar line of argument, a foreign direct investor who experiences unfavorable market conditions or a drop in productivity might be incited to refrain from FDI, and instead switch to exporting to the former export destination country, or to completely withdraw his activity from this particular market. Indeed, firm productivity development exhibits a heterogeneous picture over time and across industries. Within the mentioned Danish sample there are firms which experience a stable productivity growth over time without large deviations. Simultaneously, there are firms confronted with high growth rates over time but accompanied with either high or low volatility.

These prior considerations - above all the enormous fluctuation in market entries and exits - emphasize the importance to explicitly consider the transition dynamics between inactivity on the foreign market, exporting and foreign direct investment. As the static general equilibrium model of Helpman et al. (2004) can not be easily extended into a dynamic framework, and since there is according to our best knowledge no theoretical model which accounts for the described foreign market serving mode discontinuity, we present a theoretical framework which contributes to a better understanding of international firm behavior over time. In line with Helpman et al. (2004) we combine the proximity-concentration trade-off framework with productivity uncertainty. In order to derive serving mode transitions driven by productivity uncertainty, we extend this standard framework by modeling productivity as a Geometric Brownian motion. We are able to solve the arising analytical complexity by reducing the analysis to a single firm perspective following the seminal real option theory of Dixit (1989) which is an appropriate framework to model switching behavior under uncertainty, as it combines sunk costs with a stochastic state variable. Due to the high nonlinearity of the resulting equilibrium functions we have to apply numerical methods.

Our focus is on switches between inactivity, export or FDI on a foreign market. Each of the serving strategies is associated with a specific sunk market entry cost, whereby market entry is more costly for the FDI than for the export strategy, whereas the opposite relation holds true for the variable cost. Once a firm has decided how it serves the foreign market, it can undo its choice. But this switching comes at a price: The firm incurs an additional, switch-specific fixed cost when changing from one market serving strategy to another. Basically, a firm can switch from inactivity, exporting or FDI to one of the two alternative strategies.

Thus, our paper contributes to the existent literature in three regards: First of all, we provide a theoretical model of dynamics and transitions in foreign market serving modes. Secondly, we introduce continuous uncertainty in a firm's productivity path. Thirdly, we derive testable predictions on firm market entry and exit patterns.

The remainder is structured as follows: Section 3.2 presents stylized facts on export dynamics and productivity for a sample of Danish firms. Section 3.3 provides the intuition for foreign market serving mode discontinuities. Section 3.4 introduces the model. Section 3.5 presents the numerical results, and section 3.6 concludes.

3.2 Stylized Facts

Based on a sample of the 5000 largest Danish firms by net revenues, provided by Statistic Denmark, table 3.1 presents the market entry and exit pattern of 1406 manufacturing firms into and out of export markets within the period from 1995 till 2003.[1] During the considered 8 years, 489 companies started to export and 123 of these exporters existed already as domestic companies whereas 366 firms were born as exporting enterprises.

Most importantly, table 3.1 conveys a clear message about the switching extensity of Danish firms. During the considered time, only 20 enterprises permanently served the domestic market without any interruption in their serving mode. The remaining 1386 manufacturing firms in the sample have been involved into international trade whereas 361 companies permanently continued to export within the considered time span. Other companies were born within these

[1] A firm is identified as an exporter if it exhibits positive export revenues higher than 1,000,000 DKK.

Firms Entering	Domestic & Export Market (Simultaneously)	Export Market	Total
1 Time	366	123	489
2 Times	45	107	152
3 Times	2	10	12
Firms Exiting			
1 Time	526	100	626
2 Times	74	160	234
3 Times	5	19	24
Permanent Domestic:			20
Permanent Exporter:			361

Table 3.1: Market Entry and Exit Patterns of Danish Firms, 1995 - 2003
This table depicts export market entries and exits for Danish firms between 1995 and 2003. The sample comprises the 5000 largest Danish firms by net revenue. Data Source: Denmark Statistics.

years immediately as exporters or started after entering the domestic market to serve a foreign destination. The number of firms which entered the export market two times amounts to 152 and implicitly these firms have exited the foreign market at least once. Differently stated, about 25% of the considered exporting Danish enterprises interrupted their market serving mode within 8 years at least one time. The observed maximum amount of market entry into new foreign markets amounts to 3 times and applies to 12 companies. Similar patterns of serving mode interruptions can be observed in the exit behavior of Danish firms whereupon the total number of exits outnumbers the intensity of market entries: Denmark experienced a reduction in the number of firms between 1995 and 2003.

In a nutshell, first of all, firm market entry and exit are highly dynamic. Secondly, there are firms which exhibit a low rate of serving mode switching, whereas others are highly agile in their entry and exit behavior.[2]

Therefore, the first question which arises from these facts and which is not considered within the related literature is: What distinguishes firms with a low rate of market serving mode switching from companies which exhibit a high number of interruptions in their serving mode over time?

Theoretically and empirically, firm productivity stands out as the driving force for a firm's serv-

[2] So far it is not possible to assess horizontal foreign direct investment involvement due to data limitations.

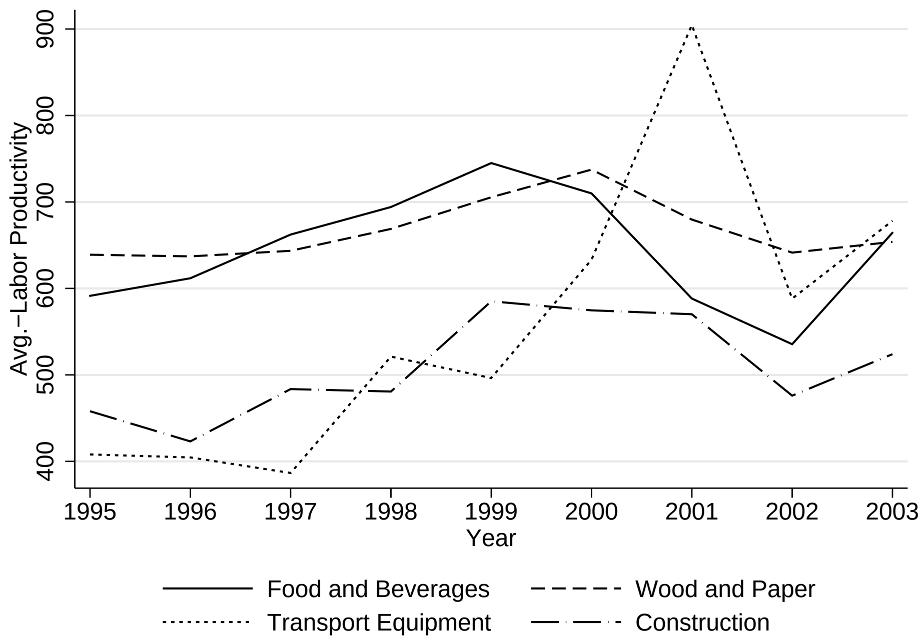


Figure 3.1: The Evolution of Productivity for Different Sectors
This figure presents the evolution of average firm productivity (value added over number of employees) for four different subsectors within the manufacturing sector for Danish firms. Source: Denmark Statistics.

ing mode selection (Melitz, 2003; Wagner, 2008). Figure 3.1 depicts four productivity paths for four Danish manufacturing sectors. These paths differ crucially in their growth rate and their volatility. Productivity growth is relatively large for transport equipment and the construction sectors as compared to the food and beverages sector as well as wood and paper sector. On the other hand, the latter two sectors exhibit a lower volatility in their productivity paths if compared to the transportation sector. Thus, even on the sectoral level, productivity growth and volatility exhibit considerable heterogeneity.[3]
Generally spoken, productivity turns out to grow over time, whereas its growth path contains a certain degree of risk, as it deviates above its average to the bottom or to the top over time. Furthermore, there exist firms with different types of productivity evolution over time.

As the New New Trade Theory explains a firm's market serving mode selection on the basis of constant productivity measures the question arises: How does a dynamic risky evolution of firm productivity influence a company's market serving mode over time?

[3] Note that for data protection policies, we are not allowed to extract firm specific productivity paths.

3.3 Economic Intuition

Consider an investor who is initially serving only his domestic market. Confronted with an uncertain productivity growth he may increase his sales by serving new foreign markets either through exports or FDI.[4] As productivity develops stochastically the investor faces a choice between three alternatives: He can either

1. Postpone market entry decision and observe the productivity development,
2. Serve the new market through exports,
3. Serve the new market through a foreign plant (FDI).

With reference to Helpman et al. (2004), a new market entry is associated with fixed costs which are irreversible, at least partly and the FDI mode generates relatively higher sunk costs. Within this simplified problem setting, general economic intuition suggests that the capability to recover additionally incurring fixed costs through an expected productivity growth is crucially responsible for a new market entry as such. Differently stated, market entry depends on the relationship between absolute fixed costs and the development of productivity over time. On the other hand, whether the initial choice of the optimal serving mode results in FDI or export is determined by the relative fixed and variable cost structure between the two modes, given the dynamic productivity development (Yalcin, 2009). Once, the investor decides on a specific serving mode, the uncertain productivity dynamics brings about to chose between three alternatives which can lead to serving mode discontinuity:

4a) Remain in the chosen serving mode,

4b) Switch to the alternative mode,

4c) Exit the foreign market.

We define the switching between market serving modes or exiting the market, as serving mode discontinuity. Here, we distinguish two different types of discontinuity in a firm's serving state over time: In the *type I* discontinuity, a firm switches from its market serving mode to inactivity on the foreign market. The *type II* discontinuity covers cases where the firm switches between the two market serving modes. For expositionary purposes, consider the chosen strategies for

[4] We call the decision maker investor or firm without distinguishing between the two terms.

Dominance of FDI: $\mathbf{I_E > I_F}$,			**$\mathbf{I_S \to \infty}$**	
Variable Cost	Entry Mode	Level of Fixed Cost	Mode Discontinuity	Type
$\tau \to 1$	FDI	$I_F \to I_E$	No	
		$I_F \to 0$	Yes	Ia
$\tau \to \infty$	FDI	$I_F \to I_E$	No	
		$I_F \to 0$	Yes	Ia

Proximity-Concentration Trade-Off: $\mathbf{I_F > I_E}$,			**$\mathbf{I_S \to \infty}$**	
Variable Cost	Entry Mode	Level of Fixed Cost	Mode Discontinuity	Type
$\tau \to 1$	Export	$I_E \to I_F$	No	
		$I_E \to 0$	Yes	Ib
$\tau \to \bar{\tau} < \infty$	Export	$I_E \to I_F$	No	
		$I_E \to 0$	Yes	Ib
$\tau > \bar{\tau}$, $\tau \to \infty$	FDI	$I_F \to \infty$	No	
		$I_F \to I_E$	Yes	Ia

			$\mathbf{I_S < \infty}$	
Variable Cost	Entry Mode	Level of Switching Cost	Mode Discontinuity	Type
$\tau \to 1$	Export	$I_S \to \infty$	No	
		$I_S \to 0$	No	
$\tau \to \bar{\tau} < \infty$	Export	$I_S \to \infty$	No	
		$I_S \to 0$	Yes	II
$\tau > \bar{\tau}$, $\tau \to \infty$	FDI	$I_S \to \infty$	No	
		$I_S \to 0$	No	

Table 3.2: Limiting Cost Constellations and Market Serving Modes
This table depicts chosen market serving strategies for limiting cost constellations. I_E (I_F) are the fixed market entry cost of exporting (FDI), τ represents the transport cost associated with exporting. $\bar{\tau}$ is a critical value of τ at which for a given productivity growth and volatility, the relative fixed cost advantage of exporting outweighs the relative variable cost advantage of FDI. Considerations in this table refer exclusively to market entry cost. Thus, the superscript N is omitted for I_E and I_F.

limiting cost structures as depicted in table 3.2.

Consider first, that switching between the two market entry modes after entry is not an attractive alternative for an investor, because switching costs I_S are prohibitively high ($I_S \to \infty$). In this case, only *type I* discontinuity arises: The top part of table (3.2) covers cases, where the export fixed cost are strictly larger than the FDI fixed cost. For this fixed cost constellation, no matter the size of the variable export cost, FDI results as the preferred serving mode (see also Yalcin, 2009). In this setup, a discontinuity in terms of type I switching occurs if FDI entry cost tend to zero. For fixed cost approaching their upper limit, a continuous market serving is chosen. Subsequently, these cost constellations between export and FDI fixed cost are no longer considered, since they are not plausible according to the proximity-concentration trade-off (Brainard, 1993).

The intermediate part of the table covers market serving strategies for scenarios, where the entry costs for FDI exceed those for exporting firms, i.e., where $I_F > I_E$.[5] If the variable cost tend to zero, exporting arises as the dominant strategy, since the fixed cost of exporting are lower than the fixed cost for foreign direct investment. Whether this mode choice is continuous or discontinuous, hinges on the size of the market entry sunk cost: If the firm has sunk very high entry cost (approaching its upper bound I_F), a firm will remain either exporter or inactive. If entry cost tend to zero, it can almost costlessly adjust to unfavorable market conditions and thus a discontinues market serving strategy (type I) results. For a τ which approaches infinity from below, there exists a critical $\bar{\tau}$ for which the fixed cost advantage is turned down by the variable cost disadvantage given the uncertain productivity development (compare Yalcin, 2009). As long as the transport cost approach $\bar{\tau}$ from below, exporting is the preferable strategy. For high export fixed cost ($I_E \rightarrow I_F$), the firm chooses a continuous market serving mode. If it is cheap to start exporting ($I_E \rightarrow 0$), the firm easily reacts to unfavorable market conditions and leaves the foreign market.

The bottom part of the table presents a scenario, where the switching costs are no longer prohibitively high, such that *type II* discontinuities may arise. In two cases, they do not arise: If FDI is the market entry mode in light of the proximity-concentration trade-off under productivity uncertainty, the investor will not change to an export market serving mode. Since export is associated with higher variable costs as compared to foreign direct investment, there is no reason for the optimizing firm to switch from exporting to FDI if sunk costs exist. Similarly, for an exporter, there is no incentive to change his market serving mode if variable cost tend to zero, or if switching costs tend to infinity. Differently, if variable cost approach their critical level of $\bar{\tau}$ for which exporting is favored over FDI, it can be beneficial for the investor to switch the market serving mode from exporting to FDI if market conditions suggest – if switching costs are low –.

[5] In subsequent derivations, we shall denote market entry cost with superscript N. This is omitted here for the sake of readability.

These considerations are based on limiting cost constellations. In intermediate cases, the chosen serving mode depends on productivity growth and volatility. As an outlook to the results from our model, the market serving mode predictions in the proximity-concentration framework as represented by the lower part of table 3.2 are influenced by the productivity growth α and volatility σ in the following way: Other things equal, a high productivity growth rate fosters market entry via FDI or a discontinuous strategy in terms of a type II discontinuity. This is due to the fact that the sunk cost of entry or switching can easily be recouped due to an increase in productivity. Similarly, ceteris paribus, a highly volatile productivity development encourages market entry via FDI. However, if the initial cost constellation is such that market entry takes place via exporting, a volatile productivity path encourages switching between exporting and FDI.

3.4 The Model

Consider a risk-neutral investor who intends to serve a new foreign market with his product brand X_i which is produced only by him. The new destination market can be served either through exporting or a new foreign plant (horizontal FDI). By comparing the investment values of these two market entry modes the investor decides on whether to enter the market directly through FDI or by exporting. Preferences of the representative consumer in the destination country are given by

$$U_t(Q_t, Y_t) = Q_t^{\gamma} Y_t^{1-\gamma} \tag{3.1}$$
$$\text{with} \quad Q_t = \left(\sum_{i=1}^{n_t} X_{i_t}^{\rho} \right)^{\frac{1}{\rho}}, \quad 0 < \rho < 1, \quad 0 < \gamma < 1,$$

where ρ is the degree of substitutability across differentiated goods, and Y is a freely-traded homogeneous good that is produced in any country. The income share spent on the heterogeneous goods is denoted by γ. Such preferences imply the following demand function for variety i,

$$X_{i_t} = \frac{p_{i_t}^{-\eta}}{P_t^{-\eta}} \cdot \frac{\gamma \xi_t}{P_t}, \tag{3.2}$$

$$\text{with} \quad \eta = \frac{1}{1-\rho}, \quad P_t = \left(\sum_{j_t}^{n_t} p_{j_t}^{1-\eta} \right)^{\frac{1}{1-\eta}},$$

where ξ_t is the destination country's gross national expenditure, P_t the price index and p_{it} the price of variety i at time t. The investor assumes that the expenditure share spent on good Q and the price index P do not change over time. Consequently, equation (3.2) represents the investor's perceived demand function which can be summarized to

$$p_t = Z X_t^{-\frac{1}{\eta}} \tag{3.3}$$

$$\text{with} \quad Z = P^{\frac{\eta-1}{\eta}} (\gamma \xi)^{\frac{1}{\eta}},$$

where the subscript i is omitted, as the considered firm exports only one brand. Due to the fact that the investor is the only producer of brand i, he possesses market power which depends on the destination country's elasticity of substitution. Therefore, he will charge a price $p = w_h \frac{Z}{\nu}$, where ν is the inverse mark-up of price over marginal costs and w_h the wage rate in the home market. The wage is determined in the homogeneous-good industry. Technology in the destination country is less productive and therefore, wages w_d are lower.[6] By reformulating the demand function as

$$p = Z X^{\nu - 1}, \tag{3.4}$$

it is possible to model the extent of market power. For ν close to 1 the market power is low since substitutability between the varieties is high ($\rho \to 1$). On the other hand for ν close to zero the investor possesses market power since the demand function becomes less elastic.

[6] In the subsequent simulation we assume $w_d = w_h$ but still maintain higher variable costs in the export mode due to transport costs $\tau > 1$. The introduction of lower variable costs in the FDI mode amplifies the derived effects but does not act as a countervailing force.

On the technology side production is described by

$$X_t(L_t) = \vartheta_t L_t^{\theta} \tag{3.5}$$
$$\text{with} \quad 0 < \theta < 1 \quad \text{and} \quad \vartheta_t > 0,$$

where labor L_t is the only periodically used input and ϑ_t the firm embedded productivity level. Exporting is associated with fixed costs I_E^N, due to a new distribution and service-network. Besides the infrastructure costs, FDI requires a new plant and therefore its fixed costs I_F^N are strictly higher compared to exporting. In serving the destination market through exports the firm faces iceberg transport costs $\tau > 1$ which are avoided in the FDI mode. Given these cost structures the investor is confronted with a proximity-concentration trade-off where he experiences a comparative variable cost advantage in the export strategy and a comparative fixed cost advantage in the FDI mode with

$$\frac{I_E^N}{I_F^N} < 1 \quad \text{and} \quad \frac{w_d}{w_h \tau^{\frac{1}{\theta}}} < 1. \tag{3.6}$$

Based on the following maximization problem

$$\Pi_E = \max_L \, p \, X_E - L w_h \quad \text{s.t.} \quad X_E = \frac{X_{DE}}{\tau} \quad \text{s.t.} \quad X_{DE} = \vartheta L^{\theta} \quad \text{s.t.} \quad p = Z X_E{}^{(\nu-1)}, \tag{3.7}$$

with X_{DE} as the domestic output produced for the destination country, periodical export cash-flows result as

$$\Pi_E(\vartheta) = M_E \vartheta_E^{\kappa} \tag{3.8}$$
$$\text{with} \quad M_E = Z^{\frac{1}{1-\nu\theta}} \left(\frac{\nu\theta}{w_h \tau^{\frac{1}{\theta}}} \right)^{\frac{\nu\theta}{1-\nu\theta}} (1-\nu\theta) \quad \text{and} \quad \kappa = \frac{\nu}{1-\nu\theta}.$$

Respectively, cash-flows in the FDI mode with $\tau = 1$ result as

$$\Pi_F(\vartheta) = M_F \vartheta^{\kappa} \tag{3.9}$$
$$\text{with} \quad M_F = Z^{\frac{1}{1-\nu\theta}} \left(\frac{\nu\theta}{w_d} \right)^{\frac{\nu\theta}{1-\nu\theta}} (1-\nu\theta) \quad \text{and} \quad \kappa = \frac{\nu}{1-\nu\theta}.$$

With reference to recent trade models (Helpman et al. 2004; Yeaple, 2008) in the remainder we assume $\kappa \geq 1$. Periodical profits increase linearly or convexly in ϑ.

Furthermore, firm embedded productivity ϑ evolves exogenously over time as a stochastic process. Specifically, we assume a Geometric Brownian motion with

$$d\vartheta_t = \alpha\vartheta_t dt + \sigma\vartheta_t dz_t, \tag{3.10}$$

where dz_t is an increment of the standard Wiener Process satisfying $\mathbb{E}(dz) = 0$ and $\mathbb{E}(dz^2) = dt$. The annual growth rate is given by α. The instantaneous volatility is denoted by σ. In $t = 0$ a firm observes its current productivity level ϑ_0 and the random productivity in t is then ϑ_t. The solution of the previous stochastic differential equation can be written as

$$\vartheta_t = \vartheta_0 \; e^{\int_0^T (\alpha - \frac{1}{2}\sigma^2)dt + \int_0^T \sigma dz_t}. \tag{3.11}$$

Since $\ln \vartheta_t$ is normally distributed with

$$N \sim \left(\ln \vartheta_0 + (\alpha - \frac{1}{2}\sigma^2)t, \sigma^2 t\right), \tag{3.12}$$

the expected periodical profit growth results as

$$\mathbb{E}\left(\frac{M_i\vartheta_t}{M_i\vartheta_0}\right) = \exp(\alpha') \quad \text{with} \quad \alpha' = \alpha\kappa + \frac{1}{2}\kappa\sigma^2(\kappa - 1), \tag{3.13}$$

where α' is the trend rate of productivity growth which is adjusted for $\kappa > 1$.[7] For linear periodical profits ($\kappa = 1$) annual growth turns out to be equal to α. With reference to the capital asset pricing model (Sharpe, 1964), μ represents the appropriate return for an asset associated with the same risk pattern as represented by the Geometric Brownian motion (3.10). Therefore, in equilibrium the difference between the appropriate return μ and the growth rate α represents a firm's opportunity costs $\delta = \mu - \alpha$.

Accounting for $\kappa > 1$ the adjusted discount rate becomes

$$\delta' = r - (r - \delta)\kappa - \frac{1}{2}\kappa(\kappa - 1)\sigma^2. \tag{3.14}$$

[7] Appendix 3.7.1 presents the derivation of α'.

Within a Marshallian investment choice problem an investor compares the expected gross firm values $V_i(\vartheta)$ of the two entry modes with their respective entry fixed costs

$$V_i(\vartheta) - I_i^N = \int_0^\infty M_i \vartheta^\kappa e^{\alpha' t} e^{-\mu' t} dt - I_i^N \tag{3.15}$$

$$V_i(\vartheta) - I_i^N = \frac{M_i \vartheta^\kappa}{r - (r-\delta)\kappa - \frac{1}{2}\kappa(\kappa-1)\sigma^2} - I_i^N \tag{3.16}$$

$$\text{with} \quad \vartheta = \vartheta_0 \quad \text{and} \quad i \in \{E, F\}$$

and chooses the entry strategy with the highest net investment value. However, such an approach neglects influential aspects. Given fixed costs and the possibility of postponing the investment, each investment strategy is associated with an option value which needs to be accounted for. Additionally, besides the entry fixed costs I_i^N there exist furthermore by assumption abandonment benefits I_i^A which are taken into account before entering the market and which generate an option value enforcing to stay longer only in the domestic market or in the export market. We impose that $I_i^N > I_i^A$. Therefore, an appropriate framework derives the value function of all possible states, staying permanently domestic, being an exporter or foreign direct investor in a more complex way.[8] Due to numerical and analytical restrictions, in the remainder we present partial equilibrium results for relevant scenarios, independently.

3.4.1 Switching between Domestic and Foreign Market

Consider first a situation where a domestic firm intends to serve a foreign market. Given the possibility to switch between the inactivity and foreign market serving, there are two state variables, productivity and the serving state. To make this clear we denote the option value of the domestic firm as $V_D(\vartheta)$. It is referred to as an option since its value accounts only for possible returns associated with selling abroad. Sales on the domestic market are normalized to 0. The value of a firm, which serves the foreign market is then denoted by $V_i(\vartheta)$ and includes perpetual cash-flows and an option of exiting the foreign market if productivity decreases too far. The subscript i captures the two alternative serving modes, namely exporting and FDI, such that $i \in (E, F)$. Generally, the investor will stay only in the domestic market if productivity

[8] A formulation of all possible serving mode strategies within a single analytical framework results in a non-linear equation system which does not converge. Therefore, we split the optimization problems in subsets in order to present a partial equilibrium result.

stays between $(0, \vartheta_{hi})$ and keep on staying in the export state if productivity lies in between $(\vartheta_l, \vartheta_{hi})$.

The existence of these two critical productivity cut-offs which determine a firm's market entry and exit decision can be explained by the distinctive relevance of the accruing types of costs. According to the Marshallian investment rule an investor enters a new market if the periodical cash-flows cover both, periodical variable costs and annualized fixed costs:

$$\text{periodical cash-flows} = \text{variable costs} \; + \; I_i\delta. \tag{3.17}$$

As a consequence the market entry cut-off ϑ_{hi} is determined by both types of costs. On the other hand if the initial fixed costs are at least partly sunk, an investor will not exit a market if the state variable falls below the entry cut-off, since the fixed costs are sunk anyway. Due to the possibility of a future recovery of the state variable, in particular if it is assumed to develop stochastically, the exit cut-off ϑ_l will be therefore always lower than the entry cut-off. Implicitly, an investor is confronted with a band of inaction which lies in between these two cut-offs.

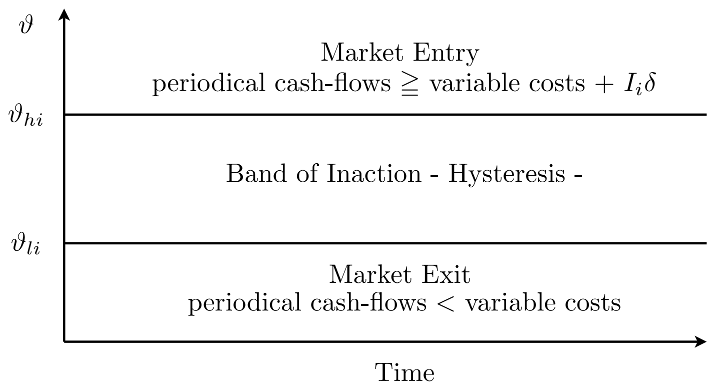


Figure 3.2: Hysteresis

This phenomenon depicted in figure 3.2 is known as hysteresis and generally defined as *"the failure of an effect to reverse itself as its underlying cause is reversed"* (Dixit, 1989).

Within the subsequent analysis, any market serving mode strategy will be influenced by the extent of this band of inaction which itself adjusts differently to changes in the accounted variables.

The derivation of critical productivity cut-offs and the value functions is achieved by applying the asset spanning method (Dixit 1994). The common differential equation for the option value

$V_D(\vartheta)$ results by constructing a portfolio which contains one unit of the option to invest, and a short position of $n = \frac{\partial V_D(\vartheta)}{\partial \vartheta}$ units of output:[9]

$$\frac{1}{2}\sigma^2\vartheta^2 V_D''(\vartheta) + (r-\delta)\vartheta V_D'(\vartheta) - rV_D(\vartheta) = 0 \tag{3.18}$$
$$\text{with} \quad V_D''(\vartheta) = \frac{\partial^2 V_D(\vartheta)}{\partial \vartheta^2} \quad \text{and} \quad V_D'(\vartheta) = \frac{\partial V_D(\vartheta)}{\partial \vartheta}.$$

The general solution to this equation is

$$V_D(\vartheta) = A_{1i}\vartheta^{\beta_1} + A_{2i}\vartheta^{\beta_2}. \tag{3.19}$$

A_{1i}, A_{2i} are constants which remain to be determined, whereas β_1 and β_2 are roots of the quadratic equation under risk neutral valuation, such that[10]

$$\beta_1 = \frac{1}{2} - (r-\delta)/\sigma^2 + \sqrt{\left((r-\delta)/\sigma^2 - \frac{1}{2}\right)^2 + 2r/\sigma^2} > 1, \tag{3.20}$$

$$\beta_2 = \frac{1}{2} - (r-\delta)/\sigma^2 - \sqrt{\left((r-\delta)/\sigma^2 - \frac{1}{2}\right)^2 + 2r/\sigma^2} < 0. \tag{3.21}$$

If productivity approaches zero, the option value of market entry approaches zero.
For this reason, the coefficient A_{2i} in equation (3.19) is equal to zero and the value of the domestic firm follows as

$$V_D = A_{1i}\vartheta^{\beta_1} \quad \forall \quad \vartheta \in (0, \vartheta_{hi}), \tag{3.22}$$

where ϑ_{hi} denotes the critical productivity level at which the firm switches from purely domestic activity to foreign market entry.
The value of the firm which serves the foreign market, V_i, consists of two components, namely the cash flows, $\frac{M_i\vartheta^\kappa}{\delta'}$, as derived earlier and the option value to abandon the foreign market if productivity falls too far. Thus, the value of the active firm has to suffice the stochastic differential equation

$$\frac{1}{2}\sigma^2\vartheta^2 V_i''(\vartheta) + (r-\delta)\vartheta V_i'(\vartheta) - rV_i(\vartheta) + \frac{M_i\vartheta^\kappa}{\delta'} = 0, \tag{3.23}$$

[9] We use Ito's lemma with $dV_D(\vartheta) = \frac{\partial V_D(\vartheta)}{\partial \vartheta}d\vartheta + \frac{1}{2}\frac{\partial^2 V_D(\vartheta)}{\partial \vartheta^2}(dx)^2$.
[10] Appendix 3.7.2 presents the derivation of these solutions.

with the general solution

$$V_i = B_{1i}\vartheta^{\beta_1} + B_{2i}\vartheta^{\beta_2} + \frac{M_i\vartheta^{\kappa}}{\delta'}. \tag{3.24}$$

If productivity rises enormously, the option to abandon the market is far out of the money, and thus tends to zero if $\vartheta \to \infty$. Therefore, the coefficient B_{1i} has to be equal to zero, and the value of the firm results as

$$V_i = B_{2i}\vartheta^{\beta_2} + \frac{M_i\vartheta^{\kappa}}{\delta'} \quad \forall \quad \vartheta \in (\vartheta_{li}, \infty), \tag{3.25}$$

where ϑ_{li} is the critical productivity level at which an exporter stops his exporting activity. In order to determine the market entry and exit cut-off productivity levels, ϑ_{hi} and ϑ_{li}, along with the coefficients A_{1i} and B_{2i}, we consider the value matching conditions: At the threshold ϑ_{hi}, a purely domestic firm will start to serve the foreign market and pay the fixed cost I_i^N if

$$V_D(\vartheta_{hi}) = V_i(\vartheta_{hi}) - I_i^N. \tag{3.26}$$

Smooth pasting requires that

$$V_D'(\vartheta_{hi}) = V_i'(\vartheta_{hi}). \tag{3.27}$$

An exporting firm will drop its activity and withdraw to serving solely the domestic market at the threshold ϑ_{li} if the following value-matching and smooth-pasting conditions are fulfilled:

$$V_i(\vartheta_{li}) = V_D(\vartheta_{li}) - I_i^A \tag{3.28}$$

$$V_i'(\vartheta_{li}) = V_D'(\vartheta_{li}). \tag{3.29}$$

Thus, by plugging in the state-dependent firm values as given in equations (3.22) and (3.25) into equations (3.26) to (3.29), we obtain a system of four equations in four unknowns, which is highly non-linear and can be solved numerically for the productivity cut-off values, at which a firm either enters or exits the export market:

$$\begin{aligned} \frac{M_i\vartheta_{hi}^{\kappa}}{\delta'} + B_{2i}\vartheta_{hi}^{\beta_2} - A_{1i}\vartheta_{hi}^{\beta_1} &= I_i^N & (3.30)\\ \frac{\kappa M_i\vartheta_{hi}^{\kappa-1}}{\delta'} + \beta_2 B_{2i}\vartheta_{hi}^{\beta_2-1} - \beta_1 A_{1i}\vartheta_{hi}^{\beta_1-1} &= 0 & (3.31)\\ \frac{M_i\vartheta_{li}^{\kappa}}{\delta'} + B_{2i}\vartheta_{li}^{\beta_2} - A_{1i}\vartheta_{li}^{\beta_1} &= -I_i^A & (3.32)\\ \frac{\kappa M_i\vartheta_{li}^{\kappa-1}}{\delta'} + \beta_2 B_{2i}\vartheta_{li}^{\beta_2-1} - \beta_1 A_{1i}\vartheta_{li}^{\beta_1-1} &= 0 & (3.33) \end{aligned}$$

This system allows us to solve numerically for the cut-off productivity levels of type I discontinuity: For $i = E$ ($i = F$), we obtain the productivity thresholds for market entry and exit of an exporter (FDI firm).

3.4.2 Switching between Export and FDI

Once an investor has decided to enter the foreign market as an exporter, he might experience a strong increase in productivity. In such a case, there exists a critical productivity level above which exporting is no longer the preferable market serving mode. Instead, at this critical productivity level ϑ_S, the firm is willing to sink additional mode switching cost I_S in order to serve the foreign market via FDI. In this case, the value of an exporting firm V_E comprises not only the export cashflows, but also the option value of the described mode discontinuity, such that

$$V_E = \frac{M_E\vartheta^{\kappa}}{\delta'} + C_1\vartheta^{\beta_1} \quad \forall \quad \vartheta \in (0, \vartheta_S). \tag{3.34}$$

Ruling out foreign market exit and switching back from FDI to exporting, the value of a firm which is in FDI mode is given by[11]

$$V_F = \frac{M_F\vartheta^{\kappa}}{\delta'} \quad \forall \quad \vartheta \in (\vartheta_S, \infty). \tag{3.35}$$

[11] A switch from FDI to export is considered to be irrelevant if additional sunk switching costs arise. Since the FDI mode's variable costs are the lowest achievable ones, there is no rational behind paying irreversible switching costs in order to pay higher variable costs.

Thus, the productivity cut-off ϑ_S at which an exporting firm switches its market serving mode can be determined from the value matching and smooth pasting condition

$$V_E(\vartheta_S) = V_F(\vartheta_S) - I_S \quad (3.36)$$

$$V_E'(\vartheta_S) = V_F'(\vartheta_S). \quad (3.37)$$

Plugging in firm values as represented in equations 3.34 and 3.35 yields

$$\frac{M_E \vartheta_S^\kappa}{\delta'} + C_1 \vartheta_S^{\beta_1} - \frac{M_F \vartheta_S^\kappa}{\delta'} = -I_S \quad (3.38)$$

$$\frac{\kappa M_E \vartheta_S^{\kappa-1}}{\delta'} + \beta_1 C_1 \vartheta_S^{\beta_1 - 1} - \frac{\kappa M_F \vartheta_S^{\kappa-1}}{\delta'} = 0. \quad (3.39)$$

From this system of equations, we determine numerically the productivity threshold at which an exporting firm stops exporting and serves the market as a foreign direct investor.

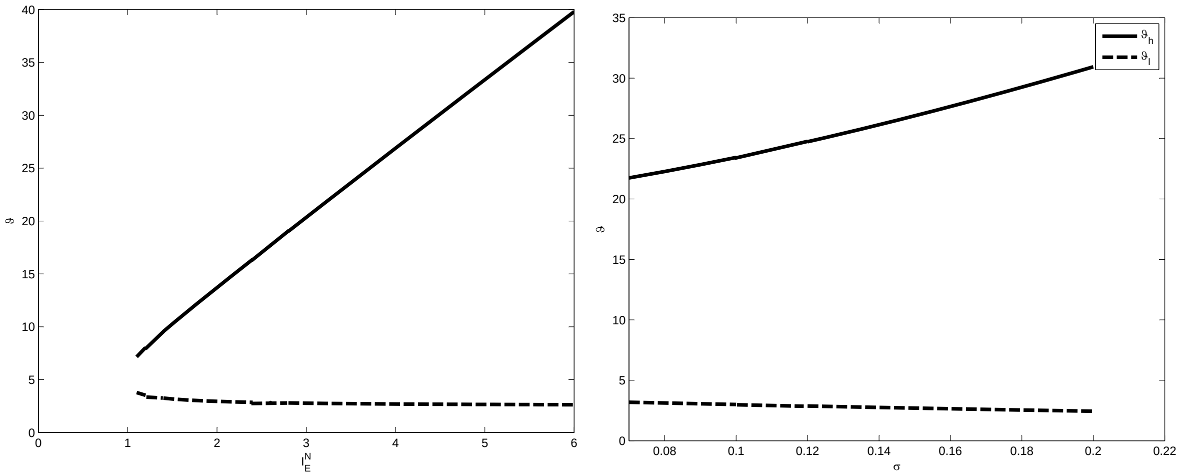
3.5 Numerical Results

Given the stochastic motion of firm productivity, the prevalence of serving mode discontinuities hinges on the extent of hysteresis, as depicted in figure 3.2. The further apart the critical level of productivity which triggers market entry is from the one which triggers market exit, the less likely it is that the firm reverts its initial choice. Importantly, our conclusions rule out to determine critical parameter values for fixed entry cost, competition, growth or volatility which distinguish a discontinuous from a continuous market serving behavior. Instead, we constrain our analysis to ceteris paribus considerations, thereby tracing the directional effect of fixed entry cost, competition, growth or volatility on the propensity to switch.

The resulting subsequent figures from numerical simulations can be interpreted in two different manners. Taking the single firm perspective the presented parameter ranges can be interpreted as a) comparative statics in order to derive a firm's possible serving mode adjustments. On the other hand, the range of defined parameter values can be interpreted as b) heterogeneity in fixed costs, productivity volatility and growth rates e.g. for different firms. In the same manner competition heterogeneity in ν can be considered to capture country specific market characteristics. This last interpretation comes closer to our initial stylized facts where we observed firms exhibiting type I discontinuity to a different extent, associated with different productivity patterns. In the remainder we allow for both perspectives.

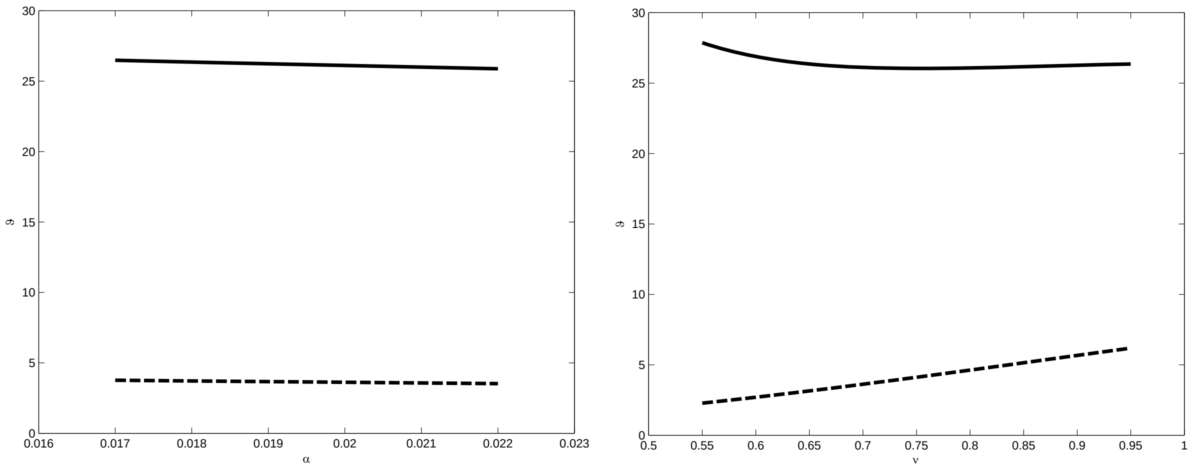
A serving mode discontinuity which includes all possible switches (Domestic → Export → FDI), needs to start necessarily with a scenario in which an investor serves a new foreign market through exports. Due to further changes in influential measures the next natural switch should then be the one into FDI. On the other hand initially an investor might need to choose directly between serving a new market through exports or FDI. Therefore, we first present the results on type I discontinuities and the differences for export and FDI specific cost structures. Once the differences are clarified, we demonstrate under which conditions an exporter would switch to the FDI serving mode.

Consider a firm for which FDI is never an interesting market serving mode, because the transport cost (and therefore the variable costs) of exporting remain below the critical $\bar{\tau}$. Under this assumption, for $I_F^N > I_E^N$, the firm would serve the foreign market as an exporter only. Whether the market serving is continuous or whether the firm switches in and out of the market depends on the level of the market entry cost, the growth rate and instantaneous volatility, as well as on the degree of competition on the foreign market. This scenario refers to the limiting considerations which are denoted by Ib in table 3.2.
Figure 3.3 depicts the cut-off productivity levels for exporting. The entry (exit) cut-off levels are drawn as a solid (dashed) line. As panel a) shows, the critical productivity level of market entry ϑ_{hi} increases in the fixed cost of market entry, whereas the market exit threshold ϑ_l stays at a similar level for the range of market entry cost. This implies that the region of hysteresis, i.e., the range between the cut-off values increases in I_E^N. That is, firms which exhibit high fixed cost of exporting, are less likely to serve the export market discontinuously (still under the assumption that FDI is not an attractive alternative). In the underlying parametrical example, once the market is entered e.g. at fixed costs of $I_E^N = 5$, productivity has to fall dramatically below the initial entry cut-off in order to generate serving mode discontinuity ($\vartheta_l = 4 < \vartheta_h = 31$). It is to emphasize that the fixed cost insensibility of the lower bound in the underlying example depends on the abandonment benefits which are at $I_E^A = -1$. In other words, one unit of the initial fixed costs can be liquidated on the foreign market (e.g. selling export specific firm entities). The



(a) $\theta = 0.7$, $\nu = 0.6$, $\tau = 20$, $\alpha = 0.02$, $r = 0.06$, $\sigma = 0.15$, $I_E^A = -1$

(b) $\theta = 0.7$, $\nu = 0.6$, $\tau = 20$, $\alpha = 0.02$, $r = 0.06$, $I_E^A = -1$, $I_E^N = 4$



(c) $\theta = 0.7$, $\nu = 0.6$, $\tau = 20$, $r = 0.06$, $\sigma = 0.15$, $I_E^A = -1$, $I_E^N = 4$

(d) $\theta = 0.7$, $\tau = 20$, $\alpha = 0.02$, $r = 0.06$, $\alpha = 0.02$, $I_E^A = -1$, $I_E^N = 4$

Figure 3.3: Export Discontinuity

lower the abandonment benefits turn out to be, the stronger decreases the exit threshold if the entry fixed costs increase.

Referring to the stylized facts from Denmark, one reason for the different extent of type I discontinuity can be found in the size of initial entry fixed costs and also in the degree of abandonment benefits.

Result 1:

The likeliness of type I discontinuity decreases in I_E^N. *The range of inaction increases further* *the lower the abandonment benefits* I_E^A *turn out to be. The lesser fixed costs* I_E^N *are sunk, the narrower becomes the range of hysteresis, with* $I_E^N = I_E^A \Rightarrow \vartheta_{lE} \rightarrow \vartheta_{hE}$.

Panel c) depicts the variation of productivity growth and its impact on the critical thresholds. Accordingly, firms with higher growth rates will experience a relative lower market entry level and simultaneously tolerate even lower exit cut-offs. This pattern coincide with economic intuition: ceteris paribus, higher productivity growth will allow a firm to cover the same fixed cost starting at a lower productivity level, which explains the lower ϑ_{hE}. On the other hand, once in the market, the investor can bear a stronger inverse productivity development since in the medium term he can expect a deterministic positive growth. It is important to emphasize that the effect of the growth rate α turns out to be not very strong, since the range of inactivity is reduced only mildly. Therefore, one can conclude that a heterogeneity in productivity growth in the export mode is not as strong an explanation for different extents of switching patterns over time as are the increasing fixed entry costs.

In contrast to α, the impact of varying volatility on the market entry and exit cut-offs is again much stronger. The higher the productivity volatility σ is, the higher becomes the entry cut-off ϑ_{hE}. Simultaneously, the exit threshold decreases. This result accords with the following intuition: a firm with high productivity uncertainty will tend to postpone the investment decision in order to gather further information on productivity development. This postponement is expressed in higher entry thresholds and represents a general real option result. Once in the market, higher volatility offers the chance to reverse an unfavorable productivity development and therefore an investor tolerates a stronger drop in productivity, which again explains the lower exit cut-offs. Similar to the fixed costs, the range of inactivity increases dramatically in σ.

Referring to the Danish firms, the extent of type I discontinuity in the wood and paper industry should not differ dramatically between different firms due to a low productivity uncertainty, as long as the firms exhibit similar fixed costs. In contrast, according to the underlying results, firms in the transport equipment sector which show a stronger productivity volatility over time, might exhibit different extents of market serving mode discontinuity, due to a higher variation in their resulting ranges of inactivity.

The impact of uncertainty on market serving mode discontinuity appears on the first sight conflicting but has a rational intuition. Firms with high productivity volatility countervail the prevailing risk by entering a market at high productivity levels. Implicitly, these firms enter markets after a longer postponement period. However, once in the market, a type I serving mode discontinuity becomes less likely, as a certain extent of uncertainty has been compensated by the higher entry cut-off.

Result 2:

Hysteresis is mildly influenced by a change in productivity growth α, but it reacts relatively stronger if productivity uncertainty σ increases. For $\sigma \uparrow$, the entry threshold ϑ_{hi} increases, and ϑ_{li} decreases, raising the probability of serving mode continuity.

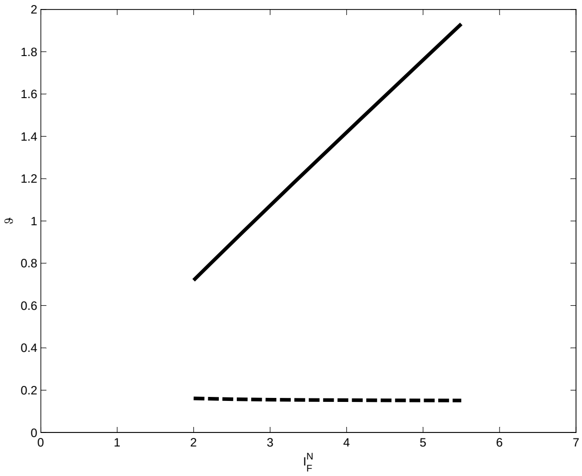
Furthermore, competition affects the serving mode continuity characteristics of exporting as depicted in panel d). Firms, which have little market power as revealed by a large inverse markup are prone to serve the market discontinuously as exporters, if confronted with volatile productivity growth - ceteris paribus. This is, because in countries with a high degree of competition, the band of inaction turns out to be relatively smaller than in countries with low competition. Therefore, in competitive markets any change in productivity over time generates a possible switch out of the serving mode in place. Importantly, the effect of competition on the region of hysteresis acts primarily through encouraging an earlier market exit.

Result 3:

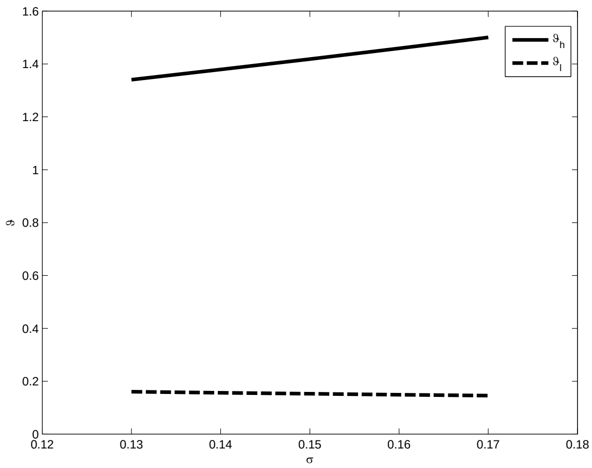
Higher competition is accompanied by weaker hysteresis whereas an increase in ν is followed by a mild decrease in ϑ_{hE} and a strong rise ϑ_{lE}.

Consider now a firm, for which exporting is no attractive alternative to FDI, since the export mode's variable costs are prohibitively high (higher than $\bar{\tau}$). Figure 3.4 depicts the cut-off productivity levels for market entry and exit as a function of fixed cost, volatility, productivity growth and market power. Note that the parameter constellation is the same as in figure 3.3, and that the cut-off values lie below the ones of exporting (ceteris paribus), because in the FDI mode no additional variable cost accrue. Concerning the mechanisms which incite either a continuous or a discontinuous market serving mode, they are the same as in exporting except the equilibria level: In a nutshell, higher fixed cost, higher volatility, a lower growth rate and less competition encourage a continuous market serving mode.

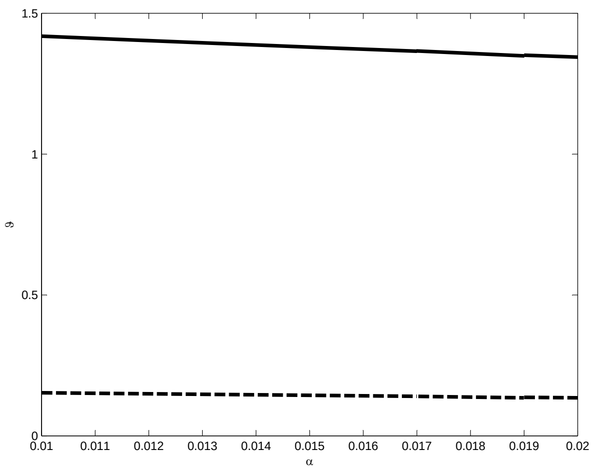
Whether an investor chooses to serve a foreign market initially through exports or FDI, can be easily derived by comparing the respective productivity cut-offs. Generally, it is the relative



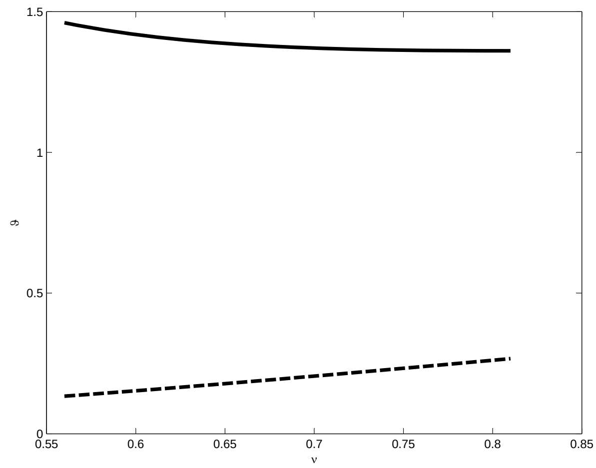
(a) $\theta = 0.7$, $\nu = 0.6$, $\alpha = 0.01$, $r = 0.06$, $\sigma = 0.15$, $I_E^A = -1$



(b) $\theta = 0.7$, $\nu = 0.6$, $\alpha = 0.01$, $r = 0.06$, $I_E^A = -1$, $I_E^N = 4$



(c) $\theta = 0.7$, $\nu = 0.6$, $\tau = 20$, $r = 0.06$, $\sigma = 0.15$, $I_E^A = -1$, $I_E^N = 4$



(d) $\theta = 0.7$, $\tau = 20$, $\alpha = 0.02$, $r = 0.06$, $\alpha = 0.02$, $I_E^A = -1$, $I_E^N = 4$

Figure 3.4: FDI Discontinuity

cost structure between the two possible serving modes, which determines the dominant serving mode for given parameter values. We do not deepen this choice problem as it is exhaustively analyzed in Yalcin (2009). In the remainder we discuss the likeliness of type II discontinuity.

Result 4:

If FDI is the only reasonable foreign market serving mode given $I_F^N > I_E^N$ and $\tau \geq 1$, the impact of changes in entry and exit fixed costs, productivity growth, uncertainty, and country specific competition is qualitatively the same as in the previous scenario, whereas quantitative effects *differ.*

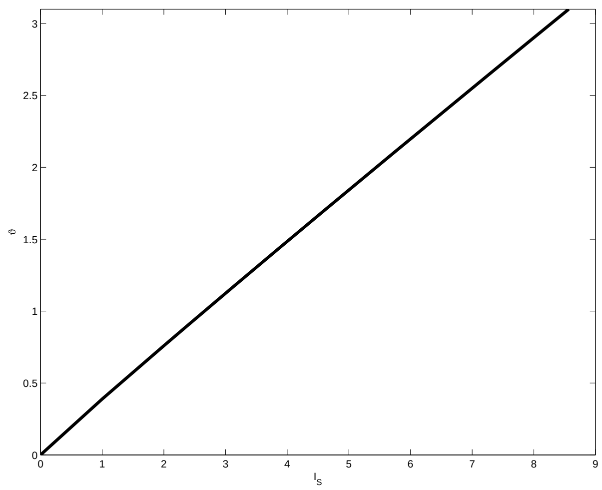
Finally consider a situation in which a firm is already serving a new foreign market through exports and contemplates switching into FDI as a new means of serving. In the following we shall address this type II discontinuity by solving the question how switching costs, volatility, productivity growth and competition do affect the continuity of a firm's market serving behavior. In principle, the investor is confronted with a mode switching problem as in the previous situation, where he had to decide on entering a new foreign market. The difference is that he is already in the foreign market and generates periodical cash-flows through exports.

Opposed to the earlier analysis, we neglect the FDI abandonment option and do not determine the exit threshold. That is, because we consider the FDI serving mode as the ultimate objective of any firm, since it exhibits the lowest achievable variable costs by paying sunk costs: in this case, incrementally first the export market entry cost I_E^N and then switching cost I_{EF}. We postulate, that within the proximity-concentration trade-off framework, once a market is served through FDI, an investor will never switch back to exporting, due to the fixed costs I_E^N and I_{EF} which are in large part sunk. Certainly, productivity might develop in such an adverse manner forcing the firm to leave the market forever. The corresponding nominal exit cut-off lies far below the two previous ϑ_{li} since the incurred sunk costs are on the highest possible level. In the remainder we focus on the critical switching cut-off ϑ_S within this type II discontinuity and omit the calculation of ϑ_{li}.

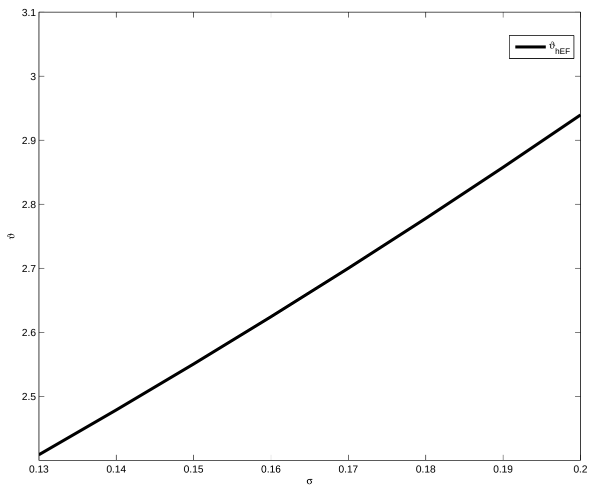
Fixed switching costs I_S for a change in serving mode from export to FDI are assumed to be higher than in a case in which firms start to serve the foreign market immediately through FDI. Although an investor might gather information as exporter and decrease e.g. marketing cost etc. still, periodical profits from the FDI serving mode need to cover the costs for a new plant $I_{EF}^N < I_F^N$ and furthermore the sunk costs of the export platform which is shut down after the serving mode switch:

$$I_S = I_{EF}^N - I_E^A + I_E^N, \tag{3.40}$$

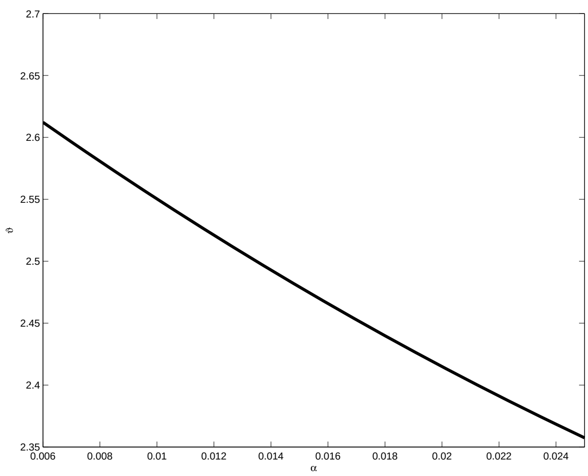
where I_{EF}^N are the fixed entry costs for FDI from an export mode. Within this setting, there is a trade-off between entering a foreign market stepwise through exporting and FDI earlier and entering directly through FDI at a later time. On the one hand, type II discontinuity reduces the inherent FDI entry costs from I_F^N to I_{EF}^N as an investor gains experience through exporting, but on the other hand the fixed cost reduction is achieved through an initial export investment which needs to be covered if it is given up later. Therefore, compared to a direct market entry through FDI, total accruing fixed costs will be higher but market entry as such will be earlier, achieved through exporting.[12]



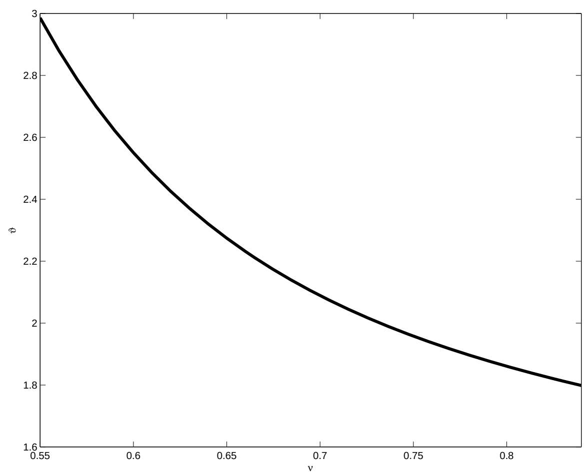
(a) $\theta = 0.7$, $\nu = 0.6$, $\alpha = 0.01$, $r = 0.06$, $\sigma = 0.15$, $\tau = 20$



(b) $\theta = 0.7$, $\nu = 0.6$, $\alpha = 0.01$, $r = 0.06$, $I_S = 7$



(c) $\theta = 0.7$, $\nu = 0.6$, $\tau = 20$, $r = 0.06$, $\sigma = 0.15$, $I_S = 7$, $I_E^N = 4$



(d) $\theta = 0.7$, $\tau = 20$, $\alpha = 0.01$, $r = 0.06$, $I_S = 7$

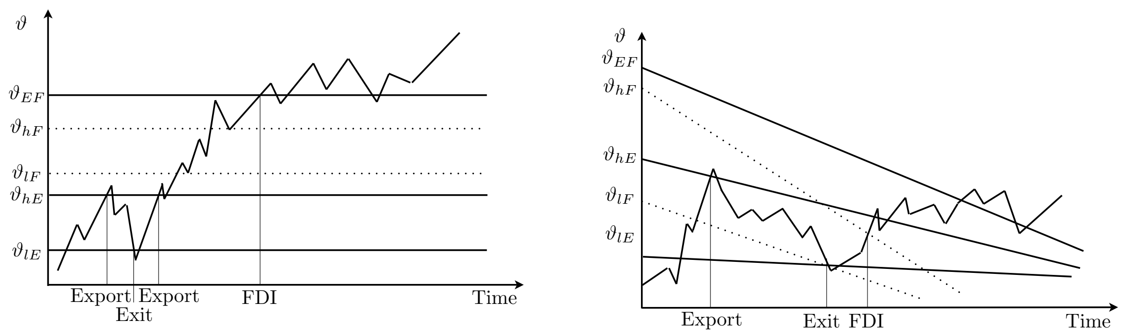
Figure 3.5: Type II Discontinuity: From Export to FDI

[12] There are alternative market serving modes which could appear as e.g. a simultaneous market serving through exports and FDI but this would necessitate a different frame of modeling.

Figure 3.5 shows that the productivity threshold for switching from exporting to FDI increases in the respective fixed cost I_S. This type of higher costs can be explained in two ways. Either abandonment benefits for the export platform worsen or the inherent FDI entry fixed costs rise, over time or across firms. The observed rise in the entry cut-off accords with economic intuition, as the investor has to cover higher sunk costs. In contrast higher productivity growth causes a reduction in the switching threshold ϑ_S which is in line with earlier observations. As the investor can cover a bigger share of fixed costs at higher growth rates over time he is willed to switch into FDI earlier. Both volatility in productivity growth and a rise in competition are accompanied by a decrease in market entry thresholds as before.

Result 5:

Qualitatively a type II discontinuity is influenced through changes in α, σ, ν and fixed costs I_S in the same way as a type I discontinuity. However, an adverse productivity development does never lead to a back switching into the export mode but causes a complete market exit.



(a) Export → FDI **(b)** Domestic → FDI

Figure 3.6: Sequence of Market Serving Mode

Panel a) in figure 3.6 presents a firm's productivity evolution over time within the proximity-concentration trade-off framework. In the underlying example, the export mode's comparative fixed cost advantage is higher than the FDI mode's comparative variable costs advantage. Therefore, the entry cut-off of exporting is below ϑ_{hF}. The only changing aspect in panel a) is the motion of productivity, all remaining influential parameters held constant. In such a naive world the exemplary firm would never consider a market entry directly through FDI, since the export entry cut-off always remains below the FDI entry cut-off. In the long run the firm might experience both type I and type II discontinuity, as in the graph.

Panel b) also represents a cost constellation which initially exhibits a dominant market entry cut-off for exporting, since it is the lowest one. With reference to the previous comparative static results, the cut-offs are assumed to change due to a decrease in fixed cost over time, which is not anticipated by the firm. A decrease of I_i^N reduces all the entry cut-offs and simultaneously the range of inaction. As a consequence, two effects are observed: a lower hysteresis band will increase the likeliness of type I discontinuity in the mid term. Secondly, in the long run the FDI mode's cut-off productivity will fall below ϑ_{lE} and the firm will choose to enter the foreign market directly through FDI. For the chosen parameter changes, an investor is only confronted with type I discontinuity.

	Entry cut-off		Exit cut-off		Hysteresis	Likeliness of serving mode discontinuity
	ϑ_{hE}	ϑ_{hF}	ϑ_{lE}	ϑ_{lF}		
$\alpha \uparrow$	$\downarrow$	$\downarrow\downarrow$	$\downarrow$	$\downarrow\downarrow$	$\downarrow$	$\uparrow$
$\sigma \uparrow$	$\uparrow$	$\uparrow\uparrow$	$\downarrow$	$\downarrow$	$\uparrow$	$\downarrow$
$I_i^N \uparrow$	$\uparrow$	$\uparrow\uparrow$	$\downarrow$	$\downarrow$	$\uparrow$	$\downarrow$
$I_I^A \uparrow$	$\downarrow$	$\downarrow$	$\uparrow$	$\uparrow$	$\downarrow$	$\uparrow$
$\nu \uparrow$	$\downarrow$	$\downarrow$	$\uparrow$	$\uparrow$	$\downarrow$	$\uparrow$

Table 3.3: Comparative Static Results
The stronger extent of adjustment in some FDI cut-offs are due to their relative lower variable costs within the proximity-concentration trade-off framework.

Depending on nominal cost levels and the extent of changes in α, σ, ν and I_i^j different market serving mode strategies and discontinuity types will result. Table 3.3 summarizes the derived results and allows the analysis of serving mode discontinuity for different scenarios.

3.6 Conclusion

Whether multinational enterprises serve new foreign markets through exports or FDI, has been analyzed in recent New New Trade models on the basis of the proximity-concentration trade-off framework which constitutes a higher comparative fixed cost advantage in the export mode and a comparative variable cost advantage in the FDI serving mode (Helpman et al., 2004). These types of models derive static firm distributions in steady states distinguishing exporting firms from foreign direct investors by means of cut-off productivity levels. However, the serving mode selection of firms which are confronted with dynamic state variables over time i.e. productivity, demand etc. can not be explained.

Empirically, two striking stylized facts support the introduction of dynamic elements into the mentioned static frameworks. Firstly, firm productivity which is considered to be distinctive in shaping the market serving mode of a firm, changes over time and exhibits a growth path similar to a stochastic process. Exemplary, we show productivity developments for several Danish manufacturing sectors. Secondly, there is evidence that internationally acting firms exhibit a high degree of dynamics in their market entry and exit behavior, either by switching between the initially chosen serving mode, e.g. exporting and not serving (type I discontinuity), or by changing the serving mode step by step from exporting to FDI (type II discontinuity), over time. Again we can demonstrate entry and exit patterns of Danish exporters supporting this statement.

Given these empirical observations we explain theoretically two aspects: First of all, we identify how uncertain productivity growth influences the serving mode decision of international firms confronted with the proximity-concentration trade-off framework. We develop a basic single firm model of timing and serving mode switching, by extending the concept of real option theory following Dixit (1989). Our setting allows for interpreting the equilibrium results as heterogeneous firms. Furthermore, we are able to identify four decisive dimensions which determine the extent of serving mode discontinuity in the presence of uncertain productivity growth. As in Dixit (1998) irreversible fixed costs generate hysteresis which represents the cause for different extents of serving mode discontinuity. Starting with a cost constellation in which a firm would choose to enter a new foreign market as an exporter we can show, that higher entry fixed cost lead to higher entry cut-offs increasing hysteresis and decreasing the likeliness of serving mode discontinuity. In the same line, higher volatility in productivity growth and lower competition in the destination country increase the range of hysteresis and reduce the probability of serving mode discontinuity. Productivity growth turns out to be less influential in the export mode compared with a type I discontinuity in the FDI mode.

After presenting numerically comparative static results we are able to analyze market serving mode discontinuity including the possibility of entering a market first as an exporter and switching afterwards into FDI. Our final results allow for directional effects of irreversible fixed costs, uncertain productivity growth and the degree of country specific competition. The last contribution of this model is the derivation of testable predictions on international serving mode patterns which - upon availability of appropriate firm level data - should open out into future empirical analysis.

3.7 Appendix

3.7.1 The Adjusted Expected Growth Rate

Given the Geometric Brownian motion

$$d\vartheta_t = \alpha\vartheta_t dt + \sigma\vartheta_t dz_t \tag{3.41}$$
$$\text{with} \quad dz_t = \epsilon_t\sqrt{dt} \quad \text{and} \quad \epsilon_t \sim N(0,1)$$

we define a function

$$f(\vartheta_t) = \vartheta_t^\kappa \qquad \text{and} \qquad \kappa \ln \vartheta_t = \kappa y_t \tag{3.42}$$

where y_t represents an arithmetic Brownian Motion. Therefore the exponential function $f(\vartheta_t)$ can be expressed as

$$\vartheta_t^\kappa = e^{\kappa y_t}. \tag{3.43}$$

The solution of y_t is

$$y_t = y_0 + \int_0^t (\alpha - \frac{1}{2}\sigma^2)ds + \int_0^t \sigma dz_s. \tag{3.44}$$

Therefore, the expected value of the exponential function $f(\vartheta_t)$ can be expressed as

$$\mathbb{E}(x_t^\kappa) = e^{\kappa y_0} e^{(\alpha - \frac{1}{2}\sigma^2)t\kappa} e^{\int_0^t \sigma dz_t}. \tag{3.45}$$

The last term in equation (3.45) still includes a random variable. By defining a moment generating function it is possible to evaluate its expected value.

Moment Generating Function

Consider a normally distributed random variable Z_t with

$$Z_t \sim N(m, \chi^2). \tag{3.46}$$

We can write

$$\mathbb{E}(e^{\kappa Z_t}) = \int_{-\infty}^{\infty} \frac{1}{\chi\sqrt{2\pi}}\, e^{\left(-\frac{(Z_t-m)^2}{2\chi^2}\right)}\, e^{\kappa Z_t} dz_t \tag{3.47}$$

$$= e^{\left(m\kappa + \frac{\chi^2\kappa^2}{2}\right)}. \tag{3.48}$$

In the underlying case $m = 0$ and $\chi = 1$. Furthermore the random variable in the Brownian motion is related to $\sqrt{t}$ with

$$dz_t = \epsilon_t \sqrt{t} \tag{3.49}$$

which leads to

$$\mathbb{E}(e^{\kappa\sigma Z_t}) = e^{\frac{\kappa^2\sigma^2 t}{2}}. \tag{3.50}$$

Therefore, applying this result to equation (3.45), the expected value of the exponential function $f(\vartheta_t)$ is given by

$$\mathbb{E}(\vartheta^{\kappa}) = e^{\kappa y_0} e^{(\alpha - \frac{1}{2}\sigma^2)t\kappa} e^{\frac{\kappa^2\sigma^2}{2}t}. \tag{3.51}$$

Using equation (3.43) the expected value results as

$$\mathbb{E}(\vartheta_t^{\kappa}) = \vartheta_0^{\kappa} e^{[\alpha\kappa + \frac{1}{2}\kappa\sigma^2(\kappa-1)]t}. \tag{3.52}$$

Finally, the expected cash-flows result as

$$\mathbb{E}(\Pi_i(\vartheta_t)) = M_i \vartheta_0^{\kappa} e^{[\alpha\kappa + \frac{1}{2}\kappa\sigma^2(\kappa-1)]t}. \tag{3.53}$$

The adjusted growth rate for convex profits with $\kappa > 1$ is then given by

$$\alpha' = \alpha\kappa + \frac{1}{2}\kappa\sigma^2(\kappa - 1). \tag{3.54}$$

3.7.2 Homogeneous Differential Function

The solution of a homogeneous differential function of second order

$$\frac{1}{2}\sigma^2\vartheta^2\frac{\partial^2 F_i(\vartheta)}{\partial\vartheta^2} + (r-\delta_u)\vartheta\frac{\partial F_i(\vartheta)}{\partial\vartheta} - rF_i(\vartheta) = 0 \tag{3.55}$$

is a linear combination of any two linearly independent solutions, as

$$A_i\vartheta^\beta. \tag{3.56}$$

Substituting this guess solution into the differential equation leads to the quadratic equation

$$\frac{1}{2}\sigma^2\beta(\beta-1)A_i\vartheta^\beta + (r-\delta)\beta A_i\vartheta^\beta - rA_i\vartheta^\beta = 0 \tag{3.57}$$

$$\frac{1}{2}\sigma^2\beta(\beta-1) + (r-\delta)\beta - r = 0. \tag{3.58}$$

The resulting two solutions for β are

$$\beta_1 = \frac{1}{2} - \frac{r-\delta}{\sigma^2} + \sqrt{\left[\frac{r-\delta}{\sigma^2} - \frac{1}{2}\right]^2 + \frac{2r}{\sigma^2}} > 1 \tag{3.59}$$

$$\beta_2 = \frac{1}{2} - \frac{r-\delta}{\sigma^2} - \sqrt{\left[\frac{r-\delta}{\sigma^2} - \frac{1}{2}\right]^2 + \frac{2r}{\sigma^2}} < 0 \tag{3.60}$$

and the final solution for the quadratic equation is

$$F_i(\vartheta) = A_{i1}\vartheta^{\beta_1} + A_{i2}\vartheta^{\beta_2}. \tag{3.61}$$

3.8 Matlab Code

The code is structured as follows: The main programm defines parameter values and a loop for the respective variables which are used in our comparative statics.[13] Furthermore, it calls the function which contains the system of equations to be solved using the Matlab function *fsolve*.

3.8.1 Main Programm

```
%Hiller, Yalcin: The Discontinuity of Foreign Market Serving Modes
%Numerical Solution Entry and Exit to/from FDI (exporting), July 2009

%This program determines the productivity cut-off levels for entry/exit
%to/from FDI.

%Input: Parameter Values
%Output: FDI cut-off thresholds and option values coefficients

%function used: sol_fdi

clear;
clc

%Definition of Parameters
Z = 1;
theta = 0.7;
mu=0.6;
tau = 20;
w = 1;
alpha = 0.01;
r = 0.06;
rho = r;
delta = rho - alpha;
sig = 0.15;
I_A = -1;
```

[13] For the sake of generality, the loop is not displayed here.

```
kappa = nu/(1-nu*theta);
alpha_ad = kappa*alpha + 0.5*kappa*sig^2*(kappa-1);
delta_ad = r - (r-delta)*kappa - 0.5*kappa*(kappa-1)*sig^2;

b = r/alpha;
if b <= kappa;
display 'Error in Parameter Constellation'
break
end

if kappa < 1
break
display 'kappa < 1'
end

%Export Cashflows;
M_E =  Z^(1/(1-nu*theta))*nu*theta/(w*tau^(1/theta))^(nu*theta/(1-nu*theta))*
(1-nu*theta);
%FDI Cashflows
M_F =  Z^(1/(1-nu*theta))*nu*theta/(w)^(nu*theta/(1-nu*theta))*
(1-nu*theta);

%Roots of Quadratic Equation;
beta_1 = 1/2 - (rho - delta)/sig^2
+ sqrt(((rho-delta)/sig^2-1/2)^2+2*rho/sig^2);
beta_2 = 1/2 - (rho - delta)/sig^2
- sqrt(((rho-delta)/sig^2-1/2)^2+2*rho/sig^2);

%Error message for invalid parameter constellation;
if beta_1<=1||beta_2>=0;
display 'Error in Parameter Constellation'
end
save setting;

x0 = [5 22 3 1];
```

```
options = optimset('LevenbergMarquardt','on','TolFun',1e-8, 'Display','iter');
[x,fval, exitflag] = fsolve(@sol_fdi,x0,options);
```

3.8.2 Fsolve Procedure: Type I Discontinuity

```
function F = sol_fdi(x)

load setting;

% x(1):  v_h
% x(2):  a1
% x(3):  b2
% x(4):  v_L

F=[(M_F*x(1)^kappa)/delta_ad + x(3)*x(1)^beta_2 - x(2)*x(1)^beta_1 - I_F;
kappa*(M_F*x(1)^(kappa-1))/delta_ad + beta_2*x(3)*x(1)^(beta_2-1)
- beta_1*x(2)*x(1)^(beta_1-1);

(M_F*x(4)^kappa)/delta_ad + x(3)*x(4)^beta_2 - x(2)*x(4)^beta_1 + I_A;
kappa*(M_F*x(4)^(kappa-1))/delta_ad + beta_2*x(3)*x(4)^(beta_2-1)
- beta_1*x(2)*x(4)^(beta_1-1)];

clear setting;
```

3.8.3 Fsolve Procedure: Type II Discontinuity

```
function F = sol_noexit(x)

load setting;
% x(1):  v_h
% x(2):  a1

F=[(M_E*x(1)^kappa)/delta_ad + x(2)*x(1)^beta_1  -
(M_F*x(1)^kappa)/delta_ad + I_S;
kappa*(M_E*x(1)^(kappa-1))/delta_ad+beta_1*x(2)*x(1)^(beta_1-1)-
kappa*(M_F*x(1)^(kappa-1))/delta_ad];
clear setting;
```

CHAPTER 4

Market Access Through Bound Tariffs

4.1 Introduction

The lions share of tariff lines affected by WTO agreements are regulated in terms of bound tariffs, i.e tariff ceilings on applied tariff rates. Bound tariffs are often substantially larger than applied tariff rates.[1] Today, the unweighed average – across 153 current WTO members – of the binding overhang amounts to 23 percentage points and for some WTO members their binding overhang measures more than 100 percentage points.[2] As a result WTO negotiations, including membership negotiations, may agree on bound rates that, even after implementing a newly agreed reduction, are above or at the current applied rates, see Evenett (2007) or Bchir et al.

This paper is a joint work with Davide Sala and Philipp Schröder from Aarhus University. The concept was developed jointly, theoretical analysis and writing were equally shared. The editors of the *Scottish Journal of Political Economy* have decided to accept a revised version of the paper. We have benefited from comments of participants on the CESifo Summer Institute Conference "Operating Uncertainty Using Real Options". In particular, we thank Giuseppe Bertola and Michael Funke and are grateful for CESifo's financial sponsorship. Philipp Schröder acknowledges financial support from the Danish Social Sciences Research Council (grant no. 275-06-0025). The usual disclaimer applies.

[1] Various reasons for this phenomenon have been identified, for example dirty tariffication, the value of unused protection, arbitrary ceiling bindings for developing countries, see Walkenhorst and Dihel (2003), Bchir et al. (2006), Anderson and Martin (2005) for detailed discussions.

[2] The binding overhang is here calculated as the simple average of 2007 final bound ad valorem duties of all bound tariff lines minus the simple average of MFN applied ad valorem duties for the same tariff lines (defined at the HS six-digit level), the data used stems from the WTO's World Tariff Profiles, 2007. See Bchir et al. (2006) for a detailed discussion and calculations of binding overhang.

(2006).

The question, that arises, is how such reductions in bound rates, even when ineffective in terms of lowering current applied rates, can generate market access, i.e. the fundamental goal of the WTO. Or put differently, why such tremendous effort is expanded on WTO negotiations that agree on bound tariffs that may be so substantially higher than applied rates, that hardly any exporter will ever face the agreed bound tariff in reality.[3] The fundamental driver is that bound tariffs can reduce the risk that exporters face on destination markets. Reduced risk on export markets – through bound tariffs and other mechanisms – is known to have substantial effects on trade and country welfare, see for example Van Winncoop (1992), Francois (2001) or Francois and Martin (2004). In an uncertain policy environment with potential changes in the protectionist stance of a given country, tariff bindings reduce the risk that exporters face. Figure 4.1 illustrates the relation between risk and the size of the binding overhang (see footnote 2 for a discussion of the data). As the fundamental arguments concerning bound tariffs and risk would suggest, riskier countries appear to have larger gaps between bound rates and applied tariff rates.

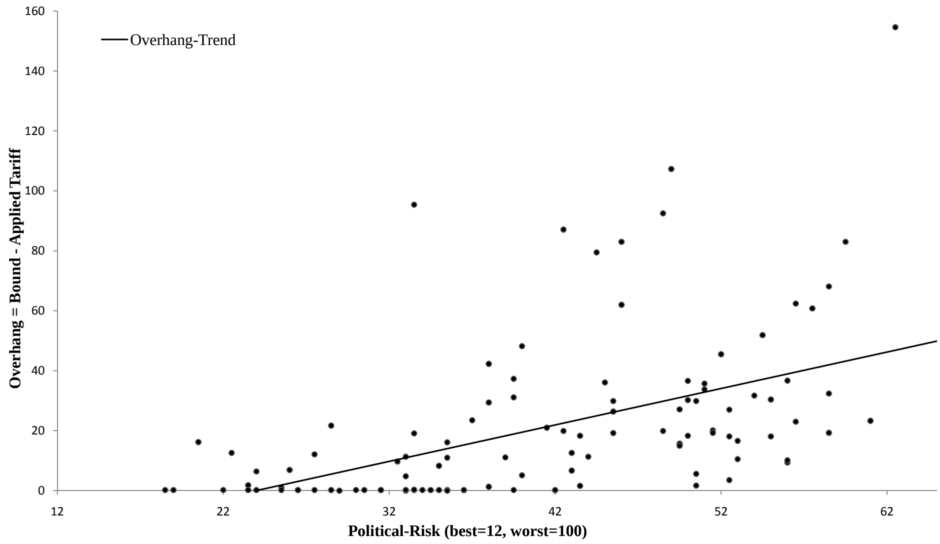


Figure 4.1: Tariff Overhang.

A one sided reduction in the volatility of trade policy may in effect appear like a reduction in

[3] See Evenett (2008) for an instructive account of the differences between the economic reasoning and political or legal reasoning in WTO negotiations. In fact, it might be the case that the focus on bound tariffs is justified by the mere fact that they are easier to negotiate compared to applied rates, see also Hoekman and Vines (2007).

expected future tariffs. However, given that current applied tariffs stay unaltered, such risk reductions can in standard market environments have no direct effect on the current prices that exporters charge on their destination markets. Thus, from the perspective of destination market consumers, reductions in bound tariffs have no effect on prices and hence the demand for and sales volume of a given product, i.e. tariff bindings above applied rates are unable to generate market access via the intensive margin of trade. Accordingly, the effect of bound tariffs on market access must be sought at the extensive margin of trade, i.e. it must stem from the export market entry decision of firms. Here a risk reduction may alter the expected profit flows and thus affect the entry calculation of potential exporters. For example, within the well known Melitz (2003) model, an increase in profits from exports, via a reduction of the average tariff, would clearly affect firm entry via movements of the exporters productivity cut-off. Yet, the focus on steady-state equilibria and general equilibrium in this and related mainstream models of international trade makes it difficult to examine the inherently dynamic timing problems of export market entry and bound tariffs.

Against this background the current paper designs a dynamic, partial equilibrium model of export market entry, dealing with the timing of entry in dependence on risk of the trade policy path in the destination market, reduction in risk via tariff bindings, and firms' fixed export market entry costs. The central driver is that potential exporters to a given destination market can delay market entry and react to the risk reductions generated by bound tariffs. We build our formal model on tools well rehearsed in the real options literature, following Dixit and Pindyck (1994). Finally, we include the feature of firm heterogeneity, in the tradition of Melitz (2003), to derive results for actual effects on market access, i.e. determining the movements of the export entry productivity cutoff in reaction to changes in the bound tariff rate and other market characteristics. In particular, the model is able to track the rescheduling (in fact a preponement) of export market entry triggered by bound tariffs, i.e. the effect that bound rates influence market entry such that some firms access earlier into the export destination, compared to a situation without bindings.

From this model we are able to derive a series of findings concerning the effect of bound tariffs and reductions in bound rates depending on the size of the binding overhang and other market characteristics. We find, that bound tariffs are more effective with higher risk destination markets, that a large binding overhang may still command substantial market access, and that reductions in bound tariffs generate effective market access even when bound rates are above current and long-term applied rates.

The paper perhaps closest to the present work is Francois and Martin (2004), who are the only previous theoretical paper providing a model of the effect of bound tariffs. Yet their focus is on the cost of protection and not on the effects of bound tariffs on the timing of firms' export market entry decisions, which are at the center of the present analysis. Also Francois and Martin (2004) operate from a country perspective and provide general equilibrium assessments, while we are able to consider the role of single firms in more detail, following the seminal contribution of Brander and Spencer (1984a,b), yet at the price of staying within a partial equilibrium framework.

The next section develops a basic single firm model of the timing of export market entry building on concepts from the real options theory following Dixit and Pindyck (1994). In Section 4.3 we extend this framework to include a continuum of heterogeneous firms and present our central results for the effects of bound tariffs on market access. Section 4.4 concludes.

4.2 The Model

In this section we model a single firm, having to decide upon entry into a new risky foreign market for its product. Competition among firms is not modeled explicitly, instead we follow Bertola (1998) and characterize the degree of competition in the potential export market through an iso-elastic demand function given by:

$$p = Zy^{\mu-1}, \quad 0 \leq \mu \leq 1 \tag{4.1}$$

where p represents the price of a firm's output y offered in the destination country. μ is indexing the market power of the firm, as for $\mu = 1$ the demand curve is horizontal (i.e. the market is perfectly competitive), whereas for $\mu \neq 1$ the demand function is negatively sloped. Z is a shift factor, including for instance factors like the income or the size of a country.

An *ad valorem* tariff τ is levied on the firm´s product, introducing a discrepancy between p^C, the price paid by a foreigner consumer and p^F, the price received by the firm, with

$$p^F = \frac{p^C}{(1+\tau)}, \quad \tau \geq 0. \tag{4.2}$$

The firm maximizes the per-period cash flow (the time subscript t is omitted to save notation as all variables are at t),

$$\pi = \max_{y \geq 0} \quad p^F y - c(w, y) \tag{4.3}$$
$$\text{s.t.} \quad p^C = Zy^{\mu - 1} \quad \text{and} \quad p^F = \frac{p^C}{(1+\tau)}, \quad \tau \geq 0$$

where $c(w, y)$ is a general cost function of a bundle of inputs describing the technology of the firm. For illustrative purposes and without loss of generality, we specify the cost function – similarly to Dixit and Pindyck (1994) – to be:[4]

$$c(w, y) = \frac{wy^{\frac{1}{\theta}}}{\phi}, \quad \theta \leq 1 \tag{4.4}$$

where w is the wage prevailing on the labor market, ϕ is the labor productivity and $\theta \leq 1$ indicates diminishing marginal return in the factor labour. Hence, the maximum per-period profit flow of the firm is,

$$\pi(\tau) = B \left(\frac{Z}{1+\tau} \right)^k \left(\frac{\phi}{w} \right)^{\mu\theta k} \tag{4.5}$$

with $k = \frac{1}{1-\mu\theta}$ and $B = (1 - \mu\theta)\,(\mu\theta)^{\mu\theta k}$. Note that it depends inversely on the ad-valorem tariff, $\partial\pi/\partial\tau \leq 0$, so that the trade policy in place in the foreign market will play an important role in the entry decision of the firm.

Given the time dynamics of the situation, τ is regarded as the expected *ad valorem* applied tariff in the foreign market. The expected tariff is composed of a low currently applied tariff τ_l (including a future liberalization path) to which the government commits and an alternative high tariff τ_h (also including an associated future tariff path). Even though initially the country in question is at the low tariff path, the government could resort to the high tariff path in the future, such a shift towards a protectionist stance could for instance be caused by unfavorable market conditions, a lack of credibility, political pressures, new political elections, etc. We capture the well established argument of "*time inconsistency*" of trade policy and assume that such policy shift towards the protectionist tariff-path occurs with (an exogenous) probability of

[4] This cost function corresponds to the technology $y = (\phi\ l)^{\theta}, \quad \theta \leq 1$. See also Dixit and Pindyck (1994).

γ, which is our measure of firm-risk into the new exporting market.[5]

The gradual tariff liberalization process to which the local government commits is described by (4.7). Yet, the firm is uncertain on possible policy reversion toward a more protectionist policy in the future, implying $\alpha_h < \alpha_l$.[6] Therefore, the two tariffs of interest can be modeled as follows:

$$\text{Applied Tariff} = \begin{cases} \frac{d\tau_l(t)}{dt} = -\alpha_l \tau_l(t), & \alpha_l \geq 0, \text{with probability } 1-\gamma \\ \frac{d\tau_h(t)}{dt} = -\alpha_h \tau_h(t), & \alpha_h \geq 0, \text{with probability } \gamma, \end{cases} \tag{4.7}$$

and the Bound Tariff is given by

$$\frac{d\tau_\beta(t)}{dt} = -\alpha_\beta \tau_\beta(t), \quad \alpha_\beta \geq 0. \tag{4.8}$$

Notice that the above tariff paths ultimately approach free trade, yet the framework can easily accommodate other scenarios as described in footnote (6). In the appendix 4.5.1 we find the solution to the homogenous differential equations (4.7) and (4.8) as:

$$\tau_j(t) = b_j e^{-\alpha_j t}, \qquad j = l, h, \beta. \tag{4.9}$$

The variable b denotes the vertical intercept indicating the starting level of protection, so that $b = 1$ is an initial *ad-valorem* tariff of 100%.

The uncertainty of a protectionist tariff jump can be limited by the presence of a bound-tariff, τ_β - the maximum tariff level a government can legally impose - negotiated multilaterally or

[5] See for example Staiger and Tabellini (1987) .

[6] It is possible to model the different tariff paths by defining an

$$\text{Applied Tariff} = \begin{cases} \frac{d\tau_l(t)}{dt} = -\alpha_l \tau_l(t) + c_l, & \alpha_l \geq 0, \text{with probability } 1-\gamma \\ \frac{d\tau_h(t)}{dt} = -\alpha_h \tau_h(t) + c_h, & \alpha_h \geq 0, \text{with probability } \gamma \end{cases}$$

$$\text{and a Bound Tariff } = \frac{d\tau_\beta(t)}{dt} = -\alpha_\beta \tau_\beta(t) + c_\beta, \quad \alpha_\beta \geq 0.$$

Such a setting would allow us to model the tariff paths converging to any target tariff rate c_l, c_h and c_β including the possibility for the government to rely on export subsidies in the future, for $c_j < 0$ with $j = l, h, \beta$. Appendix 4.5.1 derives the solution to these tariff paths as

$$\tau_j(t) = \frac{c_j}{\alpha} + b_j e^{-\alpha_j t}. \tag{4.6}$$

We restrict our focus to the case of a tariff path converging eventually to the free trade and assume henceforth $c_j = 0$.

bilaterally at the WTO table. We focus on the empirical relevant case of $\alpha_\beta = 0$ in (4.8), a flat ceiling tariff or barrier tariff, while $\alpha_\beta > 0$ would also indicate a decaying reduction of the bound tariff with time.[7]

Consistently with overwhelming recent evidence, the firm must occur a sizeable upfront entry fixed cost F_e to enter into the new export market.[8] As a consequence of forward looking behavior, it also anticipates that the per-period cash flow grows over time as the tariff rate decays at rate α_j each year, while F_e is unchanged and incurred only in the investment period. Therefore, by postponing entry, the firm can achieve a greater profitability because of the announced tariff cuts. In this paper, we propose the firm can delay entry and choose the optimal timing of entry into the exporting market. After a waiting time of T periods, entry can only be optimal provided the value of the firm V exceeds the fixed cost of entry,

$$V(\tau, T, t_0) = \int_{t_0+(T-t_0)}^{\infty} [(1-\gamma)\pi(\tau_l(s)) + \gamma\pi(\tau_j(s))]e^{-r(s-t_0)}ds \geq F_e e^{-r(T-t_0)} \tag{4.10}$$

with$j = h, \beta$.

Note that if $T = t_0$ (i.e. entry occurs in the initial period), equation (4.10) is the Marshallian entry condition simply implying entry if the expected present discounted value of the stream of profits at t_0 exceeds the fixed cost; if satisfied with equality, it is the standard free entry condition when firms have no option to postpone entry. However, if entry can be delayed, waiting extra periods turns valuable to benefit from further anticipated tariff cuts. The optimal waiting time is thus determined:

$$\max_T \qquad W(T) \equiv V(\tau, T, t_0) - F_e e^{-r(T-t_0)} \tag{4.11}$$

yielding the following FOC which makes use of the Leibnitz rule (see Appendix 4.5.2):

$$\frac{\partial W(T)}{\partial T} = -[(1-\gamma)\pi(\tau_l(T)) + \gamma\pi(\tau_j(T))]e^{-r(T-t_0)} + F_e e^{-r(T-t_0)}r = 0, \quad j = h, \beta.$$

Rearranging it, we obtain the Jorgensonian rule, equating the marginal profit forgone with

7 In the terminology of the exchange rate literature, a positive α_β would be a "crawling peg".

8 See for example Tybout et. al. (2007), Bernard et. al. (2003), Melitz (2003).

additional waiting to the per period fixed entry cost,[9]

$$E\pi(T) \equiv [(1-\gamma)\pi(\tau_l(T)) + \gamma\pi(\tau_j(T))] = F_e r, \quad j = h, \beta. \tag{4.12}$$

This rule best balances the trade-off at the heart of the *Real Option Approach* between benefiting by waiting (for further announced tariff cuts) on one hand, and the forgone profit opportunities in case of earlier entry into the market on the other hand. Substituting for (4.5) and rearranging we obtain an implicit equation for the entry time $t_0 + T$,

$$BZ^k \left(\frac{\phi}{w}\right)^{\mu\theta k} \left[(1-\gamma)(1+\tau_l(T))^{-k} + \gamma(1+\tau_j(T))^{-k}\right] = rF_e, \qquad j = h, \beta. \tag{4.13}$$

For the sake of convenience we define $t_0 = 0$ which leads to an entry time equal to the waiting time T. The implications for the optimal entry time T are best explained with the help of figure 4.2. The $\pi(\tau_l(T))$ curve represents the highest possible per-period cash flow earnable only in the low-tariff scenario, while the $\pi(\tau_h(T))$ curve represents the lowest possible cash-flow occurring in the high-tariff scenario, i.e. reversion to a protections stance. The vertical distance of these two curves represents what we could define as the "*risk band*", the potential deviation from the current tariff path. Note that the firm´s periodical cash-flow is increasing with time along these curves because of the declining tariff rate, i.e. continuing liberalization. The LHS of (4.13) is the expected periodical cash-flow among these two plausible scenarios and is depicted as the S-shape dashed curve denoted by $E\pi(T)$. By definition, it lies necessarily within the risk band. The intersection of this curve with the flat curve rF_e (the RHS of (4.13)), determines the optimal entry time, T_γ. Clearly, the optimal entry time will depend on firm and market characteristics; it will be earlier for higher productivity firms (higher ϕ) and larger foreign income Z (both shifting the $E\pi(T)$ curve up), or lower export market entry costs F_e (shifting the rF_e curve down). Finally, a reduction of the risk γ the firm is facing, results in an upward shift of the $E\pi(T)$ curve and hence, earlier entry.

Let us turn to the role of the bound tariff in reducing the firm´s risk. In presence of a bound tariff, $\tau_\beta = b_\beta$ is the highest possible applied tariff a government could resort to. Such tariff-ceiling translates into a floor for the per-period cash flow, so that the lowest possible cash-flow

[9] See Jorgenson (1963).

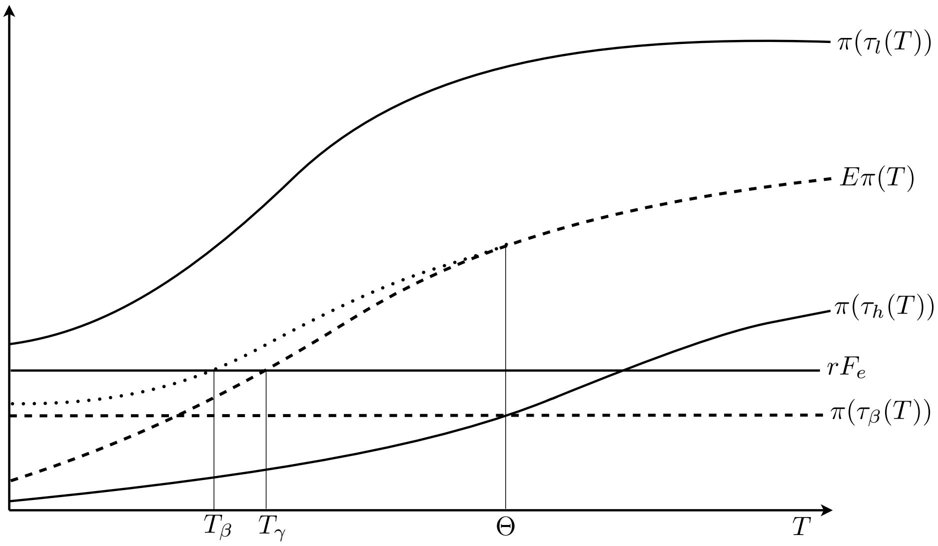


Figure 4.2: Bound Tariff and The Timing of Market Entry

in the protectionist tariff scenario is modified to be the envelope between the $\pi(\tau_h(T)$ curve and $\pi(\tau_\beta(T)$ dashed flat curve. For time $T > \Theta$, the bound tariff loses its effectiveness, as it is above τ_h, the protectionist tariff level at that time. The first implication is that a fixed bound tariff can not possibly affect the entry decision of a firm when it is higher than the highest conceivable applied tariff. Second, a bound tariff has no role on the timing of entry if the market conditions are such that the optimal entry time $T_\gamma > \Theta$ falls into the non-effectiveness region of a bound tariff. In other words, firms that are planning on market entry at a point in time in the future when even the protectionist tariff is below the bound tariff. The reason being that the tariff ceiling does not bound any risk of a policy reversion. However, a bound tariff affects positively the entry decision by a firm if $T_\gamma < \Theta$. In this case, the cash-flow floor raises the expected per period cash-flow shifting upward the $E\pi(T)$ curve and determining a shorter entry time into the market, $T_\beta < T_\gamma$, because the bound tariff has bound the possible tariff increment.

These findings lead to the following

Proposition 1. *A flat bound tariff* $\tau_\beta = b_\beta$ *implies (i)* $T_\beta = T_\gamma$*, if* $\tau_\beta \geq \tau_h \forall\ T$ *(ii)* $T_\beta = T_\gamma$*, if* $\tau_\beta \leq \tau_h$ *and* $T_\gamma \geq \Theta\ \forall\ T$ *(iii)* $T_\beta < T_\gamma$*, if* $\tau_l \leq \tau_\beta \leq \tau_h$ *and* $T_\gamma \leq \Theta\ \forall\ T$ *(iv)* $T_\beta < T_\gamma$*, if* $\tau_\beta \leq \tau_l\ \forall\ T$.

There are several contributions in this finding. First, we highlight firm entry as a channel by which the bound can be effective. Proposition 1 shows that a reduction in the bound tariff τ_β, which is not affecting the applied tariff directly, will generate market access even if τ_l is well below the bound. This appears to be in contrast to discussions taking place at WTO negotiations, where parties frequently deduce that only cuts in bound rates below current applied tariff rates can generate market access, see Evenett (2007) for an account of current negotiations. Second, the effectiveness region, here delimited by Θ, crucially depends on two factors, namely the design of the bound tariff and the width of the risk band. If the bound tariff were engineered as a "crawling peg", decaying at positive rate α_β instead of being just a ceiling tariff, its effectiveness would not be time restricted. This highlights why negotiations about reductions in bound rates might in fact be driven by reductions in applied rates and not the other way around. Third, to generate any market access, the bound tariff has to be below the highest possible applied tariff rate and, therefore, the larger the risk band (i.e. the riskier the country), the greater the likelihood that a particular bound tariff level results effective. It emerges an interesting positive relation between the risk level of a country (τ_h) and the level of bound tariff required to reduce uncertainty. This relation is best explained referring again to figure 4.2, and thinking of the area within the "risk band" as a continuum of possible bound-tariffs. The larger the area between the low-bound of the risk-band and the curve E_τ, the greater the number of bound tariffs that result binding. Or, the higher the risk level of a country, the higher the level of bound tariff sufficient to limit uncertainty. In other words, contrary to countries characterized by a low degree of risk, risky countries can resort also to high bound tariffs to attenuate risk.

4.3 Implications for Market Access

While the above framework has derived results in terms of the decision of a single firm, we are now able to move towards the implications for actual market access. Consider a continuum of potential entries into the market in question, this may be already active exporters – exporting into alternative destination markets – or pure domestic firms from various foreign countries. Furthermore, assume that all the potential entries into the market from above (home) face identical fixed export market access cost, F_e, but have different and firm specific productivities ϕ, as in Melitz (2003). Than for each point in time there exists a critical $\phi^*(t)$ such that firms with a lower productivity will not have accessed the market, while firms with higher productivity will have entered. Accordingly, changes in $\phi^*(t)$ are than a measure of market access.

Totally differentiating both sides of equation (4.13) with respect to b_β, ϕ, F_e and Z, gives the change in the optimal entry time for a small perturbation of the constellation of parameters:

$$\begin{aligned}(1-\gamma)k\alpha_l\tau_l(T)(1+\tau_l(T))^{-(k+1)}dT =& \gamma k(1+b_\beta)^{-(k+1)}db_\beta \\ &- \Gamma Z^{-k}F_e\mu\theta k\phi^{-(\mu\theta k+1)}d\phi \\ &+ \Gamma Z^{-k}\phi^{-\mu\theta k}dF_e \\ &- k\Gamma F_e\phi^{-\mu\theta k}Z^{-(k+1)}dZ \qquad (4.14) \\ & \qquad (4.15)\end{aligned}$$

which is true for $T < \Theta$, implying $dT/d\phi \leq 0$ for $db_\beta = dF_e = dZ = 0$ and which defines in figure 4.3 a negative sloped iso-bound tariff curve in the (T, ϕ) space. We depict this curve dashed because we only know qualitatively its slope, yet not its exact shape. Nevertheless, this suffices for our purposes.

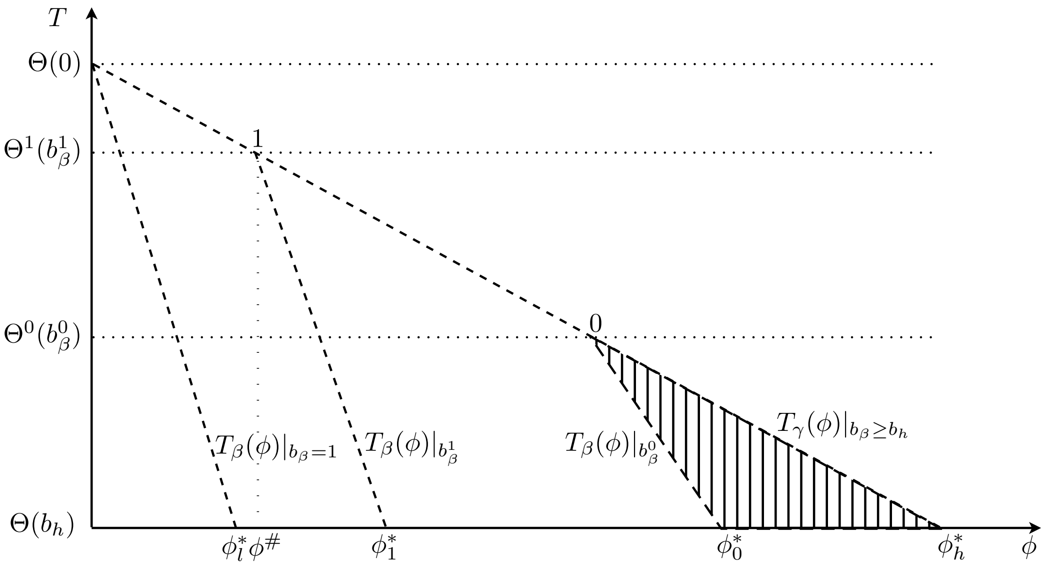


Figure 4.3: Market Access through Bound tariff.

The outer right dashed level curve $T_\gamma(\phi)$ depicts the market entry time of firms with different productivity levels for a specific bound tariff b_β higher than the highest possible applied tariff

τ_h at any time. Therefore, all firms exhibiting a productivity level higher than ϕ_h^* enter the destination market immediately ($T = 0$), whereas companies with lower productivity postpone their entry into the future. As derived earlier, the effectiveness of a bound tariff (time during which the ceiled bound tariff is strictly bigger than highest possible applied tariff) appears within a time range where the optimal market entry time T_γ is smaller than Θ. For a bound tariff e.g. $b_\beta^0 < b_h$, its effectiveness will last until $\Theta^0(b_\beta^0)$, depicted as horizontal dotted line. Respectively, all firms with an optimal market entry time $T_\gamma < \Theta^0(b_\beta^0)$ anticipate a lower expected tariff, permuted into an earlier market entry time $T_\beta(\phi)|_{b_\beta^0}$, whereas for all firms with an optimal market entry time bigger than $\Theta^0(b_\beta^0)$ there is no bound tariff effect and they enter further on in $T_\gamma(\phi)|_{b_\beta \geq b_h}$. As a result, the new iso-bound tariff curve for a given b_β^0 turns out to be kinked at point zero 0. The hatched area above the new iso-bound tariff curve represents the productivity range of firms which leads to a pre-ponement in the optimal market entry. The new productivity cut-off which determines the instantaneous market entry ($T = 0$) is ϕ_0^*. It is worth noting that all firms with a productivity level between ϕ_0^* and ϕ_h^* would have delayed their market entry without the new bound tariff, therefore, the difference ϕ_0^*-ϕ_h^* corresponds to the new market access due to a bound tariff b_β^0. Figure 4.3 also shows the effect of a further reduction of the bound tariff e.g. to b_β^1 (ceteris paribus). This reduction results in a higher effectiveness range $\Theta^1(b_\beta^1) > \Theta^0(b_\beta^0)$ depicted by the central dotted line and in a new iso-bound tariff curve $T_\beta(\phi)|_{b_\beta^1}$ which is kinked at point 1.

Implicitly, there are three groups of firms which are differently affected by the reduced bound tariff. All firms with a productivity level between ϕ_1^* and ϕ_0^* pre-pone their entry decision by such an extent that they enter today (new market access). The second group of firms exhibiting a productivity level between $\phi^\#$ and ϕ_1^* are also positively influenced by the bound tariff reduction resulting in a pre-ponement but entry is still delayed. The last group of firms with a productivity lower than $\phi^\#$, turn out to be unaffected by the introduction of b_β^1 as their initial market entry time T_γ is above the respective effectiveness range $\Theta^1(b_\beta^1)$. Therefore, the iso-bound tariff curve for productivity levels smaller than $\phi^\#$ coincides with the level curve of a boundless situation ($T_\gamma|_{b_\beta \geq b_h}$).

The effectiveness of a reduction in the bound tariff to generate market entry is clearly limited. On one hand it is limited by a natural bound which is free trade, so that the horizontal intercept of the iso-curve defined by $T_\beta(\phi)|_{b_\beta=0}$ gives the ultimate ϕ_l, the lowest productive producer

that will ever find it worthwhile to enter the market today. Analogously, we know from the previous section, no bound tariff higher than the worst-tariff rate can be effective. Therefore, the horizontal intercept of the level curve defined by $T_\gamma(\phi)|_{b_\beta \geq b_h}$ determines ϕ_h, the productivity level exactly high enough, such that a firm will enter the market at $T = 0$ without delay.
Finally, the same exercise could be performed for F_e, i.e. heterogeneous fixed export costs across firms, or market size Z, and cutoffs for market entry in terms of fixed costs and market size analogously derived.

With the findings of this section and the previous results, it is worth referring to the empirical pattern depicted in figure 4.1, where the political risk on the horizontal axes can be interpreted as the γ in our model and the overhang as the ceiled risk band since the bound tariff reduces the possibility of infinite tariff shifts. Obviously, riskier countries exhibit significantly higher overhangs and therefore larger risk bands. Following our last inference, there is still a potential use behind these relatively high bound tariffs in risky countries as the likeliness of market access control is bigger. In contrast, developed countries realize very low overhangs and seem therefore, to exhibit lower risk bands. Respectively, the importance of bound tariffs as a market access control plays a minor role.

4.4 Conclusion

Real world trade policy, as governed under WTO rules, deals at large with bound tariffs, besides applied tariffs. Economists have nominated the risk reduction – reductions in the risk of changes in the destination markets trade policy – as the main channel through which bound tariffs operate. Yet, by what mechanisms such risk reductions actually generate market access is largely unclear. In fact it is not at all obvious that a reduction in bound tariffs that remain above current applied and/or future applied tariff rates can generate additional trade. At the intensive margin, reductions in bound tariffs above applied rates have no price effect and hence can not increase the export volume of already export active firms. Accordingly, the effects of bound tariffs must be examined at the extensive margin of trade, i.e. via an increase in the number of exporters that chose to service a given destination market.

The present paper formalizes the underlying logic of firms' market entry decisions, risk and fixed export costs based on techniques known from the real options literature (e.g. Dixit, 1993). In doing so we highlight the important role of bound tariffs at the extensive margin of trade. In our model, potential exporters to a given destination market can delay market entry and react to the risk reductions driven by bound tariffs. The central results of our analysis are that bound tariffs are more effective with higher risk destination markets, i.e. a large binding overhang can command substantial market access for high risk countries. Furthermore, we show that reductions in bound tariffs do generate effective market access even when bound rates remain above current and long-term applied rates.

4.5 Appendix

4.5.1 First Order Differential Equation

$$\frac{dx_t}{dt} = -\alpha x_t + c, \quad \alpha \geq 0 \tag{4.16}$$

$$\begin{aligned}
\int e^{\alpha t} \left(\frac{dx_t}{dt} + \alpha x_t \right) dt &= \int e^{\alpha t} c dt \\
\int \frac{d}{dt} \left(e^{\alpha t} x_t \right) dt &= \int c e^{\alpha t} dt \\
e^{\alpha t} x_t + b_0 &= c \frac{e^{\alpha t}}{\alpha} + b_1 \\
x_t &= \frac{c}{\alpha} + (b_1 - b_0)\, e^{-\alpha t} \\
x_t &= \frac{c}{\alpha} + b e^{-\alpha t} \qquad (4.17)
\end{aligned}$$

for a generic constant b of integration.

4.5.2 Leibnitz rule

Let $F(c) = \int_{a(c)}^{b(c)} f(c,t)dt$,

$$\frac{\partial F(c)}{\partial c} = \int_{a(c)}^{b(c)} \frac{\partial f(c,t)}{\partial c} dt + f(c, b(c)) \frac{\partial b(c)}{c} - f(c, a(c)) \frac{\partial a(c)}{\partial c} \tag{4.18}$$

4.5.3 Derivation of (4.5) solving (4.3)

FOC:

$$\underbrace{p^C(y) + \frac{\partial p^C(y)}{\partial y} y}_{MR(y)} = \underbrace{(1+\tau) \frac{\partial c(w,y)}{\partial y}}_{MC(y)}$$

which can be written as:

$$\begin{aligned} p^C(y) =& \frac{\epsilon_p(y)}{\epsilon(y)_p - 1}(1+\tau)\frac{\partial c(w,y)}{\partial y} \\ =& \frac{1}{\mu}(1+\tau)\frac{w}{h\theta}y^{\frac{1-\theta}{\theta}} \end{aligned} \tag{4.19}$$

where $\epsilon_p(y) = -(\partial y/\partial p)(p/y) = 1/(1-\mu)$ by (4.1). Substituting (4.1) for p^C, gives the optimal output:

$$y = \left(\mu Z \frac{h\theta}{(1+\tau)w}\right)^{\frac{\theta}{1-\mu\theta}} \tag{4.20}$$

to be inserted in (4.3) to obtain (4.5).

We show $dp^C/d\tau \geq 0$, $dp^F/d\tau \leq 0$. Use (4.1), (4.20), and (4.2) to calculate:

$$p^C = Z^{\frac{1-\theta}{1-\mu\theta}} \left(\frac{\mu h\theta}{w}\right)^{\frac{\theta(\mu-1)}{1-\mu\theta}} \left(\frac{1}{1+\tau}\right)^{\frac{\theta(\mu-1)}{1-\mu\theta}} \tag{4.21}$$

$$p^F = Z^{\frac{1-\theta}{1-\mu\theta}} \left(\frac{\mu h\theta}{w}\right)^{\frac{\theta(\mu-1)}{1-\mu\theta}} \left(\frac{1}{1+\tau}\right)^{\frac{1-\theta}{1-\mu\theta}} \tag{4.22}$$

$$\frac{dp^C}{d\tau} = Z^{\frac{1-\theta}{1-\mu\theta}} \left(\frac{\mu h\theta}{w}\right)^{\frac{\theta(\mu-1)}{1-\mu\theta}} \frac{\theta(1-\mu)}{1-\mu\theta} \left(\frac{1}{1+\tau}\right)^{\frac{1-\theta}{1-\mu\theta}} \geq 0 \tag{4.23}$$

$$\frac{dp^F}{d\tau} = -Z^{\frac{1-\theta}{1-\mu\theta}} \left(\frac{\mu h\theta}{w}\right)^{\frac{\theta(\mu-1)}{1-\mu\theta}} \frac{1-\theta}{1-\mu\theta}(1+\tau)^{\frac{-2+\theta(\mu+1)}{1-\mu\theta}} < 0 \tag{4.24}$$

Note that (4.23) and (4.24) together imply an incomplete pass-through to the foreign Monopolist following a change in tariff (like in Brander and Spencer (1984)), but for $\mu = 1$, in which case the pass-through is complete since $\frac{dp^C}{d\tau} = 0$ - as to be expected in a perfectly competitive market.

4.5.4 The $(1+\tau_j)^{-k}$ curve

Using (4.9) with $c_j = 0$, we have:

$$f(t) = (1+\tau_j(t))^{-k} = (1+b_j e^{-\alpha_j t})^{-k}$$
$$\lim_{t\to\infty} f(t) = 1$$
$$\lim_{t\to 0} f(t) = (1+b_j)^{-k}$$
$$\begin{aligned}\frac{\partial f(t)}{\partial t} &= -k(1+b_j e^{-\alpha_j t})^{-k-1} b_j e^{-\alpha_j t}(-\alpha_j)\\ &= \frac{k\alpha_j b_j}{e^{\alpha_j t}(1+b_j e^{-\alpha_j T})^{k+2}} \geq 0\\ \frac{\partial^2 f(t)}{\partial t^2} &= k\alpha_j b_j e^{-\alpha_j t}(-\alpha_j)[1+b_j e^{-\alpha_j t}]^{-(k+2)} - k\alpha_j b_j e^{-\alpha_j t}(k+2)(1+b_j e^{-\alpha_j t})^{-(k+2)-1} b_j e^{-\alpha_j t}(-\alpha_j)\\ &= -\frac{k\alpha_j^2 b_j}{e^{\alpha_j t}(1+b_j e^{-\alpha_j t})^{(k+2)}} + \frac{k\alpha_j^2 b_j^2 (k+2)}{e^{2\alpha_j t}(1+b_j e^{-\alpha_j t})^{k+3}}\\ &= \frac{k\alpha_j^2 b_j}{e^{\alpha_j t}(1+b_j e^{-\alpha_j t})^{k+2}}\left[-1+\frac{b_j(k+2)}{e^{\alpha_j t}(1+b_j e^{-\alpha_j t})}\right] \lesseqqgtr 0\end{aligned}$$

Note that the sign of $\frac{\partial^2 f(t)}{\partial t^2}$, depends on the term in the square bracket. We have:

$$\begin{aligned}\frac{\partial^2 f(t)}{\partial t^2}|_{T^*} = 0 \quad &\Leftrightarrow \quad \left[-1+\frac{b_j(k+2)}{e^{\alpha_j T^*}(1+b_j e^{-\alpha_j T^*})}\right] = 0\\ &\Leftrightarrow \quad \ln b_j + \ln(k+2) = \alpha_j T^* + \ln(1+b_j e^{-\alpha_j T^*})\end{aligned}$$

and for $t > T^*$, $\frac{\partial^2 f(t)}{\partial t^2} < 0$, for $t < T^*$, $\frac{\partial^2 f(t)}{\partial t^2} > 0$. Therefore, $f(t)$ has a flex in T^*, it is concave for $t > T^*$, convex for $t < T^*$.

CHAPTER 5

The Role of Management in the Internationalization Process of a Firm

5.1 Introduction

Empirical observations in the 90s based on newly available microeconomic datasets initiated a strong focus on individual firm behavior. In particular, researchers attempted to identify the driving forces behind the internationalization process - herein the export behavior - of firms. These developments have been accompanied by theoretical developments (Hopenhayn, 1992; Melitz, 2003) providing a foundation for explaining firms' self-selection into domestic and foreign markets. Within this strand of literature, heterogeneity in firm embedded productivity and accruing fixed costs for exporting are crucial characteristics deciding on whether firms start to export. Recent empirical contributions (see e.g. Wagner, 2007) have confirmed the importance of productivity and further firm specific aspects which shape a firm's decision on exporting. Today, it is well established that on a narrow industry level exporters perform differently in several dimensions compared to solely domestic firms. Bernard and Jensen (1995, 1997, 2004) are able to show that exporters significantly differ from non-exporters in their productivity (value-added over employee), firm size, share of white-collar workers, level of average wages, et cetera. Therefore, the described *self-selection hypothesis* has been established solid as a rock.

This paper is a joint work with Davide Sala from Aarhus University. The concept for the paper was developed jointly. Writing, empirical and theoretical analysis were equally shared.

Given these insights still it is a long way to go to understand how firms internationalize. Within the business literature researchers insist that internationalization is a complex process evolving over time , which has to be guided and it is pointed out that for this reason the management in charge needs to be accounted for (Dicken, 1992). Differently, a firm's management needs to be willing to be exposed to export related problems.
From a theoretical point of view the importance of a management as a specific input factor has been already discussed by Lucas (1978). On the other hand, empirical research analyzing management characteristics and export behavior is rare and predominantly confined to general firm performance analyses. Furthermore, it is simply the unavailability of commensurate data. Since the strand of literature in international economics predominantly analyzes the export decision of domestic firms based on the mentioned firm characteristics, so far management specific aspects are missed out.

With this paper we intend to overcome the described shortcomings by first presenting a simple theoretical model in which the management plays a role for a firm's internationalization process following Lucas (1978). Additionally, we extend our model by allowing that management knowhow becomes a discriminating characteristic between exporting and domestic firms similar to Garicano (2000), Atkeson and Kehoe (2005). Furthermore, by introducing a Geometric Brownian motion we account for the fact that firm productivity evolves with a certain extent of uncertainty. All in all our simple model includes besides the commonly used firm characteristics like productivity and fixed costs, the dimension of human capital and management ability.
Our recently composed Danish data set allows us to analyze the internationalization process of individual firms within the largest companies in the Danish manufacturing sector and control for the impact of common firm characteristics, but also for management aspects. Besides human capital variables like education level, high skill workers we are able to identify whether hired managers were previously exposed to exporting. Stylized facts suggest that e.g. domestic firms started to hire more and more export experienced managers accompanied by an increase in the share of exporting firms in our sample, in particular since 1997 (form 86.7% to 89.2%).
Given this outstanding data we suggest a three step empirical strategy derived from our theoretical model. We start with a random effects probit as in previous studies and are able to show that firm productivity and export fixed cost are decisive elements in shaping the export decision

of Danish firms. Subsequently, we depart from the random effects probit model and allow for unobserved factors to be correlated with firm characteristics. At this, we follow Chamberlain (1980)'s approach entering virgin soil in the trade context as it is rather new in trade studies but turns out to be an efficient alternative to control for unobserved heterogeneity. Indeed, we are able to show that in particular management characteristics matter in a very robust way for unobserved heterogeneity. Our sample allows for the first time to include the mentioned aspects but comes with the limitation only to observe the 5000 largest firms in Denmark. As a result the number of new entries into the export market is relatively small. In order to increase the variation in market entry, we generate further sub-samples including only firms which start to export within the considered period. Our study contributes to the exiting literature twofold, first by presenting the impact of management characteristics on exporting and further by applying an innovative empirical method to identify successfully unobserved heterogeneity.

The remainder is structured as follows: Section 5.2 presents a theoretical partial equilibrium model from which we derive our empirical strategy in section 5.3. In section 5.4 we briefly describe the sample of Danish firms before we present our empirical results in section 5.5. Section 5.6 concludes.

5.2 Theoretical Model

With reference to Lucas (1978) besides the physical inputs capital k and labor l, a firm's technology contains furthermore a managerial component x. This last managerial technology is composed of two elements, namely the representative management's talent (ability) m and its knowhow s. Talent is an idiosyncratic characteristic, specific to the management whereas knowhow depends on the problems z to be solved by the executives. More precisely and similar to Garicano (2000), let Ω be the set of all possible problems z which have to be solved by the executive team and $S \subset \Omega$, the set of problems which can be solved by the management. We refer to S as the management knowhow with $S = [0, z_S]$. It is further assumed that the density function of all problems is non-increasing since problems are ordered from less to highly special knowledge and their continuous cumulative distribution is described by $F(z)$. The management knows *a priori* the distribution of F. This assumption implies that there exists a common awareness of how difficult the observed problems are.

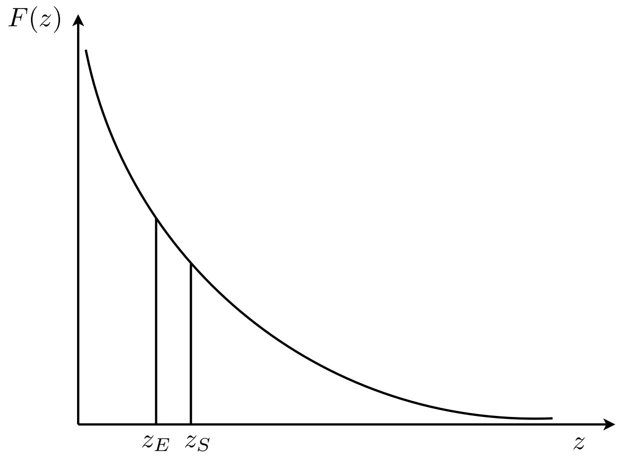


Figure 5.1: Non-Increasing Density Function of Problems

The firm's production technology is described by

$$y_t = \Psi_t x_t h A_t^{1-\nu} \left[g(k_t, l_t)\right]^{\nu} \tag{5.1}$$
$$\text{with} \quad x = m\ Pr(z \in S) \quad \text{and} \quad Pr(z \in S) = \int_0^{z_s} dF(z) = F(z_s)$$

where Pr denotes the probability that the management can solve the range of problems associated with production. Ψ is a country specific shift parameter accounting for economy wide productivity as in Lucas (1978). We extend Atkeson and Kehoe (2005) by allowing the firm specific productivity A to evolve stochastically over time. Therefore, it is modeled by a Geometric Brownian motion with

$$dA_t = \alpha A_t dt + \sigma A_t dw_t \tag{5.2}$$
$$\text{with} \quad dw_t = \epsilon_t \sqrt{dt}$$

where α is the periodical growth rate and σ represents the variance parameter. dw_t stands for the increment of a standard Wiener process with ϵ_t as a normally distributed random variable. Then, A_t is log-normally distributed with

$$A_t \sim \ln(A_0 + \alpha - \frac{1}{2}\sigma^2, \sigma\sqrt{t}), \tag{5.3}$$

where A_0 represents the firm specific productivity at t_0 (Dixit, 1993). The function g is linearly homogeneous of degree one and the parameter $\nu \in (0,1)$ is referred to as the span of control which determines the firm's degree of diminishing returns. The span of control is introduced in order to account for the fact that a management cannot handle all existing firms. In each period labor and capital are freely mobile between plants and therefore the choice of optimal inputs is a static problem. Accordingly, the management minimizes production costs with

$$\min_{k,l} w_t l_t + r_t k_t \quad \text{s.t.} \quad y \leq \Psi_t x_t A_t^{1-\nu} [g(k_t, l_t)]^{\nu}, \tag{5.4}$$

where w_t is the wage rate for labor, r_t the rental rate for capital, w_{m_t} the management costs, and τ representing transportation costs. The periodical cost function of the plant results as

$$c(r_t, w_t, w_{m_t}, A_t, \Psi_t, \tau_t). \tag{5.5}$$

We reduce the further analysis on the impact of changes in firm specific productivity and manager knowhow described by equation (5.5).
The demand side is succinctly represented by the iso-elastic demand function

$$p = By^{\mu-1} \tag{5.6}$$

where B is a shift parameter und μ indexes the degree of monopoly power. For μ approaching zero the firm faces a horizontal demand function (i.e. perfectly competitive environment).

Based on the inverse demand and the cost function the firm's management maximizes periodical profits

$$\begin{aligned} d_t(r_t, w_t, w_{m_t}, A_t, \Psi_t, \tau_t) = \max_y \; & B_t \; y_t^{\mu} - c(r_t, w_t, w_{m_t}, z_{s_t}, A_t, \Psi_t, \tau_t) \\ & - w_{m_t} - I[i=1]\tau_t y_t. \end{aligned} \tag{5.7}$$

If the investor decides on exporting, fixed costs I_E and iceberg transport costs $\tau > 1$ arise, formally indicated by the index variable $i = 1$, else 0 and I representing an index function. Furthermore, exports necessitate that z_E problems drawn from Ω are solved, which always happens if $E \subseteq S$, where $E = [0, z_E]$ represents the set of all problems associated with exporting.

Therefore, the management with adequate knowhow will initiate exporting whenever the expected value of exporting V_E exceeds the accruing costs, which can be expressed as

$$V_E(r_t, w_t, w_{m_t}, A_t, \Psi_t, \tau_t) = \int_t^\infty d(r_t, w_t, w_{m_t}, A_t, \Psi_t, \tau_t)e^{-\beta t} \geq I_E \tag{5.8}$$

$$\text{with} \quad z_s \geq z_E \quad \text{and} \quad \beta = \rho - \alpha.$$

ρ is the opportunity cost rate for all firms and therefore, β represents the adjusted discount rate as it accounts for the firm specific growth rate which reduces opportunity costs.[1] Since A_t is log-normally distributed, the log of the expected firm values V_E are normally distributed, if V_E is multiplicative in all its elements.

[1] Depending on the behavior of periodical profits $d(\cdot)$ in A, the adjusted discount rate β may differ in its extent. For convex profits e.g. in A, the adjusted discount rate decreases to $\beta = r - (r - \rho)\lambda - \frac{1}{2}\lambda(\lambda - 1)\sigma^2$, where λ represents the degree of convexity.

5.3 Empirical Strategy

We propose to follow Mundlack (1978) and Chamberlain (1980), a rather novel approach in the empirical trade literature, to analyze the participation of a firm in foreign markets (i.e. a binary variable indicating exporting), and to account explicitly for unobserved heterogeneity.[2] Let $I[\cdot]$ define an indicator function returning value one if the statement in the bracket is true and let e_{ijt} be an exporting indicator for firm i, in sector j at time t and let us model the entry condition (5.8) with the following probit model

$$\begin{aligned} V_E(\cdot) - I_E &= \mathbf{x}_{it}\theta + \mathbf{x}_{jt}\beta + \psi_t + \psi_j + c_i + u_{ijt} \\ exp_{ijt} &= I[V_E(\cdot) - I_E > 0] \\ u_{ijt}|(\mathbf{x}_i, c_i) &\sim \text{Normal}(0,1) \end{aligned} \tag{5.9}$$

where $\mathbf{x}_{it}$ is a vector of time-varying firm's characteristics including a constant, $\mathbf{x}_{jt}$ denotes a vector of time-variant industry characteristics, whereas $\mathbf{x}_i$ contains for notational convenience all explanatory variables in all periods.[3] $\mathbf{x}_{it}$ includes a number of controls like firm size, human capital (l), productivity (A), proxies for some trade costs (τ), but most importantly measures of the management knowhow (S and S_E in our model) in which we are particularly interested in. $\mathbf{x}_{jt}$ will contain mainly proxies for I_E. Industry fixed effect ψ_j and time dummies ψ_t control for industries specificities and temporary shocks.

c_i is the unobserved effect, like, in our model, the talent of the manager (m) or stochastic developments of productivity due for instance to different adoption costs or learning curves, as well as plausible different entry fixed costs (I_E). The point of introducing unobserved heterogeneity is to explicitly allow unobservables to be correlated with some elements of $\mathbf{x}_{it}$, as managerial ability or management practices affect the productivity of a firm as well as the management knowhow. We therefore depart from the assumptions of a random effects probit model and, following Mundlack (1978), assume that

$$c_i = b + \bar{\mathbf{x}}_i\delta + a_i \tag{5.10}$$

[2] This approach is not however new in the literature, but it has been extensively used in labor economics.

[3] $\mathbf{x}_i$ contains for example $\mathbf{x}_{it}$ and $\mathbf{x}_{jt}$ for all t, the set of ψ_j and ψ_t.

where $\bar{\mathbf{x}}_i$ is the average of $\mathbf{x}_{it}$, $t = 1, ..., T$, and a_i is a random component (for example manager ability) with $a_i|\mathbf{x}_i \sim \text{Normal}(0, \sigma_a^2)$. Although this assumption is still restrictive in that it specifies, as in Chamberlain (1980), a distribution for c_i given $\mathbf{x}_i$, namely, $c_i|\mathbf{x}_i \sim \text{Normal}(b+\bar{\mathbf{x}}_i\delta, \sigma_a)$ - it at least allows for some dependence between c_i and $\mathbf{x}_i$. Furthermore, relative to a random effects probit model, this approach has the advantage to allow us to relate firm's characteristics, and in particular the management to unobserved heterogeneity. Therefore, the parameter δ is equally interesting as θ: the latter is informative how the management and other dimensions of a firm affect the propensity to export, while the former is informative how the management and other characteristics of a firm relate to unobserved heterogeneity.

The probit we are estimating is therefore

$$P(exp_{ijt} = 1|\mathbf{x}_i) = \Phi\left(\frac{b + \mathbf{x}_{it}\theta + \mathbf{x}_{jt}\beta + \bar{\mathbf{x}}_i\delta + \psi_t + \psi_j + a_i}{(1+\sigma_a^2)^{1/2}}\right) \tag{5.11}$$

where Φ denotes the cumulative distribution function of a standard normal density. Note that, only the effects of time-varying elements in $\mathbf{x}_{it}$ can be estimated, otherwise undistinguishable from c_i.[4] Likewise, time dummies ψ_t as well as industry-dummies ψ_j, which do not vary across i, are omitted from $\bar{x}_i$. Adding $\bar{\mathbf{x}}_i$ as a set of controls for unobserved heterogeneity is very intuitive; it allows to estimate the response probability keeping the time average fixed.

It is worth highlighting that the Chamberlain approach is just a generalization of the random effects probit model in (5.9) with the addition of $\bar{\mathbf{x}}_i$ to each time period: c_i has been integrated out and a test for the random effects probit model is easily obtained as a test of $H_0 : \delta = \mathbf{0}$. In case of non-rejection of the null, the omission of $\bar{\mathbf{x}}_i$ would be unimportant and a random effects probit model would then be an appropriate empirical model. The relevance of this is that management characteristics are empirically rarely observable and such test can shed some light on how serious is this omission.

[4] $\mathbf{x}_{it}$ should not longer contain a constant term, as that would be indistinguishable from b. See Wooldridge (2005), pag. 488.

5.4 Data

In this paper we use a data set by Smith et. al. (2008), which comprises the largest 5000 Danish firms, as defined by total asset, in the period from 1995 and 2003. In a first step registers of Statistics Denmark are used to merge firm specific information with the considered companies' employee specific data, including information on CEOs background characteristics. Additionally, these administrative registers are merged with account data from the private Danish data register KOB (Kobmandsstandens Oplysningsbureau), which includes information on the members of the board of directors. Following Wagner (2008)'s guidelines, especially for the sake of international comparability, we consider only manufacturing firms and we exclude those in the top one percent of the labor productivity distribution and with less than 20 employees.[5] Due to the too-low number of observations, we drop the oil producing sector and metal recycling industry. Finally, we eliminate firms with inconsistent figures showing either negative total or foreign turnover, export revenue greater than total revenue, negative physical capital, or a year of foundation subsequent to when the firm is first observed, ending up with more than seven thousand firms over the whole sample, about 800 per year.[6]

A positive export turnover defines our export status, whereas from the year of foundation of a company we deduct the age of a firm, used in Atkeson and Kehoe (2005) to proxy organizational capital. Based on the county of the firm, we approximate the distance of each firm to an international transportation point (harbor, airport, major rail-station), and capture part of the logistic transport costs. By the two digits industry code, we construct the share of Danish firms already exporting to some destinations (i.e. firms that have positive export turnover) within the same defined industry. In this way, we attempt to include in the analysis a measure for the fixed cost of exporting. In fact, in Krautheim (2007), the return of networking among domestic exporters is to reduce I_E in our model and it is clearly related to the size of such network, as indicated by the fraction of exporting companies.

[5] Labor productivity is defined as value added per employee. We do not trim the data for the bottom 1 percent of the labor productivity distribution because these firms are in our Danish sample automatically excluded by threshold of 20 employees.

[6] It is common in Denmark to end up with a scarce number of observations as soon as the industry definition narrows down. Two digits is the narrowest industry level we can go with our sample to retain a good number of observations, but for the two industries dropped.

The matched employer-employee nature of data set allows us to identify managers (CEOs) on the basis of annual salaries where the employee with the highest salary is declared as the chief executive organizer. Our procedure is in line with several US studies (see e.g. Bell, 2005) as opposed to the definition of managers based on the occupational code, also available, but not as reliable, as already put forward by Smith et. al. (2008). The two strategies would anyway yield highly correlated definitions. Once a manager is identified, the years of education or the degree of eduction as well as the nationality and the tenure can be determined.

CEOs are usually tiered and companies can be lead by one person or a group. Therefore, the narrow definition of CEO includes the single person with the highest wage (CEO-1). To account for team-leadership, we introduce a broader definition of CEOs including vice presidents identified as the top five in the firm specific wage distribution (CEO-5). In this case, the education refers to the person with the longest education or the highest degree, the tenure to the longest tenure in the group, while nationality indicates whether at least one in the board is foreigner. Being able to follow people along the years and workplaces, we track whether new people are promoted internally into the CEO-1 position (internal 1) or into the CEO-5 group (internal 5). Alternatively, promotion can occur externally, hiring people from other companies to occupy CEO-1 or CEO-5 offices (external 1, external 5).

We further investigate whether externally promoted people have exporting experience (external+exp). Exporting experience is defined as having ever held, even abroad, positions within exporting companies. To be able to consider the degree of experience, we further refine our definition of exporting experience and restrict it to positions held in firms earning at least 25 or 50 per cent of their revenue on foreign markets (exp25, exp50). These sets of dummy variables are meant to account for manger knowhow.

Information at workplace is further aggregated to construct rather precise measure of human capital at the firm level, like the share of employees with a university degree, a high school degree or vocational education as well as the proportion of white-collar workers. Likewise, we construct the number of employees - our measure of the size of a company - rather than relying on the figures self reported by each company, as we think it gives a more reliable and precise measure of size.

Table 5.1: Domestic and Exporting Danish Firms

	Number of Domestic Firms	Number of Exporters	Total Number of Firms
1995	11%	89%	808
1996	11.5%	88.5%	824
1997	13.3%	86.7%	828
1998	12.8%	87.2%	828
1999	12.8%	87.2%	882
2000	12.1%	87.9%	842
2001	9.8%	90.2%	753
2002	11.3%	88.7%	736
2003	10.8%	89.2%	656
Over all Years	11.8%	88.2%	7157

Table 5.1 contains the shares of Danish manufacturing companies which are serving solely the domestic market or are involved into international trade. As the available data is restricted to the 5000 largest companies by total asset, the share of exporting firms within the sample is vast bigger than the share of purely domestic firms. However, it is to emphasize that besides the distinctiveness of the sample it is also the relative large openness of Denmark, with 80% of all firms being involved in international trade which determines the observed firm distribution.

Table 5.2: Sub-Samples of Permanently Observed and New Born Firms

	Sub-Sample: ***Always Exporter***		
	Number of Firms Always Exporter	Number of Firms Always Domestic	Number of Firms Permanently in a Market
Over all Years	5827	485	6312
% of all Firms	81.4%	6.8%	88.2%
	Sub-Sample: ***New Exporter***		
	Start as Export	Start as Domestic	New Born Firms
Over all Years	487	358	845
% of all Firms	6.8%	5%	11.8%

The first part of table 5.2 presents the shares of firms which are already serving the domestic market or exporting since the first available year in our sample. These exporters are referred to as *always exporter* and show that for a high number of observations there is no change in their export status over time. The lower part of table 5.2 shows the share of companies which are founded either for the domestic market or for exporting during the observed time span.

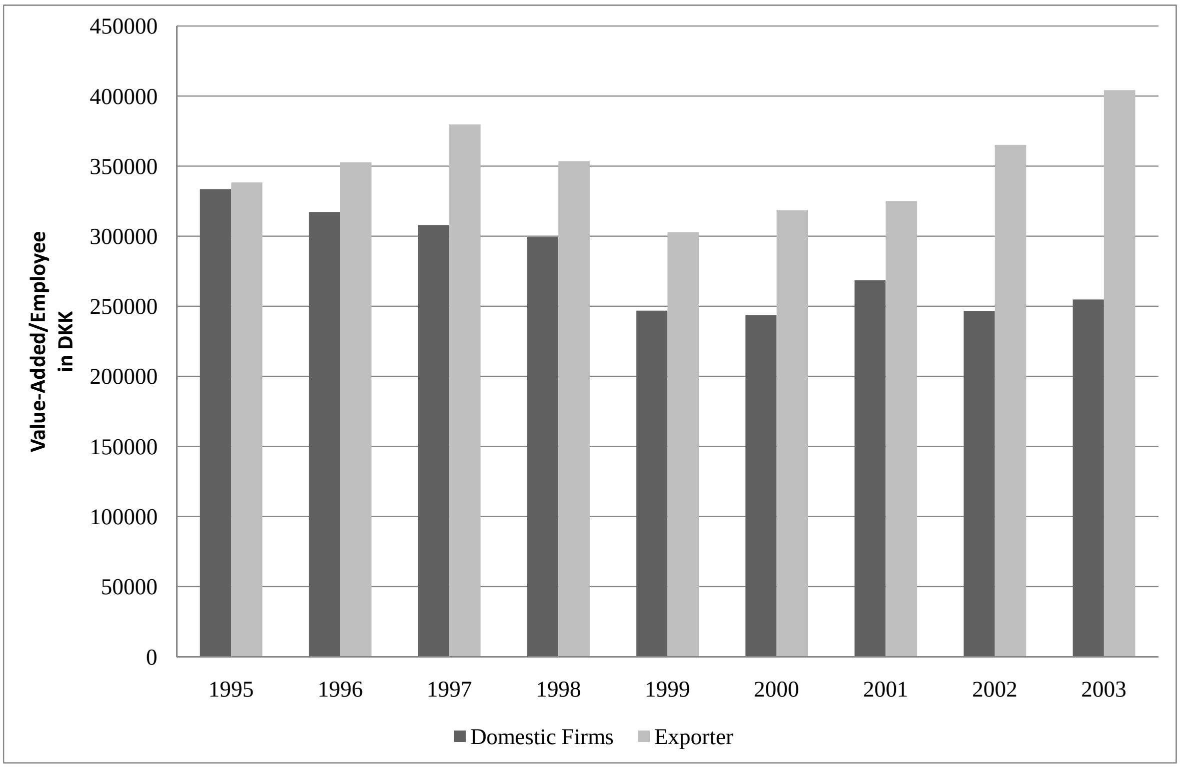


Figure 5.2: Productivity Pattern of Danish Firms

In line with the general empirical findings in the related literature (see e.g. Bernard and Wagner, 2001) the average productivity of Danish exporters - measured as value-added over employees - turns out to outperform the domestic firms' productivity. Importantly, besides their dominance Danish exporters have widened their lead since the end of the 90s whereas domestic companies' productivity stagnated. One reason for this growing disparity is the decreasing trend in the share of solely domestic firms depicted in table 5.1 and the rising trend in Denmark's internationalization since 1997. Appendix 5.7.2 and 5.7.3 present a more detailed picture of productivity developments both over time and across different sub-sectors. One further striking aspect is the different extent of productivity heterogeneity within sub-sectors measured by the standard deviation.

Besides the commonly used time-variant industry characteristics the underlying sample provides furthermore information about how a new manager within the top 5 management is promoted. Table 5.3 presents the distributions of registered internal promotions for domestic firms and exporters between 1995 and 2003. According to these figures, exporting companies exhibit on average a higher share of internal promotions relative to domestic companies pointing on a higher dynamics in the management of exporters. One possible reason for this result might again reflect the overhang of exporting firms in the underlying sample, since a larger number of observation increases the likeliness of a management reshuffle. However, more important is the fact that although the share of domestic Danish firms averagely decreased over time (see table 5.1) internal promotions within this group skyrocketed. A possible reason may be the tightened competition in the considered time span forcing domestic firms to reshape their management more often.

Table 5.3: Firms with Internally Promoted Manager

Internal Promotion for Top 5 Management Domestic Firms				Internal Promotion for Top 5 Management Exporting Firms		
Year	Yes	No		Year	Yes	No
1995	18%	82%		1995	36%	64%
1996	23%	77%		1996	39%	61%
1997	21%	79%		1997	41%	59%
1998	24%	76%		1998	41%	59%
1999	33%	67%		1999	46%	54%
2000	31%	69%		2000	47%	53%
2001	21%	79%		2001	47%	53%
2002	27%	73%		2002	47%	53%
2003	42%	58%		2003	52%	48%
Over all Years	26%	74%		Over all Years	43%	57%

Note: Shares a calculated on the basis of all firms in the sample which conducted an internal promotion for a top 5 management position. If the newly appointed manager has been recruited from within the enterprise, the promotion is considered to be internal.

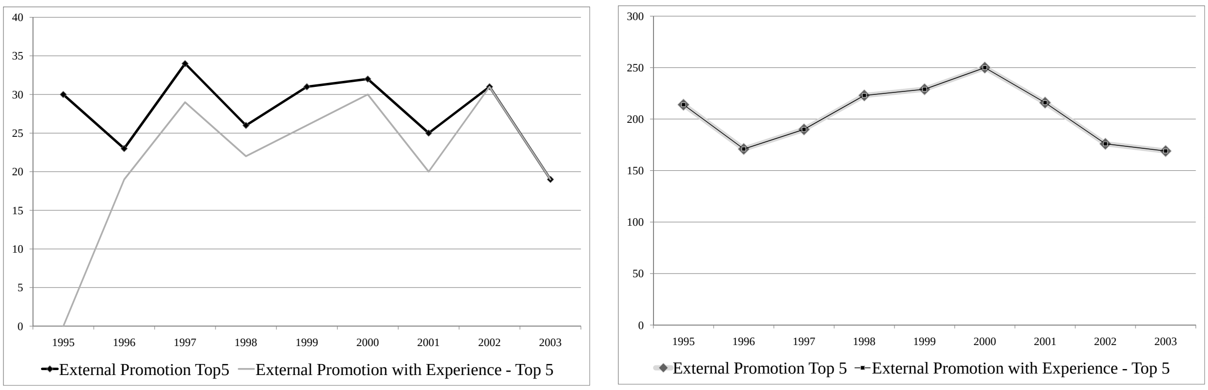
Table 5.4 presents the shares of external promotions within domestic and exporting companies. Similar to internal promotions, exporters exhibit a higher share of recruitment on average - 24% of exporters hired an external manager opposed to 17% of domestic firms - pointing on the stronger dynamics in exporting companies' recruiting behavior. However, in the last years the share of external promotions within domestic firms significantly increased, partly passing the share of exporting companies. This phenomenon might reflect two aspects. Firstly, again the tightened competition for domestic firms necessitated a stronger management reshuffle. Secondly, and in the focus of our empirical analysis, the increasing share of external manager promotions in domestic companies enforced a surge in the internationalization process of Danish firms decreasing the share of solely domestic firms.

Table 5.4: Firms with Externally Promoted Manager

External Promotion for Top 5 Management Domestic Firms			External Promotion for Top 5 Management Exporting Firms		
Year	Yes	No	Year	Yes	No
1995	17%	83%	1995	24%	76%
1996	12%	88%	1996	18%	82%
1997	18%	82%	1997	21%	79%
1998	14%	86%	1998	24%	76%
1999	16%	84%	1999	25%	75%
2000	19%	81%	2000	29%	71%
2001	20%	80%	2001	28%	72%
2002	26%	74%	2002	24%	76%
2003	19%	81%	2003	25%	75%
Over all Years	17%	83%	Over all Years	24%	76%

Note: Shares a calculated on the basis of all firms in the sample which conducted an external promotion for a top 5 management position. If the newly appointed manager has been recruited from outside the enterprise, the promotion is considered to be external.

Additionally, figure 5.3 demonstrates two important aspects. Within the group of exporting companies all newly hired managers exhibit export experience since they previously worked for an exporting enterprise. In contrast, domestic firms hired managers without export experience in the first observed years but steadily increased the share of export experienced manager and finally hired only executives coming from internationally acting firms. This patterns support the hypothesis that the increasing share of an export experienced management promotion may be one additional reason for the enhanced internationalization of Danish enterprises.



(a) External promotions within domestic companies **(b)** External promotions within exporting companies

Note: The black lines reflect the absolute number of observed external promotions whereas the gray line additionally controls for whether the recently hired manager stems from an exporting company.

Figure 5.3: External Promotion of Experienced Manager

5.5 Results

Being among the first to use Danish data to explore entry into foreign markets, we propose in the first step, to restrict our focus on firm characteristics typically considered by most of the previous studies (Roberts and Tybout, 1997; Bernard and Wagner 1997). We start with a random effects probit model accounting only for firm characteristics as firm size (employment), productivity (value added over employee), human capital (share of white collar, high skill share, high school share), distance and finally fixed costs of exporting, where we use the network variable as a proxy.

As in Bernard and Wagner (2001), all variables in the first two columns of table 5.5 are one period lagged to avoid simultaneity issues in light of the "learning by exporting" effects. In contrast, in column 3 and column 4, only productivity is lagged, because we believe the scope for simultaneity for human capital is very limited, given the substantial time necessary for a firm to fill in a newly posted vacancy.
Interestingly, the two sets of regression point to different results. While productivity is significant – as commonly found in the literature – when also all other variables are lagged, only human capital – here measured by the share of employee in the firm with university and high school degree and the proportion of white-collar workers – remain significant when only productivity is lagged.

Finally, in column 5 and 6, we depart from the random effects probit model and allow unobservable factors to be correlated with a firm's characteristics, as explained in equation (5.10). The vector $\mathbf{\bar{x}_i}$ includes all time-varying variables included in the regression. Only the variables resulting significant are listed with the asterisk in the row denoted with δ, whereas the coefficients are omitted as we are not interested in interpreting them. It emerges that those human capital factors that were explaining export decision in the random effects probit model are now related to unobserved heterogeneity among firms, but can not explain any longer the decision to become an exporter. Instead, the share of high skilled labor becomes significant.

It is to emphasize that the first three columns in table 5.5 represent a common result in the related literature (see e.g. Bernard and Wagner, 2001) but turns out to change dramatically once controlled for unobserved factors, as in our case.

Table 5.5: Probability of Exporting. No Managerial Effects.

	(1)	(2)	(3)	(4)	(5)	(6)
Dep. Var	exp_{ijt}	exp_{ijt}	exp_{ijt}	exp_{ijt}	exp_{ijt}	exp_{ijt}
Sample	all	all	all	all	all	all
uni share			1.86**	1.80*	-0.81	-0.55
			(0.94)	(1.03)	(0.71)	(0.82)
high school share			1.37	0.98	-0.64	-0.33
			(1.03)	(1.15)	(0.66)	(0.75)
vocational share			0.19	-0.23	-0.94**	-0.90
			(0.64)	(0.73)	(0.48)	(0.55)
high skill share			0.001	-0.0002	0.003**	0.004**
			(0.003)	(0.003)	(0.001)	(0.001)
white collar share			0.01**	0.01**	0.002	0.003
			(0.006)	(0.006)	(0.003)	(0.003)
size			0.008	0.007	0.001	0.001
			(0.01)	(0.01)	(0.008)	(0.009)
distance				0.0001		0.0009
				(0.0027)		(0.0014)
L productivity	0.0005*	0.0005*	0.0003	0.0002	0.0002	0.0002
	(0.00026)	(0.00027)	(0.00024)	(0.00025)	(0.0001)	(0.0001)
L firm age		-0.008		-0.006		0.006
		(0.005)		(0.005)		(0.055)
L uni share	2.99***	2.39**				
	(0.96)	(1.05)				
L high school share	2.64**	1.11				
	(1.05)	(1.1)				
L vocational share	1.06	-0.001				
	(0.65)	(0.75)				
L high skill share	0.0001	-0.003				
	(0.003)	(0.003)				
L white collar share	0.01**	0.01**				
	(0.006)	(0.006)				
L size	0.007	0.009				
	(0.01)	(0.01)				
L network		1.71		1.89*		0.62
		(1.07)		(1.05)		(0.51)
L distance		-0.0002				
		(0.002)				
δ					uni share** high school share** vocational share** white color share***	size* white color share*** network***
time dummies	YES	YES	YES	YES	YES	YES
industry dummies	YES	YES	YES	YES	YES	YES
N	5176	4724	5224	4771	5224	4771
Wald χ^2	172.42	163.28	171.41	164.78	206.61	213.85
Prob > χ^2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

Note: Coefficients represent the change in the probability of exporting due to an increase in the independent variables' standard deviation. In case of a dummy variable the probability is estimated for a change from 0 to 1. size and productivity are measured in 1000 units. δ stands for significant unobserved effects (see equation 5.10). L indicates lagged variables. *,**,*** indicate significance at the 10%, 5%, 1% levels, respectively.

Table 5.6: Probability of Exporting. With Managerial Effects.

	(1)	(2)	(3)	(4)	(5)
Dep. Var	exp_{ijt}	exp_{ijt}	exp_{ijt}	exp_{ijt}	exp_{ijt}
Sample	all	all	all	all	all
internal 5	0.01	0.01	0.01	0.007	0.009
	(0.03)	(0.03)	(0.03)	(0.038)	(0.037)
external 5 + exp	0.04	0.03	0.06		
	(0.04)	(0.04)	(0.04)		
external 5 + exp25				-0.03	
				(0.04)	
external 5 + exp50					-0.01
					(0.04)
manager 1 foreigner	-0.10	-0.1	-0.10	-0.1	-0.10
	(0.08)	(0.08)	(0.08)	(0.08)	(0.08)
manager 1 education	-0.002	-0.002	-0.002	-0.001	-0.001
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
share female manager	0.07	0.08	0.07	0.08	0.07
	(0.24)	(0.24)	(0.24)	(0.25)	(0.24)
tenure		-0.04			
		(0.04)			
manager 1 young			-0.14		
			(0.09)		
productivity	0.0007***	0.0006***	0.0006***	0.0007***	0.0007***
	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)
firm age	0.07	0.07*	0.07	0.06	0.05
	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)
uni share	-0.03	-0.0007	-0.03	-0.06	-0.06
	(0.76)	(0.76)	(0.76)	(0.78)	(0.76)
high school share	0.68	0.69	0.60	0.68	0.63
	(0.63)	(0.63)	(0.63)	(0.63)	(0.62)
vocational share	0.07	0.09	0.06	0.05	0.04
	(0.45)	(0.45)	(0.45)	(0.44)	(0.44)
high skill share	0.0009	0.001	0.0009	0.0009	0.001
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
white collar share	0.002	0.002	0.002	0.002	0.002
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
size	0.007	0.006	0.006	0.007	0.007
	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)
network	3.77***	3.76***	3.81***	3.76***	3.71***
	(0.69)	(0.69)	(0.69)	(0.69)	(0.69)
distance	0.001	0.001	0.001	0.001	0.001
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
δ	internal 5***	internal 5***	internal 5***	internal 5***	internal 5***
	ext.+exp***	ext.+exp***	ext.+exp***	ext.+exp25***	ext.+exp50***
	man. foreigner**	man. foreigner*	man. foreigner*	man. foreigner*	man. foreigner*
	man. edu.**	man. edu.**	man. edu.**	man. edu.*	man. edu.**
	w. col. share**	w. col. share**	w. col. share**	w. col. share**	w. col. share**
	network***	network***	network***	network***	network***
			firm age*		
time dummies	YES	YES	YES	YES	YES
industry dummies	YES	YES	YES	YES	YES
N	5803	5803	5803	5803	5803
Wald χ^2	283.73	288.55	284.90	292.24	293.92
Prob $> \chi^2$	0.0000	0.0000	0.0000	0.0000	0.0000

Note: Coefficients represent the change in the probability of exporting due to an increase in the independent variables' standard deviation. In case of a dummy variable the probability is estimated for a change from 0 to 1. size and productivity are measured in 1000 units. δ stands for significant unobserved effects (see equation 5.10). *,**,*** indicate significance at the 10%, 5%, 1% levels, respectively.

Table 5.6 and 5.7 go to the heart of the analysis and include the managerial characteristics of the firm. Regardless of whether the regressors are contemporaneous or lagged, it is striking how - on the one hand - none of the variables regarding the management can explain the internationalization process of a firm, which is rather related to the productivity and the fixed cost of exporting, as captured by the network variable.

Table 5.7: Probability of Exporting. With Lagged Managerial Effects.

	(1)	(2)	(3)	(4)	(5)
Dep. Var	exp_{ijt}	exp_{ijt}	exp_{ijt}	exp_{ijt}	exp_{t+1}
Sample	all	all	all	all	all
internal 5					0.05
					(0.04)
external 5 + exp					-0.01
					(0.05)
manager 1 foreigner					0.02
					(0.13)
manager 1 education					0.0003
					(0.002)
share female manager					-0.03
					(0.34)
productivity					0.0007***
					(0.0001)
firm age					0.05
					(0.05)
uni share					0.61
					(0.91)
high school share					0.80
					(0.75)
vocational share					0.31
					(0.50)
high skill share					0.0002
					(0.002)
white collar share					0.001
					(0.004)
size					0.009
					(0.008)
network					1.86***
					(0.59)
distance					0.001
					(0.001)
L internal 5	0.04	0.04	0.04	0.03	
	(0.04)	(0.04)	(0.04)	(0.04)	
L external 5 + exp	-0.02	-0.03	-0.00		
	(0.05)	(0.05)	(0.05)		
L external 5 + exp25				-0.08*	
				(0.05)	
L manager 1 foreigner	0.05	0.05	0.05	0.04	
	(0.13)	(0.13)	(0.13)	(0.14)	
L manager 1 education	0.001	0.001	0.001	0.001	
	(0.002)	(0.002)	(0.002)	(0.002)	
L share female manager	0.04	0.04	0.04	0.05	
	(0.33)	(0.33)	(0.33)	(0.33)	
L tenure		-0.05			
		(0.05)			
L manager 1 young			-0.14		
			(0.10)		
L productivity	0.0003*	0.0002	0.0002	0.0003*	
	(0.0001)	(0.0001)	(0.0001)	(0.0001)	

L firm age	0.06	0.07	0.06	0.06	
	(0.05)	(0.05)	(0.05)	(0.05)	
L uni share	0.22	0.23	0.24	0.26	
	(0.92)	(0.93)	(0.92)	(0.92)	
L high school share	0.043	0.07	0.05	0.08	
	(0.79)	(0.79)	(0.80)	(0.80)	
L vocational share	-0.70	-0.67	-0.67	-0.67	
	(0.52)	(0.52)	(0.52)	(0.52)	
L high skill share	0.0005	0.0005	0.0004	0.0007	
	(0.001)	(0.001)	(0.001)	(0.001)	
L white collar share	-0.001	-0.001	-0.001	-0.001	
	(0.004)	(0.004)	(0.004)	(0.004)	
L size	0.002	0.002	0.001	0.003	
	(0.008)	(0.008)	(0.008)	0.008)	
L network	0.99*	0.98*	1.02*	0.97*	
	(0.54)	(0.54)	(0.54)	(0.54)	
L distance	0.001	0.001	0.001	0.001	
	(0.001)	(0.001)	(0.001)	(0.001)	
δ	internal 5**	internal 5**	internal 5**	internal 5**	internal 5**
	ext.+exp***	ext.+ exp***	ext.+exp***	ext.+exp25***	ext.+exp***
	w. col. share***	w. col. share***	w. col. share***	w. col. share***	w. col. share**
			man. young*		
	network***	network***	network***	network***	network***
time dummies	YES	YES	YES	YES	YES
industry dummies	YES	YES	YES	YES	YES
N	4274	4274	4274	4274	4717
Wald χ^2	231.00	237.58	238.21	243.64	236.87
Prob > χ^2	0.0000	0.0000	0.0000	0.0000	0.0000

Note: Coefficients represent the change in the probability of exporting due to an increase in the independent variables' standard deviation. In case of a dummy variable the probability is estimated for a change from 0 to 1. size and productivity are measured in 1000 units. δ stands for significant unobserved effects (see equation 5.10). L indicates lagged variables. *,**,*** indicate significance at the 10%, 5%, 1% levels, respectively.

While this conclusion is in line with the recent trade literature on heterogenous firms, it does not seem to be firm, as the significance level in table 5.7 drops to 10%, and becomes insignificant in table 5.8, col. 1.

In table 5.8 we further take the lag of only those regressors suspicious of simultaneity, namely productivity and the management variables. Indeed, exporting firms may as well experience productivity gains from learning effects by trading, or decide to hire or promote managers with specific know-how to face the exporting-challenges. Frictional labor market seems to us - generally - less an argument for the manager category, and time to fill a vacancy is no issue for internal promotions. Similarly to table 5.5, it is again human capital, here captured by the proportion of workers with a high school degree (high skill share variable), that stands out to be marginally significant (at 10%).

Concerning the unobserved heterogeneity, management characteristics, particularly exporting experience and internal promotion, matter in a very robust way, regardless of the specification used. Interestingly, compared to table 5.5, within the δ variables only the proportion of white collar workers among all other variables inherent to human capital remains significant, once it is accounted for managerial characteristics.

Table 5.8: Probability of Exporting in Various Subsamples.

	(1)	(2)	(3)	(4)
Dep. Var	exp_{ijt}	exp_{ijt}	exp_{ijt}	exp_{ijt}
Sample	all	new exporter	new exporter	always exporter
internal 5		0.16		-0.04
		(0.11)		(0.03)
external 5 + exp		0.09		-0.01
		(0.14)		(0.04)
manager 1 foreigner		-0.36		-0.04
		(0.24)		(0.08)
manager 1 education		-0.0006		-0.004*
		(0.007)		(0.002)
share female manager		0.87		-0.10
		(0.66)		(0.26)
productivity		0.0007*		0.0006**
		(0.0004)		(0.0002)
firm age		0.32***		-0.05
		(0.10)		(0.06)
uni share	-0.55	-0.31	-0.74	-0.09
	(0.81)	(1.47)	(1.64)	(0.82)
high school share	-0.26	2.58	1.14	0.18
	(0.70)	(1.78)	(1.8)	(0.61)
vocational share	-0.65	0.89	0.25	-0.11
	(0.527)	(1.19)	(1.31)	(0.44)
high skill share	0.003*	0.002	0.002	0.001
	(0.001)	(0.004)	(0.004)	(0.001)
white collar share	0.003	-0.002	-0.008	0.004*
	(0.003)	(0.007)	(0.01)	(0.002)
size	0.001	0.01	0.004	0.02**
	(0.009)	(0.01)	(0.02)	(0.01)
network	0.77	8.23***		2.59***
	(0.53)	(1.68)		(0.69)
distance	0.001	-0.003	-0.003*	0.001
	(0.001)	(0.002)	(0.002)	(0.001)
L internal 5	0.05		0.36***	
	(0.04)		(0.12)	
L external 5 + exp	0.001		0.03	
	(0.05)		(0.14)	
L manager 1 foreigner	0.06		0.95***	
	(0.13)		(0.33)	
L manager 1 education	0.001		0.002	
	(0.002)		(0.007)	
L share female manager	0.29		-0.28	
	(0.34)		(0.79)	
L productivity	0.0002		0.00007	
	(0.0001)		(0.0003)	
L firm age	0.062		0.32***	
	(0.054)		(0.12)	
L network			1.95	
			(1.23)	
δ	internal 5**			internal 5***
	ext.+exp***	ext.+exp**	ext.+exp**	ext.+exp***
	w. col. share**	man. foreigner***		man. edu.***
		firm age***	firm age***	size*
		high school share***	high school share***	
	network***	high skill share**	high skill share**	network***
time dummies	YES	YES	YES	YES
industry dummies	YES	YES	YES	YES
N	4771	698	576	4842
Wald χ^2	230.18	-	-	183.31
Prob $> \chi^2$	0.0000	-	-	0.0000

Note: Coefficients represent the change in the probability of exporting due to an increase in the independent variables' standard deviation. In case of a dummy variable the probability is estimated for a change from 0 to 1. size and productivity are measured in 1000 units. δ stands for significant unobserved effects (see equation 5.10). L indicates lagged variables. *,**,*** indicate significance at the 10%, 5%, 1% levels, respectively.

Table 5.8: continued

	(5)	(6)	(7)
Dep. Var	exp_{ijt}	exp_{ijt}	exp_{ijt}
Sample	always exporter	non-exporter t-1	non-exporter t-1
internal 5		-0.25	
		(0.19)	
external 5 + exp		0.02	
		(0.18)	
manager 1 foreigner		0.47	
		(0.4)	
manager 1 education		-0.003	
		(0.007)	
share female manager		0.48	
		(0.97)	
productivity		0.001***	
		(0.0005)	
firm age		0.01	
		(0.08)	
uni share	-1.38	1.42	1.55
	(0.98)	(2.02)	(1.81)
high school share	-0.38	0.87	0.085
	(0.73)	(1.48)	(1.41)
vocational share	-0.75	0.66	-0.49
	(0.56)	(1.09)	(1.00)
high skill share	0.003*	0.00	0.001
	(0.002)	(0.006)	(0.006)
white collar share	0.005	-0.005	-0.002
	(0.003)	(0.009)	(0.009)
size	0.01	0.05*	0.01
	(0.009)	(0.03)	(0.03)
network		6.89***	
		(1.47)	
distance	0.001	-0.001	-0.0008
	(0.002)	(0.002)	(0.002)
L internal 5	-0.04		0.38**
	(0.05)		(0.18)
L external 5 + exp	-0.07		-0.19
	(0.06)		(0.17)
L manager 1 foreigner	-0.20		0.72*
	(0.12)		(0.40)
L manager 1 education	0.0002		-0.0009
	(0.003)		(0.006)
L share female manager	0.64		1.04
	(0.45)		(0.86)
L productivity	0.0002		0.00007
	(0.0002)		(0.0003)
L firm age	-0.051		-0.021
	(0.07)		(0.08)
L network	0.95		-3.49**
	(0.61)		(1.61)
δ	internal 5**		internal 5*
	ext.+exp***	ext.+exp**	ext.+exp**
	size*	high skill share**	
	w. col. share**		
	network***		network**
time dummies	YES	YES	YES
industry dummies	YES	YES	YES
N	3969	546	531
Wald χ^2	187.27	-	-
Prob > χ^2	0.0000	-	-

Note: Coefficients represent the change in the probability of exporting due to an increase in the independent variables' standard deviation. In case of a dummy variable the probability is estimated for a change from 0 to 1. size and productivity are measured in 1000 units. δ stands for significant unobserved effects (see equation 5.10). L indicates lagged variables. *,**,*** indicate significance at the 10%, 5%, 1% levels, respectively.

This result does not come entirely at surprise for us, as we are considering in these regressions all pooled observations, and we would expect heterogeneity to be maximum in this sample. If this conjecture is right, we should also find that management can not explain heterogeneity equally well on narrower, but more homogenous sub-samples. What it is surprising, is that neither management characteristics, even experimenting with different degree of export-intensities (not-reported), nor other variables like human capital or productivity seem related to the exporting behavior of firms. In this respect, some peculiarity of the Danish economy and of our sample may play a role. The Danish economy is a small and open economy, with, on average, more than 80% of firms exporting in each year, leaving us with fairly low variation in our dependent variable in each year. Moreover, the proportion of firms already exporting since the first period in our sample and continuing to export till they eventually die is as high as 88% in our sample – what we refer to as "*always exporter*" firm – indicating a strong persistence of the export status.[7] Therefore, for a high proportion of observations, the export status is unchanged in spite of any eventual promotion or productivity dynamic, translating in a low weight assigned by ML methods to these variables. On the contrary, a firm which is not established on the export market, yet with the goal of entry, it has to put in place accordingly a managerial strategy, plausibly involving productivity improvements and manager promotions, known in the literature as "*conscious self-selection*" *hypothesis* (see Alvarez and Lopez, 2005). Therefore, by focusing on firms that start exporting during our sample period, we should be able to better relate possible changes in the export status to some of the promotional or productivity dynamics.

To verify these conjectures, we split our sample into narrower sub-samples, at the cost of losing – unfortunately – many observations. First, we split the sample between "new exporter" (about 12% of the sample) and "always-exporter". While for the group of "always-exporter", figures are similar to those for the whole sample, for the "new exporter", internal promotion, the nationality of the manager as well as firm-age - i.e. organizational capital (see Atkeson and Kehoe, 2005) - are positive and significant at 1% level, whereas the proxy for transportation cost at 10% level, when we control for the simultaneity of some regressors taking one period lag (tab. 5.8, column 3).

Second, we pool all firms that one year before were serving only the domestic market, and therefore will eventually enter into a foreign market within at least a year. We label it the

[7] In future research, it is worth extending the analysis to a dynamic probit model.

"non-exporter" firm, almost 10% of our whole sample. One important difference with the "new exporter" group is that firms that made the transition from domestic to exporter are no longer in the pooled-sample after a year from the transition, in absence of any other changes and even if the transition occurred in the sampled period. The internal promotion and the nationality of the manager explain the exporting decision in this group (see col. 7), while firm age and distance are no longer significant at conventional levels. Network becomes significant at 5% level, with a negative sign. Given our little information, one should be cautious to interpret this sign as necessarily wrong, although it is against our prior of network effects. In fact, the network club in practice may have some barriers or costs to entry, weighting the marginal benefit from further membership, possibly low in a country with already a substantial share of exporters, against the cost of sharing information and potential foreign customers.

Again, these results are not sensitive to different degree of export-intensities. Simultaneity - at least for productivity appears to be an issue and may explain the sensitivity to the lag structure (compare for instance col. 2 with col. 3, and col. 6 with col. 7).

It is therefore highly likely that the "always-exporter" group, the most substantial group among all, is driving the results obtained with the whole sample, confirming our claim that results reflect both the openness of the Danish economy and the highly persistent export behavior in our sample, with many firms already exporting at the time the data are first available.

As expected, unobserved heterogeneity is systematically related to the manager know-how (external+exp) and if we consider at one end of the spectrum the "non-exporter" group, as the least heterogenous, and, at the other extreme, the "always-exporter" group, as the most heterogenous, a few variables other than manager know-how and promotions explain unobserved effects, while the list is far more comprehensive, including human capital, the education of managers and fixed costs, as heterogeneity increases along the spectrum.

From column 5 and 7 together, we conclude there exist some weak evidence that internal promotions are conducive to firm-internationalization, pointing - to use a military expression - "*to rise from the ranks*" effect, as an effective process to learn the potentials of the company and lead it through the complex internationalization process, definitively deserving further investigation. Complement inputs along this process are external promotions which aim at acquiring specific expertise, as suggested by management know-how being systematically related to unobserved firm-heterogeneity in the whole sample as well as across all sub-samples.

5.6 Conclusion

In this paper we are able to confirm the well established effects of productivity and trade fixed costs on the export decision of firms, based on commonly used random effects probit models (see e.g. Wagner 2001). However, given the availability of commensurate firm level data from Denmark furthermore, we are able to go beyond the existing trade literature by including management characteristics into the empirical analysis. In particular we are able to identify a new management's knowhow and experience level since we can control whether a recently hired manager stems from an exporting company. Furthermore, it is possible to control for how a manager is promoted which can be internal or external.

Our small theoretical model suggests an increase in the likeliness of exporting, the more experienced a newly hired manager turns out to be and the higher his talent (ability) is. This intuitive result does not show up in our random effects probit estimations if we include all manufacturing firms. Differently, a direct effect of management characteristics on the complex internationalization process of firms does not show up. One reason for this unexpected result is probably the peculiarity of the small Danish economy. Since more than 80% of all firms in the sample are exporting, the variation in our dependent variable turns out to be fairly low. Indeed, if we reduce the sample to only those firms which start to export during the observed time span, internal promotion of a manager and his nationality turn out to be influential for the internationalization process.

We further contribute to the existing literature by following Mundlack (1978) and Chamberlain (1980) and allowing unobservable factors to be correlated with some firm characteristics. Indeed, it turns out that management variables are systematically related to unobserved heterogeneity, in particular management knowhow (external promotion of experienced manager).

Future research within this framework will take place in several dimensions. An increase in the number of observations beyond the 5000 largest Danish firms would increase the size of non-exporting firms and probably the variance in our choice variable (export status). Such a larger sample will improve the qualitative results and might significantly change the impact of management characteristics. The introduction of export destinations is a further possible improvement which we are working on. Finally, a cross sectional analysis seems possible, since several European countries are working on generating similar data sets.

5.7 Appendix

5.7.1 Internationalization in Manufacturing

Table 5.9: Export Status of Danish Firms

Sub-Sectors	1995			1996			1997			1998		
within Manufacturing	0	1	Total	0	1	Total	0	1	Total	0	1	Total
1	18	109	127	16	114	130	20	116	136	18	113	131
2	4	51	55	6	47	53	8	41	49	7	44	51
3	15	62	77	18	61	79	19	55	74	20	56	76
5	2	39	41	2	42	44	3	48	51	2	45	47
6	1	46	47	1	52	53	3	54	57	5	49	54
7	8	28	36	9	31	40	10	28	38	13	27	40
8	2	23	25	1	22	23	3	18	21	3	22	25
9	18	67	85	16	72	88	15	66	81	17	60	77
10	6	129	135	9	120	129	9	127	136	6	133	139
11	8	8	8	8	1	9	10	1	12	13	0	0
12	4	31	35	3	31	34	3	29	32	2	32	34
13	1	24	25	2	24	26	4	22	26	3	25	28
14	2	34	36	2	36	38	3	31	34	2	30	32
15	2	13	15	2	14	16	1	17	18	16	16	0
16	12	12	1	13	14	2	11	13	1	12	13	0
17	6	43	49	7	42	49	6	46	52	6	46	52
Total	89	719	808	95	729	824	110	718	828	106	722	828

Sub-Sectors	1999			2000			2001			2002			2003		
	0	1	Total	0	1	Total	0	1	Total	0	1	Total	0	1	Total
1	22	126	148	20	126	146	18	120	138	12	117	129	11	108	119
2	5	45	50	5	47	52	5	42	47	4	40	44	2	35	37
3	39	51	90	37	55	92	14	64	78	38	44	82	31	38	69
5	4	50	54	1	43	44	2	44	46	1	40	41	1	39	40
6	2	52	54	1	51	52	1	46	47	1	47	48	0	40	40
7	9	31	40	11	26	37	11	24	35	12	25	37	11	25	36
8	0	24	24	1	28	29		21	21	0	21	21	0	19	19
9	14	72	86	12	62	74	11	54	65	6	55	61	4	48	52
10	6	143	149	6	134	140	7	127	134	6	127	133	7	110	117
11	1	8	9	0	8	8	0	6	6	0	5	5	0	5	5
12	1	31	32	2	27	29	1	25	26	1	21	22	1	20	21
13	4	27	31	1	26	27	0	19	19	0	23	23	0	17	17
14	2	32	34	1	35	36	1	32	33	1	31	32	2	28	30
15	1	15	16	1	13	14	1	12	13	0	14	14	0	12	12
16	0	15	15	0	18	18	0	11	11	0	12	12	0	11	11
17	3	47	50	3	41	44	2	32	34	1	31	32	1	30	31
Total	113	769	882	102	740	842	74	679	753	83	653	736	71	585	656

Note: This table presents the number of exporting and non-exporting firms within the Danish manufacturing sector. 17 different sub-sectors are considered between 1995 - 2003. 0 indicates domestic firms whereas 1 stands for exporters. Due to data protection policies, we do not specify the considered sub-sectors.

5.7.2 Firm Productivity

Table 5.10: Average Firm Productivity in the Manufacturing Sector

		1995	1996	1997	1998	1999	2000	2001	2002	2003	Total
1	Mean	397495	400096	420916	409735	308959	332079	324807	379589	412590	374179
	St.-Dev.	255049	261412	303435	278198	213497	244172	216243	243395	238682	253950
2	Mean	365600	386796	408905	412947	334963	346664	359376	372641	431523	378385
	St.-Dev.	228990	209377	205502	205255	186357	231427	198884	178405	182851	205521
3	Mean	230024	236499	250578	230909	185531	171722	184311	244525	218275	215441
	St.-Dev.	246371	254973	257885	255032	214251	196884	245794	257438	246810	241489
5	Mean	471565	422070	466874	485332	412135	462632	462338	449623	472399	455234
	St.-Dev.	335260	330587	333049	330183	270951	258023	321288	348748	330539	315481
6	Mean	350527	405839	366700	359566	278762	318864	319696	327280	391724	345886
	St.-Dev.	236803	222488	216699	223843	166287	163324	181664	162295	147829	197060
7	Mean	416325	351893	436595	348340	362918	389319	377734	365846	438535	386588
	St.-Dev.	272135	242816	266721	275194	231117	190634	169014	209161	262779	238360
8	Mean	364279	385749	375893	300686	345229	300662	292223	345410	404392	343599
	St.-Dev.	225717	203924	195688	216528	200761	210705	155766	155118	146872	194767
9	Mean	308064	341497	370329	312207	291358	325612	299104	358576	363432	328310
	St.-Dev.	160374	173205	232568	184288	157400	128092	147676	166872	148246	171625
10	Mean	341967	351645	354607	335364	291116	295538	319955	352774	393180	335740
	St.-Dev.	193470	205570	199569	192738	140188	173541	169583	184845	163550	182939
11	Mean	262578	307266	268849	338809	368115	479540	515338	370336	455229	361402
	St.-Dev.	158068	186660	173768	201091	258296	225388	319780	337531	349424	237743
12	Mean	305539	260066	298187	260008	212830	231420	281789	312598	348912	275362
	St.-Dev.	191664	224902	227267	193399	180723	212860	220547	206839	192149	206692
13	Mean	244444	269186	294806	334001	267138	321686	328445	376893	446975	313519
	St.-Dev.	157287	166950	187752	226779	190281	230418	260218	231458	303323	218548
14	Mean	278285	374743	403213	331352	294630	289437	310713	354208	405475	336920
	St.-Dev.	219550	234870	278698	215394	196074	169375	203989	274548	234155	228729
15	Mean	283269	270182	356162	315602	329174	296047	323860	346357	396379	322833
	St.-Dev.	154438	160663	207624	205151	162432	145146	172938	158737	80331	166439
16	Mean	308391	316641	311515	301248	244858	343960	440483	370177	418812	334942
	St.-Dev.	188757	273086	195497	225281	188138	278659	178644	182113	154214	216667
17	Mean	317869	333628	368929	349610	314346	288836	311805	369048	411195	338095
	St.-Dev.	168421	192756	224263	222370	127296	156226	155917	184407	235284	189149
Total	Mean	337878	348643	370161	346574	295686	309427	319556	351866	388016	339418
	St.-Dev.	229348	233629	251539	240818	196475	210873	214236	223864	225024	227043

Note: Productivity is measured as value-added over total number of employees (in DKK). The first number provides the mean productivity for the specific sub-sector within the manufacturing sector whereas the second number refers to the standard deviation. Due to data protection policies, we do not specify the considered sub-sectors.

5.7.3 Productivity Patterns of Exporters and Domestic Firms

Table 5.11: Productivity Patterns of Danish Firms

			1995			1996			1997	
		0	1	Total	0	1	Total	0	1	Total
1	Mean	348192	405636	397495	431727	395657	400096	375743	428705	420916
	St.-Dev	268930	253052	255049	321087	253308	261412	349574	295769	303435
2	Mean	409905	362125	365600	326989	394431	386796	410996	408496	408905
	St.-Dev	105898	236197	228990	225055	208628	209377	235615	202389	205502
3	Mean	259849	222808	230024	233676	237332	236499	203833	266726	250578
	St.-Dev	273672	241171	246371	256976	256518	254973	201727	274418	257885
5	Mean	310391	479830	471565	257293	429916	422070	358860	473625	466874
	St.-Dev	385856	336095	335260	363868	331665	330587	277123	337554	333049
6	Mean	406082	349319	350527	32400	413020	405839	351225	367560	366700
	St.-Dev		239273	236803		218368	222488	292540	215343	216699
7	Mean	547754	378774	416325	482533	313966	351893	532096	402487	436595
	St.-Dev	389251	223916	272135	287548	219071	242816	324161	240576	266721
8	Mean	313215	368719	364279	189111	394687	385749	159095	412026	375893
	St.-Dev	39148	235059	225717		204060	203924	140080	181842	195688
9	Mean	320565	304705	308064	369272	335325	341497	256589	396179	370329
	St.-Dev	159343	161679	160374	220464	162109	173205	181722	236205	232568
10	Mean	327140	342657	341967	311574	354650	351645	281307	359801	354607
	St.-Dev	268445	190681	193470	176469	207921	205570	211271	198564	199569
11	Mean		262578	262578		307266	307266	199816	276520	268849
	St.-Dev	158068	158068			186660	186660		182504	173768
12	Mean	197999	319415	305539	87070	276808	260066	245038	303685	298187
	St.-Dev	147743	194189	191664	150682	225484	224902	217976	231206	227267
13	Mean	18456	253860	244444	183919	276292	269186	299093	294026	294806
	St.-Dev		153303	157287	154916	169020	166950	226628	186075	187752
14	Mean	391943	271599	278285	405102	373057	374743	426702	400940	403213
	St.-Dev	99484	223595	219550	57378	241178	234870	447090	268428	278698
15	Mean	158939	302396	283269	311973	264212	270182	127795	369595	356162
	St.-Dev	213499	145103	154438	58459	170920	160663		205793	207624
16	Mean	308391	308391	2691		340791	316641	12369	365906	311515
	St.-Dev		188757	188757		268226	273086	15116	157125	195497
17	Mean	367619	310928	317869	172636	360460	333628	221193	388199	368929
	St.-Dev	249678	156824	168421	156869	186373	192756	167857	224899	224263
Total	Mean	333608	338407	337878	317279	352730	348643	307962	379690	370161
	St.-Dev	249569	226902	229348	254819	230599	233629	265642	248127	251539
			1998			1999			2000	
		0	1	Total	0	1	Total	0	1	Total
1	Mean	386447	413444	409735	376742	297124	308959	419667	318176	332079
	St.-Dev	313292	273557	278198	250463	205218	213497	318070	228821	244172
2	Mean	330475	426067	412947	320703	336547	334963	265942	355251	346664
	St.-Dev	193209	206145	205255	100160	194262	186357	184906	235846	231427
3	Mean	173386	251454	230909	112481	241393	185531	94220	223859	171722
	St.-Dev	174073	276753	255032	170239	228773	214251	134579	215324	196884
5	Mean	723304	474755	485332	534746	402326	412135	539485	460845	462632
	St.-Dev	295304	330614	330183	176030	276016	270951		260800	258023
6	Mean	355023	360030	359566	224839	280836	278762	403990	317195	318864
	St.-Dev	218085	226626	223843	272300	164813	166287		164501	163324
7	Mean	448110	300303	348340	291521	383646	362918	402599	383700	389319
	St.-Dev	374343	203831	275194	222617	232918	231117	150315	207806	190634
8	Mean	285627	302740	300686		345229	345229	41397	309921	300662
	St.-Dev	246161	218573	216528		200761	200761		208476	210705
9	Mean	240214	332605	312207	207711	307622	291358	276390	335139	325612
	St.-Dev	174343	183271	184288	131070	157691	157400	131134	126354	128092
10	Mean	306942	336646	335364	341635	288997	291116	223283	298773	295538
	St.-Dev	189103	193504	192738	152699	139821	140188	190853	172799	173541
11	Mean	202700	350151	338809	297833	376900	368115		479540	479540

	St.-Dev		205644	201091	274689	258296			225388	225388
12	Mean	189947	264387	260008	201	219689	212830	30470	246305	231420
	St.-Dev	268394	192759	193399		179427	180723	42953	213043	212860
13	Mean	256699	343278	334001	314995	260048	267138	74187	331205	321686
	St.-Dev	225131	229776	226779	183871	193575	190281	229503	230418	
14	Mean	202231	339960	331352	392977	288484	294630	381286	286813	289437
	St.-Dev	285998	213418	215394	35577	200553	196074		171104	169375
15	Mean		315602	315602	317226	329971	329174	297829	295910	296047
	St.-Dev		205151	205151		168101	162432		151071	145146
16	Mean		326352	301248		244858	244858		343960	343960
	St.-Dev		215471	225281		188138	188138		278659	278659
17	Mean	235748	364461	349610	260978	317752	314346	254680	291335	288836
	St.-Dev	148593	227231	222370	84335	129438	127296	116293	159584	156226
Total	Mean	299416	353498	346574	246839	302863	295686	243699	318486	309427
	St.-Dev	256986	237753	240818	214182	192846	196475	230682	206528	210873
			2001			2002			2003	
		0	1	Total	0	1	Total	0	1	Total
1	Mean	310819	326905	324807	363596	381230	379590	391816	414705	412590
	St.-Dev	234235	214388	216243	242027	244511	243395	273081	236235	238682
2	Mean	307333	365572	359376	403017	369603	372641	410780	432709	431523
	St.-Dev	179075	202189	198884	116518	184240	178405	118928	186972	182851
3	Mean	117634	198897	184311	151806	324600	244525	110335	306330	218275
	St.-Dev	154424	260222	245794	210336	269474	257438	157419	272276	246810
5	Mean	554341	458156	462338	14303	460506	449623	128963	481205	472399
	St.-Dev	766886	306494	321288		346068	348748		330072	330539
6	Mean	443430	317006	319696	453612	324592	327280		391724	391724
	St.-Dev		182722	181664		162967	162296		147829	147829
7	Mean	364252	383913	377734	321843	386968	365846	380611	464022	438535
	St.-Dev	188326	163342	169014	125631	238654	209161	202207	285397	262779
8	Mean		292223	292223		345411	345411		404392	404392
	St.-Dev		155766	155766		155119	155119		146872	146872
9	Mean	255126	308063	299104	269379	368306	358576	212954	375971	363432
	St.-Dev	135304	149657	147676	156824	166382	166873	134175	143564	148246
10	Mean	243915	324146	319955	303498	355102	352774	416077	391723	393180
	St.-Dev	163993	169518	169583	169324	185839	184846	159609	164403	163550
11	Mean		515338	515338		370337	370337		455229	455229
	St.-Dev		319780	319780		337531	337531		349424	349424
12	Mean	56419	290803	281789	313734	312544	312598	351582	348779	348912
	St.-Dev		220152	220547		211946	206839		197139	192149
13	Mean		328445	328445		376893	376893		446975	446975
	St.-Dev		260218	260218		231459	231459		303323	303323
14	Mean	324092	310295	310713	59033	363731	354209	189335	420913	405475
	St.-Dev		207238	203989		273662	274548	261347	229461	234155
15	Mean	5199	350415	323860		346357	346357		396379	396379
	St.-Dev		150419	172938		158737	158737		80331	80331
16	Mean		440483	440483		370177	370177		418812	418812
	St.-Dev		178644	178644		182113	182113		154214	154214
17	Mean	318208	311405	311805	595364	361748	369048	732380	400488	411195
	St.-Dev	61425	160480	155917		182695	184408		231499	235284
Total	Mean	268555	325115	319556	246738	365228	351866	254854	404177	388016
	St.-Dev	217199	213336	214236	212825	221839	223864	230358	219121	225024

Note: Productivity is measured as value-added over total number of employees (in DKK). The first number provides the mean productivity for the specific sub-sector within the manufacturing sector whereas the second number refers to the standard deviation. Due to data protection policies, we do not specify the considered sub-sectors.

5.7.4 External Promotion of Top 5 CEOs

Table 5.12: External Promotion of Management - Top 5

	Domestic			Exporter			Total		
	0	1	total	0	1	total			
1995	147	30	177	687	214	901	834	244	1,078
1996	165	23	188	764	171	935	929	194	1,123
1997	160	34	194	715	190	905	875	224	1,099
1998	157	26	183	709	223	932	866	249	1,115
1999	158	31	189	672	229	901	830	260	1,090
2000	138	32	170	600	250	850	738	282	1,020
2001	101	25	126	564	216	780	665	241	906
2002	88	31	119	568	176	744	656	207	863
2003	80	19	99	495	169	664	575	188	763
Total	1,194	251	1445	5774	1838	7612	6,968	2,089	9,057

Note: If one of the top 5 management members (in terms of highest income) is promoted externally, a firm is considered as an external promoter. Whether the hired manager has export experience is not controlled for.

Table 5.13: External Promotion of a Manager. With and Without Export Experience

		Domestic			Exporter			Total		
		0	1	Total	0	1	Total	0	1	Total
experience = 0	1995	147	30	177	687		687	834	30	864
	1996	165	4	169	717		717	882	4	886
	1997	155	5	160	659		659	814	5	819
	1998	150	4	154	642		642	792	4	796
	1999	147	5	152	589		589	736	5	741
	2000	129	2	131	517		517	646	2	648
	2001	93	5	98	484		484	577	5	582
	2002	78	0	78	474		474	552	0	552
	2003	74	0	74	410		410	484	0	484
	Total	1138	55	1193	5179		5179	6,317	55	6,372
experience = 1	1995	0	0	0	0	214	214	0	214	214
	1996	0	19	19	47	171	218	47	190	237
	1997	5	29	34	56	190	246	61	219	280
	1998	7	22	29	67	223	290	74	245	319
	1999	11	26	37	83	229	312	94	255	349
	2000	9	30	39	83	250	333	92	280	372
	2001	8	20	28	80	216	296	88	236	324
	2002	10	31	41	94	176	270	104	207	311
	2003	6	19	25	85	169	254	91	188	279
	Total	56	196	252	595	1838	2433	651	2,034	2,685

Note: The table accounts for whether a firm (only domestic or exporter) has promoted a person for a position within the top 5 management group externally. Furthermore, it is distinguished between a new manager who was previously employed at an exporting company (experience=1) and a person who comes from a non-exporting enterprise (experience=0).

CHAPTER 6

Concluding Remarks

This thesis comprises four self-contained studies analyzing firm behavior in an international trade and investment context. The objective within this project has been to provide sound and original research perspectives on several issues, both theoretically and empirically. In particular, motivated by the unavailability of appropriate explanations for the impact of different types of uncertainty on multinational firm behavior, I endeavored to fill some gaps by profound contributions. New problems require sometimes new procedures and with this dictum I have designed a theoretical model combining elements from international economics and finance. The resulting innovative theoretical framework fulfills as a first step the objective to assess the impact of uncertainty on firm behavior. Indeed, several new results have been derived and some of these findings herein can easily be imagined as having potential implications for the prevailing economic literature but also for policy and corporate practices.

Chapter 2 provides a new theoretical model combining the proximity-concentration trade-off framework with the real option theory. The merge of these two fundamental approaches allows the analysis of firm behavior in the presence of uncertain productivity growth, which is modeled as a Geometric Brownian motion. In particular, it is possible to determine a firm's optimal first time market entry strategy – export or FDI – into a new foreign market. Within the assumed specific cost patterns, productivity growth as such already turns out to favor FDI as the optimal market serving mode. The larger the productivity growth is the more likely is a firm to enter the new foreign market as a foreign direct investor. In case of a stochastically evolving productivity over time, market entry through FDI becomes even more likely. This result coincides with the New New Trade Theory findings in which sectors with higher productivity distortion exhibit more foreign direct investors. Finally, the model provides an analytical method to derive the market entry time of a firm confronted with uncertainty.

Chapter 3 represents an extension of my basic dynamic theoretical model. Besides answering the question which initial market entry strategy represents the optimal serving mode this framework additionally allows for analyzing a firm's switching behavior between different internationalization strategies. In line with the real option theory we find that a multinational firm is confronted with hysteresis – a band of inaction – if confronted with fixed costs and uncertain productivity growth. Four crucial dimensions are identified leading to a back and forth switching between different strategies. The likeliness of serving mode discontinuity decreases in entry fixed costs. The range of inaction increases further the lower abandonment benefits turn out to be. The lesser fixed costs are sunk, the narrower becomes the range of hysteresis increasing the likeliness of switching over time. In contrast, productivity growth as such mildly affects hysteresis whereas volatility again increases hysteresis and therefore reduces the likeliness to switch into a new serving mode once being in a market. Finally, we show that a more competitive market increases the likeliness of switching between serving modes, since competition reduces hysteresis. Our theoretical findings provide testable predictions on international serving mode patterns which will open out into future empirical research, once we completed a commensurate dataset.

Chapter 4 relates to the conundrum that WTO negotiations about tariff liberalization typically – if not exclusively – revolve around so called bound tariffs. Based on a dynamic theoretical model we are able to analyze the impact of a reduction in the risk of changes in a destination country's trade policy which affects the difference between bound and applied tariff. We show that bound tariffs are more effective if destination markets are riskier concerning their trade policy. Furthermore, larger binding tariff overhangs – difference between bound and applied tariffs – may still command substantial market access. Finally, a reduction in bound tariffs generates effective market access even when bound rates are above current and long-term applied tariff rates.

In Chapter 5 we concentrate on a new direction of empirical analysis in international trade by analyzing the impact of management characteristics on the internationalization process of firms. We are able to confirm the commonly accepted impact of labor productivity and export fixed costs on a firm's export decision based on a random effects probit model. Although we cannot prove a direct impact of management characteristics on the complex internationalization process of firms – probably due to the particularity of our dataset – still the empirical analysis contains important results. Following Mundlack (1978) and Chamberlain (1980) we find that management characteristics are systematically related to unobserved heterogeneity, in particular management knowhow. This confirms our theoretical assumption that there exist unobservable characteristics like talent or ability which can be at least controlled for in the way we suggest.

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