ESSAYS ON ASSET PRICING: LINKING MACROECONOMIC FACTORS TO EXPECTED RETURNS

by

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ABSTRACT

This thesis examines two major areas of asset pricing: the choice of risk factors in pricing stocks in a single country context, and in an international context. First, the thesis provides an economic explanation for an empirical fact that stock returns are related to firm size and the book-to-market ratio. We show that profit maximizing homogenous firms should converge to a stable long-run equilibrium, in which firm capital size and growth rates are shaped by the economic environment. Internal firm characteristics such as market value and the book to market ratio influence returns by reflecting existing macroeconomic conditions. Fama and French (1992, 1993, 1995) relate stock returns to firm characteristics and provide an intuitive explanation why firm attributes may proxy for firm risk sensitivities. In our theoretical model we provide an economic argument why this may be the case.

Second, we empirically test our theory. We find supporting evidence that firms converge to an optimal size. We also find that an increased growth rate of technology is associated with an increase in optimal size of firm capital.

Next, we estimate a time-varying market integration model to analyze the effect of the European monetary unification and economic liberalization. We use a sample of three EMU (France, Germany, Netherlands) and two non-EMU (U.K. and Switzerland) countries, as well as the European stock market index and a currency index, using monthly data from March 1984 to November 2002. We find that financial markets in

Europe followed a gradual integration process that did not jump to full integration even after the introduction of the Euro in 1999.

We find that countries with higher degrees of financial integration tend to have lower prices for market and currency risk, consistent with the prediction of models of capital market integration. We also provide additional evidence that prices of market and currency risks are significant and time varying. Evidence suggests that financial integration reduces prices of risks and risk premia. We identify two dates when integration-related structural breaks occurred in European asset pricing. No dramatic upward shift in integration associated with the introduction of the Euro is detected.

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CHAPTER 1

INTRODUCTION

1.1 Asset pricing and choice of risk factors

Asset pricing has been one of the major challenges in finance. The history of asset pricing starts with the article of Daniel Bernoulli (1738), who suggested how to calculate expected values of uncertain payoffs and how to account for investor preferences with respect to risky choices. Major developments in asset pricing took place in last half of the twentieth century and include the Markowitz (1952) Efficient Frontier, the Capital Asset Pricing Model of Sharpe (1964), Lintner (1965), and Mossin (1966), the Black (1972) pricing model, the Intertemporal CAPM of Merton (1973), the Arbitrage Pricing Theory of Ross (1976), and the International Asset Pricing Model (IAPM) of Adler and Dumas (1983). Dimson and Mussavian (2000) provide a brief history of modern asset pricing literature.

The objective of this thesis is to investigate asset pricing in both a single country setting and in an international capital market setting. The first question that we address is the choice of risk factors for stock pricing. There is empirical evidence that firm characteristics such as size and book-to-market ratio are related to asset pricing, but currently there is a controversy about whether these firm attributes have economic interpretation. We develop an economic explanation for this empirical fact, and test whether our theory has empirical support. The third issue is asset pricing in the European capital market setting. We examine the impact of the process of European monetary unification on asset pricing using a time-varying model of capital market integration. Under certain assumptions, once several European countries have introduced common currency, their capital markets should become fully integrated. However, evidence on this matter is mixed. Currency is one type of barrier for cross-border transactions. Other barriers to international investments, for example cultural differences, may still exist even when the currency barrier is removed.

1.2. Thesis research questions

All themes of this research have a common thread of asset pricing.

1.2.1. The first question is how the size of a firm's invested capital and book-to-market ratio are related to the firm's market value and how the macroeconomic environment shapes these firm characteristics. This research provides theoretical reasoning for the empirical fact that firm market value and book-to-market ratio help to explain stock returns, as shown by Fama and French (1992, 1993, 1995).

1.2.2. The second question is whether our theoretical model has empirical support. We investigate how firms converge toward the equilibrium firm characteristics, such as size or book-to-market ratio, and how firm equilibrium characteristics change along with macroeconomic conditions.

1.2.3. The third question is how the process of European integration and the introduction of the Euro affected equity pricing in Europe. We study whether or not prices of currency and market risks decreased for the countries that implemented the Euro. Next, we examine whether or not stock markets in the countries that implemented the Euro displayed signs of complete market integration as predicted by the theory.

1.3. Asset pricing and the macroeconomic environment - theory

In chapter 2 we develop a theoretical model that provides an economic explanation for the empirical results obtained by Fama and French. We use neoclassical economics modeling to derive equilibrium firm size from the perspective of profit maximization. This research is consistent with Solow (1956), Lucas (1978), or Maksimovic and Phillips (2002).

1.3.1. Literature summary

Finance research has generated several asset pricing models that relate stock returns to benchmark factors. The first major model is the capital asset pricing model (CAPM) of Sharpe (1964), Lintner (1965), and Mossin (1966). The CAPM contains a single risk factor, the market return, and relates a stock return to this risk factor via the beta, the stock's measure of riskiness. The second model is the arbitrage pricing theory (APT) of Ross (1976). The APT is a more comprehensive model than the CAPM in the sense that it relies on neither utility nor return distribution assumptions of the CAPM, and does not restrict stock returns to be dependent on a single risk factor.

Although the APT has more empirical support than the CAPM, it has its own drawbacks. The main shortcoming of the APT is that it provides no guidance about what the risk factors should be, which was noted by Dhrymes, Friend and Gultekin (1984), among others. Black (1993) also states that the APT relies on data, not utility theory, which opens a number of estimation questions. Initially estimation of the model was based on factor analysis. Cho and Taylor (1987), Connor, and Korajczyk (1988), Brennan, Chordia, and Subrahmanyan (1998), Zhou (1999), and Jones (2001) base their analyses on extracting factors from the stock returns. Chan, Chen, and Hsieh (1983) and

Chen, Roll, and Ross (1986) bring into play a different approach: they use macroeconomic variables as risk factors. On the other hand, Fama and French (1992, 1993, 1995, 1996) relate firm market value and the book-to-market ratio to stock returns and argue that these variables are proxies to firm risk sensitivities with respect to the economic environment.

Ferson and Harvey (1991, 1999) suggest that models with conditional risk sensitivities perform better than unconditional models. The variables used for conditioning are once again the macroeconomic risk factors. The link between the Fama-French factors and the economic environment was further established by Liew and Vassalou (2000), who find that Fama-French factors can predict economic growth. In addition, Cooper, Gulen, and Vassalou (2001) find that macroeconomic variables combined with Fama-French factors better predict expected returns, and Vassalou (2003) finds that information related to future macroeconomic conditions predicts stock returns.

Hodrick and Zhang (2001) compared asset-pricing models based on Hansen and Jagannathan's (1997) distance measure. They tested a number of models, including four models that used explicit macroeconomic risk factors and two versions of Fama and French (1993, 1996) models and found that none of the models were clearly superior to each other. Zhou (1999) finds that the Fama-French model performs better than a two-factor model based on Chen, Roll, and Ross (1986) factors.

To summarize the debate about risk factors, both macroeconomic variables and Fama-French factors explain stock returns. A number of studies have also related Fama-French factors and the macroeconomic variables; evidence on which set of variables is superior is mixed. A natural question arises whether the Fama-French factors and macroeconomic risk factors, for example discussed in Chen, Roll, and Ross (1986), actually convey the same information. Theory linking the two sets of factors has been almost non-existent.

1.3.2. Research design

We develop a theoretical paper based on neoclassical Solow growth models from Economics, which demonstrates the relation between economic factors and industry/company characteristics. It predicts firm convergence towards an optimal firm size, and sensitivity of optimal firm size to technological growth. Whereas a standard economic approach is to analyze economic systems aimed at maximizing output, here we analyze an economic system aimed at maximizing profit. We find that equilibrium values of capital size and output exist, and explore whether the equilibrium is stable. Next, we consider situations where firm characteristics deviate from the equilibrium values, and find possible reasons for such deviations. We consider how the macroeconomic environment and the equilibrium firm parameters shape firm market value.

1.3.3. Results

This study clarifies the impact of the macroeconomic environment on the size and market value of the firm. We show that if capital owners have the objective of profit maximization, an economy consisting of homogenous firms has an equilibrium growth path. Given the knowledge about the macroeconomic environment, we show that it is possible to infer the equilibrium size and market to book parameters of the firms that operate in the economy. We review scenarios where a firm departs from the equilibrium growth path, and find possible causes for such developments.

In this model, information about the changes in the firm parameters should be useful for understanding the type of changes occurring in the economic environment, since in equilibrium the macroeconomy influences asset size and market values of the firms. This theoretical result corresponds with recent empirical studies, including Ferson and Harvey (1999), Cooper, Gulen, and Vassalou (2001), or Carrieri et al. (2003), which use conditional pricing models as the basis for analysis of stock returns[1].

1.3.4. Contributions

Empirically, it has been shown that stock returns are related to firm size and the book-to-market ratio (Fama and French, 1993). Fama and French (1995) provide intuitive arguments that firm characteristics may be related to firm sensitivities to macroeconomic risks. However, there is little theory to explain how exactly the macroeconomic environment affects firm parameters.

This paper provides an economic explanation for this phenomenon. Profit maximizing homogenous firms should converge to a stable long-run equilibrium, in which firm capital size and growth rates are shaped by the economic environment. Knowledge of economic parameters and firm characteristics such as assets and market value reveal whether a firm is pursuing a profit maximization strategy or not. We consider cases where amounts of firm capital and/or book-to-market ratios deviate from equilibrium parameters and derive comparative dynamics that can potentially be used as testable implications. Our model is consistent with those of Fama and French (1992, 1993, 1995), who relate stock returns to firm characteristics. Our model provides the

[1] Our own empirical study (Rakhmayil and Mossman, 2003) shows that company-specific characteristics partially capture the changing macroeconomic factors.

predictions that are consistent with the empirical results that firm characteristics reflect the firm's sensitivity to the macroeconomic environment.

1.4. Asset pricing and the macroeconomic environment - evidence

Chapter 3 explores the relationship between the macroeconomic environment and optimal firm characteristics. We test whether firm size converges to equilibrium values and whether the change in equilibrium that results from an increase in technological growth is in line with predictions of our theoretical model.

1.4.1. Literature review

Fama and French (1992, 1993, 1995) relate stock returns to firm characteristics and provide an intuitive explanation of why firm attributes may proxy for firm risk sensitivities. Theoretical development of the neoclassical economic growth models includes Solow (1956), Lucas (1978), and Maksimovic and Phillips (2002). Empirical testing of neoclassical models was performed by Baumol (1986), De Long (1988), Baumol and Wolff (1988).

1.4.2. Research design

We test convergence properties of firms, as well as predictions of the theoretical model with respect to dynamics of the optimal firm size. In testing convergence properties of the model, we rely on the standard approach of testing similar models pioneered by Baumol (1986), De Long (1988), Baumol and Wolff (1988). They conduct regression-based tests of convergence and comparative dynamics for different countries using macroeconomic data such as GDP levels and GDP growth rates. Unlike these papers, we study stock returns of companies as opposed to increases in gross domestic products of countries, but the principle remains the same: we try to find a relationship between a company's starting point in terms of size of productive capital and subsequent stock returns. Companies located away from the optimal point are expected to earn lower returns, and companies located closer to the optimal point are expected to earn higher stock returns because the market will bid their prices up after recognizing that these companies are the most successful in maximizing profits in the current economic environment. We also test predictions given by comparative dynamics of the model. Specifically, we examine whether optimal firm size increases as the technological growth rate increases

1.4.3. Data

Our sample consists of 22336 companies. We use annual US data on total assets and total liabilities from 1985 to 2004 from the S&P COMPUSTAT Active+Research dataset. We also use additional S&P COMPUSTAT data from 1985 to 2004, which include market values, annualized total returns, the number of employees, and market betas. We use the Federal Reserve Board's monthly index of US industrial production of computers, communications equipment, and semiconductors, as well as annual inflation rates, all obtained from the Economagic database.

1.4.4. Results

We find statistical support for convergence properties of our model. Companies converge towards the maximum profitability parameters, as predicted. In addition, we find some empirical support for predictions given by the theoretical model's comparative dynamics. Specifically, we find that in most industries the optimal firm return increases along with the technological growth rate.

1.4.5. Contribution

We obtain statistical results consistent with the convergence prediction. Next, we discover evidence supporting predictions of our theory related to technological growth, especially among high technology users. Therefore, we find empirical evidence supporting our theory. To our best knowledge, this is the first paper that tests for and finds evidence supporting a theory that explains how optimal firm characteristics are shaped by the economic environment, although many previous studies follow Fama and French (1995) intuitive arguments and econometric specifications.

1.5. Asset pricing in European stock markets

Chapter 4 is an empirical study of European stock market integration and the relationship between the market integration and political or economic events related to European unification. We find that the degree of stock market integration gradually increases, especially among the countries that implement the Euro.

1.5.1. Literature review

The concept of financial market integration is closely related to the choice of relevant risk factors in international asset pricing. The markets are said to be fully integrated if the relevant market (in the CAPM sense) is the international market. Conversely, if a market is fully segmented, then the relevant risk factor is that country's stock market index. Any situation between these two extremes is called mild segmentation. One of the first studies on this topic was conducted by Agmon (1972), who was followed by Errunza and Losq (1985), Jorion and Schwartz (1986), Alexander, Eun, and Janakiramanan (1987), Mittoo (1992), Chan, Karolyi, and Stulz (1992), Campbell and Hamao (1992), Bekaert, and Harvey (1995), and Carrieri, Errunza, and Hogan (2002), to name a few. A general picture emerging from these studies is that in the earlier years capital markets were mostly segmented, but the degree of integration increased from the late 1980s.

Literature suggests that stock market segmentation is caused primarily by the investment barriers across countries. Stulz (1981) and Gultekin, Gultekin, and Penati (1989) indicate that the main causes of segmentation are regulatory barriers to international capital flows set by local governments. This view is supported by Domowitz, Glen, and Madhavan (1997), who find a relation between restrictions on foreign ownership and market segmentation. Errunza and Miller (2000) also mention other barriers, such as taxes, transaction costs, low liquidity, inadequate regulation of some capital markets, restrictions on capital movements and currency exchange. Bekaert, Harvey, and Lumsdaine (2002) find evidence of integration around dates of capital market liberalizations in a number of countries. Finally, Pretorius (2003) notes that economic similarities among countries contribute to integration of capital markets.

There exists a straightforward economic argument in favour of reduction in government controls[2] (and consequently capital market integration), according to which international trade extends the production possibilities frontier with positive implication for the output and income. For example, Dornbusch (1992) argues that deregulation should lead to economic growth in developing countries. On the other hand, globalization is not seen as a positive process in some studies. McKinnon and Pill (1997) and Stiglitz (1999) show how economic liberalization can hurt developing countries, and Krugman et. al. (1984) presents a case of why government controls should be reinforced in the USA. In this light a question arises as to whether integration of capital markets is advantageous for participating economies or not. Errunza and Losq (1989) develop a theoretical model where market value of securities increase and capital markets become integrated when the capital controls disappear. Obstfeld (1994) shows that simultaneous undertaking of risky projects and market integration is similar to portfolio diversification in the sense that it reduces risk and provides returns that are above the riskless rate. Basak (1996) shows that integration opens new borrowing possibilities to smooth consumption.

At the same time, Obstfeld (1998) acknowledges that while there are a lot of benefits to capital market integration, it is not possible to regulate using typical macroeconomic policy measures in a globalized economy. In addition, Kyle and Xiong (1999) derive an equilibrium model where market decline may lead to a situation in which financial intermediaries lose money and liquidate positions, thus spreading financial instability if

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[2] The government controls include stock ownership restrictions, existence of different currencies, administrative oversight on transactions, and other control measures, see Davidson (1998) for a more detailed discussion of government controls on international capital flows.

there are no government controls to stop it. Another liquidity-based model of financial contagion is developed by Lagunoff and Schreft (2001).

Many empirical results are consistent with the notion that integration leads to a reduction in risk and cost of equity capital. Stulz (1999a) finds that integration does not increase volatility of smaller markets; in another paper Stulz (1999b) confirms that globalization reduces the cost of equity capital. Bekaert, Harvey, and Lundblad (2000) find strong evidence of a relation between economic development and financial liberalization. Kim, and Singal (2000) note that efficiency of emerging markets increases as foreign investors enter the market. Finally, Henry (2000a, 2000b) finds evidence that cost of equity capital in emerging markets decreases with liberalization, and private investment increases.

On the other hand, some studies also argue that the benefits of financial integration are less obvious. Masih and Masih (1999) reveal linkages between Asian markets and Western markets. They suggest that market integration can lead to financial contagion. Contagion is loosely defined in the literature as excessive comovements of asset prices. Morck, Yeung, and Yu (2000) reject the hypothesis that comovements of asset prices are caused by comovements of fundamentals; this raises a question of whether financial integration increases uncertainty in capital markets. Bekaert, Harvey, and Ng (2005) detect return correlations in excess of what economic fundamentals would predict in Asia during the Asian crisis. Chakrabarti and Roll (2002) relate the Asian crisis to worsening diversification opportunities, a logical consequence of market integration. Francis, Hasan, and Hunter (2002) argue that while several countries gained from liberalization, overall the benefits are country-specific. In addition, Sarkissian and Schill

(2003) find that cost of capital gains from cross-listing a firm's securities on foreign exchanges appear to be modest at best even for companies from segmented markets. Thus, the question of whether capital market integration increases or decreases market risk and cost of equity capital does not seem to have a definitive answer.

Researchers have approached the issue of capital market integration (or lack thereof) in Europe from three general directions. The first line of analysis involves testing whether markets of European countries move together in a cointegrated vector[3]. The second approach evolved from the application of a multivariate GARCH framework to the problem, which includes models based on the International Asset Pricing Model (IAPM) or those stemming from moving average modeling of the data generating process. The final direction of research comprises tests for real economic integration, factor price convergence, and other methods[4].

Multivariate GARCH models offer an opportunity to estimate mean, variance, and covariance equations jointly for several processes. Bekaert and Harvey (1995) used this opportunity in their analysis of emerging markets. In the European context, Hardouvelis et al (2005) use a multivariate GARCH framework based on the IAPM. The authors find that integration in European equity markets substantially increased after 1995. Carrieri

[3] Alexakis, Apergis, and Xanthakis (1997) used cointegration to find that real interest rates had a long-run relationship within the European Monetary System (EMS). Serletis and King (1997) find common stochastic trends in ten European Union (EU) stock markets. Centeno and Mello (1999) conclude from cointegration analysis that European money markets were integrated but bank lending markets were segmented during 1985-1994. Kleimeier and Sander (2000) find little evidence of cointegration after 1992, and hypothesize that it means either absence of market integration, or movement towards convergence as a result of integration. Swanson (2003) uses cointegration and vector autoregression (VAR) to show that international money and equity markets are developing into an increasingly integrated system.

[4] European integration has also been tested using indirect approaches, mostly based on comparing returns in different countries, comparing predictive abilities of country or industry indices, or relying on other methods. Armstrong et al (1996), Samant (1999), Goodwin and Ross (2002), and Dumas et al (2003) provide evidence consistent with a high degree of financial integration in Europe. Conversely, Fraser and Power (1994), De Menil (1999), Harm (2001), Wojcik (2002), and Bieling (2003) argue that the degree of integration is quite low. Overall, the reader can conclude that research on European integration produced mixed results.

(2001) obtains evidence suggesting that European prices of market and currency risks decreased with financial liberalization. Fratzscher (2002) also discovers an increase in the degree of integration for European countries, especially since 1996. He assumes a moving average data generating process and estimates a series of 3-variate GARCH models. Sentana (2002) uses a similar model and finds evidence that the EMU reduced exchange rate and interest rate volatilities. He also tests and rejects the hypothesis of European market integration.

Several issues addressed in these papers call for further clarification. Carrieri (2001) employs a specification that does not directly incorporate regime switching between segmentation and integration. Hardouvelis, et al (2005), as well as Fratzscher (2002) use estimation procedures that involve several steps. In addition, their market integration measures are different from those used in Bekaert and Harvey (1995) in the sense that they are (in theory and in some cases in practice) not confined to [0,1]. From this perspective, it is intriguing to see whether a simultaneous estimation procedure and a logistic-type regime switching function would yield different results; therefore, we used this method for our study.

One of the possibilities for the differences in the results mentioned above could be the differences in methodologies used in these studies. In addition, the papers above analyze different markets, and it could also have some bearing on the outcome; for example, stock markets may have different degrees of integration compared with the fixed income markets. The final part of the thesis is an attempt to deepen understanding of European financial integration from the perspective of international equity pricing.

1.5.2. Research design

Our study analyzes the impact of European monetary unification on equity pricing in a regime-switching multivariate GARCH framework, where each country is allowed to switch between full integration and full segmentation regimes. We estimate time-varying pricing relationships jointly for France, Germany, Netherlands, U.K., and Switzerland, as well as for the European market index and a currency index. Next, we estimate the timing of integration-related structural breaks using the Bekaert et al (2002) method.

Our method has a number of advantages compared with the methods used in previous studies on European integration. The joint estimation for all countries provides more consistent estimates, compared with the stepwise estimation used in other studies (for example, Hardouvelis et al (2005)). For maximum likelihood models, joint estimation allows us to be confident that we achieve the maximum of the likelihood function, whereas stepwise estimation provides no such assurance. From a different perspective, joint estimation takes account of conditional return covariances among the countries in our sample, while the stepwise method assumes that no such covariances exist.

By explicitly allowing regime switching we avoid making strong assumptions of full integration or full segmentation. We use a logistic function in the regime-switching variable, which makes our study consistent with Bekaert and Harvey's (1995) original methodology. This allows us to avoid the problem encountered by Hardouvelis, et al (2005) and Fratzscher (2002), whose integration measures were not bound by a [0,1] interval, and thus are difficult to interpret. The drawback of joint estimation is that there is a large number of parameters to estimate, and a gradient-based estimation method takes a lot of computing power and time to produce the results. Thus, it is difficult to use this method for a large number of countries.

We examine the evidence on whether financial integration of stock markets in Europe followed a quick or slow process, and whether this process jumped to full integration after the Euro was introduced. We also determine whether or not differences (between a country and the international marketplace) in term premiums and differences in dividend yields are significantly related to the degree of market integration. Finally, we try to relate the estimated dates of structural breaks to political or economic events in recent European history.

1.5.3. Data

Our sample includes equity market data for France, Germany, the Netherlands, Switzerland, the UK, and Europe. Stock index data and macroeconomic indicators are also used. All stock market data are obtained from Morgan Stanley Capital International. Data series for the European term structure and the default premium for the whole sample were not available; we use corresponding US variables as proxies[5].

1.5.4. Results

First, we find that financial integration in Europe followed a gradual integration process and did not jump to full integration even after the introduction of the Euro in 1999. We also find that the Euro countries generally display higher degrees of market

[5] This assumes that the US economic variables proxy the world (including European) economic variables. The US variables were used as proxies by many studies, including Bekaert and Harvey (1995), Carrieri (2001), De Santis and Gerard (1998), Adler and Qi (2003), Carrieri et al. (2003), and shown to be useful predictors for returns in other countries, including European countries.

integration compared to the non-Euro countries in our sample. Countries with higher degrees of financial integration tend to have lower prices for market and currency risk, consistent with the prediction of most theoretical models of capital market integration. We find that prices of market and currency risks are significant and time varying in our sample. Finally, we document that structural changes in equity pricing occurred in 1986 for all countries in our sample. However, the countries that implemented the Euro also experience a second series of breakpoint dates in different months around January 1999.

An asset pricing model similar to Bekaert and Harvey (1995) and De Santis and Gerard (1998) is used. This model relates stock returns to market and currency risk factors, conditional on the macroeconomic environment. We find that macroeconomic variables have significant impact both on the prices of market and currency risks, and on determination of which set of risk factors, local or European market-wide, are relevant for stock pricing in a particular country.

1.5.5. Contribution

This study makes several contributions to the literature. The current study differs from previous research in that we perform a joint estimation of the European stock market returns using a regime-switching model consistent with Bekaert and Harvey (1995). The measure of integration that we use is also restricted to the interval [0,1]. Second, to our best knowledge, this is the first paper that estimates dates of structural breaks in European asset pricing related to market integration. We examine two variables (difference in term premiums and difference in dividend yields between a country and the

European common market) and provide evidence that they are significantly related to stock market integration.

1.6 Summary

This thesis examines several issues pertaining to asset pricing in national and international contexts. First, we construct a theoretical model that allows us to study how the size of a firm's capital and book-to-market ratio are related to the firm's market value and how the macroeconomic environment shapes these firm characteristics. Second, we provide empirical support for the theoretical model. Third, we assess how the process of European integration and the introduction of the Euro affected equity pricing in Europe.

The empirical relationship between firm characteristics and stock returns has been known for years. Chapter 2 of this thesis provides an economic explanation for this relationship. We show that if an economy consists of profit maximizing homogenous firms, they should converge to a stable long-run equilibrium, in which firm capital size and growth rates are shaped by the economic environment. Information about both the economic environment and firm characteristics, such as size and market value, is enough to make a judgment whether a firm is pursuing a profit maximization strategy or not. Testing of the theoretical model in Chapter 3 provides results consistent with the conclusions of previous research that firm characteristics reflect the firm's sensitivity to the macroeconomic environment. However, using a different empirical method, we extend this research to demonstrate that firms tend to obtain higher returns if they are closer in economic size to an optimum. We also show that in higher technology industries, returns are affected by larger economic size.

The last issue investigated in this thesis is asset pricing in Europe between 1985 and 2002. According to a number of theoretical models, the European stock markets would be expected to display higher integration with the breakdown of government barriers to cross-border transactions over time. Our evidence supports that the countries which implemented the Euro did display higher integration than those that did not but not complete market integration. We also find evidence of structural changes in European asset pricing around the dates of major political decisions related to the monetary unification of Europe, and make statistical inferences with respect to the actual dates when these political decisions were reflected in European capital markets.

Thus, our contributions to the literature consist of the following. We present an economic theory that explains how the macroeconomic environment affects characteristics of profit-maximizing firms. Next, we find empirical evidence supporting our theory. Finally, we uncover new evidence on European financial market integration by measuring the financial integration jointly for all corresponding countries, and by estimating the dates of integration-related structural changes in asset pricing for each country in our sample.

To summarize, we investigate issues of asset pricing in a national context and in an international marketplace. All fields of this research have a common thread of asset pricing. Chapter 2 provides a theoretical model that relates macroeconomic environment and firm characteristics, and Chapter 3 offers empirical support for the theory. Chapter 4 examines integration of European stock markets. This is followed by the Conclusions in Chapter 5.

CHAPTER 2

ASSET PRICING AND THE MACROECONOMIC ENVIRONMENT - THEORY

2.1 Introduction

Chen, Roll, and Ross (1986) related stock returns to macroeconomic variables. Fama and French (1992, 1995) argued that firm attributes, such as size and book-to-market ratios, or attribute-based portfolio returns, explain returns of individual stocks. Liew and Vassalou (2000) find that the Fama-French factors are related to macroeconomic conditions. Evidently, the Fama-French factors are related to macroeconomic exposure, and both types of information can be used to explain stock returns.

This leads to a question whether the Fama-French factors and exposure to macroeconomic variables are different forms of the same information. It is intuitive that the economic environment may have an impact on the way firm size and other parameters evolve through time. For example Fama and French (1995) argue that size may be related to firm profitability. The profitability must depend on the type of economic environment in which the firm operates. However, we are not aware of any theoretical work that associates the two sets of factors.

The present study uses the framework of the Solow growth model to relate the Fama-French factors to the macroeconomic environment. We derive the equilibrium size of the economy and its market value under the assumption that the firm owners seek to maximize profit on investment. In addition, we consider situations where the size and book-to-market ratio for a firm in the economy consistently deviate from the maximum profitability path, and identify possible reasons. Next, we consider the effects of changes in the macroeconomic environment on the equilibrium growth path.

We show that the macroeconomic environment does affect optimal firm size, market value, and subsequently book-to-market ratio. This paper is organized as follows. The next section provides a literature review; section three presents the model, and section four reviews changes in the dynamics of the model. Section five analyzes stock returns, and is followed by the conclusion.

2.2. Previous work on asset pricing

First attempts to construct a reliable asset pricing model date back to Markowitz (1952) who treats expected asset returns as beliefs developed after observing and experiencing capital markets. The first equilibrium capital asset pricing model (CAPM) was introduced by Sharpe (1964), Lintner (1965), and Mossin (1966) and later extended by Black (1972), Merton (1973), and Litzenberger, and Ramaswamy (1979).

The empirical support for the CAPM has been mixed. Sharpe (1965) provides empirical evidence in support of the CAPM, while Miller and Scholes (1972) and Black (1993) defend the CAPM against contradictory findings. Black, Jensen, and Scholes (1972) and Fama and MacBeth (1973) find evidence that generally supports the CAPM. On the other hand, validity of this model has been questioned by Roll (1977), Gibbons (1982), Fama, and French (1992, 1996), and many others.

Ross (1976) developed the arbitrage pricing theory (APT), which does not rely on the restrictive assumptions of the CAPM. Roll and Ross (1980) provide empirical evidence supporting the APT. Subsequently Shanken (1982) and Dhrymes, Friend and Gultekin

(1984) question testability and validity of the model, while Roll and Ross (1984) and Dybvig and Ross (1985) argue that the APT is indeed an adequate and testable model.

The major criticism of the APT is related to the fact that the theory provides no guidance about the risk factors that influence asset returns, which was noted by Dhrymes, Friend and Gultekin (1984). Black (1993) also points out that the APT relies on data, not utility theory, which opens a number of estimation questions. Initially the model is based on factor analysis. Cho and Taylor (1987), Connor, and Korajczyk (1988), Brennan, Chordia, and Subrahmanyan (1998), Zhou (1999), and Jones (2001) base their analyses on extracting factors from the stock returns. Chan, Chen, and Hsieh (1983) and Chen, Roll, and Ross (1986) bring a different approach: they use macroeconomic variables as risk factors. Many researchers have since followed this path, including Kramer (1994), Li (1998), Bjornson et al (1999), and Ogden (2003).

Further research has indicated that firm attributes such as size and book-to-market ratio, and timing of trades seem to be helpful in predicting stock returns. Fama and French (1992) conjecture that size and book-to-market ratio proxy the risk factors. Kothari, Shanken, and Sloan (1995) argue that the explanatory ability of firm attributes may result from survivorship bias, while Ferson, Sarkissian, and Simin (1999) suggest that these abnormal returns are spurious results. Daniel and Titman (1997) find that an attribute-based asset-pricing model performs better than its alternatives. But the question of what those underlying risk factors are still remains.

Fama and French (1992) relate the book-to-market ratio to a relative distress factor suggested by Chan and Chen (1991, 1998). In another paper Fama and French (1995) relate size and book-to-market ratio to underlying economic variables such as firm profitability. Empirical evidence is mixed. Fama and French (2000) showed that changes in profitability result from macroeconomic forces. This corresponds to results obtained by Ferson and Harvey (1991, 1999) who suggest that models with conditional risk sensitivities perform better than unconditional models. The variables used for conditioning in these papers are the macroeconomic risk factors.

A more explicit test of the relationship between the macroeconomic conditions and Fama-French factors is performed by Liew and Vassalou (2000), who find that Fama-French factors can predict economic growth. In addition, Cooper, Gulen, and Vassalou (2001) find that macroeconomic variables combined with Fama-French factors better predict expected returns, and Vassalou (2003) finds that it is the information related to future macroeconomic conditions that determine stock returns.

Daniel and Titman (1997) compare three pricing models; two of them are versions of the Fama-French (1996) model, and another model has firm attributes, rather than factor loadings, that determine stock returns. In response to that, Davis et al (2000) restate that Fama-French factors represent firm sensitivities to risk factors defined by the ICAPM (Merton, 1973) or the APT (Ross, 1976).

Hodrick and Zhang (2001) compared asset-pricing models based on Hansen and Jagannathan's (1997) distance measure. They tested a number of models, including four models that used explicit macroeconomic risk factors and two versions of Fama and French (1993, 1996) models. They found that none of the models were clearly superior to each other. Zhou (1999) finds that the Fama-French model performs better than a two-factor model based on Chen, Roll, and Ross (1986) factors.

To summarize the debate about risk factors, both macroeconomic variables, and Fama-French factors explain stock returns. A number of studies have also examined the relation between Fama-French factors and the macroeconomic variables. Evidence on which set of variables is superior is mixed. A natural question arises whether the Fama-French factors and macroeconomic risk factors, for example discussed in Chen, Roll, and Ross (1986), actually convey the same information, and if they do not, which model provides more information about a firm's risk and return. To date most of the work in equity pricing has been empirical; below we provide a theoretical explanation why firm size and book-to-market ratio may be related to stock returns.

2.3. The model

Consider a Solow-type production economy discussed for example in Vassalou and Apendjinou (2003), where output Y_t is given by:

$$Y_t = A_t K_t^{\alpha_1} L_t^{\alpha_2}. \qquad (2.1)$$

Here A_t is labour productivity (technical progress), K_t is capital, and L_t is labour at time t. Owners of capital are seeking to maximize gross profit $GP_t = Y_t - L_t \cdot MPL_t$, where marginal product of labour is $MPL_t = \frac{d}{dL_t} Y_t = \alpha_2 A_t K_t^{\alpha_1} L_t^{\alpha_2 - 1}$.

Assume that growth rate of population and labour productivity are constant and exogenous[6] (see Romer, 2001). In addition, assume that it is the capitalist who allocates a part of the profit to capital formation in an economy with homogenous firms and homogenous saving preferences:

$$\frac{d}{dt}K_t = sGP_t - \delta K_t . \qquad (2.2)$$

Here s is the savings propensity, and δ is the depreciation rate[7].

The gross profit in this economy is $GP_t = (1-\alpha_2)A_t K_t^{\alpha_1} L_t^{\alpha_2}$, which means that the gross return on capital is given by:

$$\rho_t = \frac{1}{K_t}GP_t = (1-\alpha_2)A_t K_t^{\alpha_1 - 1} L_t^{\alpha_2} . \qquad (2.3)$$

Consider capital owners who wish to maximize ρ_t. They will keep increasing capital stock until the maximum is reached, which means $\frac{d\rho_t}{dt} = 0$. An equivalent expression is $\frac{d\ln\rho_t}{dt} = 0$. This is the steady-state condition for our economy[8].

We have the following condition:

$$\frac{d\ln\rho_t}{dt} = g_A + (\alpha_1 - 1)g_K + \alpha_2 n \equiv 0 \qquad (2.4)$$

[6] One could verify that if the growth rate of innovation is endogenous (i.e. in Romer, 2001, p. 100), the effect of capital stock on firm profitability will be amplified because in that case the growth rate of innovation will be an increasing function of capital stock.
[7] Depreciation here is economic, rather than an accounting measure.
[8] See Appendix A for more details.

where $g_K \equiv \frac{\frac{d}{dt}K_t}{K_t}$. This means that the equilibrium rate of return on capital is related to the growth rate of capital, which is a previous finding. But in our economy the growth rate of capital is:

$$g_K = s(1-\alpha_2)A_t K_t^{\alpha_1 - 1} L_t^{\alpha_2} - \delta . \qquad (2.5)$$

Furthermore, rewrite (2.5) in terms of output (2.1) and use (2.4) to account for a steady state[9]:

$$g_K = \frac{s(1-\alpha_2)}{K_t} Y_t - \delta = \frac{1}{1-\alpha_1} g_A + \frac{\alpha_2}{1-\alpha_1} n . \qquad (2.6)$$

Equation (2.6) means that the amount of capital K_t , output Y_t, savings propensity s, parameter α_2, and depreciation δ are the factors that affect the growth rate of capital, which, in turn, affects gross return on capital in (2.3). In equilibrium, levels of output and capital are chosen in such a way as to maximize profitability of capital ρ_t and reach the maximum profitability level[10] ρ^*.

This implies that knowledge about capital stock K_t and news related to output[11] Y_t give information with respect to equilibrium firm profitability[12]. Consequently, knowledge about size of a given firm, coupled with macroeconomic news, could give an idea of this firm's profitability compared with profitability of "optimal firms" located on

[9] We tried different specifications and obtained similar results. For example, the "textbook" version of production function $Y_t = K_t^{\alpha}(A_t L_t)^{1-\alpha}$ produced the equilibrium solution $g_K = g_A + n$.
[10] See Appendix B.
[11] In our model news related to output includes information about technical progress (productivity), depreciation rate (properties of capital), population growth, and other parameters related to equation A1. One could easily draw a parallel between these variables and macroeconomic news.
[12] More detailed derivation of this is in Appendix B.

the maximum profitability frontier given by equation (2.4). Appendix B shows that size of a firm located on the maximum profitability path is given by

$$K^{*}{}_t = K_0 e^{\left(\frac{1}{1-\alpha_1}g_A + \frac{\alpha_2}{1-\alpha_1}n\right)t}. \qquad (2.7)$$

In addition, consider the book-to-market ratio. Suppose total market value is a discounted stream of gross profits generated by an economy in the foreseeable future, $t \le T$. Here we assume that capital can be reinvested at rate ρ_t, then the "fundamental" market value is a discounted stream of future income:

$$M_t = \int_t^T e^{-\rho_u} GPM_u du. \qquad (2.8)$$

Today's book-to-market ratio[13] is then:

$$\frac{B_t}{M_t} = \frac{K_t}{\int_t^T e^{-\rho_u} GPM_u du}. \qquad (2.9)$$

But the gross profit margin GPM_t is a function of output Y_t and a number of economy-specific parameters, including depreciation rate δ and propensity to save s. Substitute (2.3) into (2.9) to verify that information contained in book-to-market value B_t / M_t includes information about current and future values of both macroeconomic conditions and capital-specific parameters:

$$\frac{B_t}{M_t} = \frac{K_t}{\int_t^T e^{-\left((1-\alpha_2)A_u K_u^{\alpha_1 - 1} L_u^{\alpha_2}\right)}(1-\alpha_2)Y_u du} = \frac{K_t}{\int_t^T e^{-\left(\frac{(1-\alpha_2)}{K_u}Y_u\right)}(1-\alpha_2)Y_u du}. \qquad (2.10)$$

[13] Assuming that the price of unit of capital is \$1 and there is no borrowing. In practice B_t is a noisy estimator of firm size K_t.

Denote the book-to-market ratio for the maximum profitability path as B_t^*/M_t^* and in general superscript "*" as an indication of maximum profitability path. For firms located on the maximum this path book-to market ratio is given by[14]:

$$\frac{B_t^*}{M_t^*}=\frac{K_0 e^{\left(\frac{1}{1-\alpha_1}g_A+\frac{\alpha_2}{1-\alpha_1}n\right)t}}{R\left(\frac{1-\alpha_1}{g_a+\alpha_2 n}\right)\left(\exp\left[\frac{(g_a+\alpha_2 n)}{1-\alpha_1}T\right]-\exp\left[\frac{(g_a+\alpha_2 n)}{1-\alpha_1}t\right]\right)} \tag{2.11}$$

Thus, on the maximum profitability path book-to-market ratio and capital at time t will be determined by initial parameters of capital, labour, and technology, and the macroeconomic parameters.

Therefore, if one observes macroeconomic conditions in the economy, he/she will be able to calculate K_t and B_t/M_t implied by the maximum profitability path, given that the initial capital requirement K_0 and initial values for technology and population, A_0 and L_0, are known. Conversely, if K_t and B_t/M_t are available for a given economy, it will be possible to infer whether decision makers in this economic system are pursuing a maximum profitability strategy or not.

Consider a case where there are N firms in a homogenous economy and capital stock of one firm is $k_t < K_t^*/N$. If all firms had the same characteristics as this one firm, the economy would have capital level $K_t < K_t^*$. In this case the profit rate would be $\rho_t = (1-\alpha_2)A_t K_t^{\alpha_1 - 1} L_t^{\alpha_2} < (1-\alpha_2)A_t \left(K_t^*\right)^{\alpha_1 - 1} L_t^{\alpha_2} = \rho_t^*$. Appendix A shows that in such a situation production technology and availability of labour allow the capitalist to invest more into capital and thus increase profitability. Hence, in theory a situation where

[14] See Appendix B for derivations.

$K_t < K_t^*$, which implies $\rho_t < \rho_t^*$, should not be sustained for long periods of time. But what if it does?

Then the growth rate of capital in this economy consistently satisfies the following condition:

$$g_K = s(1-\alpha_2)A_t K_t^{\alpha_1 - 1} L_t^{\alpha_2} - \delta < \frac{1}{1-\alpha_1} g_A + \frac{\alpha_2}{1-\alpha_1} n = g_k^* . \qquad (2.13)$$

This could happen for a number of reasons. Suppose that capital's share of income α_1 and labour share of income α_2, as well as the technological progress rate g_A and labour force growth rate n, are the same on the right and on the left hand sides of (2.13). Then what makes the two sides of (2.13) unequal are the profit reinvestment rate s, the amount of technology actually used in production A_t, and the capital depreciation rate δ.

Hence, if a firm consistently displays capital stock k_t below the level suggested by maximum profitability path, K_t^* / N, it follows that the firm owner may have a profit reinvestment rate lower than the average rate in the economy, or uses outdated equipment (e.g. steel industry) so that this firm's technology level is below A_t, or the capital depreciation rate in this firm is greater than the average in the economy (e.g. tech firms). The reverse must be also true, if $k_t > K_t^* / N$, then profit reinvestment and technological level must be higher, and/or capital depreciation lower, than in the rest of the economy, ceteris paribus.

Next, consider market value. It is determined by a discounted stream of future earnings obtained during the foreseeable future T,

$$M_t = \int_t^T e^{-\left(\frac{(1-\alpha_2)}{K_u}Y_u\right)}(1-\alpha_2)Y_u du, \quad (2.14)$$

where the discount rate is determined by economic conditions. If the whole economy is at or close to the maximum profitability path, then the discount rate for all firms is the opportunity cost of capital, represented by $e^{-\left(\frac{(1-\alpha_2)}{K_u^*}Y_u^*\right)}$. At the maximum profitability path the values of K_u and subsequently Y_u for well-performing firms are determined by the underlying economic conditions, represented in this model by α_1, α_2, g_A, and *n*. Therefore, equilibrium market value of each company will be

$$m_t^* = M_t^*/N = \frac{1}{N}\int_t^T e^{-\left(\frac{(1-\alpha_2)}{K_u^*}Y_u^*\right)}(1-\alpha_2)Y_u^* du. \quad (2.15)$$

Consider an economy where all firms are located at the maximum profitability path, and one firm consistently displays $m_t < M_t^*/N$. According to (2.14), this may happen for three main reasons. First, it may be the case for this firm that $Y_u < Y_u^*$, which means the firm has less than an optimal level of production, compared with the rest of the economy. Second, labour's share of income α_2 for this firm is larger than for the rest of the economy due, for example, to a strong trade union and weak management. Finally, it may be expected that even though the firm is performing well now, in the foreseeable future the firm will cease to produce output. Formally, for some proximal time τ it is expected that the firm's output will be as follows:

$$Y_u = \{Y_u = Y_u^*, t \le \tau; Y_u = 0, t > \tau\}.$$

If the firm's market value is greater than average, in the framework of our model it means that the firm may be producing more output than the average in the economy, $Y_u > Y_u^*$.

Alternatively, the labour share of income is α_2 lower for this firm compared with the rest of the economy.

Now consider book-to-market ratio, B_t/M_t. Formula (2.11) provides an expression for the ratio B_t^*/M_t^* if an economy is located at the steady-state growth path. If most firms in the economy have $k_t^*/m_t^* = \frac{1}{N}B_t^*/\frac{1}{N}M_t^* = B_t^*/M_t^*$, and one firm has $k_t/m_t \neq B_t^*/M_t^*$, what does this mean? For example, if the average book-to-market ratio is 2, and the book to market ratio for a specific company is 10, how can we interpret this difference? There are two possible cases, $k_t/m_t < B_t^*/M_t^*$ and $k_t/m_t > B_t^*/M_t^*$; below we analyze them in more detail.

Consider the first case, $k_t/m_t < B_t^*/M_t^*$. Such a situation can occur because either $k_t < k_t^*$, or $m_t > m_t^*$, or both. We reviewed these conditions previously. They imply problems with the production process or profit reinvestment when $k_t < k_t^*$, or unusually high output given available technology, coupled with the possibility that workers receive an income share less than average in the economy when $m_t > m_t^*$. Given only the book-to-market ratio k_t/m_t, we cannot draw inferences with respect to the firm's conditions, even if we know the average B_t^*/M_t^* because there may be two conflicting scenarios at play.

Next, consider a case where $k_t/m_t > B_t^*/M_t^*$. It is possible when $k_t > k_t^*$, or $m_t < m_t^*$, or both. The first scenario implies that the firm's capital stock is too large; that would imply profit reinvestment and technological level higher than average, and/or capital depreciation is lower than average. Alternatively, $m_t < m_t^*$ suggests that the firm's expected earnings are below average, which may be caused by problems in production or overpayment to labour, or a predicted end of the company's operations. Again, the company's book-to-market ratio k_t/m_t alone sends an ambiguous signal that is impossible to interpret.

An ambiguous interpretation of the book-to-market ratio k_t/m_t calls for at least one more piece of information. We need to know either k_t or m_t to be able to clearly understand the situation for a particular company. Out of these three pieces of information, we need to know two to infer the third. We present possible combinations of k_t/m_t, k_t, and m_t in Table 2.1.

2.4. Comparative dynamics

In this section we evaluate the effects of changes in the economy and their impact on the maximum profitability levels of the key firm characteristics. We summarize the results in Table 2.2. It clearly shows that changes in technology, labour force, and distribution of income result in changes in the optimal capital size and subsequent changes market value of the economy.

In particular, when the growth rate of technology and labour force increases, optimal capital size increases as well, and it leads to an increase in the market value. An increase in market value is also associated with an increase in capital share of income α_1. In favourable economic conditions, when both technology and labour force have nonnegative growth rates $g_a + \alpha_2 n > 0$, increase in α_1 will also be associated with an increase in capital stock, while in adverse conditions characterized by $g_a + \alpha_2 n < 0$, firm owners would prefer to decrease firm size when their profit share α_1 increases.

Finally, changes in labour's share of income affect differently optimal capital growth rate, firm size, and market value in different macroeconomic conditions. The direction of the effect will depend on starting technology requirements, current income distribution, returns to scale in the technology, and timing of the changes. Appendix C shows the details of how the size of the economy (measured in units of capital) and market value change because of changes in macroeconomic conditions.

When economic conditions are favourable and it is optimal to increase capital stock K_t, then firms that had $K_{t-1} > K^*_{t-1}$ become more profitable, since now they are closer to the equilibrium K^*_t and need less time to adjust their size than firms that had $K_{t-1} = K^*_{t-1}$, because at each time $t-1+\tau, \tau \to 0$, the size of larger firms is greater than the size of the firms that used to be on the optimal path at time $t-1$. Recall that in our model optimality is determined by the growth rate of profit, hence firms that are closest to optimal capital size are the most profitable as well.

Conversely, when adverse economic conditions dictate that it is optimal to decrease firm size, $K^*_t < K^*_{t-1}$, then smaller firms become more profitable compared with the rest of the economy because they need less time to adjust to new economic environment. As in the previous case, the closer a firm is to the equilibrium, the more profitable it is. Note also that the equilibrium point shifts instantaneously when new macroeconomic information arrives, while any increase or reduction in capital (plant and equipment) takes a considerable amount of time.

In our model changes in technology growth rate and labour force result in predictable changes in capital and market value. In particular, Table 2.2 shows that increases in technology or labour force growth rates lead to increases in capital stock and market value, and vice versa. However, changes in the profit distribution scheme lead to less predictable results. When capital share of income α_1 rises, market value rises as well. But the dynamics of capital stock will depend on economic conditions; in favourable conditions economy size will increase, and in unfavourable conditions it will decrease.

The reaction of capital owners to changes in labour share of income α_2 should again depend on economic conditions. As α_2 increases, capital owners increase firm sizes, perhaps to ensure their profits are no less than they were before the increase in labour share of income. Such a situation may arise for example when trade unions obtain additional bargaining power in wage negotiations. However, the picture is not as clear for the market value. Whether market value, which is the discounted value of future profits, should increase or decrease will depend on the conditions prevailing in the economy. Appendix C provides more details on the economic conditions and their effect on market value; changes in dynamics of capital and market value are summarized in the southeast quadrant of Table 2.2.

In this study we distinguish changes of capital share of income and labour share of incomes from each other. This is done for generality of the results; if production technology exhibits decreasing returns to scale, then $\alpha_1 + \alpha_2 < 1$, constant returns to scale imply $\alpha_1 + \alpha_2 = 1$, and increasing returns to scale mean $\alpha_1 + \alpha_2 > 1$. Certainly, if we know that production technology exhibits constant returns to scale, then $\alpha_1 = 1 - \alpha_2$ and changes in capital share of income should have one-to-one correspondence with changes in labour share of income, that is, an increase in α_1 will definitely mean a decrease in α_2. It means that Table 2.2 could be further simplified into dichotomy of increases and decreases of capital share of income only instead of separate analysis with respect to α_1 and α_2. However, when technology displays more general properties, then the correspondence between capital and labour shares of income is less straightforward.

It is the macroeconomic environment (technological growth, labour growth, as well as capital and labour shares of income) that shapes optimal (profit-maximizing) firm characteristics, and most firm managers seek to maximize profits; therefore, managers will try to choose firm parameters (amount of productive capital in our case) such that the firm maximizes profits. Thus, by observing changes in firm size and its market value, one can make conclusions about changes in macroeconomic environment. For example, an increase in capital size coupled with an increase in market value would mean that technology or labour growth rate may have increased, and/or one or both shares of income α_1 and α_2 increased. Another example, if capital stock decreased and market value increased, and it is known that technology and labour growth did not change, one should conclude that this even was triggered by an increase in capital share of income. Such conclusion would have even stronger support when one observes that the economic conditions are not favourable for business, $g_a + \alpha_2 n < 0$.

Our model shows that by observing macroeconomic variables, one can make conclusions about equilibrium size and market value of firms provided they pursue profit maximizing strategies. Conversely, by observing changes in size and market values of profit maximizing firms, researchers can infer changes in macroeconomic conditions even if these changes are not publicly advertised. In all cases the information set should include both capital size and market value, otherwise there is not enough information to precisely pinpoint what process is responsible for observed changes in firm dynamics.

To summarize, under the restrictive assumptions of a Solow economy, size and the book-to-market ratio reflect firm-specific characteristics as well as interaction with macroeconomic influences[15]. Therefore, firm sensitivities to macroeconomic news and size and B/M may share the same information set. The extent to which this is true depends on the degree to which assumptions of the Solow model hold in reality.

2.5. Stock returns

Recall that the market value is given by (14). For convenience we will repeat the equation here:

$$M_t = \int_t^T e^{-\left(\frac{(1-\alpha_2)}{K_u}Y_u\right)}(1-\alpha_2)Y_u du .$$

If there are N firms in a homogenous economy, then the market value of one firm is

$$m_t = M_t / N = \frac{1}{N}\int_t^T e^{-\left(\frac{(1-\alpha_2)}{K_u^*}Y_u^*\right)}(1-\alpha_2)Y_u\, du . \qquad (2.16)$$

Consider an instantaneous change in the firm market value between time t and $t+\delta$, where that δ is much smaller than $T-t$. If nothing changes during $t+\delta$, then there will be no difference between m_t and $m_{t+\delta}$. However, equation (2.16) shows that if $m_t \neq m_{t+\delta}$, it must be because of the changes in the equilibrium parameters Y_t^*, K_t^*,

[15] Using more elaborate models, Russett and Slemrod (1993) investigate propensity to save and Gilchrist and Williams (2000) relate productivity, investment, and macroeconomic conditions.

profit distribution scheme represented by α_2, or the firm output Y_t / N. Thus, the market return

$$r_t = \frac{m_t - m_{t+\delta}}{m_t} \qquad (2.17)$$

will be nonzero whenever there are changes in the firm production process, or economic environment, or both. It follows that to evaluate stock returns, one needs to know firm characteristics such as size and technology, as well as macroeconomic conditions.

2.6. Conclusion

This paper analyzed the impact of macroeconomic environment on the size and market value of the firm. We used the Solow model framework and showed that if capital owners have the objective of profit maximization, the economy consisting of homogenous firms will have an equilibrium growth path.

We review scenarios where a firm departs from the equilibrium growth path, and find possible causes for such developments. In our model, information about the changes in the firm parameters is useful for understanding the type of changes occurring in the economic environment. This occurs because the macroeconomy shapes sizes and market values of the firms.

Table 2.1 Possible reasons why a firm-specific book-to-market value k_t/m_t could deviate from the optimal book-to-market ratio B_t^*/M_t^* implied by the macroeconomic conditions.

Firm book-to-market ratio is:	
Below optimal, $k_t/m_t < B_t^*/M_t^*$	Above optimal, $k_t/m_t > B_t^*/M_t^*$
Reason: deviations of firm market value m_t from the optimal market value m_t^*	
$m_t > m_t^*$	$m_t < m_t^*$
(i) Firm produces more output than the average in the economy, $Y_{it} > Y_{it}^*$. (ii) Labour share of income α_2 is lower than in the rest of the economy.	(i) Firm has less than the optimal level of production, $Y_{it} < Y_{it}^*$. (ii) Labour share of income α_2 is larger than the rest of the economy, (iii) in the foreseeable future the firm will cease to produce output. $Y_{it} = \{Y_{it} = Y_{it}^*, t \leq \tau; Y_{it} = 0, t > \tau\}$.
Reason: deviations of firm size k_t from the optimal size of capital stock k_t^*	
$k_t < k_t^*$	$k_t > k_t^*$
(i) Profit reinvestment rate s lower than the average rate in the economy, (ii) Firm uses outdated equipment so that this firm's technology level is below A_t, (iii) Depreciation of capital greater than the average in the economy.	(i) Profit reinvestment rate s higher than the average rate in the economy, (ii) Firm uses cutting edge equipment so that this firm's technology level is higher than A_t. (iii) Depreciation of capital lower than the average in the economy.

Table 2.2. Reactions (comparative dynamics) of the equilibrium growth rate of capital, equilibrium size of capital stock, and the equilibrium market value to changes in macroeconomic conditions.

Variable	Macroeconomic conditions							
	Technological growth rate g_a		Labor force growth rate n		Capital share of income α_1		Labor share of income α_2	
	Increases	**Decreases**	**Increases**	**Decreases**	**Increases**	**Decreases**	**Increases**	**Decreases**
Equilibrium growth rate of capital g^*_K.	$\partial g^*_K / \partial g_a > 0$		$\partial g^*_K / \partial n > 0$		$\partial g^*_K / \partial \alpha_1 > 0$ if $g_a + \alpha_2 n > 0$, and $\partial g^*_K / \partial \alpha_1 < 0$ if $g_a + \alpha_2 n < 0$		$\partial g^*_K / \partial \alpha_2 > 0$ if $n > 0$, $\partial g^*_K / \partial \alpha_2 < 0$ if $n < 0$	
	Increases	Decreases	Increases	Decreases	Depends on situation	Depends on situation	Depends on situation	Depends on situation
Equilibrium economy size, K^*_t.	$\partial K^*_t / \partial g_a > 0$		$\partial K^*_t / \partial n > 0$		$\partial K^*_t / \partial \alpha_1 > 0$ if $g_a + \alpha_2 n > 0$, and $\partial K^*_t / \partial \alpha_1 < 0$ if $g_a + \alpha_2 n < 0$		$\partial K^*_t / \partial \alpha_2 > 0$	
	Increases	Decreases	Increases	Decreases	Depends on situation	Depends on situation	Increases	Decreases
Equilibrium market value, M^*_t.	$\partial M^*_t / \partial g_a > 0$		$\partial M^*_t / \partial n > 0$		$\partial M^*_t / \partial \alpha_1 > 0$		$\partial M^*_t / \partial \alpha_2 > 0$ or $\partial M^*_t / \partial \alpha_2 < 0$	
	Increases	Decreases	Increases	Decreases	Increases	Decreases	Depends on situation	Depends on situation

Note: The macroeconomic conditions include technological growth rate, labor force growth rate, capital share of income, and labor share of income. The table should be interpreted as follows. Consider the reaction of the equilibrium growth rate of capital g^*_K to technological growth rate g^*_a. Since partial derivative $\partial g^*_K / \partial g_a > 0$, we can see that when technological growth rate g^*_a increases, equilibrium growth rate of capital g^*_K increases as well. Conversely, if technological growth rate decreases, so does the growth rate of capital.

CHAPTER 3

ASSET PRICING AND THE MACROECONOMIC ENVIRONMENT - EVIDENCE

3.1. Introduction

The empirical relationship between stock returns and firm attributes such as size and book-to-market ratio has become common knowledge in finance; however, this relationship has little theoretical grounds. In chapter 2 we presented a theoretical model that provides economic reasoning for this phenomenon. This study empirically tests the theoretical model. Macroeconomic forces shape the optimal size and other characteristics of firms, and if the primary business objective is to maximize profit, then parameters of all businesses in an industry should converge to equilibrium values dictated by the economic environment. In addition, stock returns of firms located at or near equilibrium should be the highest because these firms earn the highest profits for their risk classes. Empirical testing studies these convergence properties of size and book-to-market ratios of firms in the sample.

Fama and French (1992, 1993, 1995) relate stock returns to firm characteristics and provide an intuitive explanation of why firm attributes may proxy for firm's risk sensitivities. In our theoretical model we provide an economic argument why this may be the case, and in this paper we find supporting evidence using methods different from those of Fama and French. Our results are consistent with the general conclusion that firm characteristics reflect the firm's sensitivity to the macroeconomic environment. We find evidence supporting convergence toward an equilibrium based on economic capital size. Next, we demonstrate that an increase in the technological growth rate makes larger companies more profitable in most industry sectors.

Our theoretical model relies on the neoclassical economic growth models of Solow (1956), Lucas (1978), and Maksimovic and Phillips (2002). In testing convergence properties of the model, we rely on the standard approach of testing similar models pioneered by Baumol (1986), De Long (1988), and Baumol and Wolff (1988). Unlike these papers, we study stock returns of companies as opposed to increases in gross domestic products of countries, but the principle stays the same: we try to find a relationship between a company's starting point in terms of size of productive capital and subsequent stock returns. Companies located away from the optimal point are expected to earn lower returns, and companies located closer to the optimal point are expected to earn higher stock returns. The market will bid prices for optimum stocks up after recognizing that these companies are the most profitable in the current economic environment.

The chapter is organized as follows. The next section describes the theoretical model and empirical method. Section three provides a description of the dataset. Section four presents the results and is followed by the conclusion.

3.2. Theoretical model and empirical method

In chapter 2 of this dissertation we show that if an economy produces output Y_t according to production function:

$$Y_t = A_t K_t^{\alpha_1} L_t^{\alpha_2} \tag{3.1}$$

and the objective is to maximize profit per unit of capital,

$$\rho_t = (1-\alpha_2) A_t K_t^{\alpha_1 - 1} L_t^{\alpha_2} \tag{3.2}$$

then the profit maximizing size of firm's capital will be given by

$$K^*_t = K_0 e^{\left(\frac{1}{1-\alpha_1} g_A + \frac{\alpha_2}{1-\alpha_1} n\right)t} \qquad (3.3)$$

and the market value of the profit maximizing firm, which plans to operate between current time t and some planning horizon T, is given by:

$$V_t^* = R\left(\frac{1-\alpha_1}{g_a + \alpha_2 n}\right)\left(\exp\left[\frac{(g_a + \alpha_2 n)}{1-\alpha_1} T\right] - \exp\left[\frac{(g_a + \alpha_2 n)}{1-\alpha_1} t\right]\right). \qquad (3.4)$$

Here A_t is labour productivity (technical progress), K_t is capital, and L_t is labour at time t, n is growth rate of population, g_a is growth rate of labor productivity, α_1 and α_2 are capital and labour shares of income, and R is a constant that characterizes initial capital requirements.

If a company has K^*_t invested in productive equipment, this company is expected to earn the highest profits; conversely, if for company j, $K^j_t < K^*_t$ or $K^j_t > K^*_t$, then profits for that company will be lower and subsequent stock returns will be lower than optimal as well. Therefore, one way to test the validity of this theoretical model is to estimate a regression:

$$\tilde{r}_i = \lambda_0 + \lambda_1 \log\left|K_i - \overline{K}\right| + \lambda_2 \beta_i + e_i, \qquad (3.5)$$

where $\tilde{r}_i$ is a continuously compounded[16] stock return and K_i is capital size for company i, $\overline{K}$ is the optimal capital size, β_i is company i's beta as a measure of its market risk[17], and e_i is the regression residual.

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[16] This study uses logarithmic transformations of return and size data series in order to control for outliers, heteroskedasticity, and the effect of very small firms growing dramatically from a very low price.
[17] We are using the company beta to control for market risk, since our theoretical model assumes all companies have the same risk.

There are two difficulties associated with estimation of (3.5). First, a firm's economic capital size K_i is unobservable at each point in time, and $\overline{K}$ is unobservable as well. We mitigate this problem by using company total assets as a proxy for economic capital size[18]. The second difficulty is caused by the fact that the profit-maximizing size of capital is also unobservable. Assuming that economic conditions do not change abruptly from year to year, we conjecture that the maximum profitability size of the firm in year (t-1) can be used as a proxy for the maximum profitability size in year (t). The theoretical model predicts that in regression (3.5) we should expect $\lambda_1 < 0$.

Another way to test the theoretical model is to study behavior of market values at the times of economic shocks. If technology growth sharply increases (decreases), comparative statics of the theoretical model suggest that larger (smaller) firms should become more profitable faster, since they are likely to be closer to a new equilibrium firm capital size. In other words, $\partial K^*{}_t / \partial g_a > 0$ will imply $\partial V^*{}_t / \partial g_a > 0$, where K_t^* is optimal firm size, V_t^* is the market value for a firm that maximizes profit, and g_a is technological growth rate. Hence, the increase in the market value should be positively associated with the initial size of the productive capital. Assuming that the firm risk does not change significantly during this economic change, we estimate a regression:

$$\widetilde{r}_i = \gamma_0 + \gamma_1 \log K_i + \gamma_2 \log(K_i \times HITECH) + \gamma_3 \beta_{i,t} + v_t \qquad (3.6)$$

where $\widetilde{r}_i$ is continuously compounded stock return and K_i is capital size for company *i*, $HITECH$ is the growth rate for the index of US production of computers,

[18] Several alternative proxies give similar empirical results.

communications equipment, and semiconductors, β_i is company i's measure of market risk, and v_t is the regression residual.

We introduce HITECH as a measure of technological growth[19]. At present businesses use flexible automation of production to increase productivity, and flexible automation requires computer and robotic equipment (Ritzman et al, 2004). Thus, a technology-led increase in productivity should be associated with introduction of computer equipment into production processes. The volume of computer equipment produced should be associated with the amount of computer equipment used in company processes. We expect to see a strong impact of technological growth in all industry sectors that extensively use computer equipment in production processes. These sectors include Energy, Industrials, and especially Information Technology and Telecommunication Services.

In equation (3.6) coefficient γ_1 is introduced to account for the well-known size effect[20] in stock returns and is expected to be negative. Next, we expect coefficient γ_2 to be positive, especially for firms that use high technology in their production process. This should occur because large values of HITECH will indicate periods of rapid technological growth, and our theoretical model predicts that large companies should exhibit high increases in their market values since their parameters will be closer to the equilibrium.

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[19] To the best of our knowledge we are the first to use this variable in asset pricing. It compares with other information variables in the following way. Whereas inflation or market return characterize overall economic conditions, HITECH specifically characterizes computer-driven technological growth. In comparison with Fama-French variables, HITECH gives us information about the technological growth for the economy as a whole, while the Fama-French variables represent individual firm sensitivities to economic conditions.

[20] See for example Banz (1981), Keim (1987), or Bhardwaj and Brooks (1993) for evidence on the size effect. Note that usually values of total assets (the main measure of the economic capital in this paper) are negatively correlated with market returns.

3.3. Data

We use annual data on 22336 US public companies from the S&P COMPUSTAT Active+Research datasets. Our data includes total assets, total liabilities, market values, annualized total returns, and the number of employees. COMPUSTAT has market betas only for 1999-2004, which is much shorter than the rest of the annual dataset; thus, we had to compute market betas[21] for 1986-2004. We obtained US industrial production (IP), 1-year Treasury bill yields (TB), Treasury 10-year bond yields (LGB), and Moody's Baa-rated corporate bond yields (Baa) from the Board of Governors of the Federal Reserve system website[22]. The consumer price index (CPI) and producer price index, all commodities (PPI) originated from the Bureau of Labour Statistics[23]. We also use growth rate of the Federal Reserve Board's index of US industrial production of computers, communications equipment, and semiconductors (HITECH) and series of the West Texas intermediate crude oil price OP from the Economagic database[24].

The descriptive statistics for the company data series are presented in Table 3.1 Panel A. Examination of the company data shows the large variability in company performance. Annualized total return ranges from 29,999,901 % per year, an outstanding

[21] We used annualized monthly total returns (COMPUSTAT mnemonic: TRT1Y) for all companies and the S&P 500 index (COMPUSTAT mnemonic: i0003). Beta is calculated for a 5-year (60-month) time period. If less than 60 months of data is available, beta is calculated for as few as 12 months.
[22] http://www.federalreserve.gov
[23] http://www.bls.gov
[24] www.economagic.com

gain, to –100% per year, a complete loss for the investors, with a simple average 357.7778 % and median 4.366%. The equal-weighted sample market beta averages 0.892786 with median beta of 0.743786. Total assets average 3,018.587 million, total liabilities average 2,457.041 million, companies have on average 6.392676 thousand employees, and market value is on average 1,341.551 million dollars. Thus, we have a sample of large companies. Our dataset spans 20 years and 22,336 companies per year, which gives 446,720 data points.

We need US macroeconomic data for construction of the proxy variable OSP for the optimal firm size $\overline{K}_t$, which in our theory is determined by macroeconomic conditions. Following Chen, Roll, and Ross (1986) and Ferson and Harvey (1999), we constructed macroeconomic series as follows: growth of industrial production, $GP_t = \ln(IP_t / IP_{t-1})$, inflation, $I_t = \ln(CPI_t / CPI_{t-1})$, term structure, $UTS_t = LGB_t - TB_t$, credit risk premium, $UPR = Baa_t - LGB_t$, and oil price variable, $OG_t = \ln(PPI_t / OP_t)$. The descriptive statistics for the US macroeconomic variables are presented in Table 3.1 Panel B. We can see that industrial production in the US was growing at the mean rate GP of 0.026993, or 2.6993% per year, with average inflation I of 0.029871 or 2.9871% per year. The average term structure premium is 1.4225%, average credit risk premium is 2.114%, and average oil price index is 1.719494.

To estimate equation (3.5), we use Total Assets (ASSETS) as the main measure of company size, and perform robustness tests by using Total Liabilities (LIAB), Employees (EMPL), and Market Value (V) as alternative measures of size. We use market beta (β) as a measure of company's systematic risk. We measure the unobservable optimal size $\overline{K}_t$ as follows. First, we find median company size (MHDS), measured by Total Assets, for the companies in the highest total return decile. Second, we regress MHDS on the set of US macroeconomic variables outlined above. Next, we record the fitted values from this regression and use them as the optimal size proxy[25] OSP. Finally, we construct the size deviation (DEVSIZE) for company *j* in year *t* as follows:

$DEVSIZE_{j,t} = \left| ASSETS_{j,t} - OSP_{t-1} \right|$. Descriptive statistics for the dataset used in estimating equation (3.5) are presented in Table 3.2 Panel A. Average total return is 47.16548 % per annum, average market beta is 0.969780, and average size deviation is 3,674.306 million dollars. This dataset contains only 104,710 usable observations, which is around 24% of our initial dataset, since many data points are not available[26].

We also constructed a dataset to estimate equation (3.6). In order to identify when external shocks were affecting production technology, we turn to HITECH, the growth rate of the index of industrial production of computers, communications equipment, and semiconductors. We argue that the technological change can be measured by the production rate of computer equipment, since increased production of computers means widespread use of computer equipment in different production lines, and subsequent increase in productivity. Descriptive statistics for the series r_i, $ASSETS_i$, HITECH, and β_i are presented in Table 3.2 Panel B. Stock returns for this pooled dataset range between 531,566.7% and -99.97100 with average return 47.16548, total assets average

[25] We also tried two other proxy variables. They were the size of the company with the highest return in year t, and variable MHDS (median value for Total Assets for companies in the highest decile of stock returns).

[26] To ensure that our results are not affected by survivorship bias, we used the following procedure for inclusion of companies in the dataset. If a data point (a company) contains market values and accounting variables sufficient to calculate the relevant size proxy (for example, if total assets are available when size is proxied by total assets), it is included in the dataset. If in year (t-1) all required data are available for a company, and in year (t) and thereafter not available, we record market value for year (t) as zero and the corresponding stock return as −100%.

\$3,708.198 million, the growth rate of technology averages 0.090736 or 9.0736% per year, and average market beta for the firms in the dataset is 0.969780.

Next, we divided the whole dataset into industry sectors. The COMPUSTAT datasets satisfy our data requirement in eight sectors[27]. They are: Materials, Consumer Discretionary, Consumer Staples, Health Care, Energy, Industrials, Information Technology, and Telecommunication Services[28]. Table 3.3 Panel A presents descriptive statistics of the dataset for equation (3.5) by industry. The smallest mean size deviation of \$819.3494 million is displayed by Information technology, and Telecommunication Services have the largest mean size deviation of \$8,604.683 million. The least risky industry as measured by mean market beta of 0.533305 is Energy, and the riskiest in this sense is Telecommunication Services, with mean beta 1.535185. At the same time, Telecommunication Services has the largest mean annualized return of 261.8101%, and Materials has the smallest mean return of 23.21728%.

Table 3.3 Panel B presents the dataset for equation (3.6) for each industry. The variables include r_i, $ASSETS_i$, HITECH, and β_i. The largest mean return of 261.8101% was displayed by Telecommunication Services, and the smallest mean return was 23.21728% for Materials. The mean Total Assets range from \$8,649.180 million for Telecommunication Services to \$836.4592 million for Information Technology. Telecommunication Services also have the highest market risk as measured by mean beta of 1.535185, and the least risky industry in our dataset is Energy with mean beta of

[27] We do not present descriptive statistics and estimation results for Financials and Utilities for the following reasons. For firms in the financial sector capital has different interpretation from the rest of the economy and can hardly be modeled using Cobb-Douglas form production function. Next, Utilities are heavily regulated and cannot be compared with the firms operating in a market-based environment.

[28] The total number of observations across the eight sectors is 82683, which is 78.9638% of the total dataset consisting of 104710 observations.

0.533305. Finally, HITECH is a macroeconomic variable that affects all firms in the same way; however, because industries differ in the availability of corresponding data points, descriptive statistics for this variable differ somewhat across industries and range from about 20% in the high technology growth years to –1.26% during the years marked by technological slowdowns.

3.4. Results

A casual inspection of Table 3.4 reveals that in different years the median sizes of firms that earned the highest stock returns were different. In addition, the median size of the highest return decile companies appears to be cyclical. One could speculate that such pattern may have been caused by the business cycle. For example, in 1985 the highest total return was 906.4520% per annum, and median total assets for the top return decile were 22.092 million dollars, whereas in 2000 the highest total return was 183,463.3% and median size for the highest return decile was $118.644 million, which is almost six times as much as in 1985.

A part of the explanation for such remarkable stock performance must be risk. Nevertheless, the issue whether deviation of the firm size from the optimal level (as measured by a number of proxies) provides any additional information in explaining stock returns calls for more detailed consideration. The following sections explore two hypotheses derived from our theoretical model. These hypotheses are (1) convergence towards maximum profitability path and (2) reaction of the equilibrium to changes in macroeconomic conditions.

3.4.1. Convergence towards maximum profitability path

The first feature of the model that we test is convergence towards the maximum profitability path. The model predicts that in a homogenous economic system the aggregate capital size is given by (3.3) if all firms in that system pursue profit maximization. Therefore, if there are *n* firms in this economy, then the size of one firm should be $k_t^* = \frac{1}{n} K_t^*$ if that firm maximizes profit. Deviation from the k_t^* should lead to lower profits and subsequently lower returns. Estimation results[29] for equation (3.5) for the whole sample and for each economic sector are presented in Table 3.5.

Examination of Table 3.5 suggests that data have empirical support for the theoretical model. For example, the estimated coefficient for the whole sample is -0.07907<0 as predicted and it is highly significant with p-value < 0.0001. The estimated coefficient for DEVSIZE for industry sector Healthcare is -0.089400< 0 and its t-statistic is -10.70750, which is significant at 1% level. We interpret the results in the following way. Suppose that an average firm has deviation of $3674.306 million (whole sample average) from the optimal size, and note that the coefficient for size deviation for the whole sample is -0.07907. Then a $100 million reduction in the size deviation should lead to $-0.07907 \times [\log(3574.306) - \log(3674.306)] = 0.0021818$ % increase in the expected stock return[30].

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[29] As a robustness test, we used different measures for firm size. They include Total Assets, Total Liabilities, Market value, the Employees, and Gross Property, Plant, and Equipment. Our base case was Total Assets, and in all cases we obtained similar results.

[30] The economic significance will depend on the ratio of the size deviation before (t=0) and after (t=1) reduction in the deviation, since $E[r_{t=1} - r_{t=0}] = \lambda_1 * [\log DEVSIZE_{t=1} - \log DEVSIZE_{t=0}] = \lambda_1 * [\log [DEVISZE_{t=1} / DEVSIZE_{t=0}]$, given equation 3.5 and all other things being equal. Taking into account that it is difficult to change a large portion of firm's productive capital quickly, one can see that the most visible effect on the expected stock return will be when a company is very close to the optimal size. Consider a case when a company had $50 million size deviation and managed to reduce it down to $5 million. Then the expected stock return should increase by $-0.07907 \times [\log(5) - \log(50)]$ =0.18207%, and if

This means that deviation[31] from the maximum profitability size is associated with lower stock returns, after controlling for risk. Firms should have incentives to align their size with that determined by the objective of profit maximization given initial capital requirements and the macroeconomic reality. We observe negative and significant coefficients for the whole sample and all 8 industries[32]. Therefore, we find empirical support for our model by testing convergence towards the maximum profitability path. Of course, this convergence is toward a moving target, thus demonstrating a small economic effect.

3.4.2. Reaction to changes in macroeconomic conditions

Estimation results presented in Table 3.6 provide support for the theory, as related to technological change. The coefficient for SIZE*HITECH for the whole sample and industry sectors Energy, Industrials, Information Technology, and Telecommunication Services are positive, as predicted. In addition, the coefficient estimates for Energy, Information Technology, and Telecommunication Services are highly significant. For example, the coefficient estimate for Energy is 0.191218 with the corresponding t-value of 5.841833.

We interpret the results as evidence suggesting that large company size should lead to higher stock returns in situations when technological growth is positive[33]. For example, if

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the size deviation in our example is reduced down to 1 million, then the expected increase in the stock return should be 0.30932%.

[31] Further tests presented in Appendix G show evidence of convergence towards the optimal size for firms located both above and below the equilibrium. In addition, we find no significant difference between convergence rates from below and above the equilibrium size.

[32] This paper uses logarithmic transforms of return and size data. We also estimated the regressions with untransformed data and obtained similar results for both convergence and technological growth tests.

[33] As a robustness test we estimated a regression: $\tilde{r}_i = \gamma_0 + \gamma_1 K_i + \gamma_2 DK_i + \gamma_3 \beta_i + e_i$, where D=1 when HITECH ≥0 and D = 0 otherwise. Our results were consistent with the estimates presented in table 3.6.

a company size is at Energy sample average of $3,053.674 million, then each percentage increase in technological growth rate will result in a $0.191218 \times \log(3053.674 \times 0.01) =$ 0.56376% increase in the expected stock return on the company stock in this sector. The increase in size will make the expected stock return increase even greater: if Total Assets for a firm is at the industry maximum of $177,572.0 million, then each percentage increase in technological growth rate will result in a $0.191218 \times \log(177572 \times 0.01) =$ 1.4307% increase in the expected stock return, ceteris paribus.

We hypothesize that firms in industry sectors Energy, Information Technology, and Telecommunication Services have highly significant coefficient estimates because they were the fastest to adjust their productive capital to the pace of technological change[34]. Hence, larger companies in these sectors are expected to be closer to maximum profitability path for situations when technological growth increases. Conversely, if technological change slows down, smaller companies should exhibit the highest stock returns, ceteris paribus, because they should be closer to the equilibrium.

For industry sector Materials, Consumer Discretionary, Consumer Staples, and Health Care the coefficient for SIZE*HITECH is negative, the opposite from predicted. In addition, for sector Health Care it is significant at 5% level. We hypothesize that the latter result was obtained because of slow adjustment of the productive capital for these industry sectors. Suppose that equipment in sector Materials is less technology-intensive than equipment in Information Technology. Consequently, the growth of technology (for

[34] The technology bubble of 1995-2000 should bias the results in the opposite direction from what the theory predicts. During this period small technology companies were earning high stock returns, and therefore we would expect to see a negative relationship between returns and SIZE*HITECH. However, our estimates for SIZE*HITECH for the whole sample and industry sectors Energy, Industrials, Information Technology, and Telecommunication Services are positive, as predicted. We argue that this indicates support for our model, and our results might have been stronger if there had been no technology bubble in the late 1990s.

example computer processor speed) does not affect productivity in Materials to the same degree it changes productivity in Information Technology. As a result productive capital in the Materials sector does not change as quickly as it does in Information Technology, and the coefficient for Materials for variable SIZE*HITECH is not as predicted by our model. Certainly, there is always a possibility that the theoretical model does not adequately capture the dynamics of firm growth, in which case the theory needs further refinement[35].

To summarize, we find evidence in support of our theoretical model. Estimation results for equation (3.5) provided clear empirical support for convergence of firms towards optimal size of capital. Next, estimation results for equation (3.6) indicated that an increase in technological growth results in large firms becoming more profitable, in total, and at least in some hi-tech industry sectors.

3.5. Conclusion

This chapter tests predictions of the theoretical model presented in Chapter 2. The model relates firm characteristics, such as capital size or book-to-market ratio, to the macroeconomic environment, and derives profit maximizing trajectories for firm capital size based on initial capital requirement and macroeconomic influences. Testable implications include convergence of profit maximizing firms towards the equilibrium capital size and sensitivity of optimal size to changes in macroeconomic conditions. We

[35] There are several factors that could affect the results. First, the theoretical model is derived under the assumptions of certainty; adding uncertainty may yield different conclusions. Next, we assume one type of technological change and one production function with homogenous firms; which is not the case in the real world. The effect of using these assumptions on the model's ability to capture the properties of the economy remains unclear. Finally, using proxies introduces errors in estimation, and the directions of these errors are unknown.

use S&P COMPUSTAT data on US public companies to test the convergence prediction of the model, as well as a prediction that an increased growth rate in production technology should result in an increase in the maximum profitability firm size.

We obtain results suggesting that the convergence prediction is correct. The effect is significant and present after several robustness tests and simulation exercises. Next, we conduct tests of the optimal capital size as a function of technological growth. We find evidence that generally supports the predictions of our theory. Although some statistical results were not as predicted, we hypothesize that such outcomes may be due to slow speed of adjustment to optimal size or other factors mentioned earlier.

Overall, we find empirical evidence supporting our theory, both in the combined dataset consisting of all companies, and in most specific industry datasets. Thus, we have established that changing macroeconomic conditions result in differences in optimal company investment in capital size for generating the highest expected returns.

Table 3.1. Descriptive statistics of the data series

Panel A. Initial company data, by company by year, 1985-2004.

	Annualized total return, percent	**Market beta, β**	**Total assets, $millions**	**Total liabilities, $millions**	**Employees, thousand**	**Market value, $millions**
Mean	357.7778	0.892786	3018.587	2457.041	6.392676	1341.551
Median	4.366	0.743786	98.334	44.822	0.486	65.37
Maximum	29999901	53.58762	1264032	1166018	1500	2114728
Minimum	-100	-47.43808	0.000000	-0.666	0.000000	0.000000
Std. Dev.	80496.24	2.410427	24690.19	23011.36	28.38605	11500.33
Observations	141679	164444	172492	172055	148718	168390

Note: 20 years times 22336 companies is 446720 data points. We can see that there are a lot of missing observations in the dataset.

Panel B. US macroeconomic variables, 1985-2004.

	Growth in production GP	Inflation, I	Term Structure UTS	Credit risk premium UPR	Oil price index OG	HITECH
Mean	0.026993	0.029871	1.422500	2.114000	1.719494	0.083429
Median	0.036544	0.028431	1.375000	2.020000	1.742967	0.073414
Maximum	0.070264	0.052775	3.120000	3.190000	2.157352	0.172207
Minimum	-0.036302	0.015352	-0.080000	1.520000	1.263899	-0.005460
Std. Dev.	0.027450	0.009848	0.968128	0.470402	0.224964	0.055851
Observations	20	20	20	20	20	20

Note: The variables are: growth of industrial production, $GP_t = \ln(IP_t / IP_{t-1})$, where IP is industrial production, inflation, $I_t = \ln(CPI_t / CPI_{t-1})$, where CPI is Consumer Price Index, term structure, $UTS_t = LGB_t - TB_t$, where LGB is 10-year government bond yield and TB is 1-year T-bill yield, credit risk premium, $UPR = Baa_t - LGB_t$, where Baa is Moody's Baa corporate bond yield, and oil price variable, $OG_t = \ln(PPI_t / OP_t)$, where PPI is Producer Price Index and OP is West Texas intermediate crude oil price. HITECH is the annual growth rate of the Federal Reserve Board's index of US industrial production of computers, communications equipment, and semiconductors.

Table 3.2. Descriptive statistics for dataset used to estimate equations 3.5 and 3.6 for the whole sample.

Panel A. Data used to estimate equation 3.5, $\tilde{r}_i = \lambda_0 + \lambda_1 \log DEVSIZE_i + \lambda_2 \beta_i + e_i$, by company by year, 1986-2004.

	Annualized total return, r_i percent	**Market beta (β)**	**Deviation from optimal size, (DEVSIZE)**
Mean	47.16548	0.969780	3674.306
Median	5.543000	0.801661	98.86520
Maximum	531566.7	41.46010	1263970.
Minimum	-99.97100	-47.43808	0.002100
Std. Dev.	2117.275	2.264216	28035.27
Observations	104710	104710	104710

Note: Deviation from optimal size is calculated for year *t* as $DEVSIZE_{j,t} = \left| ASSETS_{j,t} - OSP_{t-1} \right|$, where OSP_{t-1} is the fitted value of the dependent variable in year (t-1) from the regression of the median value for Total Assets for companies in the highest decile of stock returns (MHDS) on the US macroeconomic variables, $\tilde{r}_i$ is continuously compounded stock return.

Panel B. Data used to estimate equation 3.6
$\tilde{r}_i = \gamma_0 + \gamma_1 \log K_i + \gamma_2 \log(K_i \times HITECH) + \gamma_3 \beta_{i,t} + v_t$, by company by year, 1986-2004.

	Annualized total return, r_i percent	**Total assets, \$million**	**HITECH**	**Market beta**
Mean	47.16548	3708.198	0.090736	0.969780
Median	5.543000	161.1960	0.081784	0.801661
Maximum	531566.7	1264032.	0.172207	41.46010
Minimum	-99.97100	0.000000	-0.005463	-47.43808
Std. Dev.	2117.275	28039.81	0.059856	2.264216
Observations	104710	104710	104710	104710

Note: HITECH is the annual growth rate for the index of US production of computer equipment, $\tilde{r}_i$ is continuously compounded stock return.

Table 3.3 Descriptive statistics of the dataset used to estimate equations 3.5 and 3.6 by industry sector.

Panel A. Data used to estimate equation 3.5, $\tilde{r}_i = \lambda_0 + \lambda_1 \log DEVSIZE_i + \lambda_2 \beta_i + e_i$ for each industry sector, by company by year, 1986-2004.

	Annualized total return, r_i percent	**Market beta (BETA)**	**Deviation from optimal size, (DEVSIZE)**	**Annualized total return, r_i percent**	**Market beta (BETA)**	**Deviation from optimal size, (DEVSIZE)**
Industry		Materials			Consumer Discretionary	
Mean	23.21728	0.578583	1879.143	84.79377	0.912761	2005.706
Median	4.283000	0.583839	251.2875	1.332500	0.832975	83.97860
Maximum	50250.00	33.83017	47107.91	531566.7	33.13866	448445.4
Minimum	-99.85100	-18.63570	0.002200	-99.97100	-25.79711	0.015800
Std. Dev.	619.1390	1.858520	4643.729	4382.523	2.173130	13209.97
Observations	6743	6743	6743	18870	18870	18870
Industry		Consumer Staples			Health Care	
Mean	39.86508	0.854663	2386.440	38.67200	1.218257	975.1862
Median	6.037000	0.784871	161.8435	0.288000	0.994684	60.02760
Maximum	68400.00	24.47192	104850.4	34650.00	41.46010	116713.4
Minimum	-99.87100	-14.38391	0.010200	-99.97100	-35.48143	0.003900
Std. Dev.	1100.119	1.831179	7266.999	461.4984	2.933705	5688.508
Observations	4864	4864	4864	11523	11523	11523
Industry		Energy			Industrials	
Mean	35.40115	0.533305	3023.122	27.95329	0.883277	1534.022
Median	6.061000	0.424573	99.34750	3.448000	0.779799	75.63630
Maximum	39899.99	27.92017	177510.4	72252.94	36.93763	647421.4
Minimum	-99.54500	-47.43808	0.026800	-99.83100	-21.47421	0.002100
Std. Dev.	588.7668	2.083496	11411.03	689.2218	2.010234	12018.10
Observations	5550	5550	5550	15515	15515	15515
Industry		Information Technology			Telecommunication Services	
Mean	43.64982	1.383283	819.3494	261.8101	1.535185	8604.683
Median	-3.256000	1.068433	60.03050	2.356500	1.042933	651.9504
Maximum	66775.00	35.65910	104395.4	177042.9	35.15995	270655.8
Minimum	-99.61700	-37.80671	0.003800	-99.76600	-21.01805	0.125500
Std. Dev.	596.4556	2.956042	4944.297	5728.414	3.009288	24474.64
Observations	17582	17582	17582	2036	2036	2036

Note: Deviation from optimal size is calculated for year t as $DEVSIZE_{j,t} = \left|ASSETS_{j,t} - OSP_{t-1}\right|$, where OSP_{t-1} is the fitted value of the dependent variable in year (t-1) from the regression of the median value for Total Assets for companies in the highest decile of stock returns (MHDS) on the US macroeconomic variables, $\tilde{r}_i$ is continuously compounded stock return., $\tilde{r}_i$ is continuously compounded stock return.

Table 3.3 (continued). Descriptive statistics of the datasets used to estimate equations 3.5 and 3.6 by industry sector.

Panel B. Data used to estimate equation 3.6
$\tilde{r}_i = \gamma_0 + \gamma_1 \log K_i + \gamma_2 \log(K_i \times HITECH) + \gamma_3 \beta_{i,t} + v_t$, by company by year, 1986-2004.

.	**Annual. total return, r_i percent**	**Total assets, $million**	**HITECH**	**Market beta**	**Annual. total return, r_i percent**	**Total assets, $million**	**HITECH**	**Market beta**
Industry	Materials				Consumer Discretionary			
Mean	23.21728	1918.395	0.204242	0.578583	84.79377	2039.467	0.210381	0.912761
Median	4.283000	313.8200	0.188315	0.583839	1.332500	134.9445	0.188315	0.832975
Maximum	50250.00	47169.47	0.396520	33.83017	531566.7	448507.0	0.396520	33.13866
Minimum	-99.85100	0.000000	-0.012579	-18.63570	-99.97100	0.000000	-0.012579	-25.79711
Std. Dev.	619.1390	4655.097	0.135266	1.858520	4382.523	13215.14	0.137593	2.173130
Obs	6743	6743	6743	6743	18870	18870	18870	18870
Industry	Consumer Staples				Health Care			
Mean	39.86508	2424.841	0.206792	0.854663	38.67200	986.4105	0.214417	1.218257
Median	6.037000	224.6065	0.188315	0.784871	0.288000	42.59300	0.191401	0.994684
Maximum	68400.00	104912.0	0.396520	24.47192	34650.00	116775.0	0.396520	41.46010
Minimum	-99.87100	0.000000	-0.012579	-14.38391	-99.97100	0.000000	-0.012579	-35.48143
Std. Dev.	1100.119	7276.530	0.135238	1.831179	461.4984	5698.047	0.139664	2.933705
Obs	4864	4864	4864	4864	11523	11523	11523	11523
Industry	Energy				Industrials			
Mean	35.40115	3053.674	0.206198	0.533305	27.95329	1565.637	0.205281	0.883277
Median	6.061000	158.2310	0.188315	0.424573	3.448000	114.5950	0.188315	0.779799
Maximum	39899.99	177572.0	0.396520	27.92017	72252.94	647483.0	0.396520	36.93763
Minimum	-99.54500	0.000000	-0.012579	-47.43808	-99.83100	0.000000	-0.012579	-21.47421
Std. Dev.	588.7668	11420.70	0.135097	2.083496	689.2218	12022.66	0.134964	2.010234
Obs	5550	5550	5550	5550	15515	15515	15515	15515
Industry	Information Technology				Telecommunication Services			
Mean	43.64982	836.4592	0.206190	1.383283	261.8101	8649.180	0.206350	1.535185
Median	-3.256000	53.79350	0.188315	1.068433	2.356500	723.2465	0.188315	1.042933
Maximum	66775.00	104457.0	0.396520	35.65910	177042.9	270717.4	0.396520	35.15995
Minimum	-99.61700	0.000000	-0.012579	-37.80671	-99.76600	0.000000	-0.012579	-21.01805
Std. Dev.	596.4556	4952.618	0.142181	2.956042	5728.414	24483.82	0.145357	3.009288
Obs	17582	17582	17582	17582	2036	2036	2036	2036

Note: HITECH is the annual growth rate for the index of US production of computer equipment, $\tilde{r}_i$ is continuously compounded stock return.

Table 3.4. Maximum annual return and corresponding firm size.

Year	**1985**	**1986**	**1987**	**1988**	**1989**
Average return	27.80294	17.31108	-1.079296	13.36635	17.63463
Maximum Return	906.4520	2500.000	4793.240	906.4520	2500.000
Median size for highest return decile	22.09200	48.30650	50.04700	62.18450	52.22650
Optimal size proxy	38.6121	80.1893	60.1857	66.1757	63.1666
Number of companies	4829	5085	5089	4829	5085
Year	**1990**	**1991**	**1992**	**1993**	**1994**
Average return	-11.74750	52.98893	28.87356	35.65562	0.652849
Maximum Return	7964.510	21708.51	2524.490	7964.510	21708.51
Median size for highest return decile	45.76750	36.45300	57.32250	76.69700	77.57300
Optimal size proxy	47.0975	39.5242	41.8846	54.9524	66.1644
Number of companies	5543	6157	6887	5543	6157
Year	**1995**	**1996**	**1997**	**1998**	**1999**
Average return	33.37784	28.98474	39.72117	153.9496	312.6593
Maximum Return	43233.33	1124900.	1525062.	43233.33	1124900.
Median size for highest return decile	53.17100	65.70500	133.1750	99.65950	39.67950
Optimal size proxy	77.7359	68.701	80.4648	101.696	86.7098
Number of companies	9146	9379	9859	9146	9379
Year	**2000**	**2001**	**2002**	**2003**	**2004**
Average return	36.66238	54.02239	64.11064	771.7585	4030.841
Maximum Return	183463.3	2686975.	29999901	183463.3	2686975.
Median size for highest return decile	118.644	98.5025	79.512	26.7975	22.544
Optimal size proxy	78.037	59.2585	61.5638	48.2239	45.7168
Number of companies	9906	9792	8773	9906	9792

Note: Average and maximum returns correspond to total annualized returns from the S&P COMPUSTAT database. Optimal size proxy is the fitted value of the dependent variable from the regression of the median value for Total Assets (*ASSETS*) for companies in the highest decile of stock returns on the US macroeconomic variables. The macroeconomic variables are: annual growth in industrial production GP, inflation I, term structural variable UTS, credit risk premium UPR, and oil price variable OG.

Table 3.5. Least squares estimation results for equation $\tilde{r}_i = \lambda_0 + \lambda_1 \log DEVSIZE_i + \lambda_2 \beta_i + e_i$ for each industry, by company by year, 1986-2004.

Industry		Constant	Size Deviation	Beta
Full sample		3.824419***	-0.07907***	0.036286***
	t-stats	248.3037	-33.371	10.15519
	p-value	0.0000	0.0000	0.0000
Industry subsamples				
Materials		3.678763***	-0.081213***	0.002202
	t-stats	57.13464	-8.232384	0.127468
	p-val	0.0000	0.0000	0.8986
Consumer Discretionary		3.735721***	-0.058936***	0.019701**
	t-stats	98.56079	-9.247682	2.106359
	p-val	0.0000	0.0000	0.0352
Consumer Staples		3.610381***	-0.075641***	0.042442**
	t-stats	47.46199	-6.846770	2.033746
	p-val	0.0000	0.0000	0.0421
Health Care		4.129389***	-0.089400***	0.003201
	t-stats	89.20064	-10.70750	0.396494
	p-val	0.0000	0.0000	0.6918
Energy		3.853428***	-0.087386***	0.040814***
	t-stats	60.68085	-9.048899	2.622868
	p-val	0.0000	0.0000	0.0088
Industrials		3.688646***	-0.076199***	0.029597***
	t-stats	95.97489	-11.50345	3.323275
	p-val	0.0000	0.0000	0.0009
Information Technology		3.986749***	-0.036055***	0.038431***
	t-stats	97.44783	-4.628377	5.834292
	p-val	0.0000	0.0000	0.0000
Telecommunication Services		4.287306***	-0.103058***	0.038065**
	t-stats	32.43669	-6.039918	2.004092
	p-val	0.0000	0.0000	0.0453

Note: Here $\tilde{r}_i$ is continuously compounded stock return for company i. $DEVSIZE_i$ is deviation from the optimal capital size in each year, it is calculated for year *t* as $DEVSIZE_{j,t} = \left|ASSETS_{j,t} - OSP_{t-1}\right|$, where OSP_{t-1} is the fitted value of the dependent variable in year (t-1) from the regression of the median value for Total Assets for companies in the highest decile of stock returns (MHDS) on the US macroeconomic variables. β_i is company beta in each year, and e_i is regression residual. Estimation is performed with White correction for heteroskedasticity.

*** indicates 1% significance, ** indicates 5% significance, * indicates 10% significance.

Table 3.6. Least squares estimation results for equation $\tilde{r}_i = \gamma_0 + \gamma_1 \log K_i + \gamma_2 \log(K_i \times HITECH) + \gamma_3 \beta_{i,t} + v_t$, by company by year, 1986-2004.

Industry	Constant	Size	Size * HITECH	Beta
Whole sample	3.962092***	-0.117928***	0.030361***	0.036880***
t-stats	168.0639	-17.42811	4.889196	10.25091
p-value	0.0000	0.0000	0.0000	0.0000
Industry subsamples				
Materials	3.604966***	-0.052380**	-0.036062	0.013743
t-stats	38.28318	-2.050708	-1.578389	0.788320
p-value	0.0000	0.0404	0.1146	0.4306
Consumer Discretionary	3.796972***	-0.064154***	-0.009427	0.017428*
t-stats	62.24049	-3.611342	-0.596655	1.876968
p-value	0.0000	0.0003	0.5508	0.0606
Consumer Staples	3.685638***	-0.078771***	-0.015361	0.044447**
t-stats	32.34612	-2.643452	-0.587069	2.129834
p-value	0.0000	0.0083	0.5572	0.0333
Health Care	3.997663***	-0.042400*	-0.048420**	0.005958
t-stats	56.28406	-1.934659	-2.435381	0.747781
p-value	0.0000	0.0531	0.0149	0.4546
Energy	4.224289***	-0.255094***	0.191218***	0.031788**
t-stats	39.83919	-7.336920	5.841833	2.004276
p-value	0.0000	0.0000	0.0000	0.0451
Industrials	3.820792***	-0.102304***	0.007901	0.028654***
t-stats	62.11712	-5.689219	0.486581	3.232271
p-value	0.0000	0.0000	0.6266	0.0012
Information Technology	4.547580***	-0.245468***	0.192843***	0.043168***
t-stats	72.24752	-12.11362	10.35576	6.533179
p-value	0.0000	0.0000	0.0000	0.0000
Telecommunication Services	4.603533***	-0.232948***	0.133988***	0.041687**
t-stats	25.35269	-4.637504	2.832008	2.101931
p-value	0.0000	0.0000	0.0047	0.0358

Note: $\tilde{r}_i$ is continuously compounded stock return, Size (K_i) is Total Assets for company *i*, HITECH is the annual growth rate for the index of US production of computer equipment, $\tilde{r}_i$ is continuously compounded stock return, β_i is company beta in each year, and v_i is regression residual. Estimation is performed with White correction for heteroskedasticity.

*** indicates 1% significance, ** indicates 5% significance, * indicates 10% significance.

CHAPTER 4

ASSET PRICING IN EUROPEAN STOCK MARKETS

4.1 Introduction

The creation of the European Monetary Union (EMU) in 1991 provides a unique opportunity to study the impact of financial liberalization on the integration of capital markets of different countries in Europe. The main objective of this paper is to estimate the time-varying financial market integration process for both EMU and Non-EMU countries. We assume an International Asset Pricing Model (IAPM) proposed in Adler and Dumas (1983) and estimate the integration process for the regional European market using a sample of three EMU (France, Germany, Netherlands) and two non-EMU (U.K. and Switzerland) countries using monthly data from March 1984 to November 2002. Our main focus is to examine the impact of the process of regional integration in the European capital markets on market and currency risks.

Specifically, we investigate whether this process is similar or different for the EMU and Non- EMU countries. We employ the regime-switching model of Bekaert and Harvey (1995) but modify their asset pricing specification to include currency risk as well as market risk. Our specification is similar to that in Hardouvelis et al (2005) and Adler and Qi (2003) but unlike the separate estimations for individual countries in these papers, we conduct joint estimation of the system for our five sample countries.

Another objective of our paper is to estimate the dates of integration-related structural breaks in the European financial markets using the methodology in Bekaert et al. (2002). We perform a number of univariate and multivariate tests to check robustness of these breaks using financial and macroeconomic variables suggested in Bekaert et al (2002) as well as examining whether the estimated structural dates are related to any political events in the European markets such as the implementation of the Single European Act, the Maastricht Treaty, and the introduction of the Euro.

Our main findings are as follows. First, we find that financial integration in Europe followed a gradual process and did not jump to full integration even after the introduction of the Euro in 1999. We also find that the Euro countries generally display higher degrees of market integration compared to the non-Euro countries in our sample. We find that countries with higher degrees of financial integration tend to have lower prices for market and currency risk, consistent with the prediction of most theoretical models of capital market integration. We also find that prices of market and currency risks are significant and time varying in our sample. Finally, we document that structural changes in equity pricing occurred around June 1986 for all countries in our sample. However, the countries that implemented the Euro also experienced a second series of breakpoint dates that occurred at different times around January 1999. These results are consistent with prior research on financial integration, including Errunza and Losq (1985), Bekaert, and Harvey (1995), and Bekaert et al (2002), among others, in the sense that once governments started moving towards reducing cross-border capital controls, the financial markets of corresponding countries started to display signs of higher integration.

Our study makes several contributions to the literature. First, several studies have examined the capital market integration in the EMU using different methodologies but the evidence is mixed. Carrieri (2001) uses a single-regime asset pricing model and finds evidence suggesting that European prices of market and currency risks decreased with financial liberalization through time. Sentana (2002), on the other hand, uses a similar model and finds evidence that the creation of the EMU reduced exchange rate and interest rate volatility but he rejects the hypothesis of European market integration. Hardouvelis et al. (2005) use a regime-switching model, and find that integration in European equity markets substantially increased after 1995. Fratzscher (2002) also discovers an increase in the degree of integration for European countries, especially since 1996 using a similar methodology. However, both Hardouvelis, et al (2005) and Fratzscher (2002) use estimation procedures that involve several steps. In addition, their market integration measures are different from those used in Bekaert and Harvey (1995) as they are (in theory and in some cases in practice) not confined to [0, 1].

Our study differs from the previous research in that we perform a joint estimation of the European stock market returns using a regime-switching model consistent with Bekaert and Harvey (1995) and our measure of integration is restricted to the interval [0,1]. Second, to the best of our knowledge, this is the first paper that estimates dates of structural breaks in European asset pricing related to market integration. We examine two variables (difference in term premiums and difference in dividend yields between a country and the European common market) and provide evidence that they are significantly related to stock market integration.

This chapter is organized as follows. The next section outlines the theoretical model and estimation method, and section 3 describes the data set. Section 4 presents our finding for the asset pricing processes within Europe and provides estimates of the dates where integration-related structural changes most likely occurred. Section 5 concludes.

4.2. Theoretical model

Our pricing model includes market and currency risks, as well as regime shifting between segmentation and integration. We start with the model of Adler and Dumas (1983). Under the assumption of fully integrated financial markets the asset pricing relationship is specified as follows:

$$E_{t-1}[r_{i,t}] = \sum_{j=1}^{L} \delta_{j,t-1} \operatorname{cov}_{t-1}[r_{i,t}, \pi_{j,t}] + \delta_{M,t-1} \operatorname{cov}_{t-1}[r_{i,t}, r_{M,t}] \qquad (4.1)$$

In this model there are L+1 countries, $r_{i,t}$ is the excess return for market index in country i, and $r_{M,t}$ is the excess return for the world market portfolio at time t, $\pi_{j,t}$ is country j's inflation rate, all in reference currency (US dollars in present study), the currency j's risk is measured by $\operatorname{cov}_{t-1}[r_{i,t}, \pi_{j,t}]$ and $\delta_{j,t-1}$ is the price of currency risk. Finally, the market risk is measured by $\operatorname{cov}_{t-1}[r_{i,t}, r_{M,t}]$ and $\delta_{M,t-1}$ is the price of the market risk.

Following Dumas and Solnik (1995) and De Santis and Gerard (1998) we also assume that domestic inflation is non-stochastic[36]. In such a case[37] foreign exchange risk becomes the only component of the additional exposure faced by an investor who holds asset i with respect to currency j. Thus, $\operatorname{cov}_{t-1}[r_{i,t}, \pi_{j,t}]$ is approximated by $\operatorname{cov}_{t-1}[r_{i,t}, e_{j,t}]$, where $e_{j,t}$ denotes change in the exchange rate of currency j with respect to the US dollar[38], and equation (1) can be rewritten as follows:

[36] This is a reasonable assumption for all countries in our sample since we study well developed European countries with negligible local currency inflation risk. See Dumas and Solnik (1985, p. 448) for further discussion of this simplification.
[37] Carrieri et al. (2003) provide formal derivation of this result. In addition, Carrieri et al. (2002) represents an alternative approach to estimate time-varying integration. The empirical approach in that paper is based on the theoretical model of mild segmentation of Errunza and Losq (1985), and thus exploits the importance of substitute assets in integrating financial markets.
[38] Or any other reference currency.

$$E_{t-1}[r_{i,t}] = \sum_{j=1}^{L} \delta_{j,t-1} \operatorname{cov}_{t-1}[r_{i,t}, e_{j,t}] + \delta_{M,t-1} \operatorname{cov}_{t-1}[r_{i,t}, r_{M,t}] \quad (4.2)$$

The model in equation (4.2) is based on a rather strong assumption of full integration of the capital markets. Bekaert and Harvey (1995) relax this assumption and explicitly account for the degree of market integration; however, their model includes only market risks. De Santis and Gerard (1998) allow for market and currency risks, as well as the possibility of partial integration by adding country-specific market risk, but they do not quantify the degree of integration for a particular country.

To extend model (4.2) and allow regime shifting, we follow Bekaert and Harvey (1995) and introduce a state variable $\varphi_{j,t-1}$ that indicates time-varying degree of integration. Our asset pricing model includes global market and currency risks, as well as local market risks for each country. In light of Adler and Dumas (1983) model, this specification translates into the following[39]:

$$E_{t-1}[r_{j,t}] = \varphi_{j,t-1}(\delta_{M,t-1} \operatorname{cov}_{t-1}[r_{j,t}, r_{M,t}] + \sum_{j=1}^{L} \delta_{j,t-1} \operatorname{cov}_{t-1}[r_{i,t}, e_{j,t}]) +$$

$$+ (1 - \varphi_{j,t-1})\delta_{j,m,t-1} \operatorname{var}_{t-1}[r_{j,t}] \quad (4.3)$$

Equation (4.3) encompasses the IAPM of Adler and Dumas (1983) and the classical CAPM of Sharpe (1964) and Lintner (1965). Full integration is denoted by $\varphi_{j,t-1} = 1$, which results in the expected market excess return in country *j* being a function of price of currency risk $\delta_{c,t-1}$, the covariance of excess asset and currency returns $\operatorname{cov}_{t-1}[r_{j,t}, r_{c,t}]$,

[39] This model is similar to those used in Hardouvelis et al. (2005) and Adler and Qi (2003).

the price of market risk $\delta_{M,t-1}$, and the covariance of the country *j* market excess return and the excess return on the international market portfolio $\text{cov}_{t-1}[r_{j,t}, r_{M,t}]$. In other words, if the market in country *j* is fully integrated with the other countries, then investors are compensated for their exposure to both the market risk and the currency risk stemming from uncertainty with respect to the purchasing power of returns earned in country *j* and spent in other countries.

In the case of fully segmented market, stringent government controls on cross-border capital flows can restrict or prohibit international investments. In such a case, the returns earned in country j have purchasing power only in country j, and thus only the risk-return relationship within country j is relevant, as is the case in the traditional CAPM. Therefore, if the market in country *j* is fully segmented from the international marketplace, $\varphi_{j,t-1} = 0$ and the expected market excess return in country *j* is a function of only the local market price of risk $\delta_{j,m,t-1}$ and its own variance $\text{var}_{t-1}[r_{j,t}]$.

4.3. Empirical method

4.3.1. Time varying market integration

We estimate the regime-switching international asset pricing model (4.3) jointly for all countries using the multivariate GARCH methodology with regime switching in the mean equations. We extend the methodology of Bekaert and Harvey (1995) by adding currency risk to the mean equations, as well as by using variance targeting and adding conditional covariances to the variance equations[40]. In order to reduce the number of

[40] The conditional covariances among countries are added because the system is estimated jointly. These covariances are ignored when the model is estimated for each country separately.

equations, we use a currency index instead of bilateral exchange rates. Thus, we have the following specification:

$$r_{i,t} = \varphi_{i,t-1}(\delta_{M,t-1} \operatorname{cov}_{t-1}[r_{i,t}, r_{M,t}] + \delta_{c,t-1} \operatorname{cov}_{t-1}[r_{i,t}, r_{c,t}]) +$$

$$+ (1 - \varphi_{i,t-1})\delta_{i,m,t-1} \operatorname{var}_{t-1}[r_{i,t}] + e_{i,t} \qquad (4.4)$$

where $r_{i,t}$ is excess return on country i's market index, $\delta_{M,t-1}$ is price of international market risk, $\operatorname{cov}_{t-1}[r_{i,t}, r_{M,t}]$ denotes country i's exposure to international market risk, $\delta_{c,t-1}$ is the price of currency risk given information available at time t-1, $\operatorname{cov}_{t-1}[r_{i,t}, r_{c,t}]$ denotes country i's currency exposure, and $e_{i,t}$ is residual at time t.

We have two more elements in the system[41]. First, international market excess return is:

$$r_{M,t} = \delta_{M,t-1} \operatorname{var}_{t-1}(r_{M,t}) + \delta_{c,t-1} \operatorname{cov}_{t-1}(r_M, r_c) + e_{M,t}, \qquad (4.5)$$

and the currency index return is:

$$r_{c,t} = \delta_{M,t-1} \operatorname{cov}_{t-1}(r_M, r_c) + \delta_{c,t-1} \operatorname{var}_{t-1}(r_{c,t}) + e_{c,t}. \qquad (4.6)$$

We estimate the prices of international market risk[42] and of local market risk as follows:

[41] As a robustness test, we try several alternatives to our main models. These include (i) a model where the equity market is fully segmented and currency market is fully integrated, (ii) a model which assumes mild segmentation in the equity market only, while currency markets are fully integrated, (iii) a reverse situation where the currency market integration is time varying and the equity market is fully integrated, and (iv) a model that assumes the integration measure to be the same for all countries. These models are very similar, but they cannot be easily nested. Therefore, instead of using the likelihood ratio test, we select them based on the log likelihood criterion. The values of the log likelihood functions that correspond to alternative models, as well as log likelihoods of our full integration and time varying integration models, are presented in Table 5. The model that assumes time varying integration for both markets attains the highest level of log likelihood, and is therefore superior to its alternatives, including the cases of full integration and an assumption that all countries are integrated to the same degree at each point in time.

[42] The price of market risk must be positive if investors are risk-averse and have nonnegative commitments (i.e. investments or margins in case of short sales) in the stock market. Consider the IAPM described by equation (1). The price of international market risk is a weighted average of degrees of risk aversion for

$$\delta_{M,t-1} = \exp[Z_{t-1}^{EU} k_1] \qquad (4.7)$$

and

$$\delta_{i,m,t-1} = \exp[Z_{t-1}^{m,i} k_{1,i}], \qquad (4.8)$$

where Z_{t-1}^{EU} is a set of international information variables, k_1 is a vector of coefficients, $Z_{t-1}^{m,i}$ is a set of country-specific pricing information variables for country *i*, and $k_{1,i}$ is a vector of coefficients for country *i*. Model (4.1) places no restriction on the sign of the price of currency risk, therefore, we specify it as a linear function:

$$\delta_{c,t-1} = Z_{t-1}^{EU} k_2, \qquad (4.9)$$

where k_2 is a vector of coefficients.

System (4.4), (4.5), and (4.6) includes a measure of country *i*'s integration $\varphi_{i,t-1}$. Following Bekaert and Harvey (1995), we estimate it as a logistic function:

$$\varphi_{i,t-1} = \frac{\exp(Z_{t-1}^{\varphi,i} k_{3,i})}{1+\exp(Z_{t-1}^{\varphi,i} k_{3,i})}, \; i = 1,...,5. \qquad (4.10)$$

Elements of equation (4.10) include $Z_{t-1}^{\varphi,i}$, a set of instrumental variables providing information related to the degree of integration, and $k_{3,i}$, a vector of coefficients corresponding to the integration measure of country *i*.

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investors in all countries. Since relative wealth is nonnegative, and provided investors are risk-averse, the price of international market risk must be nonnegative, and if relative wealth in at least one country is positive, then the price of international market risk must be strictly positive. Following the same logic, if an investor in country *i* is risk averse and has some amount of money committed to the stock market, the price of local market risk must be strictly positive as well. The price of local market risk is restricted to be positive in Adler and Qi (2003), while Carrieri, Errunza, and Majerbi (2003) do not include such a restriction. We estimated the models both ways and it did not cause a major change in the conclusion. In addition, our "unrestricted" model on a sample of 225 observations $\times 5$ local market price series produced only 30 cases where the fitted local market price of risk was negative, for all local prices combined. It appears that positivity of the local market price of risk makes more sense at least from ex ante viewpoint. Therefore, we only report the results obtained from the model where both International and local market risk prices are restricted to be positive.

Excess returns in the full integration model (4.4), (4.5), and (4.6) are assumed to be jointly normally distributed,

$$e_t \equiv (e_{1,t},\dots,e_{5,t},e_{M,t},e_{FX,t})' \sim N(0,\mathrm{H}_t).$$

We estimate the system using a multivariate GARCH specification for the variance-covariance matrix H_t,

$$\mathrm{H}_t = \mathrm{H}_0 \circ (\mathrm{ii}' - AA' - BB') + A\mathrm{e}_{t-1}\mathrm{e}'_{t-1}A' + B\mathrm{H}_{t-1}B' \qquad (4.11)$$

where, H_0 is an unconditional 7x7 variance-covariance matrix, e_{t-1} is a 7x1 vector of residuals at time t, i is a 7x1 vector of ones, A and B are 7x7 diagonal matrices of coefficients, and finally "$\circ$" denotes Hadamard matrix product or element by element multiplication.

The system was estimated using the Marquardt algorithm[43] under an assumption of multivariate normality. To ensure that coefficient estimates correspond to the global maximum of the log likelihood function $l(\Theta)$ with respect to parameter space Θ,

$$l(\Theta) = -\frac{1}{2}\left(T\ln 2\pi + \sum_{t=1}^{T}\ln|\mathbf{H}_t| + \sum_{t=1}^{T}\mathbf{e}'_t\,\mathbf{H}_t^{-1}\mathbf{e}_t\right), \qquad (4.12)$$

we used a number of different combinations of starting values for estimation.

4.3.2. Dating the integration process

We estimate the integration-related structural changes in asset pricing of all countries in the sample by using Bekaert et al (2002) methodology. They suggest a test for market integration based on the supremum of Wald test statistic or Sup-W test introduced by Bai

[43] A refinement of BHHH (Bernt, Hall, Hall and Hausman, 1974) algorithm, see EViews 4.1 manual and/or Robert Engle's website http://pages.stern.nyu.edu/~rengle/ for details.

et al (1998). This test[44] performs a Wald test for structural change[45] in q parameters of the vector autoregression of order p[46] for each data point,

$$\mathrm{y_t = A_1 y_{t-1} + \ldots + A_p y_{t-p} + C + \varepsilon_t} \qquad (4.13)$$

In equation (4.13) $\mathbf{y}_t$ is a $n \times 1$ vector of variables, $\mathbf{A}_j, j = 1,\ldots,p$ is a $n \times n$ matrix of coefficients, $\mathbf{C}$ is a $n \times 1$ vector of constants, $\boldsymbol{\varepsilon}_t$ is a $n \times 1$ vector of residuals, and the number of parameters $q = n(np+1)$.

The estimated date of structural change k will maximize the Sup-W test statistic $F_T(k)$. In order to compute confidence intervals for the estimated date of structural change, we use critical values for the test statistics provided by Bekaert et al (2002). We estimate several univariate and multivariate autoregressive specifications for each country. Our base case for an individual country VAR includes 4 variables: country index return, country dividend yield, European index return, and European dividend yield.

4.4. Data

We analyze the influence of European unification on stock markets in five countries, including three EMU (France, Germany, the Netherlands) and two non-EMU (U.K. and Switzerland) countries. We use monthly returns from March 1984 to November 2002 for

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[44] Another option would be to test for structural breaks in our fully or partially integrated models. However, this approach has two shortcomings. First, there is no way it can pinpoint a precise date, or even a confidence interval of actual structural change, since the Chow-type test statistic is a function of the pre- and post-date subsamples. Second, our models, especially the model assuming time varying integration, have a very large number of parameters compared with the number of data points in the sample, which poses a serious problem with degrees of freedom.

[45] The structural changes could occur due to market integration, or due to other events relevant to the stock markets, and there is no way to tell whether it is specifically integration-related structural breaks or not. To achieve higher degree of certainty, one might want to compare the estimated dates of the breaks with changes in the estimated measures of integration for each country, and with the timeline of the political events. We do the latter comparison in this thesis, and leave for future research the more detailed comparison of trajectories for the estimated measures of integration with the estimated breakpoint dates.

[46] We use the Akaike information criterion to determine lag length p.

five European stock market indices, as well as returns for the European market index. In addition, we construct the US trade weighted index against major currencies as a common measure of the currency exposure[47]. Stock market data are obtained from Morgan Stanley Capital International[48]. We used the US dollar-denominated MSCI gross index series to calculate stock returns. The data on dividend yields and short- and long-term riskless rates for European countries is obtained from the dataset that accompanies the Solnik and McLeavey (2002) textbook[49] on international investments. The data on the US trade-weighted foreign exchange index, Eurodollar rate, and the US government bond yields are obtained from the US Federal Reserve Board website[50]. The paper measures the riskless rate as the 1-month Eurodollar rate. Altogether, the system consists of seven equations: five country indices, the European market index, and the currency index.

Table 4.1 presents descriptive statistics for the country excess returns and the currency return. Switzerland displays the highest mean excess return of 0.5202% per month or roughly 6.4% annualized return, while Germany has the lowest mean return of 0.1988 per month or 1.7% annualized return. Germany also had the largest stock return standard deviation of 0.07802, whereas the European market index has the standard deviation of 0.05012, the smallest among all monthly stock returns. For all stock return series, the hypothesis of normality is rejected by the Jarque-Bera statistic, and all series are stationary according to the ADF test. Table 4. 1 Panel B shows substantial cross-

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[47] See Jorion (1990), Ferson and Harvey (1993, 1994), Carrieri et al. (2003). In constructing the currency index, we follow Carrieri, Errunza, and Majerbi (2003) and use log changes in the inverse of the trade-weighted US foreign exchange index against major currencies $r_{c,t}$. Alternatively, one could follow Hardouvelis et al (2005) or Fratzscher (2002) and estimate pricing relationships for each county separately, but this would result in obtaining coefficients given by local maxima (as opposed to the global maximum) in the maximum likelihood estimation.

[48] www.msci.com

[49] http://wps.aw.com/aw_solnik_intlinv_5/0,7654,716896-,00.html

[50] http://www.federalreserve.gov

correlations of all stock returns and relatively lower correlation of the stock returns and the currency index.

Several previous studies[51] use a set of instrumental variables that convey information about the market and economic conditions in the European marketplace, as well as in each country. We use these variables in pricing equations to compute prices of market and currency risks. The instrumental variables used in measuring integration are constructed in such a way that they reflect any differences in economic conditions between each specific country and the European market.

European information variables include a constant, the MSCI Europe index return in excess of one-month Eurodollar rate (XER), the European dividend yield in excess of one-month Eurodollar rate (XEDY), the US default premium (USDP) and a change in the US term premium (ΔUSTP), all lagged one month. Data series for the European term structure and the default premium for the whole sample were not available; we use corresponding US variables as proxies[52]. The term structure variable is calculated as the difference between the 7-year US government bond yield and the 1-year US government

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[51] See for example Dumas and Solnik (1995), De Santis and Gerard (1998), or Carrieri (2001).

[52] The US variables were used as proxies by many studies, including Bekaert and Harvey (1995), Carrieri (2001), De Santis and Gerard (1998), Adler and Qi (2003), Carrieri et al. (2003), and shown to be useful predictors for returns in other countries, including European countries. We used these variables assuming that the US is the most influential part of the world market, and the world market affects the European returns. The US economic variables affect the US market and they should have an impact on the European stock returns. One might argue that it could be possible to construct aggregate measures for the European term and default premiums, as well as for other series, by aggregating the relevant economic series of the individual European countries. However, the aggregation itself would involve strong assumptions with respect to weighting for individual countries, and it is unclear whether the benefit of having the European index will outweigh the cost of using some particular weighting scheme in constructing this index. We leave the issue of the best measure for the European economic conditions for future research. In addition, the use of proxy variables introduces noise to the estimation, and therefore we expect that significance of the estimated coefficients should be lower than in the case when the European macroeconomic data becomes available.

bond yield[53]. The default premium is calculated as a difference between the Baa and Aaa corporate bond yields in Moody's classification, available at the US Federal Reserve Board's website.

Descriptive statistics for the European information variables are presented in Table 4.2. All variables are stationary according to the ADF test statistic, and the null hypothesis of normal distribution is strongly rejected for all series based on the Jarque-Bera test. The cross-correlations of the information variables range from -0.109444 to 0.059265.

Country-specific information variables include two subsets. The first subset characterizes particular countries and contains four variables, a constant, a local market return in excess of the corresponding riskless rate (XLR), a country-specific term premium (LTP), and a country-specific dividend yield (XLDY) in excess of the corresponding riskless rate[54]. Several previous studies, including Bekaert and Harvey (1995), De Santis and Gerard (1998), Carrieri (2001), De Santis et al (2003), Carrieri et al. (2003) have shown that these variables have the ability to forecast future economic conditions in a country. The second subset characterizes how a specific country's economy differs from the aggregate European economy. These variables include the absolute difference between the country's excess returns and European excess returns (ADXR), the difference between the country's term premium (the country's government bond rate less this country's short-term riskless rate, adjusted for the change in the corresponding exchange rate) and the US term premium (DTP), and the difference

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[53] We used 7-year instead of 10-year or longer maturity because those yields were not available for all data points.
[54] We tried to achieve maximum possible correspondence between local pricing information variables and the European information variables. The discrepancy stems from data availability.

between a particular country's dividend yield and the European dividend yield (DDY) [55]. All variables are lagged one month. The first three variables are used in the asset pricing model. The other three variables are used as instrumental variables to determine a specific country's degree of integration.

Descriptive statistics for the local information variables are presented in Table 4.3. All series are stationary according to the ADF test statistics. The null hypothesis of normality for variable XLR (lagged local market return in excess of the corresponding riskless rate) and variable ADXR (absolute difference between a country's excess return and the European excess return) is strongly rejected for all countries. In addition, the hypothesis of normality is rejected for variable DDY (difference between a local dividend yield and the European dividend yield) for Germany, France, the UK, and Switzerland. Next, normality is rejected for variable DTP (difference in term premiums between a specific country and the European market, the latter proxied by the US term premium) for the UK. Finally, the local pricing variables (XLR, LTP, and XLDY) display quite high cross-correlations, which should bias the results against finding individual significance of coefficients due to anticipated multicolinearity. Cross-correlations among integration variables (ADXR, DTP, and DDY) are not as large as those among the pricing variables.

[55] We follow Fedorov and Sarkissian (2000) in constructing variable ADXR. In fact, we tried both absolute deviation and a simple return difference as an instrument and obtained similar results. Next, we construct variables DTP and DDY using logic analogous to Fedorov and Sarkissian (2000, p. 139).

4.5. Empirical results

4.5.1. Stock pricing under time varying integration

In this section we discuss estimation results for system (4.4), (4.5), and (4.6), which assumes that degree of market integration varies over time. The econometric model is based on the IAPM and on empirical work of Bekaert and Harvey (1995), Hardouvelis et al (2005), and theoretical models of Errunza and Losq (1985) and Bhamra (2002). The estimation of this model is presented in Table 4.4a.

An interesting observation emerges from inspection of signs of the local coefficients compared with the signs of the European coefficients. Whereas the coefficient for the European market excess return XER is positive and significant, all but one (Switzerland) coefficients for corresponding local excess returns XLR are negative; the local coefficients are significant at the 1% level for Germany and Netherlands and at the 5% level for the UK. It appears that an increase in the overall European excess return increases the price of European market risk, while an increase in individual country returns should decrease the price of local market risk. This would make sense when investors exhibit increasing relative risk aversion while investing into the European market, and decreasing relative risk aversion in investment decisions within their home countries. We hypothesize that such seemingly contradictory results may be related to home bias, a situation where investors allocate funds into their own country more frequently than abroad, perhaps because they are less risk averse with respect to their home market[56].

[56] See Cooper and Kaplanis (1994). There may be some alternative explanations for this phenomenon; we leave a more detailed investigation for the future.

Residual diagnostics in Table 4. 4b show that most standardized residuals have considerable kurtosis and are non-normal except for France and the currency index, consistent with the results obtained for the full integration model. Most p-values of Ljung-Box statistics are once again above 10% level, which suggests that most mean, variance, and covariance equations are adequate; however, the diagonal BEKK parameterization does not fully capture the dynamics of the system.

To investigate formally whether European prices of market and currency risks are zero or constant, we test a number of joint hypotheses presented in Table 4.4c. Hypotheses about prices of risks strongly suggest that the prices of market and currency risks, and local prices of market risks are significant and time varying. In addition, tests concerning integration coefficients for all countries jointly, and separate tests for the Netherlands and Switzerland[57] provide evidence about importance of absolute return difference ADXR, the difference in term premiums DTP, and the difference in dividend yields DDY in determining whether or not a local market is integrated with the European marketplace. Finally, all estimated coefficients corresponding to the variance-covariance matrix are individually highly significant[58] and satisfy the stationarity condition[59].

[57] We hypothesize that the insignificant coefficients for Germany, France, and the UK result from a small number of degrees of freedom in estimation. However, we acknowledge that there may be other reasons for such an outcome, i.e. multicolinearity of the information variables, different combinations of relevant factors for different countries, estimation problems, or non-normal probability distribution of residuals.

[58] Thus, our time-varying integration model is "well-behaved", since the estimation results are consistent with those presented in Dumas and Solnik (1995), De Santis and Gerard (1998), Carrieri (2001), or Carrieri et al. (2003). We also estimate a system that assumes full integration of capital markets, specified by (4), (5), and (6). Our full integration model is also "well-behaved". In particular, in this model both market and currency risk prices are significant and time-varying, and all parameters of the diagonal specification are highly significant.

[59] Stationarity condition $a_i a_j + b_i b_j < 1$, $\forall i, j$ is satisfied. We have $\max\{a_i a_j + b_i b_j\} = 0.993092$ for i=2 and j=2, and $\min\{a_i a_j + b_i b_j\} = 0.541684$ for i=4 and j=4.

We plot integration measures[60] in Figure 4.1. The highest level of integration is displayed by France, which is immediately followed by Germany, and the lowest integration level is displayed by the UK. This is what we expected, since the theory predicts that a common currency should reduce transaction costs and increase market integration across countries. Thus, the EMU countries (France and Germany) should have higher degree of market integration[61] than a non-EMU country (the U.K.).

An interesting result is discovered by analyzing time varying market integration for the Netherlands and Switzerland. Our estimates for the integration measure for Switzerland, a non-EMU country, are slightly higher than those for the Netherlands, an EMU country, whereas we would expect to observe the opposite. However, given the number of international banks operating in Switzerland, as well as the number of Swiss banks[62] that have investments overseas, it is plausible that Switzerland should have very strong economic ties[63] with other countries even without participating in the EMU.

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[60] We tried alternative specifications for the integration measure. They included a functional form used by Fedorov and Sarkissian (2000) $\varphi_{i,t-1} = \frac{1}{1+\exp(\mathbf{Z}_{t-1}^{\varphi,i}\mathbf{k}_{3,i})}$, exponential function used by Adler and Qi (2003) $\varphi_{i,t-1} = \exp(\mathbf{Z}_{t-1}^{\varphi,i}\mathbf{k}_{3,i})$, and a linear specification $\varphi_{i,t-1} = \mathbf{Z}_{t-1}^{\varphi,i}\mathbf{k}_{3,i}$. All specifications produced similar dynamics of the integration measure in a sense that it did not display a sharp increase after the introduction of Euro. We also estimated a model with a single integration measure for all countries and verified via a likelihood ratio test that levels of integration for different countries are distinct from each other.

[61] A note of caution is warranted in interpreting the results. All monthly fitted series potentially contain estimation errors. Thus, the integration measure that we use should not be interpreted in a way that the degree of integration between each country and Europe changes on a monthly basis. Instead, analysis of mean values, smoothed series, long-term trends, and simultaneous variations of the integration measures and other relevant variables should provide a more accurate picture of events.

[62] See http://www.swconsult.ch/

[63] Switzerland and the UK have different estimated degrees of integration, which may appear odd at first. They both retained their own currencies instead of implementing the Euro, and both of these countries are geographically located in Western Europe and have economic ties with all major European countries. In addition, the UK took some part in the unification process, while Switzerland did not participate in it. It would appear logical to see higher integration of the UK stock market, compared with that of Switzerland. However, we observe the opposite. Our results contribute to the on-going discussion on whether the UK market is integrated or segmented. Howe and Madura (1990), Heimonen (2002), and Nikkinen and Sahlstrom (2004) present evidence supporting integration of the UK stock market. At the same time, many

Alternatively, the role of government controls on capital flows across different countries could also explain the differences in the degree of integration across countries.

Another interesting result is discovered by analyzing the trajectories of integration measures after the mid-1990s. Our results show that the integration is a slow upward moving process that did not sharply rise towards full integration after the Euro was introduced even for the Euro countries. This is in contrast with the results[64] presented by Hardouvelis et al (2005) and Fratzscher (2002), who find that many countries display integration measures close to full integration in magnitude, especially in the late 1990s. Our results are consistent with Harm (2001) and Wojcik (2002), who also present evidence suggesting lack of full market integration in European countries.

We plot the prices of European market and currency risks in Figure 4.2. As De Santis and Gerard (1998) note, the fitted risk prices are always plagued with the estimation error. To deal with his problem, we present estimated, Hodrick-Prescott (HP) filtered[65], and mean values of integration and risk price series. Inspection of the trajectories for both European risk prices reveals that their volatilities and magnitudes steadily decline over time, even though the currency risk price does not decline in

papers, including Chelley-Steeley et al (1998), Lyons et al (2001), Kalemli-Ozcan et al (2003), Oh (2003), and Fraser and Oyefeso (2005) find that the UK stock market displays signs of segmentation. A possible reason why the UK market may be segmented is offered by Chelley-Steeley et al (1998). They point that the nature of cross-border capital flow controls was different in each country. The UK had restrictions on capital outflows, which implies that any investor who wanted to participate in the UK stock market already had this opportunity. Germany and Switzerland used to restrict capital inflows, thus, abolishing flow controls was going to launch an inflow of new investments into these countries. When Germany, the UK, and Switzerland started eliminating the capital flow restrictions in the early 1980s, the UK indeed had an outflow of funds, while Germany and Switzerland experienced inflows. Thus, an outflow of investments from the UK may have contributed to its segmentation, whereas an inflow of investments to Switzerland worked the opposite way.

[64] Our integration measure is based on the logistic function that ensures that estimated integration is no greater than 1 (full integration) and no less than 0 (full segmentation). Hence, it compares favorably with the measures used by both Hardouvelis et al (2005) and Fratzscher (2002), since those measures in theory and in some cases in practice are not restricted to [0,1] interval, and we were able to solve this problem.

[65] See Hodrick and Prescott (1997).

magnitude and volatility as much as the market price of risk does. This result is consistent with theories of Errunza and Losq (1985) and Obstfeld (1994) and with empirical evidence presented in De Santis and Gerard (1998), Carrieri (2001), Adler and Qi (2003), De Santis et al (2003), and Carrieri et al. (2003).

The graphs of price of local market risk are presented in Figure 4.3. It appears that higher degree of capital market integration results in a lower market risk price[66], especially for large economies such as France and Germany. Finally, We present graphs of the market and currency premia in Figure 4.4. Risk premia have a lot of turbulence in the mid-1980s, which eventually dies out towards the end of the 1990s. These results are in line with previous research; we hypothesize that the decline in risk premia occurred as a result of increased market integration and subsequent risk sharing[67].

4.5.2. Timing of structural breaks

In this section we examine the likely timing of the structural breaks in asset pricing that occurred as a result of European liberalization. We employ a test suggested by Bekaert et al (2002) aimed at determining the point estimates of structural breaks and their confidence intervals. To identify specific dates of structural changes related to integration of particular countries, we follow Bekaert et al (2002), estimate individual VARs for the countries, and compute the corresponding Sup-W test statistics for a series

[66] According to Figure 4.1, the UK has lower degree of market integration compared to that of the Netherlands, while examination of Table 4.5 reveals that the mean price of local market risk is lower for the UK than in the Netherlands. It appears that the Netherlands is going through a period of unusually high uncertainty before the introduction of the Euro, Honig (1996) reports higher volatility of the Dm/NLG exchange rate, Wijffels (1997) notes that the Dutch banks decided to postpone some of the Euro-related changes till 2002, and Hebbink and Peeters (1999) anticipate problems related to changes in the currency circulation. We hypothesize that while all countries were facing similar problems, the Netherlands appears to be the most susceptive to uncertainty associated with introduction of the Euro because it has the smallest economy compared to Germany and France, the other EMU-area countries in our sample.

[67] See Obstfeld (1994).

of univariate and multivariate tests. We followed Bekaert et al. (2002) in choosing variables[68] and putting them into groups according to the economic information they reflect.

The univariate tests are designed to detect timing of breaks in intercept and autoregressive coefficient for market return, short rate, bond yield, inflation, and exchange rate for all countries. Multivariate tests include 3 bivariate tests and one 4-variate test. The bivariate tests detect breaks in all coefficients of bivariate vector autoregressions. These vector autoregressions have the following variables: (i) stock market return in excess of riskless rate and dividend yield in excess of riskless rate, (ii) inflation and exchange rate, and (iii) riskless rate and bond yield. Finally, the 4-variate tests detect breaks in all coefficients of 4-variate vector autoregressions, which include stock returns and dividend yield for a country and the European stock market[69].

To illustrate the dynamics of the SupW statistics for the country stock markets, we present the graphs of Sup-W statistics for 4-variate system in Figure 4.5. In addition to the break in 1986, the Euro-area countries had significant peaks of Wald statistics in the late 1990s and early 2000s. France has a 1% significant peak in the test statistic in April 2000, Germany has a 1% significant peak in September 2000, and the Netherlands have the maximum Wald statistics in March 2001. This indicates a possibility of a structural break occurring in the Euro-area countries only around the year 2000.

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[68] We put series in groups in multivariate tests so that the systems provide us information separately on the stock market (systems of series that include stock returns), the fixed income markets (systems of series containing interest rates), and the economic conditions (systems of series containing inflation). Note that the systems can provide us with a mix of information on the stock and fixed income market if we include both stock returns and interest rates in a system, thus one type of information does not preclude another type of information to be analyzed jointly in the SupW test.

[69] The number of autoregressive lags is 1 as determined by the Akaike information criterion for all cases. We use critical values for the test from Bekaert et al (2002). Test dimension for univariate analysis is $q = 1(1 \cdot 1 + 1) = 2$, for bivariate $q = 2(2 \cdot 1 + 1) = 6$, and for 4-variate $q = 4(4 \cdot 1 + 1) = 20$.

We show a timeline for peaks of the multivariate[70] Wald statistics and the political events related to European integration in Appendix A. First, 1985 was the year of the Second Intergovernmental Conference and the agreement on the Single European Act, and in 1986 Spain and Portugal acceded to the EC. In 1999 the single currency was launched in 11 members states, and in 2001 the Treaty of Nice was signed by the 15 member states. These dates coincide with the peaks of Wald test statistic for our series that indicate changes in the capital markets and economic variables. In addition, the peaks appear to be happening in all countries at approximately the same time.

The maximum Wald statistics for the stock market variables are concentrated around the middle of 1986 (except for the Netherlands, which had the maximum test statistics in March 2001 in the 4-variate case), with secondary peaks in the early 2000s. Next, economic variables such as interest rates, exchange rates, and inflation appear to have breaks in the mid-1990s. Estimated changes in the interest rates and stock returns seem to have occurred after the corresponding political events, as shown in Appendix E. Our estimated event dates[71] seem to be lagging the official dates when the key documents

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[70] The results of the univariate tests are consistent with the results of the multivariate tests presented here.

[71] To verify that the changes indeed occurred around the estimated dates, and to see in exactly what series they occurred, we conducted a series of equality tests. First, we tested whether sample means and variances for a number of series related to our countries are equal before and after June 1986. The series are: estimated conditional variances of returns, estimated conditional covariances with the currency index, estimated conditional covariances with the European return, estimated prices of risks, and estimated risk premia. Test results (not reported here) confirmed that the changes took place in all variables. The SupW test also indicated a number of dates in early 2000s where more changes may have occurred for the EMU countries, since there were several highly significant peaks of the Wald statistic. To verify whether there was a second series of structural changes at that time, we test for equality in means and variances for the same set of series around April 2000 for France, September 2000 for Germany, and April 2001 for the Netherlands. To see whether there were breaks in the non-EMU countries at that time, we also calculate hypotheses tests about equality of mean and variance for series related to the UK and Switzerland around September 2000. Test results (not reported here) provide some evidence for structural changes in the EMU countries, especially the Netherlands, which has the maximum Wald statistics in April 2001. To check robustness, we performed a regression-based procedure with heteroskedasticity and autocorrelation correction as in De Santis et al (2003, p. 456). This method produced results similar to those obtained by our equality of means tests.

were signed; a similar effect was noted by Bekaert et al (2002) with respect to market liberalization of emerging countries.

To summarize, we were able to identify dates that displayed signs of structural changes in European asset pricing that occurred because of increases in financial integration. While the first break in the mid-1980s took place because of an expectation that Europe was going to merge in the future, the last structural break of 1999 was associated with introduction of the Euro.

4.6. Conclusion

This paper examines time variation in equity pricing for European stock markets. We estimate this variation in the European and local prices of risks for a sample of three EMU and two non-EMU countries. We examine how risk premia of the countries that implemented the Euro differ from risk premia of the countries that kept their own currencies. In addition, we are able to identify when these changes took place.

Our analysis reveals that both market risk and currency risk are priced in the European marketplace. This finding is consistent with the IAPM of Adler and Dumas (1983) and empirical findings of other studies. The estimated European prices of market and currency risk have a period of large volatility in mid-1980s, but both volatility and magnitude of European prices of the two risks decreased with time.

Next, we find that estimated local market risk prices in countries that did not join the Euro system were higher than both the price of European market risk, and prices of market risk in countries that undertook currency unification. Our results are in line with predictions of the model offered by Bharma (2002), especially for large countries. We also find evidence consistent with Cooper and Kaplanis (1994) model that explains home bias in asset allocation.

Finally, we determine two dates when structural breaks in asset pricing for European countries occurred. The first structural break affected all countries in our sample and took place around June 1986; it may have resulted from the Second Intergovernmental Conference that advanced the process of European integration. The second structural break happened in July 1999 for France and Germany, and in March 2001 for the Netherlands. We conjecture that this structural break was caused by introduction of the Euro in these countries. Overall, we document progress towards the European integration in financial markets of all countries in our sample.

Table 4.1. Summary statistics for market returns.

Panel A. Descriptive statistics

	Germany	France	Netherlands	United Kingdom	Switzerland	Europe	Exchange Rate Index
Mean	0.001988	0.003460	0.004848	0.001442	0.005202	0.002695	0.000867
Std. Dev.	0.078020	0.074471	0.066428	0.064653	0.067204	0.050120	0.017234
Skewness	-0.698179	-0.234349	-0.425549	-0.538783	-0.291180	-0.828402	0.224058
Kurtosis	4.615945	3.629655	4.289202	5.177314	4.019578	4.655856	3.019647
Jarque-Bera	42.76026***	5.776345*	22.37258***	55.32979***	12.92514***	51.43929***	1.886186
ADF Statistics♣	-17.50456***	-16.66553***	-17.90298***	-18.60905***	-16.50127***	-15.55878***	-10.44287***

*** indicates 1% significance, ** indicates 5% significance, * indicates 10% significance

♣ Null hypothesis is that a series contains unit root. Significance levels determined using MacKinnon (1996) one-sided p-values.

Panel B. Correlation matrix

	Germany	France	Netherlands	United Kingdom	Switzerland	Europe	Exchange Rate Index
Germany	1.000000						
France	0.827167	1.000000					
Netherlands	0.838374	0.821391	1.000000				
UK	0.644935	0.695730	0.758535	1.000000			
Switzerland	0.746793	0.754222	0.825044	0.713117	1.000000		
Europe	0.799003	0.783136	0.768041	0.742887	0.702916	1.000000	
Exchange Rate Index	0.074752	0.159928	0.110074	0.205503	0.163808	0.223805	1.000000

Note: Returns for Germany, France, Netherlands, United Kingdom, and Switzerland are in excess of their riskless rates. MSCI Europe return in excess of 1-month Eurodollar rate. All returns converted into $US terms. Exchange rate index is constructed using the US trade-weighted index against major currencies. Sample range is 3/1984-11/2002.

Table 4.2. Summary statistics for the European information variables.

Panel A. Descriptive statistics

	XER	ΔUSTP	USDP	XEDY
Mean	0.002553	-0.001378	0.953778	-0.001165
Std. Dev.	0.050026	0.159394	0.311533	0.029701
Skewness	-0.828537	0.117364	0.787159	-0.020619
Kurtosis	4.677418	4.155019	2.860512	3.755838
Jarque-Bera	52.12149***	13.02342***	23.41814***	5.371797*
ADF Statistics♣	-15.61771***	-10.67569***	-3.292130***	-14.03758***

*** indicates 1% significance, ** indicates 5% significance, * indicates 10% significance
♣ Null hypothesis is that a series contains unit root. Significance levels determined using MacKinnon (1996) one-sided p-values.

Panel B. Correlation matrix

	XER	ΔUSTP	USDP	XEDY
XER	1.000000			
ΔUSTP	-0.043932	1.000000		
USDP	0.059265	-0.020779	1.000000	
XEDY	-0.109444	-0.052832	0.059236	1.000000

Note: XER is lagged European stock return in excess of 1-month Eurodollar rate, ΔUSTP is lagged change in the US term premium[72], where term premium is calculated as a difference between 7-year and 1-year US Government bond yields, USDP is lagged US default premium, calculated as the difference between Aaa and Baa US corporate bond yields, and XEDY is lagged European dividend yield, in US dollar terms, in excess of 1-month Eurodollar rate. Sample range is 3/1984-11/2002.

[72] ADF test statistic for level of US term premium is t=-2.109039, p-value 0.2414.

Table 4.3. Summary statistics for local information variables

Panel A1. Descriptive statistics for Germany

	Pricing Instruments			Integration Instruments		
	XLR	LTP	XLDY	ADXR	DTP	DDY
Mean	0.002113	0.002714	0.004228	0.037978	0.001417	0.000409
Std. Dev.	0.078039	0.032683	0.032701	0.029844	0.032610	0.011859
Skewness	-0.702276	-0.095943	-0.079021	1.217204	-0.110314	-0.051925
Kurtosis	4.615850	3.520253	3.472248	4.946791	3.515311	3.763752
Jarque-Bera	42.97252***	2.882652	2.324957	91.09069***	2.945834	5.569710*
ADF Statistics♣	-17.60803***	-14.42357***	-14.44821***	-14.92955***	-14.49000***	-16.10575***

Panel B1. Correlation matrix for Germany

	XLR	LTP	XLDY	ADXR	DTP	DDY
XLR	1.000000					
LTP	-0.506015	1.000000				
XLDY	-0.509570	0.999374	1.000000			
ADXR	-0.167557	0.013264	0.014580	1.000000		
DTP	-0.507658	0.999800	0.998993	0.011945	1.000000	
DDY	-0.304194	0.423037	0.426634	-0.026854	0.421093	1.000000

Panel A2. Descriptive statistics for France

	XLR	LTP	XLDY	ADXR	DTP	DDY
Mean	0.003314	0.002460	0.004402	0.036925	0.001157	8.38E-05
Std. Dev.	0.074187	0.031791	0.031900	0.029022	0.031724	0.010855
Skewness	-0.229663	-0.135792	-0.103805	1.076149	-0.148517	0.127100
Kurtosis	3.651348	3.561762	3.513881	3.954343	3.562425	4.376568
Jarque-Bera	6.008272**	3.682448	2.905365	52.42905***	3.826380	18.53414***
ADF Statistics♣	-16.71370***	-14.40415***	-14.34479***	-13.39540***	-14.45865***	-15.93073***

Panel B2. Correlation matrix for France

	XLR	LTP	XLDY	ADXR	DTP	DDY
XLR	1.000000					
LTP	-0.568999	1.000000				
XLDY	-0.567280	0.999096	1.000000			
ADXR	0.135001	-0.086787	-0.085537	1.000000		
DTP	-0.570822	0.999788	0.998433	-0.089050	1.000000	
DDY	-0.305755	0.334391	0.339721	-0.186505	0.332803	1.000000

Panel A3. Descriptive statistics for the Netherlands

	Pricing Instruments			Integration Instruments		
	XLR	LTP	XLDY	ADXR	DTP	DDY
Mean	0.004944	0.003252	0.005415	0.033126	0.001950	0.001097
Std. Dev.	0.066148	0.032935	0.033155	0.026417	0.032852	0.011086
Skewness	-0.431384	-0.049481	-0.019509	0.855608	-0.063599	0.003742
Kurtosis	4.326024	3.489929	3.423522	3.099777	3.484231	3.401248
Jarque-Bera	23.67147***	2.362915	1.710949	27.79059***	2.370814	1.523322
ADF Statistics♣	-17.94538***	-14.29833***	-14.17179***	-16.52084***	-14.36453***	-15.12481***

Panel B3. Correlation matrix for the Netherlands

	XLR	LTP	XLDY	ADXR	DTP	DDY
XLR	1.000000					
LTP	-0.618495	1.000000				
XLDY	-0.618428	0.999225	1.000000			
ADXR	0.104891	-0.103245	-0.101120	1.000000		
DTP	-0.620436	0.999804	0.998679	-0.104319	1.000000	
DDY	-0.385026	0.433260	0.438027	-0.017336	0.430660	1.000000

Panel A4. Descriptive statistics for the UK

	XLR	LTP	XLDY	ADXR	DTP	DDY
Mean	0.001579	0.000918	0.004357	0.032389	-0.000385	3.88E-05
Std. Dev.	0.064535	0.031246	0.031437	0.028863	0.031246	0.014704
Skewness	-0.539761	-0.079957	0.005956	1.450160	-0.100564	-0.326429
Kurtosis	5.177611	5.492346	5.557164	5.206732	5.471331	3.910608
Jarque-Bera	55.87377***	58.99505***	61.85023***	125.6210***	58.14915***	11.87428***
ADF Statistics♣	-18.65752***	-14.21196***	-14.21158***	-14.39726***	-14.21036***	-13.52097***

Panel B4. Correlation matrix for the UK

	XLR	LTP	XLDY	ADXR	DTP	DDY
XLR	1.000000					
LTP	-0.571641	1.000000				
XLDY	-0.571373	0.998604	1.000000			
ADXR	-0.118668	0.119392	0.129552	1.000000		
DTP	-0.572383	0.999779	0.998317	0.117582	1.000000	
DDY	-0.115049	0.333293	0.329179	0.025602	0.337076	1.000000

Panel A5. Descriptive statistics for Switzerland

	XLR	LTP	XLDY	ADXR	DTP	DDY
Mean	0.004853	0.003140	0.004375	0.038260	0.001837	5.69E-05
Std. Dev.	0.067116	0.035197	0.035336	0.029280	0.035113	0.014414
Skewness	-0.281570	0.068061	0.085736	1.385106	0.053562	0.293251
Kurtosis	4.007780	3.182503	3.149185	6.427173	3.172706	4.126299
Jarque-Bera	12.60556***	0.490288	0.488607	183.6769***	0.390657	15.25190***
ADF Statistics♣	-16.58114***	-13.69135***	-13.63801***	-15.76126***	-13.74765***	-14.58466***

Panel B5. Correlation matrix for Switzerland

	XLR	LTP	XLDY	ADXR	DTP	DDY
XLR	1.000000					
LTP	-0.607634	1.000000				
XLDY	-0.608281	0.999292	1.000000			
ADXR	0.109203	-0.096782	-0.095791	1.000000		
DTP	-0.610199	0.999828	0.998992	-0.097937	1.000000	
DDY	-0.332383	0.544471	0.546045	-0.084898	0.543184	1.000000

*** indicates 1% significance, ** indicates 5% significance, * indicates 10% significance
* Null hypothesis is that a series contains unit root. Significance levels determined using MacKinnon (1996) one-sided p-values.

Note: Information variables for Germany, France, Netherlands, United Kingdom, and Switzerland. XLR is lagged market return in excess of corresponding riskless rate, LTP is a lag in the corresponding term premium, LXDY is lagged country dividend yield converted into US dollar terms, ADXR is absolute difference between a country's excess return and European excess return, DTP is a difference in term premiums between a particular country and Europe (proxied by US term premium), and DDY is a difference between dividend yield in a specific country and European dividend yield. Sample size is 225 observations.

Table 4.4a. Maximum likelihood estimates for model with time-varying integration

Pricing equations

$$r_{i,t} = \varphi_{i,t-1}(\delta_{M,t-1}\operatorname{cov}_{t-1}[r_{i,t}, r_{M,t}] + \delta_{c,t-1}\operatorname{cov}_{t-1}[r_{i,t}, r_{c,t}]) +$$

$$+ (1-\varphi_{i,t-1})\delta_{i,m,t-1}\operatorname{var}_{t-1}[r_{i,t}] + e_{i,t}\ i = 1,\dots,5$$

$$r_{M,t} = \delta_{M,t-1}\operatorname{var}_{t-1}(r_{M,t}) + \delta_{c,t-1}\operatorname{cov}_{t-1}(r_M, r_c) + e_{M,t}$$

$$r_{c,t} = \delta_{M,t-1}\operatorname{cov}_{t-1}(r_M, r_c) + \delta_{c,t-1}\operatorname{var}_{t-1}(r_{c,t}) + e_{c,t}$$

Integration measure

$$\varphi_i = \frac{\exp(k^i_{\text{int}1}ADXR + k^i_{\text{int}2}DTP + k^i_{\text{int}3}DDY)}{1+\exp(k^i_{\text{int}1}ADXR + k^i_{\text{int}2}DTP + k^i_{\text{int}3}DDY))}, i = 1,\dots,5$$

European Price of risks

$$\delta_{M,t-1} = \exp[k_{1,1} + k_{1,2}\cdot XER + k_{1,3}\cdot \Delta USTP + k_{1,4}\cdot USDP + k_{1,5}\cdot XEDY]$$

$$\delta_{FX,t-1} = k_{2,1} + k_{2,2}\cdot XER + k_{2,3}\cdot \Delta USTP + k_{2,4}\cdot USDP + k_{2,5}\cdot XEDY$$

Price of local market risk

$$\delta^i{}_{d,t-1} = \exp[k^i{}_{d,1} + k^i{}_{d,2}\cdot XLR + k^i{}_{d,3}\cdot LTP + k^i{}_{d,4}\cdot XLDY],\ i = 1,\dots,5$$

$$(e_{1,t},\dots,e_{5,t},e_{M,t},e_{c,t})' \sim N(0,H_t)$$

$$H_t = H_0(ii' - aa' - bb') + ae_{t-1}e'_{t-1}a' + bH_{t-1}b'$$

Price of European market risk

	Constant	XER	ΔUSTP	USDP	XEDY
Coefficient	-1.111414**	9.480548***	-0.858417	1.629568***	33.03236***
Std. Error	0.506261	2.609344	0.827804	0.418118	4.273381

Price of European currency risk

	Constant	XER	ΔUSTP	USDP	XEDY
Coefficient	-4.113871	315.3642***	3.330225	6.272857	1054.214***
Std. Error	7.085848	57.87713	16.98780	7.647411	101.8844

Local Coefficients

Germany

	Local Market Risk				Integration Measure		
	Constant	XLR	LTP	XLDY	ADXR	DTP	DDY
Coefficient	-0.814263	-10.15485***	74.88066	-40.13173	13.12853	8.722757	-31.48930
Std. Error	1.083656	2.555201	289.4888	290.7894	9.877101	21.31483	40.38887

France

	Constant	XLR	LTP	XLDY	ADXR	DTP	DDY
Coefficient	-6.202636	-18.73774	43.00690	38.67665	29.43028	-8.087159	-62.14704
Std. Error	7.469798	24.49056	569.3150	571.0399	44.40505	63.45331	118.1257

Netherlands

	Constant	XLR	LTP	XLDY	ADXR	DTP	DDY
Coefficient	1.502948***	-9.486885***	-8.899282	7.743538	-65.43549***	105.1130***	-90.26654***
Std. Error	0.101962	0.724653	33.23894	33.30893	18.00414	23.33389	27.51116

UK

	Constant	XLR	LTP	XLDY	ADXR	DTP	DDY
Coefficient	0.797628***	-3.002344**	4.153146	6.016990	-101.6209**	7.961660	79.06507
Std. Error	0.225021	1.226177	67.23989	66.78295	47.00330	24.85160	62.06984

Switzerland

	Constant	XLR	LTP	XLDY	ADXR	DTP	DDY
Coefficient	1.273489***	1.349886	-7.476105	25.46076	-14.82156*	34.75299***	-122.7129***
Std. Error	0.142676	1.014706	53.15414	53.62082	8.614640	12.77069	41.88499

ARCH and GARCH coefficients

	ALPHA(1)	ALPHA(2)	ALPHA(3)	ALPHA(4)	ALPHA(5)	ALPHA(6)	ALPHA(7)
Coefficient	0.160083***	0.106860***	0.122946***	0.520954***	0.326195***	0.557034***	0.304831***
Std. Error	0.006848	0.003517	0.004996	0.004537	0.004141	0.011002	0.009941

	BETA(1)	BETA(2)	BETA(3)	BETA(4)	BETA(5)	BETA(6)	BETA(7)
Coefficient	0.960710***	0.990794***	0.976950***	0.519895***	0.816885***	0.522334***	0.937767***
Std. Error	0.002246	0.000934	0.001455	0.011558	0.006084	0.024402	0.002280

*** indicates 1% significance, ** indicates 5% significance, * indicates 10% significance

Model Diagnostics

Parameter	Value
Log Likelihood	4285.9796
Number of observations	225
Number of Coefs.	59
Akaike info criterion	-37.573152

Table 4.4b. Diagnostics of standardized residuals

	Germany	France	Netherlands	U.K.	Switzerland	Europe	FX Index
Residuals	$e_1/h_1^{1/2}$	$e_2/h_2^{1/2}$	$e_3/h_3^{1/2}$	$e_4/h_4^{1/2}$	$e_5/h_5^{1/2}$	$e_M/h_M^{1/2}$	$e_c/h_c^{1/2}$
Prob(Q_{12})	0.532	0.919	0.362	0.404	0.562	0.922	0.057
Squared residuals	e_1^2/h_1	e_2^2/h_2	e_3^2/h_3	e_4^2/h_4	e_5^2/h_5	e_M^2/h_M	e_c^2/h_c
Prob(Q_{12})	0.796	0.686	0.001	0.967	0.721	0.954	0.266
Cross-products		e_1e_2/h_{12}	e_1e_3/h_{13}	e_1e_4/h_{14}	e_1e_5/h_{15}	e_1e_M/h_{1M}	e_1e_c/h_{1c}
Prob(Q_{12})		0.478	0.075	0.587	0.269	0.991	0.976
Cross-products			e_2e_3/h_{23}	e_2e_4/h_{24}	e_2e_5/h_{25}	e_2e_M/h_{2M}	e_2e_c/h_{2c}
Prob(Q_{12})			0.223	0.908	0.527	0.990	0.140
Cross-products				e_3e_4/h_{24}	e_3e_5/h_{35}	e_3e_M/h_{3M}	e_3e_c/h_{3c}
Prob(Q_{12})				0.166	0.178	0.971	0.754
Cross-products					e_4e_5/h_{45}	e_4e_M/h_{4M}	e_4e_c/h_{4c}
Prob(Q_{12})					0.960	0.991	0.963
Cross-products						e_5e_M/h_{5M}	e_5e_c/h_{5c}
Prob(Q_{12})						0.987	1.000
Cross-products							e_Me_c/h_{Mc}
Prob(Q_{12})							0.704

Table 4.4c. Wald tests

Panel A. Hypotheses related to European prices of risks

Hypothesis	Chisq. Statistic	DF	Probability
Are all coefficients irrelevant in explaining the price of market risk?			
$k_{1,a} = 0,\ a = 1,\ldots,5$	46.35708	4	0.0000
Is price of market risk constant?			
$k_{1,b} = 0,\ b = 2,\ldots,5$	29.12550	3	0.0000
Are all coefficients irrelevant in explaining the price of currency risk?			
$k_{2,a} = 0,\ a = 1,\ldots,5$	33.11173	4	0.0000
Is price of currency risk constant?			
$k_{2,b} = 0,\ b = 2,\ldots,5$	29.91042	3	0.0000

Panel B. Hypotheses related to local prices of risks

Hypothesis	Chisq. Statistic	DF	Probability
Are all coefficients irrelevant in explaining the price of market risk in Germany?			
$k_{1,1,n} = 0, n = 1,\ldots,4$	185.0158	4	0.0000
Is price of market risk constant in Germany?			
$k_{1,1,x} = 0, x = 2,\ldots,4$	21.49980	3	0.0001
Are all coefficients irrelevant in explaining the price of market risk in France?			
$k_{1,2,n} = 0, n = 1,\ldots,4$	72.80083	4	0.0000
Is price of market risk constant in France?			
$k_{1,2,x} = 0, x = 2,\ldots,4$	2.029925	3	0.5662
Are all coefficients irrelevant in explaining the price of market risk in Netherlands?			
$k_{1,3,n} = 0, n = 1,\ldots,4$	1136.696	4	0.0000
Is price of market risk constant in Netherlands?			
$k_{1,3,x} = 0, x = 2,\ldots,4$	176.7425	3	0.0000
Are all coefficients irrelevant in explaining the price of market risk in UK?			
$k_{1,4,n} = 0, n = 1,\ldots,4$	148.5972	4	0.0000
Is price of market risk constant in UK?			
$k_{1,4,x} = 0, x = 2,\ldots,4$	31.44897	3	0.0000
Are all coefficients irrelevant in explaining the price of market risk in Switzerland?			
$k_{1,5,n} = 0, n = 1,\ldots,4$	509.0352	4	0.0000
Is price of market risk constant in Switzerland?			
$k_{1,5,x} = 0, x = 2,\ldots,4$	218.6121	3	0.0000

Table 4.4c (continued).

Panel C. Hypotheses related to integration measures

Hypothesis	Chisq. Statistic	DF	Probability
Are all integration coefficients zero? $k^{i}_{\text{int},s} = 0, s = 1,2,3, i = 1,\ldots,5$	282.8648	15	0.0000
Are integration coefficients zero in Germany? $k^{1}_{\text{int},s} = 0, s = 1,2,3$	2.440956	3	0.4861
Are integration coefficients zero in France? $k^{2}_{\text{int},s} = 0, s = 1,2,3$	0.527894	3	0.9127
Are integration coefficients zero in Netherlands? $k^{3}_{\text{int},s} = 0, s = 1,2,3$	21.82709	3	0.0001
Are integration coefficients zero in the UK? $k^{4}_{\text{int},s} = 0, s = 1,2,3$	5.774767	3	0.1231
Are integration coefficients zero in Switzerland? $k^{5}_{\text{int},s} = 0, s = 1,2,3$	180.4576	3	0.0000

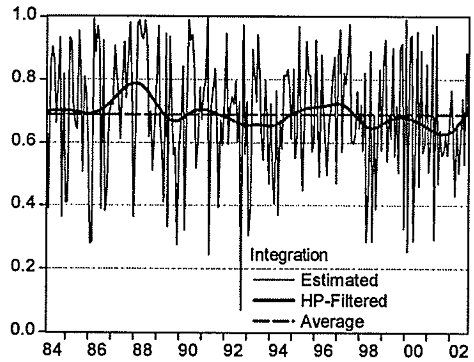
Panel D. Hypotheses related to variance-covariance equations

Hypothesis	Chisq. Statistic	DF	Probability
Is variance constant? alpha(i)=beta(i)=0,i=1,...,7	49598113	14	0.0000
Are ARCH coefficients relevant? alpha(i)=0,i=1,...,7	27962.59	7	0.0000
Are GARCH coefficients relevant? beta(i)=0,i=1,...,7	3944578	7	0.0000

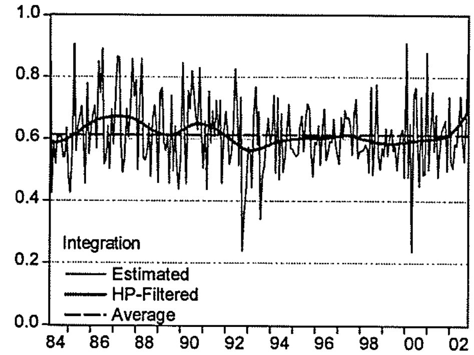
Table 4.5. Log likelihood values for alternative specifications

Null Hypothesis	Log Likelihood	Number of Coefficients
Base model 1. All Markets Fully Integrated	3488.311	24
Equity Market Fully Segmented, Currency Market Fully Integrated	3299.422	44
Mild segmentation in Equity Market only, Currency market fully integrated	3494.188	59
Mild segmentation in Currency Market only, Equity market fully integrated	1705.516	59
Integration Measure Same for All	4153.860	47
Base model 2. Mild segmentation in all markets, Explicit pricing of local market risk.	4285.979	59

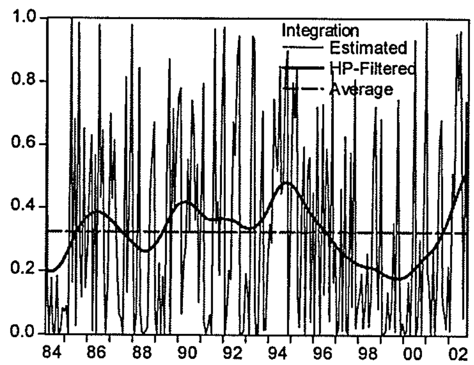
Figure 4.1. Integration measures



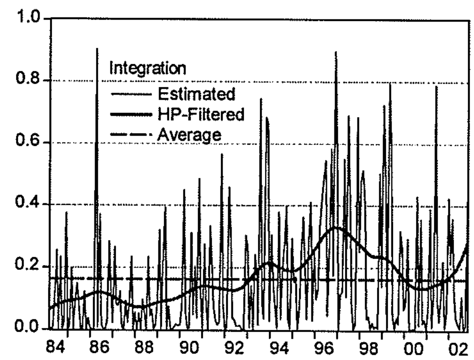
(a) France



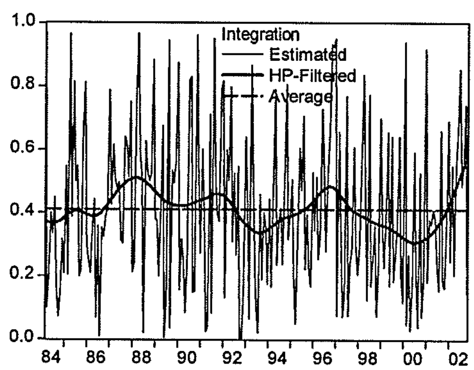
(b) Germany



(c) Netherlands

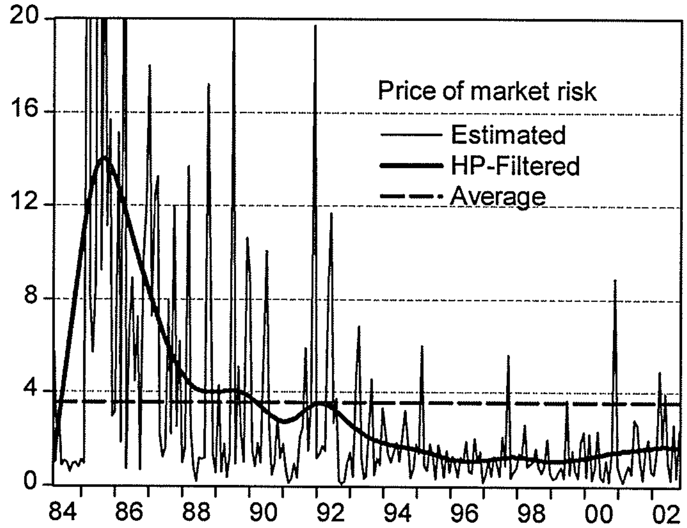


(d) United Kingdom

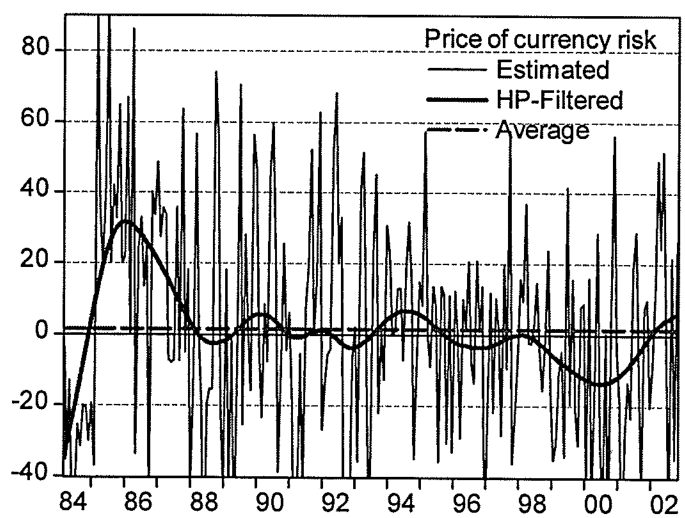


(e) Switzerland

Figure 4.2. European prices of risk



(a) Price of European market risk.

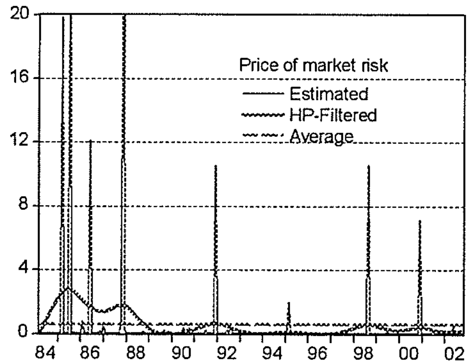


(b) Price of European currency risk.

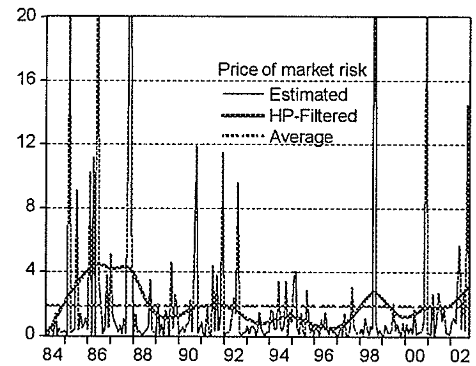
Table 4.6. Descriptive Statistics for prices of risks

Descriptive Statistics	Europe		Germany	France	Netherlands	U.K.	Switzerland
	Market	Currency	Local Prices of Market Risk				
Mean	3.557351	1.441235	1.906578	0.576019	5.379713	2.534903	4.649682
Median	1.329099	0.192121	0.413246	0.002517	4.253225	2.208217	3.854544
Maximum	66.13856	92.29459	42.57754	31.60645	48.07859	16.68813	26.82941
Minimum	0.046372	-110.2454	0.001012	5.24E-09	0.842986	0.491098	0.743323
Std. Dev.	7.134633	33.66915	5.237413	3.343114	4.924648	1.526308	3.181941
Observations	225	225	225	225	225	225	225

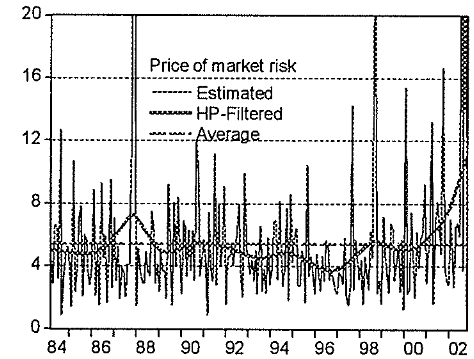
Figure 4.3. Estimated prices of local market risks.



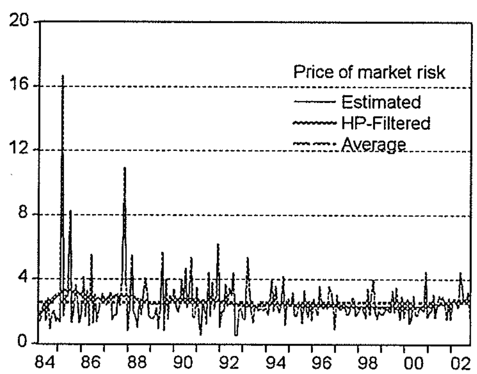
(a) France



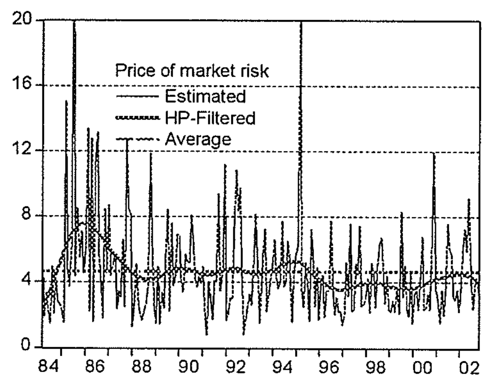
(b) Germany



(c) Netherlands

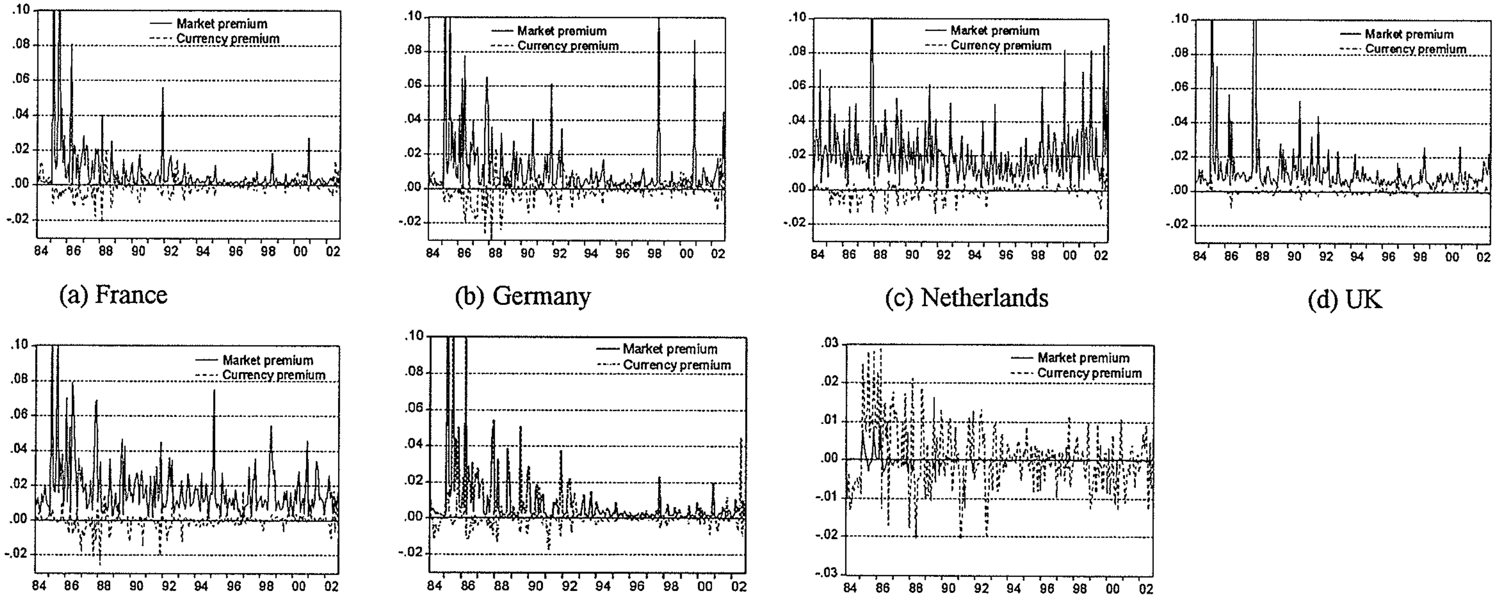


(d) United Kingdom



(e) Switzerland

Figure 4.4. Estimated market and currency risk premia♦

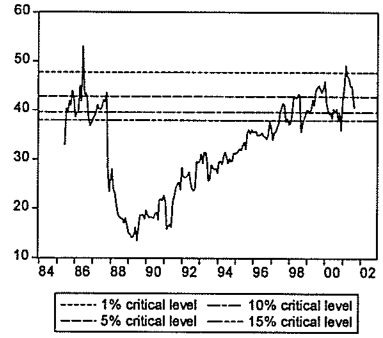


(a) France (b) Germany (c) Netherlands (d) UK

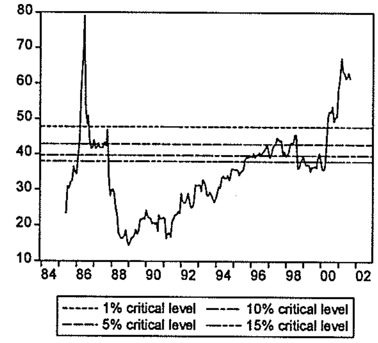
(e) Switzerland (f) Europe (g) Currency

♦ The market premium is calculated by substituting estimated coefficients and series into the following equations: $r_{i,t,market} = \varphi_{i,t-1}\delta_{M,t-1}\,\mathrm{cov}_{t-1}[r_{i,t}, r_{M,t}] + (1-\varphi_{i,t-1})\delta_{i,m,t-1}\,\mathrm{var}_{t-1}[r_{i,t}]$, $i = 1,\ldots,5$ for all countries, $r_{M,t,market} = \delta_{M,t-1}\,\mathrm{var}_{t-1}(r_{M,t})$ for Europe, and $r_{c,t,market} = \delta_{M,t-1}\,\mathrm{cov}_{t-1}(r_M, r_c)$ for the currency index. The currency premium is calculated as $r_{i,t,currency} = \varphi_{i,t-1}\delta_{c,t-1}\,\mathrm{cov}_{t-1}[r_{i,t}, r_{c,t}]$, $i = 1,\ldots,5$ for all countries, $r_{M,t,currency} = \delta_{c,t-1}\,\mathrm{cov}_{t-1}(r_M, r_c)$ for Europe, and $r_{c,t,currency} = \delta_{c,t-1}\,\mathrm{var}_{t-1}(r_{c,t})$ for the currency index. These are parts of equations 4, 5, and 6 related to either market or currency risks.

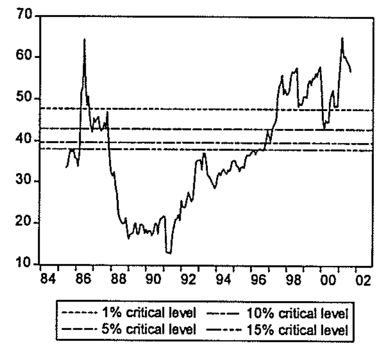
Figure 4.5. SupW statistic for 4-variable VAR



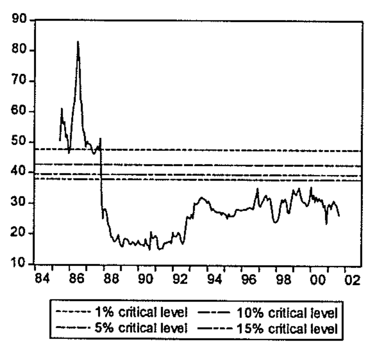
(a) France



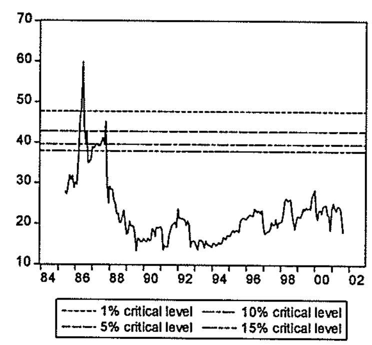
(b) Germany



(c) Netherlands



(d) United Kingdom



(e) Switzerland

Order of autoregression[73] p=1. The variables are: (i) stock return for each country (Germany, France, Netherlands, UK, and Switzerland), (ii) dividend yield for each country, (iii) stock return for Europe; and (iv) dividend yield for Europe.

[73] Number of lags in VAR is determined by Akaike information criterion, test dimension is $q = 4(4 \cdot 1 + 1) = 20$. Very similar test results were obtained for 2-variable VARs (variables: country return and dividend yield) and 5-variable VARs (country return, country dividend yield, European return, European dividend yield, and exchange rate index).

CHAPTER 5

CONCLUSIONS AND FUTURE RESEARCH

This thesis examines two aspects of asset pricing. We explore the issue of optimal firm characteristics that generate expected returns and their relationship with the macroeconomic environment by constructing a theoretical model and testing this model. Then we consider stock pricing in Europe during the process of financial liberalization, and evaluate the effects of political and economic processes on European stock returns. Theoretical derivations and empirical findings indicate some general conclusions.

5.1. Conclusions

We provide economic reasoning for the stylized fact that firm market value and the book-to-market ratio help to explain stock returns. We show that in a homogenous economy profit maximizing firms should converge to a stable equilibrium growth path, in which the economic environment shapes optimal firm capital size, investment growth rates, and market values. For every period, the firm characteristics in relation to the economic factors determine the highest expected returns.

Empirical testing provides support for the theoretical model. We find statistical evidence supporting the hypothesis of firm convergence toward the optimal investment capital characteristics. The statistical results in tests of the predicted reaction of the optimal firm characteristics to changes in technological growth are mixed. In most hi-tech industry segments we find evidence supporting our theory, while in the other industries the results are not as predicted or inconclusive.

Finally, we study how the process of European integration and the introduction of the Euro have affected equity pricing in Europe. We find that prices of currency and market risks are generally lower for the countries that implemented the Euro compared with those countries that did not implement the Euro. We also find that stock markets in the countries that implemented the Euro do not display complete market integration as predicted by the theory; however, the level of financial integration for the Euro-area countries was generally higher than the level of integration for countries that did not introduce the common currency.

We discover that financial markets in Europe have followed a gradual, rather than rapid, integration process, and that the estimated integration measure did not jump to full integration even after the introduction of the Euro in 1999. We also estimate dates of structural changes that occurred in European stock pricing as a result of political decisions aimed at the unification of Europe. We document that structural changes in equity pricing occurred in 1986 for all countries in our sample. We relate these changes to the Second Intergovernmental Conference and the Single European Act. The countries that implemented the Euro also experience a second series of breakpoint dates at different times around January 1999, when the single currency was launched in 11 members states.

All sections of this thesis share a common theme of asset pricing. Chapter 2 presents a theoretical model, which relates stock returns to a combination of macroeconomic conditions, and Chapter 3 provides empirical support for this model. Using an asset pricing model, Chapter 4 analyzes whether it is country-specific or Europe-wide risk factors that determine stock returns in European countries. In both local and global versions of the pricing model market risk factors are conditional on macroeconomic environment. We find additional evidence that estimated prices of risks, risk premia, and levels of financial integration have significant relationships with macroeconomic variables. Therefore, the macroeconomic environment emerges as an essential part of equity pricing.

This thesis contributes to general understanding of asset pricing by showing that economic and political processes play an essential role in asset pricing in both single-country and international settings. Macroeconomic information affects firm value by shaping the optimal firm parameters, and firm managers seeking to maximize profits have incentives to align the characteristics of their firms with the optimal values. We find that political events leading toward European unification may have led to structural changes in asset pricing relationships of the countries participating in the unification process. Thus, we have explored several different dimensions of the asset pricing theme.

5.2. Implications for future research

The findings of this thesis lead to several possible extensions in both the single-country and international areas of asset pricing research. The relationship between optimal firm characteristics and the economic factors was derived under the standard assumptions of the Solow model and an objective of profit maximization. An interesting extension will be to rederive the model under assumptions of value maximization and see if any of the implications will change as the result. We also find that large firms seem to be better off during a period of technological expansion. A derivation of the model under assumptions of increasing returns to scale subject to resource constraints would provide valuable insight into the economics of large firm growth. Finally, we derived the model under a deterministic environment; it would be interesting to see if a stochastic environment would change the predictions of the model.

Next, the relationship between firm characteristics and the macroeconomic environment is established theoretically, and econometric tests provide results consistent with predictions of the theory, but their power is limited. One of the reasons for this outcome is that it is very hard to find an adequate proxy for the size of productive capital. We used market value, total assets, total liabilities, property, plant and equipment – gross, and number of employees as proxies for capital size, knowing that these variables are imperfect measures of the firm's productive capital for each industry. It was even more difficult to find an adequate proxy for the optimal size of productive capital. Therefore, a search for better proxy variables may be a task for future research.

In essay three we construct one of the size proxies using macroeconomic variables suggested by Chen, Roll, and Ross (1986). Thus, we indirectly use macroeconomic information in our empirical testing of the theoretical model. In the future it would be interesting to see the effect of direct use of the macroeconomic conditions, such as business cycle, in econometric specification.

We found evidence of the existence of and convergence toward the optimal firm size. In our model we also derive an optimal book-to-market (B/M) ratio for a profit-maximizing firm. Empirical evidence, for example Fama and French (1993, 1995), shows that B/M explains stock returns. The theoretical model also shows why B/M may be a relevant indicator of firm performance; in particular Table 2.1 outlines possible reasons why a firm book-to-market ratio may deviate from the book-to-market ratio of a firm with optimal characteristics. By analogy with the optimal size, we expect that the optimal

B/M ratio should depend on macroeconomic conditions. Ideally, we would like to test whether predictions of the theoretical model hold in our dataset.

Testing the theory for existence of the optimal B/M should be similar to the procedure used for testing the existence of the optimal firm size used in Chapter 3. If the profit maximizing B/M ratio exists, then firms should converge to it, just as they converge towards the optimum size. Similarly, firms located closer to the optimum B/M ratio should exhibit higher profits.

There are two main difficulties associated with testing for the optimal book-to-market ratio. The first difficulty arises from the market component. The "fundamental" value of the firm is a stream of discounted cash flows. Under certainty the value of the optimal firm should be given by equation (2.15) and the optimal B/M ratio as calculated using the optimal firm size and the optimal firm market value. However, we know that the assumption of complete certainty is too strong.

The observed market value of a firm could be decomposed into the "fundamental" value, given by the firm's current production opportunities, and the market expectation with respect to the firm's future. At each point in time we do not know what portion of the value is given by each component. The second difficulty would be associated with correctly measuring the size of economic capital that the firm uses in production, which is the same difficulty that we faced in testing for optimal firm size. Testing for the optimal B/M will mean that we would experience these two problems simultaneously, which could make it unclear how to interpret empirical results. Hence, we leave the issue of the optimal B/M ratio for further research, where we hope to obtain theoretical expressions for the optimal B/M under uncertainty and empirically test this prediction.

Another issue is the specification of the risk-return relationship. We use a linear specification, where return is a linear function of risks and prices of risks. However, outside the CAPM model, it might be reasonable to assume that an increase in risk may lead to a higher risk price and vice versa; in this case only a nonlinear specification is the correct way to specify the model. Next, we found empirical results using US data, which may or may not imply that these results can be generalized to stock pricing in all countries.

This thesis presents insights into asset pricing integration in Europe and its relationship with liberalization processes. However, there are several directions where this part of the study can be extended. A goal was to estimate a regime-switching model jointly for all countries in the sample, but it was impossible to include all relevant countries because of estimation problems. Gradient-based estimation breaks down when it is required to find too many coefficients. A possible extension would be to use a Bayesian estimation technique, include all European countries in the sample, and obtain the complete picture of all relevant pricing processes.

Some results obtained for individual European countries seem surprising. In particular, the estimated level of financial integration for Switzerland (a Swiss franc country) is higher than that for the Netherlands (a Euro-area country). We suggest that this result can be explained by the fact that a lot of Swiss firms have businesses around the world, including Europe. These international investments provide economic linkages of Switzerland with the rest of Europe and de-facto integrate Switzerland into the European financial markets more than the Euro integrates the Netherlands. A possible extension of current research is to explore ways to determine if this explanation is correct.

Finally, we estimate the timing of structural breaks based on the SupW test calculated for vector autoregressions. The results of this test show that the structural breaks occurred after the political events associated with European unification, at times with a considerable lag. Although these results are similar to those of other studies in this respect, it would be interesting to compute SupW or similar tests based on the pricing models, not vector autoregressions. Gradient-based estimation and current computing speed of conventional hardware does not allow this, but different estimation methods and technological progress may eventually lead to re-estimation of the structural break dates based on the pricing models. Thus, although this thesis makes a substantial contribution, many opportunities exist for future research on asset pricing in national and international contexts.

Appendix A. Derivation of the steady-state conditions, equations (2.1-2.6).

Consider an economy with the following production function, adopted from Vassalou and Apendjinou (2003):

$$Y_t = A_t K_t^{\alpha_1} L_t^{\alpha_2} \quad \text{(A1)}$$

Gross profit margin is:

$$GPM_t = Y_t - L_t \cdot MPL_t . \quad \text{(A2)}$$

Here marginal production of labour is:

$$MPL_t = \frac{d}{dL_t} Y_t = \alpha_2 A_t K_t^{\alpha_1} L_t^{\alpha_2 - 1} \quad \text{(A3)}$$

Substitute (A3) into (A2) to get:

$$GPM_t = A_t K_t^{\alpha_1} L_t^{\alpha_2} - L_t \cdot MPL_t =$$

$$= A_t K_t^{\alpha_1} L_t^{\alpha_2} - L_t \cdot \alpha_2 A_t K_t^{\alpha_1} L_t^{\alpha_2 - 1} = (1-\alpha_2) A_t K_t^{\alpha_1} L_t^{\alpha_2} \quad \text{(A4).}$$

Next, evolution of technological change and population growth are assumed to be fixed and exogenous:

$$\frac{d}{dt} L_t = n L_t \quad \text{(A5)}$$

and

$$\frac{d}{dt} A_t = g_A L_t . \quad \text{(A6)}$$

Capital owners determine evolution of capital. In particular, workers are assumed to receive their wages and consume them fully. Firm owners take whatever is left after paying out wages, and divide this amount, which we call gross profit margin, into three components. First, they allocate a portion of the gross profit to offsetting depreciation. Second, they invest a portion of the money into new capital. The new investment is determined by the capitalist's propensity to save s, which is assumed to be fixed. Finally, the leftover is allocated to the capitalist's consumption. Thus, evolution of capital is given by:

$$\frac{d}{dt}K_t = sGPM_t - \delta K_t. \qquad \text{(A7)}$$

Gross profit per unit of capital is:

$$\rho_t = \frac{1}{K_t}GPM_t = (1-\alpha_2)A_t K_t^{\alpha_1 - 1} L_t^{\alpha_2}. \qquad \text{(A8)}$$

The capitalist seeks to maximize it. He/she will expand production from period to period until the maximum return on capital is reached. When this happens, return to capital will no longer increase with time:

$$\frac{d\rho_t}{dt} = 0. \qquad \text{(A9)}$$

Condition (A9) is equivalent to the following expression:

$$\frac{d\rho_t/dt}{\rho_t} = \frac{d\ln\rho_t}{dt} = 0 \qquad \text{(A10)}$$

Return on capital is given by (A8), therefore:

$$\ln\rho_t = \ln(1-\alpha_2) + \ln A_t + (\alpha_1 - 1)\ln K_t + \alpha_2 \ln L_t. \qquad \text{(A11)}$$

Use (A11) in condition (A10) to get,

$$\frac{d\ln\rho_t}{dt} = g_A + (\alpha_1 - 1)g_K + \alpha_2 n \equiv 0. \qquad \text{(A12)}$$

Expression (A12) is a steady-state condition. Note that since (A8) includes trending variables such as technical change and labour, this models has a steady-state condition different from the one in a textbook version of Solow model (Romer, 2001, p.12). Also, (A12) suggests that the steady-state condition exists. Next, we will analyze whether the steady state is stable.

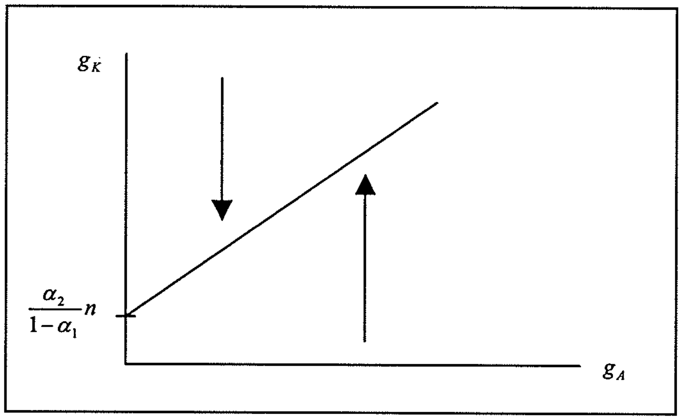


Figure A1. Phase diagram of the steady state.

Consider the phase diagram in Figure A1. If we rearrange condition (A12), we will get the following:

$$g_K = \frac{1}{1-\alpha_1} g_A + \frac{\alpha_2}{1-\alpha_1} n . \qquad \text{(A13)}$$

Thus, the steady-state line intersects with the vertical axis at point $\left(0, \frac{\alpha_2}{1-\alpha_1} n\right)$ and has a slope of $\frac{1}{1-\alpha_1}$. Consider any point above the steady-state line. This point will always satisfy the following:

$$g_K > \frac{1}{1-\alpha_1} g_A + \frac{\alpha_2}{1-\alpha_1} n . \qquad \text{(A14)}$$

Under assumption that $\alpha_1 < 1$[74], in equation (A12) the growth rate of profitability will be negative. Thus, when the economy is above the steady-state line, capitalists will have an incentive to reduce the growth rate of capital if they want to maximize profitability on capital investment. Thus, the economy will be pulled back to the steady-state line.

Next, consider any point below the steady-state line. Such point will always satisfy the condition:

$$g_K < \frac{1}{1-\alpha_1} g_A + \frac{\alpha_2}{1-\alpha_1} n. \qquad \text{(A15)}$$

It will mean that the growth rate of profitability in equation (A12) will be positive, and capitalists will have an incentive to increase the amount of capital, thus the economy will be pushed up to the steady-state line. Therefore, the steady state described on Figure A1 exists and is stable provided the production function (A1) is well behaved.

[74] That is, capital share of output is below 1, so capital owners appropriate less than 100% of output.

Appendix B. Derivation of equation (2.7-2.11).

Consider steady-state condition in equation (A6):

$$\frac{d \ln \rho_t}{dt} = g_A + (\alpha_1 - 1) g_K + \alpha_2 n \equiv 0 \qquad \text{(B1)}$$

This implies that the growth rate of capital should converge to the following:

$$g_K = \frac{1}{1-\alpha_1} g_A + \frac{\alpha_2}{1-\alpha_1} n. \qquad \text{(B2)}$$

Thus,

$$\frac{d \ln K_t}{dt} = \frac{1}{1-\alpha_1} g_A + \frac{\alpha_2}{1-\alpha_1} n, \qquad \text{(B3)}$$

which means that evolution of capital on the stead-state path up to time t is:

$$\int_0^t \frac{d \ln K_t}{dt} dt = \int_0^t d \ln K_t = \int_0^t \left(\frac{1}{1-\alpha_1} g_A + \frac{\alpha_2}{1-\alpha_1} n \right) dt. \qquad \text{(B4)}$$

Therefore,

$$\ln K_t - \ln K_0 = \left(\frac{1}{1-\alpha_1} g_A + \frac{\alpha_2}{1-\alpha_1} n \right) t;$$

$$\ln K_t = \ln K_0 + \left(\frac{1}{1-\alpha_1} g_A + \frac{\alpha_2}{1-\alpha_1} n \right) t;$$

$$K_t = e^{\ln K_t} = e^{\ln K_0 + \left(\frac{1}{1-\alpha_1} g_A + \frac{\alpha_2}{1-\alpha_1} n \right) t};$$

$$K_t = K_0 e^{\left(\frac{1}{1-\alpha_1} g_A + \frac{\alpha_2}{1-\alpha_1} n \right) t}. \qquad \text{(B5)}$$

Also note that by assumption, $\frac{d}{dt} L_t = n L_t$ and $\frac{d}{dt} A_t = g_A L_t$. It means that evolution of labour and technological change are given by the following equations: $L_t = L_0 e^{nt}$ and

$A_t = A_0 e^{g_A t}$. In steady-state profitability is at its maximum, ρ^*. Return on capital is given by the following expression: $\rho_t = \frac{1}{K_t} GPM_t = (1-\alpha_2) A_t K_t^{\alpha_1 - 1} L_t^{\alpha_2}$, and in the steady-state:

$$\rho^* = (1-\alpha_2) A_0 e^{g_A t} \left(K_0 e^{\left(\frac{1}{1-\alpha_1} g_A + \frac{\alpha_2}{1-\alpha_1} n\right)t} \right)^{\alpha_1 - 1} \left(L_0 e^{nt}\right)^{\alpha_2}.$$

Rearranging the terms will give:

$$\rho^* = (1-\alpha_2) A_0 K_0^{\alpha_1 - 1} L_0^{\alpha_2} e^{g_A t} \left(e^{(\alpha_1 - 1)\left(\frac{1}{1-\alpha_1} g_A + \frac{\alpha_2}{1-\alpha_1} n\right)t} \right) \left(e^{\alpha_2 nt}\right);$$

$$\rho^* = (1-\alpha_2) A_0 K_0^{\alpha_1 - 1} L_0^{\alpha_2} e^{\left[g_A + \alpha_2 n + (\alpha_1 - 1)\left(\frac{1}{1-\alpha_1} g_A + \frac{\alpha_2}{1-\alpha_1} n\right)\right]t}. \quad \text{(B6)}$$

Next, consider the book-to-market ratio in a steady state within foreseeable future until T:

$$\frac{B_t}{M_t} \equiv \frac{K_t}{\int_t^T e^{-\rho^*} GPM_u du} = \frac{K_t}{\int_t^T e^{-\rho^*} (1-\alpha_2) Y_u du}.$$

At each point in time equilibrium output is given by

$$Y_t^* = A_t K_t^{\alpha_1} L_t^{\alpha_2} = A_0 e^{g_A t} \left(K_0 e^{\left(\frac{1}{1-\alpha_1} g_A + \frac{\alpha_2}{1-\alpha_1} n\right)t} \right)^{\alpha_1} \left(L_0 e^{nt}\right)^{\alpha_2}.$$

Rearranging terms, we get:

$$Y_t^* = A_0 K_0^{\alpha_1} L_0^{\alpha_2} e^{g_A t} \left(e^{\alpha_1 \left(\frac{1}{1-\alpha_1} g_A + \frac{\alpha_2}{1-\alpha_1} n\right)t} \right) \left(e^{\alpha_2 nt}\right);$$

$$Y_t^* = A_0 K_0^{\alpha_1} L_0^{\alpha_2} e^{\left[g_A + \alpha_1 \left(\frac{1}{1-\alpha_1} g_A + \frac{\alpha_2}{1-\alpha_1} n\right) + \alpha_2 n\right]t}. \quad \text{(B7)}$$

It means that the equilibrium market value of the economy is

$$M_t^* = \int_t^T e^{-\rho^*}(1-\alpha_2)Y_u^* du, \qquad \text{(B8)}$$

where ρ^* is given by (B6) and equilibrium output Y_t^* given by (B7).

Consider the integrand in (B8). Substituting (B6) and (B7) into the integrand yields the following expression:

$$e^{-\rho^*}(1-\alpha_2)Y_u^* = \exp\left[-\left((1-\alpha_2)A_0K_0^{\alpha_1-1}L_0^{\alpha_2}e^{\left[g_A+\alpha_2 n+(\alpha_1-1)\left(\frac{1}{1-\alpha_1}g_A+\frac{\alpha_2}{1-\alpha_1}n\right)\right]u}\right)\right](1-\alpha_2)\times$$

$$\times A_0K_0^{\alpha_1}L_0^{\alpha_2}e^{\left[g_A+\alpha_1\left(\frac{1}{1-\alpha_1}g_A+\frac{\alpha_2}{1-\alpha_1}n\right)+\alpha_2 n\right]u} =$$

$$= A_0K_0^{\alpha_1}L_0^{\alpha_2}(1-\alpha_2)\exp\left[\frac{A_0K_0^{\alpha_1-1}L_0^{\alpha_2}(\alpha_1+\alpha_2-\alpha_1\alpha_2-1)+(g_a+\alpha_2 n)u}{1-\alpha_1}\right]. \qquad \text{(B9)}$$

Define a constant R as:

$$R \equiv A_0K_0^{\alpha_1}L_0^{\alpha_2}(1-\alpha_2)\exp\left[\frac{A_0K_0^{\alpha_1-1}L_0^{\alpha_2}(\alpha_1+\alpha_2-\alpha_1\alpha_2-1)}{1-\alpha_1}\right].$$

Then the total market value of the economy is given by

$$M_t^* = \int_t^T R\cdot\exp\left[\frac{(g_a+\alpha_2 n)u}{1-\alpha_1}\right]du =$$

$$= R\left(\frac{1-\alpha_1}{g_a+\alpha_2 n}\right)\left(\exp\left[\frac{(g_a+\alpha_2 n)}{1-\alpha_1}T\right]-\exp\left[\frac{(g_a+\alpha_2 n)}{1-\alpha_1}t\right]\right) \qquad \text{(B10)}$$

Next, using (5) and (10) in the definition of book-to-market ratio at time t, we obtain the following formula:

$$\frac{B_t^*}{M_t^*} = \frac{K_0 e^{\left(\frac{1}{1-\alpha_1} g_A + \frac{\alpha_2}{1-\alpha_1} n\right)t}}{R\left(\frac{1-\alpha_1}{g_a+\alpha_2 n}\right)\left(\exp\left[\frac{(g_a+\alpha_2 n)}{1-\alpha_1}T\right] - \exp\left[\frac{(g_a+\alpha_2 n)}{1-\alpha_1}t\right]\right)}, \qquad \text{(B11)}$$

where R is a constant and T stands for the planning horizon. Equation (B11) fully specifies the book-to-market ratio in terms of macroeconomic parameters.

Hence, to calculate size, market value, and B/M for an average profit-maximizing firm in the economy, all we will need to know is capital, labour, and technology requirements for that firm, along with macroeconomic conditions. If we know that there are N firms in the economy, the amount of capital an average firm should have at the maximum profitability path is:

$$k_t^* = \frac{K_0}{N} e^{\left(\frac{1}{1-\alpha_1} g_A + \frac{\alpha_2}{1-\alpha_1} n\right)t}, \qquad \text{(B12)}$$

and its market value at each time t should be equal to

$$m_t^* = \frac{R}{N}\left(\frac{1-\alpha_1}{g_a+\alpha_2 n}\right)\left(\exp\left[\frac{(g_a+\alpha_2 n)}{1-\alpha_1}T\right] - \exp\left[\frac{(g_a+\alpha_2 n)}{1-\alpha_1}t\right]\right), \qquad \text{B(13)}$$

finally, the book-to-market ratio should be given by (B11). If observed parameters k_t, m_t, and B_t/M_t of any given firm are located away from the equilibrium parameters k_t^*, m_t^*, and B_t^*/M_t^* for prolonged periods of time, we conclude that the firm in question is not pursuing a profit maximizing business strategy.

Appendix C. Comparative dynamics

In this appendix we will review how equilibrium growth rate of capital, capital stock, market value, and firm profitability change in response to changes in macroeconomic conditions.

Steady-state growth rate of capital

Consider the maximum profitability path of the capital growth rate g_K. It is given by:

$$g_K = \frac{1}{1-\alpha_1} g_a + \frac{\alpha_2}{1-\alpha_1} n .$$

Taking partial derivatives with respect to macroeconomic parameters g_a, n, α_1, and α_2 yields the following:

$$\frac{\partial g_K}{\partial g_a} = \frac{\partial}{\partial g_a}\left(\frac{1}{1-\alpha_1} g_a + \frac{\alpha_2}{1-\alpha_1} n\right) = \frac{1}{1-\alpha_1} > 0 \text{, as long as } \alpha_1 < 1. \quad \text{(C1)}$$

It follows that equilibrium growth rate of capital increases if the growth rate of technological advances increases. We hypothesize that it happens because the capital owner invests more to take advantage of improvements in technology that increase productivity.

$$\frac{\partial g_K}{\partial n} = \frac{\partial}{\partial n}\left(\frac{1}{1-\alpha_1} g_a + \frac{\alpha_2}{1-\alpha_1} n\right) = \frac{\alpha_2}{1-\alpha_1} > 0 \text{, as long as } \alpha_1 < 1,\ 0 < \alpha_2 . \quad \text{(C2)}$$

As the workforce grows, the full employment assumption of the model results in growth of capital to ensure all workers are employed. Note that maximum profitability growth of capital due to technological advances is greater than the capital expansion resulting from population growth by the factor α_2, which is the labour share of income assumed to satisfy $\alpha_2 < 1$.

$$\frac{\partial g_K}{\partial \alpha_1} = \frac{\partial}{\partial \alpha_1}\left(\frac{1}{1-\alpha_1} g_a + \frac{\alpha_2}{1-\alpha_1} n\right) = \frac{g_a + \alpha_2 n}{(1-\alpha_1)^2}. \qquad \text{(C3)}$$

If the capital share of income α_1 increases (for example if labour unions lose their bargaining power), there are several possible scenarios for the equilibrium growth rate of capital. If both technology and population expand, $g_a > 0$, $n > 0$, then equilibrium growth rate of capital increases, $\partial g_K / \partial \alpha_1 > 0$. The case where it is optimal to reduce the amount of capital, $\partial g_K / \partial \alpha_1 < 0$, is possible when $g_a + \alpha_2 n < 0$. Such a situation may occur either because of a large negative technology shock (e.g. scarcity of power sources leading to halting of all energy-intensive production lines), or a reduction in the labour force, $n < 0$.

$$\frac{\partial g_K}{\partial \alpha_2} = \frac{\partial}{\partial \alpha_2}\left(\frac{1}{1-\alpha_1} g_a + \frac{\alpha_2}{1-\alpha_1} n\right) = \frac{n}{1-\alpha_1} \qquad \text{(C4)}$$

If labour share of income α_2 increases (for example if labour unions increase their bargaining power), then the equilibrium capital growth rate will depend on the population growth; if $n > 0$, then $\partial g_K / \partial \alpha_2 > 0$, and if $n < 0$, then $\partial g_K / \partial \alpha_2 < 0$.

Steady-state trajectory of capital stock

Consider the maximum profitability path of capital K_t. It is given by:

$$K_t = K_0 e^{\left(\frac{1}{1-\alpha_1} g_A + \frac{\alpha_2}{1-\alpha_1} n\right) t}.$$

Taking partial derivatives with respect to macroeconomic parameters g_a, n, α_1, and α_2 yields the following:

$$\frac{\partial K_t}{\partial g_a}=\frac{\partial}{\partial g_a}\left(K_0 e^{\left(\frac{1}{1-\alpha_1}g_A+\frac{\alpha_2}{1-\alpha_1}n\right)t}\right)=\frac{K_0}{1-\alpha_1}te^{\left(\frac{1}{1-\alpha_1}g_A+\frac{\alpha_2}{1-\alpha_1}n\right)t}>0,\text{ if }\alpha_1<1. \quad \text{(C5)}$$

It implies that it is always profitable to increase capital stock when technological progress moves forward faster, and vice versa.

$$\frac{\partial K_t}{\partial n}=\frac{\partial}{\partial n}\left(K_0 e^{\left(\frac{1}{1-\alpha_1}g_A+\frac{\alpha_2}{1-\alpha_1}n\right)t}\right)=\frac{K_0\alpha_2}{1-\alpha_1}te^{\left(\frac{1}{1-\alpha_1}g_A+\frac{\alpha_2}{1-\alpha_1}n\right)t}>0,\text{ if }\alpha_1<1,\ 0<\alpha_2. \quad \text{(C6)}$$

If the labour force grows, the amount of capital grows as well to ensure full employment.

Next, partial derivatives with respect to shares of income α_1 and α_2 are:

$$\frac{\partial K_t}{\partial \alpha_1}=\frac{\partial}{\partial \alpha_1}\left(K_0 e^{\left(\frac{1}{1-\alpha_1}g_A+\frac{\alpha_2}{1-\alpha_1}n\right)t}\right)=K_0\frac{g_a+\alpha_2 n}{(1-\alpha_1)^2}te^{\left(\frac{1}{1-\alpha_1}g_A+\frac{\alpha_2}{1-\alpha_1}n\right)t} \quad \text{(C7)}$$

$$\frac{\partial K_t}{\partial \alpha_2}=\frac{\partial}{\partial \alpha_2}\left(K_0 e^{\left(\frac{1}{1-\alpha_1}g_A+\frac{\alpha_2}{1-\alpha_1}n\right)t}\right)=\frac{K_0 n}{1-\alpha_1}te^{\left(\frac{1}{1-\alpha_1}g_A+\frac{\alpha_2}{1-\alpha_1}n\right)t}>0. \quad \text{(C8)}$$

Equations (C1) through (C4) represent the same type of information as in equations (C5)-(C8), but the latter set of equations tells us what should happen to the capital stock per se rather than the equilibrium growth rate of capital. Consider equations D1, D2,D4 and D5, D6, and D10. We infer from these equations that under quite realistic regularity conditions of income distribution, the firm owners will be inclined to expand production whenever technology or labour availability allows doing so, and vice versa.

Equations D3 and D7 show something interesting. A situation where $g_a+\alpha_2 n<0$ leads to chaotic movements in the optimal production size. In this case $\partial g_K/\partial\alpha_1<0$ and

$\partial K_t / \partial \alpha_1 < 0$. It seems counterintuitive that a capitalist would prefer to reduce firm size when capital share of income α_1 increases or increase firm size when α_1 decreases. Apparently, the growth rates of technology and labour determine evolution of the economy. If $g_a + \alpha_2 n > 0$, an increase in income share of capital should motivate the firm owner to expand firm size, condition $g_a + \alpha_2 n = 0$ entails no change in capital regardless of α_1. Finally, if there is a large negative technological or demographic shock, the capitalist finds it profitable to reduce firm size.

Market value at the steady state

Next, consider the market value of the production economy M_t at the maximum profitability path:

$$M_t = R\left(\frac{1-\alpha_1}{g_a + \alpha_2 n}\right)\left(\exp\left[\frac{(g_a + \alpha_2 n)}{1-\alpha_1}T\right] - \exp\left[\frac{(g_a + \alpha_2 n)}{1-\alpha_1}t\right]\right),$$

where $R \equiv A_0 K_0^{\alpha_1} L_0^{\alpha_2}(1-\alpha_2)\exp\left[\frac{A_0 K_0^{\alpha_1 - 1} L_0^{\alpha_2}(\alpha_1 + \alpha_2 - \alpha_1\alpha_2 - 1)}{1-\alpha_1}\right]$. Taking partial derivatives with respect to macroeconomic parameters g_a, n, α_1, and α_2 yields the following.

$$\partial M_t / \partial g_a =$$

$$= R\frac{(T(g_a + \alpha_2 n) - 1 + \alpha_1)\exp\left[\frac{(g_a + \alpha_2 n)}{1-\alpha_1}T\right] - (t(g_a + \alpha_2 n) - 1 + \alpha_1)\exp\left[\frac{(g_a + \alpha_2 n)}{1-\alpha_1}t\right]}{(g_a + \alpha_2 n)^2} \tag{C9}$$

we know that $T > t$, $0 < \alpha_1 < 1$, and $0 < \alpha_2 < 1$. Therefore, the situation described by $\partial M_t / \partial g_a > 0$, where market value grows with technological advances is $(g_a + \alpha_2 n) > 0$. We saw this condition earlier in the discussion of the equilibrium capital time path.

$\partial M_t / \partial n =$

$$= R\alpha_2 \frac{(T(g_a + \alpha_2 n) - 1 + \alpha_1)\exp\left[\frac{(g_a + \alpha_2 n)}{1-\alpha_1}T\right] - (t(g_a + \alpha_2 n) - 1 + \alpha_1)\exp\left[\frac{(g_a + \alpha_2 n)}{1-\alpha_1}t\right]}{(1-\alpha_1)(g_a + \alpha_2 n)^2} \tag{C10}$$

Once again, it is obvious from (C10) that $\partial M_t / \partial n > 0$ a long as $g_a + \alpha_2 n > 0$.

Recall that the market value is determined at the equilibrium as follows:

$$M_t = A_0 K_0^{\alpha_1} L_0^{\alpha_2} (1-\alpha_2) e^{\left[\frac{A_0 K_0^{\alpha_1 - 1} L_0^{\alpha_2} (\alpha_1 + \alpha_2 - \alpha_1\alpha_2 - 1)}{1-\alpha_1}\right]} \left(\frac{1-\alpha_1}{g_a + \alpha_2 n}\right)\left(e^{\left[\frac{(g_a + \alpha_2 n)}{1-\alpha_1}T\right]} - e^{\left[\frac{(g_a + \alpha_2 n)}{1-\alpha_1}t\right]}\right) \tag{C11}$$

Equation (C11) is quite hard to differentiate as is with respect to income shares of capital α_1 and labour α_2. To simplify the exercise, we rewrite it as a product of two functions, $M_t = R(\alpha_1, \alpha_2) \cdot V(\alpha_1, \alpha_2)$. We have

$$R(\alpha_1, \alpha_2) = A_0 K_0^{\alpha_1} L_0^{\alpha_2} (1-\alpha_2) e^{\left[\frac{A_0 K_0^{\alpha_1 - 1} L_0^{\alpha_2} (\alpha_1 + \alpha_2 - \alpha_1\alpha_2 - 1)}{1-\alpha_1}\right]} \tag{C12}$$

and

$$V(\alpha_1, \alpha_2) = \left(\frac{1-\alpha_1}{g_a + \alpha_2 n}\right)\left(e^{\left[\frac{(g_a + \alpha_2 n)}{1-\alpha_1}T\right]} - e^{\left[\frac{(g_a + \alpha_2 n)}{1-\alpha_1}t\right]}\right). \tag{C13}$$

Consider the first partial derivative,

$$\partial M_t/\partial\alpha_1 = \partial/\partial\alpha_1\left(R(\alpha_1,\alpha_2)\right)\cdot V(\alpha_1,\alpha_2) + R(\alpha_1,\alpha_2)\partial/\partial\alpha_1 V(\alpha_1,\alpha_2):$$

$$\frac{\partial R(\alpha_1,\alpha_2)}{\partial\alpha_1} = \frac{\partial}{\partial\alpha_1}\left(A_0 K_0^{\alpha_1} L_0^{\alpha_2}(1-\alpha_2)e^{\left[\frac{A_0 K_0^{\alpha_1-1} L_0^{\alpha_2}(\alpha_1+\alpha_2-\alpha_1\alpha_2-1)}{1-\alpha_1}\right]}\right) =$$

$$= (1-\alpha_2)A_0\ln[K_0]\frac{\left(K_0^{\alpha_1+1}L_0^{\alpha_2} + (\alpha_2-1)A_0 K_0^{2\alpha_1}L_0^{2\alpha_2}\right)}{K_0}e^{\left[A_0 K_0^{\alpha_1-1}L_0^{\alpha_2}(\alpha_2-1)\right]} \qquad \text{(C14)}$$

$$\frac{\partial V(\alpha_1,\alpha_2)}{\partial\alpha_1} = \frac{\partial}{\partial\alpha_1}\left(\left(\frac{1-\alpha_1}{g_a+\alpha_2 n}\right)\left(e^{\left[\frac{(g_a+\alpha_2 n)}{1-\alpha_1}T\right]} - e^{\left[\frac{(g_a+\alpha_2 n)}{1-\alpha_1}t\right]}\right)\right) =$$

$$= \frac{\left[1-\alpha_1-(g_a+\alpha_2 n)T\right]e^{\left[\frac{(g_a+\alpha_2 n)}{1-\alpha_1}T\right]} - \left[1-\alpha_1-(g_a+\alpha_2 n)t\right]e^{\left[\frac{(g_a+\alpha_2 n)}{1-\alpha_1}t\right]}}{(g_a+\alpha_2 n)(\alpha_1-1)}$$

$$= \frac{(1-\alpha_1)\left[e^{\left[\frac{(g_a+\alpha_2 n)}{1-\alpha_1}T\right]} - e^{\left[\frac{(g_a+\alpha_2 n)}{1-\alpha_1}t\right]}\right] - \left[(g_a+\alpha_2 n)\right]\left(Te^{\left[\frac{(g_a+\alpha_2 n)}{1-\alpha_1}T\right]} - te^{\left[\frac{(g_a+\alpha_2 n)}{1-\alpha_1}t\right]}\right)}{(g_a+\alpha_2 n)(\alpha_1-1)} \qquad \text{(C15)}$$

Consider equation (C14). We know for sure that $(1-\alpha_2)A_0\ln[K_0]\geq 0$, $K_0>0$, $L_0>0$, $A_0>0$ and $e^{\left[A_0 K_0^{\alpha_1-1}L_0^{\alpha_2}(\alpha_2-1)\right]}>0$. The sign of (C14) is determined by

$$\left(K_0^{\alpha_1+1}L_0^{\alpha_2} + (\alpha_2-1)A_0 K_0^{2\alpha_1}L_0^{2\alpha_2}\right). \qquad \text{(C16)}$$

Since $\alpha_2<1$, the key question is how this expression behaves for different values of α_1 and α_2.

To determine whether (C16) is positive or negative we performed a simple calibration exercise, which showed that (C16) is positive when values of α_1 and α_2 are within their corresponding ranges and A_0, K_0, and L_0 are equal or greater than 1;. Thus, $\partial/\partial\alpha_1\left(R(\alpha_1,\alpha_2)\right) > 0$.

Next, consider equation (C15). We know that $(\alpha_1 - 1) < 0$. The numerator of (C15) is:

$$(1-\alpha_1)\left[e^{\left[\frac{(g_a+\alpha_2 n)}{1-\alpha_1}T\right]} - e^{\left[\frac{(g_a+\alpha_2 n)}{1-\alpha_1}t\right]}\right] - \left[(g_a+\alpha_2 n)\right]\left(Te^{\left[\frac{(g_a+\alpha_2 n)}{1-\alpha_1}T\right]} - te^{\left[\frac{(g_a+\alpha_2 n)}{1-\alpha_1}t\right]}\right).$$

Its sign will depend on the macroeconomic factors. We calibrated the expression for feasible values of the macroeconomic parameters and discovered that it seems to be always negative, regardless of the sign of $(g_a + \alpha_2 n)$. Since the numerator of (C15) and its denominator are less than zero, $\partial/\partial\alpha_1\left(V(\alpha_1,\alpha_2)\right) > 0$.

The sign of $\partial M_t/\partial\alpha_1$ is determined by

$$\partial M_t/\partial\alpha_1 = \partial/\partial\alpha_1\left(R(\alpha_1,\alpha_2)\right)\cdot V(\alpha_1,\alpha_2) + R(\alpha_1,\alpha_2)\,\partial/\partial\alpha_1\, V(\alpha_1,\alpha_2). \quad \text{(C17)}$$

The first component given by (C12) is always positive, and the sign of (C13) is always positive as well, because when $(g_a + \alpha_2 n) > 0$, $e^{\left[\frac{(g_a+\alpha_2 n)}{1-\alpha_1}T\right]} - e^{\left[\frac{(g_a+\alpha_2 n)}{1-\alpha_1}t\right]} > 0$, and when $(g_a + \alpha_2 n) < 0$, it follows that $e^{\left[\frac{(g_a+\alpha_2 n)}{1-\alpha_1}T\right]} - e^{\left[\frac{(g_a+\alpha_2 n)}{1-\alpha_1}t\right]} < 0$. Therefore, a partial derivative of the market value with respect to capital share of income $\partial M_t/\partial\alpha_1 > 0$. This result makes sense: when larger portion of earnings is allocated to the firm (as opposed to wages), the market value of the firm increases.

Next, consider a partial derivative of the market value with respect to labour share of income. It is given by:

$$\partial M_t/\partial\alpha_2 = \partial/\partial\alpha_2 \left(R(\alpha_1,\alpha_2)\right)\cdot V(\alpha_1,\alpha_2) + R(\alpha_1,\alpha_2)\,\partial/\partial\alpha_2\, V(\alpha_1,\alpha_2) \quad \text{(C18).}$$

Then first component is:

$$\frac{\partial R(\alpha_1,\alpha_2)}{\partial\alpha_2} = \frac{\partial}{\partial\alpha_2}\left(A_0 K_0^{\alpha_1} L_0^{\alpha_2}(1-\alpha_2) e^{\left[\frac{A_0 K_0^{\alpha_1 -1} L_0^{\alpha_2}(\alpha_1+\alpha_2-\alpha_1\alpha_2-1)}{1-\alpha_1}\right]}\right) =$$

$$= -A_0 K_0^{\alpha_1} K_0^{\alpha_2}\left[\left(1+\ln[L_0](\alpha_2-1)\right) + A_0 K_0^{\alpha_1-1} L_0^{\alpha_2}\left(\ln[L_0](1-\alpha_2)^2 - (1-\alpha_2)\right)\right] e^{\left[A_0 K_0^{\alpha_1-1} L_0^{\alpha_2}(\alpha_2-1)\right]}$$

(C19)

We know that $A_0 K_0^{\alpha_1} K_0^{\alpha_2} > 0$, $A_0 K_0^{\alpha_1-1} K_0^{\alpha_2} > 0$ and $e^{\left[A_0 K_0^{\alpha_1-1} L_0^{\alpha_2}(\alpha_2-1)\right]} > 0$. To determine the sign of (C19), we need to know whether $\left[1+\ln[L_0](\alpha_2-1)\right]$ and $\left(\ln[L_0](1-\alpha_2)^2 - (1-\alpha_2)\right)$ are positive or negative. In order to answer that question, we have to determine where these expressions equal to zero. We first consider the equation

$$1+\ln[L_0](\alpha_2-1) = 0 \qquad \text{(C20)}$$

and find its solution, $\alpha_2 = (\ln[L_0]-1)/\ln[L_0]$. If $\alpha_2 > (\ln[L_0]-1)/\ln[L_0]$, then $1+\ln[L_0](\alpha_2-1) > 0$, and if $\alpha_2 < (\ln[L_0]-1)/\ln[L_0]$, then $1+\ln[L_0](\alpha_2-1) < 0$.

Next, consider equation

$$\ln[L_0](1-\alpha_2)^2 - (1-\alpha_2) = 0. \qquad \text{(C21)}$$

It has two possible solutions, $\alpha_2 = 1$, which is not feasible, and $\alpha_2 = (\ln[L_0]-1)/\ln[L_0]$. Note that this solution coincides with the solution for (C20). But this expression behaves differently: If $\alpha_2 > (\ln[L_0]-1)/\ln[L_0]$, then

$\ln[L_0](1-\alpha_2)^2-(1-\alpha_2)<0$, and if $\alpha_2<(\ln[L_0]-1)/\ln[L_0]$, then

$\ln[L_0](1-\alpha_2)^2-(1-\alpha_2)>0$.

The next task is to see how (C19) behaves. When $\alpha_2=(\ln[L_0]-1)/\ln[L_0]$, it is clear that $\partial R_t/\partial\alpha_2=0$, since both (C20) and (C21) are equal to zero, which makes the whole product to be zero. For all cases where the initial values of technology A_0, capital K_0, and labour L_0 are all greater than one, expression $\ln[L_0](1-\alpha_2)^2-(1-\alpha_2)$ will dominate the sign of (C19), since $A_0K_0^{\alpha_1-1}L_0^{\alpha_2}\left(\ln[L_0](1-\alpha_2)^2-(1-\alpha_2)\right)$ will be greater in absolute value than $(1+\ln[L_0](\alpha_2-1))$. Hence, we conclude that for most feasible values of production technology we should have $\partial R_t/\partial\alpha_2>0$ when $\alpha_2<(\ln[L_0]-1)/\ln[L_0]$, and $\partial R_t/\partial\alpha_2<0$ when $\alpha_2>(\ln[L_0]-1)/\ln[L_0]$.

Finally, consider the last partial derivative,

$$\frac{\partial V(\alpha_1,\alpha_2)}{\partial\alpha_2}=\frac{\partial}{\partial\alpha_2}\left(\left(\frac{1-\alpha_1}{g_a+\alpha_2 n}\right)\left(e^{\left[\frac{(g_a+\alpha_2 n)}{1-\alpha_1}T\right]}-e^{\left[\frac{(g_a+\alpha_2 n)}{1-\alpha_1}t\right]}\right)\right)=$$

$$=\frac{n}{(g_a+\alpha_2 n)^2}\left[(T(g_a+\alpha_2 n)-1+\alpha_1)e^{\left[\frac{(g_a+\alpha_2 n)}{1-\alpha_1}T\right]}-(t(g_a+\alpha_2 n)-1+\alpha_1)e^{\left[\frac{(g_a+\alpha_2 n)}{1-\alpha_1}t\right]}\right]$$

(C22)

Expression (22) should be positive for all cases when normal economic conditions exist, which is represented by $g_a+\alpha_2 n>0$. To review case of $g_a+\alpha_2 n<0$ in more detail, consider expression

$$(T(g_a+\alpha_2 n)-1+\alpha_1)e^{\left[\frac{(g_a+\alpha_2 n)}{1-\alpha_1}T\right]}-(t(g_a+\alpha_2 n)-1+\alpha_1)e^{\left[\frac{(g_a+\alpha_2 n)}{1-\alpha_1}t\right]}=$$

$$(g_a + \alpha_2 n)\left[Te^{\left[\frac{(g_a+\alpha_2 n)}{1-\alpha_1}T\right]} - te^{\left[\frac{(g_a+\alpha_2 n)}{1-\alpha_1}t\right]}\right] - (1-\alpha_1)\left[e^{\left[\frac{(g_a+\alpha_2 n)}{1-\alpha_1}T\right]} - e^{\left[\frac{(g_a+\alpha_2 n)}{1-\alpha_1}t\right]}\right]. \quad \text{(C23)}$$

Since $T > t$, it must be that $e^{\left[\frac{(g_a+\alpha_2 n)}{1-\alpha_1}T\right]} - e^{\left[\frac{(g_a+\alpha_2 n)}{1-\alpha_1}t\right]} < 0$ when $g_a + \alpha_2 n < 0$. Next, expression $Te^{\left[\frac{(g_a+\alpha_2 n)}{1-\alpha_1}T\right]} - te^{\left[\frac{(g_a+\alpha_2 n)}{1-\alpha_1}t\right]}$ must be also negative, since function $f(x) = xe^{-kx}$ sharply decreases as x increases. Which implies that for $T > t$ and $g_a + \alpha_2 n < 0$, $Te^{\left[\frac{(g_a+\alpha_2 n)}{1-\alpha_1}T\right]} - te^{\left[\frac{(g_a+\alpha_2 n)}{1-\alpha_1}t\right]} < 0$. Hence, (C23) is positive and $\partial V_t / \partial \alpha_2 > 0$.

To see the sign of $\partial M_t / \partial \alpha_2$, we need to know values of income distribution parameters, and starting values for the production economy. Recall that

$$\partial M_t / \partial \alpha_2 = \partial / \partial \alpha_2 \left(R(\alpha_1, \alpha_2)\right) \cdot V(\alpha_1, \alpha_2) + R(\alpha_1, \alpha_2) \partial / \partial \alpha_2 V(\alpha_1, \alpha_2),$$

where $V(\alpha_1, \alpha_2) > 0$, $R(\alpha_1, \alpha_2) > 0$, $\partial V_t / \partial \alpha_2 > 0$, and $\partial R_t / \partial \alpha_2$ changes sign. When $\alpha_2 < (\ln[L_0] - 1)/\ln[L_0]$, we have $\partial R_t / \partial \alpha_2 > 0$ and $\partial R_t / \partial \alpha_2 < 0$ when $\alpha_2 > (\ln[L_0] - 1)/\ln[L_0]$. From the economics point of view, it makes more sense when $\partial M_t / \partial \alpha_2 < 0$, it would imply that market value decreases when wage payments take larger share of profits. The opposite may be a valid story as well: as workers get paid more, their purchasing power increases and they buy more, which increases profits.

Appendix D. Political events related to European integration[1] and peaks of Wald statistics associated with univariate and multivariate tests for structural change date. Univariate tests detect breaks in intercept and autoregressive coefficient for market return, short rate, bond yield, inflation, and exchange rate for all countries. Multivariate tests include 3 bivariate tests and one 4-variate test. The bivariate tests detect breaks in all coefficients of bivariate vector autoregressions. The 4-variate tests detect breaks in all coefficients of 4-variate vector autoregressions. The number of autoregressive lags is 1 as determined by Akaike information criterion for all cases.

Date	**Event**	**Univariate Tests**					**Multivariate tests**			
	European Politics	**Market return**	**Short rate**	**Bond yield**	**Inflation**	**Exchange rate**	**Market return and div. yield**	**Inflation and exchange rate**	**Short rate and bond yield**	**Stock return and dividend yield for a country and European market**
Feb-84	`Esprit', the European Strategic Programme for Research and Development in Information Technologies, is adopted.									
Dec-84	A third Lomé Convention between the Ten									

[1] Sources: Europa, http://europa.eu.int/index_en.htm and European Union Center at Georgia Tech, ttp://www.inta.gatech.edu/eucenter/resources/eu_timeline.html

Date	Event	Univariate Tests					Multivariate tests			
	European Politics	**Market return**	**Short rate**	**Bond yield**	**Inflation**	**Exchange rate**	**Market return and div. yield**	**Inflation and exchange rate**	**Short rate and bond yield**	**Stock return and dividend yield for a country and European market**
	and the ACP States, now numbering 66, is signed in Togo.									
Jan-85	Jacques Delors is appointed President of the Commission									
Jun-85						FRAN NETH UK** SWITZ		FRAN**		
Jul-85						GERM				UK***
Aug-85					FRAN***					
Nov-85										FRAN**
Dec-85	At the Luxembourg European Council the Ten agree to amend the Treaty of Rome and to □evitalize the process of European integration by									

Date	Event	Univariate Tests					Multivariate tests			
	European Politics	**Market return**	**Short rate**	**Bond yield**	**Inflation**	**Exchange rate**	**Market return and div. yield**	**Inflation and exchange rate**	**Short rate and bond yield**	**Stock return and dividend yield for a country and European market**
	drawing up a `Single European Act'.									
Jan-86	Spain and Portugal join the Community.								FRAN***	
Feb-86	The Single European Act is signed in Luxembourg and The Hague.									
Mar-86								FRAN**		
May-86			FRAN***	FRAN			GERM*** FRAN NETH SWITZ**		FRAN**	
Jun-86		GERM** *SWITZ*								GERM*** FRAN*** UK*** SWITZ***
Oct-86		*UK*								
Dec-86			UK**						UK***	
Feb-87								NETH		
Apr-87	Turkey applies to									

Date	Event	Univariate Tests					Multivariate tests			
	European Politics	Market return	Short rate	Bond yield	Inflation	Exchange rate	Market return and div. yield	Inflation and exchange rate	Short rate and bond yield	Stock return and dividend yield for a country and European market
	join the Community									
May-87							UK			
Jul-87	The Single European Act (SEA)entered into force on 1 July 1987									
Sep-87			UK**						UK***	
Oct-87										GERM** FRAN** NETH** UK*** SWITZ**
Feb-88	Financing of EEC policies reformed. Multiannual programme of expenditure for 1988-92. Reform of the Structural Funds.									
Jun-88									GERM* UK***	

Date	Event	Univariate Tests					Multivariate tests			
	European Politics	**Market return**	**Short rate**	**Bond yield**	**Inflation**	**Exchange rate**	**Market return and div. yield**	**Inflation and exchange rate**	**Short rate and bond yield**	**Stock return and dividend yield for a country and European market**
Oct-88			UK**		GERM				FRAN*	
Nov-88									GERM*	
Jan-89	Jacques Delors is reappointed President of the Commission for a further four years.									
Feb-89					NETH					
Jun-89								FRAN**		
Jul-89	Austria applies to join the Community.									
Oct-89				UK*						
Nov-89								FRAN*		
Dec-89	The Strasbourg European Council decides to convene an intergovernmental conference.									

Date	Event	Univariate Tests					Multivariate tests			
	European Politics	**Market return**	**Short rate**	**Bond yield**	**Inflation**	**Exchange rate**	**Market return and div. yield**	**Inflation and exchange rate**	**Short rate and bond yield**	**Stock return and dividend yield for a country and European market**
May-90	The Agreement establishing the European Bank for Reconstruction and Development is signed in Paris.			UK* SWITZ**				FRAN**	UK***	
Jun-90	The Schengen Agreement on the elimination of border checks is signed.				UK**					
Jul-90	Cyprus and Malta applies to join the Community.									
Oct-90	Germany is united		UK* *	GERM FRAN UK*					GERM UK***	
Nov-90					FRAN*** UK**			FRAN**		
Dec-90	Two Intergovernmental Conferences, one on economic and									

Date	Event	Univariate Tests					Multivariate tests			
	European Politics	**Market return**	**Short rate**	**Bond yield**	**Inflation**	**Exchange rate**	**Market return and div. yield**	**Inflation and exchange rate**	**Short rate and bond yield**	**Stock return and dividend yield for a country and European market**
	monetary union, the other on political union, open in Rome.									
Jul-91	Sweden applies to join the Community			UK*	UK**			SWITZ**		
Oct-91	Agreement is reached on setting up a European Economic Area (EEA) linking the Community with its western European neighbours.									
Nov-91				SWITZ**						
Dec-91	The European Council meets in Maastricht				FRAN*** SWITZ**			FRAN*** UK** SWITZ***	GERM*	
Feb-92	The Treaty on European Union signed in Maastricht on 7		UK**					UK**		

Date	Event	Univariate Tests					Multivariate tests			
	European Politics	**Market return**	**Short rate**	**Bond yield**	**Inflation**	**Exchange rate**	**Market return and div. yield**	**Inflation and exchange rate**	**Short rate and bond yield**	**Stock return and dividend yield for a country and European market**
	February 1992									
Mar-92	Finland and Norway applies to join the Community									
Apr-92				UK*					UK***	
May-92	Agreement on the European Economic Area is signed in Porto				UK**					
Jun-92	Denmark rejects the Maastricht Treaty by referendum. A referendum in Ireland approves the Maastricht Treaty				FRAN***			SWITZ**		
Jul-92			SWITZ**		SWITZ***				SWITZ***	
Aug-92				GERM						
Sep-92	A referendum in France approves the Maastricht Treaty		GERM*** NETH***	FRAN* NETH** UK** SWITZ***				UK*** SWITZ***	GERM*** NETH*** FRAN** UK***	
Dec-92	The European									

Date	Event	Univariate Tests					Multivariate tests			
	European Politics	**Market return**	**Short rate**	**Bond yield**	**Inflation**	**Exchange rate**	**Market return and div. yield**	**Inflation and exchange rate**	**Short rate and bond yield**	**Stock return and dividend yield for a country and European market**
	Council meets in Edinburgh.									
Jan-93	Introduction of the single market									
Feb-93			FRAN***						FRAN*	
Apr-93					FRAN***			SWITZ*** FRAN***		
May-93	The Maastricht Treaty is approved in a second referendum in Denmark				SWITZ***					
Jun-93					UK*					
Aug-93			FRAN***							
Nov-93	The Treaty on European Union entered into force on 1 November 1993									
Apr-94	Hungary and Poland applies to join the European Union									

Date	Event	Univariate Tests					Multivariate tests			
	European Politics	**Market return**	**Short rate**	**Bond yield**	**Inflation**	**Exchange rate**	**Market return and div. yield**	**Inflation and exchange rate**	**Short rate and bond yield**	**Stock return and dividend yield for a country and European market**
Jun-94	The European Council meets in Corfu. Treaties of Accession to the European Union are signed by Austria, Finland, Norway and Sweden. A referendum in Austria approves treaty of accession									
Oct-94	A referendum in Finland approves treaty of accession.									
Nov-94	A referendum in Sweden approves and in Norway rejects treaties of accession									
Dec-94	The European Council meets in Essen									

Date	Event	Univariate Tests					Multivariate tests			
	European Politics	Market return	Short rate	Bond yield	Inflation	Exchange rate	Market return and div. yield	Inflation and exchange rate	Short rate and bond yield	Stock return and dividend yield for a country and European market
Jan-95	Austria, Finland and Sweden join the Union. A new Commission starts work with Jacques Santer as President (1995-2000).								FRAN*	
Feb-95				GERM* NETH*						
Mar-95	The Schengen Agreement comes into force				SWITZ*			SWITZ**		
Apr-95				FRAN						
May-95									FRAN*	
Jun-95	Europe Agreements with Estonia, Latvia and Lithuania. Romania and Slovakia apply to join the Community. The European Council									

Date	Event	Univariate Tests					Multivariate tests			
	European Politics	**Market return**	**Short rate**	**Bond yield**	**Inflation**	**Exchange rate**	**Market return and div. yield**	**Inflation and exchange rate**	**Short rate and bond yield**	**Stock return and dividend yield for a country and European market**
	meets in Cannes.									
Aug-95								GERM		
Oct-95	Latvia applies to join the Community									
Nov-95	Euro-Mediterranean Conference in Barcelona. Estonia applies to join the Community									
Dec-95	Madrid European Council. Bulgaria and Lithuania applies to join the Community									
Jan-96	Slovenia and the Czech Republic apply to join the Community									
Mar-96	The Intergovernmental Conference opens at the Turin European									

Date	Event	Univariate Tests					Multivariate tests			
	European Politics	**Market return**	**Short rate**	**Bond yield**	**Inflation**	**Exchange rate**	**Market return and div. yield**	**Inflation and exchange rate**	**Short rate and bond yield**	**Stock return and dividend yield for a country and European market**
	Council									
Apr-96					FRAN***			FRAN***		
Jun-96	Florence European Council									
Nov-96								FRAN***		
Dec-96	Dublin European Council									GERM*
Jun-97	Amsterdam European Council									
Jul-97	Agenda 2000 presented to the European Parliament									GERM**
Oct-97	The Treaty of Amsterdam signed on 2 October 1997									NETH***
Nov-97	Summit on jobs in Luxembourg									
Dec-97	Luxembourg European Council									
Jan-98	Britain's Presidency									

Date	Event	Univariate Tests					Multivariate tests			
	European Politics	**Market return**	**Short rate**	**Bond yield**	**Inflation**	**Exchange rate**	**Market return and div. yield**	**Inflation and exchange rate**	**Short rate and bond yield**	**Stock return and dividend yield for a country and European market**
	of the Community starts									
Mar-98	Membership process of the ten prospective Member States of central and eastern Europe and Cyprus starts, followed by bilateral Intergovernmental Conferences, initially with Cyprus, Hungary, Poland, Estonia, the Czech Republic and Slovenia. Schengen: abolition of immigration control at Italy's land borders									
May-	European Council									NETH***

Date	Event	Univariate Tests					Multivariate tests			
	European Politics	Market return	Short rate	Bond yield	Inflation	Exchange rate	Market return and div. yield	Inflation and exchange rate	Short rate and bond yield	Stock return and dividend yield for a country and European market
98	of Finance Ministers and European Council. Decision on Member States ready to enter the 3rd stage of the EMU									
Jun-98	Cardiff European Council									
Jul-98	Austria's Presidency of the Community starts									
Aug-98										GERM** FRAN** NETH***
Jan-99	Euro is launched. Germany's Presidency of the Community starts.									
May-99	The Treaty of Amsterdam entered into force on 1 May									

Date	Event	Univariate Tests					Multivariate tests			
	European Politics	**Market return**	**Short rate**	**Bond yield**	**Inflation**	**Exchange rate**	**Market return and div. yield**	**Inflation and exchange rate**	**Short rate and bond yield**	**Stock return and dividend yield for a country and European market**
	1999									
Jul-99	Finland's Presidency of the Community starts									
Sep-99										FRAN**
Dec-99	Greece enters the Schengen area									NETH***
Jan-00	Portugal's Presidency of the Community starts									FRAN**
Apr-00		GERM								FRAN***
Jun-00	France's Presidency of the Community starts									
Sep-00		FRAN NETH*								GERM***
Nov-00		UK								
Feb-01	The Treaty of Nice signed on 26 February 2001	SWITZ								
Mar-01										NETH* **

Date	Event	Univariate Tests					Multivariate tests			
	European Politics	**Market return**	**Short rate**	**Bond yield**	**Inflation**	**Exchange rate**	**Market return and div. yield**	**Inflation and exchange rate**	**Short rate and bond yield**	**Stock return and dividend yield for a country and European market**
										GERM***
Jan-02	Euro coins and notes come into circulation									
Jun-02	European Coal and Steel Community (ECSC) expired									
Jul-02	Coins and notes in national currency withdrawn									

*** denotes 1% significance, ** denotes 5% significance, and * denotes 10% significance levels.

Bold underlined font (e.g. **FRAN**) indicates location of sample maximum values and normal font (e.g. FRAN) indicates secondary peaks (local maxima) for the Wald statistics.

Appendix E. Proof that the market price of risk must be positive

Consider the IAPM described by equation (4.1). European price of market risk is weighted average of degrees of risk aversion for investors in all countries. Since relative wealth is nonnegative, and provided investors are risk-averse, the European market price of risk must be nonnegative, and if relative wealth in at least one country is positive, then the European price of market risk must be strictly positive:

$$\delta_{M,t-1} = \theta_{t-1} \big| \{\theta_j > 0, W^r_{j,t-1} \geq 0, \forall j; W^r_{k,t-1} > 0, \exists k\} = \frac{1}{\sum_{j=1}^{L+1} \frac{W^r_{j,t-1}}{\theta_j}} > 0 .$$

Following the same logic, if an investor in country i is risk averse and has some amount of money committed to the stock market, local price of market risk must be strictly positive as well.

Local price of market risk is restricted to be positive in Adler and Qi (2003), while Carrieri, Errunza, and Majerbi (2003) do not place such restriction. We estimated the models both ways and it did not cause a major change in the conclusion. In addition, our "unrestricted" model on a sample of 225 observations $\times 5$ local market price series produced only 30 cases where fitted local market price of risk was negative, for all local prices combined. It appears that positivity of local market price of risk makes more sense at least from ex ante viewpoint. Therefore, here we report the results obtained from the model where both European and local market risk prices are restricted to be positive.

Appendix F. Hodrick-Prescott Filter

Hodrick and Prescott (1997) assume that there is a noisy signal g_t reflected in observable series y_t such that

$$y_t = g_t + c_t.$$

For time series y_t, the HP filter produces series g_t that solves the following minimization problem:

$$\min_{\{g_t\}} \left\{ \sum_{t=1}^{T} (y_t - g_t)^2 + \lambda \sum_{t=2}^{T-1} ((g_{t+1} - g_t) - (g_t - g_{t-1}))^2 \right\}$$

In this paper we use $\lambda = 1600$. Other values of λ produced similar results, which is consistent with sensitivity of the filter to parameter λ reported in Hodrick and Prescott (1997).

Appendix G. Estimation results for firms above and below equilibrium size

Least squares estimation results for equation $r_i = c_1\beta + c_2 DEVSIZE_i^+ + c_3 DEVSIZE_i^- + c_4 + e_i$ for each industry, by company by year, 1986-2004.

Industry Sector code	Beta	Positive Size Deviation	Negative Size Deviation	Constant	Wald Test c(2)=c(3)	
Whole sample	4.160370	-0.000576	-0.007540	53.22655	0.009828	F Stats
t-stats	1.752511	-3.122710	-1.753713	6.366378	(1, 3299)	DF
p-value	0.0797	0.0018	0.0795	0.0000	0.9210	p-value
1000	1.026732	-0.000804	-0.167691	26.25964	3.150370	F Stats
t-stats	0.512863	-1.044902	-1.771477	2.719877	(1, 6037)	DF
p-value	0.6081	0.2961	0.0765	0.0065	0.0760	p-value
2000	10.08978	-0.000735	-0.309289	101.4331	1.551963	F Stats
t-stats	1.157132	-1.740347	-1.247997	2.537896	(1, 14737)	DF
p-value	0.2472	0.0818	0.2121	0.0112	0.2129	p-value
3000	-26.07462	-0.000477	0.069865	64.20138	0.009442	F Stats
t-stats	-0.937996	-2.034399	0.096521	2.181896	(1, 4269)	DF
p-value	0.3483	0.0420	0.9231	0.0292	0.9226	p-value
3500	1.667014	-0.000906	-0.119543	43.00572	0.650371	F Stats
t-stats	0.760758	-2.742671	-0.811740	5.787524	(1, 9772)	DF
p-value	0.4468	0.0061	0.4170	0.0000	0.4200	p-value
4000	-1.936543	-0.000937	-0.006384	39.78398	0.411081	F Stats
t-stats	-0.661331	-2.138146	-0.764975	3.911286	(1, 5022)	DF
p-value	0.5084	0.0326	0.4443	0.0001	0.5215	p-value
5000	3.239135	-0.001719	-0.140662	22.85585	2.760892	F Stats
t-stats	1.056898	-2.205780	-1.683550	5.778915	(1, 1119)	DF
p-value	0.2908	0.0276	0.0925	0.0000	0.0969	p-value
6000	3.170349	-0.000387	-0.033600	29.16285	0.102448	F Stats
t-stats	1.469279	-0.731810	-0.323639	4.071755	(1, 12752)	DF
p-value	0.1418	0.4643	0.7462	0.0000	0.7489	p-value
8000	1.609566	-0.000866	0.017090	45.41050	0.023987	F Stats
t-stats	1.477247	-3.354691	0.147201	6.991828	(1, 14615)	DF
p-value	0.1396	0.0008	0.8830	0.0000	0.8769	p-value
8600	40.18274	-0.003496	-0.017035	247.0501	2.303733	F Stats
t-stats	1.169320	-1.807311	-1.636390	2.051328	(1, 1821)	DF
p-value	0.2424	0.0709	0.1019	0.0404	0.1292	p-value
9000	-17.85040	-0.000343	-0.000958	29.13868	0.009828	F Stats
t-stats	-0.928995	-1.019117	-0.153373	1.925853	(1, 3299)	DF
p-value	0.3530	0.3082	0.8781	0.0542	0.9210	p-value

Here r_i is stock return for company i. $DEVSIZE_i^+$ and $DEVSIZE_i^-$ are deviations from the optimal capital size in each year, they are calculated for year *t* as $DEVSIZE_{j,t}^+ = \max\{ASSETS_{j,t} - OSP_{t-1}, 0\}$ and $DEVSIZE_{j,t}^- = -\min\{ASSETS_{j,t} - OSP_{t-1}, 0\}$, where OSP_{t-1} is the fitted value of the dependent variable in year (t-1) from the regression of the median value for Total Assets for companies in the highest decile of stock returns (MHDS) on the US macroeconomic variables. β_i is company beta in each year, and e_i is regression residual. OLS estimation is performed with White correction for heteroskedasticity.

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