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Explaining the increased German credit spread: The role of supply factors

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Working Paper No. 412

**Explaining the Increased German Credit Spread:
The Role of Supply Factors**

By

Alessio J.G. Brown and Ziga Zarnic

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**“Explaining the Increased German Credit Spread:
The Role of Supply Factors”**

By Alessio J. G. Brown and Žiga Žarnić¹

Abstract

Since 1999 an increase in magnitude and volatility of the credit spread is observable in the German bond market. This paper analyses the credit spread of German industrial bonds focussing on the one hand on the recent period of high volatility of the credit spread and on the other hand on possible influences of structural demand and supply effects. Our empirical estimation is conducted using an Error Correction Model (ECM) for a dataset of monthly time series from 1970 to 2003. We provide evidence on a significant impact of supply effects on the credit spread. Our in-sample forecasts trace the volatility of the credit spread surprisingly well.

Kiel, December 2003

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I. Introduction

Since 1999 an increase in magnitude and volatility of the yield spread between corporate and government bonds is not only observable in the US bond market, but also in the German bond market.² This so called quality or credit spread is defined as the inter-market yield difference between seasoned non-government and seasoned risk-free government bonds³, which are assumed to be identical in all respects except for credit quality.

Much academic work interprets this spread as a measure of market's perception of the credit risk implied with corporate bonds. Since highly rated corporates have little probability of default, the credit spread seems too large to be explained solely by default risk premium. Additionally some studies reveal a low explanatory power of the default risk for the level as well as for the changes in the US corporate yield spread.⁴ In recent literature the yield spread is regarded as a measure of a comprehensive risk premium to compensate investors for a number of risks associated with corporate bonds. Furthermore a possible influence of demand and supply factors triggering the observed recent variations in the spread is discussed. Published empirical work has concentrated though almost uniquely on the US bond market, only very few studies are available for the German market.⁵

The purpose of this paper is to analyse the credit spread of the German corporate bond market, focussing on the one hand especially on the recent period of high volatility of the credit spread and on the other hand on possible influences of structural demand and supply effects. We apply a twofold approach in pursuing our purpose.

Firstly, based on the theoretical and empirical literature we determine the single factors influencing the credit spread and possible proxies to capture their impacts in order to provide a framework to base our empirical estimations on.

Secondly, we attempt to examine empirically the credit spread of German corporate bonds over German government bonds covering monthly time series from July 1975 to June 2003. We estimate a linear error correction model using different proxies to capture possible demand and supply effects and perform forecasts to detect the variables explaining the increased magnitude and volatility of the credit spread. Additionally we employed econometrically plausible instruments to isolate these effects.

² See Chart A-2 for the evolution of the credit spread of German industrial bonds. For the development of the credit spread in the US bond market see among others Lachhammer(2001).

³ Government bonds are generally regarded as the true default risk-free benchmark.

⁴ See Duffie/Singleton(1999), Collin-Dufresne/Goldstein/Martin(2001), Delianedis/Geske(2001), Elton/Gruber/Agrawal/Mann(2001), Huang/Huang(2002); similar Duca(1999) and Lachhammer(2001).

⁵ See Düllmann/Uhrig-Homburg/Windfuhr(2000). Annaert/DeCeuster examine the whole European market, while Nöth(1995) focuses on DM-denominated Eurobonds.

Our results are not clear-cut, which is partly related to the unavailability of sufficiently adequate data to disentangle all effects of the various determinants. Nonetheless we can support findings of previous studies and offer additional findings for the German bond market in line with our purpose. We provide evidence on significant impact of supply effects on the credit spread and our forecasts trace the high volatility of the spread surprisingly well, hinting at variables triggering this development.

The remainder of this paper is organized as follows: following our twofold approach, in the next section we survey related literature to isolate the single determinants. In the third section we pursue the second line of our approach. In the first part of this section, after presenting our methodology, we specify our model and discuss our data. In the second part we present and discuss the results of our estimations and provide some interpretation. The fourth and last section of this paper contains concluding comments.

II. Survey of the theoretical and empirical literature

In this section we survey the existing theoretical literature and previous studies on credit spread in order to isolate the single determinants of the credit spread. The most commonly mentioned factors are the default risk and the risk premium, liquidity effects, the term-structure of the risk-free interest rate and the term to maturity. In addition, according to one of our focuses in this study, we survey the literature on demand and supply effects in order to detect their possible influence and plausible proxies. Moreover we illustrate possible measurement biases, which are encountered in empirical analyses and conclude by pointing out an adequate approach for credit spread analysis.

II. 1 Default risk and risk premium

The theoretical central component of the credit spreads is the default risk, or also referred to as credit risk.⁶ It refers to the probability that the issuer of a bond may default on its obligations and to the associated capital loss, which are clearly affected by current and expected economic conditions. At any given time the yield offered in the market for a specific bond varies according to the current stage of the business cycle and market perception of future economic growth.

The quality spread theory indicates the countercyclical fashion of the default risk, as the spread tends to widen during an economic downturn and narrow during periods of economic prosperity

⁶ The credit risk represents besides the interest rate risk the most important risk investors incur in the fixed income securities market. For an overview of all several types of risks in this market see among others Alessandrini(1999), Chan-Lau/ Ivaschenko(2001), Fabozzi/Modigliani(1992).

due to changes in the perceived likelihood of default of risky issuers and the resulting demand effects of rational investors expectations.⁷ This theory is supported by empirical regularities in the studies of Fisher (1959), Brimmer (1960), Jaffee (1975), Cook/Hendershott (1978), Benson/Sprecher/Willman (1985), Duca (1999) and is consistent with fundamental economics of the business cycle. Additionally Alessandrini (1999) identifies a stronger effect of the business cycle on spreads during recessions.

Any attempt to address the valuation of default risk should start from a theoretical framework, which has received much attention in the theoretical and empirical literature and broadly distinguishes two classes of models. Structural models of default build on the original theoretical paradigm of Black/Scholes (1973), who demonstrate that equity and debt can be valued using contingent claims analysis. This approach was introduced by Merton (1974)⁸ by explicitly linking the risk of a firm's default to the volatility of the firm's value and its leverage. These models reflect the cyclicity of default risk: while leverage is build up during expansion, often revised earnings expectations lead to volatility in the firm's value in the slowdown.⁹ This class includes among others the models of Longstaff/Schwartz (1995), Bevan/Garzarelli (2000), Covitz/Downing (2002), Colin-Dufresne/Goldstein/Martin (2001) and Huang/Huang (2002). While these models allow to qualitatively identify the important factors driving default risk, their complexity and abstractness hamper practical application.¹⁰

Reduced form models represent the second class of default models and provide a simple and more analytical traceable framework for estimating credit spreads by specifying a stochastic default process without tying default risk to the value of the firm. Jarrow/Lando/Turnbull (1997), Duffie/Singleton (1999), Duffee (1999), Elton/Gruber/Agrawal/Mann (2001) among others represent this class.

Annaert/DeCeuster (1999), Bevan/Garzarelli (2000) and Elton/Gruber/Agrawal/Mann (2001) point out that the compensation of investors for the risk assumed goes well beyond the expected loss of default and represents a premium depending on the market's risk preference. Since the isolation of these two components is complicated and to a certain degree random, most of the empirical studies do not differentiate between them, while Elton/Gruber/Agrawal/ Mann (2001)

⁷ This may result form reduced earnings and net growth of corporates during recessions, which leads to impaired debt servicing. Cyclicity of the default risk is considered being the main reason underlying the leading properties of the spread. The usefulness of the yield spread to predict future economic conditions has been investigated in many studies, Chan-Lau/Ivaschenko(2001), (2002), Kwark(2002), Saiko/Takeda(2000), Zhang (2002), among others, see Stock Watson(2001) for an excellent survey. Gertler/Lown(2000) used corporate yield spreads to analyse changes in the output gap, outperforming other leading financial indicators. .

⁸ Refinements made e.g. by Lee(1981) and Pitts/Selby(1983).

⁹ Campbell/Taksler(2002) investigated empirically the effect of firm-level equity volatility on credit spreads. The counter-cyclical behaviour of the credit spreads is also reflected in Bernanke/Gertler/Gilchrist(1998), who developed a financial accelerator theory, in which risk depends inversely on the procyclical net worth.

¹⁰ Delianedis/Geske(2001) overcome the theoretical assumptions by calculating the difference between the observable and option-based estimates and explain this residual spread by non-default risk factors.

is the first study explaining the existence and presenting direct evidence of the risk premium. The authors argue and proved that this premium on corporate bonds is closely related to systematic risk factors explaining risk premium in equity markets and therefore, according to modern risk theory the nondiversificability must be compensated as well in bond markets as in equity markets.¹¹

While early cross-sectional and time series analysis primarily focused on the risk of individual firms and bond issues on a microeconomic basis, category aggregates are used since Silver (1973) and Jaffe (1975). Most empirical studies of reduced form models developed a ratings-based approach, which builds on the assumption that most market participants accept corporate issues within the same rating class as homogenous obligations with respect to risk.¹² Computing average yield spreads based on different rating classes has two advantages, first, the firm-specific unsystematic risks is eliminated, leaving the systematic business cycle related risk¹³ and second the spread contains the aggregate premium demanded by investors for holding bonds of a certain category of risk. Empirical studies, like Boardman/McEnally (1981), Nöth (1995), Duffee (1998) and Alessandrini (1999), have proven a tight relationship between rating and default experience and thus the credit spread. Fons (1987), (1994), Alessandrini (1999), Delianedis/Geske (2001) and Zhang (2002) observed a stronger reaction of low-graded corporate bonds spreads to systematic business cycle-related risk than high-grade bonds else equal.¹⁴ Alessandrini (1999) and Düllmann/Uhrig-Homburg/Windfuhr (2000) detected a higher volatility for lower-grade bonds.

II.2 Liquidity effects

Liquidity is rather subjective concept and little is known about its evolution over time and about its time-series determinants. First of all, it is difficult to define exactly what is meant by when a security is referred to be liquid or illiquid. Liquidity is usually referred to as the ease with which a financial asset can be sold at or near its value. Secondly, there are competing models, which examine different markets and use different measures to capture its effect on bond yields. Mostly it is not clear how much liquidity risk contributes to the spread between corporate and

¹¹ Elton(1999) provides evidence that government bonds are not sensitive to the influences driving stock returns. See Ilmanen(2002) for correlation and causalities between stock and bond prices.

¹² Commercial ratings are accepted due to their semi-official status. Mostly Moody's or S&P ratings are regarded as sufficient metrics for homogeneity. Examples of these models are Duffee(1996), Elton/Gruber/Agrawal/Mann(2001), (2002); Nöth(1995) for Germany. Collin-Dufresne/Goldstein/Martin(2001) group by leverage ratios.

¹³ This risk affects the whole sector of the economy and influences the risk perception of the market. Collin-Dufresne/Goldstein/Martin(2001) reveal a higher explanatory power of aggregate factors than firm-level variables.

¹⁴ Most studies concentrate on investment-grade as junk bonds are issued for special purposes, are seldom held to maturity, are less liquid, are affected by restrictive regulations for institutional investors on the purchase of such bonds and thus less adequate to reflect market expectations on fundamental economic conditions.

government yields. The great majority of the academic literature defines liquidity within market microstructure models in terms of transaction costs.¹⁵ This approach is mainly concerned about inventory risk, which will be priced by market participants in the form of higher bid-ask spreads. Almost all of the academic literature stands the paradigm that illiquid securities require a higher yield than liquid ones. Another important finding is, that in the absence of credit risk the expected liquidity premium decreases with the maturity of bonds.

The theory of immediacy is probably best described with words of James Tobin;¹⁶ a way to think of liquidity is in terms of how much sellers stand to lose if they wish to sell immediately as compared with engaging in a costly and time-consuming search. Defining liquidity in terms of immediacy goes back to Grossmann/Miller (1998) and several studies in the fixed income markets like Ericsson/Renault (2000) and Janosi/Jarrow/Yildirim (2001) refer to this notion. Along the studies of Hasbrouck (1991) some authors refer to the price impact of a potential trade like Dufour/Engle (2000) or to agent's market power like Dimson/Hanke (2001) as definitions of liquidity.

The final answer to the question if liquidity risk is priced by the market can be given empirically. In literature different measures for liquidity were used.¹⁷ For corporate bonds, where most transactions occur on the over the counter market, direct liquidity measures based on transaction data are often not reliable and difficult to obtain.

The quoted bid-ask spread is the classical measure for liquidity. Illiquid bonds imply a higher bid-ask spread due to higher inventory costs. Market participants are reluctant in bearing these costs and try to pass on these inventory costs by charging a higher bid-ask spread. Bonds with a smaller bid-ask spread are more liquid and priced higher.

Fisher (1959) was among the first academics that proposed the issued amount as a proxy variable. He claimed that large issues trade more often, so that the issued amount is actually a proxy for the direct liquidity measure trading volume. Recent studies' results suggest that larger issues are more liquid than smaller issues and should have a higher price and lower yield in order to account for the liquidity premium. Although all studies found the a positive price effect of the issued size on government bond yields, the empirical research on corporate bonds is inconclusive; both positive and negative effects are observed.

¹⁵ Liquidity risk according to transactions cost is best explained through studies of Glosten/Milgrom(1985), Amihud/Mendelson(1986), (1991), Brennan/Subrahmanyam(1996), Haugen/Baker(1996), Brennan/ Chordia/ Subrahmanyam(1998), Vayanos/Vila(1999), Kempf/Uhrig-Homburg(2000) and Chordia/Roll/Subrahmanyam (2001).

¹⁶ See Tobin (1986).

¹⁷ Research on government bonds, including Sarig/Warga(1989a), Amihud/Mendelson(1991), Warga(1992), Elton/Green(1998) and Fleming(2001), as well as on corporate bonds, like Alexander/Edwards/Ferri(2000), Collin-Dufresne/Gruber/agrawal/Mann(2001) and Ericsson/Renault (2001) has been predominately conducted on US data. Data from non-US markets were conducted by Annaert/DeCuster(1999), Dimson/Hanke(2001), McGinty(2001), Jankowitsch/Moesenbacher/Pichler(2002) and Houweling/Mnetnik/Vorst(2003).

In recent studies the number of contributors is used as a liquidity proxy.¹⁸ A bond that is quoted by a larger number of contributors allows market participants to have a wider selection of possible counter-parties for either buying or selling a bond. With respect to this, a bond with a higher number of contributors is found to be more liquid and therefore contains a lower yield.

One of the most interesting suggestions to capture liquidity effects is the use of benchmark bonds. Data vendors like Reuters or Bloomberg offer the information whether a bond is classified as a benchmark bond. Benchmark bonds cover particular maturity buckets and allow market participants to use these bonds for yield curve estimation. It is found that benchmark bonds are more liquid than non-benchmark bonds and should therefore have a higher price and a lower yield.

The difference between on-the-run bond, i.e. the most recently issued bond for a given maturity bucket, and off-the-run bond has usually proven to be a good proxy for liquidity.¹⁹ Prices of on-the-run bonds are related to the primary market and thus show particular liquidity effects. The on-the-run property is closely related to the specialness feature (a bond is said to be “on special” if its repo rate is quoted remarkably lower than the repo rate for comparable bonds) and therefore can be used as a substitute for this effect. On-the-run bonds are more liquid than off-the-run bonds and should therefore have a higher price and lower yield to maturity.

The age of the bond is a popular measure of its liquidity. Sarig/Warga (1989a) observed that while a bond gets older, an increasing percentage of its issued amount is absorbed in investors’ buy-and-hold portfolios. Thus, the older the bond gets, the less trading takes place, and the less liquid it becomes. Moreover, once a bond becomes illiquid, it stays illiquid until it matures. McGinty (2001) emphasized that the new issues are frequently also under-priced, so that traders buy bonds after the offering and sell them shortly thereafter. Usually a positive relation between age and yield is assumed.

If the liquidity of a bond is sufficiently low, it may happen that there is virtually no continuous daily trading in that bond. In some studies this effect was referred to as a price run: two consecutive prices for a bond were identical. A recent study of Houwelling/Mnetnik/Vorst (2003) extended this notion of liquidity by considering not only the occurrence of a price run, but also the occurrence of a missing value, since both cases reflect a lack of activity in a specific bond on a certain date. A positive relation between missing prices and yields is observed.

Tychon/Vannetelbosch (2002) and Houwelling/Mnetnik/Vorst (2003) suggest that yield dispersion, which reflects the extent to which market participants agree on the value of a bond, may be used as a good proxy for liquidity. The first argument is, that if investors have more

¹⁸ See Ericsson/Renault(2001), Jankowitsch/Moesenbacher/Pichler(2002) and Houweling/Mnetnik/Vorst(2003).

¹⁹ See Warga(1992) and Elton/Green(1998).

heterogeneous perceptions, the liquidity premium is larger. Secondly, in spirit of the inventory costs argument, dealers face more uncertainty if prices show a larger diffusion among contributors. Either way, the positive relation between yield dispersion and bond yields can be assumed.

II.3 The risk-free term-structure of interest rates

There are several theoretical arguments concerning the relation between credit spreads and the risk-free interest rate. While structural models postulate a negative relationship between the risk-free rate and the default risk and thus the credit spread (e.g. Longstaff/Schwartz (1995)), reduced form models usually assume for empirical implementation the independence of risk-free interest rates and default risk.²⁰

Mixed empirical evidence has been found on the relationship between the credit spread and the term-structure of the risk-free interest rate. The evolution of the term-structure was mainly associated with the expected future development of the business cycle. In order to study the relationship between credit spreads and the term-structure, empirical studies implement two variables, which summarize most of the variation of the term-structure, the level and the slope of the term structure.²¹ The latter is usually measured as the difference between the long-run government benchmark yield and the three or six-month government yield, while the definition of the level is quite arbitrary as it can be measured at any point of the term-structure.

The findings for the US among others by Duffee (1996), (1998), Alessandrini (1999), for the European market by Annaert/DeCeuster (1999) and for the German market by Düllmann/Uhrig-Homburg/Windfuhr (2000) are to a certain extent comparable. In all studies increasing risk-free government bond yields result in a less than proportional increase in corporate yields and consequently in decreasing credit spreads. This negative relation is stronger for longer maturities as well as for lower-grade bonds. Alessandrini (1999) and Annaert/De Ceuster (1999) argue that the economic significance of the reaction of the spread reflects the business cycle effect and provide evidence that the long-term risk-free yield captures a large proportion in volatility of credit spreads. This argumentation would be consistent with the quality-spread theory, as an increase in the yields reflects an expanding economy and hence lowers the default probability and the credit spread. Bevan/Garzarelli (2000) support the negative relationship over the short-term, over the long run, however, they document a theoretically inconsistent positive relationship.

²⁰ Duffee(1996) pointed out, that a major advantage of these models would be lost, if empirical evidence shows a significant relationship between interest rates and default risk.

²¹ See among others Duffee(1996), (1998), Clare/Oozeer/Preistley/Thomas(2000), Düllmann/Uhrig-Homburg/Windfuhr(2000), Collin-Dufresne/Goldstein/Martin(2001).

Empirical evidence on the reaction in terms of the change in the slope of the term structure is mixed, insignificant or weakly negative. This reaction is inconsistent with business cycle theory as the slope increases during recessions and thus when credit spreads are widening. Different argumentations assuming coupon-biases, misspecifications or different short- and long-term effects are put forward to explain this relation.

II.4 Term to maturity

Theoretically, there is a functional relationship between term to maturity of a corporate bond and its credit spread, which is referred to as the term structure of credit spreads or credit spread curve.²² This relation is regarded as complex and not always monotonically upward sloping, but also a downward sloping behaviour or a hump-shaped function is possible, depending on the risk of the issuing firm.

While the probability of a downgrade of high-rated companies increases with increasing term to maturity, resulting into a upward-sloping credit spread curve, low-grade companies experience an increasing probability of being upgraded the longer the term to maturity and thus a decreasing spread.²³ This functional dependence of the credit spread on the maturity has been empirically supported by Fons (1994) and Sarig/Warga (1989b).

Helwege/Turner (1999) argue, that the downward-slope might result from a sample selection bias related to the use of ratings-related aggregate spreads. Due to existing credit quality differences within rating classes endogeneity of maturity choice is introduced, as higher-quality companies within one class tend to issue longer-dated bonds.²⁴ Consequently the average spread for low-grade bonds with increasing maturity is underestimated, as the downward-sloping curve results from less risky bonds in the long-term market within the same class.

A large number of empirical studies find only positively sloped credit spread curves. These empirical results, which contradict theory, are explained by dependence on parameter values or no directly applicability of theories for individual firms to aggregate credit spreads. The issue is still quite controversial.

²² See Merton(1974), refined by Lee(1981), Pitts/Selby(1983),and theoretically supported by Rodriguez(1988), Longstaff/Schwartz(1995), Jarrow/Lando/Turnbull(1997).

²³ Johnson(1967) developed the crisis to maturity approach, assuming that highly-leveraged firms might face financing problems when debt matures. Consequently default risk is reflected in higher spreads at lower maturities.

²⁴ Similar Zwang(2002) and Chan Lau/Ivaschenko(2001), arguing that markets are discriminating, shutting out low-quality companies from the long-term markets.

II.5 Demand and supply effects

Several studies point out the existence of additional aggregate factors influencing the credit spread, which seldom are included in the models and distort economic relationships. These factors diminish the co-movement between the yields and lead to a certain portion of unexplained credit spread.²⁵ This residual spread is explained by demand and supply effects, which can also be triggered by market-wide shocks and structural changes.

Examples for market-wide shocks are major economic and financial market adjustments, as the Russian crisis in 1998, resulting in a flight to quality effect. Investors flee out of equities and risky bonds and seek refuge in safe havens. Government bonds are regarded as near monies and provide the wished quality and liquidity. As a result of these aggregate liquidity demand and altered aggregate risk perceptions, which should be distinguished from the liquidity risk of a specific issue or sector and the cyclical risk premium of corporate bonds, referred to above in this study, government bond yields decrease while corporate bond yields tend to increase and therefore the credit spread widens. These effects might invert the observable co-movement of corporate and government bond yields. Therefore the change of credit spreads in such periods might be not explainable through the commonly used factors.²⁶

The reasons for possible demand and supply-driven effects on credit spreads have been mainly analysed for the US-market. Various explanations have been put forward to explain the factors driving relative supply. While Brimmer (1960) and Duffee (1996) link corporate bond issuing in contrast to government bond issuing to the level of the interest rate, Bevan/Garzarelli (2000) and Chan-Lau/Ivaschenko (2001) emphasize a recently continuously growing ratio of bond financing in total debt financing of the corporate sector. Increased relative corporate bond supply will push down prices and hence widen the credit spread. A shrinking supply of government bonds also triggers an increase of relative corporate bond supply. Brooke/Clare/Lekkos (2000), Fleming (2000) and Schinasi/Kramer/Smith(2001) point out the effect of the overall reduction of budget deficits and the US debt buyback, which increase the price and hence lower the yield of government bonds.

Demand side effects can be triggered by the above mentioned flight to quality or by regulatory changes for key institutional investors like insurance companies or pension funds.²⁷ In addition the decreasing supply of US-treasuries might lead in the long-run to an intersectoral or

²⁵ See among others Duca(1999) and Collin-Dufresne/Goldstein/ Martin(2001).

²⁶ See Duca(1999), Schinasi /Kramer/Smith(2001).

²⁷ For the latter cause see Brooke/Clare/Lekkos(2000)

international substitution of US-Treasuries as safe haven and investment asset for institutional investors and hence influence the spreads in the future.²⁸

Empirical studies by Cook/Hendershott(1978) and Bevan/Garzarelli (2000), however, revealed no significant influence of relative security supplies on credit spreads.²⁹

Furthermore major structural changes like the adoption of the single currency in the Euro-area led to demand and supply effects. In the late 1990s and the beginning of 2000 remarkable increases of corporate bond issues were observable, although still very modest compared to the US.³⁰ This resulted from different financing needs generated partly by the EMU³¹ and enhanced by the opportunity of accessing the whole Euro-area bond market, especially for corporates previously absent from capital markets.

Analysing these residual factors is hampered by the difficulties involved in disentangling these structural effects as well as technological advances and regulatory developments. Moreover Annaert/DeCeuster (1999) and Friedman/Kuttner (1992) indicate the possibility of reverse causalities of the residual factors and possible correlations with the commonly used factors.

II.6 Measurement biases

Potential tax-related bias

A first possible bias is induced by the way coupons and gains are taxed. Düllmann/Uhrig-Homburg/Windfuhr (2000) introduced the tax effect in their model and used the coupon-size as a proxy for the tax effect, which led to significant results.³² Different taxation of coupon payments and capital gains imply that a higher coupon size results into higher taxable income for investors affected by this regulation. Consequently the yield spread might include an offsetting tax premium. In addition the tax timing effect might increase this tax premium, which until Elton/Gruber/Agrawal/Mann (2001) had been ignored. But since capital gains are taxed in the period of the sale, bonds with low coupons may be more valuable as the bondholder can decide on the timing of the payment of the capital gains taxes.

²⁸ See Flemming(2000).

²⁹ The former used as a proxy the difference between the book value of corporate bonds, net of the rest of the world and the level of long-term treasury debt, net holdings of the US government and the Fed and the latter used the difference between the net issuance of corporate bonds deflated by CPI and government securities.

³⁰ See Santillán/Bayle/Thygesen(2000) and ECB(2003).

³¹ Santillán/Bayle/Thygesen(2000) mention the consolidation process of the area-wide corporate sector, the boosting merger and acquisition activities and the purchases of UMTS licences.

³² The tax premium plays a greater role in the USA due to different taxation of interest payments on corporate bonds and on government bonds, see Silvers(1973), Warga(1992), Duffee(1996), Bevan/Garzarelli(2000), Delianedis/Geske(2001) and Elton/Gruber/Agrawal/Mann(2001). Elton/Gruber/Agrawal/Mann(2001) grouped corporate bonds by coupon-size.

Potential coupon-induced bias

The credit spread should not be computed on the basis of yields to maturity of coupon bonds but on the basis of yield to maturity of zero-coupon bonds as the former might introduce a bias.³³ As corporate bonds have a higher coupon than government bonds, while having the same maturity, they have a shorter duration. Hence an increase in the interest rates leads to a higher relative increase in the yield of the government bond and therefore to a decreasing spread. Using yields on zeros has the disadvantage that the yields have to be estimated.³⁴ Campbell/Taksler (2002) state that it is not clear whether a credit spread analysis must measure spreads in relation to a zero-coupon curve, as they find similar results using the estimation, or not. Delianedis/Geske (2000) propose to compare bonds with similar duration, which adjusts for differences in coupon rates.

Index-refreshing bias and sticky-rating bias

As noted above, recently ratings-based approaches are applied, assuming that issues within a rating class are regarded homogenous with respect to risk.³⁵ Aggregate measures of credit yield spreads rely on these ratings-based indices, which contain several shortcomings. As pointed out by Duffie/Singleton (1995) and Bevan/Garzarelli (2000) a bias results from the fact that these indices are refreshed, i.e. they assume a fixed measure of credit quality over time. The change in the yield between two periods measures not the change of the mean yield of the same set of bonds, but of two subsequent sets of bonds with the same credit rating. Hence using these indexes will lead to an underestimation of the spread's reaction to systematic variables, as a part of the reaction will be reflected in the change of the credit rating.³⁶

Furthermore, Düllmann/Uhrig-Homburg/Windfuhr (2000) emphasise the possibility that credit ratings might not reflect true credit qualities, as rating agencies react slower than the market and thus might not represent market's perception of credit quality and introduce a bias (sticky rating effect).³⁷ In addition Elton/Gruber/Agrwal/Mann (2002) stress the influence of possible differences between ratings by different agencies and differences between the company's rating and the rating of the issue.

Special features-related bias

In order to avoid further biases all bonds with special features introducing or weakening bond-related risks, which result in different prices and hence yields, should be eliminated. These

³³ See among others Annaert/DeCeuster(1999) and Elton/Gruber/Agrawal/Mann(2001).

³⁴ As zeros are usually not available. Most studies implement the parsimonious model by Nelson/Siegel(1987).

³⁵ For an overview of structure, significance of ratings and possible applications in estimations see Nöth(1995).

³⁶ Duffee(1996) argues, that in the extreme case the aggregate yield would be constant under the assumption of finest ratings, simultaneous reactions and market-like valuation.

³⁷ The authors controlled for this bias by considering the magnitude and timing of a bond's next rating change.

special features include convertibility, which is more common in Germany, option-like features like callability and sinking funds provisions, seniority, collaterals attached, floating-rates, odd frequency of coupon payments, government flower bonds and inflation-indexed bonds.³⁸ Especially the callability of corporate bonds, which is fairly common in the US, has been awarded attention in the literature and included in some studies. Yield spreads on callable bonds move more inversely with the risk-free interest rate as their variations over time partly reflect variation of the call option value.³⁹ As most indices include special-features bonds in order to exclude these, corporate bond indices must be constructed from individual bonds.

Cross-sectional bias

Due to the heterogeneity of issuers even in the same rating class corporates differ in their sensitivity to systematic influences and hence should be additionally grouped in more homogenous subsamples by sectors, especially in industrials and financials.⁴⁰

Summing up, in order to investigate the different components of the credit spreads, indices of corporate bonds should be computed by controlling for the several possible sources of biases and grouped by rating, maturity or even duration bucket and industry classification. While computing subsets of bonds one faces a trade-off between homogeneity on the one hand and on the other hand averaging out idiosyncratic risks and data availability, which is limited due to the sampling procedure. The corporate yield spread can be analysed by proxies for the relevant single factors influencing the spread, but nonetheless drawing economic inferences should take the into consideration interdependences between these factors.⁴¹

III. Modelling the german credit spread using an error correction model

This study models the determinants of the credit spread in an attempt to detect relevant variables triggering the increase of magnitude and volatility of the high volatility period. In addition to the focus on this period, our focus lies on the detection of possible influences of demand and supply effects. Our methodological purpose is to investigate whether a linear regression can be adopted for credit spread modelling.

³⁸ See Anderson/Pan/Sundaresan(2000) for a brief survey on pricing of convertibles; Annaert/DeCeuster(1999) for seniority and collaterals.

³⁹ Duffee(1998) presents evidence that this feature can change credit spread's behaviour and compares callable and non-callable bond indices. See also Silvers(1973), Cook/Hendershott(1978), Duffee(1996) and Duca(1999).

⁴⁰ See for example Duffee(1996). Boardman/McEnally(1981) and Düllmann/Uhrig-Homburg/Windfuhr(2000) used dummies for industry classification.

⁴¹ As for example the term structure is linked to the business cycle and the liquidity also depends on the term to maturity of the bond.

III.1 Methodology, model and data

In our empirical analysis we apply a step-by-step approach. First we estimate a base model in order to detect the main determining variables of the credit spread in Germany. Then successively we add further variables, especially different proxies designed to capture demand and supply effects.

For each of these models we first specify and estimate a model for the period from September 1977 to June 2003 in order to detect the significant determinants for the whole period.⁴² In addition we apply an in-sample forecast for the period January 1999 to June 2003, which is the period characterized by the observable increase of magnitude and volatility of the credit spread,⁴³ in order to assess the fit of our model in explaining this period. Assuming that some variables may be instable and will only be sufficiently significant in the whole sample due to their impact in the volatile period of the spread, in a second step we specify and estimate a model for the reduced series from September 1977 to December 1998. The results of this estimation together with the respective out-of-sample forecast enable us to assess whether our assumption could be verified and to identify the relevant variables. As our findings confirm our assumption, we prove them by including an interactive dummy for the specifically relevant variable.

Our analysis is conducted using a so-called Error Correction Model (ECM) in an attempt to separate the long-run relationships and short-term dynamics pertaining to the credit spread. The ECM is also appropriate in order to analyse a possible cointegration relationship between the variables. We assume weak exogeneity of our explanatory variables, which seems appropriate using long-term time series of financial markets data.

We define the following ECM for the credit spread:

$$\Delta y_{s_t} = -(1 - \bar{b}_0)ECT - \sum_{j=1}^J \bar{b}_j \Delta y_{s_{t-j}} - \Delta \bar{X}_{t-j} + \varepsilon_t \quad , \text{ where} \quad (1)$$

$$ECT = [y_{s_{t-1,m}} - \beta_0 - \beta_i X_{t-1}]$$

is the error-correction term, which contains the long-run relationship

$y_{s_{t,m}} \equiv r_{t,m}^i - r_{t,m}^g$ is the difference between the yield of industrial and government bonds for the same maturity or duration m at time t ;

$\Delta y_{s_{t-j,m}}$ is the first difference of the dependent variable $y_{s_{t,m}}$ at time $t-j$, where j stands for the number of lags and J for the maximum number of lags;

X_{t-1} is a vector enclosing the i explanatory variables in the model

⁴² In the following we will refer to this period as the whole sample.

⁴³ In the following we will refer to this period as the volatile period.

$\Delta \bar{X}_{t-j} = \sum_{j=0}^J \bar{a}_{ij} \Delta x_{t-j}$ is a vector of the first differences of the i explanatory variables at time $t-j$,
with j lags;
 ε_t is the error term at time t .

After defining the model we specify the dynamics by choosing the optimal lag order to ensure uncorrelated disturbances, as under the presence of autocorrelation the least squares estimator turns inconsistent. The choice of the optimal lag length is pursued according to the information criteria on the condition of no autocorrelation.⁴⁴ In order to avoid overparametrisation of our model in a further step we delete insignificant lags and end up with a more parsimonious specification. Additionally we include impulse dummies to eliminate a small number of extreme observations, which led to distorted estimation results.⁴⁵ Finally for each specified model we accounted for possible heteroscedasticity-problems by performing a linear regression producing robust errors, we verify the hypothesis of no autocorrelation by means of the Augmented Dickey-Fuller (ADF) and Phillips Perron (PP) test and check for cointegration.⁴⁶

We constructed a dataset of monthly time series from August 1975 to June 2003. In order to avoid the biases mentioned above and to exclude unsystematic risks we wanted to group credit spreads, as mentioned in the previous section, by ratings, sector and duration bucket. Unfortunately at present this data was not available at our sources.⁴⁷ Ratings for the German bond market are not publicly available. Government and public⁴⁸ bond yields can be obtained disaggregated by maturities. Corporate bond yields are obtainable grouped by sectors and while bank bonds yields divided by maturity bucket are available, for the industrial sector disaggregated data by maturities is not available.

Graph A-1 presents the aggregate yields of the different sectors in comparison to the government sector. Closely related movements of public and government bonds are observable as well as slight credit spreads for bank bonds. Yields on industrial bonds contain the highest credit spreads as can be seen in Graph A-2. Therefore for our credit spread analysis we have

⁴⁴ We assumed due to monthly data a maximum lag length of 25 lags. The specification criteria used are the consistent Schwartz Criterion and Hannan-Quinn Criterion. We tested for 1. to 25. order of autocorrelation by means of the Breusch-Godfrey LM-test.

⁴⁵ Naturally we did not include any impulse dummies for the volatile period, as this is the period our focus lies on.

⁴⁶ The results of the autocorrelation tests are presented in Table B-3, which includes only tests until the 12. order of autocorrelation, while we tested until the 25. order. The ADF-tests were preceded by graphical inspection suggesting the type of test to choose and represented in Table B-1. All estimated model-results are presented with the robust error feature.

⁴⁷ Our data is taken from the time series database of the German Bundesbank, Datastream Advance and the IFS database, constructing a data set of monthly time series from August 1975 to June 2003. The difference to the time period of our estimations results from the model specification as we test for a maximum number of 25 lags.

⁴⁸ German public bonds include in contrast to German government bonds issues of its special agencies and issues of local authorities.

chosen to define credit spreads as the difference between industrial bond yields and the benchmark government bond yield, being fully aware of the limitations resulting from aggregate data.⁴⁹ It should be kept in mind though that the industrial bonds, i.e. non-bank corporate bonds, represent the smallest sector in Germany due to primary reliance on bank financing.⁵⁰ Graphical inspection leads to the assumption that the credit spread is stationary until the end of 1998 and then following a random walk and being integrated of first order in the whole sample. Testing for stationarity confirmed this assumption for the reduced period, while the whole period is a border case leading us to stick to our assumption.

Following economic theory and previous studies, in section II of this study we have identified determinants of the credit spread and presented a certain choice of proxies, which we tried to apply to our study, while facing constraints by data limitations. Table 1 presents the explanatory variables of the estimated models with the expected, in line with theory and previous studies presented in section II, direction of their effects on the credit spread.

Table 1: Explanatory Variables and Expected Signs on the Coefficients of the Regression⁵¹

Variable	Description	Sign
$out_r_t \equiv \frac{out_i_t}{out_g_t}$	The ratio between the average outstanding amount of industrial bonds and the average outstanding amount of government bonds at time t	+
$out_c_t \equiv \frac{out_i_t}{credit_t}$	The ratio between the average outstanding amount of industrial bonds and bank credits to firms	+
$slope_t \equiv (r_{t,10}^g - r_{t,1/2}^g)$	The slope of the yield curve as the difference between the 10-year and 6-month government bond yields at time t	–
$lty_t \equiv r_{t,10}^g$	The long-term yield on government bonds at time t	–
$vDAX_t$	The monthly volatility of the performance index DAX at time t	+
net_i_t	The net amount of issues at time t	+
$stepvDAX_t$	The interactive dummy variable for the volatility of the performance index DAX at time t	+
$stepnet_i_t$	The interactive dummy variable for the net amount of issues at time t	+

In line with previous studies we proxy the term-structure of the risk-free interest rate by the level and the slope and expect a negative influence on the spread.⁵² The level is defined as the 10-year government benchmark rate and the slope as the difference of this benchmark rate and

⁴⁹ Yields are defined as net yields to maturity. Due to the aggregate character of the data we can neither account for the term to maturity influence nor control for coupon- and tax-related biases.

⁵⁰ See Graph A-5 presenting the relative outstanding volumes of corporate industrial bonds to government bonds and Graph A-8 presenting the net issues of the industrial bonds.

⁵¹ Values are continuously in Euro.

⁵² See Section II.2. See Graphs A-3 and A-4.

the 6-month government bond yield. According to the stationarity-tests both level and slope of the risk-free term-structure have proven to be integrated of first order.

As a proxy for the cyclical component of the credit spread we used the IFO business climate index.⁵³ In all our estimations this measure appeared to be highly insignificant. Alternative measures like GDP or the unemployment rate did not improve this result. As a consequence on the one hand we assumed in line with previous research that part of the cyclical risk is already controlled for by the term structure and follow the argumentation of Benson/Sprecher/Willman (1985), who noted that mostly one measure capturing cyclical variations would be sufficient as more might establish multicollinearity. On the other hand we tried to capture the systematic risk premium by using the monthly volatility of the equity markets and proxied it by computing the monthly variance of the DAX performance index based on daily data. As an alternative measure we also used the monthly change of the DAX performance index, which was always less significant. In line with theory and empirical studies the expected sign of the coefficient is positive.⁵⁴ The unit root-test reflects first order of integration of the variable.⁵⁵

In section II we discussed most frequently used and reasonable proxies for the liquidity risk. Neither direct measures of liquidity nor indirect measures were available due to lack of data. For example bid-ask-spreads are not published in Germany and the frequency of quotes and disaggregated turnover volume not obtainable. While on-the-run-yields of industrial bonds were obtainable in order to compute the difference between off-the-run- and on-the-run-yields as a proxy for liquidity, the inspection of the data revealed insufficiently continuous issues of industrial bonds over the whole sample. Consequently we had to omit this determinant due to unavailability of data.

As one purpose of this analysis is to investigate the influence of effects associated with demand and supply, in line with the above-mentioned growing importance of corporate bond financing⁵⁶ we constructed different proxies, supposed to capture these effects.⁵⁷ In order to account for the possible influence of an increase in the relative security supplies we computed the relative aggregate outstanding amount of industrial to government bonds (see Graph A-5). We also wanted to compute the ratio and difference of industrial to government monthly net issues to measure the impact of the increasing and highly volatile industrial net issued amounts (see

⁵³ The IFO business climate index is one of the most important indicators in Germany, based on regular qualitative company surveys and represents one of the longest data series produced by private organizations in Germany. See Kunkel(2003). Jaffee(1975) and Cook/Hendershott(1978) used a measure of consumer sentiment.

⁵⁴ See for example Bevan/Garzarelli(2000), Lachhammer(2001), Delianedis/Geske(2001).

⁵⁵ See Graph A-7.

⁵⁶ The German Bundesbank stated in the November monthly bulletin that the outstanding amount of corporate bonds has been rising by 45 % compared to the previous year.

⁵⁷ However we restrict ourselves to the detection of supply effects, because demand effects are hard to trace as at present neither theory nor previous studies revealed possibly adequate proxies.

Graph A-8), but the net issues of government bonds were not available. Hence, being aware of the misspecification of this proxy, we used just the aggregate monthly net industrial issues as a variable. Additionally we accounted for the increasing share of bond financing in overall corporate financing at the expense of bank financing by computing the relative outstanding amount of industrial bonds to overall bank financing to firms (see Graph A-6). We expect a positive sign of the coefficient of these proxies, as an increased supply pushes down the price and hence increases the yield.

Graphical inspection of the development of the different variables shows, that the volatile period of the spread approximately since 1999 can be related to the increasing supply ratio and the increasing and more volatile net issues. As a consequence, linear estimation seems to be plausible.

III.2 Results and interpretation⁵⁸

We first estimated a reduced model (ECM 1a) just containing the term-structure variables for the whole sample. The results presented in Table B-4. The coefficients have the expected negative sign and while the level is highly significant, the slope is less significant (only at 10% error probability). These results are consistent with previous studies. The estimation for the reduced period (ECM 1b, see Table B-5) leads to higher significance of the variables. Together with the higher R^2 and the lower specification criteria⁵⁹ for this model this implies that the explanatory power of the term structure is reduced in the whole sample due to the higher volatility of the spread, which cannot be explained by the term-structure. Both in-sample and out-of-sample forecasts do not trace the volatile development of the spread and the only difference between these two consists in the higher level of the forecasted spread in the whole sample due to a strong increase by 40% of the significant constant (see Graphs A-9, A-10).

In an attempt to capture the increased volatility of the credit spread we added the volatility of the DAX as a further explanatory variable. While in the whole sample (ECM 2a, see Table B-6) the aggregate volatility of the German stock market is highly significant and has the expected positive sign, in the reduced period (ECM 2b, see Table B-7) it turns out to be insignificant.⁶⁰ The in-sample forecast reflects an interesting finding, as especially the first peak of the credit spread is fairly well traced and to a minor degree the second peak (see Graph A-11). In addition the higher level of the spread can be explained by this variable, this might imply a higher premium demanded by the market due to altered risk perception. The coefficient is extremely

⁵⁸ See Table B-2 for an overview of the different estimated models.

⁵⁹ These measures are presented with every result

⁶⁰ The insignificance of the term structure, especially in the whole sample, might result from multicollinearity, omitted variables or the limitations of the aggregate data.

low, which can be explained by the very high computed volatility values since 1997.⁶¹ The out-of-sample forecast just hints at the first peak (see Graph A-12).

In a next step we included successively the proxies for the supply effects in an effort to investigate their significance and to improve the fit of the forecast regarding especially the second peak.

First we ran our models including the relative aggregate outstanding amounts. In the whole sample (ECM 3a, see Table B-8) both the relative amount of the bond supplies as well as the volatility measure are highly significant, while the level of the term-structure is still significant at a 10% level and the slope is insignificant. The coefficient of the supply variable is positive as expected and has a low value. When interpreting the size of this influence one has to keep in mind that in the period from September 1999 to June 2003 this share increased from ca. 0.01 to ca. 0.07. Additionally this relationship can be also observed in the reduced period (ECM 3b, see Table B-9), as one would assume after graphical inspection due to the evolution of this variable prior to 1986. While for the reduced period the influence is just slightly weaker, the significance is given only at a 10% level. These results lead to the conclusion that supply effects have a continuous influence on the yield spread, but which prior to 1986 was much weaker than since 1999.⁶² Unfortunately the added variable does not improve the fit of the in-sample forecast (see Graphs A-13, A-14).

In the reduced period the variance of the DAX was significant only at a 10% level. This leads to the assumption that in contrast to the ratio of outstanding amounts it does not influence the credit spread in earlier periods, as the graphical inspection reveals that high volatility of the DAX exists only since the late nineties. In order to test this assumption we construct an interactive dummy variable for the volatility⁶³ and estimate the model with this variable for the whole sample (ECM 4, see Table B-10).⁶⁴ The results confirm our assumption, as the interactive dummy is highly significant. Furthermore the significance of the level of the term-structure is improved to a 5% level.

Unfortunately in all the estimated error correction models the null hypothesis of no cointegration cannot be rejected, implying that the loading coefficient is not significantly different from zero, which hampers the interpretation.

Additionally we specify two further models using alternative proxies to capture the supply effects again attempting at explaining the second peak of the credit spread in the volatile period.

⁶¹ See Graph A-7.

⁶² The period in-between can be regarded as relative tranquil concerning the spread and the relative bond supplies.

⁶³ The interactive dummy is computed by multiplying the volatility variable with a step-dummy with the value 1 since 1997 and 0 before.

⁶⁴ For the forecast see Graph A-15.

We are fully aware of the possible theoretical and methodological misspecifications of the variables and the resulting models. Consequently we will just discuss the interesting findings. The first additional model (ECM 5, see Table B-11) is run for the whole sample and includes the computed ratio of outstanding industrial bonds to credits to the corporate non-bank sector. The added variable is highly significant, has got a high coefficient and has the expected positive sign.⁶⁵ The interesting result of this model is reflected by the in-sample forecast, as the alternative regressor improves the fit of the forecast regarding the second peak of the volatile period (see Graph A-16).

In the second additional model (ECM 6, see table B-12) while keeping in the ratio of bond to bank financing we exchange the proxy for volatility of the DAX with the respective interactive dummy in line with the argumentation above. Furthermore we add an additional interactive dummy for the monthly net issues of industrial bonds taking up the value of the issues since 1999, as the graphical inspection suggests an increase in magnitude and volatility of the net issues of the industrial sector since that time. Interestingly, in this model the in-sample forecast fits the second peak in the credit spread even better (see Graph A-17). However the sign of the coefficient of this variable is contrary, to the expectation, negative.

Summing up, our evidence for the German industrial bond market supports theoretical and empirical literature, which is mostly for the US-market. Unfortunately strong results regarding the cointegration relationship could not be detected, though this might result from the aggregate character of our data and should not be generalized. Our error-correction-models included few transitory dynamics, with a maximum of one lag, which seems to be quite plausible when dealing with financial markets data.

The signs of the coefficients for the term-structure are negative and generally, we have a significance of the level at minimum 10%, while the slope is mostly insignificant. Both results are consistent with theory and previous studies. Our base model forecast reflects a good fit until mid 1999, the beginning of the period of increasing volatility and magnitude of the credit spreads. In a next step we introduced a proxy for the stock market volatility and provided evidence on its influence on the credit spread. This influence is mainly significant since 1997, as since this point of time a huge increase in stock market volatility is observable. This can be interpreted as a structural change, which altered the risk perception of the market, as the volatility prior to this period did not have any significant impact on the spread. We showed that

⁶⁵ In addition, we can reject the null-hypothesis of no cointegration at 10% error probability. The long-run coefficient value of 19.85079 implies that an increase of this ratio by one percentage point increases the yield spread by approximately 0.2 percentage points. The interpretation of this influence has to consider the increase of this variable from 0.01 in June 2000 to 0.06 in May 2003. We are not going to further pursue the interpretation of the value due to the misspecifications mentioned.

the first of the two highest peaks of the credit spread can be explained by the volatility of the stock market.

The combination of the base model with this volatility measure represents the only model in which the level of the term-structure is insignificant, this can be explained by multicollinearity, as the volatility of the stock market will have reflected prior to 1997 the business cycle effect, which according to our argumentation above is at least partly captured by the term-structure.

We have proven significant influence of supply effects on the magnitude and volatility of the credit spread for the German bond market, fulfilling also this main purpose. While our “clean” proxy provided evidence on an increasing influence and reflected the increasing importance of the industrial sector bonds relative to the government bonds, it could not explain the peaks in the latest credit spread evolution. Using alternative measures we could provide some evidence reflecting the impact of supply factors on the high volatility of the spread as the respective forecasts traced the second peak surprisingly well. Being aware of the limitations related to the last two proxies and the misspecifications of the resulting models we attempt at interpreting these results. The higher reliance of corporations on bond financing relative to bank financing reflects the change of capital structure of corporates, moving from former bank-based financing to the bond market. This supply effect triggers higher credit spreads.

The negative coefficient of the interactive dummy related to the net issues of industrial bonds can be explained, though partly contradictory to the interpretations for the two former proxies, by the expansion of the bond markets in euro-area as a result of the EMU, which leads to increasing liquidity and transparency in this market and hence reduces the credit spread.

The instability of the variables, reflecting structural changes, the lacking robust cointegration relationship and the highly unstable results to altering specifications imply that non-linear estimations might provide more stable results.

We are fully aware of the limitations of our estimations, especially the highly aggregated data that might disguise important influences, as well as our omission of determining variables and finally the assumption of weak exogeneity. The former two limitations though result from the present unavailability of adequate data in Germany. While the latter limitation arises due to possible reverse causalities, especially concerning the supply effects.

IV. Conclusion

Our aim was to try to explain the recent remarkably volatile development of the credit spread in the German corporate bond market. In addition we wanted to investigate the role played by the demand and supply effects, at which the literature mainly just hinted at. We presented the possible determinants and an appropriate approach for an empirical estimation of the credit spread. Though, we could not apply our findings to our estimations due to the unavailability of disaggregated data for the German bond market, which hindered us in disentangling all the relevant effects.

Generally, we confirmed for the German market results of previous studies and our findings support the view that the credit spread is not an adequate measure for default risk. We have provided proof that supply effects play a significant role in determining the credit spread on German industrial bonds. Furthermore our findings suggested a change in the risk perception of the market since the late nineties in line with the increased volatility of the stock market. Our forecasts for the highly volatile period presented a fairly good fit of the development of the credit spread. Employing econometrically plausible instruments we achieved the isolation of the variables explaining the recent development of the spread. We provided evidence that the first peak in the latest development of the credit spread can be traced by the volatility of the stock market and that the second peak is influenced heavily by supply effects.

Nonetheless we could not detect a long-run relationship, our results are not very robust and consequently include some limitations. We assume that a non-linear estimation would be better suited for an empirical analysis of the German credit spread.

Concluding, this paper attempted to contribute in extending the scarce literature on German credit spreads, especially in light of the recent developments, like EMU and the resulting evolution of the European corporate bond market. These developments are reflected in the German bond market and have affected the credit spread significantly.

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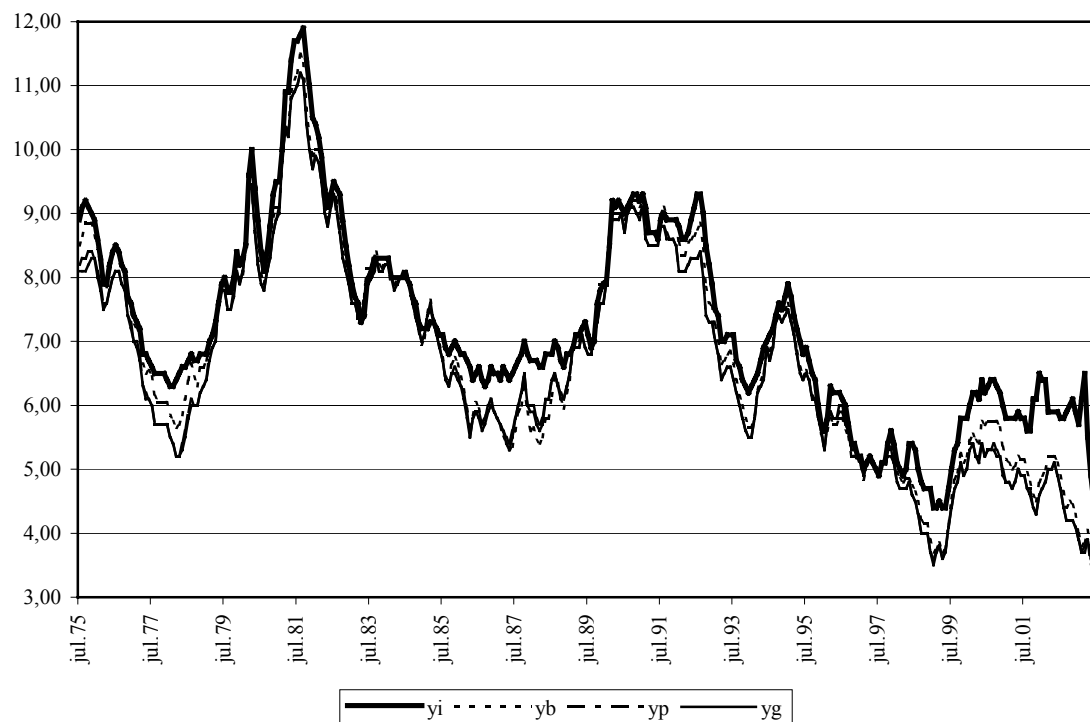
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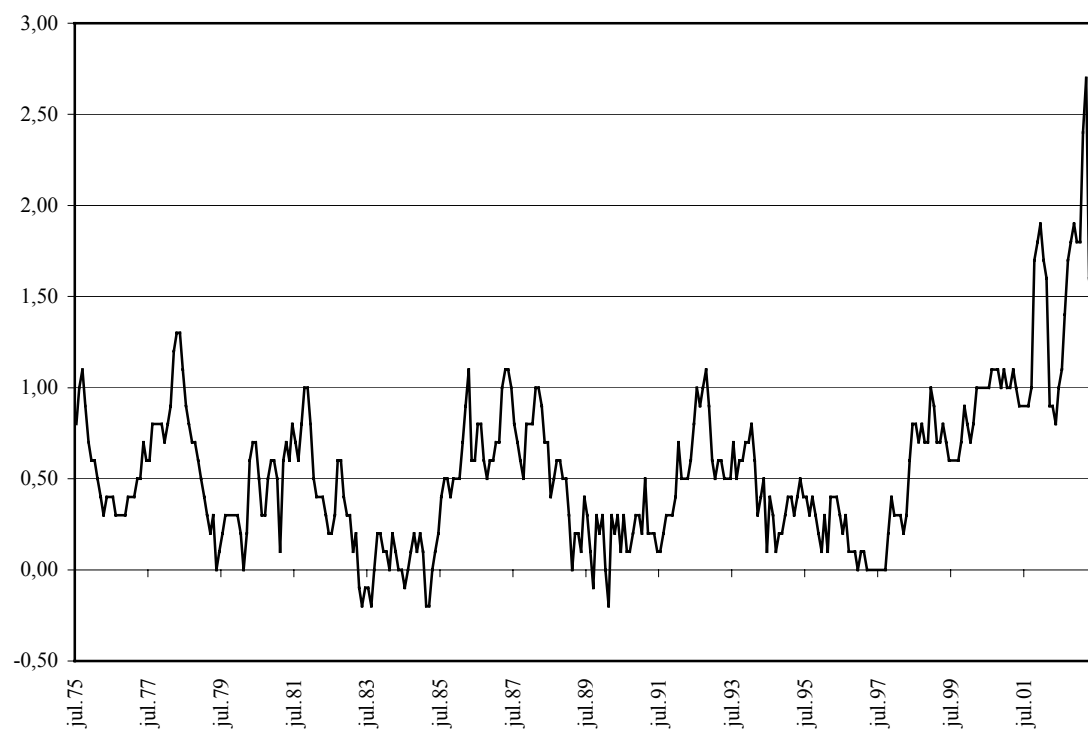
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Appendix A: Graphical presentations

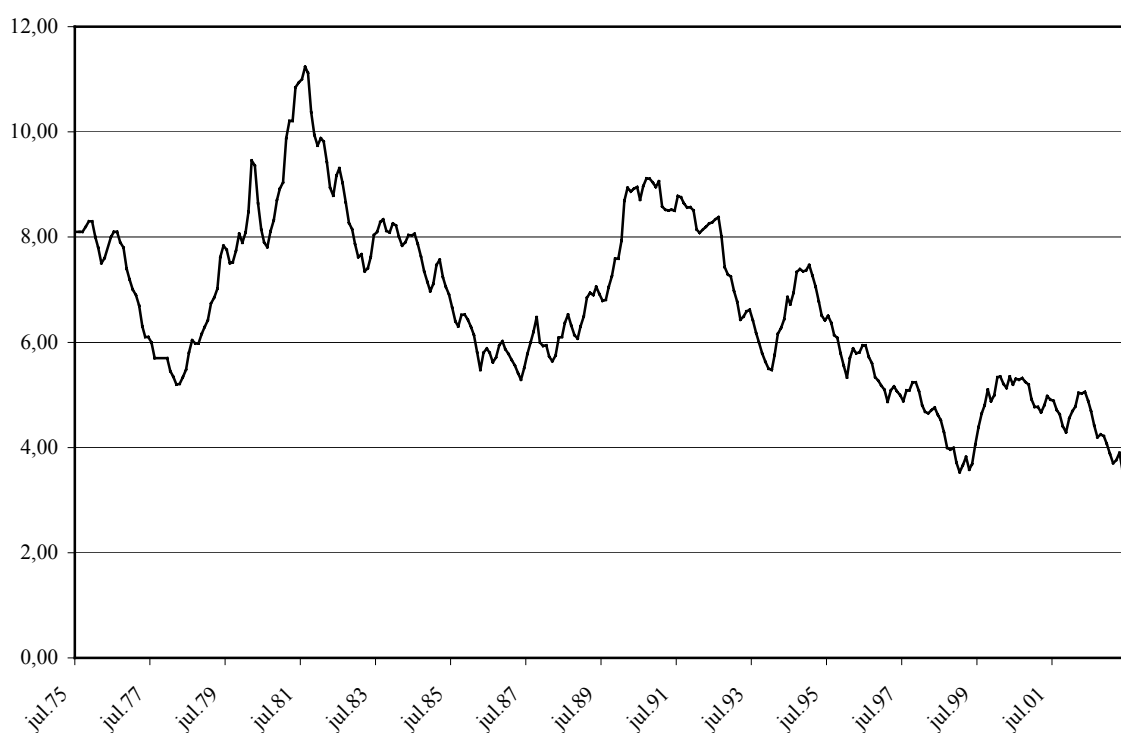
Graph A-1: Monthly series of industrial bond yields [yi], bank bond yields [yb], public bond yields [yp] and industrial bond yields [yi]



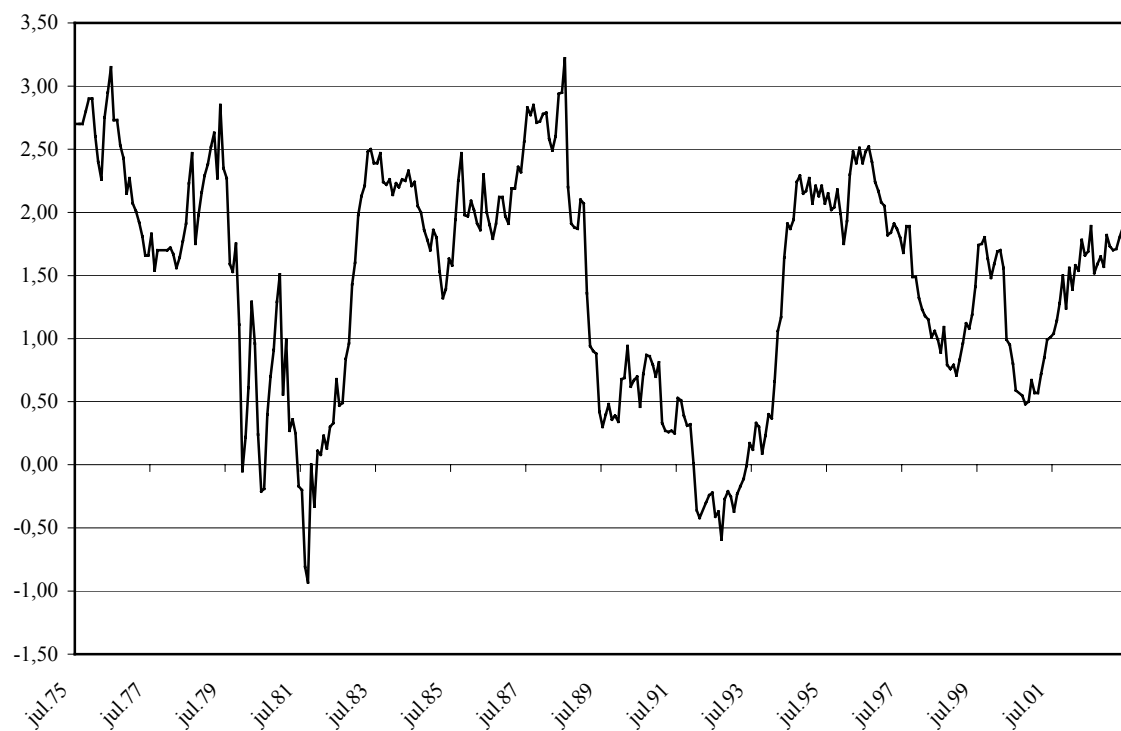
Graph A-2: Monthly series of the credit spread between industrial and government yields [ys] from July 1975 to June 2003



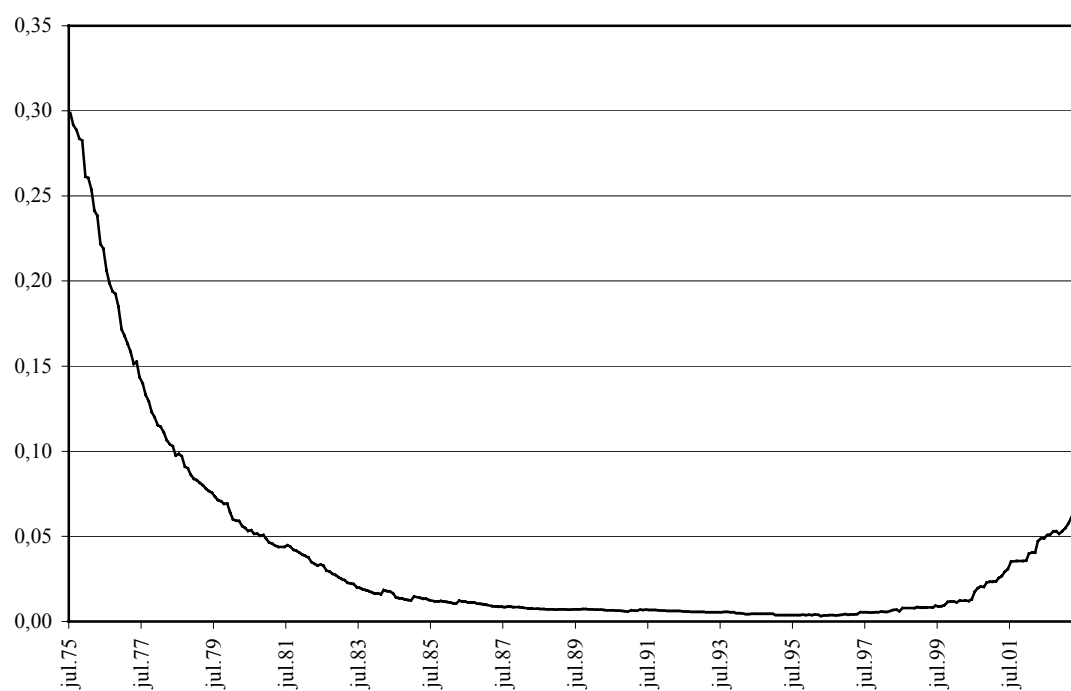
Graph A-3: Monthly series of long-term government yield [lty] from July 1975 to June 2003



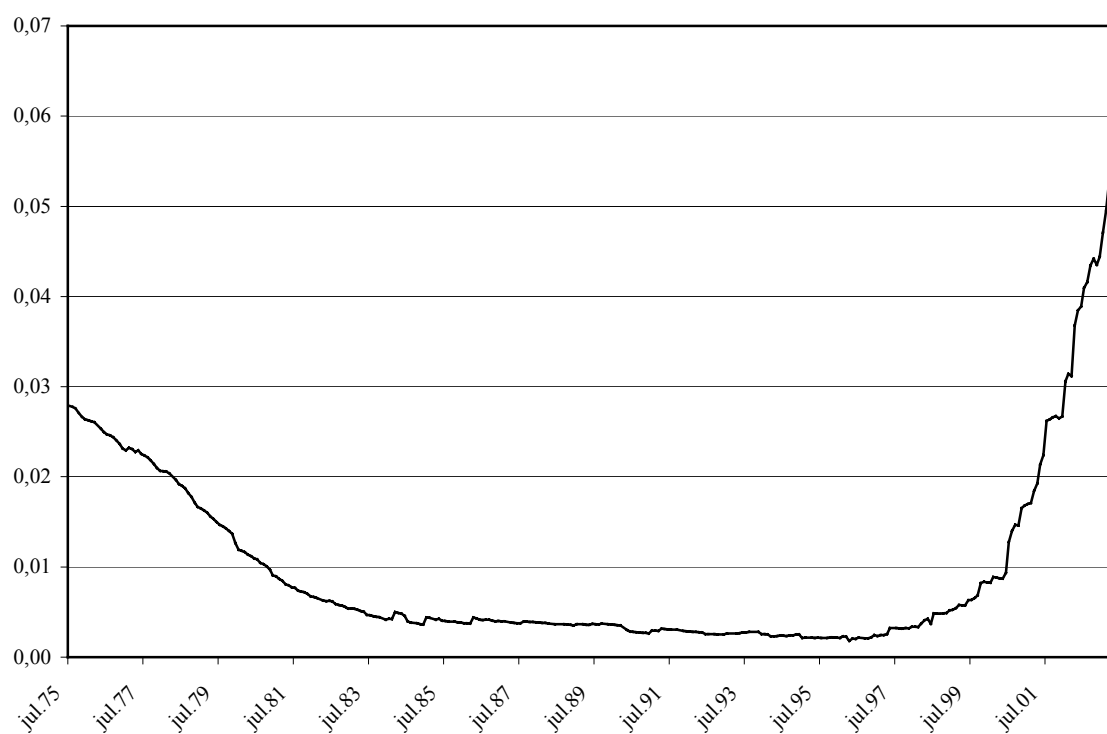
Graph A-4: Monthly series of the slope of the yield curve [slope] from July 1975 to June 2003



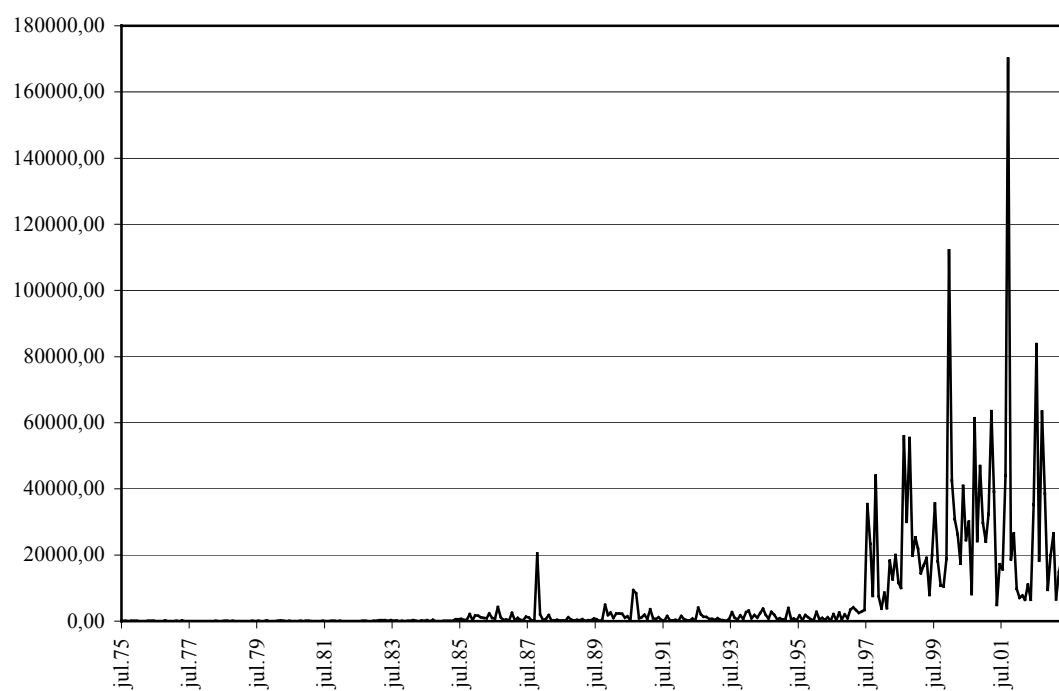
Graph A-5: Monthly series of the relative security supplies [out_r] from July 1977 to June 2003



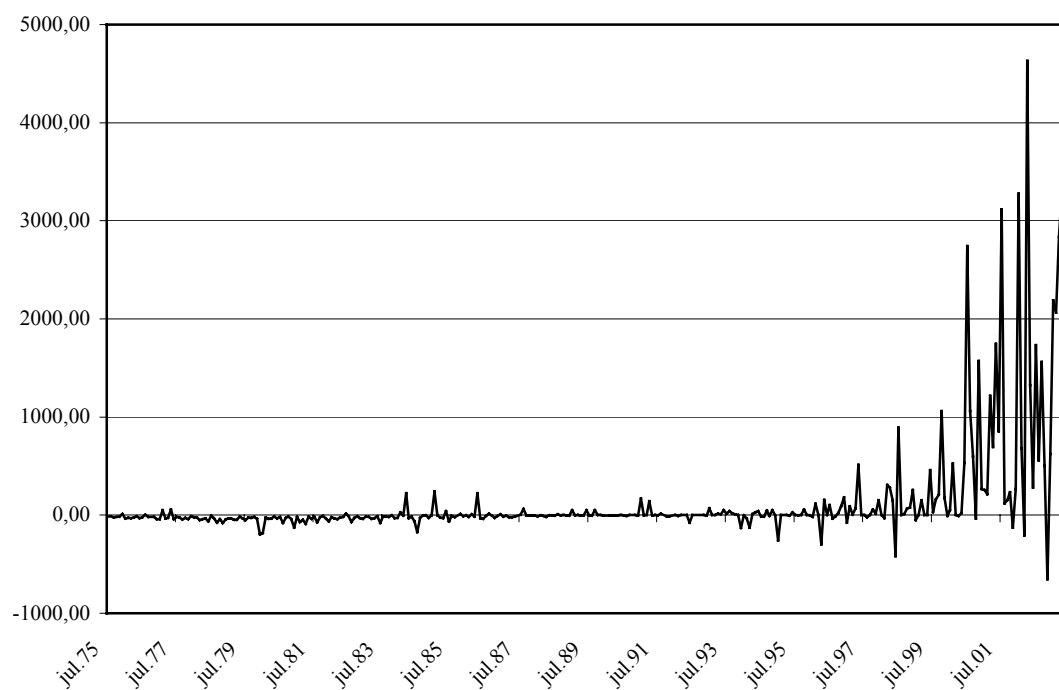
Graph A-6: Monthly series of bond-to-bank financing [out_c] from July 1975 to June 2003



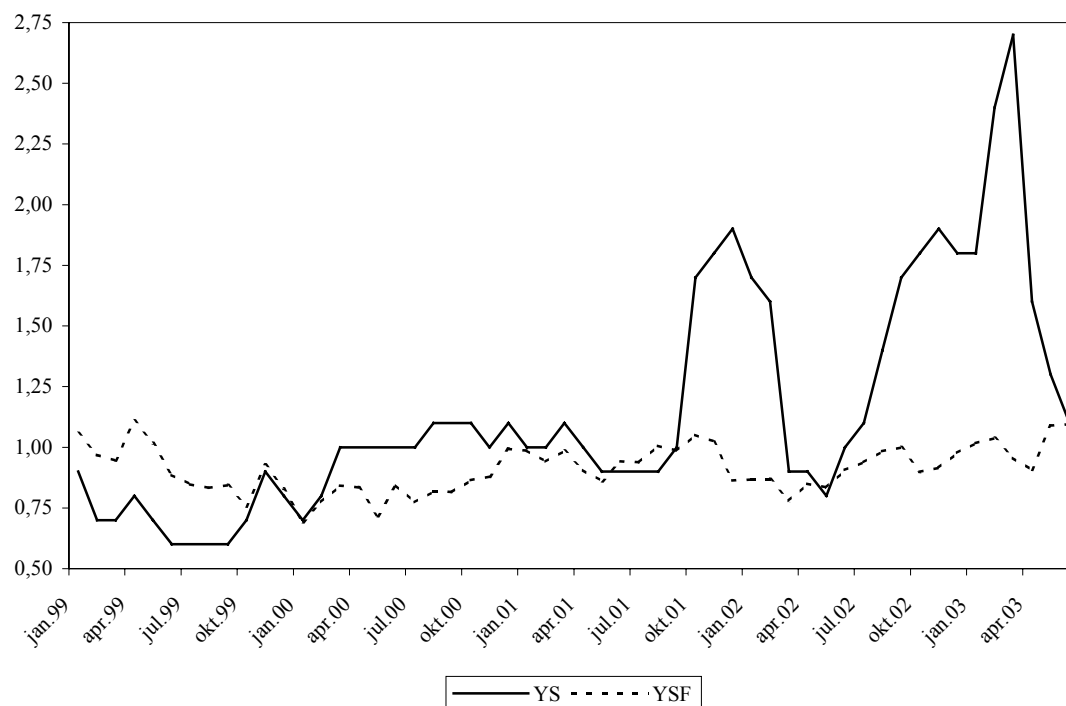
Graph A-7: Monthly series of the volatility of DAX [vdax] from July 1975 to June 2003



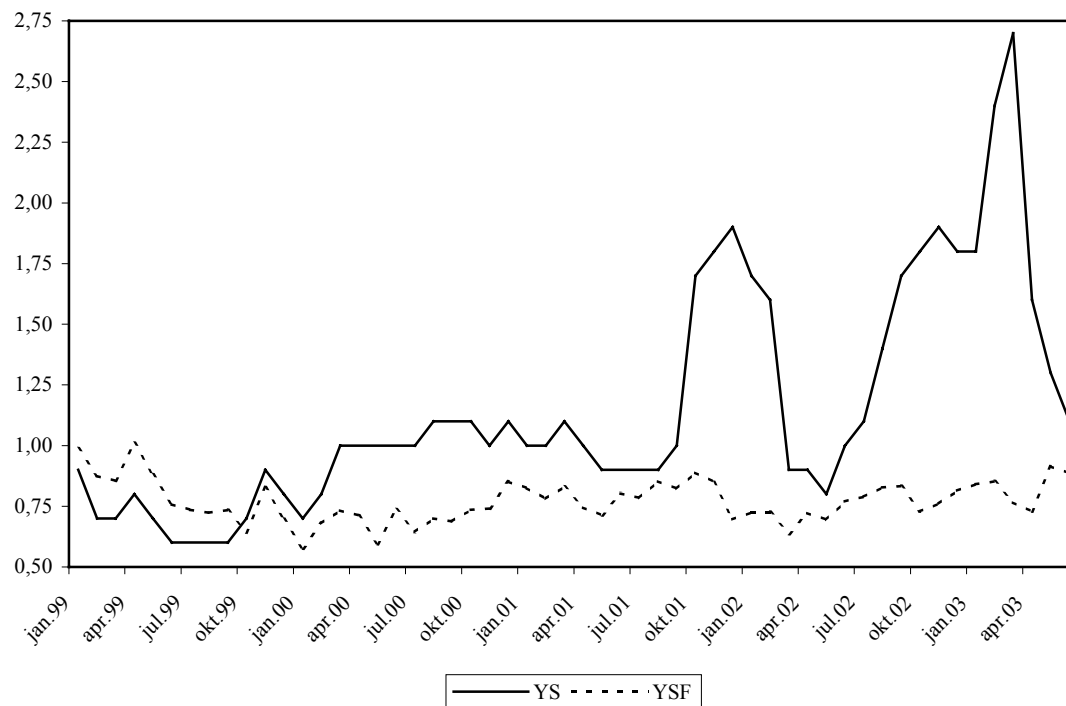
Graph A-8: Monthly series of the net issued amount of the industrial bonds [net_i] from July 1975 to June 2003



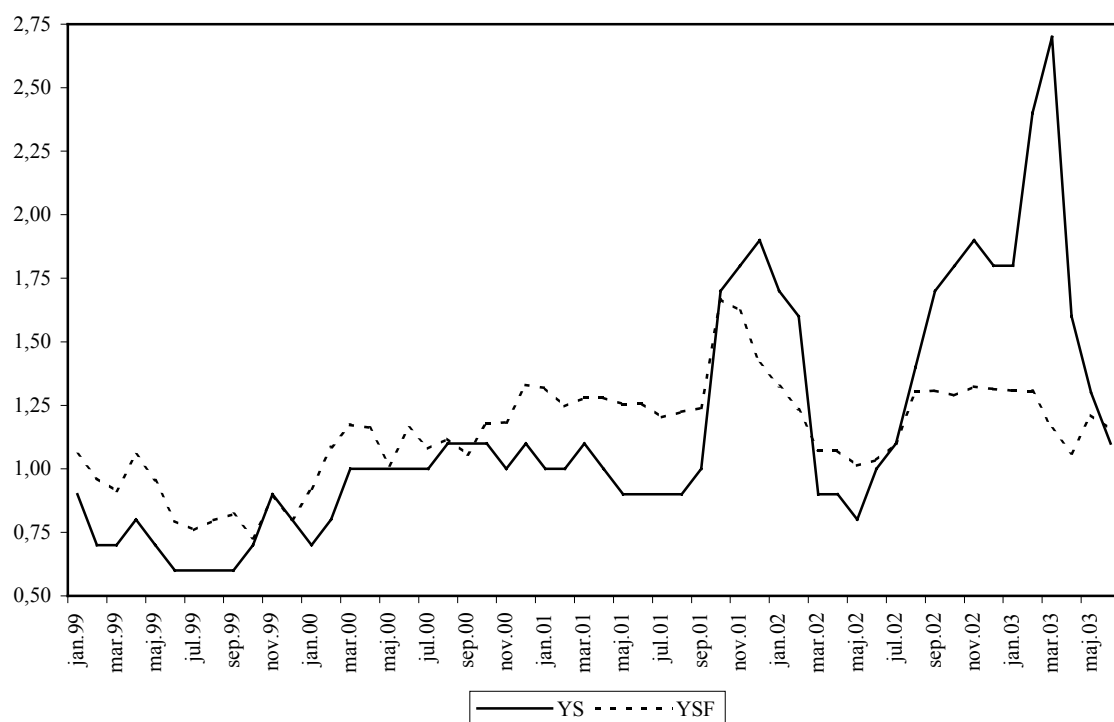
Graph A-9: Comparison of the credit spread [ys] to the forecasted credit spread [ysf] with the ECM 1a (in-sample forecast)



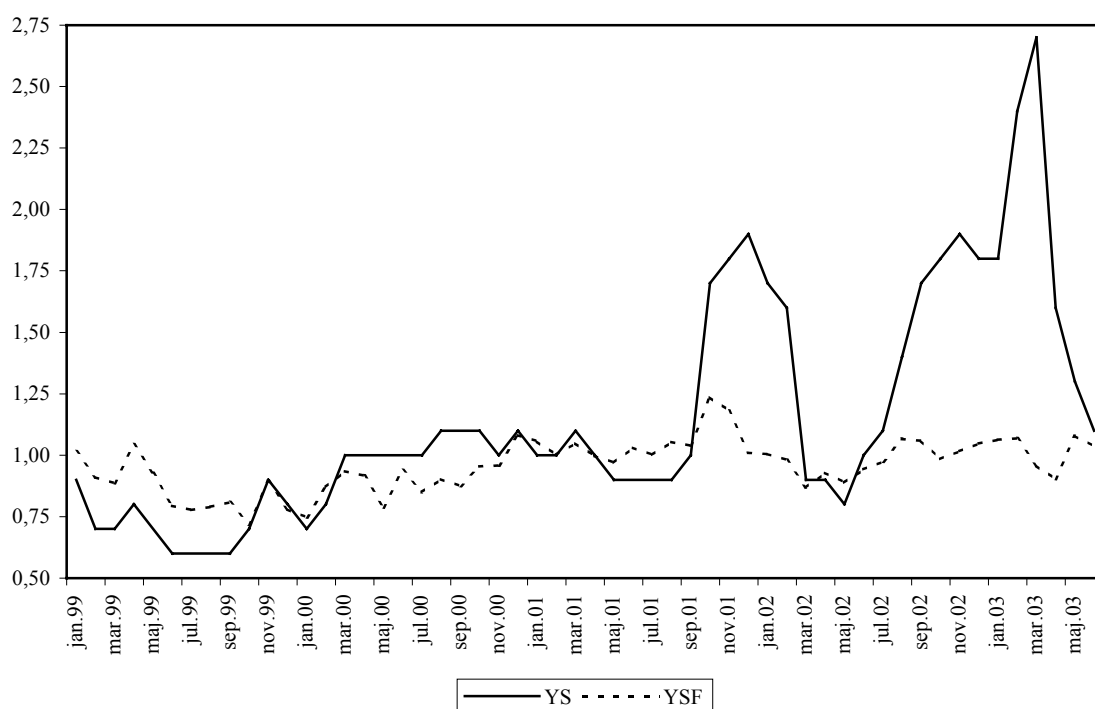
Graph A-10: Comparison of the credit spread [ys] to the forecasted credit spread [ysf] with the ECM 1b (out-of-sample forecast)



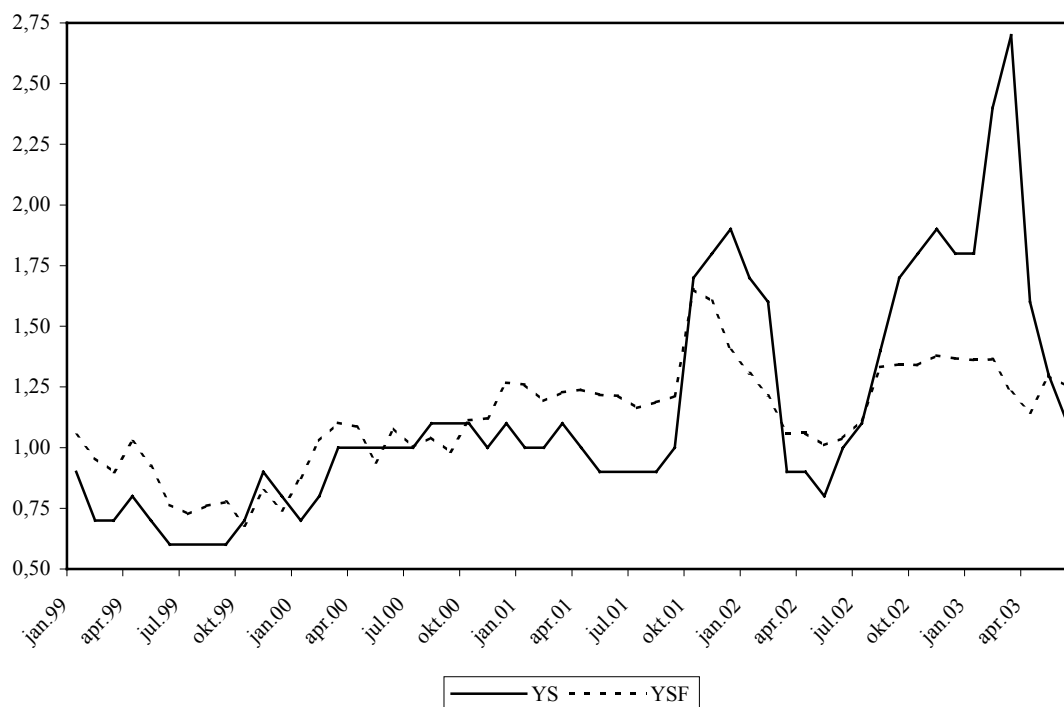
Graph A-11: Comparison of the credit spread [ys] to the forecasted credit spread [ysf] with the ECM 2a (in-sample forecast)



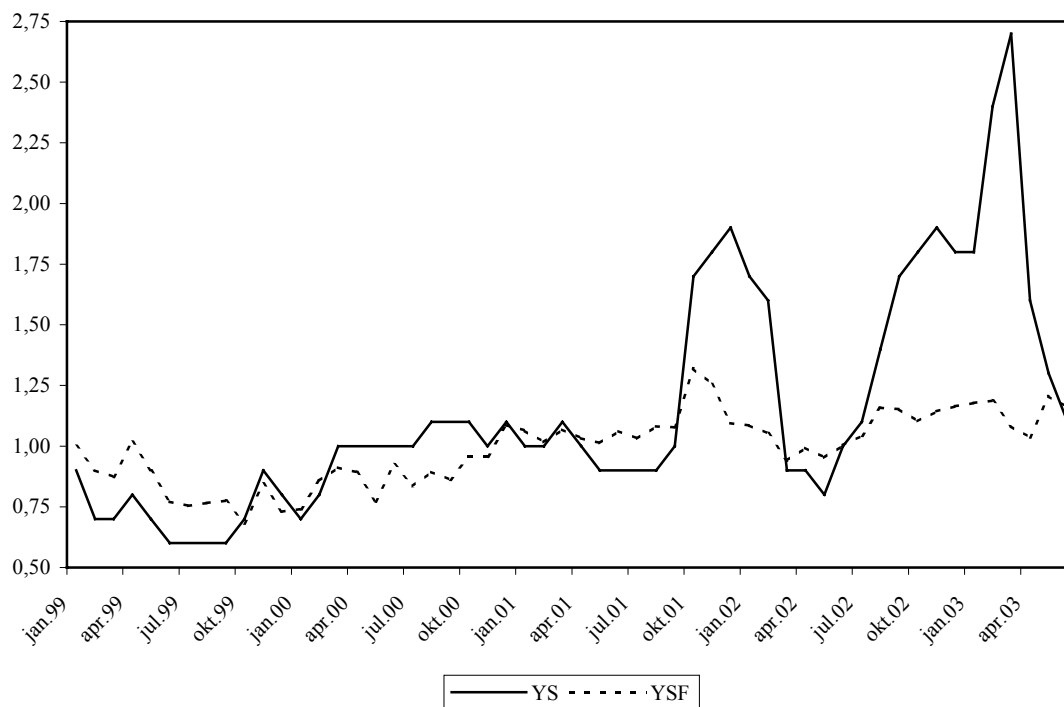
Graph A-12: Comparison of the credit spread [ys] to the forecasted credit spread [ysf] with the ECM 2b (out-of-sample forecast)



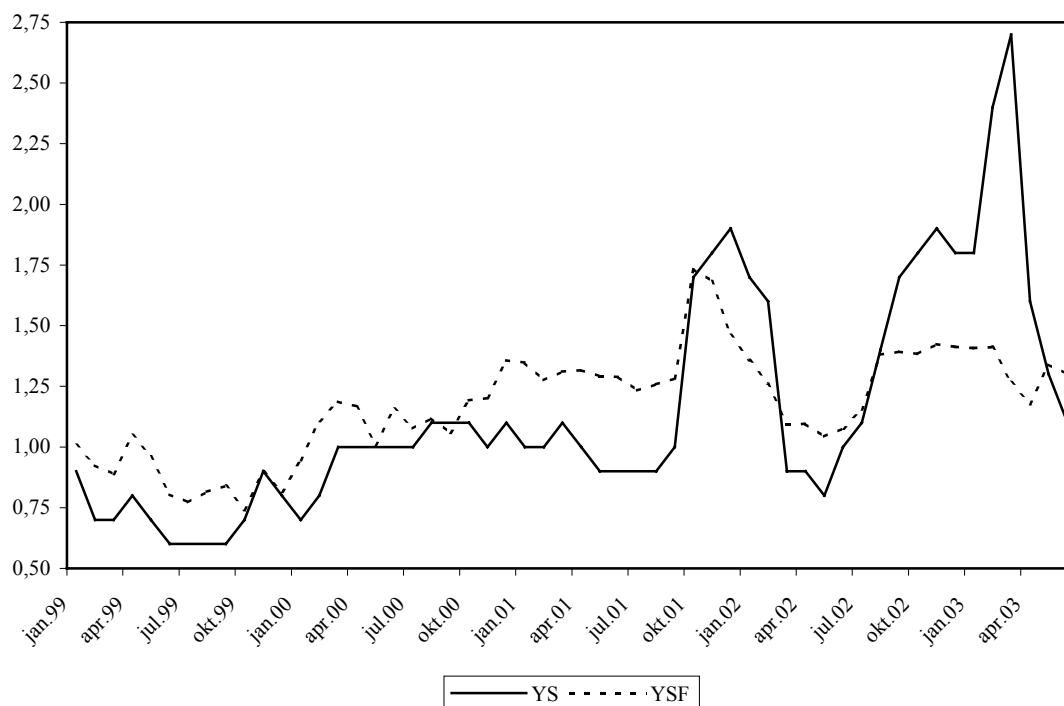
Graph A-13: Comparison of the credit spread [ys] to the forecasted credit spread [ysf] with the ECM 3a (in-sample forecast)



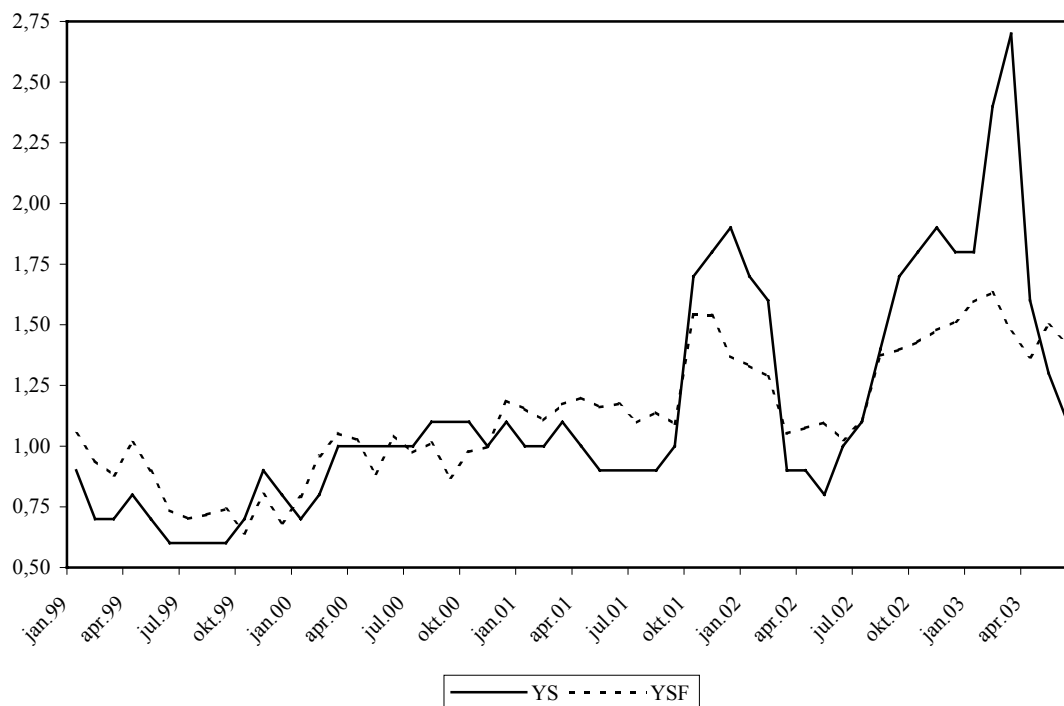
Graph A-14: Comparison of the credit spread [ys] to the forecasted credit spread [ysf] with the ECM 3b (out-of-sample forecast)



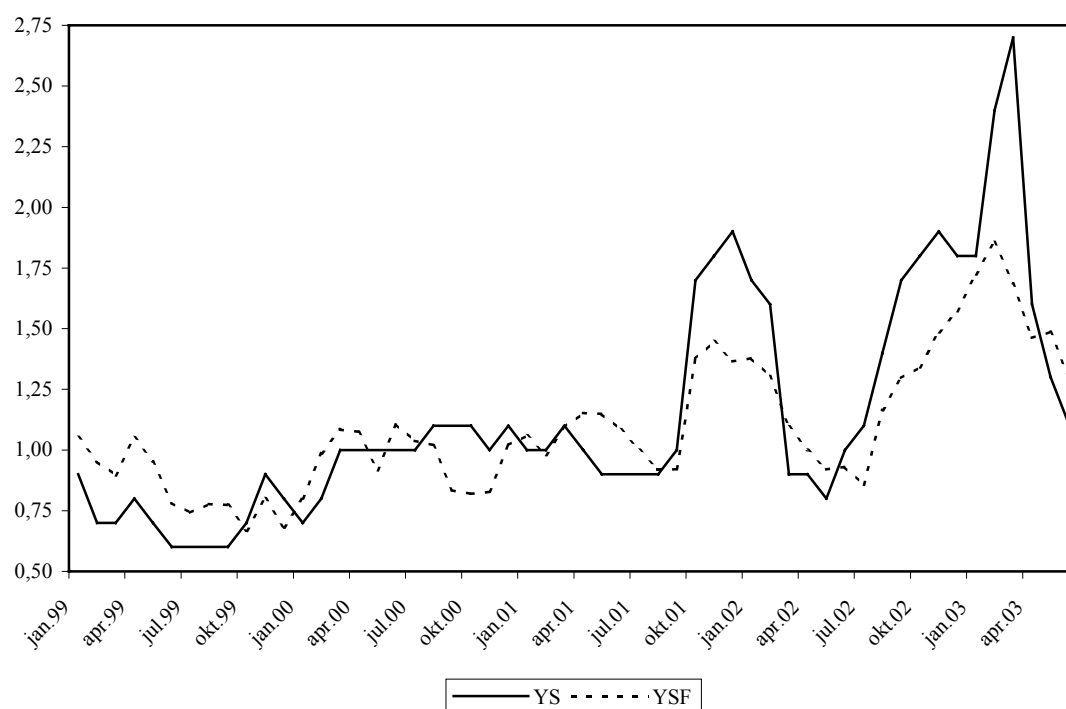
Graph A-15: Comparison of the credit spread [ys] to the forecasted credit spread [ysf] with the ECM 4 (in-sample forecast)



Graph A-16: Comparison of the credit spread [ys] to the forecasted credit spread [ysf] with the ECM 5 (in-sample forecast)



Graph A-17: Comparison of the credit spread [ys] to the forecasted credit spread [ysf] with the ECM 6 (in-sample forecast)



Appendix B: Tables

Table B-1: Unit root tests

Variables	Non-stationarity of the level			Non-stationarity of the first difference			Order of integration
	Type	ADF - Test	PP - Test	Type	ADF - Test	PP - Test	
		t-statistic	t-statistic		t-statistic	t-statistic	
Unit root test for the reduced data sample (from July 1975 to December 1998)							
ys	2	-4.1687	-4.0409	/	/	/	I(0)
lty	3	-1.9968	-1.1797	2	-10.1423	-10.2679	I(1)
slope	2	-2.3697	-2.4079	1	-16.3702	-16.4280	I(1)
out_r	3	-18.6917	-26.0214	/	/	/	I(0)
out_c	3	-9.4703	-8.0676	2	-11.7626	-12.2955	I(1)
vdax	1	2.1147	-8.1935	1	-2.4435	-38.0184	I(1)
net_I	1	1.0190	-17.8717	1	-8.8372	-54.2843	I(1)
Unit root test for the whole data sample (from July 1975 to June 2003)							
ys	3	-4.0135	-3.6439	/	/	/	I(0)
lty	3	-2.3935	-1.2424	2	-11.0832	-11.4400	I(1)
slope	2	-2.6943	-2.7596	1	-17.9571	-18.0092	I(1)
out_r	3	3.6111	-14.9697	2	-7.9431	-12.6364	I(1)
out_c	3	0.9568	-5.1604	2	-5.6545	-10.5291	I(1)
vdax	1	-0.5777	-10.6730	1	-3.0643	-39.2084	I(1)
net_I	1	2.6459	-10.9715	1	-2.6292	-36.6704	I(1)

The 5% (1% and 10%) critical values are -1.95 (-2.58 and -1.62) for ADF type 1, -2.88 (-3.46 and -2.57) for ADF type 2, -3.43 (-3.99 and -3.13) for ADF type 3 and -2.874 (-3.460, -2.574) for Phillips-Perron test.

Table B-2: Overview of the estimated models

Explanatory variables	Whole sample	Reduced sample
lty and slope	ECM 1a	ECM 1b
lty, slope and vdax	ECM 2a	ECM 2b
lty, slope, out_r and vdax	ECM 3a	ECM 3b
lty, slope, out_r and stepvdax	ECM 4	
lty, slope, out_c and vdax	ECM 5	
lty, slope, out_c, stepvdax and stepnet_i	ECM 6	

The whole sample covers the period from September 1977 to June 2003 and the reduced sample covers the period from September 1977 to December 1998.

Table B3: Autocorrelation tests for different estimated models

Autocorrelation Tests (LM)	ECM 1a	ECM 1b	ECM 2a	ECM 2b	ECM 3a	ECM 3b	ECM 4	ECM 5	ECM 6
AR	0.0834	0.5668	0.0251	0.0802	0.3711	1.3930	0.0403	0.1808	0.1426
Chi-Squared (1)	(0.7728)	(0.4515)	(0.8740)	(0.7770)	(0.5424)	(0.2379)	(0.8410)	(0.6707)	(0.7057)
AR	0.1262	0.5920	0.7867	0.1291	1.5811	1.3990	0.6111	0.8802	0.2736
Chi-Squared (2)	(0.9389)	(0.7438)	(0.6748)	(0.9375)	(0.4536)	(0.4968)	(0.7367)	(0.6440)	(0.8721)
AR	2.0189	0.8946	3.4895	0.3400	4.1278	1.5903	2.9707	2.9483	0.5390
Chi-Squared (3)	(0.5685)	(0.8267)	(0.3221)	(0.9523)	(0.2480)	(0.6616)	(0.3962)	(0.3997)	(0.9102)
AR	2.1891	2.2979	3.6278	1.6793	4.5572	3.2040	3.0950	3.0216	0.9048
Chi-Squared (4)	(0.7010)	(0.6812)	(0.4587)	(0.7945)	(0.3358)	(0.5243)	(0.5421)	(0.5542)	(0.9239)
AR	3.1071	2.3182	3.6827	1.7665	4.7985	3.9254	3.2419	3.1252	2.6519
Chi-Squared (5)	(0.6835)	(0.8036)	(0.5959)	(0.8804)	(0.4410)	(0.5602)	(0.6627)	(0.6807)	(0.7535)
AR	5.5327	3.0033	4.9578	2.9651	5.2483	4.2672	3.9366	3.6924	2.6402
Chi-Squared (6)	(0.4775)	(0.8084)	(0.5492)	(0.8132)	(0.5124)	(0.6406)	(0.6853)	(0.7182)	(0.8525)
AR	5.7793	3.8415	5.5856	3.9543	5.4093	6.7719	4.5872	3.9659	3.4529
Chi-Squared (7)	(0.5657)	(0.7978)	(0.5889)	(0.7850)	(0.6101)	(0.4530)	(0.7102)	(0.7837)	(0.8402)
AR	8.7326	3.7259	7.7183	4.4990	6.3213	6.8468	6.3418	5.0675	3.9950
Chi-Squared (8)	(0.3654)	(0.8810)	(0.4615)	(0.8095)	(0.6113)	(0.5532)	(0.6090)	(0.7503)	(0.8576)
AR	9.0176	5.0902	10.7091	6.4755	9.5292	8.6564	9.8099	9.2828	8.5170
Chi-Squared (9)	(0.4356)	(0.8264)	(0.2962)	(0.6915)	(0.3899)	(0.4696)	(0.3661)	(0.4116)	(0.4830)
AR	9.6278	5.5214	10.6706	6.8350	9.3607	8.6167	9.4348	9.7778	8.5245
Chi-Squared (10)	(0.4737)	(0.8537)	(0.3837)	(0.7409)	(0.4982)	(0.5688)	(0.4914)	(0.4602)	(0.5777)
AR	11.0423	5.3088	10.8756	6.7051	9.2618	8.3928	9.6238	9.7836	9.1076
Chi-Squared (11)	(0.4397)	(0.9153)	(0.4537)	(0.8224)	(0.5977)	(0.6777)	(0.5645)	(0.5500)	(0.6120)
AR	11.0937	5.7586	10.8444	7.3315	9.1678	9.1761	9.5652	10.1837	9.6612
Chi-Squared (12)	(0.5209)	(0.9278)	(0.5423)	(0.8349)	(0.6885)	(0.6878)	(0.6540)	(0.5998)	(0.6457)
AR	11.0889	5.7462	10.8169	7.4071	9.0597	8.2982	9.2771	10.3348	9.8368
Chi-Squared (13)	(0.6034)	(0.9549)	(0.6262)	(0.8800)	(0.7684)	(0.8236)	(0.7517)	(0.6664)	(0.7072)

The values in parentheses represent significance values of the autocorrelation tests.

Table B-4: Estimation results for the ECM 1a corrected for heteroscedasticity errors

Linear Regression - Estimation by Least Squares				
Dependent Variable DYS				
Monthly Data From 1977:09 To 2003:06				
Usable Observations	310	Degrees of Freedom	301	
Centered R**2	0.349851	R Bar **2	0.332571	
Uncentered R**2	0.349871	T x R**2	108.460	
Mean of Dependent Variable	0.0009677419			
Std Error of Dependent Variable	0.1770827031			
Standard Error of Estimate	0.1446700174			
Sum of Squared Residuals	6.2997535920			
Durbin-Watson Statistic	1.967971			

Variable	Coeff	Std Error	T-Stat	Signif
1. Constant	0.211046534	0.065894123	3.20281	0.00136092
2. YS{1}	-0.104526874	0.049267521	-2.12162	0.03386980
3. LTY{1}	-0.019924808	0.005781194	-3.44649	0.00056793
4. SLOPE{1}	-0.018649007	0.010117249	-1.84329	0.06528694
5. DYS{1}	0.151481328	0.062387089	2.42809	0.01517867
6. DLTY	-0.432727114	0.039283657	-11.01545	0.00000000
7. DLTY{1}	0.305821377	0.041208031	7.42140	0.00000000
8. DIMP1	0.504390231	0.042580547	11.84556	0.00000000
9. DIMP2	0.461228293	0.036618857	12.59538	0.00000000

SC	HQ			
-3.730	-3.795			

Table B-5: Estimation results for the ECM 1b corrected for heteroscedasticity errors

Linear Regression - Estimation by Least Squares				
Dependent Variable DYS				
Monthly Data From 1977:09 To 1998:12				
Usable Observations	256	Degrees of Freedom	248	
Centered R**2	0.456205	R Bar **2	0.440856	
Uncentered R**2	0.456219	T x R**2	116.792	
Mean of Dependent Variable	0.0007812500			
Std Error of Dependent Variable	0.1571791004			
Standard Error of Estimate	0.1175321216			
Sum of Squared Residuals	3.4258223			
Durbin-Watson Statistic	1.907172			

Variable	Coeff	Std Error	T-Stat	Signif
1. Constant	0.153584317	0.057392162	2.67605	0.00744954
2. YS{1}	-0.093879696	0.026297711	-3.56988	0.00035714
3. LTY{1}	-0.013387722	0.005971403	-2.24197	0.02496315
4. SLOPE{1}	-0.016917094	0.009754222	-1.73434	0.08285856
5. DLTY	-0.429176454	0.035158023	-12.20707	0.00000000
6. DLTY{1}	0.311836245	0.036759025	8.48326	0.00000000
7. DIMP1	0.469239780	0.039755344	11.80319	0.00000000
8. DIMP2	0.384508050	0.033085665	11.62159	0.00000000

SC	HQ			
-4.141	-4.207			

Table B-6: Estimation results for the ECM 2a corrected for heteroscedasticity errors

Linear Regression - Estimation by Least Squares				
Dependent Variable DYS				
Monthly Data From 1977:09 To 2003:06				
Usable Observations	310	Degrees of Freedom	300	
Centered R**2	0.393632	R Bar **2	0.375441	
Uncentered R**2	0.393650	T x R**2	122.031	
Mean of Dependent Variable	0.0009677419			
Std Error of Dependent Variable	0.1770827031			
Standard Error of Estimate	0.1399468128			
Sum of Squared Residuals	5.8755331256			
Durbin-Watson Statistic	2.012218			

Variable	Coeff	Std Error	T-Stat	Signif

1. Constant	0.1011	0.0645	1.56799	0.11688351
2. YS{1}	-0.1146	0.0488	-2.34898	0.01882503
3. VDAX{1}	2.5716e-06	7.5350e-0	3.41286	0.00064286
4. LTY{1}	-7.4087e-03	6.0088e-3	-1.23297	0.21758658
5. SLOPE{1}	-7.6620e-03	0.0100	-0.76295	0.44549048
6. DYS{1}	0.1370	0.0635	2.15749	0.03096774
7. DLTy	-0.4184	0.0371	-11.29268	0.00000000
8. DLTy{1}	0.2823	0.0418	6.75444	0.00000000
9. DIMP1	0.4936	0.0410	12.03675	0.00000000
10. DIMP2	0.4469	0.0364	12.26184	0.00000000
SC HQ				
-3.781 -3.853				

Table B-7: Estimation results for the ECM 2b corrected for heteroscedasticity errors

Linear Regression - Estimation by Least Squares				
Dependent Variable DYS				
Monthly Data From 1977:09 To 1998:12				
Usable Observations	256	Degrees of Freedom	246	
Centered R**2	0.460296	R Bar **2	0.440551	
Uncentered R**2	0.460310	T x R**2	117.839	
Mean of Dependent Variable	0.0007812500			
Std Error of Dependent Variable	0.1571791004			
Standard Error of Estimate	0.1175642026			
Sum of Squared Residuals	3.4000500658			
Durbin-Watson Statistic	2.021111			

Variable	Coeff	Std Error	T-Stat	ignif

1. Constant	0.1379	0.0657	2.09835	0.03587397
2. YS{1}	-0.0965	0.0260	-3.70383	0.00021237
3. VDAX{1}	9.4953e-07	7.2263e-07	1.31399	0.18884915
4. LTY{1}	-0.0117	6.8108e-03	-1.71113	0.08705641
5. SLOPE{1}	-0.0151	0.0102	-1.48052	0.13873468
6. DYS{1}	0.0551	0.0532	1.03594	0.30023128
7. DLTy	-0.4227	0.0356	-11.87540	0.00000000
8. DLTy{1}	0.3191	0.0387	8.25420	0.00000000
9. DIMP1	0.4709	0.0396	11.87951	0.00000000
10. DIMP2	0.3954	0.0345	11.44506	0.00000000
SC HQ				
-4.105 -4.188				

Table B-8: Estimation results for the ECM 3a corrected for heteroscedasticity errors

Linear Regression - Estimation by Least Squares				
Dependent Variable DYS				
Monthly Data From 1977:09 To 2003:06				
Usable Observations	310	Degrees of Freedom	299	
Centered R**2	0.391693	R Bar **2	0.371348	
Uncentered R**2	0.391711	T x R**2	121.430	
Mean of Dependent Variable	0.0009677419			
Std Error of Dependent Variable	0.1770827031			
Standard Error of Estimate	0.1404045771			
Sum of Squared Residuals	5.8943201341			
Durbin-Watson Statistic	1.986057			

Variable	Coeff	Std Error	T-Stat	Signif
1. Constant	0.1212	0.0662	1.83242	0.06688895
2. YS{1}	-0.1361	0.0519	-2.62224	0.00873538
3. OUT_R{1}	0.6610	0.2757	2.39726	0.01651823
4. VDAX{1}	2.6437e-06	7.3519e-07	3.59590	0.00032328
5. LTY{1}	-0.0102	6.1789e-03	-1.64717	0.09952394
6. SLOPE{1}	-0.0120	0.0106	-1.12984	0.25854196
7. DYS{1}	0.1394	0.0625	2.22890	0.02582073
8. DLTy	-0.3917	0.0449	-8.73093	0.00000000
9. DLTy{1}	0.2573	0.0384	6.70569	0.00000000
10. DIMP1	0.4435	0.0362	12.24162	0.00000000
11. DIMP2	0.3679	0.0369	9.97360	0.00000000

SC	HQ			
-3.759	-3.839			

Table B-9: Estimation results for the ECM 3b corrected for heteroscedasticity errors

Linear Regression - Estimation by Least Squares				
Dependent Variable DYS				
Monthly Data From 1977:09 To 1998:12				
Usable Observations	256	Degrees of Freedom	246	
Centered R**2	0.447961	R Bar **2	0.427764	
Uncentered R**2	0.447974	T x R**2	114.681	
Mean of Dependent Variable	0.0007812500			
Std Error of Dependent Variable	0.1571791004			
Standard Error of Estimate	0.1189001381			
Sum of Squared Residuals	3.4777617415			
Durbin-Watson Statistic	1.872623			

Variable	Coeff	Std Error	T-Stat	Signif
1. Constant	0.1343	0.0653	2.05673	0.03971193
2. YS{1}	-0.1079	0.0286	-3.77166	0.00016217
3. OUT_R{1}	0.4499	0.2730	1.64824	0.09930358
4. VDAX{1}	1.2684e-06	7.6905e-07	1.64937	0.09907280
5. LTY{1}	-0.0116	6.7906e-03	-1.71535	0.08628151
6. SLOPE{1}	-0.0167	0.0106	-1.57986	0.11413840
7. DLTy	-0.3964	0.0444	-8.92810	0.00000000
8. DLTy{1}	0.2811	0.0340	8.27289	0.00000000
9. DIMP1	0.3822	0.0324	11.79295	0.00000000
10. DIMP2	0.3363	0.0340	9.90423	0.00000000

SC	HQ			
-4.082	-4.165			

Table B-10: Estimation results for the ECM 4 corrected for heteroscedasticity errors

Linear Regression - Estimation by Least Squares				
Dependent Variable DYS				
Monthly Data From 1977:09 To 2003:06				
Usable Observations	310	Degrees of Freedom	299	
Centered R**2	0.401983	R Bar **2	0.381982	
Uncentered R**2	0.402000	T x R**2	124.620	
Mean of Dependent Variable	0.0009677419			
Std Error of Dependent Variable	0.1770827031			
Standard Error of Estimate	0.1392120169			
Sum of Squared Residuals	5.7946157097			
Durbin-Watson Statistic	2.008814			

Variable	Coeff	Std Error	T-Stat	Signif
1. Constant	0.1709	0.0642	2.66160	0.00777707
2. YS{1}	-0.1456	0.0529	-2.75146	0.00593294
3. OUT_R{1}	0.5173	0.2631	1.96650	0.04924047
4. STEPVDAX{1}	2.6999e-06	7.3305e-07	3.68312	0.00023039
5. LTY{1}	-0.0149	5.8529e-03	-2.55381	0.01065509
6. SLOPE{1}	-0.0157	0.0103	-1.51561	0.12961705
7. DYS{1}	0.1525	0.0623	2.44593	0.01444794
8. DLT	-0.4278	0.0379	-11.28735	0.00000000
9. DLT{1}	0.2822	0.0419	6.72929	0.00000000
10. DIMP1	0.4745	0.0418	11.36182	0.00000000
11. DIMP2	0.4484	0.0363	12.35985	0.00000000

SC	HQ			
-3.776	-3.856			

Table B-11: Estimation results for the ECM 5 corrected for heteroscedasticity errors

Linear Regression - Estimation by Least Squares				
Dependent Variable DYS				
Monthly Data From 1977:09 To 2003:06				
Usable Observations	310	Degrees of Freedom	298	
Centered R**2	0.408888	R Bar **2	0.387069	
Uncentered R**2	0.408906	T x R**2	126.761	
Mean of Dependent Variable	0.0009677419			
Std Error of Dependent Variable	0.1770827031			
Standard Error of Estimate	0.1386379101			
Sum of Squared Residuals	5.7277000955			
Durbin-Watson Statistic	2.039020			

Variable	Coeff	Std Error	T-Stat	Signif
1. Constant	0.13859208	0.06597515	2.10067	0.03566988
2. YS{1}	-0.15082201	0.03985099	-3.78465	0.00015393
3. OUT_C{1}	2.99394470	1.37964024	2.17009	0.02999996
4. LTY{1}	-0.01186727	0.00643504	-1.84416	0.06515910
5. SLOPE{1}	-0.01452277	0.01022686	-1.42006	0.15558987
6. VDAX{1}	0.00000239	0.00000073	3.28270	0.00102817
7. DYS{1}	0.14559007	0.06689399	2.17643	0.02952315
8. DLT	-0.42196031	0.03825524	-11.03013	0.00000000
9. DLT{1}	0.27472973	0.04084555	6.72606	0.00000000
10. DOUT_C{2}	-31.01724075	21.93408098	-1.41411	0.15732911
11. DIMP1	0.44713885	0.04074400	10.97435	0.00000000
12. DIMP2	0.44580368	0.03620321	12.31393	0.00000000

SC	HQ			
-3.769	-3.856			

Table B-12: Estimation results for the ECM 6 corrected for heteroscedasticity errors

Linear Regression - Estimation by Least Squares				
Dependent Variable DYS				
Monthly Data From 1977:09 To 2003:06				
Usable Observations	310	Degrees of Freedom	296	
Centered R**2	0.435111	R Bar **2	0.410302	
Uncentered R**2	0.435128	T x R**2	134.890	
Mean of Dependent Variable	0.0009677419			
Std Error of Dependent Variable	0.1770827031			
Standard Error of Estimate	0.1359849698			
Sum of Squared Residuals	5.4736059586			
Durbin-Watson Statistic	2.021196			
Variable	Coeff	Std Error	T-Stat	Signif

1. Constant	0.144466131	0.065879765	2.19288	0.02831634
2. YS{1}	-0.159143622	0.039115432	-4.06856	0.00004730
3. OUT_C{1}	5.850045227	1.771849760	3.30166	0.00096115
4. LTY{1}	-0.013221117	0.006544652	-2.02014	0.04336880
5. SLOPE{1}	-0.017744529	0.010749944	-1.65066	0.09880751
6. STEPNET_I{1}	-0.000134134	0.000053695	-2.49807	0.01248701
7. STEPVDAX{1}	0.000003010	0.000000875	3.44188	0.00057769
8. DYS{1}	0.120198992	0.067028331	1.79326	0.07293192
9. DLTY	-0.433455199	0.038731121	-11.19139	0.00000000
10. DLTY{1}	0.272322772	0.040795032	6.67539	0.00000000
11. DSTEPNET_I{1}	0.000100898	0.000044262	2.27954	0.02263505
12. DSTEPNET_I{2}	0.000062732	0.000034149	1.83699	0.06621085
13. DIMP1	0.452041347	0.040210070	11.24199	0.00000000
14. DIMP2	0.431297274	0.036178776	11.92128	0.00000000
SC	HQ			
-3.778	-3.879			