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THE HIGH-YIELD SEGMENT OF THE CORPORATE BOND MARKET: A DIFFUSION MODELLING APPROACH FOR THE UNITED STATES, THE UNITED KINGDOM AND THE EURO AREA

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In 2004 all publications will carry a motif taken from the €100 banknote.

1 We are grateful for comments by Edward Altman, Jesper Berg, Hans-Joachim Klöckers, Andrés Manzanares, Phil Molyneux, several Merrill Lynch Staff Members from the Global Securities Research & Economics Group, and an anonymous referee. All views expressed are those of the authors alone and do not necessarily reflect those of the ECB or the Eurosystem.
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Abstract

This study empirically examines the development of the high-yield segment of the corporate bond market in the United States, as a pioneer country, and the United Kingdom and the euro area, as later adopting countries. Estimated diffusion models show for the United States a significant pioneer influence factor and autonomous speed of diffusion. The latter is found to be higher in Europe than in the United States as also macroeconomic factors are considered. The high-yield bond diffusion pattern is significantly affected by financing need variables, e.g. leverage buy-outs, mergers and acquisitions, and industrial production growth, and return or financing cost variables, e.g. stock market return and the spread between the yield on speculative-grade and BBB-rated investment-grade bonds. These findings suggest that the diffusion of new financial products depends on the macroeconomic environment and can be quickly in case of the diffusion from a pioneer country to later adopting countries.

Keywords: high-yield bond market; financial innovation; diffusion models

JEL classification: G32; E44

Non-technical summary

An important feature of a well-developed financial system is the existence of a robust corporate bond market working alongside a sound banking system. The existence of a mature corporate bond market including a deep high-yield bond segment, i.e. below investment-grade rated corporate bonds, appears to be positive for economic development. It allows corporations to raise funds more quickly and on more flexible terms than would otherwise have been available. The existence of this avenue of corporate finance complementary to bank and equity finance is particularly beneficial for economies with a large number of small and medium sized firms.

This study aims to provide empirical insights into the development of the high-yield segment of the corporate bond market in the United States, as a pioneer or early adopting country, and the United Kingdom and the euro area, as imitating or later adopting countries. In order to model the pattern of growth of the high-yield bond market, high-yield bonds are viewed as a financial innovation. High-yield bond issuance is expected to grow over time as the high-yield bond financial innovation is diffused among corporations. As such, it is natural to model its growth pattern by applying the diffusion models utilised in the literature for the adoption of new products or technologies, such as the spread of medical diseases or the adoption of new telecommunication technologies.

Along these lines of applying a diffusion modelling approach, the focus of this study is on the relative size of the high-yield bond market: the market share of high-yield bonds in the overall corporate bond market in terms of amounts outstanding. Starting from a very low base, the market share of high-yield bonds in the United States grew very fast during the 1980s, but settled down to around 6% in the early 1990s, a share it has oscillated around ever since. During the 1980s, the United States market for junk bonds was set in motion to facilitate the financing of highly leveraged or start-up companies, which were unable to raise funds from banks or were unable to borrow on flexible conditions. High-yield bond issuance peaked in the late 1980s, subsequently dropping off in the early 1990s as the United States went through a recession and heightened credit risk concerns. The high-yield bond market in Europe, divided into the United Kingdom and the euro area, which had shown some incipient signs of developing as early as mid-1997, began to grow substantially in the run up of the introduction of the euro. The period at which high-yield bonds started to be issued up to the peak in the high-yield segment of the corporate bond market, the so-called diffusion sample period, covers for the United States January 1981 to August 1988, for the United Kingdom December 1998 to July 2000, and for the euro area December 1998 to January 2001. For the United Kingdom and the euro area also estimation results on the basis of a full sample up to December 2001 are shown, because we can not yet be sure whether the observed peaks in the high-yield bond market penetration are local or absolute maxima.

Three key potential determinants of the high-yield bond diffusion pattern are considered. The first determinant is a pioneer influence factor. This explanatory variable reflects the role of innovators and affects the years needed to reach a peak in the cumulative adoption of high-yield bonds. The second explanatory factor is an autonomous speed of diffusion. The larger this rate of imitation, the more rapid

the diffusion of the financial innovation. The third set of determinants is macroeconomic factors, since the development of the high-yield bond market may depend on the macroeconomic conditions. Regression results of different diffusion models indeed show that these three determinants play a significant role in the diffusion process of high-yield bonds. In the United States a pioneer influence factor and an autonomous speed of diffusion predominantly determine the diffusion of high-yield bonds. In the United Kingdom and the euro area, not surprisingly, the former is not found to be relevant, while the latter is found to be faster than in the United States, at least as macroeconomic factors are taken into account. The high-yield bond diffusion is found to be significantly affected by both the corporate financing needs, e.g. leverage buy-outs, mergers and acquisitions, and the industrial production growth, and return and financing cost considerations, e.g. stock market return and the spread between the yield on speculative-grade and BBB-rated investment-grade bonds.

The above suggests two main messages. The first is our main contention that high-yield bonds are diffused in the United States and other countries as a financial innovation, whereby the macroeconomic environment, fully neglected in previous studies, plays a significant role. The second, more tentative in nature but supported by our empirical findings, is that the high-yield bond diffusion in the United States has been substantially slower than in European countries. The United States was an early adopter where the high-yield bond technology became gradually available, while for the European countries, as late adopters, all information concerning the financial innovation was immediately available at the beginning of the diffusion period. Consequently, the financial landscape in the later adopting countries might change within a short time span because of a quick adoption of already existing "foreign" financial products from a pioneer country, e.g. the United States, towards later adopting countries, e.g. the United Kingdom and euro area countries.

From a modelling point of view, this study provides a framework, which takes account of the macroeconomic environment and may form the starting point for future research on the diffusion of other financial innovative products, for instance all type of securitised assets. Another promising avenue for future research is the diffusion of financial innovations across regions, for instance from industrialised countries to emerging market economies.

1. Introduction

In recent years, a growing branch of the economic literature has focused on the relationship between financial structure and the real economy. An important finding of theoretical and empirical studies is the existence of a causal link between financial development and economic growth.[1] The main reasons for this link are twofold. First, a developed financial system allocates funds into their most profitable uses. Second, it stabilises consumption by allowing individuals to diversify their investments more effectively. An important feature of a well-developed financial system is the existence of a robust corporate bond market working alongside a sound banking system (Herring and Chatusripitak, 2001, de Bondt, 2002). Within the corporate bond market, high-yield bonds form a particularly interesting segment for at least four main reasons.

First, high-yield bonds provide, under usual credit conditions, a larger degree of flexibility than bank loans which are subject to more strict covenants and narrower investment conditions. These flexibility features of high-yield bonds are particularly enticing for fast-growing firms that tend to rely extensively on bank financing (Gilson and Warner, 1997). More generally, a well-developed high-yield bond market could be beneficial towards smoothening the financing of firms as the junk bond market could provide funds complementary to bank-based debt or equity (Allen and Gale, 2000, and Davis 2001).

Secondly, financing via high-yield bonds can encourage a swifter reallocation of funds from cash-rich but economically declining sectors, to fast-growing sectors with urgent needs of funds. Consequently, a well-developed financial sector, in which there is a deep and liquid market for bonds which are either rated below investment grade or unrated, should facilitate both innovative new business and the transition of medium sized firms into large enterprises (Rajan and Zingales, 1998). Corporations which issue high-yield bonds have typically outperformed industrial averages in terms of industrial performance, such as employment growth, productivity and capital investment (Yago and Trimbath, 2003).

Thirdly, the market pricing of speculative-grade bonds takes place on a continuous basis by the interplay of market participants. In this way, the quality of credit is monitored by a large number of market participants on a continuous basis. Consequently, a financial system with a well-developed high-yield bond market provides immediate discipline for lower credit quality corporations' activities via prices of their marketable corporate liabilities. In this sense, by continuously monitoring firms performance, the creation of this segment of the corporate bond market also favours the creation of value-added by aligning the incentives of managers with those of shareholders (Altman and Smith, 1991).

Finally, from a macroeconomic perspective the high-yield segment of the corporate bond market could be a useful source of information on future economic activity and on current credit conditions in the economy (Gertler and Lown, 1999, Cooper et al., 2001, and Zhang, 2002). Price spreads over other financial instruments as well as issuance conditions on the high-yield bond market may capture the general degree of concern in the economy about credit risk. More generally, the development of the high-

[1] Although this literature has its roots in the 1960s and early 1970s (Goldsmith, 1969), it has recovered prominence over the last decade (Stulz, 2000). For a more specific review focusing on the effect of the corporate bond market on economic development, see Herring and Chatusripitak (2001).

yield bond market may affect the costs and scope of financial intermediation and therefore the process of monetary policy transmission.

Against this background, this study aims to provide empirical insights into the development of the high-yield segment of the corporate bond market. A diffusion modelling approach is adopted by considering high-yield bonds issued by residents and denominated in the national currency as a financial innovation. This approach seems natural because the high-yield bond market activity is expected to grow over time as the high-yield bond financial innovation is diffused among corporations. The model also takes account of macroeconomic factors that may have an impact on the diffusion process of high-yield bonds. Furthermore, the diffusion adoption pattern in the United States in the 1980s, which represents the time in which junk bonds started to diffuse, is compared with the prevailing one in Europe, divided into the United Kingdom and the euro area, which had shown some incipient signs of developing as early as mid-1997. A more general purpose of this study is to provide a modelling framework which can be used as a starting point for the examination of the diffusion of other financial innovations and across countries.

The main message of this study is twofold. The first is our main contention that high-yield bonds are diffused as a financial innovation, whereby the macroeconomic environment plays a significant role. The second is our suspicion, but supported by our empirical results, that the high-yield bond diffusion in the United States has been substantially slower than in Europe. The United States was an early adopter where the high-yield bond technology became gradually available, while for the later adopting European countries all information concerning the financial innovation was immediately available at the beginning of the diffusion period. Consequently, the financial landscape in later adopting countries might change within a short time span because of a quick diffusion of financial products from a pioneer or early adopting country, e.g. the United States, towards imitating or later adopting countries, e.g. the United Kingdom and euro area countries.

From an empirical modelling point of view, two main conclusions emerge. First, the Bass model, which besides a rate of imitation or autonomous speed of diffusion also models a pioneer influence factor or rate of innovation, seems to be typically the most statistically appropriate diffusion model for the United States. The popular Mansfield logistic diffusion model, which only models an autonomous speed of diffusion, is found to be the most appropriate diffusion model for the high-yield bond adoption in Europe. The second empirical conclusion is that besides a rate of innovation and diffusion, macroeconomic factors are relevant in the determination of the high-yield bond diffusion. Diffusion models including macroeconomic factors show that the high-yield bond diffusion slows down following a rise in M&A activity. At the same time, it is found that leverage buy-outs and stock market developments positively affect the adoption of high-yield bonds and that the impact of business cycle conditions is ambiguous. On the one hand, the financing needs of high-yield bond issuers, for instance high-growth companies, tend to be relatively cyclical. On the other hand, during economic downturns the share of "fallen angels" in the high-yield segment of the corporate bond market, that is the downgrading of investment-grade bonds to junk quality, rises, implying a negative relationship between high-yield bond diffusion and industrial production. The latter effect is found to dominate during the core diffusion sample period for the United

States and the former for the United Kingdom and the euro area. The spread between the yield on speculative-grade and BBB-rated, the most risky investment-grade, bonds is found to be insignificant for the high-yield bond diffusion process in the United States and the euro area. In the United Kingdom, however, this spread has significantly positively affected the high-yield bond diffusion process, suggesting that investor return considerations (demand factor) has dominated financing cost thoughts (supply factor).

The remainder of this study is organised as follows. Section 2 provides an introductory note on the key characteristics of the high-yield bond market. Section 3 highlights the literature on the diffusion of financial innovations. Section 4 introduces high-yield bond diffusion models. Section 5 describes the data. Section 6 presents and discusses the empirical results based on diffusion models without and with macroeconomic variables. Section 7 provides concluding remarks. Finally, Annexes 1, 2 and 3 describe the data in detail, plot diffusion patterns based on different values for the estimated diffusion model parameters, and provide estimation results for different market penetration levels, respectively.

2. High-yield bond market: key characteristics

Although the high-yield corporate bond market is normally described as a single market, it encompasses a wide range of different high-yield instruments: straight non-convertible bonds, exchangeable variable rate notes, increasing rate notes, reset notes, extendable notes, commodity linked bonds, usable bonds and springing issues, among others. These bonds can be viewed as substitutes for bank loans and private placements, which the original lenders typically hold until maturity. In other words, high-yield bonds can be thought of as term loans that have been packaged to enhance their liquidity and divisibility.

The creation in the United States of the high-yield segment of the corporate bond market in the late 1970s and early 1980s is viewed as a major financial innovation of the fixed income market over the last decades. Prior to the early 1980s, the high-yield bond market in the United States consisted entirely of bonds issued by “fallen angels” (Taggart, 1988). During the 1980s, the United States market for junk bonds was set in motion to facilitate the financing of highly leveraged or start-up companies, which were unable to borrow on flexible conditions or to raise funds from banks. High-yield bond issuance peaked in the late 1980s, subsequently dropping off in the early 1990s as a rise in credit risk concerns was observed, as triggered by a massive increase in corporate defaults in the United States, a business recession and a poorly performing stock market. As defaults on high-yield bonds mounted, the market’s leading underwriter and trader of high-yield debt securities, Drexel Burnham Lambert, went bankrupt and several major investors were barred from buying new high-yield bonds and were forced to liquidate their high-yield bond positions (Ma et al., 1989, Altman, 1992, Brewer and Jackson, 2000). Due to its role on the high-yield market, the collapse of Drexel Burnham Lambert had a major impact on the market in terms of issues and prices. After its collapse the market for newly issued high-yield bonds almost ground to a halt and no significant new issue came to the market for more than a year (Brewer and Jackson, 2000).

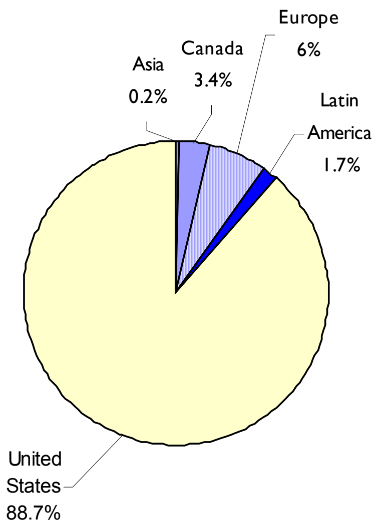
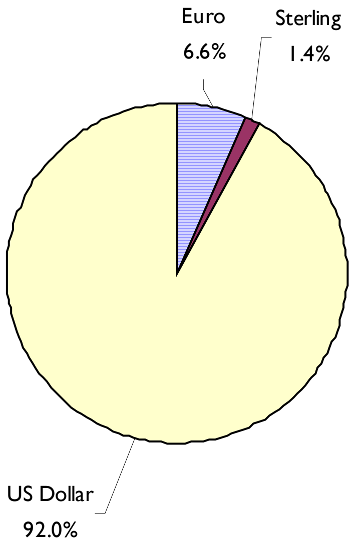
Later on, after 1993, as interest rates declined and the economy recovered, many issuers returned to the market to refinance old debt at the lower interest rate levels prevailing at that time. New issuers also came to the market during the second half of the 1990s. Despite a record number of bond defaults in 2001 and a flight to quality, following the terrorist attacks in September 2001, the high-yield bond market displayed impressive resiliency (Altman and Arman, 2002). Nowadays the market has broadened to include a variety of issuers with diverse financing needs, such as funding for working capital for growing companies.

While the US high-yield bond market has flourished over the last two decades, in other countries this market has only begun to develop in the late 1990s and remains both in terms of amounts outstanding and gross issuance well below the US market (see Charts 1 and 2). High-yield bonds have remained an overwhelmingly US development with little exposure to the global markets except initially for a second order effect, being primarily the operational exposure to the international markets from US-based corporations, e.g. American Standard's European and Far East operations, etc. (DeRosa-Farg and Blau, 1999). Besides the United States this study focuses on Europe, the second largest region of the global high-yield bond market. In this respect, Europe is divided into the United Kingdom and the euro area. Other regions with some high-yield bond issuance activity are Canada, Latin America and Asia. High-yield bonds in Canada are predominantly denominated in the US dollar instead of the Canadian dollar (Miville and Bernier, 1999). This study, however, examines high-yield bonds issued by residents denominated in the national currency. In Japan the abolition of issue standards in January 1996 has made possible the issuance of high-yield bonds, enabling a, still rather low, number of companies to engage in this type of financing.

Turning to Europe, in the early 1990s some authors were already arguing that the development of this market in Europe was likely to take place in the wake of the introduction of the Single Market for Financial Services in 1993 (Molyneux, 1990). It was argued that from a demand perspective, European institutional investors had been actively investing in the US junk bond market. Also from a supply side, management buy-outs had for some time been financed in Europe with mezzanine debt finance.[2] However, despite these factors, the European high-yield bond market, which had shown some incipient signs of developing as early as mid-1997,[3] began only to grow substantially around the start of Stage Three of EMU. This development seems to be related to expectations of a truly integrated financial market, which in turn was triggered by the launch of the euro (Marqués et al., 2000, ECB, 2000 and 2001). Besides the catalytic impact of the euro, two major underlying factors seem to spear the development of the high-yield bond market in the euro area (Altman, 1998). First, the euro area financial landscape encompassed a large number of small and medium-sized companies in need of finance but lacking the size and earnings predictability to obtain investment-grade ratings. Second, bond financing provides an instrument to restructure firms that are financed with usually more restrictive bank loans.

[2] Mezzanine debt is an European term used to describe the unsecured component of a management or leverage buy-outs and shares a number of features with high-yield bonds (Molyneux, 1990). Mezzanine debt tends to be sold to a smaller investor group and therefore is less rigid and quicker to arrange than high-yield bonds.
[3] Figures are from Bondware. High-yield bond issued by residents and denominated in currencies other than the national one, took, however, incidentally place in the 1990s.

This is particularly the case in the euro area due to the predominant role that banks play in most euro area countries.

Chart 1 Global high yield bond new issuance by region in 2001	Chart 2 Global high yield bond new issuance by currency in 2001
	
Source: Merrill Lynch.	*Source: Merrill Lynch.*

Turning to the currency of issuance in Europe, the proportion of European borrowers issuing high-yield bonds denominated in euro has been systematically increasing over the last years at the expense of dollar-denominated issues (see Table 1). Despite this advancement, the role of the euro in the high-yield global market remains limited (see Chart 2). In terms of ratings, the proportion of BB rated bonds as a percentage of total high yields issuance has been increasing since the inception of the high-yield bond market in Europe, suggesting an increase on perceived credit quality among high-yield European issuers (see Table 2).

Table 1 European high-yield new issuance by currency distribution

	Currency				Total volume
Year	Euro (%)	Sterling (%)	US Dollar (%)	Other (%)	($ millions)
1998	8.4	12.8	66.2	12.5	13,321
1999	36.3	10.4	53.4	5.4	17,834
2000	56.9	13.2	29.0	5.3	14,058
2001	74.8	17.0	8.1	5.0	6,758

Source: Merrill Lynch.

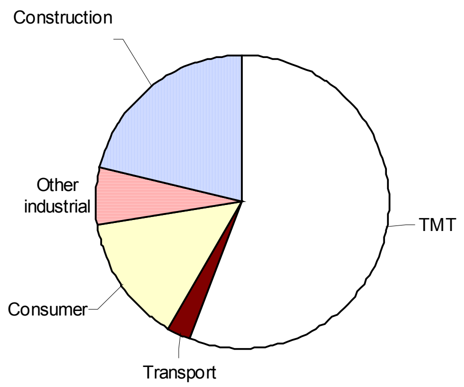
Table 2 European high-yield new issuance by rating distribution

Year	Volume ($ millions)	BB	B	CCC/CC/C	Not rated
1998	13,321	3%	81.5%	9.1%	5.5%
1999	17,834	12.3%	75.3%	5.4%	7.0%
2000	14,058	12.1%	80.6%	5.3%	2.0%
2001	6,758	30.1%	63.1%	5.0%	1.7%

Sources: Merrill Lynch and Moody's.

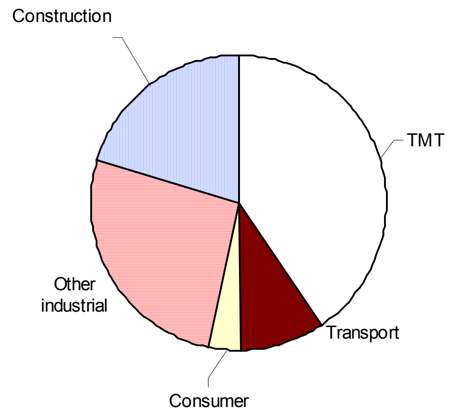
Concerning the sector composition, the telecommunication, media and technology (TMT) and consumer sector hold a more important weight at the euro-denominated high-yield bond market than at the more consolidated US dollar-denominated market. The latter shows a sector composition which is more heterogeneous and less dependent on a limited number of predominant issuers and sectors (see Charts 3 and 4).

Chart 3 Sector breakdown of euro-denominated high-yield bonds, 1998-2001



Source: Bondware.

Chart 4 Sector breakdown of US dollar-denominated high-yield bonds, 1998-2001



Source: Bondware.

Finally, it is noteworthy that the bulk of euro-denominated high-yield bonds has US banks as underwriters (see Table 3). This may be explained by the fact that US banks have considerable experience in pricing credit risk. Euro area banks more or less only started to focus on credit risk in the run up of the introduction of the euro. With the advent of the euro, credit risk has become more imperative in pricing securities than the knowledge of national factors (read: exchange rate risk). The main possible source of comparative advantage for European investment banks in terms of high-yield bond underwriting, namely a closer relationship with the customer and a better understanding of the national accounting, legal, fiscal and monetary environment have been eroded, owing to the introduction of the euro. Meanwhile, US banks have been generally quicker to develop an analytical and marketing capacity at a pan-European level.

Table 3 Underwriters of euro-denominated high-yield bonds, 1998-2001

Position	Bookrunner	Share in % of total
1	Goldman Sachs	16
2	Merrill Lynch	14
3	Credit Suisse First Boston	14
4	Salomon Brothers	13
5	Lehman Brothers	5
6	Barclays Capital	5
7	WestLB Panmure	5
8	ABN AMRO Rothschild	5
9	Morgan Stanley	3
10	Banca Commerciale Italiana	2

Source: Bondware.

3. Previous studies on the diffusion of financial innovations

The finance literature provides a wide range of frameworks for the analysis of financial innovations. It investigates whether and how a financial innovation is affected by a) external environmental factors (which could be of an economic, regulatory and/or technological nature), b) the interplay between supply and demand forces on the financial innovation process, or c) product characteristics (Allen and Gale, 1994, and Jesswein et al., 1996). For example, Tufano (1989) examines for the United States 58 financial innovations during the years 1974–1986, including mortgage-backed securities, asset-backed securities, non-equity-linked bonds and equity-linked bonds. By using a simple profit maximising framework, he analyses how investment bankers are compensated for their investments in developing new financial products. The empirical evidence on prices and quantities suggests that banks do not charge higher prices for innovative products before rivals offer imitative products, but instead capture a larger market share with innovations than with imitative products. Table 3 in the previous section suggests a similar phenomenon for high-yield bonds, US banks have captured as innovators a large market share in the euro-denominated high-yield bond market.

Another strand of the literature focuses on the empirical functional form of the diffusion process of new products. Starting from the seminal work on agricultural economics by Griliches (1957), this kind of diffusion model has been widely applied to different problems, ranging from models dealing with the spread of medical diseases (Davies, 1979) to the diffusion of new telecommunication technologies (Gruber and Verboven, 2001). In the field of financial innovation, several studies have followed a diffusion modelling approach to model the adoption rate of new financial products. Jagtiani et al. (1995) and de Bondt (2000) examine off-balance sheet activities in the United States and Europe, respectively, while Molyneux and Shamroukh (1996) analyse the high-yield bond diffusion process in the United States.

As regards the off-balance sheet diffusion, the substantial growth in off-balance sheet activities can be viewed as a reflection of the growing importance of securitisation. Jagtiani et al. (1995) examine for the United States the impact of bank capital regulation on the adoption pattern of five off-balance sheet products, e.g. standby letters of credit, loan sales, swaps, options, and futures and forwards. Their results, based on the logistic diffusion modelling approach of Mansfield (1961), suggest that neither changes in capital regulation nor bank-specific characteristics have had a consistent effect on the adoption of off-balance sheet products. De Bondt (2000) extends the work of Jagtiani et al. (1995) by also considering macroeconomic conditions as determinants of OBS diffusion. His regression results show that an autonomous speed of diffusion, bank-specific characteristics, regulatory and macroeconomic factors have significantly affected the off-balance sheet diffusion in Europe during 1989–1995.

Turning to the diffusion process of high-yield bonds, Molyneux and Shamroukh (1996) examine this issue within the Mansfield (1961) model and two other diffusion models for the United States during the years 1977–1986.[4] They decompose the number of adopters into two categories, namely external adopters or innovators and internal adopters or imitators. External adopters are influenced in their adoption by the initial exogenous factors, such as changes in the regulatory environment or demand factors. Internal adopters are, in turn, affected by bandwagon pressures of institutional and/or competitive nature and also by their updated cost/benefit assessment of adopting the innovation due to endogenous factors, the so-called rational efficiency effects. Their results suggest that both external and internal adoption factors were significant in the diffusion pattern of high-yield bonds in the United States.

Overall, a selected review on previous studies reveals that there is a paucity of empirical work on the diffusion of financial innovations. Also, from a research perspective, when trying to model diffusion processes of financial innovation, it is important to focus both on the empirical functional form of the diffusion process as well as on external economic determinants, which are likely to affect the diffusion process.

4. High-yield bond diffusion model specifications

From the previous sections, it is clear that in order to analyse the pattern of growth of the high-yield segment of the corporate bond market, three main factors have to be taken into account. First, the high-yield bond market is a financial innovation, and as such, it is natural to model its pattern of growth by applying the diffusion models utilised in the financial innovation literature. Second, the development of this market seems to be dependent on a number of macroeconomic factors, which are likely to influence the progress of this market in conjunction with the financial innovation dynamics. Finally, and due to the earlier development of the market in the United States, there is likely to be a pioneer influence effect for the United States, but not necessarily for later adopting countries.

4.1 Standard diffusion models

This section introduces standard new product diffusion models as reviewed by Mahajan et al. (1990), Parker (1994) and Geroski (1999). These diffusion model generally generate an S-shape or sigmoidal pattern for the cumulative adoption over time and a bell-shaped diffusion curve for new adopters.

[4] They also examine the diffusion pattern of note issuance facilities in the United States during 1983–1986.

Due to its simplicity, the majority of studies use the Mansfield (1961) model, which was first applied in economics by Griliches (1957)[5] to model the diffusion pattern of hybrid corn in the United States. The Mansfield model has been successfully empirically applied in case of a high diffusion rate or word-of-mouth effect. Some of the restrictions of this model were successfully relaxed by the Bass (1969) model, which postulates the following diffusion model:

$$\Delta N(t) = n(t) = [a + b\left(\frac{N(t)}{M}\right)] \cdot [M - N(t)] \qquad [1]$$

With M defined as the *market potential* or more graphically as the peak of the ultimate number of total adopters,[6] *n(t)* as the number of adopters in time *t*, and *N(t)* as the total number of cumulative adopters at time t. In other words, *ΔN(t)* equals *n(t)*. Coefficient *a* represents the initial proportion of innovators or pioneer influence factor, and coefficient *b* is the proportion of imitators or the rate of diffusion or more intuitively the speed of adoption. The main advantage of this model is that it generalises the earlier models by Fourt and Woodlock (1960), which sets *b*=0, and Mansfield (1961), which assumes *a*=0.

During the late 1970s and 1980s the original Bass model was extended in various ways.[7] Foremost among the proposed model's extensions were a dynamic market potential by making the market potential dependent on time *(M(t))* (Mahajan and Peterson, 1978). Other improvements were the possibility to consider a long-term term *market penetration ceiling*, defined by the coefficient *c,* that allows for non-adoption for a percentage of the market potential. Also the possibility of having a non-symmetric diffusion curve or *non-uniform influences* represented by the coefficient *d* (Easingwood et al., 1983) or to allow for *heterogeneity in the adopter population*, indicated by the coefficient *e* (Jeuland, 1981). These modifications of the Bass model result in the following five-parameter innovation diffusion model.[8]

$$n(t) = [a + b\left(\frac{N(t)}{cM(t)}\right)^d] \cdot [cM(t) - N(t)]^e \qquad [2]$$

4.2 Diffusion models with macroeconomic variables

For our purpose, a caveat of standard diffusion models is that they do not combine the "contagion or diffusion effects" with other factors that may play a role in the determination of high-yield bond diffusion (Bass et al., 1994). The diffusion process is made dependent on a range of macroeconomic variables likely to influence it over time by adding macroeconomic variables linearly to the main diffusion equation. The effects of the macroeconomic explanatory variables are influenced by the diffusion process

[5] These functions had already been applied in other fields, see for instance Winsor (1932).
[6] Economically the upper limit represents the achievement of the market potential. The mathematical derivation of the logistic curve used by Griliches (1957) and Mansfield (1961) is a bounded continuos time function in which the lower limit is 0 and the upper limit is a bounded upper limit, the market potential or peak.
[7] In addition to Bass-type diffusion models, any number of growth models can be used to characterise cumulative distribution functions, and thus S-shaped diffusion curves. Early examples are for instance the Gompertz curve or the Floyd model.
[8] It is worth noting that within equation [2] there are some 20-nested models which have all different characteristics and seen some empirical application in the diffusion literature.

via the multiplicative inclusion of a dampening effect with the functional form of equation [2].[9] Following the above, equation [3] reads as follows.

$$n(t) = [a + b\left(\frac{N(t)}{cM(t)}\right)^{d}] \cdot [cM(t) - N(t)]^{e} \cdot t \cdot [1 + \beta X(t)] \qquad [3]$$

X is a vector of macroeconomic variables relevant for the high-yield bond diffusion and β the corresponding vector of parameters. X(t) may reflect current and lagged or carry-over effects on the adoption pattern at time t.

The selection of macroeconomic variables likely to have a bearing on the diffusion process draws on the main determinants of this market underlined by practitioners and academics, which broadly relate corporate financing needs and costs and investor return considerations. According to our review, the high-yield bond market structure is expected to depend mainly on five macroeconomic variables.

The first macroeconomic factor taken into account is leverage buy-outs. In the 1980s high-yield bonds were a controversial instrument in the United States because of their use in financing hostile take-overs and leverage buy-outs (Becketti, 1986, and Taggart, 1988). At that time leverage buy-outs were a major source of primary high-yield bond issuance in the United States, suggesting a positive relationship between leverage buy-outs and high-yield bond diffusion.

The second macroeconomic variable considered is M&A activity. One may expect that high-yield bonds are less frequently used to finance M&A than investment-grade bonds, because notably investment-grade companies acquire other companies. For instance, euro area corporations have tapped the corporate bond market heavily to finance M&A in the first years of the euro (de Bondt, 2002). Hence a negative relationship between high-yield bond diffusion, measured as the percentage of high yield bonds to the overall corporate bond market, and M&A activity is expected.

Given that a major part of revenues obtained from high yield bonds are used to finance investment (Gilson and Warner, 1997) and other business-related financing needs, the third macroeconomic variable taken into account is industrial production. The impact of the business cycle on the diffusion of high-yield bonds could work in both directions. On one hand, when the business cycle is heading upwards, the financing needs of high-yield bond issuers, which are mainly high-growth companies (Yago and Trimbath, 2003), tends to grow above that of other industries. This suggests a positive relationship between high-yield bond diffusion and industrial production. On the other hand, the share of "fallen angels" in the high-yield segment of the corporate bond market rises during economic downturns. This implies a negative relationship between high-yield bond diffusion and industrial production.

The fourth macroeconomic variable taken into account is stock price developments. Movements in the high-yield bond and equity markets are typically positively related. An increase in stock market prices implies an increase in the market value of the firm, which is often perceived both as a form of collateral

[9] See Ratkowsky (1990). The mathematical derivation of the logistic curve used by Griliches (1957) and Mansfield (1961) is a bounded continuos time function in which the lower limit is 0 and the upper limit amounts to the market potential. This dampening effect makes sense from an economic perspective but is also analytical needed in order to have an upper limit, since the mathematical solution of the logistic curve (solving a linear differential equation) is a bounded continuos time function.

and as an indication of expected future revenues. Likewise, from an investor perspective, rising stock prices are generally associated to improve economic perspective and lower risk aversion, thereby increasing investors demand for high-yield bonds (Altman, 1992). Consequently, increases in stock market prices would, other things being equal, enhance the demand for junk bonds.

The fifth and final macroeconomic factor considered is the spread between the yield on speculative-grade bonds and BBB-rated bonds, the most risky class of investment-grade bonds. On the one hand, this spread determines the attractiveness for investors to invest in high-yield bonds (demand factor). High-yields are only attractive if they provide, given the perceived credit risk differential, a yield high enough compared with BBB-rated investment-grade bonds. On the other hand, the yield on bonds reflects the (re)financing costs for corporations (supply factor). The higher the costs for corporations to tap the bond market, the less likely they will issue a bond. Which of the factor prevails would depend on the relative attractiveness of alternative financing and investment opportunities.

5. Data

The diffusion of financial innovations, and thus also high-yield bonds, can be measured in a number of ways, such as the amounts outstanding in the market, gross/net issues, the number of issues/issuers, and the number of banks or investors participating in the high-yield bond market. This study focuses on the size of the high-yield bond market vis-à-vis the total corporate bond market in terms of the amounts outstanding, both in face and market value terms.[10] The advantage of this measure is, as already pointed out by Berger (1996), that the degree to which financial innovations are adopted is often more important for policy purposes than the number of economic agents participating in the market as Molyneux and Shamroukh (1996) examined.

Chart 5 plots the amounts outstanding of the high-yield bond market in the United States, the United Kingdom and the euro area. The Merrill Lynch data for the United States start in January 1980 and for the United Kingdom and the euro area in December 1997.[11] The chart shows that while the United States market took some time to take off, the European market grew relatively quickly since its inception at the end of 1997. In the United States amounts outstanding started to decline in the late 1980s and recovered after 1993, suggesting a relationship with macroeconomic variables such as the business cycle and stock market developments.

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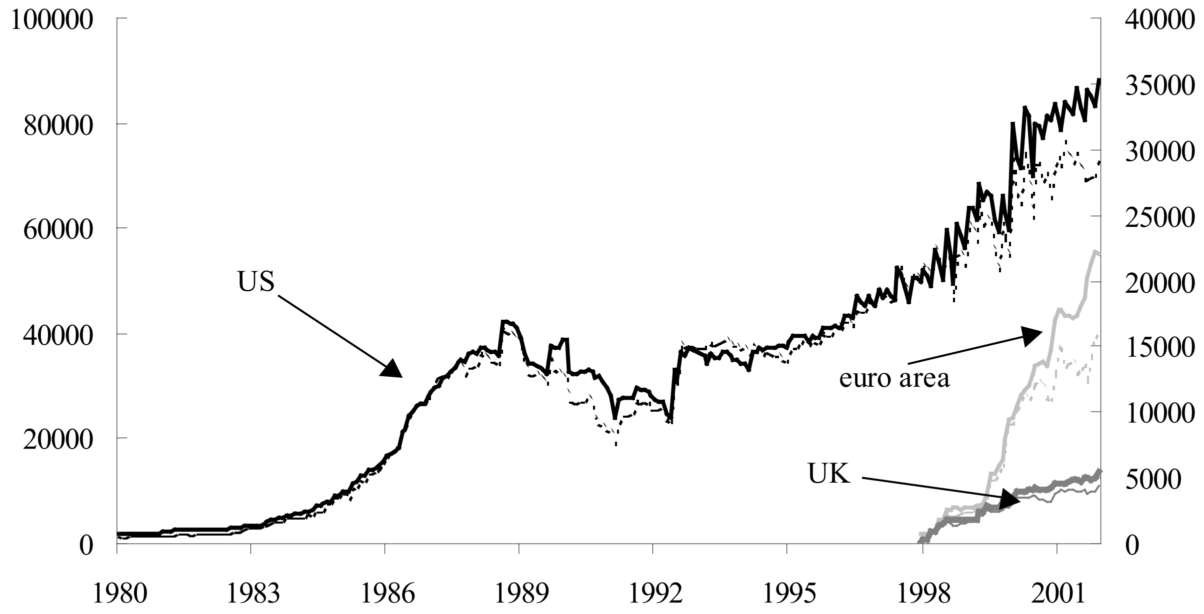
[10] Annex 1 provides detailed information on the data. The source used for the bond data is Merrill Lynch, because they have historical information for the United States and Europe and use an equivalent definition in the construction of indices across countries. Their high-yield bond data are based on a composite of Moody's and Standards and Poors which are in national currency and issued by domestic issuers, have at least one year remaining term to maturity, a fixed coupon, and a minimum amount outstanding of EUR 50 million. As regards the coverage of these indices, Merrill Lynch London and New York estimate the coverage for their corporate bond indices in general to be above 90% of the market of publicly issued bonds. This figure has changed over time in the case of the US high-yield index.

[11] A drawback of this data, however, is that the US broad high yield index (H0A0) starts in August 1986. Hence we use an earlier but less broad US index (X0A0), which starts in 1980. Although the difference in levels between the two indices is substantial, particularly for the second half of the 1990s, both indices have tended to co-move (see Chart A.1 in Annex 1) and therefore the latter index has been used in the empirical analysis. This index tracks the performance of a selected basket of the most liquid below-investment grade US dollar-denominated corporate bonds publicly issued in the United States domestic market.

Chart 5 Amounts outstanding of high-yield bonds in the United States, United Kingdom and the euro area

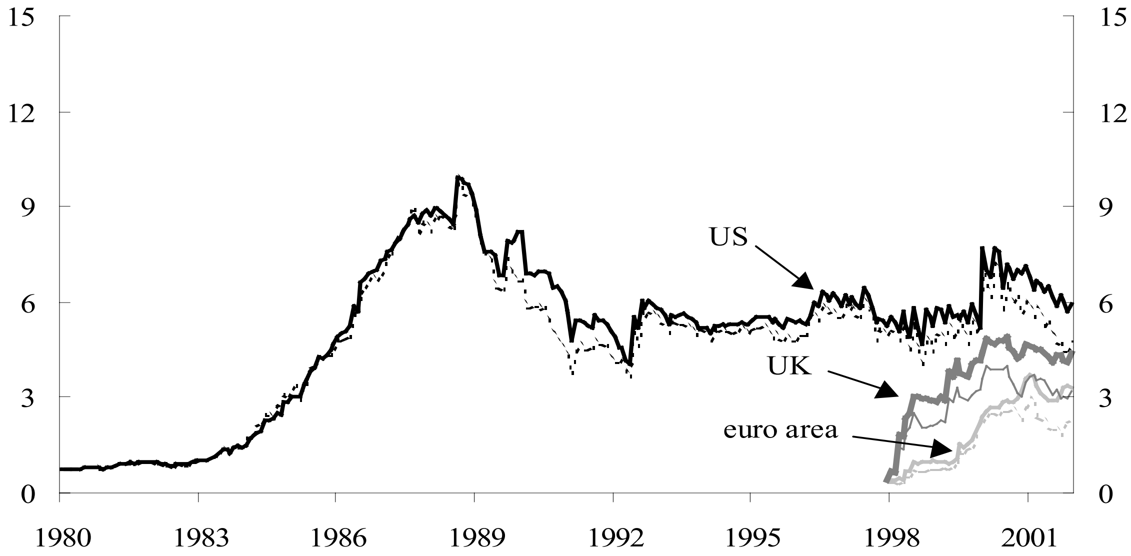
(United States in US dollar millions (left-hand scale); United Kingdom in British pound millions and euro area in euro millions (right-hand scale); the continuous lines represent face value, the dotted lines represent market value)



Source: Merrill Lynch.

Chart 6 shows the development of the high-yield bond market measured in amounts outstanding as a proportion of the overall corporate bond market. Starting from a very low base, the market share of the high-yield bond market in the United States grew very fast during the 1980s, but subdued in the early 1990s. It stabilised in the second part of the 1990s. In the United Kingdom, the high-yield segment of the corporate bond market grew quicker than in the euro area, probably benefiting from having a more market-based financial structure. The share of the euro area high-yield bond market as a share of the overall corporate bond market grew steadily since the beginning of 1998, and stabilised in 2001. From a modelling perspective this would suggest a faster speed of diffusion, as measured by the coefficient b, in Europe than in the United States.

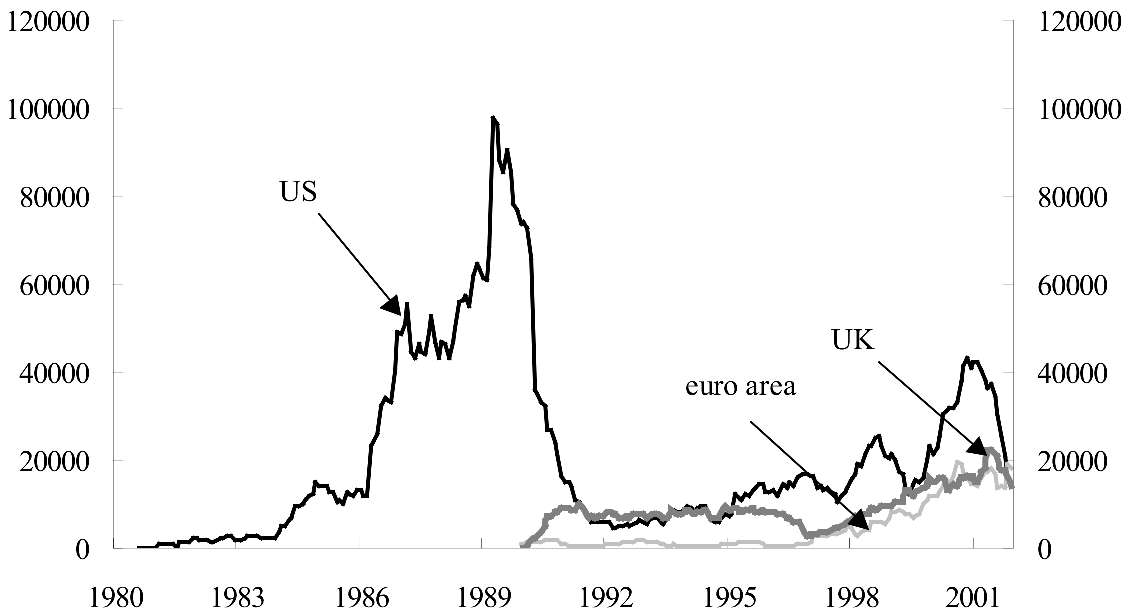
Chart 6 Market share of high-yield bonds in the United States, United Kingdom and the euro area
(in %; the continuous lines represent face value, the dotted lines represent market value)



Source: Merrill Lynch.

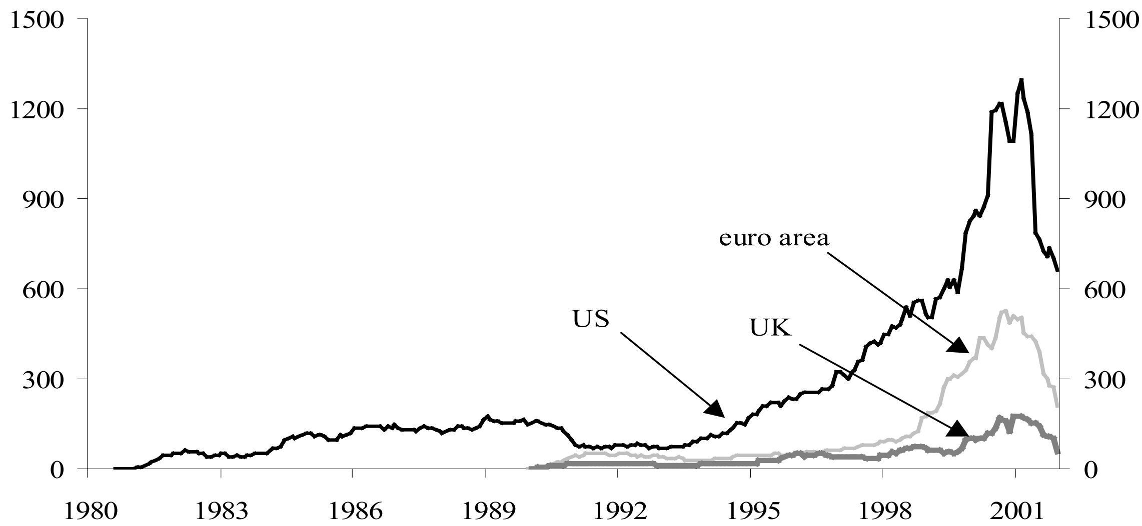
Two potential determinants of high-yield bonds issuance are leverage buy-outs and M&A. Chart 7 indicates that United States leverage buy-outs reached extraordinary peaks in the 1985-1989 period, and declined sharply during the early 1990s. The United Kingdom, the United States and the euro area show an increase in leverage buy-outs in the second part of the 1990s. In the United States the value of leverage buy-outs declined again in 2001, whereas the European figures, although at a lower level, remained similar to 2000 values. As shown in Chart 8, the United States has experienced a fast process of industrial concentration, as reflected in M&A, which accelerated substantially in the second half of the 1990s. This process declined with the slowdown on economic activity in 2001. On a much lower scale, during the 1980s there was an increase in the amount of M&As which peaked in the late 1980s in the United States (Altman and Smith, 1991). A similar pattern of a peak in M&A around 2000, albeit on a lower base, is visible for the United Kingdom and the euro area.

Chart 7 Leverage buy-outs in the United States, United Kingdom and the euro area
(12 month flows of effective values in billions of the national currency)



Source: Thomson Financial.

Chart 8 Mergers and acquisitions in the United States, United Kingdom and the euro area
(12-months flows of effective values in millions of the national currency)



Source: Thomson Financial.

6. Empirical results

The empirical results are based on a diffusion period for the United States and for the United Kingdom and the euro area on a diffusion period and a full sample period, which ends in December 2001. The diffusion periods are defined as the period from the start of the high-yield bond market up to the peak of the market penetration level, e.g. the maximum share of high-yield bonds in the total corporate bond market.[12] For the United States the diffusion period ends in August 1988, well before Drexel Burnham Lambert declared bankruptcy in early 1990. For the United Kingdom and the euro area the diffusion period ends in July 2000 and January 2001, respectively. Since we can not yet be sure whether the peaks in the high-yield market penetration as observed for the United Kingdom and the euro area are a local or absolute maximum also full-sample results are shown for Europe. In other words, the short history of these high-yield bond markets stresses the need to interpret the European empirical results with more than usual caution.

6.1 Empirical diffusion models

Our empirical analysis starts with a simple diffusion model, because increasing the model complexity might increase the bias in the estimates of the diffusion parameters (Van de Bulte and Lilien, 1997). Consequently, our starting point is the one-parameter diffusion model introduced by Mansfield (1961), assuming that in equation [2] and [3] parameters *c* and e equals 0.15 and 1, respectively. The value of 0.15 for the market ceiling or market penetration level is based on the maximum value achieved of 0.10 for the US high-yield market share, *MS*, plus two standard deviations. The results for the diffusion parameters presented in this paper appear, however, to be rather insensitive of using different values for the market potential, at least as set above any observed market penetration level (see Annex 3). It is tested whether the one-parameter diffusion model (Mansfield model) can be extended to a two-parameter diffusion model (Bass model, $a \neq 0$) or even a three-parameter model (non-uniform influence (NUI) model, $a \neq 0$ and $d \neq 1$). Our focus is on the annual rate of diffusion and we refer to Annex 1 for the notation of the variables. This results in the following empirical diffusion model, including macroeconomic variables, which has been estimated by non-linear least squares.[13]

$$\Delta_{12}MS_t = [a + b\left(\frac{MS_t}{0.15}\right)^d] \cdot [0.15 - MS_t]^1 \cdot t \cdot [1 + \beta_1 \ln(\sum_{i=0}^{2} LBNV_{t-3-i}) + \beta_2 \ln(\sum_{i=0}^{11} MANV_{t-3-i} + \beta_3 \frac{1}{3}\sum_{i=0}^{2} \dot{IPIN}_{t-i} + \beta_4 \frac{1}{3}\sum_{i=0}^{2} \dot{SMIN}_{t-i} + \beta_5 \Delta_{12}(hyyi - bbbyi)_t] \qquad [4]$$

With:

[12] Van den Bulte and Lilien (1997) show that there is no general understanding of the number of data required to obtain stable parameter estimates and whether this number typically occurs prior to or after the peak in adoption. For the reason that estimates of diffusion model coefficients may change as one extends the number of observations, the sample is broken at the peak in the high-yield bond adoption. The maximum Chow breakpoint F-statistic, based on the standard Mansfield and Bass models, is reached in April 1988 in the United States, in October 2000 in the United Kingdom, and in March 2001 in the euro area. The breakpoint chosen on the basis of the maximum high-yield bond market share is four months later for the United States, three months earlier for the United Kingdom, and two months earlier for the euro area.

$$MS_t = \frac{HYFV_t}{TCFY_t} \quad or \quad \frac{HYMV_t}{TCMV_t}$$

$$\dot{X}_t = 100 \cdot \frac{X_t - X_{t-12}}{X_{t-12}}$$

The lag structure of M&A and the industrial production growth is in line with the empirical findings of de Bondt (2002) for the euro area. This study shows that M&A financing needs affects bond financing up to one year and industrial production up to one quarter. Given the fact that bridge financing is less likely for leverage buy-outs compared with M&A, a quarterly instead of annual flow of leverage buy-outs is considered. In addition, it is assumed that it typically takes one quarter before the financing of leverage buy-outs and M&A is settled. The lag structure of the annual stock market return is identical to that of the annual growth of industrial production, that is a quarterly moving average. The high-yield spread is expected to have an immediate impact, given that it reflects the forward looking expectations of expected credit risk, taking into acount the price of the quantity developments we want to explain.

6.2 Estimates

The estimates of equation [4] appear to be rather insensitive to whether the high-yield bond diffusion is measured in face or market value terms (compare Table 4 with Table 5). Six main findings emerge from Table 4 and 5.

First, the high-yield bond diffusion rate is significant in all cases except one. The next section examines in detail the estimated diffusion rates. For the United States also a pioneer influence factor or rate of innovation is typically found to be significant. The United States was the innovator of junk bonds and the high-yield bond technology became therefore gradually available, while for Europe all information concerning the high-yield bond innovation was, as a late adopter, immediately available at the beginning of the diffusion period. Consequently, the pioneer influence factor is found to be important in the United States, but not in Europe.

The second empirical finding is that leverage buy-outs have had a significantly positive impact on the high-yield bond diffusion. An increase in leverage buy-outs by one million has resulted in a rise in the high-yield bond market share of around 0.01 percentage points in the United States and the euro area. This suggests that high-yield bonds have been issued to finance leverage buy-outs, confirming the US debate in the 1980s of buoyant junk bond financing of leverage buy-outs.

Third, M&A activity has significantly negatively affected the high-yield bond diffusion process. An increase in the annual flow of M&A by one million has resulted in a decrease in the high-yield bond share in all corporate bonds of around 0.08 percentage points in the United States and Europe. This result

[13] This estimation method is in line with Srinivasa and Mason (1986) and Hansen et al. (2003), which broadly show that a relatively simple method such as non-linear least squares tend to be very close to those obtained with more complicated estimation procedures.

indicates that high-yield bonds were less frequently used to finance M&A than investment-grade bonds, in line with the fact that typically investment-grade companies acquire speculative-grade companies.

The fourth finding is that the output impact of fallen angels seems to have been dominant in the United States during the high-yield bond diffusion period, but not in Europe. A one-percentage point increase in industrial production growth has resulted in the United States to a decrease of around 0.3 percentage points in the share of high-yield bonds in the total corporate bond market, whereas it has led in Europe to an increase by up to 2 percentage points. This finding suggests that the high-yield bond market in Europe has been particularly important for growth companies.

Fifth, stock market developments have significantly positively affected the high-yield bond diffusion. The impact of the stock market return on the high-yield bond diffusion process is found to be larger in the United States and the United Kingdom than in the euro area. Broadly speaking, a one-percentage point increase in the stock market return leads to a rise in the share of high-yield bonds in all corporate bonds of between 0.1 and 0.2 percentage points in the United States and the United Kingdom and 0.05 percentage points in the euro area. This finding may be related to the fact that the stock market capitalisation in the United States and the United Kingdom is higher than in the euro area.

The sixth and last finding is that the spread between the yield on speculative-grade bonds and BBB-rated investment-grade is found to have plaid an insignificant role in the high-yield bond diffusion process in the United States and the euro area. In the United Kingdom, however, this high-yield spread has significantly positively affected the high-yield bond diffusion process. This suggests that a strong demand from high-yield bond investors, searching for higher yields, have been dominant in the United Kingdom during this period.

In sum, the macroeconomic conditions do play a significant role for the high-yield bond diffusion (see also the Wald tests in Table 4 and 5). The models including macroeconomic variables are therefore preferred above the models without any macroeconomic effects.

Table 4 Estimation results of high-yield bond diffusion in face value terms

Pioneer influence factor	Diffusion speed	LBO	M&A	Output growth	Stock market return	High-yield spread	Wald test Bass/NUI model[1)]	Wald test macro factors[2)]	R^2
a	b	β_1	β_2	β_3	β_4	β_5			
United States 1981.1-1988.8[3)]									
	0.507**						6.94**		0.73
	(0.04)								
-0.021**	0.578**						5.80**[4)]		0.76
(0.01)	(0.07)								
	0.053*	0.007	-0.082**	-0.318	0.243	-0.734	11.3**	607**	0.85
	(0.02)	(0.01)	(0.01)	(0.32)	(0.14)	(0.93)			
-0.009**	0.170**	0.006**	-0.086**	-0.260*	0.085**	-0.146	5.51*[4)]	6887**	0.87
(0.00)	(0.04)	(0.00)	(0.00)	(0.11)	(0.03)	(0.26)			
United Kingdom 1988.12-2000.7									
	0.465**						6.06*[5)]		0.00
	(0.07)								
	0.495**	0.001	-0.084**	2.258**	0.177*	3.066**	0.57	11224**	0.53
	(0.06)	(0.01)	(0.01)	(0.30)	(0.07)	(0.49)			
United Kingdom 1988.12-2001.12									
	0.233**						7.60**[5)]		0.00
	(0.09)								
	0.337**	-0.004	-0.077**	1.174**	0.047	0.241	1.70	12290**	0.42
	(0.17)	(0.01)	(0.01)	(0.26)	(0.07)	(0.65)			
Euro area 1998.12-2001.1									
	0.603**						0.43		0.75
	(0.05)								
	0.335**	0.012**	-0.083**	0.574**	0.050	-0.119	0.68	38566**	0.95
	(0.07)	(0.00)	(0.00)	(0.12)	(0.03)	(0.15)			
Euro area 1998.12-2001.12									
	0.389**						3.32		0.00
	(0.10)								
	0.329**	0.007*	-0.080**	0.755**	0.042	-0.005	5.30*	97695**	0.92
	(0.08)	(0.00)	(0.00)	(0.11)	(0.04)	(0.15)			
0.011*	0.192*	0.010**	-0.082**	0.942**	0.048	-0.097	0.91	53147**	0.93
(0.00)	(0.08)	(0.00)	(0.00)	(0.18)	(0.04)	(0.20)			

*Notes: heteroscedasticity and autocorrelation-corrected standard errors between parentheses; ** and * denote significance at the 1% and 5% level, respectively; [1)] F-statistic, insignificance denotes that a more extended diffusion model is not rejected against the estimated diffusion model, that is, the Bass against Mansfield model (test a=0 in Bass model) and the NUI against Bass model (test a=0 and d=1 in NUI model); [2)] F-statistic; significance denotes that macroeconomic effects are jointly significantly different from zero; [3)] starting in 1981.03 for diffusion models including macroeconomic variables; [4)] non-uniform influence factor, d, however, not significantly different from 0; [5)] b < 0, however.*

Sources: various and authors' estimates.

Table 5 Estimation results of high-yield bond diffusion in market value terms

Pioneer influence factor	Diffusion speed	LBO	M&A	Output growth	Stock market return	High-yield spread	Wald test Bass/NUI model[1)]	Wald test macro factors[2)]	R^2
a	b	β_1	β_2	β_3	β_4	β_5			
United States 1981.1-1988.8[3)]									
	0.490**						4.15*		0.66
	(0.05)								
-0.019*	0.554**						3.25		0.69
(0.01)	(0.08)								
	0.046*	0.006	-0.083**	0.245	0.357*	-1.075	6.56**	501**	0.82
	(0.02)	(0.01)	(0.01)	(0.44)	(0.19)	(1.35)			
-0.007*	0.151**	0.006	-0.087**	-0.046	0.126**	-0.320	2.15	5990**	0.84
(0.00)	(0.04)	(0.00)	(0.00)	(0.12)	(0.05)	(0.44)			
United Kingdom 1998.12-2000.7									
	0.454**						5.04*[4)]		0.00
	(0.05)								
	0.440**	0.001	-0.083**	2.251**	0.175*	2.643**	1.01	6214**	0.30
	(0.06)	(0.01)	(0.01)	(0.33)	(0.08)	(0.57)			
United Kingdom 1998.12-2001.12									
	0.210*						1.10		0.04
	(0.09)								
	0.273	-0.006	-0.074**	1.252**	0.040	-0.438	0.55	11369**	0.59
	(0.15)	(0.01)	(0.01)	(0.30)	(0.07)	(1.02)			
Euro area 1998.12-2001.1									
	0.596**						0.03		0.53
	(0.08)								
	0.318**	0.010*	-0.080**	0.426**	0.055*	-0.610**	0.35	103003**	0.97
	(0.06)	(0.00)	(0.00)	(0.12)	(0.03)	(0.20)			
Euro area 1998.12-2001.12									
	0.339*						0.01		0.05
	(0.14)								
	0.373**	0.005*	-0.079**	0.645**	0.047	-0.376	0.18	206901**	0.96
	(0.09)	(0.00)	(0.00)	(0.08)	(0.03)	(0.23)			

*Notes: heteroscedasticity and autocorrelation-corrected standard errors between parentheses; ** and * denote significance at the 1% and 5% level, respectively; [1)] F-statistic, insignificance denotes that a more extended diffusion model is not rejected against the estimated diffusion model, that is, the Bass against Mansfield model (test a=0 in Bass model) and the NUI against Bass model (test a=0 and d=1 in NUI model); [2)] F-statistic; significance denotes that macroeconomic effects are jointly significantly different from zero; [3)] starting in 1981.03 for diffusion models including macroeconomic variables; [4)] b < 0, however.*

Sources: various and authors' estimates.

6.3 Comparison of high-yield bond diffusion rates

Two main conclusions emerge when comparing the US results for the estimated autonomous speed of diffusion in an illustrative way with those of the United Kingdom and the euro area (see Table 6).

First, the diffusion rate in the United States seems to have been more sensitive to macroeconomic developments than in Europe. This may be related to the pioneer stage of high-yield bond diffusion in the United States during the period under review. Uncertainty about the longer-term viability of junk bonds may have resulted in a relatively strong response to the macroeconomic environment. Second, the diffusion rate is found to be slower in the United States than in Europe, at least as macroeconomic factors are taken into account. This suggests a much slower high-yield bond diffusion pattern in the United States than in the United Kingdom and the euro area, which may again be explained by the pioneer and early adopting stage of the high-yield bond market in the United States during the period under review.

Table 6 High-yield bond diffusion rates in the United States, United Kingdom and the euro area

Diffusion models	**United States**	**United Kingdom**	**United Kingdom**	**Euro area**	**Euro area**
	1981.1-1988.8	**1998.12-2000.7**	**1998.12-2001.12**	**1998.12-2001.1**	**1998.12-2001.12**
Face value					
Mansfield	0.51	0.47	0.23	0.60	0.39
Bass	0.58	–	–	–	–
Mansfield with macroeconomic variables	0.05	0.50	0.34	0.34	0.33
Bass model with macroeconomic variables	0.17	–	–	–	0.19
Market value					
Mansfield	0.49	0.45	0.21	0.60	0.34
Bass	0.55	–	–	–	–
Mansfield with macroeconomic variables	0.05	0.44	0.27	0.32	0.37
Bass model with macroeconomic variables	0.15	–	–	–	–

Note: figures are based on the estimation results of Table 4 and 5.
Sources: various and authors' estimates.

Given the fact that when modelling a financial innovation the corresponding market is in a transition stage, a stage of innovation and imitation, the diffusion rate using the classic Mansfield model is estimated repeatedly, using ever larger subsets of the sample data. The first observation is used to form the first estimate of the diffusion rate. The next observation is then added to the data set to compute the second estimate of the diffusion rate. This process is repeated until all observations up to December 2001 have been used (see Chart 9). Two observations emerge from this.

The first observation is that the coefficient of imitation or the diffusion rate increases as observations are added up to a certain point for the United States and the euro area, after which the imitation rate tends towards zero. For the United Kingdom the estimated diffusion rate declines steadily as we add more data over the sample period, approaching a value of zero. The tendency to decline towards zero is exactly what one expects given the fact that the diffusion of a financial innovation is expected to take place only for a limited time span. For example, the classic diffusion periods as used in the diffusion literature for black & white televisions and colour televisions are 1947-1953 and 1963-1970, respectively. These diffusion periods matches well with the length of the diffusion period for high-yield bonds in the United States of 1981-1988, as defined in this study. After the diffusion of a financial innovation is completed no longer an impact of the autonomous speed of diffusion is expected. Given the tendency to decline for the UK and euro area diffusion rates, Chart 9 suggests that the diffusion period has completed in Europe.

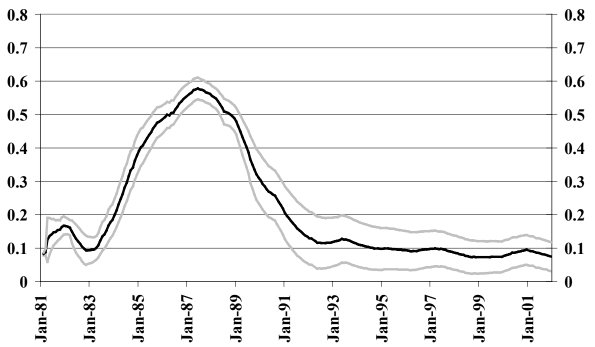
Secondly, it seems to be the case that the fastest diffusion speed of around 0.6 reached for the United States forms more or less the starting point for the high-yield bond diffusion in Europe. The comparatively fast speed of diffusion in Europe can be attributed to two factors. First and foremost, it could be due to the fact that there is a "bandwagon effect", that is the junk bond market was a US innovation that has since spilled over to the European market. Moreover, most of the main underwriters in Europe are US banks (see Table 3 in Section 2), which had already acquired the pricing, underwriting and placement expertise in their home country (Harm, 2001). More generally, a mechanism of financial innovation diffusion across countries may exist. Gatignon et al. (1989) and Dekimpe et al. (1996) show that a so-called "left-hand truncation bias" exists: later adopting countries show a relatively quick diffusion rate. The country that "imports" the financial innovation, i.e. Europe, adopts much faster than the pioneer country, i.e. the United States, because late adopters are in a better position to assess the new technology than earlier ones since all or at least more information concerning the innovation is available. Finally, improvement in computers, telecommunications, and other advances in technology coupled with financial de-regulation may have all contributed to speeding up the diffusion of financial innovations and shortening the innovation and imitation cycle (Merton, 1995).

Chart 9 Recursive estimates of Mansfield diffusion rates

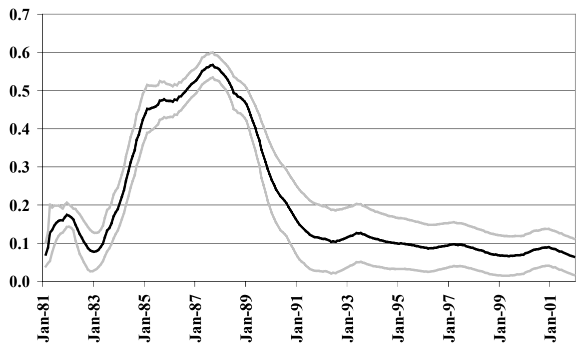
(grey lines denote two standard errors confidence interval)

United States

Face value

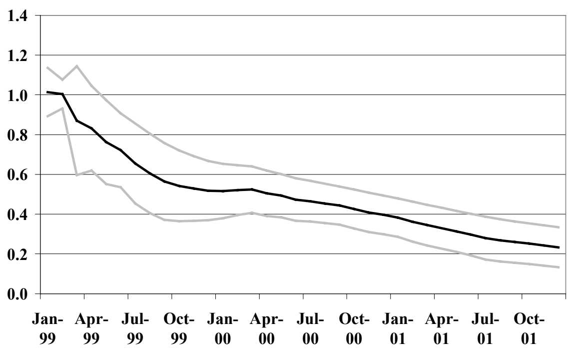


Market value

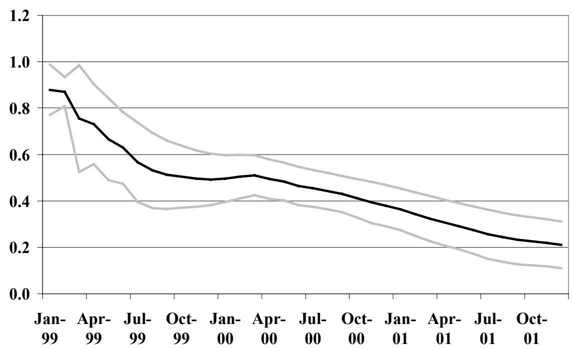


United Kingdom

Face value

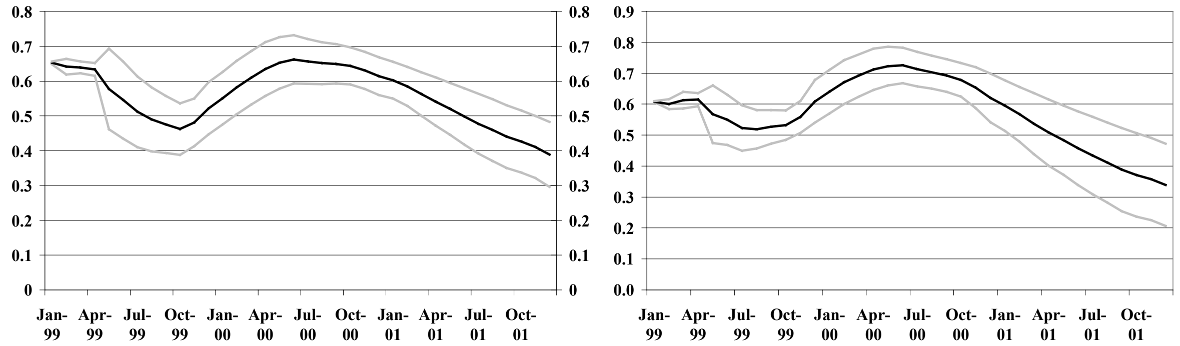


Market value



Euro area

Face value **Market value**



Sources: Merrill Lynch and authors' estimates.

7. Concluding remarks

The existence of a mature corporate bond market including a deep high-yield bond segment appears to be positive for economic development. It allows many corporations to raise funds more quickly and on more flexible terms than would otherwise have been available solely from the banking sector. We believe that the existence of this avenue of corporate finance complementary to the finance provided by the loan and equity market is particularly beneficial for Europe due to the existence of a large number of small and medium sized firms.

Unlike in the United States, where the high yield bond market developed in the early 1980s, in Europe the high-yield segment of the corporate bond market is a phenomenon of the late 1990s. The observed quick diffusion of high-yield bonds in Europe suggests that a national financial landscape might change within a short time span, because of a quick adoption of financial innovations from a pioneer country, e.g. the United States, to later adopting countries, e.g. the United Kingdom and euro area countries.

From a modelling point of view, this study provides a framework, taking account of the macroeconomic environment, which may form the starting point for future research on the diffusion of other financial innovative products, for instance all type of securitised assets. Another promising avenue for future research is the diffusion of financial instruments from industrialised economies to emerging market economies, since industrial economies appear, in contrast to emerging market economies, to benefit from the existence of multiple avenues of corporate finance (Davis and Stone, 2003). Corporations from emerging markets, which often have a credit quality below investment grade, could, however, also benefit from tapping the bond market when corporate profits are under pressure or when banks cut back their lending. High-yield bond markets could thus play a very important role in the development of financial markets in emerging market zones and therefore economic growth.

ANNEX 1 Data description

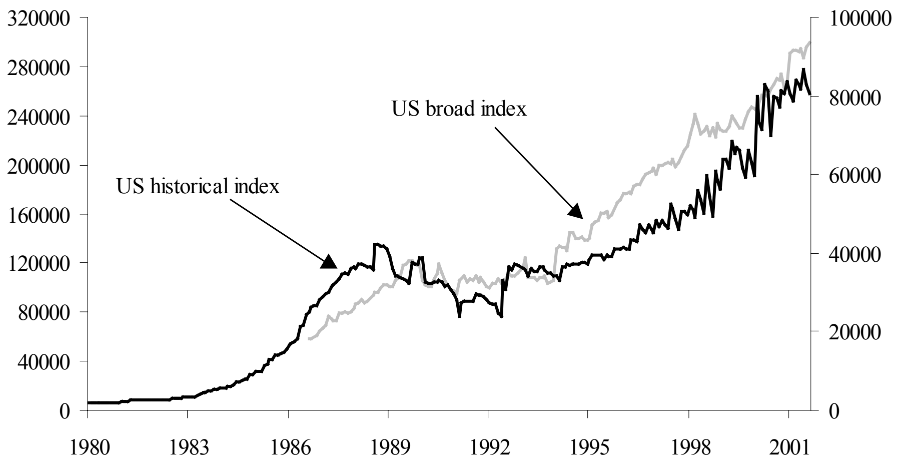
Table 1.1 Overview data

Code	Description	Unit[1]	Source
USHYFV	US High Yield 175 (X0A0), face value	US dollar millions, end of month	Merrill Lynch
UKHYFV	UK High Yield (HL00), face value	Pound millions, end of month	Merrill Lynch
EAHYFV	Euro High Yield (HE00), face value	Euro millions, end of month	Merrill Lynch
USHYFV2	US High Yield Master II (H0A0), face value	US dollar millions, end of month	Merrill Lynch
UKHYMV	UK High Yield (HL00), market value	Pound millions, end of month	Merrill Lynch
EAHYMV	Euro High Yield (HE00), market value	Euro millions, end of month	Merrill Lynch
USHYMV	US High Yield 175 (X0A0), market value	US dollar millions, end of month	Merrill Lynch
USHYMV2	US High Yield Master II (H0A0), market value	US dollar millions, end of month	Merrill Lynch
USTCFV	US total corporate (C0A0), face value	US dollar millions, end of month	Merrill Lynch
UKTCFV	UK total corporate (UC00), face value	Pound millions, end of month	Merrill Lynch
EATCFV	Euro total corporate (ER00), face value	Euro millions, end of month	Merrill Lynch
USTCMV	US total corporate (C0A0), market value	US dollar millions, end of month	Merrill Lynch
UKTCMV	UK total corporate (UC00), market value	Pound millions, end of month	Merrill Lynch
EATCMV	Euro total corporate (ER00), market value	Euro millions, end of month	Merrill Lynch
USHYYI	Yield on US high-yield bonds (XOA0)	% per annum, end of month	Merrill Lynch
UKHYYI	Yield on UK high-yield bonds	% per annum, end of month	Merrill Lynch
EAHYYI	Yield on euro area high-yield bonds (HE00)	% per annum, end of month	Merrill Lynch
USBBBYI	Yield on US BBB-rated investment-grade bonds (C0A4)	% per annum, end of month	Merrill Lynch
UKBBBYI	Yield on UK BBB-rated investment-grade bonds (UC40)	% per annum, end of month	Merrill Lynch
EABBBYI	Yield on euro area BBB-rated investment-grade bonds (ER40)	% per annum, end of month	Merrill Lynch
USMANV	Nominal value of effective M&A deals involving US non-financial corporations as targets	US dollar millions, monthly flows	Thomson Financial
UKMANV	Nominal value of effective M&A deals involving UK non-financial corporations as targets	British pound millions, monthly flows	Thomson Financial
EAMANV	Nominal value of effective M&A deals involving euro area non-financial corporations as targets	EUR millions, monthly flows	Thomson Financial
USLBNV	Nominal value of effective leverage buy-outs deals involving US non-financial corporations as targets	US dollar millions, monthly flows	Thomson Financial
UKLBNV	Nominal value of effective leverage buy-outs deals involving UK non-financial corporations as targets	British pound millions, monthly flows	Thomson Financial
EALBNV	Nominal value of effective leverage buy-outs deals involving euro area non-financial corporations as targets	EUR millions, monthly flows	Thomson Financial
USIPIN	US industrial production index	1992=100	Federal Reserve
UKIPIN	UK industrial production index	1995=100	National Statistical Office
EAIPIN	Euro area industrial production index	1995=100	Eurostat
EAIPAG	Euro area industrial production, adjusted for working days	Annual percentage changes in three-month moving averages	Eurostat
USSMIN	US stock market index, Standard & Poor's 500	1973=100, end of month	Datastream
UKSMIN	UK stock market index, Datastream UK index	1973=100, end of month	Datastream
EASMIN	Euro area stock market index, Dow Jones EURO STOXX broad	1973=100, end-of-month	Datastream

1) *Euro is euro or euro legacy currencies.*

Chart 1.1 Comparison of the two US high-yield bond indices calculated by Merrill Lynch

(US dollar millions; broad index is on the left-hand scale, historical index is on the right-hand scale)



Source: Merrill Lynch.

ANNEX 2 Diffusion patterns according to different values for the Bass diffusion model parameters

The impact of different values for the estimated diffusion model parameters is graphically shown below for Bass models with a market penetration ceiling of 15%. Coefficient *a* captures the role of external adopters, innovators or pioneers. This pioneer influence factor does not affect the overall shape of the adoption curve, but does affect the intercept, and therefore the number of periods necessary needed to reach the peak (see Chart 2.1). Parameter *b* reflects the role of internal adopters or imitators. The larger this autonomous speed of diffusion or rate of imitation, the more rapid the new product diffusion. The diffusion parameter *b* affects both the timing and amplitude of the peak (see Chart 2.2).

Chart 2.1 Diffusion patterns based on different values for the pioneer influence factor *a*

(b = 0.1)

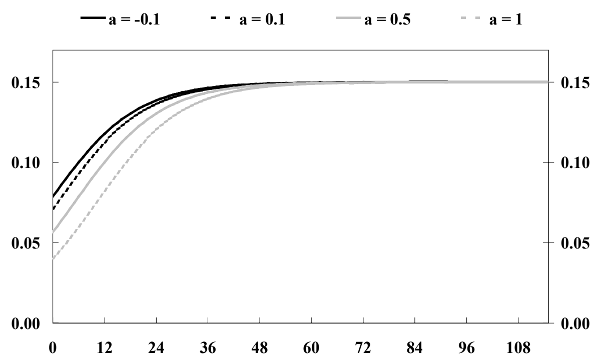
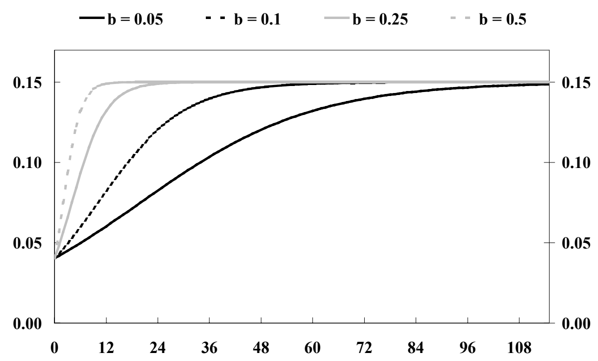


Chart 2.2 Diffusion patterns based on different values for the diffusion rate *b*

(a = 1)



ANNEX 3 Estimation results of high-yield bond diffusion based on different market penetration levels

An exogenous set market potential or market penetration ceiling is a common practice and the value of 15%, as used in the main text, is based on the actual observed maximum plus two standard deviations. Nevertheless, Table 2a and 2b below show the sensitivity of our results to changes in the market potential to 6% (the level around which the US market share of high-yield bonds fluctuates since the early 1990s) and to 10% above 15%, that is 25%. Table A.3a provides economically and statistically implausible results for the United States, simply due to the fact that the maximum market penetration level is assumed to be below observed values, which is inappropriate in a diffusion modelling framework. Comparing the other results as reported in Table A.3a and Table A.3b with Table 4 in the main text, one may conclude that the results remains very similar for other values of the market potential as long as the assumed potential market share is above any observed market share.

Table A.3a Estimation results of high-yield bond diffusion in face value terms, based on a maximum market penetration level of 6%

Pioneer influence factor	Diffusion rate	LBO	M&A	Output growth	Stock market return	High-yield spread	Wald test Bass/NUI model[1)]	Wald test macro factors[2)]	R^2
a	b	β_1	β_2	β_3	β_4	β_5			
United States 1981.1-1988.8[3)]									
	-0.196						17.8**		0.00
	(0.11)								
0.166**	-0.406**						0.33		0.00
(0.04)	(0.12)								
	0.103*	-0.065	-0.040	0.522	-0.180*	2.327	18.0**	5448**	0.00
	(0.04)	(0.03)	(0.02)	(0.69)	(0.09)	(2.29)			
-0.077**	0.474**	-0.020**	-0.071**	0.062	-0.050**	1.108*	0.84	150705**	0.07
(0.02)	(0.11)	(0.01)	(0.00)	(0.22)	(0.02)	(0.50)			
United Kingdom 1998.12-2000.7									
	1.097**						0.28		0.04
	(0.14)								
	0.779**	0.021	-0.097**	2.829**	0.126	3.014**	0.23	5590**	0.53
	(0.15)	(0.02)	(0.01)	(0.53)	(0.07)	(0.61)			
United Kingdom 1998.12-2001.12									
	0.619**						5.83**[4)]		0.05
	(0.21)								
	0.758*	0.004	-0.083**	1.420**	0.028	0.315	1.15	7003**	0.46
	(0.35)	(0.02)	(0.01)	(0.40)	(0.09)	(0.69)			
Euro area 1998.12-2001.1									
	0.879**						11.0**		0.66
	(0.07)								
-0.111**	1.198**						0.11		0.81
(0.03)	(0.11)								
	0.414**	0.015**	-0.085**	1.018**	0.038	-0.078	0.00	12391**	0.95
	(0.08)	(0.00)	(0.00)	(0.16)	(0.03)	(0.15)			
Euro area 1998.12 2001.12									
	0.611**						0.07		0.08
	(0.14)								
	0.409**	0.010**	-0.082**	0.986**	0.039	-0.015	0.01	75024**	0.94
	(0.09)	(0.00)	(0.00)	(0.10)	(0.04)	(0.13)			

*Notes: heteroscedasticity and autocorrelation-corrected standard errors between parentheses; ** and * denote significance at the 1% and 5% level, respectively; [1)] F-statistic, insignificance denotes that a more extended diffusion model is not rejected against the estimated diffusion model, that is, the Bass against Mansfield model (test a=0 in Bass model) and the NUI against Bass model (test a=0 and d=1 in NUI model); [2)] F-statistic; significance denotes that macroeconomic effects are jointly significantly different from zero; [3)] starting in 1981.03 for diffusion models including macroeconomic variables; [4)] b < 0, however.*

Sources: various and authors' estimations.

Table A.3b Estimation results of high-yield bond diffusion in face value terms, based on a maximum market penetration level of 25%

Pioneer influence factor	Diffusion rate	LBO	M&A	Output growth	Stock market return	High-yield spread	Wald test Bass/NUI model[1)]	Wald test macro factors[2)]	R^2
a	b	β_1	β_2	β_3	β_4	β_5			
United States 1091.1-1998.8[3)]									
	0.368**						0.01		0.65
	(0.04)								
	0.071**	0.004	-0.083**	-0.433*	0.130*	-0.335	6.66**	3996**	0.82
	(0.02)	(0.00)	(0.00)	(0.20)	(0.06)	(0.56)			
-0.004*	0.148**	0.004	-0.084**	-0.334**	0.068**	-0.049	4.35*[4)]	12852**	0.84
(0.02)	(0.04)	(0.00)	(0.00)	(0.11)	(0.03)	(0.27)			
United Kingdom 1998.12-2000.7									
	0.400**						6.85**[5)]		0.00
	(0.06)								
	0.443**	-0.000	-0.082**	2.227**	0.181*	3.105**	0.90	10955**	0.52
	(0.06)	(0.01)	(0.01)	(0.30)	(0.08)	(0.53)			
United Kingdom 1998.12-2001.12									
	0.199**						7.38**[5)]		0.00
	(0.07)								
	0.292*	-0.004	-0.076**	1.154**	0.049	0.232	1.72	12924**	0.41
	(0.15)	(0.01)	(0.01)	(0.25)	(0.07)	(0.65)			
Euro area 1998.12-2001.1									
	0.554**						0.04		0.74
	(0.05)								
	0.320**	0.012**	-0.083**	0.510**	0.047*	-0.120	1.09	47642**	0.94
	(0.07)	(0.00)	(0.00)	(0.11)	(0.03)	(0.16)			
Euro area 1998.12-2001.12									
	0.354**						4.37*		0.00
	(0.09)								
	0.310**	0.006**	-0.080**	0.727**	0.042	-0.002	6.94*	90572**	0.92
	(0.08)	(0.00)	(0.00)	(0.11)	(0.04)	(0.16)			
0.007*	0.157*	0.010*	-0.082**	0.949**	0.049	-0.113	0.69	49497**	0.93
(0.03)	(0.07)	(0.00)	(0.00)	(0.18)	(0.05)	(0.21)			

*Notes: heteroscedasticity and autocorrelation-corrected standard errors between parentheses; ** and * denote significance at the 1% and 5% level, respectively; [1)] F-statistic, insignificance denotes that a more extended diffusion model is not rejected against the estimated diffusion model, that is, the Bass against Mansfield model (test a=0 in Bass model) and the NUI against Bass model (test a=0 and d=1 in NUI model); [2)] F-statistic; significance denotes that macroeconomic effects are jointly significantly different from zero; [3)] starting in 1981.03 for diffusion models including macroeconomic variables; [4)] non-uniform influence factor, d, however, not significantly different from 0; [5)] b < 0, however.*

Sources: various and authors' estimations.

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