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Structural Reforms in Government Bond Markets

Prepared by Mark De Broeck, Dominique Guillaume, and Emmanuel Van der Stichele[1]

Authorized for distribution by Graham Hacche

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Abstract

The paper documents institutional reforms that have taken place in the government debt markets of many industrial countries since the early 1980s, and investigates the impact of three key changes: (i) the move from relationship financing to market funding; (ii) the introduction of options; and (iii) the introduction of futures. Variance ratio tests on bond data for 14 industrial countries indicate that the move to market funding increased the volatility of bond yields and improved the informational efficiency of the secondary markets. The introduction of options and futures increased the informational efficiency of the underlying market, but did not have a stabilizing effect.

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Author's E-Mail Address: mdebroeck@imf.org

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[1]Mark De Broeck is Economist in the Research Department of the International Monetary Fund, Dominique Guillaume is at the University of Oxford, C.S.A.E.--Institute of Economics and Statistics, and Emmanuel Van der Stichele is at J.P. Morgan. We are grateful for useful comments from Sushil Bikhchandani, Charles Goodhart, Graham Hacche, Dirk Heremans, Andrei Kirilenko, Jan Lemmen, Hanno Lustig, Michael Mussa, Patrick Van Cayseele and seminar participants at EHESS-GREQAM in Marseilles, the IMF, the University of Leuven, and the University of Oxford. The usual disclaimer applies. Dominique Guillaume acknowledges financial support of an E.U. TMR fellowship. The project was funded by the Fund for Scientific Research--Flanders and anchored at the University of Leuven; it was completed while Dominique Guillaume was a visiting scholar at the Research Department of the IMF.

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Summary

Since the early 1980s, major structural changes have taken place in the organizational and regulatory framework of government debt markets in many industrial countries. The paper documents these reforms, and analyzes how they have affected the risk characteristics of government debt management.

The institutional reforms in government debt markets can be classified into two main categories: changes in issuing techniques and the introduction of new instruments in the secondary markets. Most far-reaching among the reforms has been the shift from relationship financing to market-based funding in countries that traditionally relied on underwriting syndicates and directly placed bank loans. Paralleling the changes in issuing techniques, a range of new instruments was introduced, options and futures in particular.

According to the theoretical literature on financial innovation, the move to market-based funding is expected to raise the volatility of government service, and to be at the origin of a learning process in previously inactive and illiquid secondary markets. The introduction of futures and options can either decrease or increase the volatility in government debt markets, while the informational efficiency of these markets should unambiguously improve.

On the basis of a variance ratio analysis on high-frequency bond data for 14 countries, the paper demonstrates that the move to market-based funding had the theoretically expected effects. The empirical analyis also illustrates how futures and options indeed have improved the informational efficiency in the markets. On the other hand, no evidence is found that these new instruments have either increased or reduced the volatility of government bond yields and thereby systematically altered the overall risk characteristics of these markets debt management has to consider.

I. INTRODUCTION

From the early 1980s on, government debt management issues gained prominence in many industrial countries. As these countries experienced sustained increases in government debt-GDP ratios, a growing concern for more cost-effective financing strategies emerged. As a result, governments now systematically aim at minimizing debt management costs.[1] Governments are also increasingly aware of the trade-offs they face between reducing the average cost of debt service and raising exposure to risk. Moreover, financial, not just budgetary or accounting, costs are taken into account when considering these trade-offs.[2] Financial costs include both the interest costs and changes in the market value (capital costs) of the entire debt portfolio. Risk, in turn, can be defined in terms of the volatility of the debt service resulting from fluctuations of inflation, interest rates, and exchange rates and from changes in the financial environment such as spillovers between different markets and changes in the composition of investors.[3] In practice, governments have begun to construct benchmark or target portfolios that quantify the optimal debt service cost-risk trade-off they prefer (Cassard and Folkerts-Landau, 1997).

So as to reduce borrowing costs, and against the background of a broader process of financial innovation, deregulation, and international integration, industrial country governments have been introducing new financing methods and instruments since the early 1980s. In countries where relationship financing techniques such as underwriting bank consortia and special non-marketable debt instruments were previously used, governments switched to market-based techniques to issue debt. At the same time, secondary markets were reorganized and new instruments, derivatives in particular, were introduced in a large number of industrial countries.[4]

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[1]Other issues in the theory of public debt management, such as time-consistency issues, policy signaling with incomplete information, and the use of debt management to affect the market-clearing structure of asset yields, are not considered here.

[2]In Belgium, for instance, the objective of public debt management is to "minimize the financial cost of the public debt, while maintaining market and operating risks at an acceptable level" (Ministry of Finance, 1997).

[3]From a broader perspective, risk can also be described in terms of the variability of tax rates resulting from the underlying volatility in tax revenue and government spending. Indeed, such variable tax rates are undesirable in an environment of distorting taxation because distortions increase more than proportionally with the tax rate levied in a particular time period; see Barro (1995).

[4]We do not further consider the implications of the active use of derivatives by governments as they are mainly used in connection with foreign currency debt management, which is

(continued...)

Analytical models of government debt management that are developed in analogy with the asset choice models from finance theory, as surveyed in de Fontenay et al. (1997), typically do not take into account changes in the methods and instruments governments use to cover financing needs.[5] However, changes in the parameters of the distribution of asset returns--such as volatility--due to financial innovation should lead to an adjustment in the optimal debt portfolio (Hadar and Seo, 1990). Also, countries that use efficiency frontier models to construct benchmark portfolios derive variances and covariances from historical data, without controlling for changes following financial innovation. In this paper, we show that the volatility characteristics of governments' financial policies have been affected by the shift from relationship financing toward market funding and by the introduction of futures and options observed in many industrial countries.

The paper does not further analyze the origins of or the rationale for the types of financial innovations considered, as opposed to their consequences. Governments typically have taken the initiative to move from relationship financing to market funding. As will be argued below, relationship financing allows governments to dampen fluctuations in debt service. At the same time, such financing carries a premium to cover intermediation costs, and therefore raises the average debt service.[6] Relationship financing appears to have ceased being the preferred arrangement when, with rising debt levels in the 1980s, the costs of higher debt service began to outweigh the benefits of debt service smoothing. As Allen and Gale (1997) show, relationship financing tends not to survive the opening up of domestic financial markets to international competition. Futures and options on government securities, on the other hand, in rule have been introduced at the initiative of the private sector. Duffee and Jackson (1990)

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[4](...continued)
outside the scope of this paper. Spain and Sweden, for example, hedge the currency risk on their foreign currency debt through swaps and swap options. Switzerland, on the other hand, has, in anticipation of falling interest rates, swapped domestic currency long-term debt issued at fixed interest rates for funds at variable rates; Canada has used domestic swap transactions as well: the government has resorted to interest rate swaps instead of 3-month treasury bill issues to lower the cost of its 3-month borrowing.

[5]These models adapt the mean-variance model and, when the broader perspective on risk is taken, the consumption asset pricing model, to government debt management issues.

[6]A syndicate of financial institutions who commit themselves to purchase a certain amount of government securities or to lend to the government, typically will negotiate the price of the security or loan and receive a commission. Prior to reforms, the Belgian consortium received an underwriting commission of 1.6 percent of the face value of new bond issues. In France, the commission was 0.8 percent, in Germany 1.25 percent, and in Japan 0.90 percent. While the use of a group of primary dealers may also involve a cost for the government, the price of the security should be market determined and the dealer margin narrower, provided there is sufficient competition between the dealers.

study the introduction of new futures contracts in a model in which futures exchanges choose contracts to maximize trading volume. Allen and Gale (1994) study the incentives to set up an option exchange, and demonstrate that the costs of introducing such an exchange can be compensated by fees that the option market owner will charge to investors. Moreover, this exchange will generate Pareto superior allocations.

The empirical literature on the implications of financial innovations in government debt markets is not extensive. A number of studies have investigated the impact of the introduction of derivatives on treasury bill and government bond markets. Bortz (1984), Simpson and Ireland (1985) and Edwards (1988) study the effects of the introduction of futures on U.S. treasury bills and bonds, and find a moderate decrease in the volatility of the underlying markets, at least initially. Cronin (1993) sees no effect or an increase in volatility in the Irish market for long-term gilts following the introduction of futures. Ayuso and Núñez (1995) conclude that spot volatility decreased after the introduction of futures and options on the Spanish ten-year bond. Cohen (1996), finally, presents an empirical analysis of the effects of the creation of futures and options on long-term government bonds in Germany, Japan, and the United States, and finds an increase in the volatility of short-term price changes in the German and U.S. underlying markets. It is difficult to draw general insights from these studies, since they cover only five countries in total and yield mixed conclusions. Moreover, they suffer from methodological shortcomings, such as the neglect of structural breaks during the sample period and the use of volatility measures that are not statistically robust.

This paper offers a more comprehensive empirical analysis of the impact of financial innovations on the behavior of domestic currency government bond yields. The paper is organized as follows. Section 2 presents an overview of the main reforms in the government debt markets of the industrial countries since the early 1980s. Section 3 discusses the theoretically expected effects of three key changes: (i) the move from relationship lending to securities financing; (ii) the introduction of options; and (iii) the opening of futures markets. Section 4 empirically investigates the impact of these three changes, and Section 5 concludes.

II. INSTITUTIONAL CHANGES IN GOVERNMENT BOND MARKETS IN INDUSTRIAL COUNTRIES

The institutional changes that have taken place in the government bond markets of most industrial countries since the early 1980s can be classified into two main categories: changes in issuing techniques and the introduction of new instruments in the secondary market. The structural changes are summarized in Table 1. Major events are grouped under the following headings: the (partial) abandonment of consortium techniques ("A"); the start of futures trading in government bonds ("B"); and the beginning of trading in options on government bonds ("C"). In countries where the consortium technique was abandoned, measures were often taken to reform the institutional set-up of secondary markets as well, and turnover in these markets in many instances increased sharply. To supplement this information, Tables 2 and 3 include an overview of the issuing techniques and methods currently used in

Table 1. Overview of Recent Structural Changes in Industrial Country Government Bond Markets

AUSTRIA			
A	1989	Jan	move from consortium to auction technique
B	1993	July	futures on 10 year government bond
BELGIUM			
A	1989	May	introduction of linear bonds and end of consortium technique
B	1991	Dec	start of Belgian government bond future
DENMARK			
B	1989	Sept	futures contract on basket of three government bonds
FRANCE			
B	1986	Feb	start of MATIF: futures on 10 year government bond and on 90 day Treasury-bill
C	1988	Jan	introduction of options on financial futures in government bonds
GERMANY			
B	1988	Sept	introduction of Bund futures contract on LIFFE
C	1989	Apr	options on Bund futures are launched on LIFFE
A	1990	July	the traditional underwriting procedure for Bunds is combined with an auction
IRELAND			
B	1989	May	opening of the Irish Futures and Options Exchange with contracts on 5 and 10 years government bonds
ITALY			
B	1991	Sept	futures contract on 10 year BTP launched on LIFFE
C	1994	May	options on BTP futures are introduced into the MTO
JAPAN			
B	1985	Oct	introduction of government bond futures contract on TSE
A	1989	April	the consortium technique is combined with an auction
C	1990	May	introduction of option contract on TSE
THE NETHERLANDS			
B	1989	June	futures on bonds start trading
C	1994	Mar	first flexible options on government bonds
NORWAY			
A	1991	Feb	first auction for government bonds
B	1993	April	futures on government bonds on the OSE
SPAIN			
B&C	1990	Mar	start of futures and options on medium term government bonds
SWEDEN			
B&C	1986		interest rate futures and options based on 5 year bonds introduced on the Stockholm Options Market
C	1990	Sep	new futures contract on 5 and 10 years government bonds
SWITZERLAND			
B	1992	May	introduction of a futures contract on 8 to 12 years Swiss Government Bonds
C	1994	Jan	options on bond futures
U.K.			
C	1986	Ma	introduction of options on Gilts

Note: Structural changes include (i) the use of a new issuing instrument (e.g. auctions) (A); (ii) the start of futures trading on government bonds (B); (iii) the beginning of trading in options on government bonds (C). Sources: information from respective stock exchanges, debt management offices, treasury departments, Joint Report (1992), OECD (1993).

Table 2. Issuing Techniques for Government Bonds in Industrial Countries

Country	Fixed Price Public Subscription	Private Placement	Tap Issue	Auction
Australia		+	+	multiple price
Austria	+			multiple price
Belgium	+			multiple price
Canada			+	multiple price
Denmark	+		+	
Finland	+	+		uniform price
France			+	multiple price
Germany[1]	+	+	+	multiple/uniform
Greece	+			multiple price
Ireland			+	multiple price
Italy			+	uniform price
Japan[2]	+			multiple price
The Netherlands		+	+	uniform price
New Zealand			+	multiple price
Norway	+			uniform price
Spain	+			multiple/uniform
Sweden	+		+	multiple price
Switzerland	+	+	+	uniform price
UK[3]			+	multiple/uniform
USA			+	multiple/uniform

Sources: information from respective stock exchanges, debt management offices, treasury departments, Joint Report (1992), OECD (1993).

[1]The first part (forty percent) of an issue is sold to members of a syndicate (consisting of over 110 members) for which they get a fee and a second forty percent is sold via a multiple price auction. The third tranche is kept by the central bank for market intervention purposes, using tap issues.

[2]Sixty to eighty percent of the issue amount is sold through the auction, the remainder is distributed through a 900-member syndicate.

[3]Debt is sold through multiple and uniform price auctions combined with a tap issue into the secondary market of amounts not sold in the auction.

Table 3. The Secondary Market Lay-Out in the Industrial Country Government Bond Markets

Country	Bond Trading	Derivatives Exchange
Australia	Australian Stock Exchange OTC	Sydney Futures Exchange: F/O
Austria	Vienna Stock Exchange OTC	Austrian Futures and Options Exchange (ÖTOB): F
Belgium	Brussels Stock Exchange OTC	Belgian Futures and Options Exchange (BELFOX): F/O
Canada	OTC	Montreal Exchange: F/O
Denmark	Copenhagen Stock Exchange	Guarantee Fund for Danish Options and Futures (FUTOP):F/O
Finland	OTC	-
France	OTC	Marché à Terme International de France (MATIF): F/O
Germany	8 German Stock Exchanges OTC	Deutsche TerminBörse (DTB): F/O
Greece	Athens Stock Exchange OTC	-
Ireland	Irish Stock Exchange	Irish Futures and Options Exchange (IFOX): F
Italy	Mercato Telematico Secondario OTC	Mercato Italiano dei Futures (MIF): F Mercato Telematico dei Opzione (MTO): O
Japan	Tokyo Stock Exchange OTC	Tokyo Stock Exchange (TSE): F/O
Netherlands	Amsterdam Stock Exchange	Financial Futures Market (FTA): F European Options Exchange (EOE): O
New Zealand	OTC	New Zealand Futures and Options Exchange: F
Norway	Oslo Stock Exchange	Norwegian Option Centre (NOC): F
Spain	Madrid Stock Exchange OTC	Mercado Espanol de Futuros Financieros (Meff): F/O
Sweden	OTC	Stockholm Options Market (OM): F/O
Switzerland	Zurich Stock Exchange	Swiss Options and Financial Futures Exchange (SOFFEX): F/O
U.K.	London Stock Exchange	London International Financial Futures and Options Exchange (LIFFE): F/O
U.S.	New York Stock Exchange OTC	Chicago Board of Trade (CBOT): F/O Chicago Board Options Exchange (CBOE): O Mid-America Commodity Exchange (MIDAM): F/O New York Cotton Exchange (FINEX):F

Note: F indicates that futures are traded, O that options are traded. Sources: Information from respective stock exchanges, debt management offices, treasury departments, Joint Report (1992), OECD (1993).

countries.[7] A number of these countries, such as Australia, New Zealand and the USA already had a relatively sophisticated government bond market structure at the beginning of the 1980's. In this group, which does not include any European country, relatively few changes have taken place in recent years. In contrast, the process of financial reform has only recently been gaining momentum in other countries with less developed financial systems. Greece, for instance, announced in the summer of 1997 a shift from financing through a bank consortium toward market-based funding through auctions.

III. THEORETICAL IMPLICATIONS OF INSTITUTIONAL CHANGES

A. The Move From Relationship Financing to Market Funding

According to the financial contracting literature, relationship financing allows governments to reduce debt service fluctuations. By building up reserves, as in Allen and Gale (1997), banks can intertemporally smooth fluctuations in debt service that would result from shocks in the financial and general economic environment. Under normal market conditions, banks can provide credit at interest rates that are less volatile than those on market-based funding. In addition, in case of extreme events, such as confidence crises or severe payment bunching problems, banks can provide renegotiation and restructuring services since the power to renegotiate is not dispersed among multiple bond holders (Freixas and Rochet, 1997). The abandonment of relationship financing is therefore expected to increase the volatility of debt service.

The move toward market-based funding also has implications for the price discovery process in the secondary markets more specifically. In the case of relationship financing, members of the underwriting syndicate typically keep a significant part of the debt in their own portfolio, and secondary markets are largely inoperative.[8] With publicly issued debt, a more liquid secondary market with market participants other than the ones involved in the auction process will tend to develop, which will raise the informational efficiency of the market. Once secondary markets have been fully established and are highly liquid, if traders' private information is aggregated differently in the primary market, prices in the former market will also reflect unexpected price changes in the latter market (Cammack, 1991).

These theoretical insights can be summarized in the following two hypotheses:

Hypothesis 1: the move from relationship financing to market funding will raise the volatility of government debt service.

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[7]See De Broeck et al. (1997) for an in-depth description.

[8]In case of privately placed loans, there is no secondary market at all.

Hypothesis 2: the move from relationship financing to market funding is at the origin of an information discovery process in the secondary market

B. The Introduction of Futures

Introducing futures can affect both the volatility of the price of the underlying asset and the informational efficiency of the spot market. While the effect of futures on price volatility is ambiguous a priori, the effect on informational efficiency may be expected to be positive. Two channels through which futures affect volatility in the spot market can be identified.

Futures markets serve as a channel for communicating information. These markets provide an outlet for additional information by attracting more traders. If futures traders are better informed, as in Danthine (1978), they can convey information on the state of the economy to the holders of the spot instrument. This informational role of futures trading has a stabilizing influence on spot prices. If, however, the assumption of better informed speculators in the futures markets is dropped, as in Stein (1987), where agents in the futures market have heterogeneous information and the share of poorly informed traders is large, the net effect on spot price variability may be destabilizing.

Future markets also perform an insurance role. Under certain assumptions, futures markets, by allowing investors to pool risks more efficiently, will stabilize the price of the underlying asset (Chari et al., 1990). In a general equilibrium analysis of the risk sharing role of futures markets, as in Weller and Yano (1987), an income transfer effect between agents who bear capital gains or losses in the spot market at the settlement of futures contracts also has to be taken into account. If individuals have different degrees of risk aversion, the income transfer effect will influence spot price variability. Income transfers influence demands and, depending upon the relative degrees of risk aversion, will dampen or increase spot price variability.

In addition, the introduction of futures has implications for the informational efficiency of the spot markets. As argued by Cox (1976), efficiency is expected to improve for two reasons. First, futures markets attract additional traders to a market. Moreover, since transactions costs are lower in futures markets than in the spot market, trading can take place more quickly and convey information to the spot market.

We therefore have the following set of hypotheses:

Hypothesis 3: the introduction of futures can have a stabilizing effect on government debt spot prices.

Hypothesis 4: the introduction of futures can have a destabilizing effect on government debt spot prices.

Hypothesis 5: the introduction of futures improves the informational efficiency of the government debt spot market.

C. The Introduction of Options

The effects of the introduction of options can be analyzed along the same lines: the informational and risk-sharing effects of options can either decrease or increase the volatility in the market for the underlying asset, while the informational efficiency of this market improves. The analytical literature tends to focus upon the positive, stabilization and information enhancement, effects of introducing options.

The availability of options can improve the information about the underlying security, and thereby have a stabilizing effect. As with futures, however, introducing options can be destabilizing if agents trading in derivatives have inferior information (Stein, 1987). Another line of enquiry, pursued by Grossman (1988) in an asymmetric information setting, is to distinguish between "real" and "synthetic" options, the latter based upon replicating strategies. With a "synthetic" option, traders do not have to commit themselves to the strategy they wish to follow in the future. Consequently, they will also not be informed about other traders' strategies, and will not be able to foresee any large future price jumps resulting from a large volume of trading according to the same strategy. Conversely, the existence of a market with "real" options allows the revelation of information about traders' diverse opinions, and will dampen volatility.

Introducing options can improve risk sharing opportunities among agents with different risk assessments, providing another channel through which spot prices are stabilized. Using a general equilibrium framework, Detemple and Selden (1991) show that if the divergence in risk assessments between agents exceeds a certain threshold, setting up an option exchange will be useful, as more (less) risk-averse investors who believe that the volatility of the underlying asset will be high (low) will sell (buy) the asset and buy (sell) options. These shifts in demand will result in a more efficient allocation of risk and an increasing aggregate demand for the underlying security, causing its price to rise. Since the payoffs on the underlying security are given, the volatility of the rate of return perceived by each investor will decrease, resulting in a stabilization of the security market.

Finally, the introduction of options is considered to make spot markets more efficient in providing new information. In Grossman's (1988) asymmetric information setting, option markets also provide an outlet for the dissemination of private information so that prices become more informative with the introduction of derivative markets.

These insights can be summarized in the following set of hypotheses:

Hypothesis 6: the introduction of options can have a stabilizing effect on government debt spot prices.

Hypothesis 7: the introduction of options can have a destabilizing effect on government debt spot prices.

Hypothesis 8: the introduction of options improves the informational efficiency of the government debt spot market.

IV. EMPIRICAL ANALYSIS

A. Data Set

The data set consists of domestic currency government bond yields at daily frequencies. This choice of variable offers a threefold advantage. First, yield data are a good proxy for appropriately defined debt service costs since they incorporate both coupon payments and capital gains or losses, the two ways in which a government compensates its debt holders. Indeed, fluctuations of implicit debt service costs are directly correlated with fluctuations of bond yields (Sargent, 1993). Second, the data exclude the foreign currency component of the debt, the management of which is beyond the scope of the analysis in this paper. Finally, the high frequency at which these data are available allows us to study the volatility effects of different forms of financial innovation within the context of a single data set.

The yield data, provided by Datastream, are the average yield-to-maturity for all the government bonds with a maturity of more than five years that are included in the EFFAS government bond indices for the corresponding maturity sector.[9] The choice of a maturity sector rather than a single maturity class, say 10-year bonds, is motivated by the fact that the maturity of the most liquid debt instrument is not the same across countries and over time. Using the EFFAS bond indices, which by construction give a higher weight to the most liquid instrument for each country, has the advantage of making the yield data more comparable across countries.[10] In addition, the correlation between the yields of different maturity classes and the bond index yield is typically very high. We use daily yield observations from January 1985 until end July 1994, giving a sample of 2492 observations for most countries. Fourteen countries are considered: Austria, Belgium, Denmark, France, Germany, Ireland, Italy, Japan, the Netherlands, Norway, Spain, Sweden, Switzerland, and the U.K.

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[9]The corresponding EFFAS mnemonic is DEF.. G5(RY). The index portfolios include all bonds which are not too illiquid or unusual. In particular, bonds for which no price quotes are available, certain very small or tightly held issues, and bonds with uncertain cash flow (except for simple calls) are not included. Moreover, uniformity of tax treatment within-country is obtained by excluding bonds with differing taxation regime from their country's standard.

[10]To construct the indices, each individual bond's redemption yield is weighted by the product of that bond's face amount and Macaulay duration.

The summary statistics, displayed in Table 4, are computed for the full sample of the yield returns. They exhibit the usual features of financial asset price returns. In declining order of the magnitude of bond-yield variance, the countries are Sweden, Italy, Spain, Ireland, and the U.K. Five of the fourteen countries exhibit negative skewness and all have more mass in the tails than the normal distribution would predict. Ljung-Box tests on the returns and squared returns show the presence of both autocorrelation and heteroscedasticity. PP is the Phillips-Perron test to identify unit roots in the data; we included a constant term but no trend, as also suggested in Hamilton (1994) for nominal interest rates.[11] For all countries, the null hypothesis of a unit root is rejected.

B. A Variance Ratio Approach

Most of the theoretical models outlined in the previous section investigate the effects of changes following financial innovation by studying their impact on the volatility process rather than modeling the modified cost-risk trade-off in a full portfolio model. This is also the approach adopted in this section. In testing the above hypotheses, it is moreover important to distinguish which component of volatility will be affected. As in other financial markets, we expect longer-term volatility to reflect changes in the underlying fundamentals whereas short-term volatility also incorporates the impact of the trading process. In the case of the shift from consortium to market-issuing techniques which affects the extent to which bond-holders are willing to smooth shocks to the fundamentals affecting the government, one should analyze the impact on longer-run volatility relative to short-run volatility. Conversely, in the case of the introduction of derivative markets which has primarily an impact on the trading process and its participants, the focus should be on the relative impact on short-term volatility. The variance ratio methodology adopted in this section makes it possible to study directly the relative changes in short-term versus long-term volatility. Moreover our approach, by comparing relative changes in volatility according to time horizon, controls for the effects of other determinants of the volatility process that similarly affect short- and longer-term volatility.[12]

Variance ratios are based on the insight that the variance of the increments of a random walk are linear in the sampling interval. If the price series is generated by a random walk, the variance ratio, denoted (VR(q)), of (1/q)th of the variance of q periods to the variance of one holding period must equal one. Several studies have used the variance ratio test to verify the

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[11]We opted for the Phillips-Perron test instead of the ordinary Dickey-Fuller because the former is a consistent estimator when residuals exhibit autocorrelation and heteroscedasticity.

[12]Such other determinants include inflation rates, short-term interest rates and foreign exchange rates, measures of spillover effects between markets, or proxies for the business cycle. Data on a number of these determinants are only available at the monthly frequency, thereby leaving too few observations for the investigation of structural changes in the data patterns.

Table 4. Summary Statistics of Yield Changes

	Austria	Belgium	Denmark	France	Germany
nobs	2492	2492	2492	2492	2492
mean	-0.000432	-0.001305	-0.001816	-0.001710	-0.000037
max	0.1920	0.3490	0.803000	0.395000	0.338000
min	-0.1950	-0.4020	-0.453000	-0.696000	-0.333000
st-deviation	0.0202	0.0367	0.067343	0.058281	0.039982
skewness	0.1924	-0.255	0.8857	-1.1250	0.4053
kurtosis	28.68	22.098	21.518	21.474	11.149
Q(10)	429.99*	152.30*	17.58	73.50*	51.91*
Q2(10)	546.46*	198.74*	95.07*	644.69*	461.43*
PP	-43.35*	-41.31*	-46.05*	-43.12*	-45.63*
	Ireland	Italy	Japan	The Netherlands	Norway
nobs	2492	1060	2492	2492	2492
mean	-0.002732	-0.002492	-0.002519	-0.000164	-0.001978
max	0.8480	0.7090	0.6080	0.2740	0.3750
min	-0.9380	-0.5980	-4.5280	-0.4420	-0.6540
st-deviation	0.072691	0.087909	0.046649	0.037678	0.00231
skewness	0.535	0.432	1.792	-0.600	0.836
kurtosis	33.266	13.221	25.327	18.684	41.656
Q(10)	130.89*	43.387*	108.62*	130.13*	66.78*
Q2(10)	55.72*	117.66*	79.05*	260.24*	114.57*
PP	-45.42*	-142.15*	-45.17*	-42.16*	-44.83*
	Spain	Sweden	Switzerland	U.K.	
nobs	2492	2492	2492	2492	
mean	-0.001130	-0.000545	0.000166	-0.000984	
max	1.0250	0.9140	0.1260	0.4390	
min	-1.0760	-1.6340	-0.1440	-0.5530	
st-deviation	0.0835	0.0918	0.0184	0.0719	
skewness	0.153	-1.249	0.085	-0.296	
kurtosis	37.738	62.599	12.250	8.030	
Q(10)	24.31*	31.42*	727.67*	39.869*	
Q2(10)	9.16	14.45*	592.75*	227.05*	
PP	-46.51*	-46.70*	-39.94*	-46.24*	

Note: Q(10) is a Ljung-Box Q-test for the 10th lag. Q2(10) is a Ljung-Box for the 10th lag on the square returns. A * denotes significance level at 5 percent. PP is the MacKinnon t-statistic for the Philipps-Perron unit root test. A * denotes a rejection of the null of an unit root at 5 percent.

random walk hypothesis (see, for example, Campbell and Mankiw (1987) and Poterba and Summers (1988)). However, if one observes that VR(q) can be seen as a measure of the ratio of long-term to short-term price variance, being more than 1 if prices are positively correlated in the short run and less than 1 if prices are negatively correlated in the short run, the variance ratio test can in addition be used to examine the presence of potentially spurious (long term mean-reverting) volatility, the rate at which new information is incorporated in the prices of the underlying asset, and the presence of excess volatility.[13] Moreover, the variance ratio approach also enables one to test for the presence of structural changes.

In terms of the theoretical hypotheses formulated in the previous section, the variance ratio can be interpreted as follows. The hypothesis that the shift towards market financing has increased the volatility of government bond yields and hence implicitly government debt service (hypothesis 1) cannot be rejected if long-term volatility and the variance ratio have increased.[14] The existence of a learning process in the presence of imperfect information aggregation across the primary market and a previously inactive and illiquid secondary market (hypothesis 2) cannot be rejected if the variance ratios is different from unity. Indeed, price movements will be correlated if a learning process takes place. The hypotheses that the introduction of futures and options has stabilized the underlying markets (hypotheses 3 and 6) cannot be rejected if short-term volatility decreases, and, in cases where prior to the introduction of derivatives the underlying market was excessively volatile in the short run and derivatives removed the component of volatility not related to new information about fundamentals, if the variance ratio approaches 1 from a starting point that is below that level (Cohen, 1996). Conversely, the hypotheses that the introduction of futures and options has destabilized the underlying markets (hypotheses 4 and 7) cannot be rejected if short-term volatility increases and the variance ratios fall to below 1. Indeed, if derivatives were to create excessive short-run price movements in the underlying market, their introduction would be accompanied by an increase in short-term price volatility. If these short-term movements were spurious, however, they would be reversed in the longer term, and the variance ratio as ratio of long- to short-term variance would fall below the benchmark level of 1. Finally, the hypotheses that the introduction of futures and options have increased the information efficiency of the underlying spot market (hypotheses 5 and 8) cannot be rejected if the variance ratios fall from higher values to 1, the level of a random-walk for which all information is immediately incorporated into prices.

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[13]With the exception of Cohen (1996), these issues are not analyzed in the empirical literature surveyed in Section 2.

[14]As discussed, longer-term yield volatility is most relevant in considering the change in underlying debt service volatility when the smoothing provided by relationship financing is no longer available.

Different methodologies to compute variance ratios are available. Lo and Mac Kinlay (1988) calculate, using overlapping observations, the variance ratios for different aggregation values q according to:

$$M_r(q)=[\sigma_b^2(q)/\sigma_a^2]-1 \tag{1}$$

where

$$\sigma_b^2=\frac{q}{(nq-1)}\sum_{k=q}^{nq}(X_k-X_{k-q}-q\mu)^2 \tag{2a}$$

$$\sigma_a^2=\frac{1}{nq-1}\sum_{k=1}^{nq}(X_k-X_{k-\iota}-\mu)^2 \tag{2b}$$

with

$$\mu=\frac{1}{nq}\sum_{k=1}^{nq}(X_k-X_{k-1})\ .$$

They also derive the distribution of this variance ratio under the presence of heteroskedasticity, a pervasive characteristic of financial series as stressed above in the case of government bond yield indices.

An alternative methodology, which exploits the moment restrictions embedded in the variance ratio, is to use the Generalized Method of Moments (GMM) (see for instance Smith, 1994). Other research has found that the GMM approach rejects less often the random-walk hypothesis than the more commonly adopted Lo and MacKinlay approach, which tends to be biased towards over-rejection of the random-walk (see Chow and Denning, 1993). Furthermore, the use of a GMM estimator allows to formally test for the significance of structural changes using a Wald test (Hamilton, 1994). Formally, an appropriate vector of sample moments is as follows:

$$m_{nq}(\theta)=\frac{1}{nq}\sum_{k=q}^{nq}\begin{bmatrix} 1nX_k-1nX_{k-1}-\mu \\ (1nX_k-1nX_{k-1}-\mu)^2-Var(\eta_k) \\ (\frac{1}{q})(1nX_k-1nX_{k-q}-q\mu)^2-RVar(\eta_k) \end{bmatrix}\otimes z_k \tag{3}$$

where z_k is a vector of variables in the traders information set at time k, $m_{nq}(\theta)=m_{nq}(\mu,Var(\eta_k),R)$, nq is the number of observations and R is the variance ratio. Efficient GMM estimation yields a ratio estimate, $\tilde{R}_{nq}$, and a standard error robust to conditional heteroskedasticity and serial correlation (see Andrews (1991)), $\sigma(\tilde{R}_{nq})$, such that

$$\sqrt{nq}\frac{\tilde{R}_{nq}-1}{\sigma(\tilde{R}_{nq})} \rightarrow N(0,1) \ as \ T\rightarrow\infty \quad \textbf{(4)}$$

under the null hypothesis that the variance ratio is unity.

We have computed variance ratio estimates and their standard errors according to both the Lo and MacKinlay and the GMM approaches, but only report the GMM results.[15] For our purposes, a simple exactly identified methods of moments estimator was sufficient. Thus, we have not used additional informational variables or tested a null hypothesis on the basis of overidentifying restrictions. To attribute our results correctly to a particular event, we take data points before and after an event which do not overlap with those related to another event. Furthermore, to avoid any statistical effect that could be generated by different sample sizes, we take the same number of observations before and after an event.

We have also computed simple standard deviations of one period changes and of q-period changes, respectively. A comparison of both terms before and after the event indicates in what direction, if any, the standard deviation has changed.

C. Results

Standard deviations for the different categories of events are given in Tables 5 to 7 while the results of the variance ratio tests for these categories of events are given in Tables 8 to 10. In the standard deviation tables, the first line is the standard deviation before the event and the second line is the standard deviation after the event computed for various lag lengths q. In the variance ratio tables, the first two lines display the results for the period before the event, while the following two lines show the results for the period after the event. In each case, the first of the two lines is the variance ratio and the second is the significance test under the hypothesis of heteroskedasticity. The last line in the variance ratio tables is the Wald test for structural change. For all tables, values of the lag length q equal to 10, 15 and 25, that is 2, 3 and 5 weeks of business days, were chosen to yield a volatility in the numerator of a sufficiently long term in comparison to the denominator which captures daily volatility (taking much larger values of q would leave nearly no degrees of freedom in some of our relatively small samples).

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[15]The computations on the basis of the Lo and MacKinlay formulas are available upon request. The point estimates are very close to the ones obtained via the GMM, but the variances are much smaller.

Some broad conclusions can be drawn from the variance ratio results. First, the variance ratios are generally positively related with the lag length, q. For the four events where this is not the case, the random walk hypothesis is not rejected. This is to be expected, as the rejection of the random walk for values of the ratio above 1 implies that there is positive autocorrelation for subsequent returns, an effect which gets larger as q increases. Second, the results are remarkably consistent across countries; they are not altered by differences in institutional set-ups across countries, such as the implementation of uniform versus multiple price auctions, or by the fact that events took place at different periods of time when the overall economic environment, in particular inflation rates, may have been quite different. Finally, the variance ratios never fall below a level that is significantly different from unity, evidence that no event introduced negative serial correlation or excess volatility.

Turning to the interpretation of the results for specific events, the effects of a change in issuing system are presented in Tables 5 (standard deviation) and Table 8 (variance ratios). In all countries, both short- and long-term volatility increase, supporting our conjecture that the introduction of auctions increases volatility in bond markets. More importantly, for all

Table 5. Standard Deviation of Log Yield Changes: The Auction Effect

	Q=1	Q=10	Q=15	Q=25	nobs	date
Austria	0.0130	0.0165	0.0173	0.0181	**741**	1/89
	0.0170	0.0223	0.0231	0.0231	**741**	
Belgium	0.0221	0.0314	0.0333	0.0349	**661**	5/89
	0.0296	0.0405	0.0412	0.0422	**661**	
France	0.0262	0.0426	0.0438	0.0530	**125**	6/85
	0.0236	0.0340	0.0306	0.0314	**125**	
Germany	0.0344	0.0485	0.0498	0.0495	**196**	1/90
	0.0536	0.0771	0.0741	0.0716	**196**	
Japan	0.0361	0.0505	0.0503	0.0516	**286**	4/89
	0.0316	0.0432	0.0442	0.0435	**286**	
Norway	0.0228	0.0306	0.0318	0.0316	**545**	2/91
	0.0385	0.0546	0.0546	0.0548	**545**	

Standard deviations before and after the event. Q is the lag length in number of days.

Table 6. Standard Deviation of Log Yield Changes: The Futures Effect

	Q=1	Q=10	Q=15	Q=25	nobs	date
Austria	0.0234	0.0322	0.0334	0.0326	**275**	7/93
	0.0406	0.0569	0.0533	0.0548	**275**	
Belgium	0.0296	0.0405	0.0412	0.0421	**660**	12/91
	0.0476	0.0661	0.0642	0.0625	**660**	
Denmark	0.0446	0.0603	0.0632	0.0643	**300**	9/89
	0.0732	0.1005	0.1028	0.1033	**300**	
France	0.0301	0.0412	0.0384	0.0392	**168**	2/86
	0.0639	0.0883	0.0875	0.0868	**168**	
Germany	0.0347	0.0482	0.0479	0.0489	**151**	9/88
	0.0299	0.0402	0.0399	0.0358	**151**	
Ireland	0.0750	0.1131	0.1077	0.1024	**697**	5/89
	0.0595	0.0807	0.0820	0.0868	**697**	
Italy	0.0519	0.0696	0.0724	0.0719	**331**	9/91
	0.0963	0.1389	0.1302	0.1381	**331**	
Japan	0.0392	0.0544	0.0539	0.0510	**204**	10/85
	0.0666	0.0886	0.0893	0.0959	**204**	
Netherlands	0.0336	0.0473	0.0462	0.0438	**194**	6/89
	0.0426	0.0605	0.0567	0.0519	**194**	
Norway	0.0551	0.0741	0.0801	0.0786	**289**	7/93
	0.0794	0.1156	0.1118	0.1067	**289**	
Spain	0.0409	0.0702	0.0687	0.0677	**400**	3/90
	0.0752	0.1093	0.1061	0.1072	**400**	
Sweden	0.1309	0.1523	0.1507	0.1495	**257**	1/86
	0.0984	0.1730	0.1694	0.1626	**257**	
Sweden	0.0820	0.1136	0.1142	0.1158	**305**	9/90
	0.0704	0.1043	0.1046	0.1013	**305**	
Switzerland	0.0178	0.0249	0.0242	0.0250	**437**	5/92
	0.0204	0.0277	0.0273	0.0295	**437**	

Standard deviations before and after the event. Q is the lag length in number of days.

Table 7. Standard Deviation of Log Yield Changes: The Options Effect

	Q=1	Q=10	Q=15	Q=25	nobs	date
France	0.0877	0.1256	0.1223	0.1267	**485**	1/88
	0.0505	0.0699	0.0749	0.0704	**485**	
Germany	0.0298	0.0402	0.0399	0.0357	**151**	4/89
	0.0305	0.0449	0.0406	0.0414	**151**	
Japan	0.0316	0.0432	0.0442	0.0435	**286**	5/90
	0.0439	0.0611	0.0629	0.0578	**286**	
Spain	0.0409	0.0702	0.0687	0.0677	**400**	3/90
	0.0752	0.1093	0.1061	0.1072	**400**	
Sweden	0.1309	0.1523	0.1507	0.1495	**257**	1/86
	0.0984	0.1730	0.1694	0.1626	**257**	
Switzerland	0.0103	0.0149	0.0160	0.0168	**325**	1/94
	0.0337	0.0485	0.0488	0.0477	**325**	
U.K.	0.0590	0.0856	0.0843	0.0952	**230**	3/86
	0.0878	0.1257	0.1099	0.1278	**230**	

Standard deviations before and after the event. Q is the lag length in number of days.

Table 8. Variance Ratios of Log Yield Changes: The Auction Effect

	Q=10	Q=15	Q=25	nobs	date
Austria	**2.67°**	**3.50°**	**4.72°**	**741**	
	3.24	3.43	3.59		
					1/89
	2.86°	**3.58°**	**4.50°**	**741**	
	3.06	2.82	2.79		
	0.11	0.01	0.04		
Belgium	**2.53°**	**2.98°**	**3.45°**	**661**	
	4.21	4.23	4.07		
					5/89
	2.85°	**3.47°**	**4.13°**	**661**	
	3.88	3.70	3.73		
	0.56	0.72	0.86		
Germany	**1.01**	**1.17**	**1.22**	**196**	
	0.05	0.59	0.77		
					1/90
	1.99°	**2.11°**	**2.17°**	**196**	
	2.06	2.22	2.36		
	6.56*	5.16*	5.45*		
Japan	**1.13**	**1.25**	**1.46**	**286**	
	0.61	0.93	1.24		
					4/89
	2.27°	**2.50°**	**2.77°**	**286**	
	2.51	2.69	3.04		
	8.49*	8.01*	7.23*		
Norway	**1.52**	**1.55**	**1.61**	**545**	
	0.71	0.69	0.71		
					2/91
	1.52°	**1.77°**	**1.94°**	**545**	
	2.17	2.73	2.99		
	0.00	0.13	0.25		

Variance ratios calculated using logarithms of daily changes in bond yields. For each country first the variance ratio before the event is displayed, with the heteroscedastic Z-statistics for the hypothesis that the ratio equals one. An ° indicates that the ratio is significantly different from one at the 95 percent level. Second, the variance ratio after the event is given with the same statistics. Finally, the Wald test for significance of structural change is given. A * denotes significance at 95 percent and ** at 90 percent.

Table 9. Variance Ratios of Log Yield Changes: The Futures Effect

	Q=10	Q=15	Q=25	nobs	date
Austria	**2.42°**	**2.88°**	**3.13°**	**215**	
	2.58	2.51	2.41		
					7/93
	1.89°	**2.20°**	**2.98°**	**215**	
	2.89	2.77	2.60		
	1.37	1.21	0.04		
Belgium	**2.86°**	**3.47°**	**4.13°**	**660**	
	3.88	3.70	3.73		
					12/91
	1.15	**1.16**	**1.17**	**660**	
	1.41	1.23	1.07		
	24.09*	22.90*	23.94*		
Denmark	**1.19**	**1.21**	**1.10**	**300**	
	0.69	0.73	0.32		
					9/89
	1.28	**1.37**	**1.43**	**300**	
	1.15	1.49	1.43		
	0.11	0.33	1.10		
France	**1.00**	**0.98**	**1.04**	**168**	
	0.57	0.04	0.16		
					2/86
	1.78	**2.07**	**2.25**	**168**	
	1.67	1.86	1.77		
	4.11*	5.67*	5.11*		
Germany	**1.12**	**1.21**	**1.29**	**151**	
	0.54	0.77	0.97		
					9/88
	1.35	**1.52**	**1.77°**	**151**	
	1.09	1.37	2.02		
	0.68	0.82	1.90		
Ireland	**1.80°**	**1.99**	**2.24°**	**697**	
	1.98	1.83	2.10		
					5/89
	1.54°	**1.74°**	**2.03°**	**697**	
	2.56	2.78	2.95		
	0.65	0.32	0.18		

Table 9. Variance Ratios of Log Yield Changes: The Futures Effect (Continued)

	Q=10	Q=15	Q=25	nobs	date
Italy	**1.79°**	**1.78°**	**1.83°**	**256**	
	2.34	2.10	2.49		
					9/91
	1.44	**1.42**	**1.30**	**256**	
	1.39	1.17	0.78		
	1.11	0.99	2.19		
Japan	**1.14**	**1.28**	**1.39**	**175**	
	0.33	0.56	0.56		
					10/85
	1.68	**1.82**	**1.87**	**175**	
	0.84	0.91	0.92		
	0.69	0.53	0.32		
Netherlands	**1.70**	**1.84**	**1.86°**	**194**	
	1.59	1.78	2.19		
					6/89
	1.93	**1.96**	**1.70**	**194**	
	1.84	1.59	1.44		
	0.22	0.05	0.13		
Norway	**1.56°**	**1.86°**	**2.23°**	**245**	
	2.15	2.59	3.02		
					7/93
	1.23	**1.22**	**1.23**	**245**	
	0.71	0.62	0.73		
	1.31	3.30**	7.31*		
Spain	**1.39**	**1.75**	**1.95**	**400**	
	0.90	1.25	1.37		
					3/90
	1.08	**1.02**	**0.94**	**400**	
	0.16	0.04	0.10		
	0.44	1.69	2.76**		

Table 9. Variance Ratios of Log Yield Changes: The Futures Effect (Concluded)

	Q=10	Q=15	Q=25	nobs	date
Sweden	**1.12**	**1.22**	**1.28**	**227**	
	0.19	0.27	0.30		
					9/90
	1.05	**1.05**	**1.22**	**227**	
	0.10	0.09	0.34		
	0.01	0.05	0.01		
Switzerland	**3.51°**	**4.14°**	**5.44°**	**437**	
	4.41	4.79	5.32		
					5/92
	3.43°	**3.99°**	**5.00°**	**437**	
	4.03	3.72	3.86		
	0.02	0.04	0.21		

Variance ratios calculated using logarithms of daily changes in bond yields. For each country first the variance ratio before the event is displayed, with the heteroscedastic Z-statistics for the hypothesis that the ratio equals one. An ° indicates that the ratio is significantly different from one at the 95 percent level. Second, the variance ratio after the event is given with the same statistics. Finally, the Wald test for significance of structural change is given. A * denotes significance at 95 percent and ** at 90 percent.

Table 10. Variance Ratios of Log Yield Changes: The Options Effect

	Q=10	Q=15	Q=25	nobs	date
France	**1.06**	**1.06**	**1.15**	**485**	
	0.24	0.22	0.46		
					1/88
	1.31	**1.45**	**1.51°**	**485**	
	1.73	1.92	2.01		
	1.36	2.22	1.45		
Germany	**1.35**	**1.52**	**1.77°**	**151**	
	1.09	1.37	2.02		
					4/89
	1.00	**1.16**	**1.23**	**151**	
	0.02	0.43	0.57		
	1.09	0.88	1.87		
Japan	**2.27°**	**2.50°**	**2.77°**	**286**	
	2.51	2.69	3.04		
					5/90
	1.73°	**2.15°**	**2.80°**	**286**	
	3.08	3.41	3.69		
	1.88	0.56	0.00		
Spain	**1.39**	**1.75**	**1.95**	**400**	
	0.90.	1.25	1.37		
					3/90
	1.08	**1.02**	**0.94**	**400**	
	0.16	0.04	0.10		
	0.44	1.69	2.76**		
Sweden	**1.12**	**1.22**	**1.28**	**227**	
	0.19	0.27	0.30		
					1/86
	1.05	**1.05**	**1.22**	**227**	
	0.10	0.09	0.34		
	0.01	0.05	0.01		
U.K.	**1.74**	**2.25°**	**3.20°**	**230**	
	1.91	2.20	2.40		
					3/86
	1.42	**1.65**	**1.90**	**230**	
	1.40	1.59	1.85		
	0.82	1.45	3.15**		

Variance ratios calculated using logarithms of daily changes in bond yields. For each country first the variance ratio before the event is displayed with the heteroscedastic Z-statistics for the hypothesis that the ratio equals one. An ◦ indicates that the ratio is significantly different from one at the 95 percent level. Second, the variance ratio after the event is given with the same statistics. Finally, the Wald test for significance of structural change is given. A * denotes significance at 95 percent and ** at 90 percent.

countries, the variance ratios increase after the event and, in two cases, very significantly so.[16] Therefore, neither hypothesis 1 nor hypothesis 2 can be rejected. While these results indicate that the introduction of market-based issuing techniques has led to an increase in volatility, they only capture one dimension of the modified cost-risk trade-off financial innovation involves. Because of its focus on volatility effects, our empirical analysis does not consider the reduction in interest costs that typically results from a shift to market-based techniques.[17]

The effect of the introduction of futures, shown in Tables 6 and 9, is pronounced. In most cases, the variance ratios fall, sometimes quite significantly, and when they do not, they are not significantly different from unity. In ten countries the variance ratios are not significantly different from one after the introduction of futures, supporting the hypothesis that their introduction has increased the informational efficiency of the spot markets. The results of the evolution of the short- and long-term volatility analyzed separately are noteworthy as well: in the vast majority of cases, eleven out of thirteen countries, both short- and long-term volatility rise. Thus, while the hypothesis that the introduction of futures markets created excessive short-term volatility can be rejected, these results do not support the hypothesis that this introduction stabilized the underlying spot markets. These results are not out of line with the predictions of the theoretical literature, which, as discussed in section 3, indicates that the introduction of futures not necessarily has a stabilizing effect.

Finally, the effects of the introduction of options trading are presented in tables 7 and 10. As with the introduction of futures, the variance ratios fall for all countries except France, where it is not significantly different from unity. Again, in five countries out of six, the variance ratios are not significantly different from unity after the introduction of futures, supporting the hypothesis that the introduction of futures has increased the informational efficiency of the spot markets. However, in all countries but France both short- and long-term volatilities rise after the introduction of options. Therefore, one again cannot accept the hypothesis that the introduction of options has stabilized the markets.

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[16] The statistical significance of structural changes as measured by the Wald test in a number of cases is rather low, a consequence of the larger standard errors obtained by GMM estimation.

[17] In addition to paying less commission fees, governments also benefit from the lower yields more efficient and liquid markets bring about. In Germany, for instance, following the 1990 reform, a placement commission is only paid for the first tranche (about 40 percent) of each new issue of government bonds (Bunds), and the commission is 0.875 percent instead of 1.25 percent. Moreover, the yield spread between 10-year maturity Bunds and bank bonds widened by on average around 60 basis points in the 1991-94 period following the reform compared with the preceding 1986-89 period, presumably on account of market structure innovation effects on Bund yields.

These results for the individual events indicate that the effects of major financial innovations are in many cases similar across countries. To obtain results that are mostly consistent and, in some cases, strongly statistically significant is reassuring given the methodological limitations of our simple variance ratio tests, the relatively small samples and the notorious difficulty to model high frequency financial data.[18]

V. CONCLUDING REMARKS

Since the early 1980s, major structural changes have taken place in the organizational and regulatory framework of government debt markets in a number of industrial countries. This paper documents these reforms, and analyses how they have affected the risk characteristics of government debt management.

Most far-reaching among the reforms has been the shift from relationship financing to market-based funding in countries that traditionally relied on underwriting syndicates and directly placed bank loans. On the basis of a variance ratio analysis, the paper demonstrates that such reform resulted in higher long-term volatility of government bond yields. At the same time, our analysis finds evidence of a learning process in the previously inactive and illiquid secondary markets.

Paralleling the changes in primary markets, a range of new instruments was introduced, hedging and insurance instruments in particular. The paper illustrates how derivatives have improved the informational efficiency in the markets. On the other hand, no evidence is found that these instruments have either increased or reduced the volatility of government bond yields and thereby altered the overall risk characteristics of these markets. However, a more detailed analysis of individual debt management and investment strategies is likely to reveal that both governments and investors have substantially benefited from the opportunities to improve portfolio and risk management offered by these instruments.

Financial innovation, and the introduction of new instruments in particular, is an ongoing process. In European financial markets, the monetary union will bring about further fundamental reforms in the organization of primary and secondary markets. Many non-industrial countries are preparing major reforms in government financial markets too. This paper has demonstrated that innovations and reforms affect the statistical properties of government bond yields, and therefore risk management by governments and investors alike. Therefore, as the innovation and reform process continues, more changes in the behavior of bond yields are to be expected.

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[18]To further check the robustness of our results and detect results that would be spuriously significant, we applied our variance ratio tests to U.S. data for the 1985-1994 sample period, assuming - counterfactually as auctions, futures and options were already in place - that financial innovations took place every January during the 1989-91 period. The variance ratios are not statistically different from unity and volatility does not increase after the articificial innovation dates.

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