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ABSTRACT

Defining Benchmark Status: An Application using Euro-Area Bonds*

The introduction of the euro on 1 January 1999 created the conditions for an integrated government bond market in the euro area. Using a unique data set from the electronic trading platform Euro-MTS, we consider what is the 'benchmark' in this market. We develop and apply two definitions of benchmark status that differ from the conventional view that the benchmark is the security with lowest yield at a given maturity. Using Granger-causality and cointegration methods, we find a complex pattern of benchmark status in euro-area government bonds.

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Defining Benchmark Status: An Application using Euro-Area Bonds

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1. Introduction

The introduction of the euro on 1 January 1999 eliminated exchange risk between the currencies of participating member states and thereby created the conditions for a substantially more integrated public debt market in the euro area. The euro-area member states agreed that from the outset, all new issuance should be in euro and outstanding stocks of debt should be re-denominated into euro. As a result, the euro-area debt market is comparable to the US treasuries market both in terms of size and issuance volume. Unlike in the United States, however, public debt management in the euro area is decentralised under the responsibility of 12 separate national agencies.

This decentralised management of the euro-area public debt market is one reason for the fragmentation of the market and the consequent cross-country yield spreads that exist. But the evidence for this fragmentation has not been thoroughly explored, and one of the contributions of this paper is to describe patterns in cross-country yield differences. For example, we find yields are lowest for German bonds; that there is an inner periphery of countries centred on France for which yields are consistently higher; and that the outer periphery centred on Italy display the highest yields.

We begin our analysis by discussing why such yield spreads exist. Our main contribution, however, comes in examining benchmark status. In this decentralised euro government bond market, there is no official designation of benchmark securities, nor any established market convention. Indeed, benchmark status is more or less explicitly contested among countries.

We consider in detail, with empirical evidence, the meaning of the term "benchmark" bond. The most common view associates the benchmark bond with the lowest yield. If that were all that mattered for benchmark status, then the German market would provide the benchmark at all maturities (see below). Analysts who take this view accept that the appropriate criterion for benchmark status is that this is the security against which others are priced, and they simply assume that the security with lowest yield takes that role (*e.g.*, Favero *et al.*, 2000, pp. 25-26). A plausible alternative, however, is to interpret benchmark to mean the most liquid security[1], which is therefore most capable of providing a reference point for the market. But the Italian market, not the German, is easily the most liquid for short-dated bonds; and perhaps the French is most liquid at medium maturities.

A different approach to defining benchmark status focuses directly on price discovery and regards the price discovery process as a purely empirical matter. Our perspective is that the benchmark bond is the instrument to which the prices of other bonds react. On this view, benchmark status must emerge from estimation and cannot simply be asserted or read off the data.

[1] See Blanco (2002).

We approach this estimation using two different empirical techniques. First, we conduct Granger causality tests between yields. If a bond yield at a particular maturity Granger-causes the yields of bond in other countries at the same maturity, this suggests that the Granger-causing bond is the benchmark at that maturity. The second method of analysis exploits the fact that yields are non-stationary for every country and at every maturity. If there were a unique benchmark at every maturity, then we would expect that the yields of other bonds would be cointegrated with that benchmark. Indeed, there should be multiple cointegrating vectors centering on the benchmark bond.

In the next section, we discuss the structure and development of the market for euro-area government bonds. Section 3 describes our unique data set. Section 4 presents the empirical analysis. Section 5 concludes.

2. The market for euro-area government bonds

The euro-area government bond market, at just under USD 3 trillion, is somewhat larger than that of the United States (Table 1). The largest outstanding stocks are those of Italy, Germany and France, in that order (Table 2). Turnover has risen dramatically since 1998 – by a factor of three for France, for example (Figure 1). International participation has also risen rapidly: in the three years from 1997 to 2000, the share of Belgian bonds held by non-residents rose from 29% to 53% (Galati and Tsatsaronis, 2001); for France, it doubled to reach one-third, which was also the average for the entire area (*ibid*. and Blanco, 2001).

McCauley (1999) draws some comparisons between the US municipal bond market and the euro government bond markets, but there can be no question that the latter are much more highly integrated. There has been considerable convergence among countries in the structure and maturities of government debt. The share of foreign-currency debt has fallen to negligible levels, mainly because that formerly denominated in other euro-area currencies is now denominated in euros. Privately placed loans have disappeared, and there is almost complete reliance on marketable instruments, especially fixed-rate medium- and long-term bonds. Each country is striving to achieve large liquid benchmark-size issues: recent French and Italian issues have exceeded € 20 bn, putting them at the level of US Treasury benchmark issues. German issues are in the range of € 10-15 bn, and even the small countries are now up to € 3-5 bn issue size. Secondary markets have become much deeper and more efficient (see Favero, *et al*., 2000).

There are still significant impediments to market integration. The single currency has not brought unification of tax structures, accounting rules, settlement systems, market conventions, or issuing procedures. On the other hand, a single electronic trading platform now handles about half of the total volume of secondary market transactions (see below).

Nor has market integration gone so far as to give identical yields on different countries' securities of the same characteristics. Yields have indeed converged (Figure 2). But there are still significant spreads, and since mid-2000, though not before, all countries have had positive spreads relative to Germany at all maturities (Figure 3). In our data (see below), for example, the Italian-German yield gap ranges from 18 bp at the short end to 35 bp at the very long end (it rises monotonically with maturity – see Tables 6, 8, 10, 12). Some observers conclude that this gives Germany unambiguous status as the benchmark issuer, although there might have been some multiplicity in the first eighteen months of EMU (Blanco, 2001, p. 14-15).

What are the sources of these yield differentials? It is plausible that before EMU, much of the spread simply reflected exchange-rate risk. Indeed, by comparing swap rates, Blanco (2001, Sec. 4.1) has broken down the spreads over German yields at the 10-year maturity between the foreign exchange factor and other factors, which he identifies with credit (default) risk and microstructure characteristics, in particular liquidity. He finds that for those countries with wide pre-1999 spreads, the main component was exchange-rate risk (Table 3). Moreover, taking that factor out, spreads have in fact widened significantly for all countries since the advent of the euro. And insofar as bond ratings represent default risk, it seems clear that only part of these wider spreads is attributable to this factor (Figure 4). But the interpretation of the spreads as representing different credit risks and liquidity characteristics is problematic. The spreads vary over time and along the yield curve. But credit ratings vary very little indeed over time and typically do not discriminate across maturities; and we are far from being able to identify time-varying and maturity-dependent determinants of liquidity.

Whatever the causes of the spreads for other countries over German yields, the mere fact that they are positive is enough for most observers to conclude that Germany provides the benchmark all along the yield curve. We shall find that the dynamic evidence on price discovery suggests a very different view.

3. Data

3.1 Primary data

We have a unique transactions-based data set from Euro-MTS for October and November of 2000. Since the creation of the euro in 1999, Euro-MTS has emerged as the principal electronic trading platform for bonds denominated in euros. At the end of 2000, it handled over 40% of total transactions volume (Galati and Tsatsaronis, 2001). Government bonds traded on Euro-MTS must have an issue size of at least € 5 bn. For a discussion of MTS, see Scalia and Vacca (1999).

The full data set consists of *all* actual transactions. For each transaction, we have a time stamp, the volume traded, the price at which the trade was conducted and an indicator showing whether the trade is initiated by the buyer or seller. The countries represented are Germany, Finland, Portugal, Spain, Austria, Italy, France, the Netherlands and Belgium: all euro-area countries except Ireland. Greece joined the euro-area after the time-period covered by the sample, while the twelfth euro-area country, Luxembourg, has negligible government debt.

The sample includes all Euro-MTS and country-specific MTS bonds traded on the electronic platforms. In addition to treasury paper, the data set also includes French and German mortgage-backed bonds, a European Investment Bank bond, and a euro-denominated US agency bond ("Freddie-Mac").

3.2 Derived data

In the analysis below we use the most frequently traded bond on the EuroMTS platform for each of three countries (Italy, France and Germany) and for each of four maturities. These are short, medium, long and very long. On the EuroMTS platform, all bonds are grouped into one of these four categories, as follows:

Maturity Baskets on Euro-MTS	
Short	1.25-3.5 years
Medium	3.5-6.5 years
Long	6.5-13.5 years
Very long	>13.5 years

The coverage of our data set for these three countries is set out in Table 4. It is evident that even at the very long maturity, there is much greater transactions volume for Italy on Euro-MTS than for either of the other countries (reflecting the origins of MTS in the Italian market). But there is no particular problem of ‘unrepresentativeness’ in our data for the other two countries. For our time-series analysis, we track only a single security for each country at each maturity, and there are enough transactions in the most highly traded bonds to give a fully representative series.

In each case the data are observed twice daily, at the end of each morning and afternoon. We take the transaction nearest in time to the latest transaction of the least liquid of the three bonds under scrutiny at that maturity. Our sample covers October and November of the year 2000. This was a consistently active period for the MTS electronic trading platform. Thus we have 44 trading days and 88 observations for each bond. Where liquidity was low (*e.g.*, in the case of the French bond at the long end and the German at the short end), some interpolation of missing values was conducted

Interpolation was done in relatively few cases (never for the Italian) and almost always involved the use of the most similar bonds from the same country (i.e. similar in terms of maturity, coupon, liquidity, and the yield gap against the other two countries). In the case of the long bonds, interpolation of the French benchmark was sometimes done using the most similar Dutch bond.In the instances where interpolation was not possible, the previously observed yield was continued forward[2]. This was done mostly in the cases of the German short and the French Very-Long bonds. It is worth pointing out that the periods of greatest illiquidity were also the periods of least variability, so that our practice of assuming zero change is not likely to have had significant effects on our regression results presented below.

The timing of observations is important, especially for the causality testing that we carry out in the analysis below. The most obvious problem that could arise from data of varying liquidity is that the most liquid variable will tend to be most up-to-date and appear to Granger-cause the other variables. This is most likely if data for each variable are selected according to a fixed time at the end-point of each trading period. In our case, the transactions for each variable were chosen according to their closeness in time to (either before or after) the last available transaction in each period in the least-liquid bond. This arrangement has a number of positive features: (i) our observations are likely to be close together, since we are trying to match more plentiful observations with those that are least plentiful rather than the other way around; and (ii) observations for the more liquid bonds are just as likely to precede as to follow the available illiquid bond observations, so that we would not expect a liquidity bias in the ordering.

Using ‘continuations’ is likely to have the following effect on the conclusions of section 4.2. The ‘Modified Davidson Method’, which we introduce there, is more likely to select a less variable yield as a benchmark. This discriminates against the

[2] We refer to these data points as ‘continuations’.

most liquid bonds on Euro-MTS (Italy) in favour of the less liquid (France and Germany). From the Table below, this suggests that continuations should bias our conclusions against Italy at the short-end, against France at the medium and in favour of France at the Very Long end. We shall see below that none of these outcomes actually materialise.

Continuations			
German Short	6	French Short	3
German Medium	2	French Medium	0
German Long	1	French Long	3
German Very Long	5	French Very Long	9

3.3 Data Summary

To fix ideas, we first provide a set of descriptive statistics for all of the data used in the analysis. For each of the four maturities, Tables 5, 7, 9, 11 show the mean, standard deviation, skewness, excess kurtosis and range for each of the three countries. The data are graphically displayed in Figures 5, 7, 9, 11. The units of measurement are percentage yields. The even-numbered Tables provide the same descriptive statistics for the three possible yield *gaps*. These yield gaps are displayed in the even-numbered figures. The unit of measurement for the gaps is basis points. The general pattern of the data is easy to describe. The Italian yield is always highest, the German the lowest, with the French yield in the intermediate position. The yield gap tables and figures show that the French yield is typically closer to the German than to the Italian yield. The only exception to this is displayed in Figure 10: for four days in early October 2000, the French-German yield gap was slightly higher than the Italian-German yield differential in the long-dated category.

Figures 13-16 graph the yields at each of the four maturities for most of the countries in our data set. These graphs suggest why we focus on Germany, France and Italy. Not only are they the three top countries in number of transactions at all maturities (Table 4), we see also that France and Italy appear to be the centre countries of two groups that emerge from the data, whereas Germany consistently carries the lowest yield.[3]

The final set of descriptive statistics anticipates the analysis. For each maturity, each bond and yield gap is subjected to a stationarity test. We use the Dickey-Fuller test or the Augmented Dickey-Fuller test where necessary. The results are reported in Tables 13 to 16 with one table devoted to each maturity. The columns in each table are as follows: the first shows the series under study; the second column shows whether the Dickey-Fuller or Augmented Dickey-Fuller test was used, indicating the number of lags required to obtain white noise. The column headed "t-value" shows the value of the statistic, and the following column provides the 95% critical value for the test. As usual, large t-values provide evidence for stationarity and vice-versa. For ease of comparison, the outcome of the testing procedure is listed in the last column. The intermediate columns simply provide evidence of test quality control: they show Ljung-Box test statistics and their p-values for first, second, third and sixth order autocorrelation.

The outcome of the tests is simple to summarise. In every case, the *yield* is unambiguously *non-stationary*. The results for the *yield gaps*, however, are not so clear. This is reflected in the fact that all of the tests on the yield gaps were carried out first with just a constant in the specification and then repeated with both a

[3] Inspection of Figures 14 and 15 (the intermediate maturities) may suggest four rather than three groupings (with Spain, Austria and Finland somewhat below Italy and Portugal). But the

constant and a trend. For example, at the short end (Table 13), it is unclear whether the Italian-German or the Italian-French yield gaps are stationary, whereas the French-German gap appears to be stationary. The implications of this will be developed in the next section.

4. Results and analysis

4.1 Granger causality

We begin by examining the flow of causality among the yields at each maturity. We bypass the issues raised by changes in the term structure by carrying this out for each maturity separately. We construct a three-variable vector autoregression at each maturity. Tables 17-20 report tests for lag length. This is done using Sims likelihood ratio tests, the Akaike Information criterion and Schwarz's Bayesian criterion. The tests are carried out on univariate autoregressions and the VAR system.[4] On the basis of the results reported in the Tables, the following lag lengths were selected for the vector autoregressions at each maturity.

VAR lag length at each maturity	
Short	1
Medium	1
Long	3
Very long	1

central positions of Germany, France and Italy in their respective places are sufficiently distinct to warrant our focus on them.

[4] We include dummy variables for the source of the order (trade type): a trade is either seller- or buyer-initiated, and we control for this.

Tables 21-24 report the results of the Granger Causality Tests. At the short end (Table 21), *no country emerges as benchmark*. Non-causality is rejected in every case: lagged yields of each country affect the yields of one or both of the other countries. For the medium maturity, the *German bond can be ruled out* as a possible benchmark, but both the Italian and French yields have predictive power for other countries' yields. At the long end, the *Italian bonds emerge as a benchmark* and have predictive power for both French and German yields. Finally, for the very long maturity, as with the medium maturity, only the *German bond can be ruled out* as benchmark.

These results strongly reject the hypothesis that innovations in German yields Granger-cause innovations in French and Italian yields, at all maturities. That interpretation of Germany as the benchmark issuer is not consistent with our data.

4.2 Cointegration

The Granger-causality analysis is simple but perhaps rather crude. It ignores long-run relationships. Such a structure to the price discovery process should appear from an analysis of cointegration of the yield series. If a particular country provides the benchmark at a given maturity, then there should be two cointegrating vectors in the three-variable system of country yields. For example, if Germany were the benchmark, then the cointegrating vectors could be[5]

Italian yield = γGerman yield + nuisance parameters

French yield = δGerman yield + nuisance parameters

.

The difficulty with the above analysis emerges from the identification problem. Even if we are satisfied that cointegration vectors along the lines of the above exist, we still cannot draw any immediate conclusion about the structure of the relationships between yields such as the identity of the benchmark. The reason for this is that any linear combination of multiple cointegrating vectors is itself a cointegrating vector. In particular,

Italian yield = (γ/δ)French yield + nuisance parameters

provides us with a perfectly valid cointegrating vector derived from the above. On the face of it, any one of the yields can provide the benchmark and we have made no progress.

A recent development in non-stationary econometrics due to Davidson (1998) and developed by Barassi, Caporale and Hall (2000) [BCH] enables us to explore the matter further. This involves testing for irreducibility of cointegrating relations and ranking according to the criterion of minimum variance. The interesting feature of this method is that it allows us to learn about the structural relationship that links cointegrated series from the data alone, without imposing any arbitrary identifying conditions. In this case, the 'structural' relationship which we are exploring is the identity of the benchmark in a set of bond yields.

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[5] A strong restriction is that the constant in both cointegrating vectors be unity. This corresponds to two stationary yield gaps. We already know from the discussion in Section 3 that this is problematic.

There is a risk of confusion in the use of the word structure, because of the many different uses to which it has been put by different authors. Davidson uses the term to mean parameters or relations that have a direct economic interpretation and may therefore satisfy restrictions based on economic theory. It need not mean a relationship that is regime-invariant. The possibility that "incredible assumptions" (Sims, 1980) need not always be the price of obtaining structural estimates turns out to be a distinctive feature of models with stochastic trends.

We begin with the concept of an irreducible cointegrating vector.

Definition 1 (Davidson): A set of I(1) variables is called irreducibly cointegrated (IC) if they are cointegrated, but dropping any of the variables leaves a set that is not cointegrated.

IC vectors can be divided into two classes: structural and solved.   A structural IC vector is one that has a direct economic interpretation.

Theorem (Davidson). If an IC relation contains a variable which appears in no other IC relation, it is structural.

The less interesting solved vectors are defined as follows:

Definition 2 (Davidson). *A solved vector is a linear combination of structural vectors from which one or more common variables are eliminated by choice of offsetting weights such that the included variables are not a superset of any of the component relations.*

A solved vector is an IC vector which is a linear combination of structural IC vectors. Once an IC relation is found, interest focuses on the problem of distinguishing between structural and solved forms. Of course, the theoretical model might answer this question for us, but this would then simply be using the theory to identify the model, so in the absence of overidentifying restrictions we could learn nothing about the validity of the theory itself. The compelling issue is whether we can identify the structure from the data directly.

BCH introduce an extension of Davidson's framework which can be illustrated concretely with our problem as follows. In our system made up of three I(1) variables, the French, German and Italian bond yields, consider the case where the pairs (German yields, French yields) and (German yields, Italian yields) are both cointegrated. It follows necessarily that the pair (French yields, Italian yields) is also cointegrated. The cointegrating rank of these three variables is 2, and one of these three IC relations necessarily is solved from the other two. The problem is that we cannot know which, without a prior theory. Here is where the BCH extension of Davidson's methodology shows its effectiveness. In order to detect which of the cointegrating relations is the solved one and which of the vectors are irreducible and structural, we calculate the descriptive statistics of each cointegrating relation and rank these vectors on the basis of the magnitude of their variance. The reason for this is suggested by standard statistical theory and can be illustrated as follows: Let x, y and z be our cointegrated series and let

$x - \beta y = e1$

$y - \gamma z = e2$

$x - \delta z = e3$

be the three irreducible cointegrating relations. Now assume that the structural relationships are the first two, (x-βy and y-γz), with e1 and e2 being the structural error terms from the first two which are therefore assumed to be distributed independently N(0, σ_i^2), i=1,2. The third equation is just solved from the first two. This implies that e3 is a function of e1 and e2, and therefore we expect it to be distributed N(0, $\sigma_1^2 + \sigma_2^2$). Basically, cointegrating relations that display lower variance should be the structural ones, the remaining others being just solved cointegrating relations.

In the light of the above, our empirical strategy is as follows. First, we use the Johansen procedure to identify the number of cointegrating vectors at each maturity in our three-variable system. Secondly, we use Phillips-Hansen fully modified estimation to estimate the irreducible cointegrating vectors as recommended by Davidson. Finally we rank the irreducible cointegrating vectors using the variance ranking criterion of BCH. From this we identify the structural vectors and therefore the benchmark. The latter must be the common yield in the two structural irreducible cointegrating vectors.

The results of the Johansen Procedure and Phillips estimation are shown for each maturity in Tables 25-28.

(i) Johansen Procedure: In Tables 25 , 27 and 28, it is clear that that there are two cointegrating vectors among the three yields at the short, long and very long maturities. Tables 26 provides more ambiguous evidence. For the medium maturity, there is at least one cointegrating vector using the trace and

$\lambda \max$ tests, but only the latter suggests that there are two cointegrating vectors.

(ii) Phillips-Hansen Estimation:

Short: All three pairs are irreducibly cointegrated using standard ADF tests. Interestingly, the coefficients are statistically significantly less than unity in each case.

Medium: Two of the pairs are irreducibly cointegrated using standard ADF tests. This supports the evidence provided by the $\lambda \max$ but not the trace test above. The remaining pair must be cointegrated as a consequence. Two out of the three cointegrating vectors displayed slopes that were significantly less than unity. The third was less than unity but not significantly so.

Long: Two of the pairs are irreducibly cointegrated using standard ADF tests. From both the Johansen results and arithmetic of multiple cointegration, the third pair must also be cointegrated. All three pairs have slopes that are insignificantly different from unity.

Very Long: All three pairs are irreducibly cointegrated using standard ADF tests. For two out of three pairs, the coefficients are statistically significantly less than unity.

(iii) BCH minimum variance ranking:

Short: The ranking of the variances of the residuals of the three cointegrating vectors from smallest to largest is:

Italian-German

Italian-French

French-German

From this we conclude that that the Italian-German and Italian-French pairs are structural and that the Italian yield provides the benchmark at the short end.

Medium: The ranking of the variances of the residuals of the three cointegrating vectors from smallest to largest is:

French-German

French-Italian

Italian-German

On this basis, the French yield is the benchmark at the medium maturity.

Long and Very Long: For both these maturities, the ranking of the variances of the residuals of the three cointegrating vectors from smallest to largest is:

Italian-German

German-French

Italian-French

Thus the German market provides the benchmarks at both the long and very long maturities.

The results here contrast sharply with those based on Granger-causality, as shown in this summary table (using the standard symbols D, F, I for Germany, France, Italy):

Benchmark issuers		
Maturity	*Granger-causality tests*	*Cointegration* analysis
Short	None	Italy
Medium	France or Italy	France
Long	Italy	Germany
Very long	France or Italy	Germany

The simplest explanation for this unexpectedly contradictory picture is that the Granger-causality tests are representing the daily dynamics, while the cointegration analysis reveals the long-run relationships. The latter supports the conventional view of Germany as the benchmark issuer at the long end of the market. That Italy provides the benchmark at the short end is perhaps not surprising, in view of the relative volume of Italian issues and the historical absence of German issues at this maturity. It could be argued that the French domination at the medium maturity is due to some combination of liquidity dominance over German bonds and "low yield" dominance over the Italian bonds. What is clear is that some role for liquidity in determining benchmark status emerges from the cointegration analysis.

4.3 An interpretation of the cointegration/ECM results from arbitrage pricing theory

Arbitrage Pricing Theory (in this application, better described as an affine theory of bond pricing) argues that the return on an asset is composed of three elements: an expected return, the systematic risk and the idiosyncratic risk. The systematic risk arises from the sensitivity of the asset return to a parsimonious number of *factors*. These factors are arbitrarily determined, and they may indeed be derived atheoretically from (for example) factor analysis.

This offers a new interpretation of the benchmark problem. Consider the canonical case. If Germany were to provide the benchmark, we expect that the *yield gap* between that country and each of France and Italy would be stationary, mindful of the fact that all yields are non-stationary. Specifically, the cointegrating vectors take the form:

Italian yield = α_0 + α_1German yield + stationary error ($\alpha_1 = 1$)

French yield = β_0 + β_1German yield + stationary error ($\beta_1 = 1$)

From the Granger Representation Theorem, the system has the following error correction representation:

ΔItalian yield = λ_0 + λ_1(German/Italian yield gap) + λ_2(German/French yield gap) + nuisance lags + noise

There are similar equations describing the evolution of the other yields.

The ECM equation above can be interpreted as an affine equation as follows: Construct a portfolio consisting of a long position in German bonds and an equal short position in Italian bonds. Call this the first canonical benchmark portfolio. Its return equals the German/Italian yield gap by construction. The parameter λ_1 can be understood as the loading sensitivity to that portfolio. A similar interpretation also applies to λ_2 with respect to a portfolio that is long in German bonds with an equal short position in French bonds. Call this the second canonical benchmark portfolio.

In fact, however, we find that the two canonical portfolios constructed above are *not* always the benchmark portfolios. Instead, we identify the benchmark portfolios through estimation using the Phillips-Hansen FMOLS procedure. For example, at the short maturity, the benchmark portfolios consist of

(i) a portfolio which is long in the Italian bond and (almost in equal measure) short in the French bond

(ii) a portfolio which is long in the Italian bond and has an almost equal short position in the German bond

The specific factors change depending on the structural relations chosen on the basis of the cointegration analysis. As shown in Table 29, at the short maturity the two factors are only significant for adjustment of yields in two cases. This is consistent with the view that the benchmark is solely the Italian bond. The Italian yield changes are not related to either factor, so that the Italian yield is weakly exogenous - a likely property of a benchmark. Remarkably, the French and German yield changes significantly relate only to the factor involving their own long-run yield relation with the Italian benchmark.

At the other maturities things are not as straightforward. Yield changes appear to react significantly to perturbations in both factors. While this may simply reflect complexity in the adjustment of the entire system of yields to disequilibria, it also suggests that benchmark status could be shared by more than one country. This is particularly relevant to the medium maturity, where the German yield changes relate significantly only to the factor that does not involve the German yield. It could therefore be concluded that the benchmark is some combination of the Italian and French bonds.

The concept of a benchmark security as a basket of bonds is not entirely new. Galati and Tsatsaronis (2001) raise the idea in the context of euro-area government bonds, only to dismiss it immediately: 'Market participants, however, are not yet ready to accept a benchmark yield curve made up of more than one issuer, being wary of the problems posed by small but persistent technical differences between the issues that complicate hedging and arbitrage across the maturity spectrum (p. 10).' But market participants themselves are not always fully aware of the structure of their behaviour. Moreover, this market is changing rapidly, so that both perceptions and analysis may not yet have assimilated fully the new conditions in the market after early 2000 (cf. our discussion in Section 2).

The view that there must be a single benchmark issuer, at least at a given maturity, is equivalent in our analysis to stipulating that the 'benchmark portfolios' enter into the yield change equations in a particularly simple form. In general, this is not what the data are telling us. The benchmark portfolios are typically simple, but not that simple.

5. Conclusion

We focus on the meaning of 'benchmark' bond in the context of the market for euro-area government securities. This market has developed rapidly since the beginning of monetary union, but it is still not fully integrated, and there is no consensus[6] regarding which securities have benchmark status. That is partly because this status has not been carefully defined. We investigate two possible criteria, using Granger-causality and cointegration frameworks. We find rather different results with the two methods, reflecting their different temporal focus. But with neither do we find the unambiguous benchmark status for German securities that would come from a simple focus on the securities with lowest yield at a given maturity. Our interpretation of the cointegration results in an arbitrage pricing theory framework leads naturally to looking for benchmark portfolios rather than a single benchmark security. This may be particularly appropriate in this newly and only partially integrated market.

Clearly more research is needed, and the Euro-MTS data base that we use is a rich source. Meanwhile, however, we believe it is clear from the research reported here that at least in the euro area, no simple definition of benchmark status will do.

Perhaps the markets are coming to understand this too:

‘German government bonds, long the unrivalled royalty of the European debt market, now find pretenders to the throne. The German government is careful…to protect the benchmark status of its bonds…But all the good intentions…are nothing in the face of the inexorable march of European monetary union. The euro-driven integration of European financial markets is creating vigorous competition to Germany’s long reign as king of the region’s bond markets. “Benchmark status is more contended now than it ever was,” said Adolf Rosenstock, European economist in Frankfurt at Nomura Research…’ (*International Herald Tribune*, 21 March 2002)

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[6] Remolona (2002) argues that the swaps market now provides the benchmark yield curve for euro denominated bonds.

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Table 1

The size of government bond markets
Outstanding stock in billions of US dollars

	Face value			Market value	
	1998	**2000**	**2002**[1]	**1998**	**2000**
Euro 11	3,474	2,834	2,900	2,266	2,430
United States	3,347	2,993	2,438	1,838	1,740
Japan	2,709	3,626	4,115	1,282	1,733

[1] Projections based on OECD projections of central government deficits.
Sources: BIS; OECD; European Commission; Schroeders Salomon Smith Barney; authors' calculations.

Source: Galati and Tsatsaronis (2001, p. 7)

Table 2

Size of government securities markets. Outstanding amounts. July 2001

EUR billions

Austria	106
Belgium	243
Germany	700
Spain	281
Finland	53
France	661
Ireland	22
Italy	1102
Luxemburg	1
Netherlands	186
Portugal	49
Greece	106
Euro Area	**3510**
United States (a)	3217
Japan (a)	3897

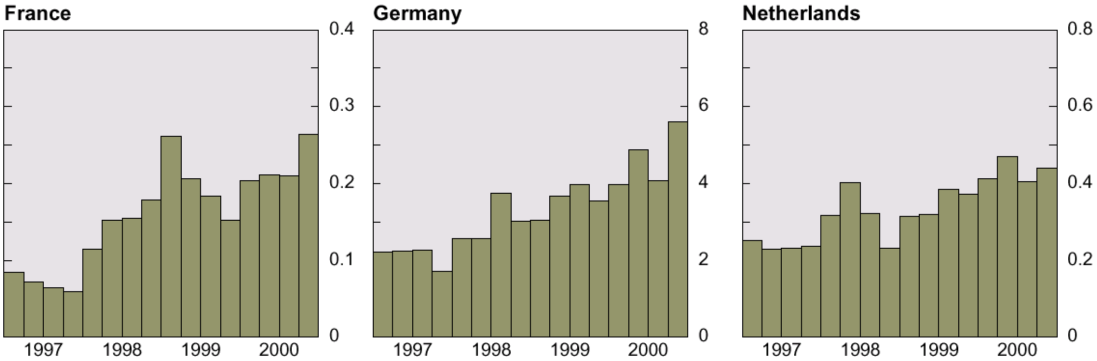
Sources: ECB, BIS.
(a) December 2000.

Source: Blanco (2001, p. 23)

Figure 1

Turnover of euro area government securities

Average daily turnover of bonds most actively traded on Euroclear, in billions of euros

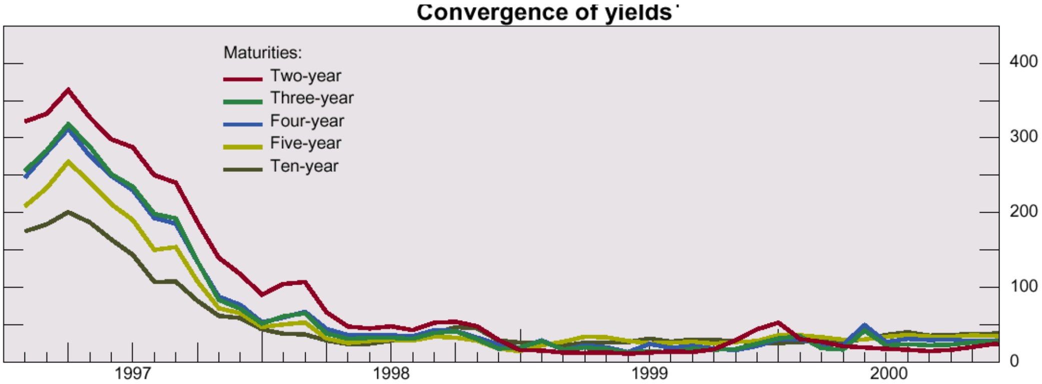


Source: Euroclear.

Source: Galati and Tsatsaronis (2001, p. 8)

Figure 2

Convergence of yields[1]

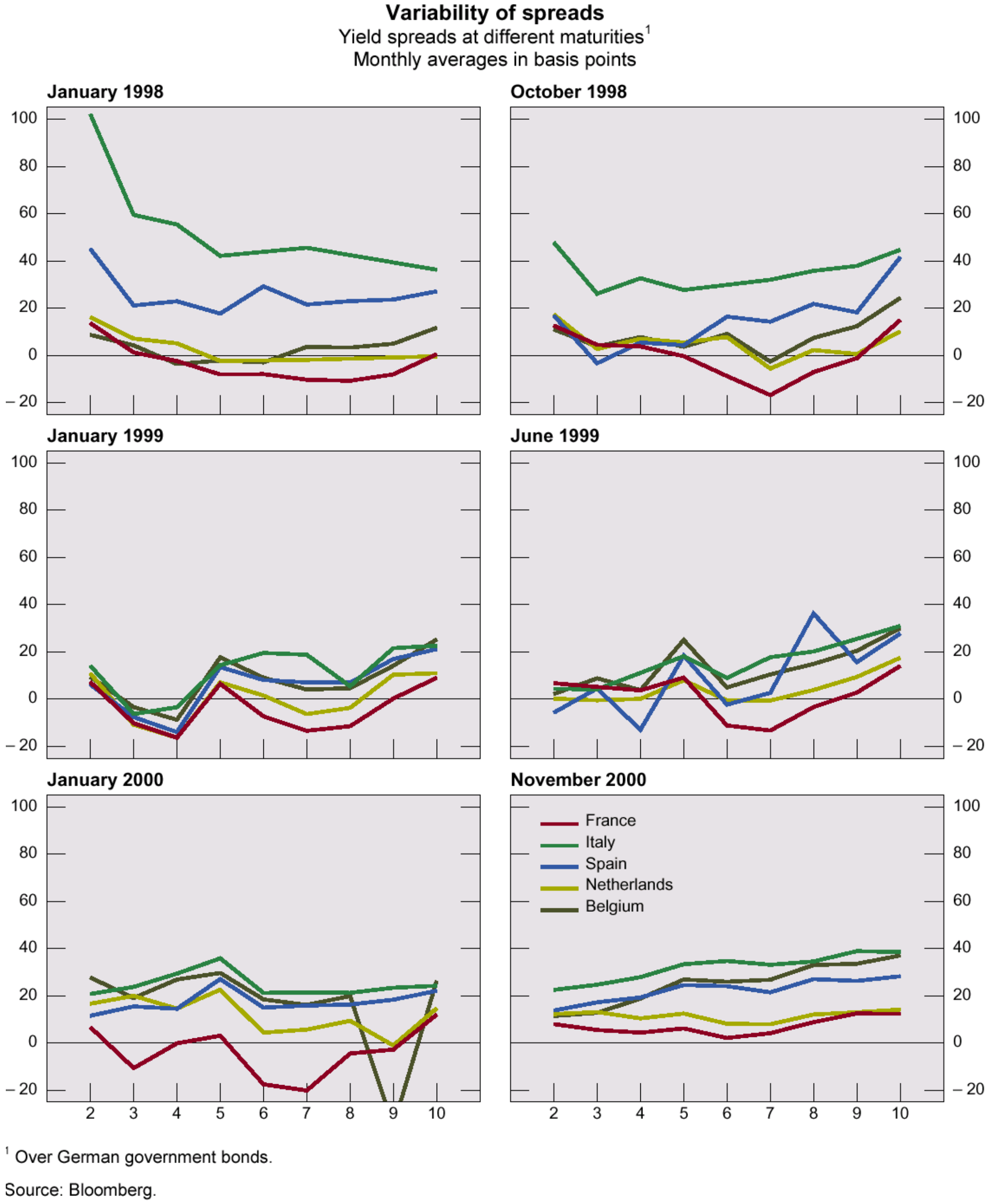


[1] Calculated as monthly averages of the difference between the highest and lowest yield of a given maturity of government bonds in Germany, France, Italy, Spain, the Netherlands and Belgium.

Source: Bloomberg.

Source: Galati and Tsatsaronis (2001, p. 7)

Figure 3



[1] Over German government bonds.

Source: Bloomberg.

Source: Galati and Tsatsaronis (2001, p. 9)

Table3

10-year yield spreads before and after EMU. Breakdown by factors (a)

Basis points

	Before EMU (1996-1998)			After EMU (1999-2001)
	Spread	Foreign exchange factor (b)	Other	Spread
Austria	9.7	1.3	8.4	26.2
Belgium	19.0	4.5	14.5	31.0
Finland	46.2	40.9	5.3	22.8
France	3.8	-2.9	6.8	13.1
Ireland	45.4	36.6	8.9	23.1
Italy	154.4	132.2	22.2	31.5
Netherlands	-2.2	-3.8	1.6	14.8
Spain	114.9	96.4	18.6	27.0

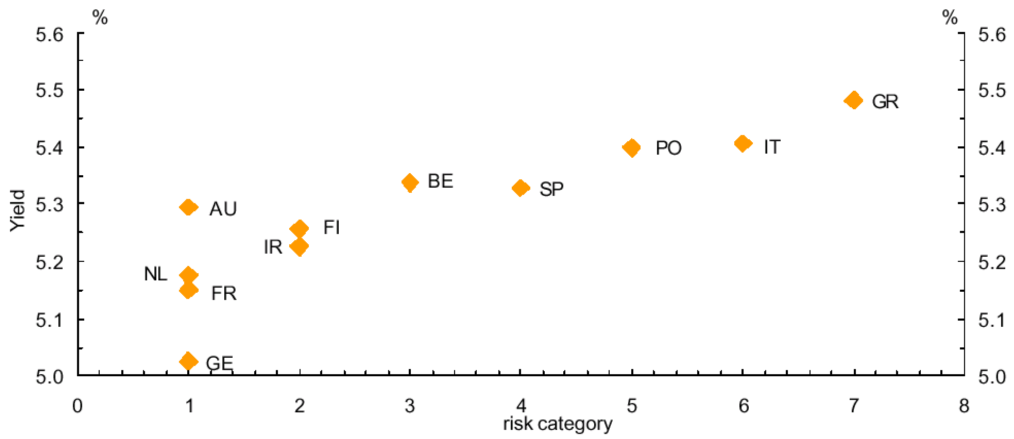
(a) Spread over German bonds.

(b) Approximated as the spread beween the swap rate in the currency of denomination of the bond and the swap rate in DM.

Source: Blanco (2001, p. 28)

Figure 4

10-year government bond yields by risk category (June 2001)



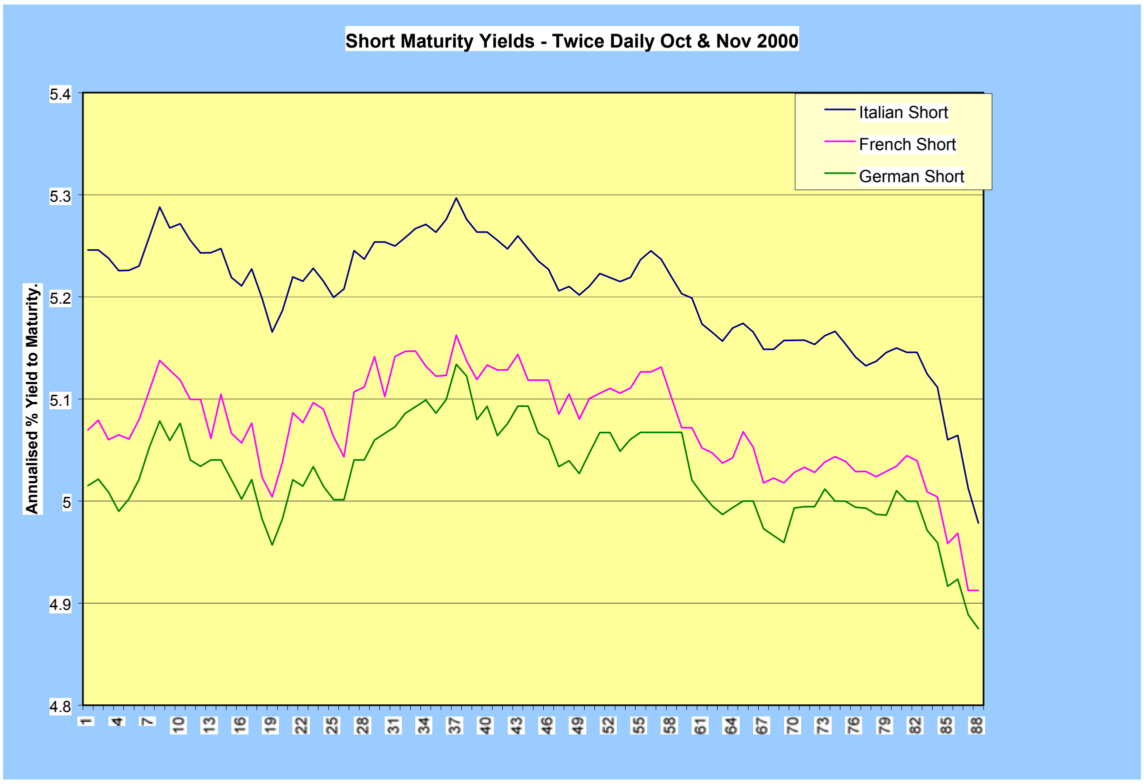
Source: Bloomberg.

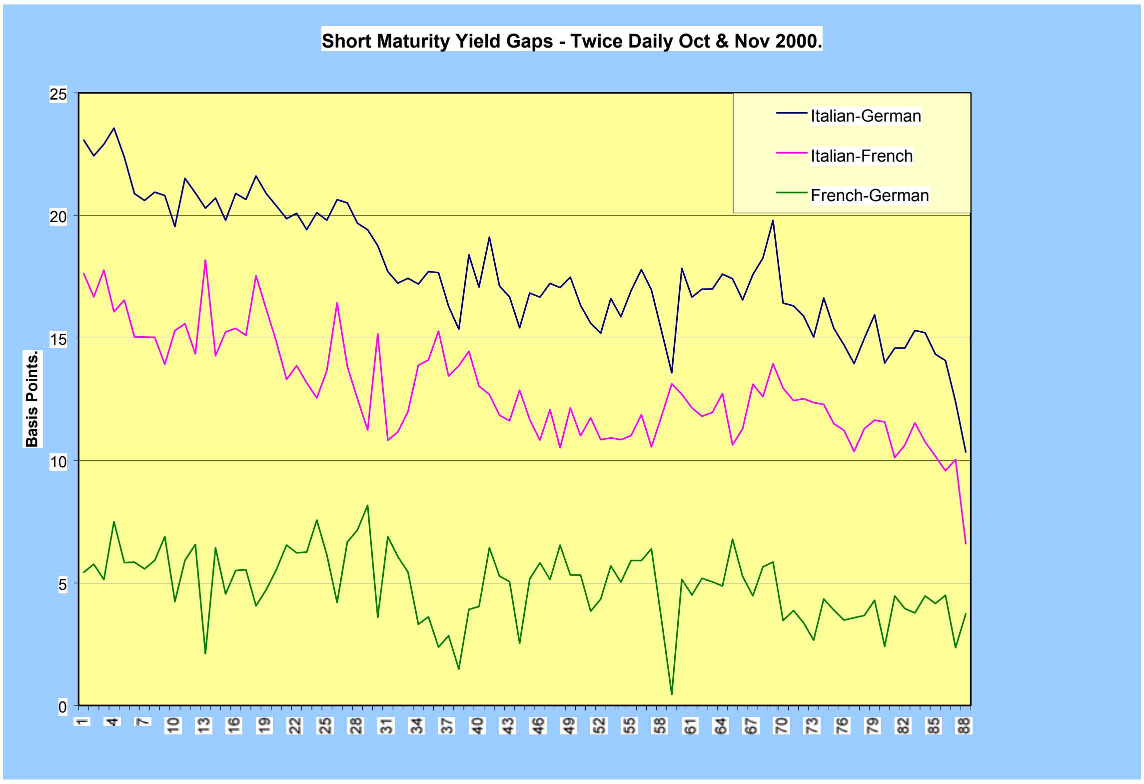
Source: Blanco (2001, p. 31)

Table 4

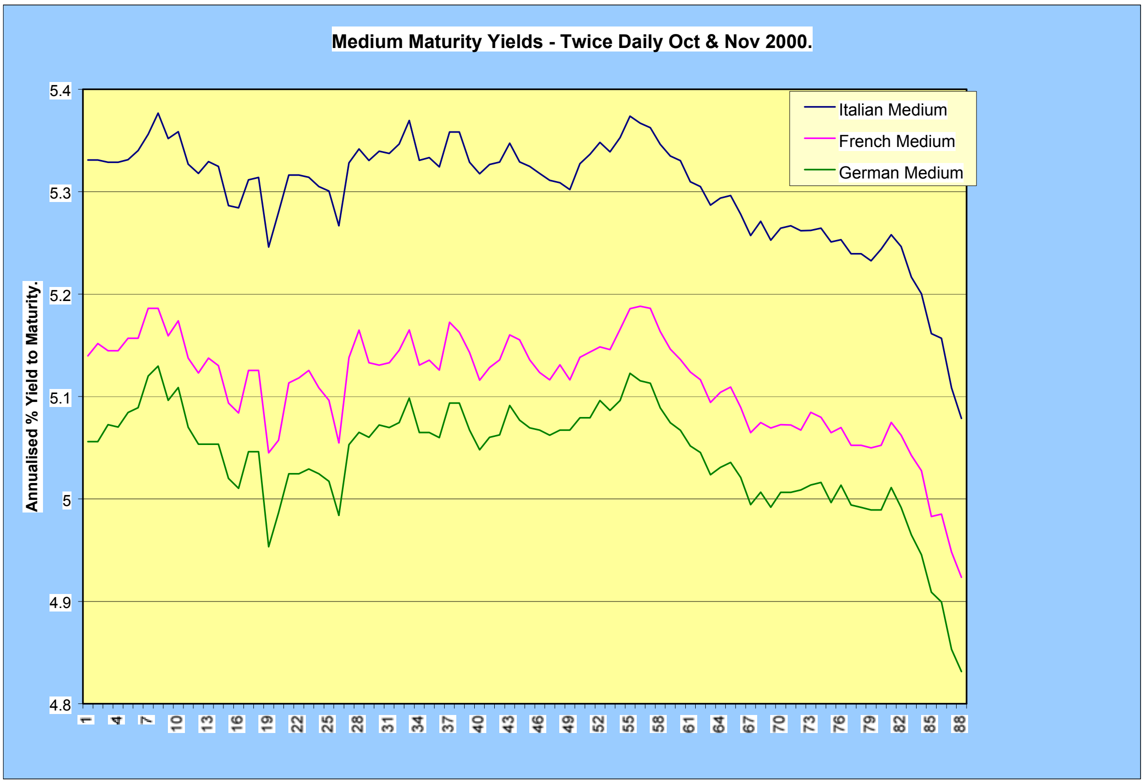
OVERVIEW OF THE COVERAGE OF THE DATA SET.						
Country	Number of Bonds	%	Total Number of Tranactions	%	Number of Transactions in the most liquid bond	%
Short Maturity.						
German	7	16.7	808	3.7	280	11.9
French	4	9.5	938	4.3	517	22.0
Italian	31	73.8	20151	92.0	1551	66.1
Medium Maturity.						
German	23	36.5	1358	4.9	407	6.0
French	11	17.5	2048	7.5	606	9.0
Italian	29	46.0	24046	87.6	5744	85.0
Long Maturity.						
German	20	43.5	2221	6.3	722	3.0
French	15	32.6	2426	6.8	1081	4.5
Italian	11	23.9	30873	86.9	22059	92.4
Very-Long Maturity.						
German	4	28.6	1127	13.5	679	12.2
French	5	35.7	451	5.4	261	4.7
Italian	5	35.7	6767	81.1	4641	83.2
All Maturities.						
Totals for Short Maturity.	42	25.5	21897	23.5	2348	6.1
Totals for Medium Maturity	63	38.2	27452	29.5	6757	17.5
Totals for Long Maturity	46	27.9	35520	38.1	23862	61.9
Totals for Very-Long Maturity	14	8.5	8345	9.0	5581	14.5
Totals for All Maturities.	165	100.0	93214	100.0	38548	100.0

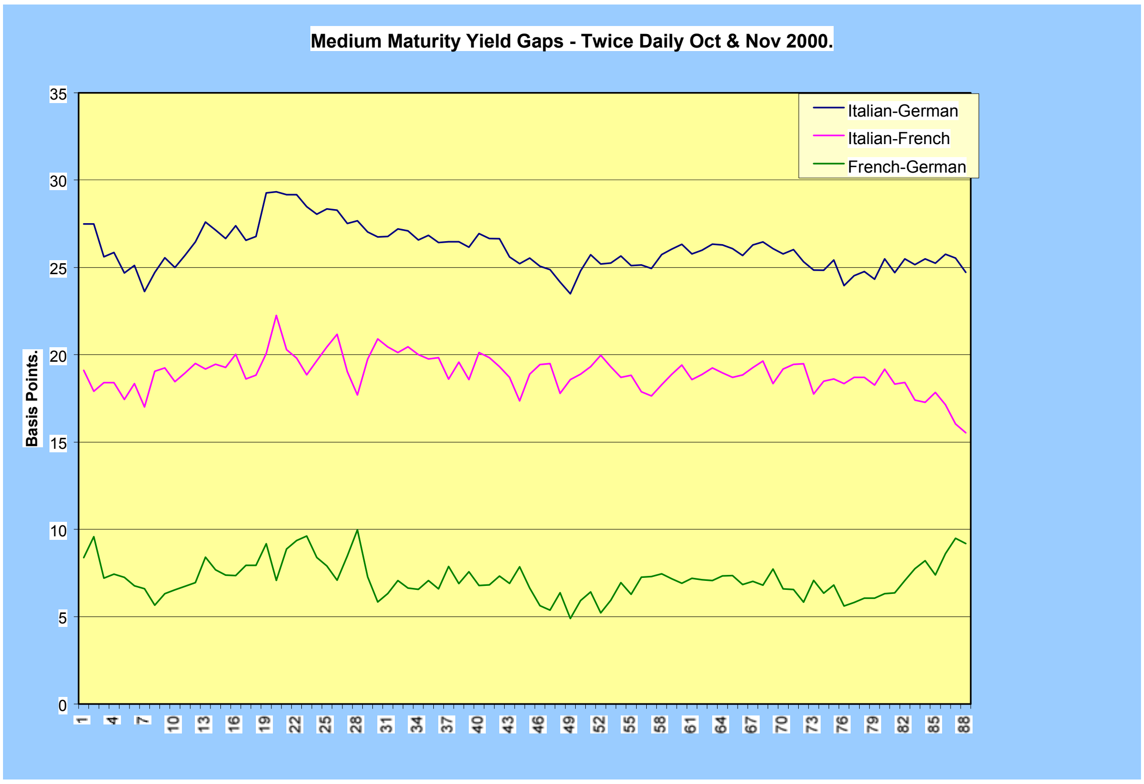
Figures 5 and 6



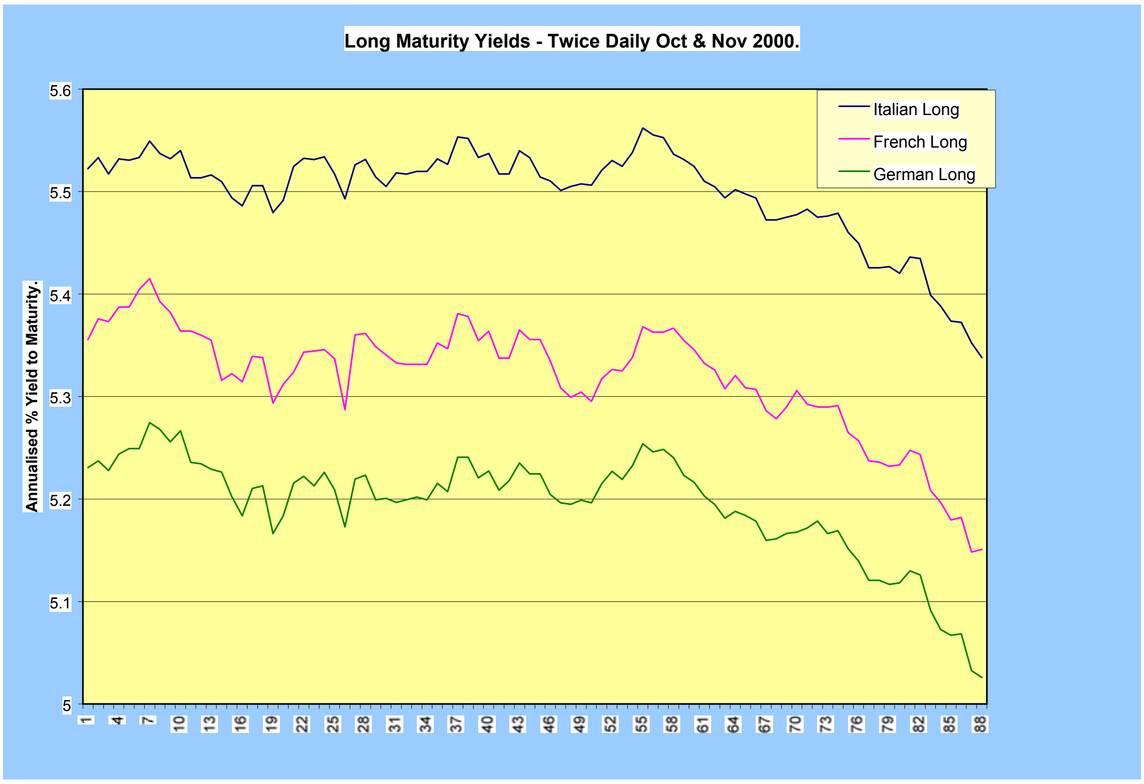


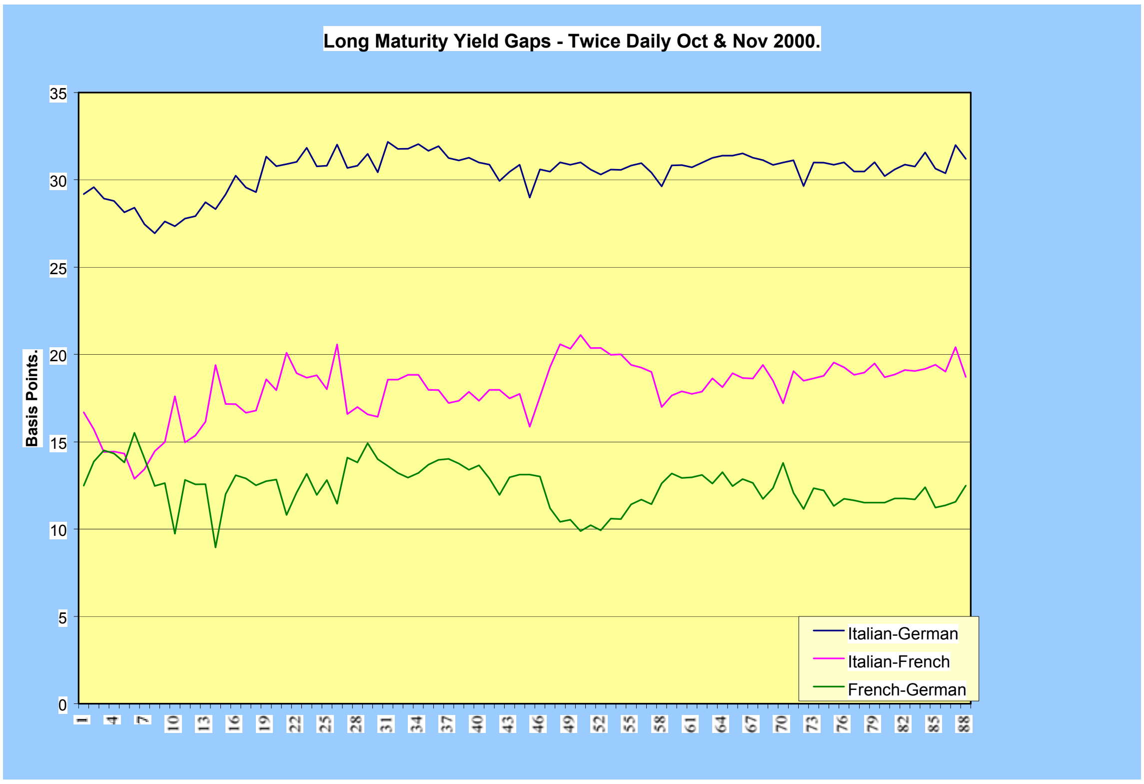
Figures 7 and 8



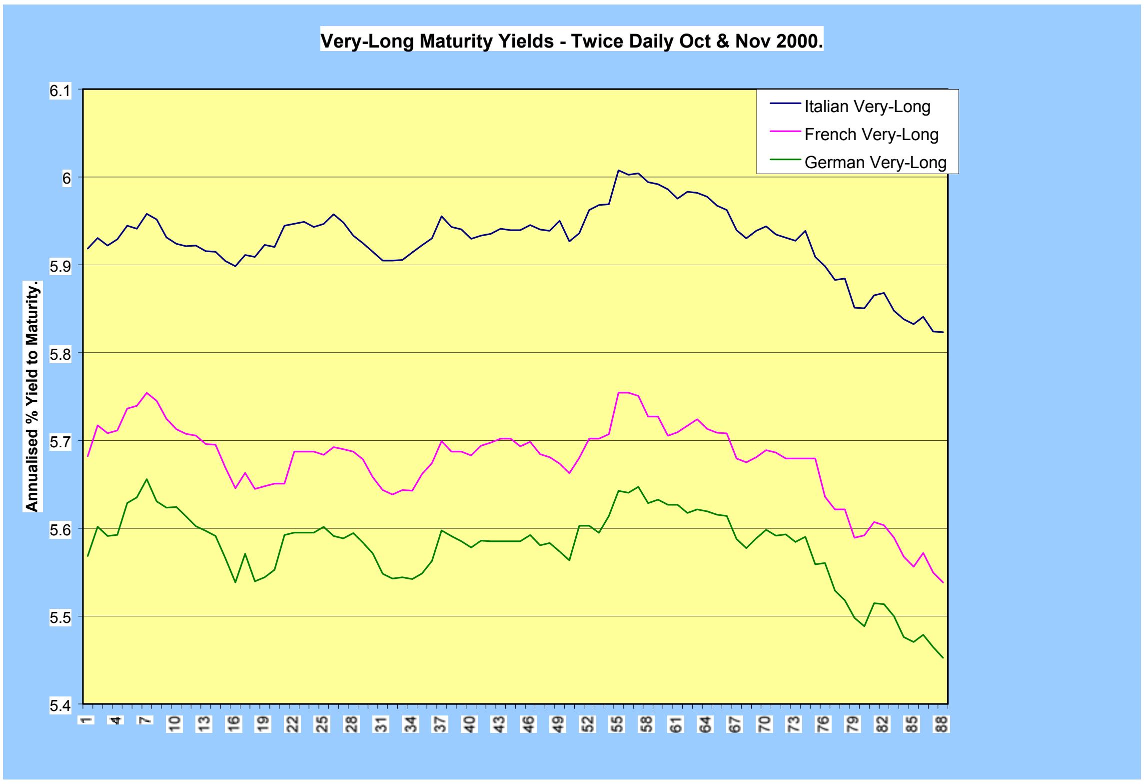


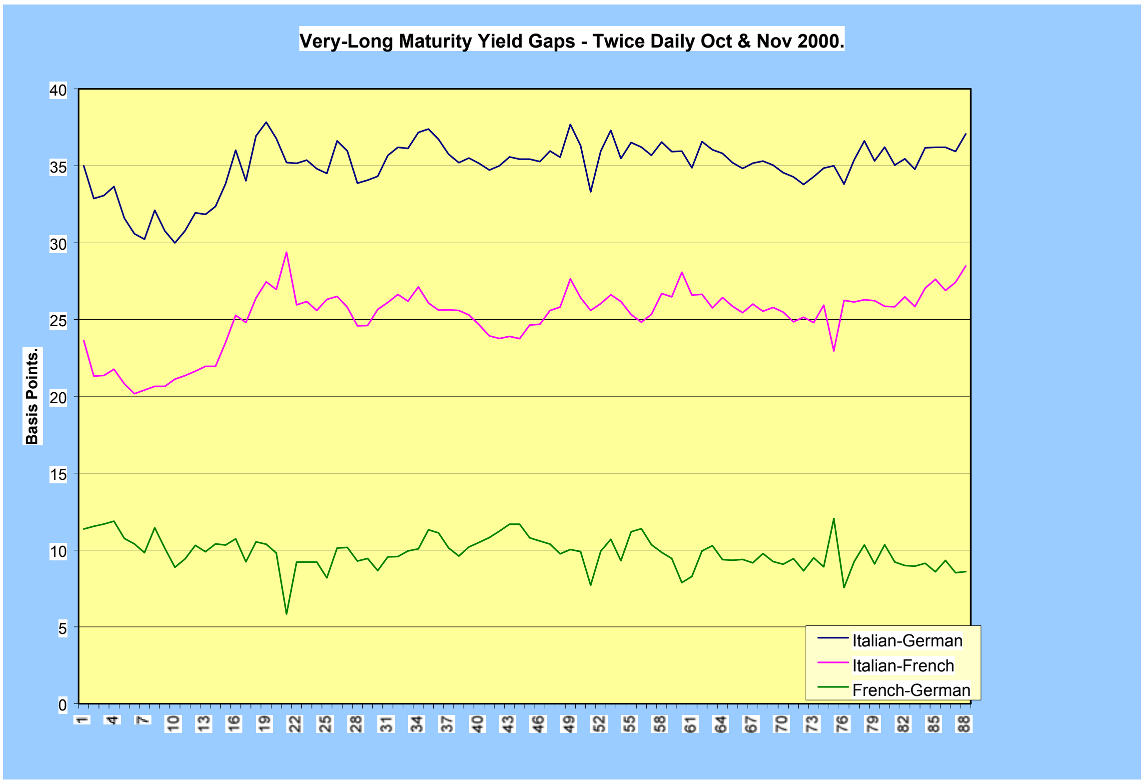
Figures 9 and 10



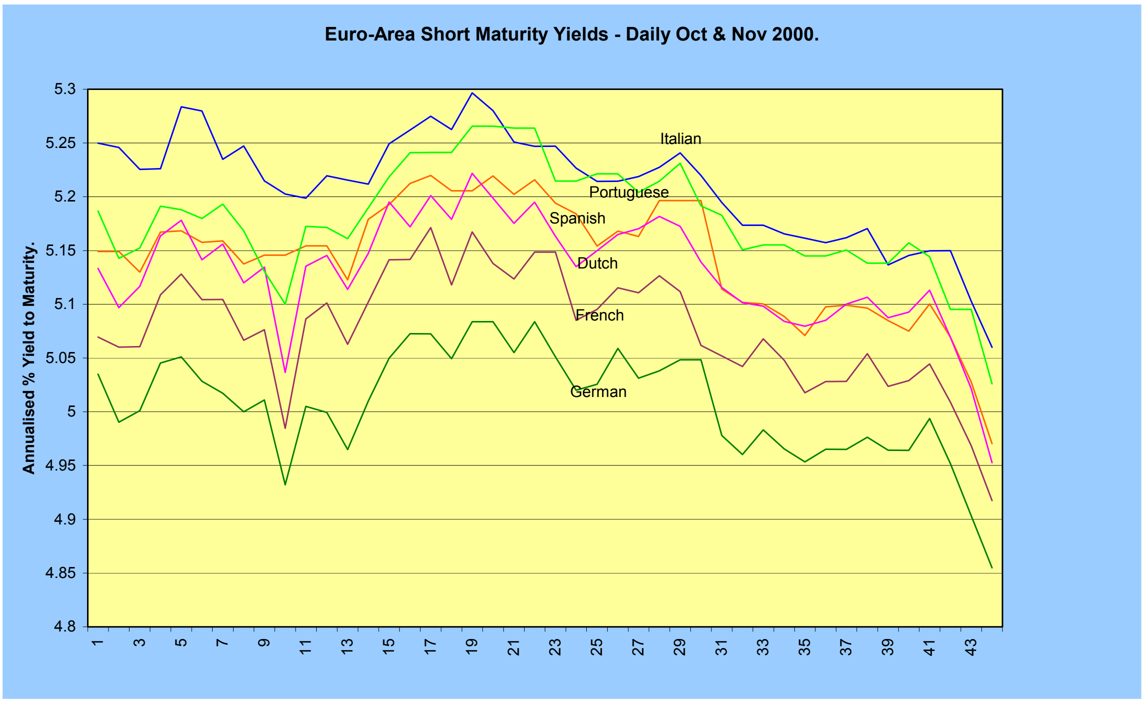


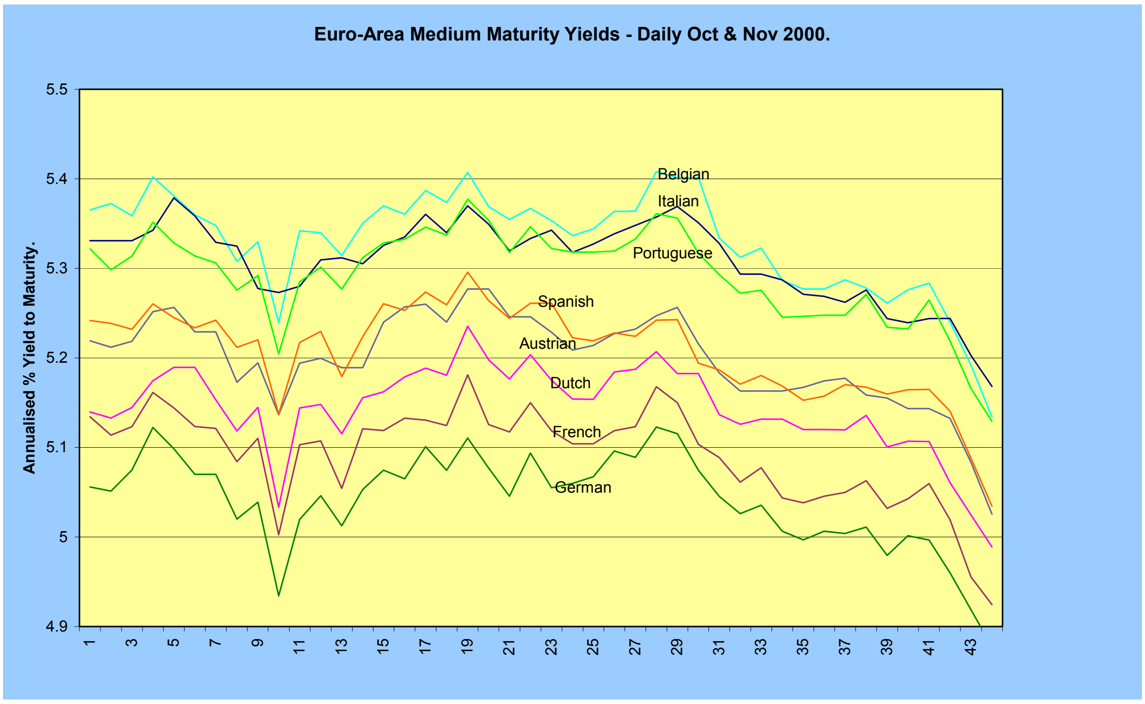
Figures 11 and 12



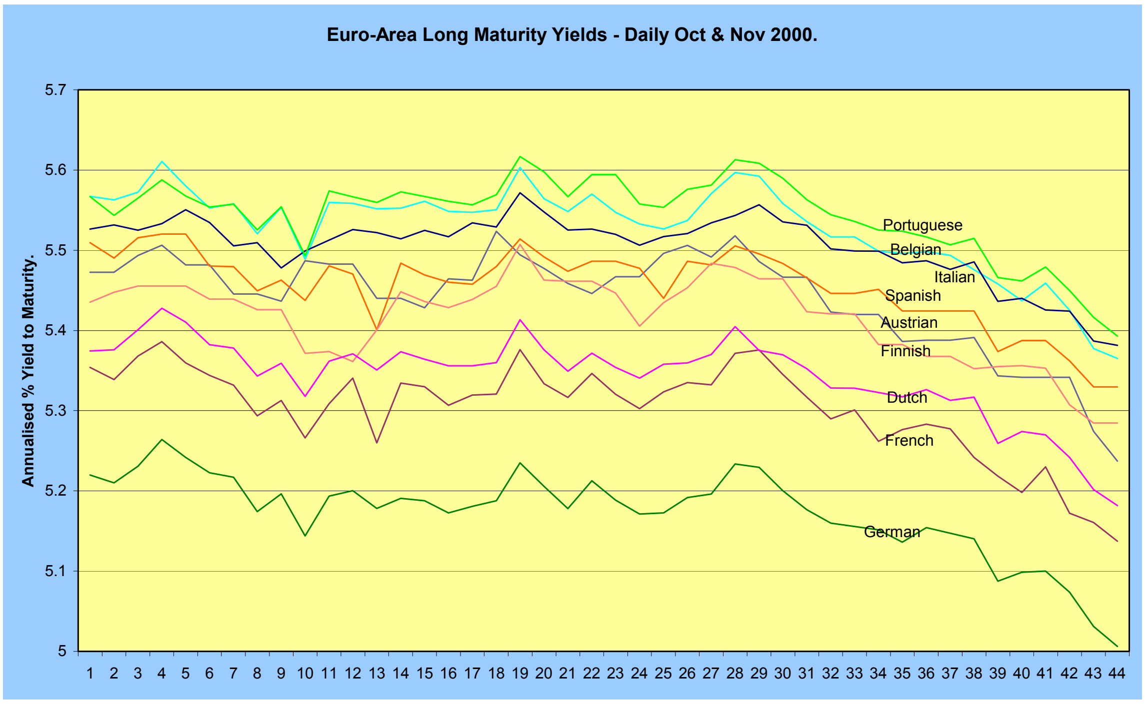


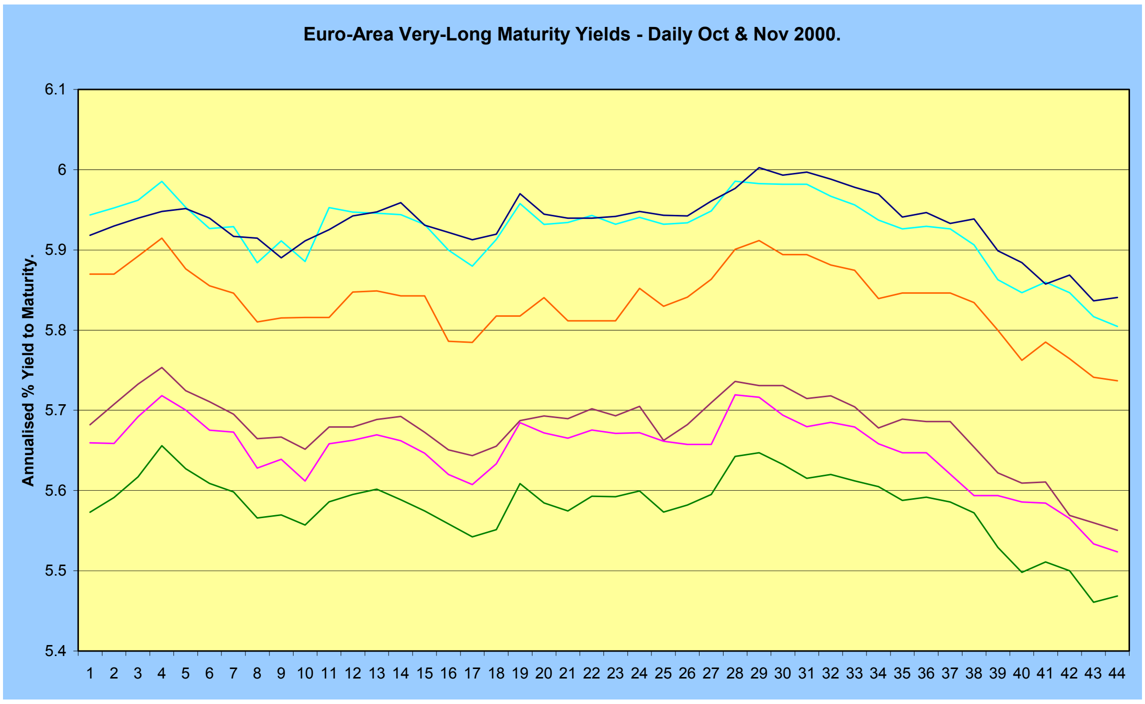
Figures 13 and 14





Figures 15 and 16


Euro-Area Long Maturity Yields - Daily Oct & Nov 2000.
Annualised % Yield to Maturity.
5.7
5.6
5.5
5.4
5.3
5.2
5.1
5
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44
Portuguese
Belgian
Italian
Spanish
Austrian
Finnish
Dutch
French
German


Euro-Area Very-Long Maturity Yields - Daily Oct & Nov 2000.
Annualised % Yield to Maturity.
6.1
6
5.9
5.8
5.7
5.6
5.5
5.4
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44

Tables 5-8

Short Maturity Yield Descriptive Statistics.			
	Italian Short	*French Short*	*German Short*
Mean	5.204	5.075	5.026
Standard Deviation	0.059	0.051	0.049
Excess Kurtosis	2.407	0.859	0.627
Skewness	-1.291	-0.790	-0.463
Minimum	4.978	4.912	4.875
Maximum	5.297	5.162	5.134
Count	88	88	88

Short Maturity Yield-Gap Descriptive Statistics.			
	Italian-German	*Italian-French*	*French-German*
Mean	1.778	1.291	0.487
Standard Deviation	0.262	0.214	0.144
Kurtosis	-0.277	0.187	0.174
Skewness	0.034	0.349	-0.372
Minimum	1.034	0.660	0.046
Maximum	2.356	1.817	0.817
Count	88	88	88

Medium Maturity Yield Descriptive Statistics.			
	Italian Medium	*French Medium*	*German Medium*
Mean	5.301	5.112	5.040
Standard Deviation	0.055	0.052	0.055
Kurtosis	3.679	1.940	2.894
Skewness	-1.661	-1.195	-1.361
Minimum	5.079	4.923	4.831
Maximum	5.377	5.188	5.130
Count	88	88	88

Medium Maturity Yield-Gap Descriptive Statistics.			
	Italian-German	*Italian-French*	*French-German*
Mean	2.608	1.893	0.715
Standard Deviation	0.126	0.104	0.104
Kurtosis	0.320	1.666	0.454
Skewness	0.622	-0.215	0.629
Minimum	2.349	1.553	0.490
Maximum	2.933	2.226	0.998
Count	88	88	88

Tables 9-12

Long Maturity Yield Descriptive Statistics.			
	Italian Long	*French Long*	*German Long*
Mean	5.499	5.319	5.194
Standard Deviation	0.047	0.055	0.051
Kurtosis	2.269	1.292	1.803
Skewness	-1.579	-1.164	-1.329
Minimum	5.338	5.148	5.026
Maximum	5.562	5.415	5.275
Count	88	88	88

Long Maturity Yield-Gap Descriptive Statistics.			
	Italian-German	*Italian-French*	*French-German*
Mean	3.044	1.801	1.243
Standard Deviation	0.118	0.169	0.123
Kurtosis	0.976	0.707	0.192
Skewness	-1.230	-0.893	-0.305
Minimum	2.694	1.288	0.894
Maximum	3.217	2.111	1.552
Count	88	88	88

Very-Long Maturity Yield Descriptive Statistics.			
	Italian Very-Long	*French Very-Long*	*German Very-Long*
Mean	5.928	5.677	5.579
Standard Deviation	0.040	0.047	0.044
Excess Kurtosis	0.796	1.003	0.712
Skewness	-0.713	-1.004	-0.963
Minimum	5.823	5.539	5.453
Maximum	6.008	5.754	5.656
Count	88	88	88

Very-Long Maturity Yield-Gap Descriptive Statistics.			
	Italian-German	*Italian-French*	*French-German*
Mean	3.498	2.515	0.983
Standard Deviation	0.171	0.199	0.107
Kurtosis	1.175	0.442	1.372
Skewness	-1.156	-0.959	-0.434
Minimum	2.998	2.017	0.583
Maximum	3.783	2.937	1.205
Count	88	88	88

Tables 13-16

SHORT MATURITY YIELD - STATIONARITY TESTS								
SERIES	Statistic	t-value	95% Crit.	L-B(1) [p-val]	L-B(2) [p-val]	L-B(3) [p-val]	L-B(6) [p-val]	Conclude
YIELDS(constant)								
Italian Yield	ADF(1)	1.23	(-2.8955)	0.004 [0.94]	0.440 [0.80]	0.646 [0.88]	3.142 [0.79]	Non-stationary
French Yield	DF	-0.78	(-2.8955)	1.416 [0.23]	1.931 [0.38]	2.179 [0.53]	3.582 [0.73]	Non-stationary
German Yield	DF	-0.48	(-2.8955)	0.289 [0.59]	0.415 [0.81]	0.619 [0.89]	4.021 [0.67]	Non-stationary
YIELD-GAP(constant)								
Italian-German	ADF(1)	-0.97	(-2.8951)	0.032 [0.85]	1.496 [0.47]	5.098 [0.16]	5.223 [0.51]	Non-stationary
French-German	DF	-6.27	(-2.8955)	0.476 [0.49]	2.483 [0.28]	3.204 [0.36]	5.654 [0.46]	Stationary
Italian-French	ADF(1)	-1.81	(-2.8951)	0.244 [0.62]	2.698 [0.25]	2.706 [0.43]	5.085 [0.53]	Non-stationary
YIELD-GAP(constant & trend)								
Italian-German	DF	-4.32	(-3.462)	0.352 [0.55]	1.104 [0.57]	2.009 [0.57]	2.920 [0.81]	Stationary
French-German	DF	-7.29	(-3.462)	0.059 [0.80]	1.097 [0.57]	1.265 [0.73]	3.951 [0.68]	Stationary
Italian-French	DF	-5.57	(-3.462)	0.725 [0.39]	2.422 [0.29]	2.726 [0.43]	4.096 [0.66]	Stationary

MEDIUM MATURITY YIELD - STATIONARITY TESTS								
SERIES	Statistic	t-value	95% Crit.	L-B(1) [p-val]	L-B(2) [p-val]	L-B(3) [p-val]	L-B(6) [p-val]	Conclude
YIELDS(constant)								
Italian Yield	ADF(2)	1.605	(-2.8955)	0.010 [0.91]	0.016 [0.99]	0.142 [0.98]	0.972 [0.98]	Non-stationary
French Yield	ADF(2)	0.48	(-2.8955)	0.074 [0.78]	0.075 [0.96]	0.624 [0.89]	1.483 [0.96]	Non-stationary
German Yield	ADF(2)	0.842	(-2.8955)	0.002 [0.96]	0.004 [0.99]	0.157 [0.98]	0.530 [0.99]	Non-stationary
YIELD-GAP(constant)								
Italian-German	ADF(1)	-2.211	(-2.8951)	1.034 [0.30]	1.256 [0.53]	2.392 [0.49]	2.676 [0.84]	Non-stationary
French-German	DF	-3.917	(-2.8955)	1.119 [0.29]	1.414 [0.49]	1.414 [0.70]	6.635 [0.35]	Stationary
Italian-French	DF	-3.8	(-2.8955)	0.001 [0.97]	0.396 [0.82]	1.470 [0.68]	9.534 [0.14]	Stationary
YIELD-GAP(constant & trend)								
Italian-German	DF	-2.45	(-3.462)	0.648 [0.42]	0.964 [0.61]	2.158 [0.54]	2.478 [0.87]	Non-stationary
French-German	DF	-3.86	(-3.462)	0.014 [0.90]	0.047 [0.97]	0.599 [0.89]	7.122 [0.30]	Stationary
Italian-French	DF	-4.4	(-3.462)	0.002 [0.96]	0.497 [0.77]	1.805 [0.61]	8.140 [0.22]	Stationary

LONG MATURITY - STATIONARITY TESTS								
SERIES	Statistic	t-value	95% Crit.	L-B(1) [p-val]	L-B(2) [p-val]	L-B(3) [p-val]	L-B(6) [p-val]	Conclude
YIELDS(constant)								
Italian Yield	ADF(2)	1.67	(-2.8955)	0.144 [0.70]	0.322 [0.85]	0.935 [0.81]	2.328 [0.88]	Non-stationary
French Yield	DF(0)	-0.134	(-2.8955)	0.955 [0.32]	0.998 [0.60]	1.030 [0.79]	2.457 [0.87]	Non-stationary
German Yield	ADF(3)	0.3129	(-2.8955)	0.003 [0.95]	0.029 [0.98]	0.050 [0.99]	1.123 [0.98]	Non-stationary
YIELD-GAP(constant)								
Italian-German	ADF(2)	-1.529	(-2.8959)	0.265 [0.60]	1.201 [0.54]	6.238 [0.10]	6.698 [0.34]	Non-stationary
French-German	ADF(2)	-3.147	(-2.8959)	0.033 [0.85]	0.106 [0.94]	0.641 [0.88]	2.428 [0.87]	Stationary
Italian-French	ADF(1)	-2.905	(-2.8959)	0.032 [0.85]	0.033 [0.98]	0.545 [0.90]	3.398 [0.75]	Stationary
YIELD-GAP(constant & trend)								
Italian-German	ADF(3)	-1.907	(-3.463)	0.293 [0.58]	0.318 [0.85]	1.232 [0.74]	2.254 [0.89]	Non-stationary
French-German	DF	-4.764	(-3.463)	0.542 [0.46]	1.362 [0.50]	1.394 [0.70]	5.308 [0.50]	Stationary
Italian-French	DF	-4.399	(-3.462)	1.320 [0.25]	4.357 [0.11]	4.390 [0.22]	8.382 [0.21]	Stationary

VERY-LONG MATURITY - STATIONARITY TESTS								
SERIES	Statistic	t-value	95% Crit.	L-B(1) [p-val]	L-B(2) [p-val]	L-B(3) [p-val]	L-B(6) [p-val]	Conclude
YIELDS(constant)								
Italian Yield	DF	-0.098	(-2.8955)	0.140 [0.70]	0.511 [0.77]	0.959 [0.81]	5.018 [0.54]	Non-stationary
French Yield	DF	0.044	(-2.8955)	1.098 [0.29]	1.205 [0.54]	2.022 [0.56]	3.509 [0.74]	Non-stationary
German Yield	DF	-0.32	(-2.8955)	0.067 [0.79]	0.331 [0.84]	0.389 [0.94]	5.142 [0.52]	Non-stationary
YIELD-GAP(constant)								
Italian-German	ADF(2)	-1.908	(-2.8955)	0.025 [0.87]	0.193 [0.90]	0.277 [0.96]	1.887 [0.92]	Non-stationary
French-German	DF	-6.312	(-2.8951)	0.585 [0.44]	0.989 [0.60]	1.835 [0.60]	4.007 [0.67]	Stationary
Italian-French	ADF(1)	-1.788	(-2.8951)	0.058 [0.80]	0.878 [0.64]	1.011 [0.79]	1.678 [0.94]	Non-stationary
YIELD-GAP(constant & trend)								
Italian-German	ADF(2)	-2.24	(-3.463)	0.037 [0.84]	0.299 [0.86]	0.554 [0.90]	2.113 [0.90]	Non-stationary
French-German	DF	-6.71	(-3.462)	0.205 [0.65]	0.596 [0.74]	1.356 [0.71]	3.371 [0.76]	Stationary
Italian-French	ADF(1)	-2.179	(-3.462)	0.000 [0.99]	1.250 [0.53]	1.252 [0.74]	2.096 [0.91]	Non-stationary

Table 17

SHORT MATURITY - AR/VAR Lag Length Analysis.				
Based on 85 observations from 4 to 88.				
Deterministic variables:CONSTANT AND TRADE-TYPE DUMMIES				
	Log Likelihood	**AIC**	**SBC**	**LR Test of lag reduction[p-value]**
ITALIAN YIELD				
AR of Order 3	627.418	620.418	611.869	------
AR of Order 2	627.087	621.087	613.759	CHSQ(1)= .66337[.415]
AR of Order 1	626.762	621.762	615.655	CHSQ(2)= 1.3130[.519]
AR of Order 0	519.121	515.121	510.236	CHSQ(3)= 216.5947[.000]
Conclude	AR of Order 1			
FRENCH YIELD				
AR of Order 3	600.933	593.933	585.384	------
AR of Order 2	600.845	594.845	587.517	CHSQ(1)= .17635[.675]
AR of Order 1	600.382	595.382	589.275	CHSQ(2)= 1.1028[.576]
AR of Order 0	533.744	529.744	524.858	CHSQ(3)= 134.3793[.000]
Conclude	AR of Order 1			
GERMAN YIELD				
AR of Order 3	610.218	603.218	594.669	------
AR of Order 2	610.186	604.186	596.858	CHSQ(1)= .063493[.801]
AR of Order 1	610.030	605.030	598.923	CHSQ(2)= .37599[.829]
AR of Order 0	535.441	531.441	526.556	CHSQ(3)= 149.5531[.000]
Conclude	AR of Order 1			
ALL THREE YIELDS: VAR LAG-LENGTH SELECTION				
VAR of Order 3	1954.6	1915.6	1868.0	------
VAR of Order 2	1951.4	1921.4	1884.8	CHSQ(9)= 6.3958[.700]
VAR of Order 1	1947.4	1926.4	1900.7	CHSQ(18)= 14.5555[.692]
VAR of Order 0	1779.4	1767.4	1752.8	CHSQ(27)= 350.4430[.000]
Conclude	VAR of Order 1			

Table 18

MEDIUM MATURITY - AR/VAR Lag-Length Analysis.				
Based on 85 observations from 4 to 88.				
Deterministic variables:CONSTANT AND TRADE-TYPE DUMMIES				
	Log Likelihood	**AIC**	**SBC**	**LR Test of lag reduction[p-value]**
ITALIAN YIELD				
AR of Order 3	606.899	599.899	591.350	------
AR of Order 2	605.679	599.679	592.351	CHSQ(1)= 2.4392[.118]
AR of Order 1	605.404	600.404	594.297	CHSQ(2)= 2.9896[.224]
AR of Order 0	519.343	515.343	510.458	CHSQ(3)= 175.1108[.000]
Conclude	AR of Order 1			
FRENCH YIELD				
AR of Order 3	596.841	589.841	581.292	------
AR of Order 2	593.867	587.867	580.539	CHSQ(1)= 5.9470[.015]
AR of Order 1	593.863	588.863	582.757	CHSQ(2)= 5.9555[.051]
AR of Order 0	524.568	520.568	515.683	CHSQ(3)= 144.5452[.000]
Conclude	AR of Order 3 by AIC & LR Test, AR of Order 1 by SBC.			
GERMAN YIELD				
AR of Order 3	597.715	590.715	582.166	------
AR of Order 2	596.672	590.672	583.344	CHSQ(1)= 2.0865[.149]
AR of Order 1	596.469	591.469	585.362	CHSQ(2)= 2.4929[.288]
AR of Order 0	518.948	514.948	510.062	CHSQ(3)= 157.5350[.000]
Conclude	AR of Order 1			
ALL THREE YIELDS: VAR LAG-LENGTH SELECTION				
VAR of Order 3	2023.4	1984.4	1936.7	------
VAR of Order 2	2021.7	1991.7	1955.0	CHSQ(9)= 3.3807[.947]
VAR of Order 1	2013.5	1992.5	1966.8	CHSQ(18)= 19.8209[.343]
VAR of Order 0	1855.0	1843.0	1828.4	CHSQ(27)= 336.7015[.000]
Conclude	VAR of Order 1			

Table 19

LONG MATURITY - AR/VAR Lag-Length Analysis.				
Based on 85 observations from 4 to 88.				
Deterministic variables:CONSTANT AND TRADE-TYPE DUMMIES				
	Log Likelihood	**AIC**	**SBC**	**LR Test of lag reduction[p-value]**
ITALIAN YIELD				
AR of Order 3	635.482	627.482	617.759	------
AR of Order 2	635.023	628.023	619.515	CHSQ(1)= .91764[.338]
AR of Order 1	631.879	625.879	618.587	CHSQ(2)= 7.2047[.027]
AR of Order 0	631.878	626.878	620.801	CHSQ(3)= 7.2067[.066]
Conclude	AR of Order 2 by AIC & LR Test, AR of Order 0 by SBC.			
FRENCH YIELD				
AR of Order 3	614.968	607.968	599.419	------
AR of Order 2	614.852	608.852	601.524	CHSQ(1)= .23365[.629]
AR of Order 1	614.197	609.197	603.091	CHSQ(2)= 1.5422[.463]
AR of Order 0	519.989	515.989	511.104	CHSQ(3)= 189.9583[.000]
Conclude	AR of Order 1			
GERMAN YIELD				
AR of Order 3	613.821	604.821	593.937	------
AR of Order 2	613.661	605.661	595.985	CHSQ(1)= .32111[.571]
AR of Order 1	612.191	605.191	596.725	CHSQ(2)= 3.2607[.196]
AR of Order 0	609.290	603.290	596.034	CHSQ(3)= 9.0620[.028]
Conclude	AR of Order 2 by AIC, AR of Order 1 by SBC & LR Test.			
ALL THREE YIELDS: VAR LAG-LENGTH SELECTION				
VAR of Order 4	2019.6	1971.6	1913.3	------
VAR of Order 3	2013.1	1974.1	1926.7	CHSQ(9)= 13.0538[.160]
VAR of Order 2	2001.3	1971.3	1934.9	CHSQ(18)= 36.5837[.006]
VAR of Order 1	1989.4	1968.4	1942.9	CHSQ(27)= 60.4879[.000]
VAR of Order 0	1816.1	1804.1	1789.5	CHSQ(36)= 407.0707[.000]
Conclude	VAR of Order 1 by SBC, VAR of Order 3 by AIC & LR Test.			

Table 20

VERY-LONG MATURITY - AR/VAR Lag-Length Analysis.				
Based on 85 observations from 4 to 88.				
Deterministic variables:CONSTANT AND TRADE-TYPE DUMMIES				
	Log Likelihood	**AIC**	**SBC**	**LR Test of lag reduction[p-value]**
ITALIAN YIELD				
AR of Order 3	651.205	644.205	635.656	------
AR of Order 2	651.165	645.165	637.837	CHSQ(1)= .080573[.777]
AR of Order 1	651.159	646.159	640.053	CHSQ(2)= .092219[.955]
AR of Order 0	545.899	541.899	537.013	CHSQ(3)= 210.6134[.000]
Conclude	AR of Order 1			
FRENCH YIELD				
AR of Order 3	633.952	626.952	618.403	------
AR of Order 2	633.942	627.942	620.614	CHSQ(1)= .020422[.886]
AR of Order 1	633.634	628.634	622.527	CHSQ(2)= .63599[.728]
AR of Order 0	531.628	527.628	522.742	CHSQ(3)= 204.6482[.000]
Conclude	AR of Order 1			
GERMAN YIELD				
AR of Order 3	628.862	621.862	613.313	------
AR of Order 2	628.738	622.738	615.410	CHSQ(1)= .24725[.619]
AR of Order 1	628.706	623.706	617.600	CHSQ(2)= .31122[.856]
AR of Order 0	536.206	532.206	527.321	CHSQ(3)= 185.3107[.000]
Conclude	AR of Order 1			
ALL THREE YIELDS: VAR LAG-LENGTH SELECTION				
VAR of Order 3	2021.9	1982.9	1935.3	------
VAR of Order 2	2018.7	1988.7	1952.1	CHSQ(9)= 6.4019[.699]
VAR of Order 1	2006.8	1985.8	1960.2	CHSQ(18)= 30.2008[.036]
VAR of Order 0	1834.0	1822.0	1807.3	CHSQ(27)= 375.8738[.000]
Conclude	VAR of Order 2 by AIC & LR Test, VAR of Order 1 by SBC.			

Table 21

SHORT MATURITY - Granger Block Non-Causality Tests.	
Endogenous Variables: Italian, French and German Yields.	
Deterministic variables: Constant and Italian, French and German Trade-Type Dummies.	
Granger Non-Causality of Italian Yield	
Unrestricted Maximized value of log-likelihood.	1993.8
Restricted Maximized value of log-likelihood	1985.3
Non-Causality LR Test.	CHSQ(2)= 16.9464[.000]
Conclude	Reject Non-Causality.
Granger Non-Causality of French Yield	
Unrestricted Maximized value of log-likelihood.	1993.8
Restricted Maximized value of log-likelihood	1989.8
Non-Causality LR Test.	CHSQ(2)= 7.9651[.019]
Conclude	Reject Non-Causality.
Granger Non-Causality of German Yield	
Unrestricted Maximized value of log-likelihood.	1993.8
Restricted Maximized value of log-likelihood	1987.7
Non-Causality LR Test.	CHSQ(2)= 12.1048[.002]
Conclude	Reject Non-Causality.
Test for exclusion of Deterministic Variables.	
Excluding All Trade-Type Dummies.	
Unrestricted Maximized value of log-likelihood.	1993.8
Restricted Maximized value of log-likelihood	1984.3
LR Test of restriction.	CHSQ(9)= 18.8973[.026]
Conclude	Reject exclusion restriction (Marginally).

Table 22

MEDIUM MATURITY - Granger Block Non-Causality Tests.	
Endogenous Variables: Italian, French and German Yields.	
Deterministic variables: Constant and Italian, French and German Trade-Type Dummies.	
Granger Non-Causality of Italian Yield	
Unrestricted Maximized value of log-likelihood.	2056.7
Restricted Maximized value of log-likelihood	2046.4
Non-Causality LR Test.	CHSQ(2)= 20.7317[.000]
Conclude	Reject Non-Causality.
Granger Non-Causality of French Yield	
Unrestricted Maximized value of log-likelihood.	2056.7
Restricted Maximized value of log-likelihood	2051.8
Non-Causality LR Test.	CHSQ(2)= 9.9366[.007]
Conclude	Reject Non-Causality.
Granger Non-Causality of German Yield	
Unrestricted Maximized value of log-likelihood.	2056.7
Restricted Maximized value of log-likelihood	2054.8
Non-Causality LR Test.	CHSQ(2)= 3.8216[.148]
Conclude	Accept Non-Causality.
Test for exclusion of Deterministic Variables.	
Excluding All Trade-Type Dummies.	
Unrestricted Maximized value of log-likelihood.	2056.7
Restricted Maximized value of log-likelihood	2052.9
LR Test of restriction.	CHSQ(9)= 7.6377[.571]
Conclude	Accept exclusion restriction.

Table 23

LONG MATURITY - Granger Block Non-Causality Tests.	
Endogenous Variables: Italian, French and German Yields.	
Deterministic variables: Constant and Italian, French and German Trade-Type Dummies.	
Granger Non-Causality of Italian Yield	
Unrestricted Maximized value of log-likelihood.	2037.5
Restricted Maximized value of log-likelihood	2030.6
Non-Causality LR Test.	CHSQ(6)= 13.8659[.031]
Conclude	Reject Non-Causality.
Granger Non-Causality of French Yield	
Unrestricted Maximized value of log-likelihood.	2037.5
Restricted Maximized value of log-likelihood	2033.2
Non-Causality LR Test.	CHSQ(6)= 8.5729[.199]
Conclude	Accept Non-Causality.
Granger Non-Causality of German Yield	
Unrestricted Maximized value of log-likelihood.	2037.5
Restricted Maximized value of log-likelihood	2036.2
Non-Causality LR Test.	CHSQ(6)= 2.6320[.853]
Conclude	Accept Non-Causality.
Test for exclusion of Deterministic Variables.	
Excluding All Trade-Type Dummies.	
Unrestricted Maximized value of log-likelihood.	2037.5
Restricted Maximized value of log-likelihood	2038.8
LR Test of restriction.	CHSQ(9)= 17.3046[.044]
Conclude	Reject exclusion restriction.

Table 24

VERY-LONG MATURITY - Granger Block Non-Causality Tests.	
Endogenous Variables: Italian, French and German Yields.	
Deterministic variables: Constant and Italian, French and German Trade-Type Dummies.	
Granger Non-Causality of Italian Yield	
Unrestricted Maximized value of log-likelihood.	2050.8
Restricted Maximized value of log-likelihood	2046.4
Non-Causality LR Test.	CHSQ(2)= 8.8651[.012]
Conclude	Reject Non-Causality.
Granger Non-Causality of French Yield	
Unrestricted Maximized value of log-likelihood.	2050.8
Restricted Maximized value of log-likelihood	2041.9
Non-Causality LR Test.	CHSQ(2)= 17.7714[.000]
Conclude	Reject Non-Causality.
Granger Non-Causality of German Yield	
Unrestricted Maximized value of log-likelihood.	2050.8
Restricted Maximized value of log-likelihood	2049.8
Non-Causality LR Test.	CHSQ(2)= 2.0123[.366]
Conclude	Accept Non-Causality.
Test for exclusion of Deterministic Variables.	
Excluding All Trade-Type Dummies.	
Unrestricted Maximized value of log-likelihood.	2050.8
Restricted Maximized value of log-likelihood	2040.9
LR Test of restriction.	CHSQ(9)= 19.8047[.019]
Conclude	Reject exclusion restriction (Marginally).

Tables 25 and 26

SHORT MATURITY - COINTEGRATION ANALYSIS - Johansen Test of Cointegrating Rank.						
Endogenous Variables: Italian, French and German Yields.						
Exogenous variables in the cointegration space: Drift & Italian, French & German Trade-Type Dummies.						
Unrestricted constant outside cointegration space.						
Lag length: 1	Effective sample: 2 to 88		Observations less the number of Variables: 76			
DETERMINATION OF NUMBER OF COINTEGRATING VECTORS.						
Eigenv.	L-max	Trace	H0: r	p-r	L-max Crit. 90%	Trace Crit. 90%
0.4276	48.55	75.12	0	3	16.13	39.08
0.1743	16.66	26.58	1	2	12.39	22.95
0.1077	9.92	9.92	2	1	10.56	10.56
Conclusion: Both the L-Max and Trace statistics imply that there are two cointegrating vectors.						

PAIRWISE COINTEGRATION ANALYSIS - Estimation by Phillips-Hansen FMOLS.			
Regressing one yield on another and including nuisance parameters: constant, trend and trade type dummies.			
Trade type (i) is for the trade type of the dependent variable and trade type (ii) is for trade type of the regressor yield.			
Std. Errors In brackets & **Std. Errors from Unity** in the case of the coefficient on the yield regressor.			
Regressing ….	French on German	Italian on French	Italian on German
Yield (**It**,Ge **or** Fr)	0.879 (0.034)	0.897 (0.035)	0.848 (0.033)
Std. Err. from 1.	3.46	2.88	4.52
Constant	0.665 (0.175)	0.682 (0.181)	0.979 (0.168)
Trend	-0.0003 (0.0001)	-0.0007 (0.0001)	-0.0009 (0.0001)
Trade Type (i)	-0.088 (0.032)	-0.063 (0.029)	-0.006 (0.028)
Trade Type (ii)	0.095 (0.030)	0.018 (0.033)	0.051 (0.030)
Resid. Analysis			
ADF (Crit.10% -3.5)	DF -7.76	DF -5.07	DF -3.97
Std. Dev.	1.22	1.17	1.09
Conclusion	All three pairs are cointegrated. Pairs involving Italian Yield have lowest residual variance.		

MEDIUM MATURITY - COINTEGRATION ANALYSIS - Johansen Test of Cointegrating Rank.						
Endogenous Variables: Italian, French and German Yields.						
Exogenous variables in the cointegration space: Drift & Italian, French & German Trade-Type Dummies.						
Unrestricted constant outside cointegration space.						
Lag length: 1	Effective sample: 2 to 88		Observations less the number of Variables: 76			
DETERMINATION OF NUMBER OF COINTEGRATING VECTORS.						
Eigenv.	L-max	Trace	H0: r	p-r	L-max Crit. 90%	Trace Crit. 90%
0.4277	48.55	67.73	0	3	16.13	39.08
0.139	13.02	19.18	1	2	12.39	22.95
0.0684	6.16	6.16	2	1	10.56	10.56
Conclusion: The L-Max statistic implies 2 cointegrating vectors while the Trace statistics implies 1.						

PAIRWISE COINTEGRATION ANALYSIS - Estimation by Phillips-Hansen FMOLS.			
Regressing one yield on another and including nuisance parameters: constant, trend and trade type dummies.			
Trade type (i) is for the trade type of the dependent variable and trade type (ii) is for trade type of the regressor yield.			
Std. Errors In brackets & **Std. Errors from Unity** in the case of the coefficient on the yield regressor.			
Regressing ….	French on German	French on Italian	Italian on German
Yield (**It**,Ge **or** Fr)	0.855 (0.022)	0.958 (0.028)	0.864 (0.029)
Std. Err. from 1.	6.39	1.43	4.56
Constant	0.814 (0.115)	0.024 (0.155)	0.967 (0.151)
Trend	-0.0002 (0)	0.0000 (0.0001)	-0.0003 (0.0001)
Trade Type (i)	-0.046 (0.021)	-0.060 (0.024)	-0.098 (0.027)
Trade Type (ii)	-0.047 (0.020)	0.079 (0.025)	-0.051 (0.027)
Resid. Analysis			
ADF (Crit.10% -3.5)	DF -6.71	ADF(2) -3.73	ADF(1) -2.88
Std. Dev.	0.847	0.949	1.009
Conclusion	Italian-German pair fail cointegration test but must be cointegrated since the two other pairs are.		
	Pairs involving French Yield have lowest residual variance.		

Tables 27 and 28

LONG MATURITY - COINTEGRATION ANALYSIS - Johansen Test of Cointegrating Rank.						
Endogenous Variables: Italian, French and German Yields.						
Exogenous variables in the cointegration space: Drift & Italian, French & German Trade-Type Dummies.						
Unrestricted constant outside cointegration space.						
Lag length: 3	Effective sample: 4 to 88		Observations less the number of Variables: 62			
DETERMINATION OF NUMBER OF COINTEGRATING VECTORS.						
Eigenv.	L-max	Trace	H0: r	p-r	L-max Crit. 90%	Trace Crit. 90%
0.3034	30.74	66.43	0	3	16.13	39.08
0.2829	28.26	35.7	1	2	12.39	22.95
0.0838	7.44	7.44	2	1	10.56	10.56
Conclusion: Both the L-Max and Trace statistics imply that there are two cointegrating vectors.						

PAIRWISE COINTEGRATION ANALYSIS - Estimation by Phillips-Hansen FMOLS.			
Regressing one yield on another and including nuisance parameters: constant, trend and trade type dummies.			
Trade type (i) is for the trade type of the dependent variable and trade type (ii) is for trade type of the regressor yield.			
Std. Errors In brackets & **Std. Errors from Unity** in the case of the coefficient on the yield regressor.			
Regressing ….	German on French	Italian on French	Italian on German
Yield (It,Ge **or** Fr)	0.927 (0.042)	0.917 (0.049)	0.967 (0.042)
Std. Err. from 1.	1.71	1.69	0.78
Constant	0.256 (0.227)	0.607 (0.264)	0.466 (0.222)
Trend	0.0000 (0.0001)	0.0002 (0.0001)	0.0001 (0.0001)
Trade Type (i)	-0.011 (0.030)	0.069 (0.035)	0.011 (0.029)
Trade Type (ii)	0.036 (0.029)	-0.038 (0.034)	0.000 (0.029)
Resid. Analysis			
ADF (Crit.10% -3.5)	DF -4.50	DF -4.58	ADF(3) -1.89
Std. Dev.	1.09	1.29	0.97
Conclusion	Italian-German pair fail cointegration test but must be cointegrated since the two other pairs are.		
	Pairs involving German Yield have lowest residual variance.		

VERY-LONG MATURITY - COINTEGRATION ANALYSIS - Johansen Test of Cointegrating Rank.						
Endogenous Variables: Italian, French and German Yields.						
Exogenous variables in the cointegration space: Drift & Italian, French & German Trade-Type Dummies.						
Unrestricted constant outside cointegration space.						
Lag length: 1	Effective sample: 2 to 88		Observations less the number of Variables: 76			
DETERMINATION OF NUMBER OF COINTEGRATING VECTORS.						
Eigenv.	L-max	Trace	H0: r	p-r	L-max Crit. 90%	Trace Crit. 90%
0.4064	45.37	70.67	0	3	16.13	39.08
0.1726	16.48	25.3	1	2	12.39	22.95
0.0964	8.82	8.82	2	1	10.56	10.56
Conclusion: Both the L-Max and Trace statistics imply that there are two cointegrating vectors.						

PAIRWISE COINTEGRATION ANALYSIS - Estimation by Phillips-Hansen FMOLS.			
Regressing one yield on another and including nuisance parameters: constant, trend and trade type dummies.			
Trade type (i) is for the trade type of the dependent variable and trade type (ii) is for trade type of the regressor yield.			
Std. Errors In brackets & **Std. Errors from Unity** in the case of the coefficient on the yield regressor.			
Regressing ….	German on French	Italian on French	Italian on German
Yield (It,Ge **or** Fr)	0.955 (0.028)	0.858 (0.049)	0.880 (0.050)
Std. Err. from 1.	1.56	2.85	2.35
Constant	0.150 (0.163)	1.046 (0.283)	1.004 (0.285)
Trend	0.0000 (0.0001)	0.0003 (0.0001)	0.0002 (0.0001)
Trade Type (i)	-0.003 (0.023)	-0.016 (0.040)	-0.055 (0.039)
Trade Type (ii)	0.032 (0.023)	-0.174 (0.040)	0.077 (0.039)
Resid. Analysis			
ADF (Crit.10% -3.5)	DF -6.92	DF -5.23	DF -3.49
Std. Dev.	0.97	1.49	1.4
Conclusion	All three pairs are cointegrated. Pairs involving German Yield have lowest residual variance.		

Table 29

FACTOR LOADINGS.				
(Insignificant coefficient estimates restricted to zero).				
	Short	Medium	Long	Very-long
Italian Yield Change on Factor 1	0.0	0.0	0.0	0.0
T-Statistic	--	--	--	--
Italian Yield Change on Factor 2	0.0	-0.065	0.028	0.021
T-Statistic	--	-2.94	2.01	2.17
French Yield Change on Factor 1	0.065	-0.066	0.040	0.033
T-Statistic	5.31	-2.33	2.26	2.14
French Yield Change on Factor 2	0.0	-0.083	0.056	0.028
T-Statistic	--	-3.18	2.94	2.61
German Yield Change on Factor 1	0.0	0.0	0.0	-0.039
T-Statistic	--	--	--	-2.46
German Yield Change on Factor 2	0.064	-0.078	0.050	0.035
T-Statistic	5.18	-3.16	3.15	3.19
FACTOR DETAILS - excluding nuisance parameters.				
Short Factor 1:	Italian Yield-0.897 French Yield			
Short Factor 2:	Italian Yield - 0.848 German Yield			
Medium Factor 1:	French Yield - 0.855 German Yield			
Medium Factor 2:	French Yield - 0.958 Italian Yield			
Long Factor 1:	German Yield - 0.967 French Yield			
Long Factor 2:	Italian Yield - 0.927 German Yield			
Very Long Factor 1:	German Yield - 0.955 French Yield			
Very Long Factor 2:	Italian Yield - 0.967 German Yield			