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EMU and European Stock Market Integration*

The launch of the single currency in Europe in January 1999 was preceded by a period of regulatory harmonization, convergence in bond yields and inflation rates, and strict fiscal policy across the Eurozone countries. We examine whether the 1990s also were characterized by increased stock market integration. The results indicate that, as forward interest differentials benchmarked against Germany and inflation differentials benchmarked against the three best performing states shrank toward zero, stock markets converged toward full integration. The United Kingdom, a country that chose not to enter the Eurozone, shows no such increase in stock market integration.

I. Introduction

On January 1, 1999, 11 of the 115 European Union (EU) countries formed the Economic and Monetary Union (EMU), adopting the euro as their common currency. Since then, in the so-called Eurozone, the European Central Bank carries out a common monetary policy, and money and, to a high degree, bond markets, are fully integrated. In this paper, we ask if a similar integration took place among the stock markets of individual Eurozone countries.

The creation of the Eurozone did not occur in a vacuum. It was preceded by a gradual regulatory

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harmonization among European stock markets and the abolition of various restrictions on nonresidents (Licht 1998), which facilitated stock market integration. It was also preceded by a concerted effort among EU countries to satisfy the Maastricht criteria for joining the Eurozone. This effort led to the so-called nominal convergence, that is, a gradual convergence of inflation and long-term interest rates toward German levels, which resulted in a convergence of real risk-free rates. The effort to satisfy the Maastricht criteria also led to better-balanced fiscal budgets, which may have led to a "real convergence" of European economies, that is, an increased synchronization in business cycles across the European economies. This synchrony can cause higher cross-country correlations in expected real corporate earnings.

The introduction of the euro improved transparency, standardized the pricing in financial markets, and reduced investors' transaction and information costs. Moreover, with no change in domestic law, it nullified various legal restrictions within the EU on the foreign currency composition of assets held by institutional investors, like pension funds and life insurance companies.[1] This expected broadening of investment opportunities across the EMU countries at the inauguration of the euro could have affected market expectations before the advent of the monetary union. In turn, this may have increased the integration of European stock markets as the probability of the formation of a monetary union gained strength.

Finally, the introduction of a single currency eliminated intra-European currency risk and, to the extent that currency risk was priced, reduced the overall exchange rate exposure of European stocks. This factor, coupled with the nominal and real convergence just outlined, should have led to a more homogeneous valuations of equities in EMU countries.

One way to assess whether or not the European stock markets became more integrated during the 1990s is to examine the evolution of the relative influence of EU-wide risk factors over country-specific risk factors on required rates of return. When stock markets are partially integrated, both global and local risk factors are priced. We thus estimate a conditional asset pricing model with a time-varying degree of integration, which measures the importance of EU-wide market and currency risks relative to country-specific risk. The model allows for time-varying quantities and prices of risk and accounts explicitly for intra-European currency risk.

In the model, each Eurozone country has its own time-varying degree of stock market integration. The degree of integration is bounded between

1. Typically, in most EU countries, these institutions were required to hold assets primarily in domestic currency. Moreover, their portfolios were subject to an 80% currency-matching rule between liabilities and assets. Danthine, Giavazzi, and von Thadden (2000) report on existing regulations in individuals EU countries.

zero and unity and conditioned on a broad set of monetary, currency, and business cycle variables. These variables are proxies for the gradual nominal and real convergence of the European economies during the pre-monetary union period. Among the included variables, the most prominent one is each country's forward interest rate differential with Germany. During the 1990s, this forward interest differential was widely used by market analysts as an indicator of the probability that an EU country would eventually manage to join the Eurozone.[2] The sample includes 11 Eurozone countries plus the United Kingdom, which is an EU country that eventually chose not to join the Eurozone. The inclusion of the United Kingdom in the sample acts as a useful benchmark in helping us interpret the deeper cause of our results. The United Kingdom was always ambivalent about joining the Eurozone, had secured an "opt-out" clause, and to this date, continues to be ambivalent about joining.

We find that, in the second half of the 1990s, the degree of integration gradually increased to the point where individual Eurozone country stock markets appear to be fully integrated into the EU market. Two main factors drove the increase in the level of integration: the evolution of the probability of joining the single currency and the evolution of inflation differentials. The EU country that did not show any signs of increased stock market integration was the United Kingdom, but as mentioned earlier, the United Kingdom is the exception that proves the rule, indicating that the forces behind the formation of the Eurozone had a special role in stock market integration.

Our results are robust with respect to a battery of specification tests, some of which examine the possibility that the EU stock market integration of the 1990s reveals nothing more than an integration of each country's stock market to the world market at large. We found that the stock markets of the Eurozone countries did not show such a striking increase in their degree of integration with the world market as they did with the EU market. This empirical observation led us to the conclusion that the integration of European stock markets during the 1990s was intimately related to a unique European feature, namely, the prospect of the monetary union.[3]

2. See, e.g., JP Morgan, "The EMU Calculator" (October 1996) and "EMU Calculator Handbook" (January 1997); Paribas, "EMU Countdown" (February 1997); Credito Italiano, "Economic Trends in Italy" (IV 1996); Goldman Sachs, "European Bond Spreads and the Probability of EMU" (May 1996); Favero et al. (2002). Please note that EMU, which stands for Economic and Monetary Union, is used by most authors and commentators synonymously with the term *Eurozone*. This is how we also use it in the present paper. In reality, these two technical terms differ slightly. On January 1, 1999, all 15 EU countries were members of EMU but only 11 became members of the Eurozone.

3. Subsequent to our work, other authors have extended the analysis by utilizing the period following the launch of the euro to make comparisons with the period immediately before. Examples are Bris, Koskinen, and Nilsson (2003), who examine corporate valuations, and Bartram and Karolyi (2003), who show that currency risk declined significantly.

The rest of the paper is organized as follows. Section II presents our empirical asset pricing model and its econometric implementation. Section III describes the data. Section IV contains the main empirical results along with a series of specification tests. Section V concludes.

II. The Empirical Model

A long literature finds evidence of partial integration of both developed and emerging markets to the world market.[4] Our empirical asset pricing model resembles that of Bekaert and Harvey (1995) and is based on the theoretical models of partial integration of Black (1974), Stulz (1981), Errunza and Losq (1985), Eun and Janakiramanan (1986) and Cooper and Kaplanis (2000). Given that our analysis is driven by the event of monetary union and the imposition of a common currency, our model is expanded to include currency risk. Indeed, currency risk may have played a substantial role in the evolution of required returns.[5]

Consider the stock market index of a European country, say, Italy. The index consists of both "local" and "global" assets. Local assets are held by Italian investors only, because for foreign investors, the cost of holding them exceeds the expected diversification benefit from including them in their portfolio. Their pricing reflects local market risk, since local investors are not internationally diversified. Global assets, on the other hand, are held by well-diversified investors, since their cost falls short of the expected diversification benefit from including the assets in the portfolio. They are priced according to their exposure to EU market risk and currency risk. Hence, the expected return of the Italian stock market index (which is a value-weighted average of global and local stocks) consists of three risk premia: an EU market premium, a currency premium, and a local premium. In general, the conditional mean excess return on the ith stock market index can be written as

$$E_{t-1}(r_{i,t}) = \varphi_{i,t-1}[\lambda_{\mathrm{EU},t-1}\mathrm{cov}_{t-1}(r_{i,t}, r_{\mathrm{EU},t}) + \lambda_{C,t-1}\mathrm{cov}_{t-1}(r_{i,t}, r_{C,t})] + (1-\varphi_{i,t-1})\lambda_{i,t-1}\mathrm{var}_{t-1}(r_{i,t}) \quad (1)$$

where $E_{t-1}(r_{i,t})$ is the expected excess return on the local stock market index, given information up to time $t-1$, $r_{\mathrm{EU},t}$ is the excess return on the EU stock market index, $r_{C,t}$ is the excess currency return, $\lambda_{\mathrm{EU},t-1}$

4. See, for example, Korajczyk and Viallet (1989), Chan, Karolyi, and Stulz (1992), Bekaert and Harvey (1995, 1997), Foerster and Karolyi (1999), Dumas, Harvey, and Ruiz (2003), Carrieri, Errunza, and Hogan (2003), Carrieri, Errunza, and Sarkissian (2004), Bekaert, Harvey, and Ng (2004). Karolyi and Stulz (2003) provide an excellent survey of the literature on testing international asset pricing models.

5. De Santis, Gerard, and Hillion (1999) find that, prior to the EMU, intra-European currency risk was significant and equity investors indeed were compensated for their exposure to this source of risk. Furthermore, they find that the importance of this risk factor declined over the 1990s.

is the price of EU market risk, $\lambda_{C,t-1}$ is the price of currency risk, $\lambda_{i,t-1}$ is the price of local risk, cov_{t-1} is the conditional covariance operator, and var_{t-1} is the conditional variance operator. The time-varying parameter $\varphi_{i,t-1}$ measures the conditional level of integration of market *i* based on information up to time $t-1 (0 \leq \varphi_i \leq 1)$. Alternatively, in the context of a regime switching model, $\varphi_{i,t-1}$ could be interpreted as the conditional probability that market *i* is fully integrated (Bekaert and Harvey 1995, 1997). In Cooper and Kaplanis (2000), the parameter $\varphi_{i,t-1}$ can be interpreted as the relative weight of "global" assets in total market value.

At a given moment in time, the model resembles the static formulation in Errunza and Losq (1985), Eun and Janakiramanan (1986), and Cooper and Kaplanis (2000). In those models, the local and global risk factors are orthogonal to each other, a condition absent from our framework, as we tie our factors to observable market variables. Our specification is also more general, as we include the currency risk component, $\lambda_{C,t-1}\text{cov}_{t-1}(r_{i,t}, r_{C,t})$. This risk is faced by investors even in a perfectly integrated global asset market, due to differences in purchasing power indices across countries (see Adler and Dumas 1983 and Dumas and Solnik 1995).

For each country *i,* the estimated model consists of a system of eight equations, (2) through (9). Equations (2), (3), and (4) describe excess stock and currency returns:

$$r_{EU,t} = \lambda_{EU,t-1}\text{var}_{t-1}(r_{EU,t}) + \lambda_{C,t-1}\text{cov}_{t-1}(r_{EU,t}, r_{C,t}) + \varepsilon_{EU,t} \quad (2)$$

$$r_{C,t} = \lambda_{EU,t-1}\text{cov}_{t-1}(r_{EU,t}, r_{C,t}) + \lambda_{C,t-1}\text{var}_{t-1}(r_{C,t}) + \varepsilon_{C,t} \quad (3)$$

$$\begin{aligned} r_{i,t} = {} & \varphi_{i,t-1}[\lambda_{EU,t-1}\text{cov}_{t-1}(r_{i,t}, r_{EU,t}) + \lambda_{C,t-1}\text{cov}_{t-1}(r_{i,t}, r_{C,t})] \\ & + (1-\varphi_{i,t-1})\lambda_{i,t}\text{var}_{t-1}(r_{i,t}) + \varepsilon_{i,t}, \end{aligned} \quad (4)$$

where $\varepsilon_t = (\varepsilon_{EU,t}, \varepsilon_{C,t}, \varepsilon_{i,t}|\mathbf{X}_{t-1}) \sim N(0, \mathbf{H}_t)$ is the vector of unexpected excess returns given the set of information $\mathbf{X}$ available at time $t-1$, and $\mathbf{H}_t$ is the conditional variance-covariance matrix of excess returns.

The time-varying parameter $\varphi_{i,t-1}$ is conditioned on a set of variables that measure integration:

$$\varphi_{i,t-1} = \exp(-|\mathbf{g}_i' \mathrm{X}_{i,t-1}^I|), \quad (5)$$

where exp(·)denotes exponentiation, $|\cdot|$ denotes absolute value, $\mathbf{g}_i$ is a vector of country-specific parameters (including a constant), and $\mathbf{X}_{i,t-1}^I$ is a vector of country-specific predetermined information variables related to convergence toward EMU. Observe that, by construction, $\varphi_{i,t-1}$ takes a value between zero and unity. By taking the absolute value of $\mathbf{g}_i'\mathbf{X}_{i,t-1}^I$, we assume that deviations of the information variables from zero, independent of their sign, reduce the degree of integration.

Equation (6) describes the conditional variance-covariance matrix of excess returns, $\mathbf{H}_t$, which follows a GARCH(1, 1) process (see Engle and Kroner 1995):

$$\mathbf{H}_t = \mathbf{C}'\mathbf{C} + \mathbf{A}'\varepsilon_{\mathbf{t-1}}\varepsilon'_{\mathbf{t-1}}\mathbf{A} + \mathbf{B}'\mathbf{H}_{\mathbf{t-1}}\mathbf{B}, \tag{6}$$

where for N assets $\mathbf{C}$ is a $(N+2) \times (N+2)$ lower triangular coefficient matrix and $\mathbf{A}$ and $\mathbf{B}$ are $(N+2) \times (N+2)$ diagonal coefficient matrices.

Finally, the last three equations of the system, equations (7)–(9), specify the evolution of the conditional prices of risk:

$$\lambda_{\mathrm{EU},t-1} = \exp\left(\delta'_{\mathrm{EU}}\mathbf{X}^{\mathrm{EU}}_{t-1}\right) \tag{7}$$

$$\lambda_{C,t-1} = \delta'_{C}\mathbf{X}^{\mathrm{EU}}_{t-1} \tag{8}$$

$$\lambda_{i,t-1} = \exp\left(\gamma_i\mathbf{X}^{L}_{i,t-1}\right), \tag{9}$$

where $\mathbf{X}^{\mathrm{EU}}$ represents EU-wide information variables, $\mathbf{X}^{L}$ represents local information variables specific to country i and δ'_{EU}, δ'_{C}, and γ'_i are vectors of coefficients. The functional forms of $\lambda_{\mathrm{EU},t-1}$, $\lambda_{C,t-1}$, and $\lambda_{i,t-1}$ are dictated by the implications of the theoretical model. Under risk aversion, the prices of risk $\lambda_{\mathrm{EU},t-1}$ and $\lambda_{i,t-1}$ must be always positive (see Merton 1980). Therefore, we assume that $\lambda_{\mathrm{EU},t-1}$ and $\lambda_{i,t-1}$ are exponential functions of the instruments. The theory does not impose any restrictions on the sign of the price of currency risk, since market participants may be willing to attach a negative premium to currency deposits if their expected return in excess of the risk-free rate is negative and currency returns covary positively with the market. Therefore, a linear specification is chosen for $\lambda_{C,t-1}$.

The parameters are estimated by maximum likelihood, assuming conditional normally distributed errors. To avoid problems due to nonnormality in excess returns, we provide quasi-maximum likelihood (QML) estimates, as proposed by Bollerslev and Wooldridge (1992), which are robust to departures from normality. Given the highly nonlinear structure of the model and the large number of parameters involved in estimation, we estimate the model in two steps. First we estimate a bivariate model of the EU market returns and currency returns—equations (2) and (3) plus the relevant variance-covariance elements of equation (6). This provides estimates of the price of EU market risk, the price of currency risk, the conditional variances, and the covariance of the EU market excess return and the excess currency return. To maintain the assumption that these prices of risk are equal across countries, we then impose these estimates on a set of N bivariate equations, one for each country, along with the EU index and the excess currency return. This strategy is also employed by Bekaert and Harvey (1995), who note that a two-step procedure leads to some loss of efficiency, since sampling error from the first stage estimation is omitted from the second stage. The standard errors may be smaller than the true ones, and this should be taken into consideration when interpreting the results. The two-step method has one advantage, in that it imposes the same world prices of risk on each country, which should lead to more powerful tests (see Bekaert and Harvey 1995). A simultaneous estimation of the full model is not practically feasible, given that—with 11 national markets, 5 local, 5 global, and 6 integration instruments—a total of 219 parameters would need to be estimated.

III. Data

A. Returns

The data source is Datastream International. We used weekly, deutschmark-denominated, dividend-adjusted, and continuously compounded stock returns based on Friday closing prices in the 11 EU countries. The weekly risk-free rate is the German Eurocurrency rate. Belgium and Luxembourg are aggregated into one market. Greece, an EU country, which joined the Eurozone after a 2-year delay, is excluded because of lack of sufficient data. We include the United Kingdom, which has yet to decide when and if it will enter EMU, because it can act as a control.

For most of the countries, the sample covers the period February 7, 1992, to June 26, 1998, except for Austria (April 14, 1995), Finland (January 24, 1997), Ireland (November 8, 1996), and Portugal (August 18, 1995), where the start dates vary with the availability of data. Panel A of table 1 reports summary statistics of excess returns. Column 2 reports the mean and standard deviation of the excess returns over the sample period for each country. There is considerable cross-sectional variation in excess stock returns. Column 2 also reports statistics for (i) the excess return on the EU-12 benchmark index, constructed from the capitalization-weighted equity price index of the EMU-11 countries plus the United Kingdom; and (ii) the excess return of a basket of currencies. The currency basket is the trade-weighted excess currency return vis-à-vis the deutschmark of the six most actively traded European currencies.[6] Individual excess currency returns, which compose the basket, are calculated as the continuously compounded difference in the 1-month Eurocurrency interest rates between a given country and Germany, adjusted for the rate of depreciation against the deutschmark.

B. Global and Local Instruments for the Prices of Risk

We use instruments that are proven to predict returns in developed markets; see, for example, Campbell (1987), Harvey (1991), Ferson and

6. British pound, French franc, Italian lira, Belgian franc, Dutch guilder, and Spanish peseta. The weights used to construct the aggregate measure of currency risk are the 1994 export shares of each country in total intra-EC trade. The source for trade weights is "European Economy," European Commission, Brussels, DG II, No. 64, 1997, Table 45, column EUR12.

TABLE 1 Excess Returns and Instruments

Panel A. Summary Statistics

	Price of Risk Instruments					Integration Instruments				
Country	$r_{i,t}$	DIV	ΔTERM	ΔSHORT	DEF	FSPREAD	CURVOL	SRD	INFD	IPRD
AU	.24	−1.89	−.82	−.66		.77	.84	.07	.35	1.58
	(1.74)	(.32)	(10.2)	(6.10)		(5.96)	(.13)	(.18)	(.66)	(4.71)
BE	.27	−2.56	.62	−1.73		.35	.13	.31	.41	.12
	(1.63)	(2.09)	(38.5)	(40.1)		(.29)	(.17)	(.81)	(.53)	(2.30)
FN	.77	−1.03	−2.01	.60		.21	.29	−.15	.16	5.04
	(3.01)	(.37)	(12.4)	(8.57)		(.18)	(.06)	(.18)	(.34)	(.78)
FR	.22	−3.03	.74	−1.80		.23	.24	.86	.15	−.44
	(2.21)	(2.48)	(46.8)	(47.8)		(.41)	(.13)	(1.09)	(.47)	(.46)
GE	.22	−3.45	.89	−1.83		−.47	.00	.00	1.08	−1.13
	(1.88)	(2.02)	(14.4)	(12.4)		(.36)	N.A.	N.A.	(.95)	(1.38)
IR	.77	−3.56	−2.20			.22	.64	.51	.52	10.17
	(2.10)	(.27)	(9.63)			(.21)	(.11)	(.27)	(.53)	(2.58)
IT	.18	−6.77	−.25	−1.99		2.53	.75	4.04	2.33	.45
	(3.51)	(2.03)	(54.2)	(58.4)		(1.39)	(.36)	(1.75)	(1.10)	(1.99)
NL	.34	−2.00	.69	−1.75		.03	.04	−.18	.76	1.11
	(1.72)	(1.69)	(13.8)	(11.8)		(.12)	(.01)	(.23)	(.46)	(1.58)
PO	.67	−4.70	−.25	−3.11		1.13	.21	3.17	1.56	2.25
	(2.09)	(1.06)	(14.1)	(9.18)		(1.16)	(.06)	(1.31)	(.77)	(3.26)
SP	.29	−5.07	.49	−2.51		2.28	.57	3.61	2.26	.59
	(2.46)	(2.17)	(51.8)	(53.0)		(1.47)	(.31)	(1.64)	(1.05)	(2.10)
UK	.24	−2.87	−.04	−.97		1.14	.24	1.37	1.12	.79
	(2.04)	(1.22)	(20.5)	(17.1)		(.34)	(.13)	(1.91)	(.94)	(2.43)
EU	.26	−2.15	.84	−1.85	.55					
	(2.15)	(1.88)	(21.6)	(21.6)	(.29)					
CUR	.00	−2.15	.84	−1.85	.55					
	(.44)	(1.88)	(21.6)	(21.6)	(.29)					

Panel B. Predictability Tests

	Exclude $\mathbf{X}_{t-1}^{\mathrm{EU}}$		Exclude $\mathbf{X}_{t-1}^{L}$		Exclude $\mathbf{X}_{t-1}^{\mathrm{EU}} + \mathbf{X}_{t-1}^{L}$	
Country	χ^2	*p*-Value	χ^2	*p*-Value	χ^2	*p*-Value
AU	8.421	[.13]	5.587	[.35]	10.790	[.29]
BL.	10.447	[.06]	36.350	[.00]	28.899	[.00]
FN	10.760	[.05]	8.759	[.12]	12.725	[.18]
FR	7.883	[.16]	8.303	[.14]	14.654	[.10]
GE	12.585	[.03]	10.408	[.06]	21.347	[.01]
IR	24.900	[.00]	21.570	[.00]	22.280	[.00]
IT	7.260	[.20]	7.610	[.17]	13.710	[.13]
NL	26.169	[.00]	28.049	[.00]	37.899	[.00]
PO	22.316	[.01]	18.831	[.01]	28.845	[.00]
SP	19.475	[.00]	15.255	[.01]	31.113	[.00]
UK	18.232	[.00]	21.804	[.00]	37.061	[.00]
EU	28.697	[.00]				
CUR	24.723	[.00]				

NOTE.—The sample consists of weekly observations from February 7, 1992 through June 26, 1998. The sample for Austria begins on April 14, 1995; for Finland on January 24, 1997; for Ireland on November 8, 1996; and for Portugal on August 18, 1995. Panel A reports summary statistics (means and standard deviations in parenetheses) of weekly, deutschmark-denominated excess stock returns, excess currency returns, and a set of price of risk instrumental variables: the dividend yield in excess of the 1-month interest rate (DIV), the change in the term spread between 10-year and 1-month interest rates (ΔTERM), the change in 1-month interest rate (ΔSHORT), the default spread (DEF), and a set of integration instruments—the forward interest rate differential (FSPREAD) with Germany, currency volatility (CURVOL), the 1-month interest rate differential with Germany (SRD), the inflation differential with the best three performing countries (INFD), and the industrial production growth differential with the EU (IPRD). Means and standard deviations are expressed in annualized percentage points with the exception of excess stock and currency returns, which are not annualized. Panel B reports predictability results of excess returns. Exclude $\mathbf{X}_{t-1}^{\mathrm{EU}}$ is the vector of EU-wide instruments: a constant, and the first lags of DIV, ΔTERM, ΔSHORT, and DEF. Exclude $\mathbf{X}_{t-1}^{L}$ is the vector of local instruments: a constant and the first lags of the local market excess return, DIV, the local ΔSHORT, and the local ΔTERM. Wald tests of the null hypothesis of no predictability of excess returns by local, $\mathbf{X}_{t-1}^{L}$, or EU, $\mathbf{X}_{t-1}^{\mathrm{EU}}$, instruments are reported in columns 2, 4, and 6. Column 2 reports a $\chi^2(5)$ test that the four EU-12 instruments and the constant have zero coefficients. Column 4 reports a $\chi^2(5)$ test that the four local instruments and the constant have zero coefficients (note, in Ireland, this is a $\chi^2(4)$ test). Column 6 reports a $\chi^2(9)$ test that the all nine instruments (including the constant) have zero coefficients (note, in Ireland, this is a $\chi^2(8)$ test). Probability values are reported in square brackets. Country codes are as follows: AU, Austria; BL, Belgium-Luxembourg; FN, Finland; FR, France; GE, Germany; IR, Ireland; IT, Italy; NL, the Netherlands; PO, Portugal; SP, Spain; UK, United Kingdom; EU-12 is the aggregate EU stock excess return; CUR is the excess currency return.

Harvey (1993, 1994), Hardouvelis, Kim, and Wizman (1996), and De Santis and Gerard (1997). For the aggregate EU market and the currency basket, the instruments $\mathbf{X}^{EU}$ that we chose are (1) a constant; (2) DIV, the first lag of the EU-12 index dividend yield in excess of the 1-month euro-DM deposit rate; (3) ΔTERM, the first lag of the change in the term spread; (4) ΔSHORT, the first lag of the change in the 1-month ECU deposit rate; and (5) DEF, the first lag of the default spread. The term *spread* is defined as the difference between the yield on ECU government bonds with 10 years to maturity and the 1-month ECU deposit rate. The default spread is the difference between a weighted average of the corporate bond yields in France, Germany, Italy, the Netherlands, Spain, and the United Kingdom (weights based on stock market capitalizations) and the yield on 10-year ECU government bonds. Summary statistics of these variables are reported in panel A of table 1 (row EU).

Panel B of table 1 reports Wald tests of the predictive power of the EU instruments by regressing the aggregate EU excess return and the currency basket excess return on this set of EU instruments (rows EU, CUR). A robust variance covariance matrix (see White 1980) is used to construct the χ^2 statistics and their associated probability values. The results show considerable predictive power.

The local instruments $\mathbf{X}^L$ are (1) a constant; (2) $r_{i,t-1}$, the first lag of the local market excess return; (3) DIV, the first lag of the dividend yield in excess of the local market 1-month interest rate; (4) ΔSHORT, the first lag of the change in the local 1-month interest rate; and (5) ΔTERM, the first lag of the change in the local market term spread. The *local market term spread* is defined as the spread between the yield on 10-year benchmark government bonds and the 1-month euro-deposit rate of the local currency. For Ireland, where no short-term interest rate data are available over the whole sample, we replace the change in the short-term rate with the change in the long-term rate and omit the term spread instrument. Summary statistics of these variables are reported in panel A of table 1 (columns 2–5).

Panel B of table 1 reports results from regressing the excess returns of the 11 local markets on both the local and the EU instruments. In most cases, it is not possible to exclude both sets of instruments. For most markets, there is predictive power from the set of EU instruments. Also, in the majority of cases, local instruments have predictive power independent of the EU instruments.

C. Instruments for The Time-Varying Integration Parameters

Earlier, we suggested a number of economic channels that may help describe EU stock market integration during the 1990s, all of which are related to the prospect of the monetary union. Next, we discuss the variables we use to capture those channels.

Forward interest rate differentials. Forward interest rate differentials with Germany play a dual role. First, they capture the probability of a country joining the EMU. The higher is the probability, the closer future nominal long-term interest rates will be to the German ones; hence, the lower is the current forward interest rate differential. Second, they capture the size of the transaction cost in trying to speculate either on the size of future nominal interest rates or the future spot exchange rate or, alternatively, in hedging an open foreign currency position. The lower is the differential, the lower the transaction cost. Both characteristics of the forward interest rate differential are intimately related to the degree of stock market integration, making it a very useful instrument.

Forward interest differentials are calculated from interest rate swap yields, collected from Datastream International. For most of the countries, 2–10-year swap data are available over the period June 29, 1991, to June 26, 1998, except for Portugal and Austria (January 6, 1995, to June 26, 1998), Finland (October 18, 1996, to June 26, 1998) and Ireland (August 2, 1996, to June 26, 1998). For each country, we calculated forward interest rate differentials as follows: we defined $w_{i,\tau,t}$ as the swap rate at time t in country i for an interest rate contract in which the interest payments of a variable rate government bond with τ years to maturity are exchanged against the interest payments of a fixed-rate government bond with the same years to maturity and the same notional principal on which the interest payments are based. The n-year forward rate T years from now is given as

$$f^{n}_{i,T,t} = \left[\frac{(1 + w_{i,T+n,t})^{T+n}}{(1 + w_{i,T,t})^{T}} \right]^{\frac{1}{n}} - 1.$$

We set $n = 8$ and $T = 2$, and hence calculate for each market the 8-year forward rate in 2 years' time. Subsequently, we calculated spreads for each market vis-à-vis Germany, the anchor country, as $s_{i,t} = \ln(1 + f^{8}_{i,2,t}) - \ln(1 + f^{8}_{\mathrm{GE},2,t})$. For Germany itself, we constructed the spread between the German forward rate and the ECU forward rate.[7]

Summary statistics of forward interest rate differentials (column FSPREAD), along with a number of other integration instruments described in the following text are reported in panel A of table 1. Forward interest differentials correspond to expected future premia in the foreign exchange market and, as a consequence, ought to be stationary over long

7. Our choice of the particular forward rate is dictated by data availability and the desire to capture market expectations about convergence in long-term yields, one of the main Maastricht criteria for joining EMU. The 8-year rate is closest to the 10-year maturity, which is the most liquid segment of the government bond market. Forward rates of longer maturity than 8 years could not be constructed, as no swap rates existed with maturities shorter than 2 years.

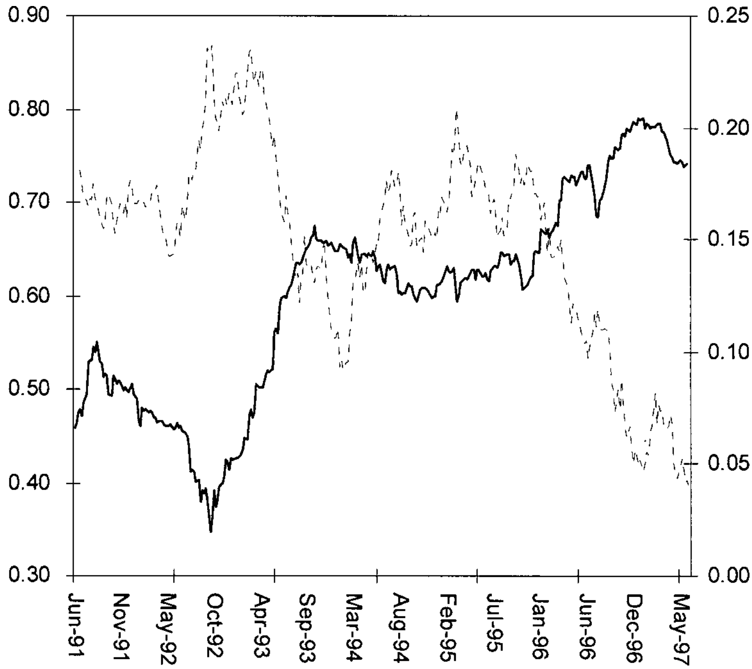

FIG. 1.—On the left scale, the figure displays a 52-week rolling estimate of the average cross-correlation coefficient between local stock returns and the EU-12 market return (continuous line). Individual cross-correlations of the 12 countries with the EU-12 market return are equally weighted. The right scale of the figure displays the average forward interest differential (dashed line) vis-à-vis Germany divided by the German long bond yield for the seven countries for which data on interest rate swaps are available over a longer sample (Belgium-Luxembourg, France, Germany, Italy, the Netherlands, Spain, and the United Kingdom). The forward interest differential contains information about the expected 8-year interest rate differential vis-à-vis Germany in 2 years' time. The German forward interest differential is calculated vis-à-vis the ECU.

periods of time. In small samples, however, nonstationarity may be a problem. Since European interest rates were on a downward trend since 1992, forward interest differentials may have had a similar trend as interest rates. In this case, it would be more appropriate to measure forward interest differentials relative to the level of interest rates. Therefore, in our subsequent empirical analysis, we use the ratio between the forward interest differential and the German long bond yield.

A first piece of preliminary evidence that forward interest rate differentials could be related to the degree of integration of European stock markets comes from simple graphical analysis. Figure 1 displays on the left scale a 52-week-ahead rolling estimate of the average cross-correlation coefficient between local stock returns and the EU-12 market return. The cross-correlation is a simple arithmetic average of 12 individual correlation coefficients. The EU-12 market return is computed as the value-weighted return of the 11 EMU countries plus the United Kingdom. The figure also displays, on the right scale, the average forward interest rate differential of the seven countries for which data on interest rate swaps are available over a longer sample (Belgium-Luxembourg, France, Germany, Italy, the Netherlands, Spain, and the United Kingdom) divided by the German long bond yield. The average cross-correlation between local returns and EU-12 returns increases significantly over the sample from less than 0.5 in 1991 to around 0.75 in June 1997. Over the same period, the average forward differential fluctuates in the opposite direction. The sample correlation coefficient between the average forward interest rate differential and the average cross-correlation of local returns and EU-12 returns is −0.88, suggesting a strong negative association between the series. This correlation is similar whether or not we exclude the volatile EMS crisis period of 1992–93.

Nominal convergence. Whereas forward interest rate differentials capture market expectations of future nominal convergence, current interest rate differentials and current inflation differentials capture current nominal convergence. One of the criteria of joining EMU was a low level of inflation, no higher than 2 percentage points above the average of the best three performing states in terms of inflation. We measured inflation as the monthly logarithmic change in the consumer price index, collected from Datastream. We computed the inflation differential of each country from the benchmark inflation rate, which is the average inflation of the three countries with the lowest inflation rate in the EU. To account for the downward trend in EU inflation over the 1990s, for each country, we used the local inflation differential as a ratio of benchmark inflation. Weekly inflation differentials, INFD, were linearly interpolated from monthly observations.

We also used short-term interest differentials with Germany as an additional proxy of nominal convergence (SRD). There was no legal requirement that short-term interest rates had to converge prior to joining EMU. Nevertheless, a convergence toward the low levels of Germany would show that the country's monetary authority was in no pressure to follow an unusually strict policy to satisfy the Maastricht criteria. Short-term interest rates are 1-month Eurocurrency rates, collected from Datastream. To account for the downward trend in German short-term interest rates over the 1990s, for each country, we used the local interest rate differential as a fraction of the German short-term interest rate.

Intra-European currency volatility. According to Stulz (1981), investors may avoid a market in which the costs outweigh the benefits of diversification. If a currency is going through a period of high volatility, the costs of diversifying into this currency would increase, shutting some investors out of the specific market, hence, leading to less diversification and a lower level of integration. This effect may have been especially important for countries that were hit by unexpected European

Monetary System (EMS) crises. We measured local currency volatility by a 52-week moving average of the standard deviation of the local currency return relative to the deutschmark (CURVOL).

Business-cycle convergence. Artis, Krolzig, and Toro (1999) found evidence that economic integration resulted in business-cycle convergence. Erb, Harvey, and Viskanta (1994) show that cross-country return correlations and business cycles are related. Monetary and fiscal policy coordination may have led to increased synchronization of business cycles among EMU member countries, which, in turn, could have led to increased correlation of expected corporate earnings and more homogeneous valuations of European equities. We proxy business-cycle convergence with the difference between a country's industrial production growth from the average industrial production growth in the EU (IPRD). Average EU industrial production is computed as a GDP-weighted average of industrial production of all countries in the sample. Data are monthly observations from Datastream, which were allocated to a weekly frequency in a manner similar to the inflation differentials.[8]

IV. Empirical results

The first two rows of panel A in table 2 report results from estimating the price of EU-12 market risk and the price of currency risk associated with fluctuations of a trade-weighted basket of European currencies vis-à-vis the deutschmark. The estimated parameters are from equations (2), (3), and (6)–(8). All the coefficients in the conditional (co)variance equations (not reported) and most of the coefficients on the EU instruments are significantly different from 0 at the 1% confidence level. This suggests time-variation in both prices and quantities of risk.[9]

The remaining rows of panel A report individual country estimates, which are obtained by augmenting the earlier equations (2), (3), and (6)–(8) with equations (4), (5), and (9) and reestimating, while imposing the

8. More variables could be important for integration. One-off events such as the signing of treaties or referenda may have led to a stepwise increase in the level of integration. The importance of such events is difficult to measure, however, because their effect may have been either anticipated before the actual event or have occurred with a time lag. Empirical studies that examine the integration of emerging markets (see, e.g., Bekaert and Harvey 1997, 2000; Carrieri et al. 2003; and Bekaert et al. 2005) often use variables such as the stock market capitalization to GDP ratio and the foreign trade to GDP ratio. These types of variables are aimed at capturing the emerging nature of the economy and are less likely to be important in developed countries. In addition, these variables are measured quarterly and would be unable to capture changes in the degree of stock market integration within the quarter.

9. It is possible that the instruments we use for capturing the time-varying stock market integration also are helpful in capturing the prices of risk. For example, as the probability that the EMU will materialize increased, the probability that the intra-EU currency risk would disappear also increased. Thus, the price of currency risk may be conditional on the forward interest differential. We included the average EU forward interest rate differential as an instrument for the conditional currency price of risk. It was not statistically significant and its inclusion did not affect the model estimates.

TABLE 2 Time-Varying Integration and Expected Returns

Panel A. Model Estimates of Mean Return Equation

	Constant	DIV	ΔTERM	DEF	ΔSHORT
EU	1.109**	.177*	−9.435**	.596	−8.358**
	(3.85)	(2.31)	(6.77)	(1.52)	(6.25)
CUR	−13.605	30.821**	150.781**	130.041**	24.754
	(1.52)	(15.28)	(4.03)	(7.94)	(.61)

	FSPREAD	CURVOL	SRD	INFD	IPRD
AU	2.061**	.086	.117	.124	.126
	(2.88)	(.02)	(.01)	(.02)	(.20)
BL	1.306**	.327**	.148	.774*	.048
	(53.66)	(4.06)	(.36)	(2.04)	(.08)
FN	.896**	.049	.009	.132	.045
	(6.52)	(.02)	(.02)	(.06)	(.00)
FR	1.503**	.373	.047	.550**	.052
	(25.25)	(.89)	(.05)	(3.15)	(.01)
GE	.976**			.301	.202
	(35.05)			(.45)	(.01)
IR	1.425**	.024	.002	.447	.005
	(8.27)	(.01)	(.01)	(.35)	(.00)
IT	.985**	.004	.007	.805**	.069
	(2.61)	(.01)	(.02)	(2.62)	(.00)
NL	.967**	.191	.016	.661**	.052
	(589.4)	(.18)	(.04)	(30.16)	(.04)
PO	.501**	.049	.021	.729**	.005
	(150.0)	(.12)	(.02)	(5.21)	(.00)
SP	.830**	.195	.142	.367	.028
	(8.64)	(.11)	(.12)	(1.33)	(.00)
UK	.605**	.019	.010	1.304**	.039
	(14.93)	(.41)	(.12)	(21.98)	(.01)

Panel B. Residual Analysis

	N	H	S.C.	EN				
	χ^2 (2)	χ^2 (4)	χ^2 (4)	χ^2 (3)	W	O_{EU}	O_L	O_W
EU	4.49	1.47	6.67	3.36	92.73**	4.70		4.15
	[.11]	[.83]	[.15]	[.30]	[.00]	[.45]		[.53]
CUR	4761.8**	1.01	1.80	1.92	313.78**	.58		5.42
	[.00]	[.91]	[.77]	[.59]	[.00]	[.98]		[.37]
AU	6.18*	25.91**	14.32**	4.28	123.07**	3.82	2.55	5.49
	[.02]	[.00]	[.00]	[.23]	[.00]	[.57]	[.76]	[.36]
BL	1.61	10.78*	10.91**	2.22	175.63**	7.53	4.52	5.98
	[.45]	[.03]	[.03]	[.53]	[.00]	[.18]	[.47]	[.31]
FN	24.64**	3.37	4.82	1.51	1.26	3.82	3.37	10.62***
	[.00]	[.49]	[.31]	[.68]	[.86]	[.57]	[.64]	[.06]
FR	.29	8.50***	1.76	4.12	637.24**	.33	3.47	5.31
	[.86]	[.07]	[.77]	[.25]	[.00]	[.99]	[.63]	[.38]
GE	8.77**	8.88***	1.86	2.77	110.48**	1.35	1.37	8.06
	[.01]	[.06]	[.76]	[.43]	[.00]	[.92]	[.92]	[.15]
IR	0.47	5.93	1.71	1.20	1.82	5.09	7.50	7.46
	[.79]	[.20]	[.79]	[.75]	[.61]	[.40]	[.11]	[.19]
IT	2.74	4.53	4.34	3.37	1159.23**	3.07	5.14	3.97
	[.25]	[.34]	[.36]	[.34]	[.00]	[.69]	[.39]	[.55]

TABLE 2 (*Continued*)

Panel B. Residual Analysis

	N	H	S.C.	EN				
	χ^2 (2)	χ^2 (4)	χ^2 (4)	χ^2 (3)	W	O_{EU}	O_L	O_W
NL	160.59**	14.19**	9.51*	.71	1,332.54**	8.87	7.88	10.73***
	[.00]	[.01]	[.05]	[.87]	[.00]	[.11]	[.16]	[.06]
PO	62.77**	1.33	10.86**	3.12	63.85**	4.96	5.57	4.30
	[.00]	[.85]	[.03]	[.37]	[.00]	[.42]	[.34]	[.49]
SP	6.57*	2.34	4.46	1.84	1,083.93**	4.43	1.55	5.69
	[.04]	[.66]	[.34]	[.61]	[.00]	[.48]	[.91]	[.34]
UK	6.12*	2.54	5.14	5.31	208.16**	4.46	13.90*	5.77
	[.05]	[.64]	[.27]	[.15]	[.00]	[.48]	[.02]	[.33]

NOTE.—Panel A reports parameter estimates of model (2)–(9). The second and third rows report estimates of the mean return in the EU-12 stock (EU) and currency (CUR) equations. DIV is the dividend yield in excess of the 1-month interest rate, ΔTERM is the change in the term spread, DEF is the default spread, ΔSHORT is the change in 1-month interest rate, FSPREAD is the forward interest rate differential with Germany, CURVOL is currency volatility, SRD is the 1-month interest rate differential with Germany, INFD is the inflation differential with the best three performing countries, and IPRD is the industrial production growth differential with the EU. All instrumental variables enter with one lag. The t-statistics are given in parentheses below coefficient estimates. Panel B reports residual analysis and tests of the model. N is the Bera-Jarque test for normality of the standardized residuals. H is a test statistic for fourth-order serial correlation of the squared standardized residuals. S.C. is a test statistic for fourth-order serial correlation of the standardized residuals. EN is the Engle-Ng joint test for asymmetries in conditional volatility. W is a robust Wald test of the null hypothesis that the prices of EU market risk is constant (row EU), the price of currency risk is 0 (row CUR) or the price of local risk is constant (remaining rows). O_{EU}, O_L, and O_W are Wald tests of orthogonality of the residuals to the EU, local, and world instruments, respectively. The tests are distributed $\chi^2(5)$ except for Ireland, where the test for orthogonality with respect to the local instruments is distributed $\chi^2(4)$. The asterisks **(*, ***) indicate significance at the 1% (5%, 10%) level, respectively.

estimates from (2), (3), and (6)–(8). For reasons of brevity, we do not report estimates of the individual coefficients on the local instruments. However, many of the local instruments are significant, suggesting time variation in the local prices of risk. In panel B, column W, we report a Wald test that the coefficients on the local instruments, with the exception of the constant, are jointly 0: hence, the price of local risk is constant. We fail to reject only in the cases of Finland and Ireland.

The country estimates reported in panel A (rows AU to UK) indicate that both the forward interest rate differentials and the inflation differentials are important determinants of the degree of stock market integration. The forward interest rate differential is statistically significant in all countries and the inflation differential is significant in 6 out of 11 cases, suggesting that, as these spreads converged across countries, the integration of European stock markets increased.[10] Currency volatility is statistically significant only in Belgium, and the proxy for business cycle convergence (industrial production growth differential) is not significant in any of the countries. Finally, short-term interest rate differentials have

10. This is our preferred interpretation of the coefficient signs. In reality, given the functional form of equation (5), the signs of parameters $\mathbf{g}_i$ are irrelevant in the estimation.

no predictive power for the degree of integration, suggesting that current nominal convergence is successfully proxied by inflation differentials.

Figures 2 and 3 display the estimated integration weight for each local market. All the weights approach unity at the end of the sample, with the interesting exception of the United Kingdom, which did not choose to adopt the single currency. The patterns in the integration weights are similar across countries. After the Exchange Rate Mechanism (ERM) crisis in September 1992, there was a general increase in the degree of integration as the Bundesbank began a policy of gradual monetary easing and ERM fluctuation bands were widened to $\pm 15\%$, allowing interest rate differentials with Germany to decline and increasing the likelihood of a future monetary union. The decrease in the degree of integration during 1994 coincides with a period of pessimism in Europe and a sharp increase in global bond yields, following the aggressive tightening of U.S. monetary policy. Concerns about the ability of highly indebted governments to control budget deficits led to a substantial widening of long-term interest rate differentials among European countries. Growing uncertainty about the future of the EMU during this period was reflected in a general increase in forward interest differentials with Germany and a corresponding decrease in integration weights. In 1995, integration weights gradually rose again to peak at end of the sample.

Overall, there has been a clear increase in the level of integration over the sample period, suggesting that, as the event of EMU was becoming more certain and currency-related barriers to intra-European investments were falling, coupled with a convergence in inflation rates, the relative exposure of local markets to pan-European market risk increased substantially.

Panel B of table 2 reports a detailed residual analysis of the model. Normality of estimated residuals can be rejected for excess currency returns and for 7 out of 11 local excess stock returns, justifying the use of QML inferential procedures. Heteroscedasticity of the standardized residuals cannot be rejected at the 5% significance level in four cases, while serial correlation cannot be rejected in three cases. Using the joint bias test of Engle and Ng (1993) for asymmetries in conditional variances, we cannot reject the null hypothesis that the symmetric GARCH model fits the data well. Column 6 reports Wald tests of constancy restrictions on the prices of risk. The test clearly rejects the null hypothesis that the price of EU market risk and (with the exception of Finland and Ireland) the price of local risk is constant. In the case of intra-European currency risk, the null hypothesis is that its price is 0. This hypothesis also is rejected, confirming the results of De Santis et al. (1999).

The final three columns of panel B, $O_{\mathrm{EU}}, O_L, O_W$, report orthogonality tests of the residuals against the instruments. With few exceptions, the tests cannot reject orthogonality of residuals to both EU and local instruments, suggesting that the empirical asset pricing model is well specified. To test whether missing global factors affect expected returns,

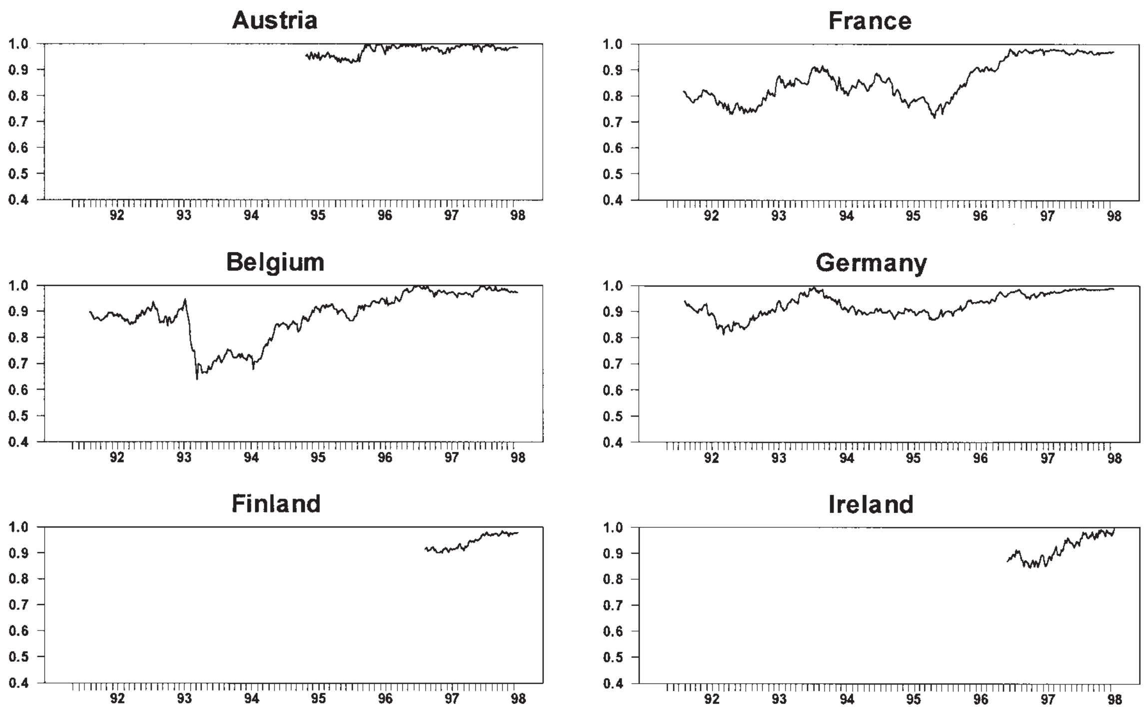

FIG. 2.—Estimates of integration weights, φ_i, from (2)–(9) in the text

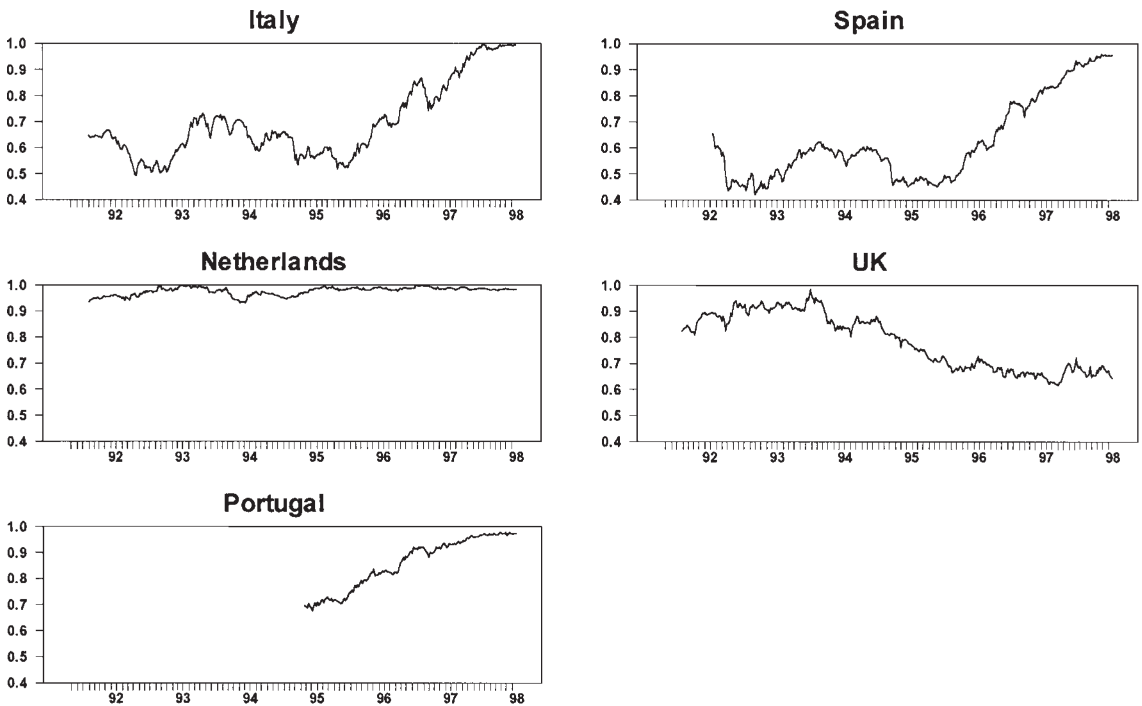

FIG. 3.—Estimates of integration weights, φ_i, from model (2)–(9) in the text

we also considered orthogonality of the residuals to a set of global instruments.[11] In an attempt to increase the power of these tests, we made the global instruments orthogonal to the EU instruments by regressing each global instrument on the EU instruments and using the residuals from the regression as the new global instrument. With the exception of Finland and the Netherlands (in column O_W), the residuals are orthogonal to global instruments, suggesting that leaving out the influence of world factors on expected excess returns does not lead to misspecification of the empirical model. In the next section, we address this issue further.

Finally, note that currency risk contributes substantially to total risk. First, as mentioned earlier, currency risk was priced prior to EMU. In panel B of table 2, the Wald test of the null hypothesis that the price of currency risk is 0; that is, $\delta_C = 0$ in equation (8), gives a value of 314 (see column W). Compared with the critical value of the χ^2 distribution with the 5 degrees of freedom, the test clearly rejects the null, indicating that investors require compensation for intra-European currency risk. Second, panels A and B of table 3 report the sample means and standard deviations of the estimated risk premia, revealing the important contribution of currency risk. Currency risk is over 20% of total risk in 6 of the 11 countries. The cross-country mean of the annualized currency risk premium is over 3.5% and accounts on average for 22% of total risk. Moreover, currency risk is very volatile. Its standard deviation, on average, is over one quarter of the standard deviation of total risk. Hence, our results suggest that the launch of the euro and the resulting elimination of intra-European currency risk has contributed, ceteris paribus, to a significant reduction in the riskiness of European equities. Panel C of the table reports the annual means and standard deviations of currency risk as a fraction of total risk in the 3 years preceding the launch of the euro. Currency risk premia decline as a fraction of the total risk premium from a cross-country average of 34% in 1996 to less than 20% in 1997 and to 0 in 1998.

A. Sensitivity to Alternative Model Specifications

This subsection addresses a number of potential problems with the estimated model. First, it is possible that forward interest differentials simply proxy for some worldwide convergence in interest rates as a result of increased synchronization of business cycles and monetary policy across the world, rather than capture convergence toward the EMU. To check the sensitivity of our results to such a phenomenon, we reestimate the

11. These are the world stock market dividend yield in excess of the 1-month euro-dollar deposit rate; the change in the term spread, defined as the yield on 10-year benchmark U.S. government bonds and the 1-month euro-dollar deposit rate; the changes in the default spread, defined as the yield on U.S. AAA corporate bonds minus the U.S. 10-year government bond yield; and the change in the 1-month euro-dollar deposit rate. All data are taken from Datastream. Previous studies on international asset pricing utilized similar instruments (Harvey 1991; Bekaert and Harvey 1995; De Santis and Gerard 1997).

TABLE 3 **Estimates of Risk Premia**

	AU	BL	FN	FR	GE	IR	IT	NL	PO	SP	UK	Average
Panel A. Sample Means												
CR	.027	.049	.004	.103	.041	.045	.192	.067	.038	.112	.092	.070
TR	.127	.311	.321	.402	.324	.313	.367	.290	.462	.426	.234	.325
CR/TR	.213	.157	.012	.256	.126	.144	.523	.231	.082	.263	.393	.218
Panel B. Standard Deviations												
CR	.039	.051	.015	.109	.043	.069	.207	.074	.043	.122	.096	.074
TR	.123	.305	.223	.329	.222	.162	.279	.651	.199	.411	.164	.278
CR/TR	.317	.167	.067	.331	.194	.426	.742	.113	.216	.297	.585	.314
Panel C. Annual Means and Standard Deviations of Currency Risk as a Fraction of Total Risk												
1996	.321	.160		.314	.158		.631	.392	.172	.373	.502	.336
	(.168)	(.104)		(.210)	(.137)		(.483)	(.261)	(.254)	(.214)	(.362)	(.243)
1997	.195	.202	.024	.228	.111	.130	.472	.133	.050	.211	.322	.189
	(.530)	(.661)	(.761)	(.431)	(.311)	(.515)	(.985)	(.658)	(.207)	(.277)	(.899)	(.566)
1998	.001	.000	.000	.000	.000	.000	.000	.000	.000	.000	.038	.003
	(.181)	(.249)	(.014)	(.289)	(.186)	(.250)	(.696)	(.241)	(.086)	(.186)	(.429)	(.255)

NOTE.—The table reports estimates of weekly risk premia in percentage points and the contribution of currency risk to total risk from the beginning of 1996 to the end of the sample. Currency risk is the price of currency risk multiplied by the covariance of the country stock return with the currency factor. Total risk is the sum of EU market risk, currency risk and local risk. Panel A reports sample means of currency risk premia (CR), total risk premia (TR), and the fraction of total risk due to currency risk (CR/TR). Panel B reports standard deviations of currency risk premia, total risk premia, and the fraction of volatility of total risk due to currency risk. Panel C reports annual means and standard deviations (in parentheses) of currency risk as a fraction of total risk in the years preceding the launch of the euro.

TABLE 4 Robustness of Results

	Model 1		Model 2		Model 3		Model 4
Country	$J_{0,1}$	$J_{1,0}$	$J_{0,2}$	$J_{2,0}$	$J_{0,3}$	$J_{3,0}$	W
AU	1.22	1.27	1.32	1.30	2.17*	1.99*	.00
	[.22]	[.20]	[.19]	[.19]	[.03]	[.05]	[.98]
BL	.81	.90	1.57	3.35**	.54	.92	.00
	[.42]	[.36]	[.11]	[.00]	[.58]	[.36]	[.99]
FN	1.19	1.28	1.05	1.43	1.19	1.00	.00
	[.23]	[.19]	[.29]	[.15]	[.23]	[.32]	[.98]
FR	.14	.29	.34	.75	.36	.16	.00
	[.88]	[.76]	[.73]	[.45]	[.71]	[.86]	[.99]
GE	.08	.25	.68	1.01	.37	.05	.01
	[.93]	[.79]	[.49]	[.31]	[.71]	[.96]	[.95]
IR	1.79***	2.06*	1.56	1.70***	1.56	1.70***	.00
	[.07]	[.04]	[.12]	[.08]	[.12]	[.09]	[.99]
IT	.89	1.70***	.32	3.33**	.61	1.85†	.02
	[.37]	[.09]	[.74]	[.00]	[.54]	[.06]	[.90]
NL	.84	.45	1.56	2.87**	.78	.32	.00
	[.39]	[.65]	[.12]	[.00]	[.43]	[.56]	[.99]
PO	.89	1.17	1.39	2.80**	.85	.85	.00
	[.37]	[.24]	[.16]	[.00]	[.39]	[.30]	[.99]
SP	1.01	.72	1.62***	2.88**	.92	1.97*	.00
	[.31]	[.47]	[.10]	[.00]	[.36]	[.05]	[.98]
UK	1.22	.70	.57	1.70***	.91	.94	.03
	[.22]	[.48]	[.57]	[.09]	[.36]	[.34]	[.88]

NOTE.—The table reports tests of the model against five alternative models. Model 0 is the underlying model for local returns. Model 1 uses a measure of the forward interest differential that is orthogonal to the U.S. forward interest differential against Germany. Model 2 does not impose the restriction that the prices of market risk and local risk are positive. In model 3, we make the currency risk premium independent from the integration parameter. In model 4, the spread is included as a predictor of the local price of risk. Model 0 is tested against models 1–4 using *J*-tests of the Davidson and MacKinnon (1981) type. Each column $J_{0,n}$ reports *J*-tests of the null hypothesis that model 0 is true against the alternative hypothesis that model n is true. For each model, we repeated the *J*-test by reversing the null and the alternative hypothesis (column $J_{n,0}$). Significance of the test statistic $J_{0,n}$ ($J_{n,0}$) means that model 0 (n) can be rejected against the alternative model. W is a Wald test, distributed $\chi^2(1)$, that the forward interest differential does not predict the local price of risk. **(*, ***) indicates statistically significant at the 1% (5%, 10%) level, respectively.

model using a proxy for each country's forward interest rate differential with Germany, which has been "cleaned" of major non-EU influences by making the forward interest rate differential with Germany orthogonal to the German-U.S. interest differential. Specifically, we regressed the original forward interest differential with Germany on the German forward interest differential with the United States (both variables are divided by the German long bond yield). The residual from this regression contains information more intimately related to EMU. We then reestimated the model using this residual as the new forward interest differential (model 1 in table 4).

Second, our model imposes the assumption that the price of market risk is positive. De Santis and Gerard (1997) show that, in a model of full integration, this restriction is rejected by the data. To assess whether the assumption of a positive price of risk matters, we simply omitted the exponentiation of the prices of EU-12 market risk and local risk and reestimated the model (model 2 in table 4).

Third, in the specification of local excess returns in equation (4), currency risk is weighted with the integration parameter $\varphi_{i,t-1}$. The specification, therefore, assumes that, although currency risk may be priced, its importance diminishes with decreasing market integration. However, following Solnik (1974), currency risk could still be priced even if capital markets are fully segmented. To test the sensitivity of our specification to this assumption, we make the currency risk premium independent of the integration parameter (model 3 in table 4).

Fourth, the forward interest rate differential may influence the local price of risk directly. With increasing probability of joining EMU, a market's local price of risk could decrease independent of the degree of integration. To assess this possibility, we included the forward interest rate spread as an extra predictor of the local price of risk (model 4 in table 4).

Table 4 reports nonnested hypothesis tests (*J*-tests) of our model specification (model 0) against each of the first three models described previously, following Davidson and MacKinnon (1981). The test results indicate that, out of a total of 33 cases of model comparisons, our model specification is preferred in 11 cases, whereas in the remaining 22 cases, the test is inconclusive. There is no case where our model specification could be rejected.

The last column of table 4 reports Wald tests of the null hypothesis that the forward interest differential does not predict the local price of risk. The test cannot reject the null hypothesis, providing further supportive evidence for our model specification.

B. *Is European Stock Market Integration Driven by Global Market Integration?*

In this subsection, we examine an alternative interpretation of the evidence, which claims that the increased integration of European stock markets during the 1990s is simply the result of European countries becoming increasingly integrated with the world market, fooling us into thinking that the integration is caused by the prospect of a common currency.

Recall that we already performed a test to distinguish between the two explanations of the evidence. If the correct model is integration in a broader world market portfolio, then restricting the model to the EU market would ignore the covariance of the local markets with the rest of the world (see Chan et al. 1992). However, according to the orthogonality tests of table 2 (see column O_W), the resulting potential misspecification does not appear to be very important.

We now present three additional tests, two of which are designed to have power against specific alternative hypotheses. In the first test, the alternative hypothesis is motivated by the observation that, over the

TABLE 5 Tests of European versus World Integration

	Model 5		Model 6		Model 6		Model 0		
Country	$J_{0,5}$	$J_{5,0}$	$J_{0,6}$	$J_{6,0}$	Start φ	End φ	Start φ	End φ	W
AU	.69	3.72**	0.31	2.97**	.51	.39	.95	.99	4.29
	[.48]	[.00]	[.75]	[.00]					[.11]
BL	.05	1.20	1.58	1.41	.11	.36	.89	.98	.02
	[.96]	[.23]	[.11]	[.16]					[.98]
FN	1.29	5.24**	2.08*	1.44	.59	.58	.91	.98	.29
	[.19]	[.00]	[.04]	[.15]					[.86]
FR	.01	.31	2.68**	3.23**	.29	.58	.81	.97	.96
	[.99]	[.75]	[.01]	[.00]					[.62]
GE	.00	.55	1.29	1.73***	.09	.28	.93	.98	.37
	[.99]	[.58]	[.19]	[.08]					[.83]
IR	1.55	1.90***	.21	3.73**	.78	.83	.86	.99	1.21
	[.12]	[.06]	[.83]	[.00]					[.55]
IT	.78	.81	.18	1.98*	.41	.94	.64	.99	1.31
	[.43]	[.42]	[.85]	[.05]					[.52]
NL	2.98**	.19	1.47	.82	.63	.88	.93	.98	6.35*
	[.00]	[.85]	[.14]	[.41]					[.04]
PO	.82	.95	.67	2.50**	.18	.71	.69	.98	.12
	[.41]	[.34]	[.50]	[.01]					[.94]
SP	.41	1.74***	1.41	3.06**	.04	.72	.65	.96	.75
	[.68]	[.08]	[.16]	[.01]					[.98]
UK	.11	.68	.28	4.48**	.87	.96	.81	.83	3.50
	[.91]	[.49]	[.78]	[.00]					[.59]

Note.—The table reports robustness tests of the model against two alternative models. Model 0 is the underlying model for local excess returns. In model 5, the EU market risk premium is weighted with the EU-12 capitalization in the world equity market. Model 6 is the world integration model with global currency risk and time-varying prices and quantities of risk. Model 0 is tested against models 5 and 6 using J-tests of the Davidson and MacKinnon (1981) type. Each column $J_{0,n}$ reports J-tests of the null hypothesis that model 0 is true against the alternative hypothesis that model n is true. For each model, we repeated the J-test by reversing the null and the alternative hypothesis (column $J_{n,0}$). The significance of the test statistic $J_{0,n}$ ($J_{n,0}$) means that model 0 (n) can be rejected against the alternative model. **(*, ***) indicates statistically significant at the 1% (5%, 10%) level, respectively. Start φ and End φ are the first and last observations of the integration parameter for the world integration model (model 5) and the EU integration model (model 0). W is a Wald test, distributed $\chi^2(2)$, that the residuals from a regression of country i stock returns on the EU market portfolio return are orthogonal to U.S. and Japanese stock returns.

period 1991–98, the weight of the EU stock market in the world portfolio increased by about 4 percentage points. Hence, the increase in the degree of integration could reflect the increase in the EU market weight in the world portfolio rather than an increase in the importance of the EU market risk premium. To assess this possibility, we weighed the EU market risk premium with the EU market value as a proportion of total world market capitalization at each point in time and reestimated the model (model 5). Columns 2 and 3 of table 5 report the results of nonnested hypothesis tests of our model specification against model 5. The results of the J-tests suggest that, with the exception of the Netherlands, our specification cannot be directly rejected in any of the cases: in four cases, the underlying model is clearly preferred, whereas in six cases the test is inconclusive.

In the second test, we compare our model of regional integration within the EU to a model of world market integration (model 6). To do this, we estimated a model of partial integration of European markets in the world market and recovered estimates of integration weights, so that both the degree and the time path of integration with the world market could be depicted over time. We estimated models (2)–(9) using (i) the world market index return in excess of the U.S. 1-month risk-free rate instead of the EU-12 excess stock return and (ii) the total currency excess return instead of the intra-European currency return. The world stock return is the return on the Datastream total market index. The world currency risk is computed in the same way as the EU currency risk with the addition of the trade-weighted excess currency return vis-à-vis the Japanese yen and the U.S. dollar. The instruments for the world price of market and currency risk are (1) a constant, (2) the world dividend yield in excess of the U.S. short-term rate, (3) the change in the slope of the U.S. term structure, (4) the U.S. default spread, and (5) the change in the U.S. short-term rate.

To estimate the new integration parameters, we constructed a set of world integration instruments analogous to the EU ones: (1) the forward interest rate spread of each country relative to the United States, (2) the difference between the local short-term rate and the U.S. short-term rate, (3) the volatility of the local currency relative to the dollar, (4) the difference between local inflation and U.S. inflation, and (5) the difference between local industrial production growth and U.S. industrial production growth.

Estimation results for this model (available on request) suggest that, with the exception of France, the forward interest rate spread is not a significant determinant of the degree of integration in any country. Inflation differentials and short-term interest rate differentials are significant in most countries, whereas currency volatility is significant only in the United Kingdom and the proxy for business cycle convergence is not significant in any country.

Columns 4 and 5 of table 5 report the results of nonnested hypothesis tests of our model specification against the world integration model. The results suggest that our specification can be rejected only in Finland. It should be noted, however, that the sample size for this country is relatively small and, consequently, the test statistic is less reliable. In seven cases, the underlying model is clearly preferred against the model of world market integration, whereas in three cases the test in inconclusive.

Columns 6 and 7 of table 5 report the first and the last observations of the integration parameter for the world integration model (model 6). For comparison purposes, in columns 8 and 9, we also report the first and last observations of the integration weight for the underlying EU integration model (model 0). Several interesting results emerge from this comparison, suggesting that integration of European markets over the 1990s was driven mainly by the event of the EMU rather than by integration of world equity markets. First, integration within the EU is generally higher than integration within the world for all countries, with the exception of the United Kingdom, which has not joined EMU. At the end of the sample, the United Kingdom appears to be fully integrated into the world market but has the lowest degree of integration within the EU among all countries. Second, although in most EMU countries integration with the world market increased over the sample period, local risk retained a significant weight in determining expected excess returns, which is not the case in our original model.

Finally, we performed a third unconditional test, asking whether omitting non-EU factors is important for local returns. We regressed each country's stock market return on the EU market return plus the return in the U.S. and Japanese stock markets. If these markets are important in determining local expected returns, they ought to have explanatory power over and above the explanatory power of the EU return. Column 10 of table 5 presents a Wald test that the two coefficients associated with the U.S. and Japanese stock market returns are jointly 0. With the exception of the Netherlands, the null hypothesis cannot be rejected in any country.

V. Concluding Remarks

The paper found evidence linking the process of increased integration of European stock markets in the 1990s to the prospects of the formation of EMU and the adoption of the euro as the single currency. During the 1990s, the degree of integration of each country's stock market with the EU market was negatively related to both its forward interest rate differential with Germany and its inflation differential with the best three performing countries. At that time, the forward interest rate differential with Germany was widely perceived as an indicator of the probability of a country joining EMU. Also, the inflation differential was a major indicator of whether a country with a high inflation had the ability to achieve nominal convergence and satisfy a major criterion for admittance into the Eurozone. The paper finds that the degree of integration had ups and downs, but in the second half of the 1990s, as these differentials shrank in the process toward EMU, stock markets converged toward full integration; that is, their expected returns became increasingly determined by EU-wide market risk and less by local risk.

Supporting evidence on the hypothesis that the prospect of EMU was the causal driver behind the observed increase in stock market integration among Eurozone countries comes from two main sources. First, the experience in the United Kingdom, an EU country that chose not to join the Eurozone, is substantially different than the rest of the European stock markets. The UK market showed no signs of increased integration with the EU stock market. Second, the integration in Europe appears to be a Eurozone-specific phenomenon, independent of a possible simultaneous world-market integration. A battery of specification tests show that the hypothesis of European stock market integration cannot be interpreted as a consequence of worldwide market integration.

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