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Firm-Level Evidence on International Stock Market Comovement ⋆

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Abstract. We explore the link between international stock market comovement and the extent to which firms operate globally. Using stock returns and balance sheet data for companies in 20 countries, we estimate a factor model that decomposes stock returns into global, country- and industry-specific shocks. We find a large and statistically significant link for global shocks. A firm raising its international sales by 10 percent raises the exposure of its stock return to global shocks by two percent. This link has grown stronger over time since the mid-1980s. We find no similarly robust link between international sales and exposure to country-specific shocks.

1. Introduction

There is mounting evidence that firms around the world are becoming more global. For example, the World Investment Report (2000) by UNCTAD (United Nations Conference on Trade and Development) reports that the global stock of FDI has gone from 5 to 16 percent of world GDP in the last two decades, while international production has increased from about 5 to 10 percent of world output over the same period. Indeed, the pace at which companies have been diversifying internationally accelerated in the late 1990s, when the value of cross-border mergers and acquisitions (M&A) rose sharply. According to the World Investment Report, cross-border M&A as a share of world GDP rose from around 0.5 percent in the mid-1990s to around 2.5 percent in 1999. With this rise in the globalization of businesses, one of the most pronounced empirical regularities in international finance – the low degree of comovement across national stock markets – has broken down. As Brooks and Del Negro (2004a) show, the correlation coefficient of U.S. stock returns with equity returns in other developed markets has risen from a relatively stable level of

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around 0.4 from the mid-1980s through the mid-1990s to close to 0.9 more recently (see also Longin and Solnik, 1995; and Goetzmann et al., 2005). Of course, the increase in the correlation of U.S. stock returns with returns in other markets may be partly due to the "demand side" (increased presence of investors with global portfolios, financial integration in the EU, etc.), rather than the globalization of the "supply side" (the operation and structure of firms).

We investigate the empirical link between comovement in international stock returns and the extent to which firms operate across countries. Using data for 1,239 firms in 20 developed and emerging markets from 1985 to 2002, we estimate a latent factor model for international stock returns, which yields firm-level exposures on (i) a global factor common to all stocks; (ii) country-specific factors that capture common variation within countries; (iii) industry-specific factors that capture common variation within industries; and (iv) a component that captures idiosyncratic variation in each stock. The model differs in an important respect from the prevailing approach in the international portfolio diversification literature. Earlier work, such as Heston and Rouwenhorst (1994) and Griffin and Karolyi (1998), assumes that country and industry shocks affect all stocks within a given country or industry in the same way. In contrast, our model estimates separate exposures to the global, country- and industry-specific shocks for each stock in our sample. We use these firm-level exposures, called betas below, to investigate the link between stock market comovement and the degree to which firms are international. Is it the case, for example, that global shocks account for more return variation for stocks where the underlying company is highly international? Do country-specific shocks account for less return variation for such stocks? And if there is such a link, is it economically important?

How to interpret the betas? The betas measure comovement across returns at the global level, within countries, and within industries. Stock returns in turn reflects two elements: (i) innovations in future dividends and (ii) innovations in the interest rate at which dividends are discounted. Innovations to dividends will depend on the extent to which firms operate across countries: global shocks are likely to be more important for firms that operate globally, while shocks to the domestic economy may be more important for firms with primarily domestic operations. Innovations to the discount rate will depend on the extent to which financial markets are integrated: if a country is financially integrated with the rest of the world, global shocks are likely to be more important, while domestic shocks will be more important if a country is segmented. Since our betas are a summary measure of comovement, they will capture comovement associated with innovations to dividends and innovations to the discount rate. This paper focuses on the former: *ceteris paribus*, stocks of more international companies should comove more across countries, while those of less international firms should comove less. As a robustness check, we control in our analysis for the market where a company is listed. We do this to control for the degree to which a country is segmented from the rest of the world, in an effort to control for the balance of innovations to the discount rate.

How do we identify global, country- and industry-specific shocks? By assumption, global shocks impact all stocks in our sample. They therefore capture variation that is common to all stocks, such as variation associated with a global oil price shock. A country-specific shock is assumed to impact only stocks within a given country. To identify these shocks, we need a measure of the country affiliation for each stock. One approach could be to construct a measure of which country a firm generates most of its revenue in. Another approach is to use the location for a company's primary listing to identify country affiliation. We use the latter approach, because this data is readily available. However, this approach has the disadvantage that country shocks may capture primarily risk associated with the primary listing location, not risk associated with where a company does business. There is unfortunately no easy way to disentangle these risk factors, a deficiency of our approach that we hope to address in future work. Finally, an industry-specific shock is assumed to affect only firms within a given industry. We use widely-used data sources to identify industry affiliation for the firms in our sample.

Before we turn to our results, a more basic question arises: how to measure the degree to which firms operate internationally? The existing literature in this area, consisting of Cavaglia et al. (2001), Diermeier and Solnik (2001) and Lombard et al. (1999), relies primarily on the percentage of sales from firms' operations in foreign countries as a measure.[1] We broaden our focus to include the percentage of assets associated with companies' foreign operations and the fraction of operating income generated by their operations abroad. These measures have an important shortcoming: they fail to capture the importance of exports as a channel through which firms operate across countries. To address this deficiency, we estimate our factor model for the annual growth rates of total sales for the firms in our sample. The resulting factor exposures, called "sales betas" below, capture the degree of international exposure both through exports and through sales from operations abroad. They also capture foreign exposure of firms that are purely domestic in terms of sales, but are nonetheless exposed to global shocks through foreign competition. Our sales betas thus address a key measurement problem in the existing literature.

Our results suggest that global shocks are a more important source of return variation for stocks whose underlying company operates globally, according to our various measures of firm-level globalization. This link is economically and statistically significant. For example, a company that raises the international component of its sales by 10 percent raises the exposure of its stock return to the global shock by 2 percent. A similar economically and statistically significant relationship exists for our other measures of firm-level globalization, notably our sales betas. Finally, consistent with the recent wave of cross-border M&A, we find that the economic and statistical importance of the link between return comovement and the extent

[1] Diermeier and Solnik (2001) use foreign revenues as their measure of international operations of companies. They note that this measure includes foreign and export sales, when such data are available.

to which firms operate globally has grown dramatically in recent years. We also find evidence of a negative link between the importance of country-specific return variation and the extent to which firms operate globally: a firm raising its international sales by 10 percentage points reduces the exposure of its stock return to country-specific shocks by 1.5 percent. However, this link is driven by data from a single country – Japan – and, unlike our evidence for global shocks, is therefore not robust across countries. The disparity between our findings for global and country-specific shocks could reflect the difficulties in measuring a company's true country affiliation. As we discuss above, we identify country affiliation using the primary listing location, not the location where a firm generates most of its revenue. As a result, our country betas may not accurately reflect sources of domestic, as opposed to foreign, volatility. We leave this issue for future research.

The paper is organized as follows. Section 2 discusses our empirical approach, while Section 3 reviews our data. Section 4 presents the results. Finally, Section 5 concludes.

2. The model

This section briefly outlines the factor model used to extract firms' betas with respect to the global, country- and industry-specific shocks. Let us denote by R_{nt} the excess return on stock n in period t over the riskless rate, where n goes from 1 to N and t goes from 1 to T. We index countries with the letter c ($c = 1, \ldots, C$) and industries with the letter i ($i = 1, \ldots, I$). The model is described by the following equation:

$$R_{nt} = \mu_n + \beta_n^G f_t^g + \sum_{c+1}^{C} \beta_{nc}^C f_t^c + \sum_{i=1}^{I} \beta_{ni}^I f_t^i + \varepsilon_{nt} \tag{1}$$

where f_t^g, f_t^c and f_t^i denote the global factor, the country-specific factor c and the industry-specific factor i, respectively, and ε_{nt} represents the idiosyncratic shock to the return on stock n, all in period t. The factors are unobservables, as in the latent factor models employed widely in the Aribitrage Pricing Theory literature. However, unlike that literature, our focus is on modeling covariation in stock returns, rather than excess returns. We therefore model excess returns in the simplest possible way: μ_n is simply the average excess return on stock n over the sample. This means that we demean excess returns before estimating our model.

Our main innovation is in how we model comovement. Unlike the Asset Pricing Theory literature, we decompose returns into factors that are identified. The identification arises from the fact that we impose the following set of zero restrictions on the betas:

$$\beta_n^G = \text{unconstrained},$$

$$\beta_{nc}^C = \begin{cases} \text{unconstrained} & \text{if stock } n \text{ is listed in country } c, \\ 0 & \text{otherwise,} \end{cases} \tag{2}$$

$$\beta_{ni}^I = \begin{cases} \text{unconstrained} & \text{if stock } n \text{ belongs to industry } i, \\ 0 & \text{otherwise.} \end{cases}$$

For example, if stock n is a U.S. chemical company, we restrict the loadings of stock n on any country factor other than that for the U.S. and on any industry factor other than that for the chemical industry to be zero. In the absence of these zero restrictions, the factors could be rotated arbitrarily and thus not be identified separately. In our model, the zero restrictions pin down the rotation matrix and give an economic interpretation to the factors, allowing us to characterize them as global, country- and industry-specific factors.[2] Formally, model (1) can be rewritten in stacked form as:

$$\mathbf{R}_t = \boldsymbol{\mu} + \mathbf{B}\mathbf{f}_t + \boldsymbol{\varepsilon} \tag{3}$$

where $\boldsymbol{\mu}$ denotes the $N \times 1$ vector of mean returns, $\mathbf{f}_t$ is the $K \times 1$ vector of factors (K is the total number of factors), $\mathbf{B}$ is $N \times K$ matrix of βs, and $\boldsymbol{\varepsilon}_t$ is the $N \times 1$ vector of idiosyncratic shocks. Without restrictions (2), model (1) is not identified: if we replace $\mathbf{B}$ with $\mathbf{B\Omega}$ and $\mathbf{f}_t$ with $\Omega'\mathbf{f}_t$, where $\mathbf{\Omega}$ is an orthonormal matrix, the likelihood is unchanged. However, in our model the zero restrictions (2) are enough to pin down the rotation matrix $\mathbf{\Omega}$: only if $\mathbf{\Omega}$ is equal to the identity matrix, will $\mathbf{B\Omega}$ have the same zero restrictions as $\mathbf{B}$. With $\mathbf{\Omega}$ pinned down, the factors are identified.

Our approach bridges two extremes in the factor model literature. One extreme, see Cho et al. (1986) and Heston et al. (1995), uses latent factor models to decompose returns into common shocks. This approach has the advantage that it captures a substantial amount of covariation, but since the factors are unidentified, it yields little information on their economic interpretation. The other extreme, see Chen et al. (1986), relates stock returns to pre-specified variables. This approach has the advantage that the factors are identified, but their choice is somewhat arbitrary. Our approach is grounded in the latent factor approach, but imposes restrictions on the variance-covariance matrix such that the latent factors are identified as global, country, industry and other factors.

We use the EM algorithm to obtain maximum likelihood estimates of the betas in model (1), as in Lehman and Modest (1985). This approach, which is described

[2] In contrast, Diermeier and Solnik (2001) note that their domestic factor is correlated with international factors, making their results hard to interpret. Cavaglia et al. (2001) use an empirical model very similar to ours, but their betas are estimated using the iterative approach of Marsh and Pfleiderer (1997), while we use maximum likelihood estimation. The latter estimates are consistent and asymptotically efficient while, to our knowledge, there is no evidence that their estimator enjoys such properties.

extensively in Brooks and Del Negro (2004b), lets us estimate model (1) via maximum likelihood even when the size of the cross sections N is large, as it is here. We make the following distributional assumptions: the factors and idiosyncratic shocks are normally distributed independent and identically distributed (*i.i.d.*) random variables and are uncorrelated with each other for all t:

$$\mathbf{f}_t \xrightarrow{d} N(\mathbf{0}, \mathbf{I}), \tag{4a}$$

$$\boldsymbol{\varepsilon}_t \xrightarrow{d} N(\mathbf{0}, \boldsymbol{\Sigma}), \tag{4b}$$

$$E[\mathbf{f}_t \boldsymbol{\varepsilon}_t'] = \mathbf{0} \tag{4c}$$

where I is a $K \times K$ identity matrix and $\boldsymbol{\Sigma}$ is a diagonal $N \times N$ matrix. The assumption is that $\boldsymbol{\Sigma}$ is diagonal implies that the idiosyncratic shocks are cross-sectionally uncorrelated:

$$E[\varepsilon_{nt}\varepsilon_{mt}] = 0 \tag{4d}$$

for all $t, n \neq m$. The assumption that the factors have unit variance is purely a normalization assumption. However, the assumptions that the factors are uncorrelated is not without loss of generality, given that the rotation matrix $\boldsymbol{\Omega}$ has already been pinned down by the zero restrictions in (2). From a Bayesian perspective, assumption (4a) can be seen as a prior on $\mathbf{f}_t$. Upon convergence, the EM algorithm delivers a (conditional) posterior distribution for the factors, which is normal with first and second moments equal to $E[\mathbf{f}_t \mid \mathbf{B}, \boldsymbol{\Omega}, \mathbf{R}_t]$ and $E[\mathbf{f}_t\mathbf{f}_t' \mid \mathbf{B}, \boldsymbol{\Omega}, \mathbf{R}_t]$, respectively. From the average of the posterior second moments matrix of the factors, computed as $\sum_{t=1}^{T} E[\mathbf{f}_t\mathbf{f}_t' \mid \mathbf{B}, \boldsymbol{\Omega}, \mathbf{R}_t]/T$, one can assess whether the orthogonality assumption is borne out by the data or not. In the remainder of the paper we use of the following *ex ante* variance decomposition of returns for individual stocks:

$$\mathrm{Var}(R_{nt}) = (\beta_n^G)^2 + (\beta_{nc}^C)^2 + (\beta_{ni}^I)^2 + \sigma_n^2. \tag{5}$$

Equation (5) follows from model (1) and assumption (4a). This decomposition holds ex post only if global, country, and industry factors are indeed uncorrelated with each other. In section (4) we provide evidence that this is the case: global, country, and industry factors are (nearly) orthogonal not only *ex ante*, but also *ex post*.

Model (1) is a fairly simplified description of the sources of return comovement, in that it omits other factors, such as an emerging versus mature markets factors, regional factors for Europe, the Americas, and Asia, and style factors such as size and book-to-market. With the exception of regional factors, Brooks and Del Negro (2004b) document that these added factors do not add substantially to the ability of the model to capture international return comovement. This is of course not to say that our list of factors is exhaustive. Rather, it suggests that our focus on global, country- and industry-specific factors provides a good first pass at the data.

What are the theoretical underpinnings of the link between our stock market betas and the degree to which firms operate internationally? Campbell and Mei (1993) show that, up to a linear approximation, innovations in excess return for stock n can be decomposed as the sum of news about future dividend growth and future discount rates. Formally:

$$R_{nt} - E_{t-1}[R_{nt}] = (E_t - E_{t-1}) \left\{ \sum_{j=0}^{\infty} \rho^j \Delta d_{n,t+j} - \sum_{j=0}^{\infty} \rho^j r_{t+j} - \sum_{j=1}^{\infty} \rho^j R_{n,t+j} \right\}, \tag{6}$$

where $\Delta d_{n,t}$ and r_t are dividend growth for stock n and the riskless rate in period t, respectively. In our setting, all variables are measured in US dollars. In this paper, we first postulate a factor model (model (1)) for the left hand side of (6), assuming that $E_{t-1}[R_{nt}]$ is constant and equal to μ_n. Second, we use different proxies to measure the extent to which news in dividend growth rates are subject to global and country-specific shocks. Third, we relate the estimates of our betas from model (1) to these proxies. The underlying assumption is that the dividend growth rates of more international firms are more influenced by global shocks, and less subject to country shocks, than dividend growth rates of domestic firms. From (6) it follows that the exposure of the "real" side of the firm (dividend news) translates into an exposure on the financial side (innovations in excess returns). That is, we expect that firms that are more international on the real side to have, *ceteris paribus*, a higher stock market exposure to global shocks and a lower exposure to country-specific shocks. Note that dividend news relates to where firms operate, rather than where their stocks are listed. However, there are other determinants of stock market comovement besides news in dividends. Most important among these is the pricing kernel at which future dividends are discounted, captured by the remaining terms in Equation (6).[3] In terms of shocks to the pricing kernel, it matters where the stock is listed. Firms that are listed in a stock market where the marginal investor is international may be more exposed to global shocks than firms listed in a market where the marginal investor is domestic. Therefore, as a robustness check, we also control in our regressions for the market where the stock is listed.

3. The Data

We use data constructed by Brooks and Del Negro (2004a). Their data cover monthly U.S. dollar-denominated stock returns from January 1985 to February

[3] Taken literally, the assumption that $E_{t-1}[R_{nt}]$ is constant and equal to μ_n implies that $(E_t - E_{t-1})R_{n,t+j} = 0$ for all $j > 0$. This assumption was only made for computational tractability in the estimation of the factor model and should not be imposed directly on Equation (6). Hence, we need to consider innovations in the discount rate.

2002 for 9,679 companies.[4] We download the country and industry affiliation for each stock from Datastream International. With regard to industry affiliation, Datastream has six levels of disaggregation. At each level, there are more disaggregated industry definitions, up to the most disaggregated classification, level 6. We report results based on level 4. The results are qualitatively unchanged using higher levels of disaggregation.

Our sample is a subset of that in Brooks and Del Negro (2004a) because we use data only for those firms for which monthly stock returns from Datastream and annual total sales data in U.S. dollars from Worldscope are available continuously. The cross-section of firms for which this is the case amounts to 1,239 companies in 20 developed and emerging markets. This sample is balanced over time – there are thus no changes in composition driving our results. Table AI in Appendix A describes the country and industry composition of our sample and compares it to the original sample in Brooks and Del Negro (2004a). Appendix A is available on the web at http://gerda.univie.ac.at/rof/papers/supplements/BrooksDelNegrowebappendix.pdf. It gives a similar breakdown from the Standard & Poor's Stock Market Factbook (2001). This comparison demonstrates that coverage *across* countries and industries is reasonably representative, although balancing shrinks coverage *within* countries and industries.

We follow common practice in the literature, see Ferson and Harvey (1994) and Heston et al. (1995), and estimate our model for excess returns. We compute these as the difference between individual stock returns and the return on a three month U.S. Treasury Bill, which we obtain from Datastream International. Although our balanced sample covers fewer stocks than the original data by Brooks and Del Negro (2004a), Table AII in Appendix A shows that our sample is comparable in terms of the means and standard deviations of the equal-weighted excess return across all stocks. In particular, there is little indication of a systematic bias in the standard deviation of excess returns, which is important because we focus on return variability and comovement.

Following Griffin and Karolyi (1998) and Griffin and Stulz (2001), we also distinguish between traded and non-traded goods industries. In this dimension, our dataset has 611 traded and 628 non-traded goods firms. Our data coverage compares favorably to that in other papers that use firm-level international stock returns. For example, Heston and Rouwenhorst (1994) examine data on 829 stocks in 12 European countries. Griffin and Karolyi (1998) collect data on 2,400 firms in 25 developed and emerging markets.

Finally, we collect annual Worldscope data from 1985 to 2001 for each firm on the share of total sales generated abroad, the fraction of total assets held overseas

[4] Using U.S. dollar-denominated returns has the effect of lumping nominal currency influences into country-specific shocks in international stock returns. However, Griffin and Stulz (2001) and Heston and Rouwenhorst (1994) find that exchange rates play only a minor role in explaining international return variation.

and the fraction of total income generated abroad. Panel A in Table I describes these data. It shows the means across firms for the international sales ratio, the international asset ratio, and the international income ratio. For individual firms, we construct the international sales ratio as the mean over time of that company's annual international sales ratios. We proceed in a similar fashion for the international asset and income ratios. Table I shows that data for the international sales ratio is available for 1,170 firms, while it is available for 1,071 and 1,059 firms, respectively, for the international asset and income ratios. The importance of international sales in total sales is 22.35 percent on average for our sample. This ratio is higher for traded goods firms (28.40 percent), while it is lower for firms in non-traded goods industries (16.00 percent). A similar pattern, whereby firms in traded goods industries are more international than firms in non-traded goods industries, can also be seen in the international asset and income data. Table III in Appendix A gives the exact variable definitions for the Worldscope data we use.

Does balancing the Brooks and Del Negro (2004a) data systematically bias our sample towards more international firms? Panel B in Table I investigates this issue. It is analogous to Panel A, but is based on the original dataset constructed by Brooks and Del Negro (2004a). It shows that in this larger sample international sales data are available for 6,941 firms, while international asset and income data are available for 5,649 and 5,494 firms, respectively. For this sample, the international sales ratio averages 20.76 percent across all firms, while it measures 28.55 percent and 14.61 percent, respectively, for traded and non-traded goods firms. These numbers are very similar to our smaller sub-sample and suggest that balancing the data does not systematically bias our sample towards more global firms. The same conclusion carries over for international asset and income ratios, although here the differences are somewhat larger. As a result, our results below may carry over to much broader samples with larger cross-sections of companies.

4. The Results

This section reports the estimation results for model (1) with one global factor, 20 country factors (one for each country) and 34 industry factors (one for each industry). It has two sub-sections. Section 4.1 quantifies the empirical link between international stock market comovement and the degree to which firms operate internationally. We call this the "cross-sectional link". Section 4.2 then asks whether this cross-sectional link has changed over time, using a more general specification in which we allow the relative importance of the different factors (global, country and industry) to change over time.

4.1. THE CROSS-SECTIONAL LINK

This section explores the link between international stock market comovement and the degree to which firms operate across countries. Do stocks of more international

Table I. Does balancing the data bias the sample towards more international firms? Average international sales, asset and income ratios in the balanced sample and the original data

Panel A in Table I shows the mean international sales, asset and income ratios for the data used in this paper, along with the number of firms for which these variables are available in each case. The data are a balanced sub-sample of a dataset constructed by Brooks and Del Negro (2004a). Panel B is analogous to Panel A, but is based on the full dataset constructed by Brooks and Del Negro (2004a).

Panel A. Balanced panel of 1,239 firms						
	International sales		International assets		International income	
	Average	No. of firms	Average	No. of firms	Average	No. of firms
All firms	22.35	1170	15.05	1071	18.10	1059
Traded goods industries	28.49	595	19.30	535	22.75	523
Non-traded goods industries	16.00	575	10.81	536	13.57	536
Panel B. Original data from Brooks and Del Negro (2004a)						
	International sales		International assets		International income	
	Average	No. of firms	Average	No. of firms	Average	No. of firms
All firms	20.76	6941	9.38	5649	11.66	5494
Traded goods industries	28.55	3059	13.96	2346	16.62	2245
Non-traded goods industries	14.61	3882	7.16	3303	8.23	3249

firms comove more across countries? Do stocks of firms with primarily domestic operations comove less in this dimension?

First, we need to discuss how we measure the extent to which firms are international. The first measure we consider is whether a firm belongs to a traded or non-traded goods industry, in recognition of the fact that some industries are more global than others. This notion is tested explicitly in Griffin and Karolyi (1998) who find that global industry effects are more important relative to country effects for traded than for non-traded goods industries. But there are limitations to this industry-level analysis. First, though firms may nominally belong to a traded goods industry, their true exposure to stock market shocks may be different. Second, there may be heterogeneity across sectors in the exposure to global shocks – some traded goods industries may be more global than others. Third, there may be substantial heterogeneity within countries and industries in the exposure of firms to shocks.

Following Cavaglia et al. (2001), Lombard, Roulet, and Solnik (1999) and Diermeier and Solnik (2001), we consider a second measure, namely balance sheet data on the global exposure of firms through the international component of their sales, income, or assets. One advantage of this approach is that it exploits firm-level information and hence takes firm-level heterogeneity into account. However, an important disadvantage is that these variables only capture operations of foreign subsidiaries. They do not account for exports. We provide an additional approach to measuring the extent to which firms are international. We estimate the factor model described in Section 2 for the annual U.S. dollar-denominated growth rates of total sales for our panel of firms. This gives us the exposure to global, country- and industry-specific shocks in annual sales growth for each firm in our data. We expect to find that the global shock is more important, and the country-specific shock less important, for more internationalfirms. The advantage of these sales betas is that they may also capture international exposure via export sales, an additional channel through which firms are exposed to global shocks.

Our task now is to determine whether there is a relationship between firms' stock market betas and the degree to which firms are international, as measured by these three approaches. First, we look for a qualitative link between the stock market and sales growth betas and the variables that measure the international component in sales, assets and income. Table II sorts the sample according to our accounting measures and compares the average variance decomposition for the top quartile of our sample (the most international) with that for the bottom quartile (the least international). The variance decompositions are computed using Equation (5). As discussed in Section 2, this decomposition holds ex post only if global, country, and industry factors are indeed uncorrelated with each other. Table III shows that the ex post median correlation between country and global, country and industry, and global and industry shocks is negligible, always less than 2 percent. Correlation among country factors is much larger, above 30 percent. Brooks and Del Negro (forthcoming) show that this is because of regional factors that are embedded within the country factors. However, the fact that country shocks are correlated with each other does not affect the interpretation of the results in Table II, as long as they are not correlated with global or industry shocks. The numbers in parentheses in Table II give the standard errors associated with these variance decompositions. These standard errors are obtained from Monte Carlo simulations with the betas drawn from their asymptotic distributions.[5]

Table II shows that, both for stock returns (Panel A) and sales growth (Panel B), the global factor is significantly more important and the country factor significantly less important for firms in the top quartile based on international sales, asset and income ratios. Comovement in both real and financial variables is thus greater for firms that operate globally than for firms that do not. Next we group firms by whether they belong to traded or non-traded goods industries. Here, the qualitative link goes the right way for stock returns (Panel A), but not for sales growth (Panel B) where the global factor is less important for traded than for non-traded goods firms. Finally, we rank firms by their global and country sales betas. Our variance decompositions for stock returns (Panel A) point to some inaccuracy in the measurement of the global sales betas: the global factor is on average more important for the bottom quartile (low global sales betas) than for the top quartile (high global sales betas). Similarly, country-specific shocks are more important on average for the top quartile than for the bottom quartile. However, measurement of the country sales betas is more accurate: firms with high country sales betas have a lower exposure to the global stock market factor and a higher exposure to country-specific stock market shocks. The variance decompositions for sales growth with respect to the global and country sales betas (Panel B) are as expected.

Table II thus establishes a qualitative link between firm-level integration and international stock market comovement. But how important is this link quantitatively? In order to investigate this issue, we regress the stock market betas (in percent) on an array of measures of real side exposure: the international sales, asset and income ratios, the respective sales betas and a dummy variable equal to one if a firm belongs to a traded goods sector and zero otherwise.[6] We focus only on the global and country stock market betas on the grounds that: (i) from Table II there is no apparent link between industry betas and firm-level measures of globalization, (ii) it is not clear that any such link should a priori exist.

All of these regressors, for the reasons discussed before, likely contain measurement error, which leads to a downward bias in the coefficients. In order to address this problem, we adopt an approach similar to Fama and MacBeth (1973). We: (i) sort firms according to the dependent variable, (ii) construct N portfolios containing n/N firms (where n is the total number of firms in the sample), (iii) use as data

[5] We use 10,000 draws. The analytical derivation of the information matrix, whose inverse is the variance covariance matrix of the asymptotic distribution of the estimates, is included in an appendix available upon request.

[6] For each firm we use the full sample average over time for the international sales, asset and income ratios, whenever these variables are available.

Table II. Variance decompositions for international stock returns and sales growth (in %) by different measures of firm-level diversification. Standard errors in parentheses

This table shows the qualitative link between stock return and sales betas and the degree to which firms operate globally. The variance for stock returns (Panel A) and sales growth rates (Panel B) for each firm in our sample can be decomposed into the contributions from global, country- and industry-specific factors according to $\mathrm{Var}(R_{nt}) = (\beta_n^G)^2 + (\beta_{nc}^C)2 + (\beta_{ni}^I)^2 + \sigma_n^2$. The table shows simple averages across firms for these variance decompositions. The top and bottom quartiles represent the most and least international firms in our sample, sorting according to the international sales, international asset and international income ratios, the traded goods industry dummy and the respective sales betas. Standard errors are from Monte Carlo simulations for asymptotic distributions of the betas.

Panel A. Stock Market Betas				Panel B. Sales Betas			
All firms				All Firms			
	Global	Country	Industry		Global	Country	Industry
All Firms	6.9	32.2	7.0	All Firms	10.4	16.6	13.5
	(1.0)	(1.9)	(0.2)		(3.9)	(2.7)	(1.3)
Sorted by International Sales Ratios				Sorted by International Sales Ratios			
	Global	Country	Industry		Global	Country	Industry
Top Quartile	11.3	25.6	6.7	Top Quartile	13.2	14.6	16.1
	(1.4)	(1.0)	(0.3)		(5.2)	(2.2)	(2.4)
Bottom Quartile	3.9	34.3	7.1	Bottom Quartile	11.2	17.1	14.4
	(0.7)	(2.5)	(0.3)		(4.3)	(3.7)	(1.6)
Difference	7.4	8.7	0.4	Difference	2.0	2.5	1.6
	(1.0)	(2.0)	(0.4)		(2.6)	(3.3)	(2.6)
Sorted by International Asset Ratios				Sorted by International Asset Ratios			
	Global	Country	Industry		Global	Country	Industry
Top Quartile	10.0	26.3	8.4	Top Quartile	13.2	14.7	15.2
	(1.3)	(1.2)	(0.4)		(5.3)	(2.4)	(2.3)
Bottom Quartile	4.1	35.8	6.5	Bottom Quartile	10.0	17.5	12.8
	(0.7)	(2.5)	(0.2)		(3.9)	(3.5)	(1.5)
Difference	6.0	9.6	1.8	Difference	3.3	2.8	2.4
	(0.8)	(1.8)	(0.4)		(2.8)	(3.0)	(2.4)
Sorted by International Income Ratios				Sorted by International Income Ratios			
	Global	Country	Industry		Global	Country	Industry
Top Quartile	11.0	25.6	7.3	Top Quartile	15.1	16.0	11.1
	(1.5)	(1.3)	(0.4)		(6.0)	(2.6)	(1.6)
Bottom Quartile	4.1	34.9	6.9	Bottom Quartile	10.2	17.8	13.3
	(0.7)	(2.4)	(0.2)		(4.0)	(3.6)	(1.5)
Difference	6.9	9.3	0.5	Difference	4.9	1.9	2.3
	(1.0)	(1.6)	(0.4)		(3.3)	(2.9)	(1.8)
Sorted by Traded/NonTraded Industry				Sorted by Traded/NonTraded Industry			
	Global	Country	Industry		Global	Country	Industry
Top Quartile	8.5	30.4	7.7	Top Quartile	8.8	16.5	16.5
	(1.3)	(2.1)	(0.3)		(3.5)	(3.3)	(2.4)
Bottom Quartile	5.1	34.4	6.2	Bottom Quartile	11.9	16.6	10.9
	(0.7)	(1.7)	(0.2)		(4.5)	(2.6)	(1.3)
Difference	3.4	4.0	1.6	Difference	3.1	0.1	5.6
	(0.8)	(0.9)	(0.4)		(2.2)	(2.2)	(2.7)

Table II. Variance decompositions for international stock returns and sales growth (in %) by different measures of firm-level diversification. Standard errors in parentheses (continued)

Panel A. Stock Market Betas				Panel B. Sales Betas			
Sorted by Global Sales Betas				Sorted by Global Sales Betas			
	Global	Country	Industry		Global	Country	Industry
Top Quartile	7.3	33.6	4.9	Top Quartile	20.2	14.5	10.4
	(1.0)	(1.6)	(0.2)		(7.6)	(2.4)	(1.3)
Bottom Quartile	7.7	25.6	9.6	Bottom Quartile	6.7	16.2	17.3
	(1.1)	(1.7)	(0.4)		(3.2)	(3.3)	(2.1)
Difference	0.4	8.0	4.7	Difference	13.5	1.8	6.9
	(0.6)	(0.9)	(0.4)		(5.9)	(3.1)	(2.1)
Sorted by Country Sales Betas				Sorted by Country Sales Betas			
	Global	Country	Industry		Global	Country	Industry
Top Quartile	6.8	33.6	6.0	Top Quartile	9.9	30.6	9.2
	(0.9)	(2.1)	(0.3)		(4.1)	(4.7)	(1.2)
Bottom Quartile	7.8	25.0	7.8	Bottom Quartile	11.7	5.6	20.9
	(1.1)	(1.3)	(0.3)		(4.6)	(1.8)	(3.2)
Difference	1.0	8.5	1.8	Difference	1.7	25.0	11.7
	(0.7)	(1.8)	(0.4)		(2.7)	(4.4)	(3.3)

Table III. Median factor correlations

This table shows the median *ex post* factor correlation over time for each class of factors (global, country and industry). The diagonal elements show the median covariance across factors within the same class, while off-diagonal elements show the median correlation across classes. These correlations are calculated fixing the mean of the factors at zero.

	Global	Country	Industry
Global	1.000	0.000	0.000
Country	0.000	0.331	0.016
Industry	0.000	0.016	0.028

the N within-portfolio averages for the dependent and explanatory variables.[7] If measurement error in the regressors is not too correlated within each portfolio, this averaging should reduce the bias due to the law of large numbers.[8]

[7] A difference with Fama and MacBeth (1973) is that they sort firms according to their *independent* variable. Thus, the betas in their sorted portfolio are still measured with error. Hence, they sort firms by the betas estimated in a previous sub-period – assuming that the measurement error in the two sub-periods is independent. In contrast, we sort firms according to the dependent variable and hence do not encounter the same problem: our dependent variable is still likely to be measured with error, but this does not bias our estimates.

[8] Of course, the sorting is done according to the dependent variable *only*. We use $N = 20$ portfolios for the bivariate regressions. There is a trade-off between bias and degrees of freedom

Table IV presents the regression results and contains four panels. Panel A reports results for bivariate portfolio-level regressions of the global and country-specific stock market betas (in percent) on each of the regressors (and a constant). The t-ratios are computed using robust standard errors (White, 1980) and reported in parentheses. In both panels, the coefficients largely have the expected sign: an increase in the extent to which firms operate globally raises their exposure to global stock market shocks and reduces their exposure to country-specific shocks. An increase in the real-side exposure of firms to global and country shocks-as measured by our sales betas-is associated with an increase in stock market exposure to global and country shocks. Panel A shows that the estimated link between stock market comovement and the degree to which firms operate across countries is highly significant and economically large: a 10 percent increase in the international sales ratio increases firms' exposure to global stock market shocks by 2 percent and reduces their exposure to country-specific shocks by 1.5 percent. If for individual stocks a change in the exposure of 2 percent may not seem large (the average stock in the sample has a standard deviation of about 10 percent), for portfolios these numbers are considerable: the equally-weighted world market portfolio has an in-sample standard deviation of 4.6 percent. Our results are therefore important for portfolio managers. The respective sales betas (also measured in percent) have a 3/4 to one percent impact on the stock market betas. Again, the impact of real-side exposure on stock market exposure is therefore estimated to be large.

Panel B reports regression results for firm-level cross-sectional regressions, without the within-portfolio averaging. It is reassuring to observe that none of the coefficients changes sign under this alternative procedure. In addition, most of the coefficients that are significant at the five percent level using the portfolio-level regressions are also significant at the five percent level at the firm level. As expected, the difference between the two procedures lies in the size of the coefficient. Within-portfolio averaging generally increases the coefficients by one order of magnitude, suggesting that bias in the firm-level regressions is considerable.

As we note above, comovement across stocks may arise from innovations to dividends, which will reflect the degree to which firms operate across countries, and innovations to the interest rate at which these dividends are discounted, which may depend on where a stock is listed. We now check whether our results are robust controlling for where a stock is listed. We demean within each country both the dependent and the independent variables. This eliminates systematic cross-country differences in stock market exposures, which could be due to the fact that the marginal investor – and hence the pricing kernel – may be different across countries. Such differences could reflect differences across countries

in the regressions. The higher is N, the higher the degrees of freedom, but the higher also the bias because averaging occurs among n/N firms. Increasing N to 30 reduces the coefficients somewhat, but not sizably. The number of portfolios is 40 for the regressions with more than 2 variables (shown in the appendix), given that more degrees of freedom are needed when there are more regressors. The multivariate regression results are virtually unchanged for $N = 30$.

Table IV. Cross-sectional regressions of the stock market betas on firm-level measures of international diversification: Full sample (January 1985–February 2002)

Panel A shows bivariate portfolio-level regression results of stock market betas on firm-level measures of international diversification (and a constant). It also shows multivariate regression results. Panel B shows the same estimates for firm-level data. Panels C and D show analogous regression results where the underlying data have been demeaned by country, to control for differences across countries in the interest rate at which future earnings are discounted. All variables are measured in percent. t-ratios are computed using robust standard errors as in White (1980) and shown in parentheses.

Panel A: Portfolio-Level Regressions							
	Global Stock Market Betas						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
International Sales	0.191					0.126	0.217
	(8.886)					(4.982)	(1.851)
International Assets		0.297					−0.110
		(9.343)					(−0.663)
International Income			0.217				0.038
			(14.426)				(0.474)
Traded/Non-Traded				9.352		3.368	
				(5.468)		(2.876)	
Respective Sales Beta					0.768	0.056	
					(6.620)	(0.523)	
Adjusted R^2	0.859	0.864	0.897	0.609	0.507	0.826	0.783
	Country Stock Market Betas						
	(8)	(9)	(10)	(11)	(12)	(13)	(14)
International Sales	−0.151					−0.091	−0.068
	(−2.549)					(−3.618)	(−0.749)
International Assets		−0.274					−0.334
		(−2.821)					(−1.933)
International Income			−0.138				0.170
			(−1.438)			(2.018)	
Traded/Non-Traded				13.750		2.952	
				(2.471)		(1.921)	
Respective Sales Beta					0.722	0.529	
					(11.548)	(7.939)	
Adjusted R^2	0.263	0.301	0.167	0.234	0.803	0.777	0.320

Table IV. Cross-sectional regressions of the stock market betas on firm-level measures of international diversification: Full sample (January 1985–February 2002) (continued)

Panel B: Firm-Level Regressions

	Global Stock Market Betas						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
International Sales	0.027					0.021	0.029
	(11.916)					(9.383)	(4.399)
International Assets		0.033					−0.011
		(9.329)					(−1.568)
International Income			0.029				0.011
			(10.594)				(2.174)
Traded/Non-Traded				0.968		0.739	
				(8.989)		(7.192)	
Respective Sales Beta					0.040	0.036	
					(4.080)	(4.008)	
Adjusted R^2	0.113	0.082	0.104	0.018	0.062	0.155	0.129
	Country Stock Market Betas						
	(8)	(9)	(10)	(11)	(12)	(13)	(14)
International Sales	−0.012					−0.016	−0.008
	(−5.301)					(−7.039)	(−1.201)
International Assets		−0.016					−0.013
		(−4.679)					(−1.699)
International Income			−0.010				0.005
			(−3.937)				(0.779)
Traded/Non-Traded				0.158		0.342	
				(1.311)		(2.808)	
Respective Sales Beta					0.097	0.098	
					(9.341)	(8.787)	
Adjusted R^2	0.019	0.018	0.012	0.098	0.002	0.130	0.023

in legal or institutional frameworks, differences in market liquidity and openness, and other factors. By demeaning the stock market betas by country we remove these cross-country differences and exploit only within-country information. The results based on the demeaned regressions (Panel C for portfolio- and Panel D for firm-level regressions) suggest that our results are robust. The sign of almost all coefficients is unchanged, most of the coefficients are still significant, and their magnitude is if anything larger in the demeaned regressions. The only exception is the regression of the country stock market betas on the accounting variables:

Table IV. Cross-sectional regressions of the stock market betas on firm-level measures of international diversification: Full sample (January 1985–February 2002) (continued)

Panel C: Portfolio-Level Regressions Demeaned							
	Global Stock Market Betas						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
International Sales	0.217					0.139	0.242
	(13.684)					(6.599)	(2.106)
International Assets		0.310					−0.087
		(9.304)					(−0.597)
International Income			0.227				0.002
			(12.466)				(0.041)
Traded/Non-Traded				8.527		2.848	
				(6.526)		(2.355)	
Respective Sales Beta					0.877	0.090	
					(5.188)	(0.815)	
Adjusted R^2	0.895	0.873	0.870	0.719	0.377	0.846	0.763
	Country Stock Market Betas						
	(8)	(9)	(10)	(11)	(12)	(13)	(14)
International Sales	−0.106					−0.077	−0.154
	(−1.101)					(−1.579)	(−1.189)
International Assets		−0.098					−0.008
		(−0.694)					(−0.071)
International Income			−0.029				0.120
			−0.290)				(1.151)
Traded/Non-Traded				−6.423		−0.979	
				(−1.442)		(−0.458)	
Respective Sales Beta					1.095	0.599	
					(4.966)	(4.082)	
Adjusted R^2	0.137	0.085	0.056	0.161	0.442	0.352	0.165

the coefficients have the expected negative signs, but are smaller and no longer significant in the portfolio regressions (the coefficients are still significant in the firm-level regressions).

How important is variation in our stock market betas across versus within countries? We investigate this question by regressing our firm-level global and country-specific stock market betas on 20 country dummies (we drop the constant) in addition to each of our explanatory variables. Table V reports the estimated coefficient on international sales, the associated t-ratio using robust standard errors

Table IV. Cross-sectional regressions of the stock market betas on firm-level measures of international diversification: Full sample (January 1985–February 2002) (continued)

Panel D: Firm-Level Regressions Demeaned

	Global Stock Market Betas						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
International Sales	0.033					0.025	0.032
	(11.710)					(9.134)	(4.678)
International Assets		0.036					−0.011
		(9.550)					(−1.446)
International Income			0.030				0.010
			(10.192)				(1.884)
Traded/Non-Traded				1.153		0.825	
				(11.158)		(8.197)	
Respective Sales Beta					0.028	0.034	
					(2.657)	(3.597)	
Adjusted R^2	0.126	0.089	0.101	0.008	0.093	0.175	0.132

	Country Stock Market Betas						
	(8)	(9)	(10)	(11)	(12)	(13)	(14)
International Sales	−0.006					−0.006	−0.010
	(−2.782)					(−2.620)	(−1.745)
International Assets		−0.005					−0.003
		(−1.825)					(−0.479)
International Income			−0.003				0.008
			(−1.296)				(1.617)
Traded/Non-Traded				−0.180		−0.074	
				(−2.047)		(−0.773)	
Respective Sales Beta					0.024	0.027	
					(3.294)	(3.379)	
Adjusted R^2	0.008	0.004	0.002	0.010	0.004	0.020	0.011

(White, 1980), and the adjusted R-squared for the regression. The first row has the global stock market betas as the dependent variable, the second row has country-specific stock market betas as the dependent variable. The regression results with international assets, international income, the traded goods industry dummy, and our sales betas as the explanatory variable are qualitatively similar and therefore omitted for brevity. Table V shows that the positive link between global stock market betas and international sales is robust to including country dummies (the coefficient is now 0.033 compared to 0.027 in Panel B of Table II and is highly

Table V. Regressions of global and country stock market betas on country dummies and the international sales ratio

This table explores the relative importance of cross- versus within-country variation in the global and country-specific stock market betas. The dependent variable in the first row are the global stock markets betas. This row reports results for a regression of these global betas on 20 country dummies and the international sales ratio. It reports the coefficient on international sales, the associated t-ratio using White (1980) robust standard errors, and the adjusted R-squared. The second row is analogous to the first, except that country betas are the dependent variables.

	Coefficient	t-Ratio	R-Squared
Global Stock Market Betas	0.033	11.752	0.177
Country Stock Market Betas	−0.006	−2.830	0.479

significant). This is less so for the link between country stock market betas and international sales, where the coefficient is now smaller in absolute magnitude but still significant. However, the main difference between these two regressions is that the explanatory power of the country dummies is vastly different. For the global stock market betas, including country dummies raises the adjusted R-squared to 18 percent, up from 11 percent in Panel B of Table II. For the country betas, the adjusted R-squared rises to 48 percent with country dummies, compared to 2 percent in Panel B in Table II. We conclude that our global stock market betas capture comovement associated with international activity. This is less so for our country betas.

As a final robustness check, we investigate whether our results are driven by a particular country or industry. Table VI does this by re-estimating the firm-level bivariate regressions in Panel B of Table IV, omitting one country or industry at a time. Panel A does this for the global stock market betas, with international sales as the dependent variable. Panel B does this for our country betas, with international sales as the dependent variable. The results for the other measures of international activity are similar and therefore omitted for brevity. Panel A shows that the link between global stock market betas and international activity is not driven by individual countries or industries. Panel B shows that this is not the case for country betas. Here, the coefficient turns positive when Japan is dropped from the sample, meaning that Japan largely drives the negative association between country betas and the international sales ratio.

Overall, we conclude that the cross-sectional association between our global stock market betas and measures of international activity is robust: stocks of more international companies have greater exposure to global shocks. There is evidence that this association genuinely reflects a link between comovement and the degree to which firms operate across countries, not country-specific shocks to the discount

Table VI. Robustness tests with respect to country and industry

This table asks whether the results are driven by a particular country or industry. It re-estimates the firm-level bivariate regressions in Panel B of Table IV, dropping one country or industry at a time. The country or industry dropped is given in the first column. The explanatory variable is always the international sales ratio. Table VI reports the coefficient on international sales, the White (1980) corrected t-ratio, and the adjusted R-squared.

	Panel A: Global Betas			Panel B: Country Betas		
	Coefficient	t-Ratio	R-Squared	Coefficient	t-Ratio	R-Squared
United States	0.023	9.908	0.108	−0.024	−10.041	0.093
United Kingdom	0.030	11.122	0.118	−0.014	−5.089	0.021
France	0.028	11.923	0.115	−0.012	−5.275	0.019
Germany	0.028	11.744	0.113	−0.012	−5.164	0.019
Italy	0.027	11.904	0.113	−0.012	−5.418	0.020
Japan	0.022	8.376	0.084	0.008	3.706	0.017
Canada	0.028	11.672	0.111	−0.012	−5.103	0.019
Australia	0.027	11.796	0.111	−0.012	−5.361	0.020
Austria	0.028	12.048	0.115	−0.012	−5.258	0.019
Belgium	0.028	12.129	0.117	−0.012	−5.256	0.019
Denmark	0.028	12.232	0.119	−0.012	−5.072	0.018
Hong Kong	0.028	12.135	0.119	−0.011	−4.963	0.017
Ireland	0.028	11.866	0.113	−0.012	−5.336	0.020
Netherlands	0.028	11.871	0.113	−0.012	−5.103	0.018
Norway	0.027	11.754	0.111	−0.012	−5.378	0.020
Sweden	0.028	11.545	0.111	−0.013	−5.507	0.021
Switzerland	0.028	12.162	0.118	−0.012	−5.001	0.017
Malaysia	0.027	11.949	0.113	−0.012	−5.261	0.019
Singapore	0.027	11.903	0.113	−0.012	−5.468	0.021
South Africa	0.028	11.942	0.114	−0.012	−5.118	0.018
Chemicals	0.028	11.722	0.116	−0.010	−4.452	0.015
Construction & Building Materials	0.028	11.326	0.111	−0.011	−4.502	0.015
Forestry & Paper	0.028	11.846	0.113	−0.012	−5.165	0.019
Steel & other Metals	0.027	11.616	0.110	−0.012	−5.023	0.018
Aerospace & Defense	0.028	12.022	0.115	−0.012	−5.387	0.020
Diversified Industry	0.027	11.864	0.114	−0.013	−5.673	0.022
Electronic & Electrical Equipment	0.026	11.093	0.107	−0.010	−4.376	0.014
Engineering	0.029	11.446	0.117	−0.012	−5.058	0.019
Automobiles & Parts	0.027	11.626	0.111	−0.012	−5.210	0.019
Household Goods	0.027	11.697	0.112	−0.011	−4.908	0.017
Beverages	0.028	12.125	0.117	−0.012	−5.176	0.019

Table VI. Robustness tests with respect to country and industry (continued)

	Panel A: Global Betas			Panel B: Country Betas		
	Coefficient	t-Ratio	R-Squared	Coefficient	t-Ratio	R-Squared
Food Producers and Processors	0.028	11.930	0.119	−0.011	−4.653	0.016
Health	0.028	11.864	0.114	−0.011	−4.897	0.017
Personal Care & Household Products	0.029	12.288	0.121	−0.011	−4.902	0.017
Pharmaceuticals	0.029	12.328	0.122	−0.011	−4.794	0.016
Tobacco	0.028	12.072	0.115	−0.012	−5.267	0.019
Retailers	0.028	11.955	0.116	−0.012	−4.945	0.018
Leisure, Entertainment & Hotels	0.028	11.878	0.114	−0.012	−5.193	0.019
Media	0.027	11.755	0.111	−0.012	−5.011	0.018
Support Services	0.028	11.888	0.115	−0.012	−5.289	0.020
Transport	0.027	11.388	0.109	−0.012	−5.099	0.018
Food & Drug Retailers	0.027	11.766	0.111	−0.012	−5.384	0.020
Telecom Services	0.027	11.809	0.111	−0.013	−5.553	0.021
Electricity	0.024	10.649	0.094	−0.016	−7.023	0.035
Gas Distribution	0.026	11.469	0.106	−0.013	−5.640	0.022
Information Technology Hardware	0.023	11.474	0.105	−0.010	−4.447	0.014
Software & Computer Services	0.027	11.777	0.111	−0.012	−5.228	0.019
Banks	0.026	11.282	0.104	−0.014	−6.055	0.026
Life Assurance	0.027	11.901	0.112	−0.012	−5.298	0.019
Investment Companies	0.028	12.241	0.119	−0.013	−5.618	0.022
Real Estate	0.028	12.085	0.118	−0.011	−4.733	0.016
Specialty & Other Finance	0.027	11.888	0.113	−0.012	−5.208	0.019
Mining	0.028	11.953	0.115	−0.012	−5.129	0.018
Oil & Gas	0.028	11.975	0.115	−0.012	−5.118	0.019

rate, nor that it is driven by a particular country or industry. The same cannot be said for the association between our country betas and our measures of international activity. The relation – that more international firms are less exposed to country-specific shocks – is substantially weaker when allowing for country dummies to control for discount rate effects. Most important, the relation is driven by one country: Japan.

4.2. THE CROSS-SECTIONAL LINK OVER TIME

We now modify our model to allow the importance of global, country and industry shocks in international returns to change over time, motivated by Goetzmann et al. (forthcoming) and Longin and Solnik (1995) who report that comovement in international equity returns is time varying and L'Her et al. (2002) who find that country shocks have fallen in importance in recent years. We use this expanded approach to ask if the cross-sectional link between international stock market comovement and firm-level international diversification found in the previous section is robust, and how it has evolved over time.

To this end, we estimate a more general specification of the model in Section 2, one that allows for the importance of the global, country and industry factors to vary across sub-periods of the data. In our baseline specification, the factors in every period are drawn from the same distribution, as described in Equation (4a). Now we allow for these distributions to evolve over time. Assumption (4a) is therefore replaced with:

$$f_t^g \xrightarrow{d} N(0, \xi_l^g),\ f_t^c \xrightarrow{d} N(0, \xi_l^c),\ f_t^i \xrightarrow{d} N(0, \xi_l^i),$$
$$\text{for} \quad t_{l-1} + 1 \le t \le t_l \quad \text{and} \quad l = 1, \ldots, L \tag{7}$$

where $t_0 = 1$ and $t_L = T$. Assumption (7) says that our sample period is divided into L periods, each starting at time $t_{l-1} + 1$ and ending at time t_l. In each period, we let the variance and therefore the importance of our factors change. For normalization purposes, we still constrain the variance in the first sub-period to be one for all factors. Hence ξ_l^g can be interpreted as the variance of the global factor relative to its variance in the first period. The variance of excess returns for stock n in period l can therefore be decomposed as follows:

$$\mathrm{Var}(R_{nl}) = (\beta_n^G)^2 \xi_l^g + (\beta_{nc}^C)^2 \xi_l^c + (\beta_{ni}^I)^2 \xi_l^i + \sigma_n^2 \tag{8}$$

for $t_{l-1} + 1 \le t \le t_l$. As the ξs change over time, the relative importance of the global, country- and industry-specific shocks in explaining variation in stock returns can also change.[9]

The choice as to the number and timing of sub-periods is somewhat arbitrary. We therefore allow for two through eight equally-spaced sub-periods and systematically test for the increase in explanatory power relative to our baseline model with fixed factor variances. Our results below are qualitatively robust across specifications, which we demonstrate in Appendix C. However, since the model with four sub-periods has the highest BIC (Bayesian Information Criterion), we present the

[9] An alternative approach would be to estimate our original model for different sub-periods of the data. However, because of the large number of parameters we estimate, this severely reduces the efficiency of our estimates. In an appendix available upon request we describe in detail the implementation of the EM algorithm when the variances of the factors change across sub-periods.

results for that specification only. Appendix B shows that the cross-sectional results are robust for the four subperiods. Appendices B and C are available on the web at http://gerda.univie.ac.at/rof/papers/supplements/BrooksDelNegrowebappendix.pdf.

Table VII shows the variance decompositions over time for international stock returns, based on the model with four sub-periods. As in Table II, we show the variance decomposition for the average across all firms, for firms in the top quartile according to the international sales ratio (the most international firms) and for firms in the bottom quartile (the least international firms). Let us first focus on the variance decompositions for the full sample. The results suggest that the importance of the global factor has grown from 4.26 percent in the first sub-period to 16.49 percent in the last sub-period. The importance of the industry factors has been approximately constant over time. Country shocks are the most important source of return variation in all four periods, although their importance has declined relative to that of the global factor in the last period. Importantly, this pattern is not the same across all companies, as can be seen from the comparison of the variance decompositions for high and low international sales firms. Note that in the first sub-period, country shocks are more important for firms with relatively high international sales. This pattern is reversed in all subsequent periods. In the last period, country-specific shocks are less important for high than for low international sales firms. Notably, for high international sales firms, the global shock is the most important source of return variation in the last period.

Table VIII takes a different look at this same phenomenon. It explores the evolution over time of the cross-sectional link between stock market comovement and firm-level international diversification. Note that in each period the exposure of firm n to world, country- and industry-specific shocks is given by the expressions $\beta_n^g {\xi_l^g}^{1/2}$, $\beta_n^c {\xi_l^c}^{1/2}$, and $\beta_n^i {\xi_l^i}^{1/2}$, respectively. We regress these exposures on within-period measures of firm-level integration, such as the international sales ratio and the sales betas, using within-portfolio averages to reduce the impact of measurement error on our estimates. For each sub-period, Table VIII presents the estimated slope coefficient on the within-period average international sales ratio and indicates whether this coefficient is significant at the 5 or 10 percent levels. We again use White (1980) robust standard errors. Table VIII suggests that the cross-sectional link between the global stock market betas and the international sales ratio has increased by a factor of 2.3 from the first to the last sub-period. Meanwhile, the coefficient on the international sales ratio in the country beta regressions has switched from 0.181 in the first period (consistent with the greater importance of the country factor for highly international firms than for the average firm in Table VII) to -0.191 in the most recent sub-period. The coefficients in the regressions of the stock market betas on the respective sales betas always have the expected positive sign: an increase (decrease) in real-side exposure to global (country) shocks maps into an increase (decrease) in stock market exposure.

It is important to bear in mind that our model does not allow for time-varying exposures at the firm level, but only for a change in the variances of the factors. It

Table VII. Variance decompositions of international stock returns (in %) over time

This table is constructed is the same manner as Table II. It is based on an extended version of our model in which the variances of the global, country- and industry-specific factors are allowed to vary across four exogenously specified sub-periods in our sample. The variance decomposition for each stock is now given by $\text{Var}(R_{nt}) = (\beta_n^G)^2\zeta_l^G + (\beta_{nc}^C)^2\zeta_l^C + (\beta_{ni}^I)^2\zeta_l^I + \sigma_n^2$, where the index l denotes the sub-period and ζ_l^G, ζ_l^C and ζ_l^I scale the factor variances of the global, country- and industry-specific factors in the l'th sub-period relative to their variances in the first sub-period. Standard errors are from Monte Carlo simulations for asymptotic distributions of the betas.

	Variance Decomposition (in %) of International Stock Returns								
	All firms			Top Quartile: Int'l Sales			Bottom Quartile: Int'l Sales		
	Global	Country	Industry	Global	Country	Industry	Global	Country	Industry
1985:1 to 1989:3	4.3	29.6	9.6	6.7	32.4	7.9	2.3	25.1	9.9
	(0.7)	*(1.6)*	*(0.4)*	*(1.1)*	*(1.7)*	*(0.6)*	*(0.4)*	*(1.7)*	*(0.5)*
1989:4 to 1993:7	2.0	42.0	4.3	3.4	31.0	4.0	1.1	45.1	4.3
	(0.4)	*(13.3)*	*(0.4)*	*(0.6)*	*(5.0)*	*(0.6)*	*(0.2)*	*(16.5)*	*(0.7)*
1993:8 to 1997:10	2.7	30.9	5.4	4.5	22.1	5.8	1.6	34.9	5.4
	(0.9)	*(16.4)*	*(0.5)*	*(1.4)*	*(5.7)*	*(0.6)*	*(0.5)*	*(20.9)*	*(0.5)*
1997:11 to 2002:02	16.5	29.5	8.7	24.8	21.9	9.0	10.2	32.8	8.7
	(3.4)	*(2.8)*	*(0.7)*	*(4.9)*	*(1.6)*	*(1.0)*	*(2.3)*	*(3.7)*	*(1.2)*

Table VIII. Cross-sectional regressions of the stock market betas on the international sales ratio and the respective sales betas over time

This table reports the results of cross-sectional regressions analogous to those shown in Table II. All variables are measured in percent. t-ratios are computed using robust standard errors as in White (1980). * denotes significance at the 5 percent level, ** denotes significance at the 10 percent level. Because of the possibility of measurement error in the regressors, the regressions for each sub-period are performed on the within-portfolio averages for $N = 20$ portfolios. We construct these portfolios by (i) sorting firms according to the dependent variable, (ii) constructing N portfolios containing n/N firms (where n is the total number of firms in the sample), (iii) using as observations the N within-portfolio averages for the dependent and explanatory variables.

	Global Stock Market Betas	
	International Sales Ratio	Global Sales Betas
1985:1–1989:3	0.123**	0.634**
1989:4–1993:7	0.088**	0.430**
1993:8–1997:10	0.079**	0.403**
1997:11–2002:02	0.280**	1.440**
	Country Stock Market Betas	
	International Sales Ratio	Country Sales Betas
1985:1–1989:3	0.181**	0.794**
1989:4–1993:7	−0.154*	1.050**
1993:8–1997:10	−0.123**	0.628**
1997:11–2002:02	−0.191**	0.911**

is apparent for instance that the change in the coefficients for the regressions featuring the global stock market betas on the left hand side is because the importance of the global shocks, ξ_l^g, has changed over time. The change in the coefficients in the country beta regressions is not as mechanical. In this case compositional effects play an important role. The results suggest that country shocks have fallen in importance more for countries where firms are more international.

We now focus on trying to explain the changing country factor variances over time, because the cross-country dimension of the data allows us to use regression analysis to link the evolution of these factors to country averages of our firm-level international sales variable and to macroeconomic data on capital account and trade openness (because we lack the same cross-sectional dimension for the global factor, we do not perform similar analysis for it). Is it the case, for example, that the importance of country-specific stock market shocks has declined more in countries where firms are on average more international? Or is it the case that macroeconomic measures of openness are more successful in explaining the evolution of the country factor variances? Table XI presents bivariate cross-

Table IX. Explaining the changing importance of country factors in international stock returns

This table shows the slope coefficients for period by period bivariate cross-country regressions of the variance scale parameters for the country factors, ζ_l^C, on full sample averages of firm-level and macroeconomic measures of openness (and a constant): country-level averages for the international sales ratio, country-level averages for the global and country sales betas, the capital account openness measure (CA Open) of Lane and Milesi-Ferretti (2001) who compute the ratio of foreign assets and liabilities to GDP annually for each country in our sample, the Chinn and Ito (2002) measure of capital account restrictions (CA Restrict) that is based on the IMF's annual measure of capital account restrictions that takes a value of one if restrictions exist and zero otherwise, and the annual ratio of trade to GDP for each country in our sample from the World Bank's World Development Indicators. * denotes significance at the 5 percent level, ** denotes significance at the 10 percent level.

	Int'l Sales Ratio	Global Sales Betas	Country Sales Betas	CA Open	CA Restrict	Trade Open
1989:4–1993:7	−0.0001	−1.394	−1.1163	−0.2722	0.0591	−0.0026*
1993:8–1997:10	−0.0114**	0.7543	1.0476	−0.2878**	−0.0337	0.0004
1997:11–2002:2	−0.0168**	−9.900**	3.8162	−0.0115	−0.0147	0.0033**

sectional regressions for each period (except the first period when the country factor variances are normalized to one) of the country factor scale parameters on the full sample averages for the following variables: the country-level averages for the international sales ratio, the country-level averages for the global and country sales betas, the capital account openness measure (CA Open) of Lane and Milesi-Ferretti (2001) who compute the ratio of foreign assets and liabilities to GDP annually for each country in our sample, the Chinn and Ito (2002) measure of capital account restrictions (CA Restrict) that is based on the IMF's annual measure of capital account restrictions that takes a value of one if restrictions exist and zero otherwise, and the annual ratio of trade to GDP for each country in our sample from the World Bank's World Development Indicators. Table IX shows that firm-level diversification across countries is on average negatively associated with the evolution of the country factor variances. This suggests that the more international is a country's average firm, as measured by international sales ratio, the higher the decline in the importance of its country-specific stock market factor over time. More important, this link has become progressively stronger and more significant over time. This suggests that the rise in the importance of the cross-sectional link between international stock market comovement and firm-level trade integration is not entirely spurious, at least as far as the changing importance of the country factors is concerned. Finally, it does not appear that macroeconomic measures of openness rival our firm-level international sales measure in explaining the evolution of the country factors over time. The capital account openness measure of Lane and Milesi-Ferretti (2001) comes closest, but here it seems that the relationship has weakened over time.

5. Conclusion

We investigate the empirical link between international stock market comovement and the degree to which firms operate internationally. Using stock returns and balance sheet data for companies in 20 countries, we measure the sensitivity of stock returns with respect to global, country-and industry-specific shocks. In contrast to earlier papers, we find a strong and highly significant link between the importance shocks and firm-level variables that measure the degree to which firms operate across countries. For example, a firm raising its international sales by 10 percent raises the exposure of its stock return to global shocks by two percent. We also find evidence of a negative link between the importance of country-specific return variation and the extent to which firms operate across countries: a firm raising its international sales by 10 percentage points reduces the exposure of its stock return to country-specific shocks by 1.5 percent. However, this link is driven by data for Japanese firms and is thus, unlike our evidence for global shocks, not robust across countries.

We also estimate a more general version of our model, in which we allow the variances of the global, country- and industry-specific factors to vary over time.

Using this specification, we find that the link between international stock market comovement and the degree to which firms operate internationally has grown substantially since the mid-1980s.

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