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Economic News and International Stock Market Co-movement*

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Abstract. We analyze the effects that real-time domestic and foreign news about fundamentals have on the co-movement between stock returns of a small, open economy, Portugal, and a large economy, the United States. Consistent with our theoretical model, we find that US macroeconomic news and Portuguese earnings news do not affect stock market co-movement, whereas Portuguese macroeconomic news lowers stock market co-movement. We find that US news affects Portuguese stock market returns, though less so when US stock market returns are included in the regression. We provide evidence, contrary to common wisdom, that this last result does not derive from contagion.

JEL Classification: F3, G12, G14, G15

1. Introduction

Why do stock markets around the world co-move? There are two leading theories: Co-movement is due to global factors in cross-country returns and co-movement is not related to fundamentals (contagion). The former theory implies that conditional correlations are higher on days of innovations to global factors. Given the extant evidence that US macroeconomic variables are informative about global factors, the corresponding testable prediction is that co-movement is higher on days of US economic news announcements. However, the empirical evidence does not support this hypothesis, leading some to explore contagion as the main driver of these

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correlations. In this paper we revisit empirically and theoretically the role of news about fundamentals in cross-country correlations.[1]

The literature that studies the role of US news announcements on stock market co-movement has focused on the US and other large economies like the UK and Japan. Instead, we study co-movement between the US and Portugal, a small and open economy. The choice of studying co-movement between a large and a *small, open economy* is motivated by three reasons. First, suppose the absence of higher co-movement during US news announcement days is due to a small global component present in US news announcements (Karolyi and Stulz, 1996). Then looking at countries that have greater exposure to the worldwide economy can increase the statistical power to reject the null hypothesis in favor of the alternative that US news announcements are drivers of co-movement.[2] Second, suppose the observed pattern of co-movement is due to omitted news from the foreign economy. When the foreign economy is the UK or Japan, such news are informative about global factors, and their omission may bias the estimated effect of US news announcements. This problem is less severe with a small economy. Third, studying the drivers of international co-movement using pairs of large economies introduces endogeneity biases in returns.

In addition, our choice of Portugal has two main advantages. First, Portugal is a representative small, open economy, increasingly exposed to external shocks, making it a prime candidate to identify information linkages at par with any emerging economy. Second, we benefit from the availability of high quality Portuguese data. The existence of high frequency stock market data in Portugal allows us to create daily synchronous returns for the United States and Portugal, and a unique feature of the Portuguese data is that it contains information on signed trades.[3] We can thus conduct our exercise conditioning on public as well as on private information, which is required by our model and contributes to the novelty of our study. In particular, having signed trades means that there is no need to rely on algorithms for inferring the direction of trades, which add measurement error to estimated order flow imbalances.

Our empirical results show that while US macroeconomic news affect Portuguese returns, US news announcements do not affect the correlation of stock returns across the two countries, consistent with the stylized finding discussed above. We

[1] We review the related literature below.

[2] Portugal is more exposed to the global economy than the UK or Japan with a trade volume –ratio of exports plus imports of goods and services to GDP – 27 percent higher than that of the UK and 3 times that of Japan (data from the World Bank's World Development Indicators database).

[3] One notable exception is the TORQ database, which contains signed trades for a sample of 144 NYSE stocks for the three months November, 1990 through January 1991. The advantage of our dataset is that we have nine and a half months of data from January 4, 2002 to October 15, 2002.

also show that Portuguese earnings news do not affect the correlation of stock returns across the two countries, whereas this correlation is much lower on Portuguese macroeconomic announcement days. This observation adds to our empirical knowledge of co-movement of returns, as most other studies have focused on news from the United States alone. It also adds complexity to the pattern of time-varying correlations that needs to be explained with an equilibrium model of asset returns.

The paper provides a simple model that is consistent with the existence of global factors in returns and can endogenously generate the observed time-series pattern of co-movement in response to US and Portuguese news, even when the cross-country correlation of fundamentals is constant through time. The model differs from the fundamentals-based hypothesis in that it considers the role of private information in generating co-movement. Intuitively, stock return co-movement arises as investors in Portugal use US returns to infer the *private information* of US informed investors about the global factor. On days of good private information about US assets, US order flow is large and positive and so are US returns. Since fundamentals are correlated across countries, this information is good news for the Portuguese stock market and prices rise locally as well. Thus, in the model, Portuguese and US stock market returns move together in the absence of public news. What local investors attempt to learn from the foreign economy is the private information about the global factor that gets revealed in the US price. Time-varying cross-country correlations in returns arise if news arrive that change the informativeness of US returns.

The model also predicts that market liquidity increases on days of news announcements. The reason is that, as in the Kyle (1985) and Admati and Pfleiderer (1988) models, public news 'destroys' some of the value of private information, thereby making market makers less concerned about exposure to adverse selection. Empirically, we show that public news in the United States increases liquidity in the US market, and that the same is true for Portuguese earnings news and liquidity in the Portuguese market. While these observations are consistent with our model, we also find that Portuguese macroeconomic news decrease liquidity in the Portuguese market. One explanation for this unexpected behavior of liquidity is that Portuguese macroeconomic news necessitate more analysis to be exploited, leading to the entry in the market of a different class of informed investors (see Kim and Verrecchia, 1994).

Finally, the model predicts that the information contained in the US stock return subsumes that of public news. In our tests, we find supporting evidence that the explanatory power of US news for Portuguese returns decreases significantly if the US return is also included. The evidence that US news have little or no statistical power over and above US stock returns is generally viewed as supportive of the contagion hypothesis. To address this possibility further we investigate the high-frequency response in Portugal to US news. We show that in response to positive US news about output or investment, which can be viewed as positive shocks to a global factor, both the US and Portuguese stock markets appreciate, with the Portuguese market response *following* the US response within 5 to 15 minutes. This delayed response does not appear to be evidence of contagion or portfolio rebalancing, however, as positive surprises about US net exports and inflation, which can be viewed as shocks to competitive factors similar to Karolyi and Stulz (1996),[4] lead to opposite responses in each market, but again with the Portuguese market following the US response. Given this *intra-day* delayed response in the local market, it is then not surprising to see that in regressions of *daily* local returns, the inclusion of the US returns removes the explanatory power of US news surprises. In contrast to the contagion view, we stress the informational role of US returns. Our interpretation is that US returns are a summary statistic for US public and private information and that Portuguese investors try to filter the private information contained in US returns. We provide further evidence against the portfolio rebalancing and contagion mechanisms: (*i*) our results are robust to excluding Portuguese ADRs from our sample; and, (*ii*) controlling for US macroeconomic news surprises, Portuguese stock market returns do not react to "extreme" US stock market moves.

To test the hypotheses of our model we use real-time US and Portuguese macroeconomic announcements and high frequency stock market returns. Such high frequency data allows us to probe the workings of the marketplace in powerful ways because: (*i*) we measure more accurately the effects that macroeconomic news announcements have on US and Portuguese prices (Andersen et al., 2003) by focusing on episodes during which the source of price revisions is well identified, thus leading to a high signal-to-noise ratio; (*ii*) we are able to test the assumption that US news are first incorporated into US prices and only then into local stock prices; (*iii*) we measure unanticipated order flow which proxies for private information-based trading, enabling us to analyze the effects of public news conditional on private information.

We proceed as follows. Next we give a brief literature review. In Section 3, we construct and solve a simple model of co-movement to guide our empirical analysis. Section 4 describes the data. In Sections 5 and 6, we present the empirical results and Section 7 concludes. The appendix contains the proofs of the model propositions.

[4] Unexpected improvements in US net-exports generate US stock price hikes and lower Portuguese stock prices. Similarly by definition, all else equal, unexpectedly high US inflation leads to an unexpected real USD appreciation to which the US stock market responds negatively, but the Portuguese market responds positively. In theory, US inflation could lead to a nominal depreciation of the USD, however most empirical studies find that inflation has little effect on nominal exchange rates. Hence, the statement 'all else equal' is not unrealistic.

2. Related Literature

Our paper is most closely related to two areas of research. The first examines the role of public news in international asset market co-movement and the second highlights the role of order flow in the price formation process. In this paper, the two are related because we take the view that both public news and order flow are important in the price discovery process. We briefly discuss these research areas in turn.

Several papers have shown that US news affect the behavior of asset prices around the world, but that the opposite is not true (e.g., Andersen et al. 2003, Becker et al. 1995, Ehramann and Fratzscher, 2003, and Wongswan, 2006).[5] Gande and Parsley (2005) show that news ratings on sovereign debt in one country affect yields in other countries and tie the spillover effects to country fundamentals. In line with these papers, we find that the Portuguese stock market reacts to US macroeconomic news. We also show that the US does not react to Portuguese news. Our study is novel in that it looks at information spillovers in the conditional mean of stock returns. In addition, theory papers like Brennan and Cao (1997) and Albuquerque et al. (2007) explore the role of public news in the local economy and the US in explaining the return chasing phenomenon.

In the context of stock markets it has been argued that the association between US news and foreign returns discussed above is to a large extent spurious, as it is driven by the existence of stock market contagion (e.g., King et al., 1994, and Connolly and Wang, 2003). While we find that US news does lose explanatory power when the US return is included in a regression of Portuguese returns, we show that this finding is consistent with a rational asset pricing model where US returns summarize both private and public information of US investors. In addition, we analyze theoretically and empirically how the correlation across markets changes in the presence of local and foreign news.

In a seminal contribution, Karolyi and Stulz (1996) model the correlation between US and Japanese stock markets and test how much of that correlation is explained by the presence of US news. They find that stock market co-movement is not changed in days of US news and interpret this finding as evidence that the global component of US news is small. Relative to their results, we also find that US news do not change the cross-country correlation of returns. However, we find that Portuguese macroeconomic news lower the cross-correlation of returns and provide a simple model that can account for these apparently puzzling patterns.[6]

[5] These empirical results refer to "normal news," as the US did respond to major international financial crisis, e.g., the Russian default and the East Asian crisis.

[6] The evidence in Karolyi and Stulz (1996) is especially disappointing in light of the papers that have shown empirically and theoretically the significance of cross-country correlation in economic fundamentals in explaining the observed size of international return correlations (e.g., Ammer and

In our theoretical model there are no contagion effects.[7] As in King and Wadhwani (1990), informed investors in one market use returns in other markets to infer additional information on fundamentals and hence they will sometimes mistakenly interpret a high foreign return as evidence of a high private information signal in the foreign market. However, in our paper the equilibrium on days of no news displays a return correlation that equals the correlation in the underlying economic fundamentals: On average investors are inferring just the correct amount of information. Another important difference between the two setups is that we adopt an equilibrium model of strategic informed trading similar to Kyle (1985) whereas King and Wadhwani (1990) adopt a rational expectations equilibrium. This allows us to study the role of order flow in the price discovery process following local and foreign news, and its effect on international stock return co-movement which has not been previously addressed. Finally, our model generates predictions on time-varying return correlations that are not borne by existing contagion models.

Several recent studies have highlighted the role of order flow in the price formation process (e.g., Brandt and Kavajecz, 2004, and Evans and Lyons, 2002), while others have highlighted the role of public information in the price formation process (e.g., Fleming and Remolona, 1997, Balduzzi et al., 2001, Green, 2004, and Andersen et al., 2003, 2005). Typically, however, the roles of order flow and public information are examined in isolation. Some notable exceptions are Green (2004), Pasquariello and Vega (2007), and Evans and Lyons (2004) who examine both the role of public information and order flow in the bond and foreign exchange markets, respectively. At least two features differentiate our study from theirs. First, asymmetric information may be more severe in the stock market context than in the bond and foreign exchange market; in the latter private information is about macroeconomic factors, while in the former both macroeconomic and firm specific factors matter. Second, we simultaneously investigate cross-country stock market linkages rather than estimating the effect of order flow and public news on one market in isolation.

3. A Simple Model of Return Co-Movement

There is a local, small economy and a foreign, large economy.[8] Each economy has its own stock market where a single stock is traded (the market index) and a distinct

Mei, 1996, Bekaert, Harvey and Ng, 2005, and Dumas, Harvey, and Ruiz, 2003). By studying contagion effects in extreme market movements, Bae, Karolyi, and Stulz (2003) are able to find some evidence in favor of the contagion hypothesis, but they also show that modeling international returns with fat tail distributions can rationalize most of the observed extreme events.

[7] See Claessens, Dornbusch, and Park (2001) for a comprehensive review of the contagion literature.

[8] We have in mind that the U.S. is the foreign economy and a country such as Portugal the small economy.

Foreign Economy			Local Economy		
t	Public news U_t^* arrives, informed traders learn s_t^*	Market makers observe aggregate order flow $w_t^* = \sum_{i=1}^{n} x_{it}^* + z_t^*$	Public news U_t and P_t^* arrives, informed traders learn s_t	Market makers observe $w_t = \sum_{i=1}^{n} x_{it} + z_t$	$t+1$
	Orders are placed: x_{it}^*, z_t^*	Price is chosen P_t^*.	Orders are placed: x_{it}, z_t	Price is chosen P_t.	

Figure 1. Timeline of Events.

pool of investors. Investors can also invest in the bond market at a zero interest rate. The local (foreign) stock market is composed of n (n^*) informed investors, uninformed investors, and a perfectly competitive market maker. All optimizing agents are risk neutral. Time is described by $t = 1, 2, \ldots, T$ periods, where T is the time at which the stock pays a liquidating dividend. Foreign economy prices and quantities are identified with an asterisk '*'.

Stock trading in each period is à la Kyle (1985): investors submit trades given their information sets; the market maker sets prices given the publicly available information and aggregate order flow; and the market clears. Markets are assumed open 24 hours. At the end of each period t the innovation to the underlying value of the asset, v_{t+1}, is realized and becomes public information. Figure 1 shows the timing of the model.

At the start of period t the underlying liquidation value of the local asset is $V_t = \bar{V} + \sum_{\tau=1}^{t} v_\tau$ known by all investors (there is a similar process for the foreign economy V_t^*). The asset dividend V_T is paid out at the beginning of period T. The variance of the incremental valuation in the local (foreign) market, $\tilde{v}_t$ ($\tilde{v}_t^*$), is δ (δ^*). It is assumed that the local asset's fundamental value is affected by a global factor that drives the returns in the foreign economy, i.e. $E[\tilde{v}_t \tilde{v}_t^*] = \psi$. This assumption is justified by previous literature (e.g., Harvey, 1991, and Ferson and Harvey, 1993) and in the specific case of Portugal-US by noting that Portuguese real GDP growth is significantly positively correlated with US real GDP growth.

Before trading, informed investors in the local (foreign) market observe a private information signal $\tilde{s}_t = \tilde{v}_{t+1} + \tilde{\varepsilon}_t$ ($\tilde{s}_t^* = \tilde{v}_{t+1}^* + \tilde{\varepsilon}_t^*$) about next period's incremental valuation, $\tilde{v}_{t+1}$ ($\tilde{v}_{t+1}^*$), where the variance of $\tilde{\varepsilon}_t$ ($\tilde{\varepsilon}_t^*$) is ϕ (ϕ^*). The signal $\tilde{s}_t$ can be interpreted as market-wide private information.[9] In some periods, before trading takes place, market participants receive local or foreign public news about local or foreign asset values, respectively.[10] Public news in the local (foreign) market are modeled by the random variable $\tilde{U}_t = \tilde{v}_{t+1} + \tilde{\mu}_t$ ($\tilde{U}_t^* = \tilde{v}_{t+1}^* + \tilde{\mu}_t^*$), with the

[9] Evidence of the existence of market-wide private information can be found in Barclay, Litzenberger and Warner (1990), Chan and Hameed (2006), Bauer and Vega (2007), Albuquerque, de Francisco and Marques (2008) and Albuquerque, Bauer and Schneider (2007).

[10] Whether news come at known dates or not does not affect the equilibrium we study.

variance of $\tilde{\mu}_t$ ($\tilde{\mu}_t^*$) equal to κ (κ^*). As in Admati and Pfleiderer (1988), this setup guarantees that any private or public information received at t is short lived and cannot be used beyond forecasting time $t+1$ valuations. We assume that all variables are normally distributed and have zero mean and, with the exceptions noted above, all variables are independently and identically distributed. All value increments are assumed to be independently distributed across time and across markets. We stress that there is no built-in time-variation in conditional correlations and hence that any time-variation in conditional correlations of returns is endogenously generated.

Because informed investors submit their orders without knowing the stock price, they choose trading based on the private and public information in their information set $\mathcal{I}_t^I$ and their conjecture of the price process $\{\tilde{P}_\tau\}_{\tau \geq t}$ to solve

$$\max_{x_{it}} E\left[\sum_{t=1}^{T-1} (\tilde{P}_{t+1} - \tilde{P}_t) x_{it} | \mathcal{I}_t^I\right], \tag{1}$$

with the convention that $\tilde{P}_T = \tilde{V}_T$. Uninformed investors in the local (foreign) economy trade the random quantity $\tilde{z}_t$ ($\tilde{z}_t^*$) in period t, where $\tilde{z}_t$ ($\tilde{z}_t^*$) has variance ζ (ζ^*). Total order flow in the local stock market is thus $\tilde{\omega}_t = \sum_{i=1}^n \tilde{x}_{it} + \tilde{z}_t$. For simplicity local and foreign informed investors only trade in their respective markets (e.g., King and Wadhwani, 1990). This assumption is not restrictive, but simplifies the analysis considerably. It is straightforward, but inconsequential for our qualitative results, to allow the private information of informed investors in different markets to be correlated (i.e., $E(\tilde{\varepsilon}_t \tilde{\varepsilon}_t^*) \neq 0$) which would correspond to a case where some of the informed investors participated in both markets.

The market maker chooses prices to maximize

$$E\left[\sum_{t=1}^{T} (P_{t+1} - P_t)\omega_t | \mathcal{I}_t^M\right]. \tag{2}$$

Being perfectly competitive maximum profits are zero. By market efficiency, the market makers' information set in period t, $\mathcal{I}_t^M$, includes all available information: the aggregate order flow ω_t and any available public news.

With short lived private information, the problems (1) and (2) are equivalent to solving the sequence of single period problems:

$$\max_{x_{it}} E\left[(\tilde{P}_{t+1} - \tilde{P}_t) x_{it} | \mathcal{I}_t^I\right], \tag{3}$$

and

$$0 = E\left[(P_{t+1} - P_t)\omega_t | \mathcal{I}_t^M\right]. \tag{4}$$

In our model, investors act strategically on their private information and hence order flow is a noisy measure of their private information. This feature allows us to determine theoretically and empirically the effects of public news controlling for private information. In addition, it allows us to study liquidity effects around announcements. Both of these features are absent in rational expectations equilibrium models of information linkages such as King and Wadhwani's (1990).

3.1 FOREIGN STOCK MARKET, NO FOREIGN NEWS

Consider first a period t without public news announcements in the foreign economy. Informed foreign investors' information set is $\mathcal{I}_t^{I*} = \{V_t^*, s_t^*\}$. Informed investors conjecture that the equilibrium price is

$$\tilde{P}_t^* = V_t^* + \lambda^* \tilde{\omega}_t^*.$$

They also need to conjecture a price for period $t+1$ which depends upon the existence or lack thereof public news in the foreign economy: If there are news announcements at $t+1$ the price displays a different liquidity parameter λ^* and depends on the public news released (see below). In equilibrium, because private information is short lived and uninformative of future payoffs $E[\tilde{P}_{t+1}^* | \mathcal{I}_t^{I*}] = V_t^* + E[\tilde{v}_{t+1}^* | \mathcal{I}_t^{I*}]$. Hence, the solution to the foreign informed investors' problem is obtained from

$$\max_{x_{it}^*} E\left[\tilde{v}_{t+1}^* - \lambda^* \sum_{j=1}^{n^*} \tilde{x}_{jt}^* | \mathcal{I}_t^{I*}\right] x_{it}^*.$$

Similarly, knowing $\mathcal{I}_t^{M*} = \{V_t^*, \omega_t^*\}$, the foreign market maker solves $E[\tilde{v}_{t+1}^* | \omega_t^*] - \lambda^* \omega_t^* = 0$, where λ^* measures the information content of order flow. It is well known (Admati and Pfleiderer, 1988) that the solution to this static problem is

$$\lambda^* = \frac{\delta^*}{n^* + 1} \sqrt{\frac{n^*}{\zeta^* (\delta^* + \phi^*)}}, \tag{5}$$

and

$$x_{it}^* = \sqrt{\frac{\zeta^*}{n^* (\delta^* + \phi^*)}} s_t^*. \tag{6}$$

Informed investors trade more aggressively when they can benefit more from their informational monopoly power (see equation (6)). This happens when the signal is very informative (ϕ^* is low), there are fewer of them (n^* is low), and there are many uninformed investors (ζ^* is large). In contrast, the market maker, fearing more informed trading, responds by reducing liquidity (i.e., λ^* increases) when the signal is very informative (ϕ^* is low) or there are fewer informed investors (n^* is low) (see equation (5)). Note that foreign investors and market makers do not condition on order flow from the local economy. See subsection 3.7 for a discussion relating our assumptions about public information.

3.2 FOREIGN STOCK MARKET, FOREIGN NEWS

Let t be a period with a public news announcement in the foreign economy, $\tilde{U}_t^* = \tilde{v}_{t+1}^* + \mu_t^*$, with $E[\tilde{\mu}_t^{*2}] = \kappa^*$. Foreign informed investors correctly conjecture that the equilibrium stock price is,[11]

$$\tilde{P}_t^* = V_t^* + \lambda^* \tilde{\omega}_t^* + \sigma^* \tilde{U}_t^*.$$

With this conjecture, the information set $\mathcal{I}_t^{I*} = \{V_t^*, s_t^*, U_t^*\}$, and the equilibrium property that $E[\tilde{P}_{t+1}^* | \mathcal{I}_t^{I*}] = V_t^* + E[\tilde{v}_{t+1}^* | \mathcal{I}_t^{I*}]$, we solve the problem faced by informed investors (see the appendix). The market maker observes the aggregate order flow, i.e., $\mathcal{I}_t^{M*} = \{V_t^*, \omega_t^*, U_t^*\}$. The equilibrium price parameters are:

$$\lambda^* = \frac{var(\tilde{v}_{t+1}^* | \tilde{U}_t^*)}{n^* + 1} \sqrt{\frac{n^*}{\zeta^* var(\tilde{s}_t^* | \tilde{U}_t^*)}}, \tag{7}$$

$$\sigma^* = \frac{\delta^*}{\delta^* + \kappa^*},$$

with $var(\tilde{v}_{t+1}^* | \tilde{U}_t^*) = \frac{\delta^* \kappa^*}{\delta^* + \kappa^*}$ and $var(\tilde{s}_t^* | \tilde{U}_t^*) = \frac{\delta^* \kappa^* + \phi^* \delta^* + \phi^* \kappa^*}{\delta^* + \kappa^*}$ and the asset demand is

$$x_{it}^* = \sqrt{\frac{\zeta^*}{n^* var(\tilde{s}_t^* | \tilde{U}_t^*)}} (s_t^* - \sigma^* U_t^*). \tag{8}$$

The coefficient σ^* associated with the public news is given by the ratio of the covariance of the public news with the private information signal $\tilde{s}_t$ to the variance of the public news. It describes the part of private information that can be inferred from public news.

Public news introduces two conflicting implications for trading by informed investors (see equations (8) and (6)). On the one hand, the 'amount' of private information is reduced to the unforecastable part of informed investors' private information, $s_t^* - E(\tilde{s}_t^* | U_t^*) = s_t^* - \sigma^* U_t^*$, making informed investors trade less. On the other hand, the public news reduces the conditional variance of the private information to $var(\tilde{s}_t^* | \tilde{U}_t^*) = \frac{\delta^* \kappa^* + \phi^* \delta^* + \phi^* \kappa^*}{\delta^* + \kappa^*}$ from $var(\tilde{s}_t^*) = \delta^* + \phi^*$. This makes informed investors trade more aggressively. Both of these effects affect the liquidity parameter λ^* in the pricing function, but in opposite ways. However, it can be show that the former effect is stronger:

[11] The parameter λ^* here is not equal to that when there are no news. Indeed all equilibrium price parameters used in the model should carry a time subscript to reflect whether news are announced or not in a particular period. We omit the time subscript to avoid cluttering the notation.

Proposition 1. *In the foreign market, liquidity increases in news days relative to no news days.*

3.3 LOCAL MARKET, NO LOCAL OR FOREIGN NEWS

Investors in the local stock market observe the time t price of the foreign stock asset R_t^* and use this knowledge to infer the private information of informed investors in that market. Because stock fundamentals are correlated, $\omega_t^* = \lambda;^{*-1}\ (P_t^* - V_t^*)$ is also informative about the local stock market (provided $\lambda^* > 0$). With this additional information, the local economy's informed investors conjecture the pricing function to be

$$\begin{aligned}\tilde{P}_t &= V_t + \lambda\tilde{\omega}_t + \eta\omega_t^* \\ &= V_t + \lambda\tilde{\omega}_t + \eta(\lambda^{*-1}(P_t^* - V_t^*)). \end{aligned} \tag{9}$$

This pricing function implies that returns in both markets are correlated, with the conditional association being given by $\eta\ \lambda^{*-1}$. Cross-country correlation of returns arises because fundamental asset valuations are correlated and foreign returns carry the private information of foreign informed investors about their own asset's valuation. Intuitively, after large price changes in the foreign market, local investors try to infer whether such move was motivated by informed or uninformed trading and use this information to improve their forecasts of local valuations.

Local informed investors solve equation (3) knowing $E[\tilde{P}_{t+1}|\mathcal{I}_t^I] = V_t + E[\tilde{v}_{t+1}|\mathcal{I}_t^I]$, and $\mathcal{I}_t^I = \{V_t, s_t, \omega_t^*\}$. The solution to this problem, described in the appendix, enables us to compute the local aggregate order flow. Given the local and foreign aggregate order flow and $\mathcal{I}_t^M = \{V_t, \omega_t, \omega_t^*\}$, the local market maker sets prices to meet the zero profit condition equation (4). The time t equilibrium is described by:

$$\lambda = \frac{var(\tilde{v}_{t+1}|\omega_t^*)}{n+1}\sqrt{\frac{n}{\zeta var(\tilde{s}_t|\omega_t^*)}}, \tag{10}$$

$$\eta = \frac{\psi}{n^*+1}\sqrt{\frac{n^*}{\zeta^*(\delta^*+\phi^*)}},$$

where $var(\tilde{v}_{t+1}|\omega_t^*) = \delta - \frac{n^*}{(n^*+1)(\delta^*+\phi^*)}\psi^2$ and $var(\tilde{s}_t|\omega_t^*) = \delta + \phi - \frac{n^*}{(n^*+1)(\delta^*+\phi^*)}\psi^2$. The liquidity parameter thus has a similar form and interpretation to those in equations (5) and (7). The parameter η describes how much of the foreign order flow can be used to forecast the local private information, i.e. $E(\tilde{s}_t|\omega_t^*) = \eta\omega_t^*$. The equilibrium asset demand is:

$$x_{it} = \sqrt{\frac{\zeta}{n var(\tilde{s}_t|\omega_t^*)}}(s_t - \eta\omega_t^*). \tag{11}$$

As the order flow from the foreign stock market is public information to all investors (via knowledge of the foreign return), its effects on the asset demand of informed investors are identical to those discussed above regarding the informed asset demand in the foreign country in the presence of public news, equation (8).

We can now state the time t price function:

Proposition 2. *The time t equilibrium price when there are no public news in either market is*

$$P_t - V_t = \lambda \tilde{\omega}_t + \frac{\psi}{\delta^*}(P_t^* - V_t^*).$$

The slope coefficient on foreign returns of regressing local returns on foreign returns and local order flow on no news days is simply the ratio of the covariance of valuations ψ to the variance of the foreign asset value δ^*. On average the correlation of stock returns reflects the correlation on fundamentals, because the local order flow and the foreign stock return are independent in no news days. Finally, looking back at equation (9), if there is no private information in the foreign market $\lambda^* = 0$, foreign returns become uninformative and there is no stock market co-movement.

3.4 LOCAL MARKET WITH LOCAL NEWS, NO FOREIGN NEWS

Suppose now that period t has a public news announcement in the local economy and recall that local news are assumed not to affect investor behavior in the foreign economy. News in the local economy are $\tilde{U}_t = \tilde{v}_{t+1} + \tilde{\mu}_t$, with $E[\tilde{\mu}_t^2] = \kappa$. The market maker is conjectured to choose the following price function:

$$\tilde{P}_t = V_t + \lambda \tilde{\omega}_t + \eta \tilde{\omega}_t^* + \sigma U_t.$$

The appendix describes how the market maker solves out for P_t given $\mathcal{I}_t^M = \{V_t, U_t, \omega_t, \omega_t^*\}$. We show that in equilibrium:

$$\lambda = \frac{var(\tilde{v}_{t+1}|\tilde{\omega}_t^*, \tilde{U}_t)}{n+1}\sqrt{\frac{n}{\zeta var(\tilde{s}_t|\tilde{\omega}_t^*, \tilde{U}_t)}},$$

$$\eta = \frac{\kappa}{var(\tilde{U}_t|\tilde{\omega}_t^*)}\frac{var(\widetilde{v}_{t+1}^*)}{n^*+1}\sqrt{\frac{n^*}{\zeta^* var(\tilde{s}_t^*)}}\frac{\psi}{\delta^*},$$

$$\sigma = \frac{var(\tilde{v}_{t+1}|\tilde{\omega}_t^*)}{var(\tilde{U}_t|\tilde{\omega}_t^*)}.$$

Expressions for the conditional variances are given in the appendix. The appendix also gives the solution to the informed investors' problem given the information set

$\mathcal{I}_t^I = \{V_t, s_t, U_t, \omega_t^*\}$. Equilibrium asset trades of informed investors are:

$$x_{it} = \sqrt{\frac{\zeta}{nvar(\tilde{s}|\tilde{\omega}^*, \tilde{U})}}[s_t - \eta\omega_t^* - \sigma U_t].$$

The parameters η and σ are the components of the linear projection $E[\tilde{s}_t|\tilde{\omega}_t^*, \tilde{U}_t]$ associated with $\tilde{\omega}_t^*$ and $\tilde{U}_t$, respectively. This is because informed investors trade only on the component of their private information that cannot be forecasted with available public information: $\tilde{s}_t - E[\tilde{s}_t|\tilde{\omega}_t^*, \tilde{U}_t] = s_t - \eta\omega_t^* - \sigma U_t$. Adding ω_t does not affect the values of η and σ because the private information contained in the local order flow already 'subtracts' the information in $\tilde{\omega}_t^*$ and $\tilde{U}_t$. We are now ready to give our next result:

Proposition 3. *The local equilibrium price when there are public news in the local market is*

$$\tilde{P}_t - V_t = \lambda\tilde{\omega}_t + \eta\lambda^{*-1}(P_t^* - V_t^*) + \sigma U_t,$$

with

$$\eta\lambda^{*-1} = \frac{\kappa}{var(\tilde{U}_t|\tilde{\omega}_t^*)}\frac{\psi}{\delta^*}. \tag{12}$$

The slope $\eta\ \lambda^{*-1}$ *increases with the noise in the public news,* κ, *and* $\eta\lambda^{*-1} \to \frac{\psi}{\delta^*}$ *if* $\kappa \to \infty$. *Expressions for* λ *and* σ *are given in the appendix.*

The price coefficient η contains three parts. The first is an adjustment for how useful the foreign net order flow is given the local public news ($\kappa/var(\tilde{U}_t|\tilde{\omega}_t^*)$). The second accounts for liquidity in the foreign market (λ^*) and the third measures the ex-ante co-variation between incremental dividends (ψ/δ^*). If the local public news are uninformative and $\kappa \to \infty$, we recover a correlation between markets of $\eta\lambda^{*-1} = \frac{\psi}{\delta^*}$. Also, because the slope in the price equation $\eta\ \lambda^{*-1}$ increases with the uninformativeness of public information κ, it must be that for any informative piece of news $\kappa < \infty$, $\eta\lambda^{*-1} < \frac{\psi}{\delta^*}$. Thus:

Corollary 4. *Days with news in the small, local market display lower correlation of returns between countries than days without news.*

Intuitively, on days of local market news, local prices respond less to foreign prices because some of the information contained in the foreign order flow is disclosed via the local public news. This is true unless the local public news are uninformative and $\kappa = \infty$.

The next result indicates the effect of local news on liquidity:

Proposition 5. *In the local market, liquidity increases on days of local news relative to no news days.*

Recall that public information has two opposing effects. First, it increases the precision of the private information of informed investors, which leads to an increase in adverse selection costs to the market maker and a higher λ. This effect is outweighed by the fact that public news reduces the amount of private information that informed investors trade on (see equation (8)).

3.5 LOCAL MARKET WITH FOREIGN NEWS, NO LOCAL NEWS

When there are news in the foreign economy, but not in the local economy, the foreign order flow incorporates these news. Hence, the local market maker does not care about the total order flow, but he only cares about the component of order flow that is unrelated to news, $\tilde{\omega}_t^* - \beta U_t^*$. We use similar reasoning for the local order flow. Informed investors conjecture that the time t equilibrium price function is:

$$\tilde{P}_t = V_t + \lambda\tilde{\omega}_t + \eta\tilde{\omega}_t^* + \sigma\tilde{U}_t^*.$$

The relevant information sets are $\mathcal{I}_t^I = \{V_t, s_t, U_t^*, \omega_t^*\}$ for informed investors and $\mathcal{I}_t^M = \{V_t, U_t^*, \omega_t, \omega_t^*\}$ for the market maker. The equilibrium expressions for λ, η, and σ are too messy and uninformative and are left to the appendix. Also, we leave the derivation of the informed order flow to the appendix.

The next proposition characterizes the equilibrium pricing rule:

Proposition 6. *The local equilibrium price when there are public news in the foreign market is*

$$\tilde{P}_t - V_t = \lambda\tilde{\omega}_t + \frac{\psi}{\delta^*}(\tilde{P}_t^* - V_t^*).$$

This proposition shows that on days of foreign news the return correlation is the same as the return correlation on days without news, and is higher than that for days with news in the local economy. The intuition for this result is that as news are released in the foreign market, foreign informed investors optimally filter their private information and combine it with the public information in a way that makes the foreign return a sufficient statistic for both foreign private and public information. Foreign news do not contribute to price formation in the local market after accounting for the foreign return.

The proposition can explain the evidence in Karolyi and Stulz (1996), and ours below, that correlations between stock returns in US and Japan do not vary with news announcements in the US, if, as it is reasonable, one takes the Japanese market as a *follower* to the US market in the presence of *US news*. While such lack of connection between fundamentals and international return correlations has often been viewed as evidence of contagion, in our model it occurs because investors in the follower market cannot use the US public news to help them filter the private information of US investors contained in the US return.

Another important result from Proposition 6 is that after controlling for the foreign price, $\tilde{P}_t^* - V_t^*$, foreign news are no longer relevant to forecast local prices. Foreign prices already include the impact of foreign news and local investors' inference accounts for that as well. If we omit the foreign return as an explanatory variable of local prices, foreign news have explanatory power, but as the model suggests foreign returns are a summary statistic for foreign private and public information. Hence, Proposition 6 can be used to explain, without appealing to a contagion story, the results of King, Sentana and Wadhwani (1994), Connolly and Wang (2003), and ours below, where foreign news have no explanatory power for local returns over and above that implied by foreign returns.

3.6 COUNTRY-SPECIFIC NEWS

So far we have treated news in the small, local economy as also being informative of foreign valuations. Consider now that valuations in the small economy are given by $v_{t+1} = v_{1t+1} + v_{2t+1}$, with $E[\widetilde{v}_{1t+1}\tilde{v}^*_{t+1}] = \psi$ and $E[\widetilde{v}_{2t+1}\tilde{v}^*_{t+1}] = 0$. We maintain the normalization that $E[\widetilde{v}^2_{t+1}] = \delta$ so that $E[\widetilde{v}^2_{1t+1}] = \delta_1,\ E[\widetilde{v}^2_{2t+1}] = \delta_2$, and $\delta = \delta_1 + \delta_2$. We wish to characterize the equilibrium in the presence of local country-specific news: $\tilde{U}_t = \widetilde{v}_{2t+1} + \tilde{\mu}_t$, where, abusing notation, $E[\tilde{\mu}_t^2] = \kappa$, and $E[\tilde{U}_t\tilde{v}^*_{t+1}] = 0$. The signal that informed investors in the local economy get is on the common component, $\tilde{s}_t = \tilde{v}_{1t+1} + \tilde{\varepsilon}_t$. The main result below is not affected by this last assumption.

The market maker is assumed to choose the following price function

$$\tilde{P}_t = V_t + \lambda\tilde{\omega}_t + \eta\tilde{\omega}_t^* + \sigma U_t.$$

The appendix shows the equilibrium price parameters and asset trades of informed investors.

Proposition 7. *The local equilibrium price when there are local country-specific public news is*

$$\tilde{P}_t - V_t = \lambda\tilde{\omega}_t + \frac{\psi}{\delta^*}(\tilde{P}_t^* - V_t^*) + \frac{\delta_2}{\delta_2 + \kappa}\tilde{U}_t.$$

Therefore, if all news in the local, small economy are country-specific, then the return correlation should not vary over time. The intuition is straightforward. The foreign return contains information on the common valuation component $\tilde{v}_{1t+1}$, whereas the country-specific news contain information about v_{2t+1}. As these components are orthogonal, so must the news be, and the information content of the foreign return is not affected. In our empirical implementation we test this differential treatment of news by looking at macroeconomic news in Portugal and contrasting its effects with firm-specific earnings news.[12]

In terms of liquidity effects, we have:

Proposition 8. *In the local market, liquidity increases on days of local country-specific news relative to no news days.*

As before, the intuition is that local investors' private information shrinks in days of news reducing the price impact of order flow.

3.7 DISCUSSION OF MAIN MODEL ASSUMPTIONS

The model makes two main assumptions. First, investors in the foreign, large economy are assumed to ignore the public news announced in the local, small economy, but the opposite is not true. This assumption is justified by models of specialization in information acquisition where the choice of where to specialize depends on the assets owned (e.g., Van Nieuwerburgh and Veldkamp, 2006). An alternative justification is the existence of costs to acquire information in the spirit of Grossman and Stiglitz (1980): While local news (possibly in many countries) contain information regarding valuations in the foreign, large economy, the costs to investors in the foreign economy of having to process all the little pieces of dispersed local information when trading in their own market outweigh the benefits.[13] This assumption is strongly supported by the data even between developed economies

[12] To empirically test our model we need to condition on public announcements that reveal relatively more information about country-specific factors than about global factors. The PSI-20 equal weighted and value weighted earnings are not statistically significantly correlated with U.S. GDP growth, while Portuguese GDP growth is significantly correlated with U.S. GDP growth. Hence, in our empirical test we interpret Portuguese macroeconomic news as public announcements that are correlated with U.S. valuations, while earnings announcements predominantly reveal infomation about country-specific factors. Borrowing Poterba's (1990) terminology, earnings announcements are "nearly" country-specific.

[13] Strictly speaking the models in Van Nieuwerburgh and Veldkamp and Grossman and Stiglitz are about acquisition of private information. Our reference to their work presumes that public news requires some filtering to become informative as in Kim and Verrechia (1994).

as indicated above (Andersen, Bollerslev, Diebold, Vega, 2003, Becker, Finnerty and Friedman, 1995, and Ehramann and Fratzscher, 2003) and in our sample, as US returns do not respond to Portuguese news but Portuguese returns respond to US and Portuguese news.

Second, we assume that public news in the foreign economy generate price discovery in the foreign market first and only then in the local market. This assumption is made for tractability as the results on the effects of news on stock market co-movement discussed above do not hinge on it. We have worked out a version of the model above which differs in two main respects.[14] First, there are two trading sessions per day in each country, and trading sessions are concurrent across countries. Second, news in the foreign, large economy are acted upon immediately in both countries as they come out before the first trading session begins (effectively dropping the assumption in question). In addition, as in the model above, informed investors and market makers in the local, small economy also use the order flow from the first trading session of the foreign, large economy as a public signal on the payout in their market. While we solve for the equilibrium in this alternative setup, we are not able to derive clean analytical results as we do with our model above. We therefore, resort to numerical examples. We can show that in days with news in the foreign, large economy there is a small increase in stock market co-movement, whereas in days with news in the local, small economy there is a relatively larger (in absolute value) decline in stock market co-movement. Moreover, the results suggest that small levels of noise in the foreign public news can quickly lead to no change in stock market co-movement, whereas for similar amounts of noise in local public news co-movement can still decline significantly. In summary, this alternative framework shows that our main results are robust to the assumption that public news in the foreign economy generate price discovery in the foreign market first and only then in the local market.

There is another important property of this alternative model that is consistent with the findings above. We find in our numerical examples that foreign news are much less relevant to forecast local prices after controlling for the foreign price, $\tilde{P}_t^* - V_t^*$. As before this is because foreign prices act as a sufficient statistic for public and private information in the foreign market, subsuming the information contained in the public news.

4. Data Description

We conduct our analysis using Portuguese and US stock market and public announcements data. As mentioned in the Introduction, the choice of Portugal is motivated (*i*) by the quality and availability of high frequency Portuguese stock

[14] Notes are available from the authors upon request.

Table 1A Individual Stock Components of the PSI-20

This table lists the Portuguese stocks used in our empirical analysis, the ticker symbol, company name, the exchange they are more frequently traded in, the average number of transactions per day, the average number of limit orders placed per day and the percentage of orders that are limit orders. The stocks are ordered from highest to lowest market capitalization. The sample period is from January 4, 2002 to October 15, 2002.

Ticker Symbol	Company Name	Exchange	Transactions	Limit	Percent
PT	Portugal Telecom, SGPS - Nom.	Euronext Lisbon	1503	2816	93
BCP	Banco Comercial Português	Euronext Lisbon	462	879	86
BES	Banco Espírito Santo	Euronext Lisbon	79	161	87
EDP	EDP	Euronext Lisbon	471	1097	84
BRISA	Brisa (Priv.)	Euronext Lisbon	358	738	87
CIMPOR	CIMPOR, SGPS	Euronext Lisbon	104	297	89
BPI	BPI, SGPS	Euronext Lisbon	189	444	93
PTM	PT Multimédia, SGPS - Nom.	Euronext Lisbon	175	358	91
SONAE	Sonae, SGPS	Euronext Lisbon	193	564	94
JM	Jerónimo Martins, SGPS	Euronext Lisbon	126	337	94
PORTUCEL	Portucel	Euronext Lisbon	64	183	91
SEMAPA	Semapa, SGPS	Euronext Lisbon	27	101	91
SNC	Sonae.com, SGPS	Euronext Lisbon	211	501	92
TD	Teixeira Duarte, SA	Euronext Lisbon	17	67	88
SAG	SAG - Gest, SGPS	Euronext Lisbon	19	73	85
NB	Novabase, SGPS	Euronext Lisbon	40	120	87
IMPRESA	Impresa, SGPS	Euronext Lisbon	184	427	93
COFINA	Cofina, SGPS	Euronext Lisbon	26	88	91
IBERSOL	Ibersol, SGPS	Euronext Lisbon	15	67	96
PARAREDE	Pararede, SGPS	Euronext Lisbon	101	334	93

market data and (*ii*) by the fact that Portugal is a small economy with large exposure to the worldwide economy and vulnerable to US news announcements, while there is immunity of the US economy to Portuguese shocks. The later point implies that our analysis is not subject to the usual endogeneity bias present in studies of international stock market co-movement. The data are unique in several respects, such as the simultaneous high frequency data in the US and Portuguese stock markets and the availability of signed trades in the Portuguese stock market. Here we describe them in detail.

4.1 PORTUGUESE AND US STOCK MARKET DATA

We analyze the individual components of the main Portuguese stock market index, the PSI-20 Index, and the individual components of the DJ 30 Industrial Index (DJI-30) listed in Table 1A and Table 1B respectively.[15] Our sample period is determined

[15] The actual DJ-30 Industrial index is a price weighted measure. In this paper, we construct our own index using individual daily stock returns and taking a value-weighted average.

Table 1B Individual Stock Components of the DJ 30 Industrial Index

This table lists the US stocks used in our empirical analysis, the ticker symbol, company name, the exchange they are more frequently traded in, the average number of transactions per day and the average number of quotes per day. The stocks are ordered from highest to lowest market capitalization. The sample period is from January 4, 2002 to October 15, 2002.

Ticker Symbol	Company Name	Exchange	Trades	Quotes
GE	General Electric Corporation	NYSE	5005	6826
MSFT	Microsoft Corp.	NASDAQ	68213	76353
XOM	Exxon Mobil Corporation	NYSE	3427	5570
WMT	Wal Mart Stores Inc.	NYSE	2768	4828
C	Citigroup Inc.	NYSE	3889	6244
JNJ	Johnson & Johnson	NYSE	2375	3425
INTC	Intel Corp	NASDAQ	65596	72147
IBM	International Business Machines Corp.	NYSE	3277	8828
KO	Coca Cola Co	NYSE	2180	3612
MRK	Merck CO Inc.	NYSE	2393	3711
PG	Procter & Gamble Co	NYSE	2588	5754
MO	Philip Morris Companies Inc.	NYSE	2976	4812
SBC	S B C Communications Inc.	NYSE	2935	4534
HD	Home Depot Inc.	NYSE	3433	4853
JPM	J P Morgan Co	NYSE	2949	4832
T	AT&T Corp.	NYSE	2094	3232
HPQ	Hewlett Packard Co	NYSE	2537	3703
AXP	American Express Company	NYSE	2602	4178
MMM	Minnesota Mining & Mfg Co (3M Co)	NYSE	1782	3841
DD	Du Pont De Nemours E I & Co	NYSE	1972	3903
DIS	Walt Disney Company	NYSE	2878	5633
BA	Boeing Company	NYSE	2178	3990
MCD	Mcdonalds Corp	NYSE	2174	3450
UTX	United Technologies Corp	NYSE	1830	3476
GM	General Motors Corp	NYSE	2318	5284
HON	Honeywell International Inc	NYSE	1769	3505
AA	Alcoa Inc	NYSE	1809	3138
IP	International Paper Co	NYSE	1812	3553
CAT	Caterpillar Inc	NYSE	1464	3168
EK	Eastman Kodak CO	NYSE	1222	2519

by the availability of high frequency stock market data from Euronext Lisbon (called Bolsa de Valores de Lisboa e Porto until 2/6/2003) and is comparable with most studies that make use of very high-frequency data. This database contains all time-stamped transactions, signed trades and bid/ask quotes from January 4, 2002 to October 15, 2002. In total there are 195 trading days and 2,441,490 orders. Since the data contains the number of buyer-initiated and seller-initiated trades, we can measure order flow without any error. As it is shown in Table 1A, the majority of the orders (between 84 to 96 percent) are limit orders and the liquidity of the market, measured by the number of transactions, is highly correlated with market capitalization. When we analyze daily co-movement between the US and Portuguese stocks we only use Portuguese limit orders that were placed and executed on the same day (see, Antão, Antunes and Martins, 2004).

For the United States we use Trades and Quotes (TAQ) data, which contains bid quotes, ask quotes and transaction prices from stocks traded in different US stock markets. To calculate the daily number of buys and sells we use the Lee and Ready (1991) algorithm for NYSE listed stocks and the Ellis, Michaely and O'Hara (2000) suggested variation of the Lee and Ready algorithm for Nasdaq listed stocks.[16] We only use trades and quotes from the exchange they are most frequently traded in, which in our case coincides with the exchange they are listed in.

One of the main problems of using daily returns to measure asset market co-movement is the existence of non-synchronous trading periods around the globe (e.g., Karolyi and Stulz, 1996). Since stock markets around the world close at different times, measuring returns at closing is not appropriate for the study of contemporaneous stock market correlations. We avoid this problem taking advantage of our high frequency data and estimating daily returns using 11:30 ET prices, which correspond to Portuguese stock market closing prices. An advantage of using 11:30 ET prices is that the US stock market has been open for two hours and most US macroeconomic news announcements are released at 8:30 and 10:00 ET. Using prices close to these announcement release times allows us to measure more accurately the news effect on US and Portuguese prices (Andersen et al., 2003). While we note that our qualitative results do not depend on using 11:30 ET prices, the results do depend on measuring synchronous returns between the two countries.

In Table 2A and 2B, we give descriptive statistics for the Portuguese and US stock market returns for trading days common to both countries from January 4, 2002 to October 15, 2002. In total there are 189 trading days. The tables show that the average market capitalization of the components of the DJ 30 Index (100 billion dollars) is approximately 50 times larger than the average market capitalization of the individual components of the Portuguese PSI-20 (2 billion dollars). Liquidity, measured by the bid-ask spread divided by the average daily price in the sample, is twenty six times higher in the US market compared to the Portuguese market, and daily return volatility is 1.5 times larger in the US market than in the Portuguese market.

[16] Odders-White (2000), Lee and Radhakrishna (2000) and Ellis, Michaely, and O'Hara (2000) evaluate how well the Lee and Ready algorithm performs and they find that the algorithm is 81% to 93% accurate, depending on the sample and stocks studied.

Table 2A PSI-20 Summary Statistics

This table presents daily descriptive statistics for the individual components of the Portuguese PSI-20 stock market index. The first two columns report the daily mean and standard deviation of firm-specific stock returns measured as the difference in log prices from 11:30 ET today to 11:30 ET the previous day. The third column reports the daily standard deviation of unanticipated order flow estimated using Hasbrouck (1991) VAR model. The last three columns report the mean percentage spread, market capitalization and order execution time. The percentage spread is the ask price minus the bid price divided by the average daily price, market capitalization (size) is measured in millions of euros, and the order execution time is defined as the time it takes for a limit order to be executed conditional on the order being executed on the same day it is placed.

Ticker Symbol	Mean Return	Std. Return	Std. Order Flow	Mean % Spread	Mean Size	Mean Time
PT	−0.2564	2.10	181.87	0.109	8215.563	13.959
BCP	−0.3916	1.81	67.07	0.288	5304.910	23.529
BES	−0.1602	1.90	13.03	0.300	3750.000	23.123
EDP	−0.2171	1.52	66.71	0.467	3298.312	32.208
BRISA	0.0400	1.42	64.25	0.227	2842.007	20.424
CIMPOR	−0.0814	1.46	19.43	0.442	1934.312	25.722
BPI	−0.1125	1.66	43.83	0.431	1656.800	28.744
PTM	−0.1523	1.91	24.63	0.372	1571.596	22.906
SONAE	−0.3696	1.99	26.96	1.504	800.000	34.870
JM	−0.2341	2.02	18.76	0.522	666.218	27.729
PORTUCEL	−0.0020	1.36	11.98	0.783	394.188	38.139
SEMAPA	−0.1387	1.39	8.40	1.035	390.497	38.373
SNC	−0.4162	2.30	28.71	0.486	355.213	27.987
TD	−0.2712	1.22	6.88	1.185	273.000	38.180
SAG	−0.0836	0.93	7.33	0.742	222.000	31.298
NB	−0.3576	1.42	9.12	0.714	163.885	31.481
IMPRESA	−0.2168	2.20	26.45	0.588	136.800	28.044
COFINA	−0.0761	1.22	8.64	1.072	116.500	40.170
IBERSOL	−0.1118	1.21	4.21	1.351	70.000	34.125
PARAREDE	−0.6867	3.90	20.22	3.326	25.018	30.327

To obtain a measure of trading driven by private information we follow the microstructure literature and estimate the unexpected portion of aggregate order flow using the linear autoregressive model of Hasbrouck (1991, 2007),

$$x_{ih}^{por} = a_{xi} + b_i(L)r_{ih}^{por} + c_i(L)x_{ih}^{por} + v^{por}(x)_{ih}, \tag{13}$$

$$x_{ih}^{us} = a_{xi}^{*} + b_i^{*}(L)r_{ih}^{us} + c_i^{*}(L)x_{ih}^{us} + v^{us}(x)_{ih}, \tag{14}$$

where x_{ih}^{por} (x_{ih}^{us}) is the transaction by transaction net order flow for local (foreign) asset i for time interval h, r_{ih}^{por} (r_{ih}^{us}) is the quote revision change for local (foreign) asset i for time interval h, and $b(L)$, $b^{*}(L)$, $c(L)$ and $c^{*}(L)$ are polynomials in the lag operator. As in Hasbrouck (1991), we do not set the lag length optimally using the

Table 2B DJ 30 Industrial Index Summary Statistics

This table presents daily descriptive statistics for the individual components of the US DJ 30 Industrial index. The first two columns report the daily mean and standard deviation of firm-specific stock returns measured as the difference in log prices from 11:30 ET today to 11:30 ET the previous day. The third column reports the daily standard deviation of unanticipated order flow estimated using Hasbrouck (1991) VAR model. The last two columns report the mean percentage spread and market capitalization. The percentage spread is the ask price minus the bid price divided by the average daily price and market capitalization (size) is measured in billions of dollars.

	Mean Return	Std. Return	Std. Order Flow	Mean % Spread	Mean Size
GE	−0.267	2.87	106.44	0.065	309.804
MSFT	−0.186	2.41	301.38	0.006	295.425
XOM	−0.07	2.06	77.85	0.068	257.870
WMT	−0.019	1.97	70.01	0.062	246.777
C	−0.236	3.29	74.53	0.084	205.566
JNJ	−0.02	2.38	80.53	0.068	176.798
INTC	−0.431	3.63	351.17	0.011	156.148
IBM	−0.326	2.74	91.77	0.063	145.065
KO	0.052	1.61	69.38	0.059	123.754
MRK	−0.128	2.17	70.28	0.063	122.944
PG	0.058	1.42	75.28	0.047	113.952
MO	−0.091	2.06	95.75	0.055	103.439
SBC	−0.296	3.08	80.45	0.096	102.786
HD	−0.242	2.71	88.96	0.077	88.688
JPM	−0.361	3.76	77.95	0.108	57.642
T	−0.227	3.15	79.33	0.129	57.396
HPQ	−0.333	3.10	88.59	0.114	52.534
AXP	−0.058	2.97	80.85	0.094	49.408
MMM	0.014	1.77	51.23	0.055	47.732
DD	−0.036	2.37	65.76	0.078	44.984
DIS	−0.186	2.88	101.11	0.113	40.387
BA	−0.13	2.45	77.87	0.099	31.746
MCD	−0.219	2.04	76.52	0.095	31.122
UTX	−0.068	2.34	60.1	0.079	30.978
GM	−0.173	2.43	78.49	0.065	27.539
HON	−0.252	2.95	68.07	0.117	25.841
AA	−0.267	2.77	65.57	0.100	25.269
IP	−0.066	2.07	71.9	0.076	19.143
CAT	−0.162	2.23	59.35	0.078	16.530
EK	0.018	2.40	52.28	0.101	9.127

Akaike and Schwarz information criteria. Instead we choose 25 lags for all assets and all polynomials because this lag structure is sufficient to eliminate all the serial correlation in the data. However, the results that follow do not rely on this particular lag structure. Index h in equations (13) and (14) is not a wall-clock index, but an event index, i.e., it is incremented whenever a trade occurs or a quote is revised

(Hasbrouck (2001, 2007)).[17] As Hasbrouck (2007, p. 39) notes, the overnight return will almost certainly have different properties than the intraday return. Hence, we follow Hasbrouck's suggestion and drop the overnight return.[18]

In Section 6, we focus on daily horizons: Broader intervals lead to less powerful tests of market co-movement (Karolyi and Stulz, 1996) and of the influence of macroeconomic fundamentals (Andersen et al., 2003, and 2005). Thus, we compute aggregate unexpected net order flow over each day t, Ω_t^{por} and Ω_t^{us}, by summing the residuals of equation (13) (equation (14)) within each day. Consistent with the daily return definition we aggregate order flow from 11:30 ET the previous day to 11:30 ET today.

4.2 MACROECONOMIC AND EARNINGS DATA

To estimate news surprises for the United States and Portugal, we use data from four different sources: Bloomberg, International Money Market Services (MMS), Reuters and IBES. We use Bloomberg to collect real-time data on the realizations of 9 of the most relevant Portuguese macroeconomic announcements, including the European Central Bank (ECB) benchmark refinancing interest rate. Bloomberg only reports professional forecasts for the Portuguese CPI and we construct our own forecast for the remaining series listed in Table 3A. In untabulated results, we show that a seasonal random walk describes the data well.[19] The absence of Portuguese expectations data means that our surprise measures for Portugal are noisier than those for the US. Forshadowing some of our subsequent results, it could be the

[17] The choice between an event index and a wall-clock index depends on the goals of the analysis. If the analysis involves a single security, as it is the case in estimating equations (13) and (14), an event index is better than a wall-clock index because the process is more likely to be covariance stationary in event time than in wall-clock time (Hasbrouck (2007, p. 90)). However, when conducting a cross-sectional analysis or estimating a pooled regression, comparability across securities becomes the dominant consideration and that is why we adopt a wall-clock time in Section 6.

[18] The results that follow are robust to different specifications of equations (13) and (14). For example, we sample at 5-minute intervals, and instead of dropping the overnight return we weigh the overnight return by 211 (the number of overnight 5-minute intervals). The evidence presented below is qualitatively and quantitatively similar to that obtained using this alternative sampling procedure, as well as using the aggregate raw (rather than unanticipated) order flow. The robustness of the results reflect the fact that regardless of the specification the R^2 of equations (13) and (14) are close to 0.05, so that aggregate raw order flow and unanticipated order flow are highly correlated.

[19] We estimate the optimal forecast of these series using the Bloomberg sample period from July 7, 1997 to September 8, 2005. The in-sample period starts in July 7, 1997 and ends in December 31, 2004 and the out-of-sample period is from January 1, 2005 to September 8, 2005. Since we need historical data to calculate these optimal forecasts we are unable to use the following Portuguese macroeconomic announcements which started to be reported in Bloomberg in 2002 or in later years: Government Budget Deficit, Total Construction Licenses, Consumer Confidence, Labor Costs, Manufacturing Production and New Car Sales.

Table 3A Portuguese Macroeconomic News Announcements

Portuguese news announcements are partitioned into three groups: real activity, net-exports and prices. Within each group, we list Portuguese news announcements in chronological order of their release. The first column lists the total number of observations in our sample period from January 4, 2002 to October 15, 2002, the second column lists the agency that releases the public announcement, Instituto Nacional de Estatística (INE) and the European Central Bank (ECB), the third column lists the pre-scheduled release time (Eastern Standard Time), the last two columns report the mean and standard deviation of the surprise estimated using equation (15).

Announcements[1]	Obs[2]	Source	Time[3]	Mean	Std. dev.	DOW[4]
Real activity	Quarterly Announcements					
1- GDP	3	INE	6:00	−1.509	0.756	Varies
2- Unemployment Rate	3	INE	6:00	0.432	0.299	Varies
	Monthly Announcements					
3- Industrial Production	10	INE	6:00[5]	0.009	0.765	Varies
4- Industrial Sales	10	INE	6:00[6]	−0.089	1.079	Varies
5- Retail Sales	10	INE	6:00[7]	−0.050	0.796	Varies
Net Exports						
6- Trade Balance	7	INE	Varies	0.006	0.536	Varies
Prices						
7- Consumer Price Index	9	INE	6:00	−0.125	0.936	Varies
8- Producer Price Index	9	INE	6:00[8]	−0.402	1.126	Varies
	European Announcements					
9- ECB benchmark refinancing rate	8	ECB	7:45[9]	−2.773	0.928	Varies

1. Since we need historical data to estimate optimal forecasts we were unable to analyze the following Portuguese announcements which started to be released in 2002 or later: Government Budget Deficit, Total Construction Licenses, Consumer Confidence, Labor Costs, Manufacturing Production and New Car Sales.
2. Total number of observations in our sample period from January 4, 2002 to October 15, 2002.
3. Release times vary in Portugal.
4. Day of the week of announcement release.
5. Industrial Production was released at 10:00 ET on January 8, 2002, at 11:00 ET on March 13, 2002 and at 5:00 ET on April 5, 2002.
6. Industrial Sales was released at 10:00 ET on January 16, 2002.
7. Retail Sales was released at 10:00 ET on June 11, 2002.
8. Producer Price Index was released at 10:00 ET on January 25, 2002.
9. The ECB announces the benchmark interest rate at 7:45 ET, and the President of the ECB, Willem F. Duisenberg, holds a press conference that ends anytime between 8:50 to 10:00 ET.

case, then, that Portuguese surprises do not affect US returns because they are too noisy. Howevever, we find that Portuguese surprises have a statistically significant effect on Portuguese returns and Portuguese announcements have an effect on

Table 3B US Macroeconomic News Announcements

US news announcements are partitioned into seven groups: real activity, each of the GDP components (consumption, investment, government purchases and net exports), prices, and forward-looking. Within each group, we list US news announcements in chronological order of their release. The last two columns list the mean and standard deviation of the surprise estimated using equation (15).

Announcements	Obs[1]	Source[2]	Time[3]	Mean	Std. Dev.	DOW[4]
Real Activity						
	Quarterly Announcements					
1- GDP Advance	3	BEA	8:30	0.342	1.649	Varies
2- GDP Preliminary	3	BEA	8:30	0.497	1.386	Varies
3- GDP Final	3	BEA	8:30	1.108	0.508	Varies
	Monthly Announcements					
4- Nonfarm Payroll	10	BLS	8:30	−0.069	0.349	Friday[5]
5- Retail Sales	9	BC	8:30	0.143	0.975	Varies
6- Industrial Production	8	FRB	9:15	0.074	1.010	Varies
7- Capacity Utilization	8	FRB	9 : 15	0.175	0.856	Varies
8- Personal Income	8	BEA	8:30	0.049	0.680	Varies
9- Consumer Credit	9	FRB	15:00	0.352	2.174	Varies
Consumption						
10- New Home Sales	9	BC	10:00	0.262	1.038	Varies
11- Personal Consumption Expenditures	8	BEA	8:30	−0.146	0.669	Varies
Investment						
12- Durable Goods Orders	9	BC	8:30	0.284	1.020	Varies
13- Factory Orders	10	BC	10:00	−0.147	0.726	Varies
14- Construction Spending	7	BC	10:00	−0.188	1.081	Varies
15- Business Inventories	10	BC	8:30	0.171	0.886	Varies
Government Purchases						
16- Government Budget	9	FMO	14:00	−0.129	0.510	Varies
Net Exports						
17- Trade Balance	9	BEA	8:30	−0.168	1.118	Varies
Prices						
18- Producer Price Index	10	BLS	8:30	−0.546	1.076	Varies
19- Consumer Price Index	9	BLS	8:30	−0.377	0.768	Varies
Forward-Looking						
20- Consumer Confidence Index	9	CB	10:00	0.083	1.062	Tuesday[6]
21- NAPM Index	8	NAPM	10:00	0.113	1.330	Varies
22- Housing Starts	9	BC	8:30	0.103	0.572	Varies
23- Index of Leading Indicators	9	CB	8:30	0.302	1.126	Varies

co-movement. These results further validate our forecasts as good proxies for market expectations.

We use one-month Euribor futures data from Bloomberg to estimate the ECB interest rate market expectation, following the method described in Kuttner (2001)

Table 3B US Macroeconomic News Announcements (continued)

Announcements	Obs[1]	Source[2]	Time[3]	Mean	Std. Dev.	DOW[4]
	Six-Week Announcements					
24- Target Federal Funds Rate	6	FRB	14:15	−0.525	0.605	Tuesday[7]
	Weekly Announcements					
25- Initial Unemployment Claims	40	ETA	8:30	0.139	1.045	Thursday

1. Total number of observations in our sample period from January 4, 2002 to October 15, 2002.
2. Bureau of Labor Statistics (BLS), Bureau of the Census (BC), Bureau of Economic Analysis (BEA), Federal Reserve Board (FRB), National Association of Purchasing Managers (NAPM), Conference Board (CB), Financial Management Office (FMO), Employment and Training Administration (ETA).
3. Eastern Standard Time. Daylight savings time starts on the first Sunday of April and ends on the last Sunday of October.
4. Day of the week of announcement release.
5. Nonfarm Payroll is released the first Friday of the month.
6. The Conference Board's Consumer Confidence Index is released the last Tuesday of the month.
7. The FOMC has eight scheduled meetings per year. Since March 22, 1994 these meetings are usually scheduled on Tuesday, except for the first meeting of the year, which is a two-day meeting starting on Tuesday and ending on Wednesday when the announcement is released to the public.

and Cochrane and Piazzesi (2002) among others, who use the current month federal funds futures contract and the one-month Eurodollar deposit rate, respectively, to estimate the market expectation of the federal funds target rate. The Portuguese Central Bank does not control the ECB benchmark interest rate, yet it is the Portuguese monetary policy instrument. Hence, we do not consider it a Portuguese macroeconomic announcement (as we consider the federal funds rate a US macroeconomic announcement), but we control for its effect in all of our empirical specifications.

We use MMS real-time data on the realizations of 25 of the most relevant US macroeconomic announcements. For 24 US macroeconomic announcements listed in Table 3B, we use the MMS median forecast, which is better than our own univariate forecasts (see Andersen et al., 2003, for a detailed description of the MMS data). We use the one-month Eurodollar futures deposit rate from Bloomberg to estimate the market expectation of the federal funds target rate, but note that our results would not change if we used the current month Federal funds futures contract. Table 3A and 3B provides a brief description of the most salient characteristics of US and Portuguese macroeconomic news announcements: the total number of observations in our sample, the agency reporting each announcement, and the time the announcement is released. If an announcement is released after 11:00 ET, we control for its effect on the next days return, which is calculated from 11:00 ET the next day to 11:00 ET today.

We use the individual firms' earnings announcements to analyze the effect that Portuguese country-specific news have on the US-Portuguese stock market co-movement and to control for non-global US public announcements. We use IBES and Reuters data to measure the US and Portuguese earnings realizations and expectations, respectively. Since Reuters does not collect data for all Portuguese stocks, we use the previous year's earnings when the forecast is not available.[20]

We define announcement surprises as the difference between announcement realizations and their corresponding expectations. More specifically, since units of measurement vary across variables, we standardize the resulting surprises by dividing each of them by their sample standard deviation. The standardized news associated with announcement indicator j on day t is therefore computed as

$$S_{jt} = \frac{A_{jt} - E_{jt}}{\widehat{\sigma}_j}. \qquad (15)$$

A_{jt} is the announced value of indicator j E_{jt} is the respective market expectation as described above, and $\widehat{\sigma}_j$ is the sample standard deviation of $A_{jt} - E_{jt}$ estimated using the full sample period of expectations and announcements. Standardizing surprises facilitate the aggregation of news and any comparison of stock price responses to different news. Operationally, we estimate the responses by regressing stock price changes on news. Because $\widehat{\sigma}_j$ is constant for any indicator j, the standardization affects neither the statistical significance of the response estimates nor the fit of the regressions. In Table 3A and 3B we show the sample mean and standard deviation of each news announcement surprise for Portugal and the United States between January 4, 2002 and October 15, 2002. The standardized variables show a standard deviation that is not equal to one, because the standard deviation we use was obtained in a longer sample, that is not restricted by availability of stock market data, with the purpose of more accurately measuring the standard deviation of the surprises.

To keep the analysis parsimonious, we aggregate the macroeconomic announcements into seven groups as underlined in Table 3B: real activity, each of the GDP components (i.e., consumption, investment, government purchases and net exports), prices, and forward-looking announcements. For example, US real activity surprises are defined as the sum of the following standardized surprises (according to equation (15)): GDP Advance, GDP Preliminary, GDP Final, Nonfarm Payroll, Retail Sales, Industrial Production, Capacity Utilization, Personal Income and Consumer

[20] Reuters collects data regarding certain Portuguese firms from investment bank professional forecasters, e.g. Caixa Valores, Deutsche Bank, Banco Espírito Santo, Banco Finantia, Banco Santander Central Hispano, BPI, Lehman Brothers, etc. Reuters does not collect data for the following Portuguese firms: COFINA, IBERSOL, IMPRESA, NB, PARAREDE, PORTUCEL, PTM, SAG, SEMAPA, SONAE and TD.

Credit; while Portuguese real activity surprises are defined as the sum of GDP, the Employment Report, Industrial Production and Industrial Sales standardized surprises. The benchmark interest rate announcements and the weekly announcements are not aggregated because interest rate announcements do not fall into any of the categories described above and weekly announcements are more volatile than quarterly and monthly announcements. The aggregation is solely done for expositional purposes and does not affect the conclusions of the paper as we show in the robustness section below. We denote Portuguese macroeconomic news by $S_{p_{por}}$, Portuguese firm-specific earnings by $S_{p_{epor}}$, US macroeconomic news by $S_{p_{us}}$, US firm-specific earnings by $S_{p_{eus}}$ and ECB public news surprises by $S_{p_{ecb}}$. As we described above, $p_{por} = 1, 2, 3$ corresponds to the three groups underlined in Table 3A: real activity, net exports and prices; $p_{us} = 1, 2, \ldots 9$ corresponds to the target federal funds rate announcement, initial unemployment claims and the seven groups underlined in Table 3B: real activity, each of the GDP components (i.e., consumption, investment, government purchases and net exports), prices, and forward-looking announcements.

5. The High-Frequency Flow of Information

This section provides evidence for our model assumption that US news generate price discovery first in the US and only after in other economies. For this purpose, we analyze the high-frequency response in the local and foreign stock markets to US news surprises.

We calculate cumulative 5-minute responses of the Portuguese and US stock market returns to foreign public news in two scenarios: (*i*) the Portuguese stock market is open, but the US stock market is not (Figures 2A and 2B), and (*ii*) the Portuguese and US stock markets are both open (Figures 3A and 3B). We estimate the following contemporaneous pooled stock market response:

$$r_{ihn}^{us} = a^{us} + \sum_{p_{us}=1}^{9} \lambda_{p_{us}n}^{us} S_{p_{us}h} + \varepsilon_{ih}^{us}, \tag{16}$$

$$r_{ihn}^{por} = a^{por} + \sum_{p_{us}=1}^{9} \lambda_{p_{us}n}^{por} S_{p_{us}h} + \varepsilon_{ih}^{por}, \tag{17}$$

where $r_{ihn}^{por} = (\ln(P_{ih+n}^{por})) - \ln(P_{ih}^{por})) \times 100$ is the n-minute individual stock return for Portuguese firm $i = 1, \ldots, 20$, and $r_{ihn}^{us} = (\ln(P_{ih+n}^{us}) - \ln(P_{ih}^{us})) \times 100$ is the n-minute individual stock return for US firm $i = 1, \ldots, 30$. The return is measured from just before an announcement takes place at time h to n-minutes after the announcement is made, where $n = 5, 10, \ldots$ Therefore, the response coefficients to

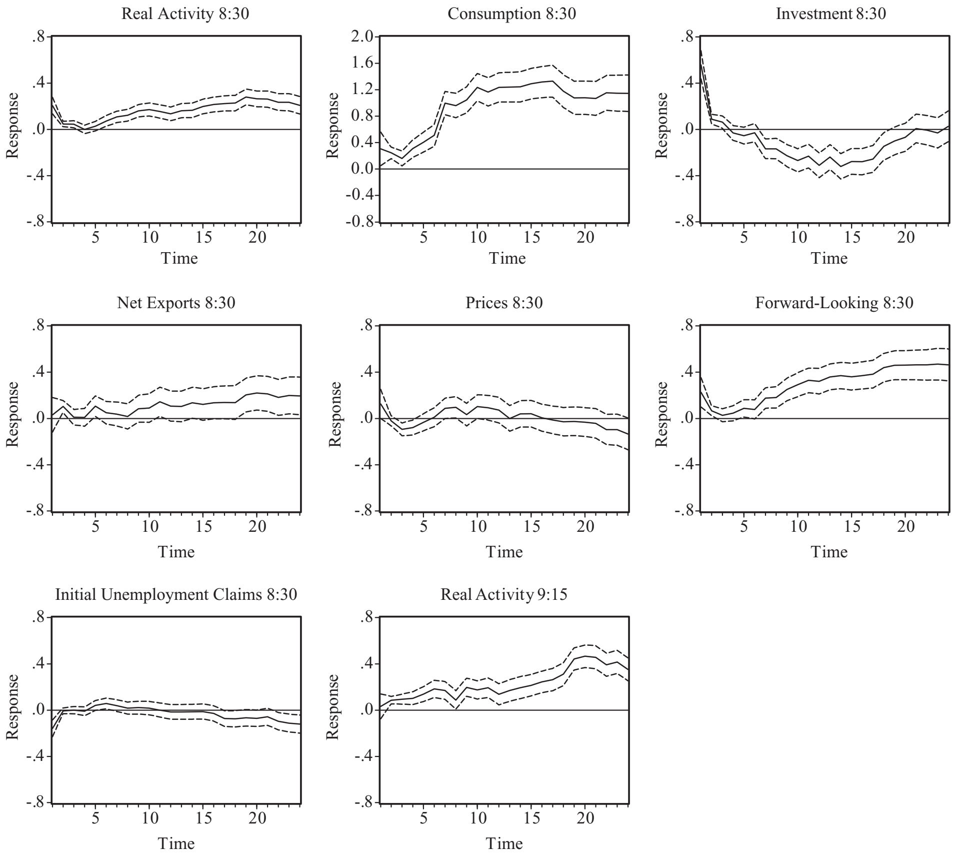

Figure 2A. US Response to 8:30 and 9:15 ET US Macroeconomic Announcements

We plot $\lambda^{us}_{p_{us}n}$ (equation (16), solid line in the graphs), the cumulative US response to 8:30 and 9:15 ET US macroeconomic announcements. Since the US stock market is not yet open, the first tick in all panels on the x-axis captures the US stock market response from the previous day's close to 9:35 ET, the second tick captures the cumulative response from the previous day's close to 9:40 ET, and so on. The last tick captures the response from the previous day's close to 11:30 ET. We also plot (dashed lines) two 95% standard error bands, under the null hypothesis of a zero response, obtained using the least-squares estimation method described in the text (equation (16)).

macroeconomic announcement $p_{us}\lambda_{p_{us}n}$, are indexed by n to indicate that they vary as we extend the return horizon. The variable $S_{p_{us}h}$ is the aggregate standardized news surprise corresponding to the group of announcements indexed by p_{us} made at time h. Since we estimate equations (16) and (17) using only those observations $(r^{por}_{ihn}, r^{us}_{ihn}, S_{p_{us}h})$ such that an announcement was made at time h, there is no need to control for heteroskedasticity (see equation (3) in Andersen et al., 2003).

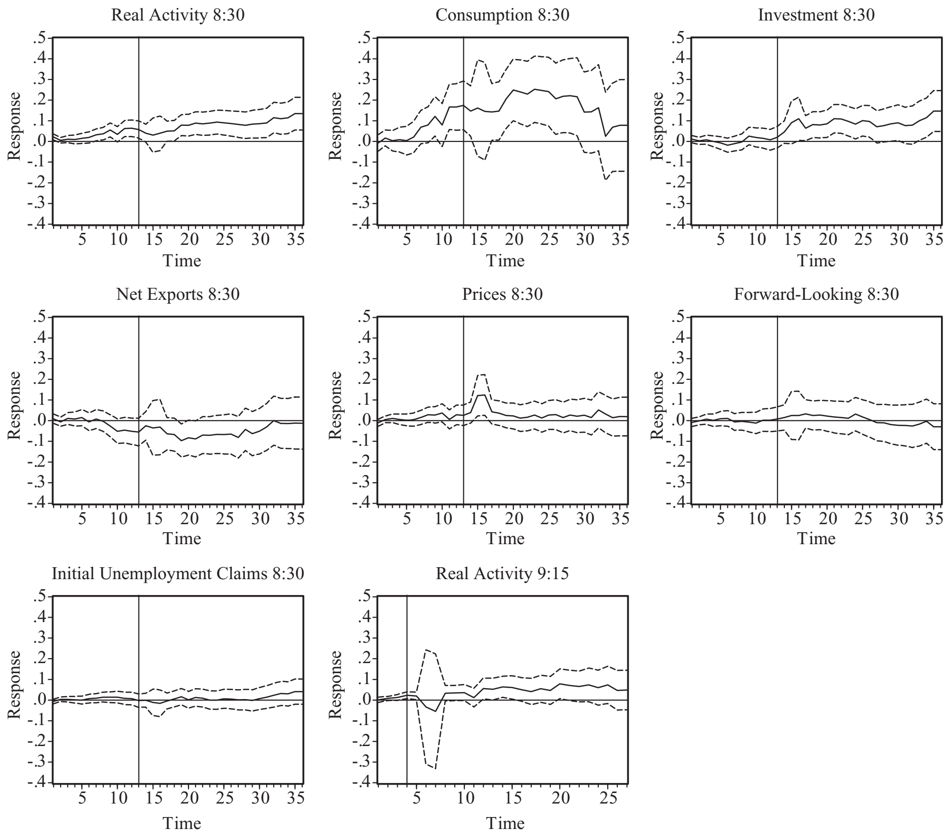

Figure 2B. Portuguese Response to 8:30 and 9:15 ET US Macroeconomic Announcements

We plot $\lambda^{us}_{p_{us}n}$ (equation (17), solid line in the graphs), the cumulative Portuguese response to 8:30 and 9:15 ET US macroeconomic announcements. The zero tick of the x-axis in each plot coincides with the time indicated in the title of the plot. Each tick advances time by 5 minutes. For example, in the top left hand corner plot the first tick indicates 8:35 ET and the return is measured from just before 8:30 ET to 8:35 ET. The second tick indicates 8:40 ET and the return is measured from just before 8:30 ET to 8:40 ET. The vertical line corresponds to 9:30 ET when the US stock market opens. The last tick captures the response from the time indicated in the title of the plot to 11:30 ET. We also plot (dashed lines) two 95% standard error bands, under the null hypothesis of a zero response, obtained using the least-squares estimation method described in the text (equation (17)).

US News Released When the US Market is Closed and the Portuguese Market is Open

We estimate the reaction to the 8:30 and 9:15 ET US macroeconomic announcements. In each panel of Figure 2A we plot $\lambda^{us}_{p_{us}n}$, the cumulative n-minute US return response following the announcement. Since the US stock market is not yet

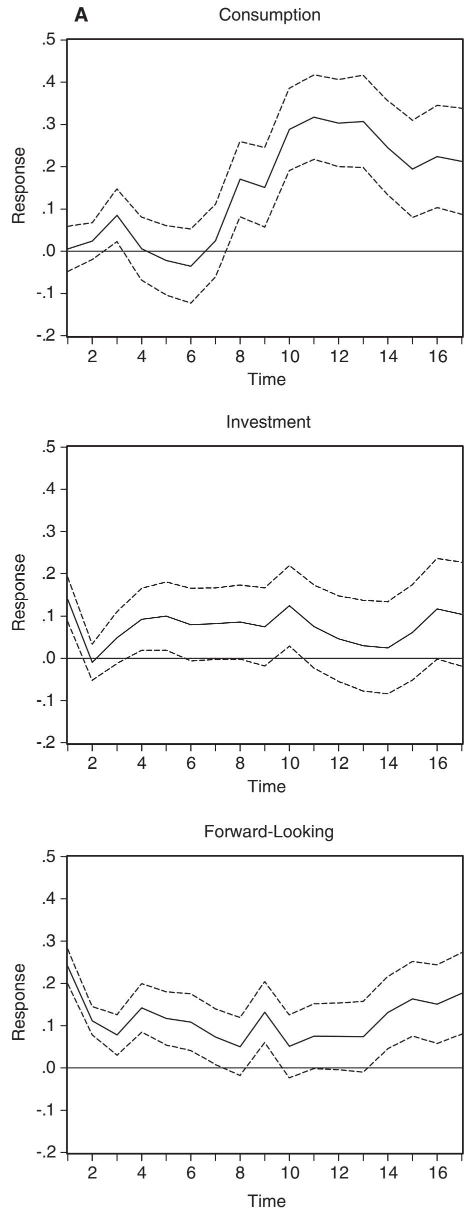

Figure 3A. US Response to 10:00 ET US Macroeconomic Announcements

We plot $\lambda^{us}_{p_{us}n}$ (equation (16), solid line in the graphs), the cumulative US response to 10:00 ET US macroeconomic announcements. The first tick in all panels on the x-axis captures the US stock market response from 10:00 to 10:05 ET, the second tick captures the cumulative response from 10:00 to 10:10 ET, and so on. The last tick captures the response from 10:00 to 11:30 ET. We also plot (dashed lines) two 95% standard error bands, under the null hypothesis of a zero response, obtained using the least-squares estimation method described in the text (equation (16)).

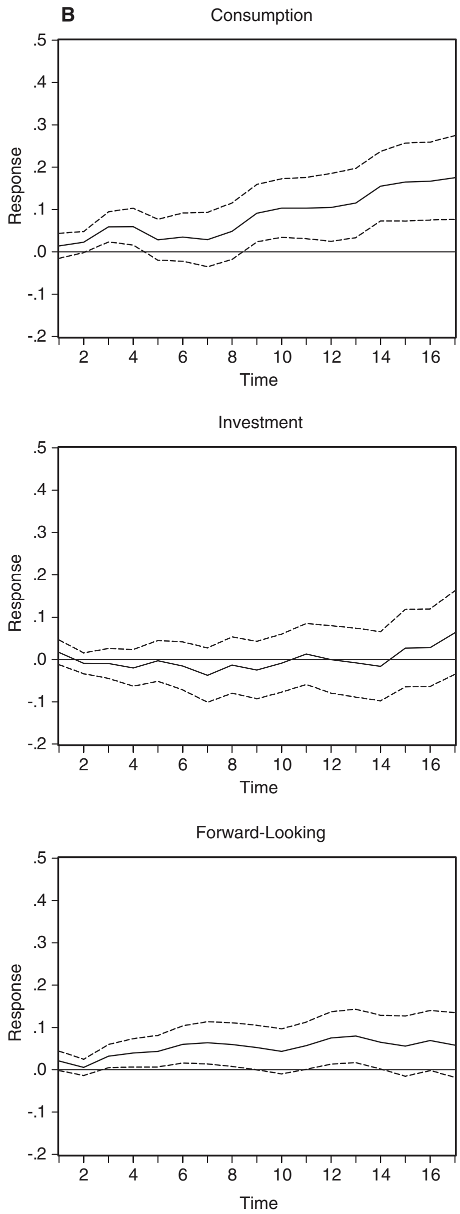

Figure 3B. Portuguese Response to 10:00 ET US Macroeconomic Announcements

We plot $\lambda_{p_{us}n}^{por}$ (equation (17), solid line in the graphs), the cumulative Portuguese response to 10:00 ET US macroeconomic announcements. The first tick in all panels on the x-axis captures the Portuguese. stock market response from 10:00 to 10:05 ET, the second tick captures the cumulative response from 10:00 to 10:10 ET, and so on. The last tick captures the response from 10:00 to 11:30 ET. We also plot (dashed lines) two 95% standard error bands, under the null hypothesis of a zero response, obtained using the least-squares estimation method described in the text (equation (17)).

open, the first interval in all panels on the x-axis captures the US stock market response from the previous day's close to 9:35 ET, the second interval captures the cumulative response from the previous day's close to 9:40 ET, and so on. The last interval captures the response from the previous day's close to 11:30 ET. For the real activity, consumption, forward-looking and initial unemployment claims announcements, the effect is immediate, with a tendency of overshooting, and becoming stable within one hour of the announcement's release. The effect of the investment announcements are fully reversed by the end of the day, the net exports announcement only becomes statistically significant towards 11:30 ET – after a short period of significance after the announcement. The price announcements only have a short period of significance about 10 minutes into the news release.

In Figure 2B we plot $\lambda^{por}_{p_{us}n}$, the cumulative n-minute Portuguese return response to the same announcements. Since the Portuguese market is open, the zero tick of the x-axis in each plot coincides with the time indicated in the title of the plot. Each tick advances time by 5 minutes. For example, in the top left hand corner plot the first tick corresponds to 8:35 ET and the return is measured from just before 8:30 ET to 8:35 ET. The second tick corresponds to 8:40 ET and the return is measured from just before 8:30 ET to 8:40 ET. In Figure 2B the vertical line indicates 9:30 ET when the US market opens.

For the US real activity, consumption, investment, net-exports and price announcements, the Portuguese stock market reacts from 15 minutes before the US market opens at 9:30 (45 minutes after the announcement is released) to 20 minutes after 9:30 (1 hour and 20 minutes after the announcement is released). For the remaining 8:30 and 9:15 ET announcements, there is no significant response. This evidence suggests that Portugal reacts more to New York's assessment of US announcements than to the news themselves. To the best of our knowledge, this is the first paper that finds direct evidence of delayed response to US macroeconomic announcements in foreign markets, which coincides with the US stock market open. We also note that the evidence discussed below where we use a sample of non-ADR Portuguese firms gives even stronger evidence on this delayed response.

We interpret the finding of a delayed response as suggestive that Portuguese investors respond more strongly to the private information component of US returns than to the US news themselves. Intuitively, Portuguese investors may be seen to free ride on US investors' analysis of the news announcement. According to our interpretation, Portuguese investors let the better informed US investors first figure out the significance of the US news and then react to such interpretation of the news. Included in the US response therefore is the news itself as well as the additional private information on the news that was used by US investors.

An alternative explanation for our finding is contagion. Portuguese investors might not even know that news were released in the United States, but see that the US return is going up and respond by bidding prices up in their local market as well. To address this possibility, we note that the response by the Portuguese market to US net-exports and inflation surprise announcements is a delayed version *in the opposite direction* of the response by the US market. Because net-exports and inflation are the two main announcements in our data that could signal different things for the two countries, we conclude against the contagion view. Note that, all else equal, unexpectedly high US inflation leads to an unexpected real USD appreciation, which is generally viewed as good for Portuguese exporters, but bad for US firms.

Naturally, in the face of predictability of Portuguese returns associated with the delayed response to US news, a question arises about the ability to generate profits from arbitraging the costs of information flow. Inspection of Table 2A reveals that the percentage spread on Portuguese stocks is quite large and that it would swamp any profits apparent in Figure 2B.[21]

Another issue of concern is that the time of the news releases in the US is close to lunch time in Portugal where the market is naturally less liquid. This is unlikely to be problematic since by 9:30 ET, when the US market opens, the Portuguese traders are more than done with their 'picnic'. Also, the large bid-ask spreads associated with Portuguese firms could suggest that the delayed response is just a natural consequence that they are not traded very often. To further address these two concerns we estimate the average number of transactions in the Portuguese market before and after the US market opens on days with announcements and on days without announcements. The results are quite striking (available upon request). In days of no US news the number of transactions around the opening in the United States is flat. In days with US news, there is a relatively lower number of transactions in the Portuguese stock market before the US market opens, followed by a relatively higher number of transactions as the US market opens. These results further support the assumption that Portuguese investors wait to see how US investors respond to US news.[22]

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[21] Doing a back-of-the-envelop calculation we estimate the average transaction cost to be 16% (2.32%) – the sum of the average percentage spread shown in Table 2A (Table 2B) – of the following trading strategy: buy each individual stock that comprises the PSI-20 index (DJ 30 index), right after the macroeconomic announcement, and sell each individual stock one hour afterwards. This means that the cumulative returns shown in Figures 3A-B should at least be 16% and 2.32%, respectively, for investor to make money based on our results. Since all the returns shown in these figures are smaller, we conclude that these figures do not provide any evidence of profitable trading strategies.

[22] We also estimate equations (16) and (17) only using the 10-most liquid Portuguese stocks: PT, BCP, EDP, BRISA, SONAE, SNC, BPI, Impresa, PTM, and JM. The shape of the graphs is very similar to that shown in Figure 3B. The two main differences are: (i) the standard error bands are wider because we use half of the observations, and (ii) the point estimate tends to be larger in magnitude, reflecting the fact that these 10 firms may be more sensitive to U.S. macroeconomic shocks than the bottom 10 firms. This is consistent with the view that the most liquid stocks are also the largest firms; firms that are more likely to export goods to the US. What is important to us, though, is that

A final concern is that even though at 8:30 ET the US spot market is not open, the S&P 500 futures market is open, hence Portuguese investors can observe the US aggregate reaction to macroeconomic news announcements. One explanation for Portuguese investors wanting to wait for the spot market to open is that individual firms react differently to macroeconomic news surprises (Ehrmann and Fratzscher, 2004), thus Portuguese investors benefit from observing the firm's individual reaction to macroeconomic announcements. They learn more from observing the disaggregate price discovery that takes place in the spot market than from the aggregate price response to macroeconomic news surprises reflected in the S&P500 futures price. The empirical stylized fact that stock market volatility in other countries (e.g. King and Wadhwani, 1990), as well as in the Portuguese stock market, increases following the NYSE market opening time further supports this claim.

US News Released When both Markets are Open

In Figures 3A and 3B, we report the contemporaneous 5-minute cumulative response to the 10:00 ET announcements, when both markets are open. Though these results are not fully satisfying because the most "important" US announcements are at 8:30 ET rather than 10:00 ET, they have the advantage of being generated when both markets are open. The US stock market (panel 1 in Figure 3A) incorporates the information in the 10:00 ET forward-looking announcements immediately, whereas the Portuguese stock market reacts to these announcements 15 minutes after they are released (panel 1 in Figure 3B). The US stock market reacts 15 minutes later to the consumption announcement (panel 2 in Figure 3A), and 40 minutes later it becomes stable. The Portuguese stock market also reacts to the consumption announcement 15 minutes after it is released (panel 2 in Figure 3B), however, this reaction temporarily reverses itself, and 45 minutes later it becomes stable. Finally, the US stock market (panel 3 in Figure 3A) has an immediate statistically significant reaction to the 10:00 ET investment announcements, which becomes insignificant by 11:30 ET, while the Portuguese stock market does not react to these announcements (panel 3 in Figure 3B). This evidence, though weaker than that presented in Figure 2A and Figure 2B, supports the view that Portugal waits for New York's assessment of US announcements.

6. The Effect of News on Co-movement

We now turn to test the implications of the model presented in Section 3. We conduct the analysis with daily returns as many finance applications of asset allocation and benchmarking rely on daily frequencies. In addition, we can measure more

the delayed response is present in these graphs as well, further supporting our view that the delayed response is not due to lack of liquidity.

accurately the effects that macroeconomic news announcements have on US and Portuguese prices at daily frequencies than at monthly or quarterly frequencies (Andersen et al., 2003).

To study co-movement we have two main alternative strategies. One approach estimates co-movement by regressing returns in Portugal on US returns. The alternative approach, is to define "excessive" co-movement across assets, that is, co-movement above what one would expect from economic fundamentals (i.e., contagion). Under this alternative, co-movement is determined by the covariation of estimated residuals from a regression of asset returns on economic fundamentals. The former approach, which we follow below, has three main advantages. First, it allows direct testing of the predictions from our model; predictions which are not borne in models of contagion. Second, the alternative approach requires the correct specification of the regression model. This is potentially problematic given the disagreement on what fundamentals to use, e.g., macroeconomic news announcements (Connoly and Wang, 2000), the US equity market return and a regional equity portfolio return (Bekaert, Harvey and Ng, 2002), Fama-French factors (Kallberg and Pasquariello, 2006), etc. Third, even if we could identify the relevant fundamentals to use, if the true model of returns includes order flow as an independent variable as in our model above, then it is easy to show that since order flow is estimated with error in the US, the residual in a regression of returns on public information variables and estimated order flow is correlated with the true order flow. The residual still contains private information and correlations of residuals cannot be claimed to represent excess-co-movement.

6.1 IMPACT OF US NEWS ON US RETURNS

We translate the equilibrium prices in Section 4.2 into an estimable equation. The regression specification loosely corresponds to the model's equilibrium equations and we add and modify certain variables to account for known microstructure effects that are absent in the model. The estimable equation is:

$$
\begin{aligned}
r_{it}^{us} = a + \lambda_{sp_{eus}} S_{ip_{eus}t} + \lambda_{sp_{ecb}} S_{p_{ecb}t} + \sum_{p_{us}=1}^{9} \lambda_{sp_{us}} S_{p_{us}t} + \sum_{j=0}^{J} \lambda_j \Omega_{it-j}^{us}\left(1 - D_t^{us}\right) \\
+ \sum_{j=0}^{J} \lambda_{pj} \Omega_{it-j}^{us} D_t^{us} + \sum_{j=1}^{J} \beta_j r_{it-j}^{us}\left(1 - D_t^{us}\right) + \sum_{j=1}^{J} \beta_{pj} r_{it-j}^{us} D_t^{us} + \varepsilon_{it},
\end{aligned}
\tag{18}
$$

where D_t^{us} is an indicator function for US public (earnings or macroeconomic) announcement release dates, $r_{it}^{us} = (\ln(P_{it}^{us}) - \ln(P_{it-1}^{us})) \times 100$ is the day t individual stock return for firm $i = 1, \ldots, 30$, in the DJ 30 Index, $S_{p_{us}t}$ is the standardized news corresponding to announcement $p_{us} = 1, 2 \ldots 9 S_{p_{ecb}t}$ is the standardized ECB benchmark interest rate news surprise on day t, and Ω_{it}^{us} is the daily US unanticipated order flow estimated using Hasbrouck's (1991) method (equation (14)). We include the ECB benchmark refinancing interest rate but none of the Portuguese macroeconomic news announcements, because we do not find that Portuguese macroeconomic announcements affect US returns. However, the ECB Governing Council news on its benchmark interest rate is known to influence the US markets (Ehrmann and Fratzscher, 2003). Lagged unanticipated order flow values and lagged price changes are included in equation (18) to differentiate between our informed-trading hypothesis from the equally sensible inventory-model alternative (first formalized by Garman, 1976).[23] Price changes may react to net order flow imbalances to compensate market participants for providing liquidity, even when the order flow has no information content. To assess the relevance of this alternative hypothesis, we follow Hasbrouck (1991) and include lagged values of unanticipated order flow and price changes in all of our equations. As in Hasbrouck (1991), we assume the *permanent* impact of trades is due to information shocks and the *transitory* impact is due to non-information (e.g., liquidity) shocks (see also Cao et al., 2006). Hence, positive and significant contemporaneous estimates for λ_0 and λ_{p0} are driven by transitory inventory control effects when accompanied by a negative and significant impact of lagged unanticipated net order flow on price changes. In other words, significant contemporaneous order flow effects are transitory if they are later reversed. On the other hand, positive and significant estimates for λ_0 and λ_{p0} are driven by permanent information effects (consistent with our model) when accompanied by positive and significant, or statistically insignificant impact of lagged unanticipated net order flow on yield changes.

We use a GARCH(1,1)-X model to control for heteroskedasticity in the data. Specifically, we model the conditional variance of ε_{it} as follows:

$$\sigma_{it}^2 = \omega + \beta_\sigma \sigma_{it-1}^2 + \beta_\varepsilon \varepsilon_{it-1}^2 + \phi T_{it-1} + \psi_{p_{eus}} D_t^{p_{eus}} + \psi_{p_{ecb}} D_t^{p_{ecb}} + \sum_{p_{us}=1}^{9} \psi_{p_{us}} D_t^{p_{us}}, \tag{19}$$

where T_{it-1} is the number of transactions on day $t - 1$ and stock $i\, D_t^{p_{eus}}$ is an indicator function equal to one when a US earnings announcement is released, $D_t^{p_{ecb}}$ is an indicator function equal to one when the ECB benchmark interest rate is announced and $D_t^{p_{us}}$ is equal to one when US macroeconomic announcement

[23] The order of the lagged polynomial, J, is set to asses the "permanence" of order flow rather than setting it optimally using the Akaike and Schwarz information criteria. In this study we define the impact of order flow on yield changes as permanent (i.e., driven by information effects) when lasting for at least five trading days. Hence, we set $J = 5$ in all equations herein.

indicator p_{us} is released. The index in the announcement dummies is t because the announcement date is known in advance.

In Table 4 we show that news on US macroeconomic fundamentals exert a significant influence in the US stock market. The sign of the coefficients indicate that an increase in real economic activity during economic recessions is "good news" for the stock market. This interpretation is consistent with the idea that these good news generate a positive cash flow effect for firms. However, they are also normally associated with a higher discount rate as investors fear a contractionary response by the Federal Reserve leading to an opposite effect. As Andersen et al. (2005) and Boyd, Jagannathan and Hu (2001) have shown the discount rate effect dominates during economic expansions while the cash flow effect dominates during economic contractions, because, they argue, the Federal Reserve Bank is less likely to increase interest rates during recessions. While our data is too short to separate between expansion periods and recession periods, we note that the period we study in 2002 is a period of economic recession for the US.[24] This claim is further supported by the statistical insignificance of the inflationary shocks (PPI and CPI surprises).

Table 4 shows that a one standard deviation unexpected increase in the federal funds target rate decreases stock market returns by 0.5 percent (-0.73×0.6). The magnitude of this response is lower than the 1 percent response Bernanke and Kuttner (2005) and Ehrmann and Fratzscher (2004) obtain. The main reason for this discrepancy is that our firm sample is the DJI-30, while the firm sample in the other two papers is the CRSP value weighted index and the S&P 500 index. Our sample contains large firms with good credit ratings and as Ehrmann and Fratzscher (2004) document these firms are affected significantly less by monetary policy surprises. Naturally, European monetary policy surprises affect US stock market returns less than US monetary policy rate surprises. One standard deviation unexpected increase in the ECB benchmark rate decreases stock market returns by 0.16 percent.

The results in Table 4 provide evidence that strongly supports the informed-trading hypothesis and some evidence supporting small inventory control effects. The estimated contemporaneous correlation between unanticipated order flow and price changes (λ_{p0} and λ_0) are positive and significant (at the 1% level). The first

[24] According to the NBER the starting date for the closest recession to 2002 in the U.S. is 03/2001 and the end date of the same recession is 11/2001. There is however wide disagreement about the recession's end date as explained in Andersen et al. (2005) and the NBER's website http://www.nber.org/cycles/recessions.html, because employment continued to decline through June 2003. Andersen et al. (2005) define the recession end date as 12/2002, which would define our sample period as a recessionary period in the U.S. Under this ambiguity it is reasonable to believe that the market did not know whether the recession was over during the 11/2001-12/2002 period (note that the end of the 03/2001 recession was declared on July 17, 2003).

Table 4 Influence of US Public Announcements on US Returns

This table reports coefficient estimates of the following equation:

$$r_{it}^{us} = a + \lambda_{sp_{eus}} S_{ip_{eus}t} + \lambda_{sp_{ecb}} S_{p_{ecb}t} + \sum_{p_{us}=1}^{9} \lambda_{sp_{us}} S_{p_{us}t} + \sum_{j=0}^{J} \lambda_j \Omega_{it-j}^{us} \left(1 - D_t^{us}\right)$$
$$+ \sum_{j=0}^{J} \lambda_{pj} \Omega_{it-j}^{us} D_t^{us} + \sum_{j=1}^{J} \beta_j r_{it-j}^{us} \left(1 - D_t^{us}\right) + \sum_{j=1}^{J} \beta_{pj} r_{it-j}^{us} D_t^{us} + \varepsilon_{it},$$

where r_{it}^{us} is the daily stock return for $i = 1, \ldots, 30$ DJ 30 individual stocks, Ω_{it}^{us} is the unanticipated order flow (defined in Section 6), D_t^{us} is an indicator function equal to one if a US public announcement (earnings or macroeconomic news) is released on date t, $S_{ip_{eus}t}$ is the standardized earnings news surprise for stock return i, $S_{p_{ecb}t}$ is the standardized ECB benchmark refinancing rate news surprise, and $S_{p_{us}t}$ is the aggregate standardized US macroeconomic news surprise for p_{us} (defined in Section 4.2). The t-statistics are estimated using the GARCH(1,1)-X model (equation (19)) to correct for heteroskedasticity and autocorrelation. We mark the coefficients and F-statistics with a " * ", " ** ", or " *** " to indicate significance at the 10%, 5%, or 1% level, respectively.

	Coefficient	t-statistic
	Contemporaneous Order Flow	
Non-Announcement, λ_0	0.0102	19.39***
Announcement, λ_{p0}	0.0084	23.08***
H_0: $\lambda_0 - \lambda_{p0} = 0$ (F-statistic)	0.0018	8.59***
	Lagged Order Flow	
Non-Announcement, λ_1	−0.0029	−5.11***
Non-Announcement, λ_2	−0.0010	−1.61
Announcement, λ_{p1}	−0.0016	−3.86***
Announcement, λ_{p2}	−0.0011	−2.78***
	European Announcement, $\lambda_{sp_{ecb}}$	
ECB benchmark refinancing rate	−0.1703	−3.44***
	US Announcements, $\lambda_{sp_{eus}}$, $\lambda_{sp_{us}}$	
Earnings	0.5595	4.58***
Real Activity	0.1680	3.38***
Consumption	0.8889	7.85***
Investment	0.1258	1.77*
Government Purchases	0.0050	0.02
Net Exports	0.3678	3.46***
Prices	−0.1570	−1.86*
Forward-Looking	0.2351	3.20***
Target Federal Funds Rate	−0.7300	−4.21***
Initial Unemployment Claims	−0.1010	−2.26**
H_0: $\lambda_{s1} = \cdots = \lambda_{s9} = 0$ (F-statistic)		13.42***
Adjusted-R^2	0.1665	

order lagged unanticipated order flow (λ_{p1} and λ_1) is negative and statistically significant at the 1% significance level, however its magnitude is about 4 times smaller than the contemporaneous coefficient. Furthermore, the third and higher order (not shown) lagged unanticipated order flow are statistically insignificant at all significance levels. In other words, we find evidence that the contemporaneous impact of unanticipated US stock market order flow is reversed the next day, but the magnitude of the reversal is small enough to be consistent with a small inventory control effect and the larger informational order flow effect studied in the model.

According to our model, we expect liquidity to increase in days of announcements, i.e., $\lambda_0 - \lambda_{p0} > 0$, holding the inventory effect constant on announcement and non-announcement days and as long as the private information which agents receive is sufficiently precise. Table 4 shows that we fail to reject this null hypothesis at the five percent significance level. In other words, liquidity is statistically significantly higher in announcement days versus non-announcement days. This contrasts with prior evidence in Krinsky and Lee (1996) and Brooks et al. (2003) who, looking at bid-ask spreads as a measure of liquidity, find that in the US liquidity decreases during earnings announcements and other unanticipated *firm* events. It is however consistent with Pasquariello and Vega (2007), who find that government bond market liquidity is higher on macroeconomic news announcement days.

In untabulated results and consistent with Andersen and Bollerslev (1998) we find that volatility is higher during announcement days, and that daily stock market volatility is positively correlated with the number of transactions (e.g., Jones et al., 1994).

6.2 IMPACT OF PORTUGUESE MACROECONOMIC NEWS ON PORTUGUESE AND US CO-MOVEMENT

We next turn to examine the impact of unanticipated Portuguese order flow and Portuguese public news surprises on Portuguese daily price changes and US-Portuguese stock market correlations. Similar to the previous specification, we translate the equilibrium prices into the following estimable equation:

$$\begin{aligned} r_{it}^{por} &= a^{por} + \lambda_{sp_{epor}}^{por} S_{ip_{epor}t} + \lambda_{sp_{ecb}}^{por} S_{p_{ecb}t} + \sum_{p_{por}=1}^{3} \lambda_{sp_{por}}^{por} S_{p_{por}t} + \sum_{p_{us}=1}^{9} \lambda_{sp_{us}}^{por} S_{p_{us}t} \\ &\quad + \sum_{j=0}^{J} \lambda_j^{por} \Omega_{it-j}^{por} \left(1 - D_t^{por}\right) + \sum_{j=0}^{J} \lambda_{pj}^{por} \Omega_{it-j}^{por} D_t^{por} \\ &\quad + \sum_{j=0}^{J} \beta_j^{por} r_{t-j}^{us} \left(1 - D_t^{por}\right) + \sum_{j=0}^{J} \beta_{pj}^{por} r_{t-j}^{us} D_t^{por} + \sum_{j=1}^{J} \beta_{porj}^{por} r_{it-j}^{por} + \varepsilon_{it}^{por}, \end{aligned} \tag{20}$$

where D_t^{por} is an indicator function for Portuguese macroeconomic announcement release dates, $r_{it}^{por} = (\ln(P_{it}^{por}) - \ln(P_{it-1}^{por})) \times 100$ is the day t individual stock return for firm $i = 1, \ldots, 20$, in the PSI-20 Index, $r_t^{us} = (\ln(P_t^{us}) - \ln(P_{t-1}^{us})) \times 100$ is the daily value weighted DJ 30 Industrial Index return, $S_{ip_{epor}t}$ is the standardized news corresponding to Portuguese earnings announcement for firm $i = 1, \ldots, 20 S_{p_{por}t}$ is the standardized news corresponding to Portuguese announcement $p_{por} S_{p_{ecb}t}$ is the standardized ECB benchmark interest rate news surprise, $S_{p_{us}t}$ is the standardized news corresponding to announcement p_{us}, and Ω_{it}^{por} is the daily Portuguese unanticipated order flow estimated using Hasbrouck's (1991) method (equation (13)). We use a similar GARCH(1,1)-X model to control for heteroskedasticity in the data. Specifically, we model the conditional variance of ε_{it}^{por} as follows:

$$\sigma_{it}^{por2} = \omega^{por} + \beta_{\sigma}^{por} \sigma_{it-1}^{por2} + \beta_{\varepsilon}^{por} \varepsilon_{it-1}^{por2} + \phi^{por} T_{it-1} + \psi_{p_{epor}}^{por} D_t^{p_{epor}} + \psi_{p_{ecb}}^{por} D_t^{p_{ecb}} + \sum_{p_{por}=1}^{3} \psi_{p_{por}}^{por} D_t^{p_{por}} + \sum_{p_{us}=1}^{9} \psi_{p_{us}}^{por} D_t^{p_{us}} + \beta_{\varepsilon_{us}}^{por} r_{t-1}^{us2}, \quad (21)$$

where r_{t-1}^{us2} in equation (21) controls for volatility spill over effects (e.g., Karolyi and Stulz, 1996) from the US market to the Portuguese market.

According to the model, we expect that stock return correlations fall on public macroeconomic news announcement days, i.e., $\beta_0^{por} - \beta_{p0}^{por} > 0$. In the second column of Table 5 we find evidence to strongly support this claim. One standard deviation shock to the value weighted DJ 30 Industrial index return (1.83 percent) increases Portuguese returns by 0.46 percent during non-announcement days and only by 0.15 percent on announcement days. This difference is statistically and economically significant.

The signs and significance of the coefficients associated with the Portuguese macroeconomic news announcements are consistent with the US market results presented above. The only exception is that Portuguese inflationary shocks have a strong negative effect on Portuguese stock market returns, while US inflationary shocks had no significant effect on US stock market returns during the US recession period. Interestingly, the US macro news announcements gain statistical significance when we drop the value weighted DJ 30 Industrial Index return from equation (20): The F-statistic in Table 5 columns 1,3 and 5 is half as small as the F-statistic of Table 5 columns 2, 4, and 6. This means that part of the co-movement between the US and Portugal is due to the effect US macroeconomic fundamentals have on the Portuguese stock market and is consistent with the evidence shown in Section 5 on a delayed high-frequency response by the Portuguese market to US macro news surprises and with our model.

Table 5 Influence of News Announcements on US-Portuguese Stock Market co-movement

This table reports coefficient estimates of the following equation:

$$r_{it}^{por} = a^{por} + \lambda_{sp_{epor}}^{por} S_{ip_{epor}t} + \lambda_{sp_{ecb}}^{por} S_{p_{ecb}t} + \sum_{p_{por}=1}^{3} \lambda_{sp_{por}}^{por} S_{p_{por}t} + \sum_{p_{us}=1}^{9} \lambda_{sp_{us}}^{por} S_{p_{us}t} + \sum_{j=0}^{J} \lambda_{j}^{por} \Omega_{it-j}^{por}(1 - D_t)$$

$$+ \sum_{j=0}^{J} \lambda_{pj}^{por} \Omega_{it-j}^{por} D_t + \sum_{j=0}^{J} \beta_{j}^{por} r_{t-j}^{us}(1 - D_t) + \sum_{j=0}^{J} \beta_{pj}^{por} r_{t-j}^{us} D_t + \sum_{j=1}^{J} \beta_{porj}^{por} r_{it-j}^{por} + \varepsilon_{it}^{por},$$

where r_{it}^{por} is the daily return for stock $i = 1, \ldots, 20$ of the PSI-20 Index, Ω_{it}^{por} is the daily Portuguese unanticipated order flow for stock i (defined in Section 6), $D_t = \{D_t^{por}, D_t^{epor}, D_t^{us}\}$ is an indicator function equal to one if a Portuguese macroeconomic announcement, Portuguese earnings announcement, and a US macroeconomic annoucement is released, respectively, on date t, $S_{p_{ecb}t}$ is the standardized ECB benchmark refinancing rate news surprise, $S_{ip_{epor}t}$ is the Portuguese standardized earnings news surprise for stock i, and $S_{p_{us}t}$ is the aggregate standardized US macroeconomic news surprise for p_{us} and $S_{p_{por}t}$ is the aggregate Portuguese standardized macroeconomic news surprise for p_{por} (both of which are defined in Section 4.2). The coefficients in column one and two correspond to the equation estimates when $D_t = D_t^{por}$, the coefficients in column three and four correspond to the equation estimates when $D_t = D_t^{epor}$, and the coefficients in the last two columns correspond to the equation estimates when $D_t = D_t^{us}$. The t-statistics are estimated using the GARCH(1,1)-X model (equation (21)) to correct for heteroskedasticity and autocorrelation. We mark the coefficients and F-statistics with a “ * ”, “ ** ”, or “ *** ” to indicate significance at the 10%, 5%, or 1% level, respectively.

	Portuguese Macroeconomic Ann.		Portuguese Earnings Ann.		US Macroeconomic Ann.	
	Contemporaneous Order Flow					
Non-Announcement, λ_0^{por}	0.0182***	0.0186***	0.0193***	0.0141***	0.0235***	0.0165***
Announcement, λ_{p0}^{por}	0.0240***	0.0244***	0.0097	0.0101*	0.0187***	0.0131***
H_0: $\lambda_0^{por} - \lambda_{p0}^{por} = 0$ (F-statistic)	−0.0058***	−0.0058***	0.0096	0.0039	0.0048**	0.0034***
	Lagged Order Flow					
Non-Announcement, λ_1^{por}	−0.0038***	−0.0048***	−0.0036***	−0.0033***	−0.0060**	−0.0045***
Non-Announcement, λ_2^{por}	−0.0027**	−0.0020*	−0.0023**	−0.0015**	−0.0050**	−0.0016
Announcement, λ_{p1}^{por}	−0.0051*	−0.0044	−0.0025	−0.0034	−0.0036**	−0.0033***
Announcement, λ_{p2}^{por}	−0.0012	−0.0001	−0.0050*	−0.0022*	−0.0013	−0.0013**

	US Value Weighted Return					
Non-Announcement, β_0^{por}		0.2515***		0.2289***		0.2278***
Announcement, β_{0p}^{por}		0.0867***		0.2367*		0.2370***
H_0: $\beta_0^{por} - \beta_{0p}^{por} = 0$ (F-statistic)		0.1648***		−0.0078		−0.0092
	Portuguese Announcements, $\lambda_{sp_{epor}}^{por}$, $\lambda_{sp_{por}}^{por}$					
Earnings	0.8201***	0.7349***	0.8411***	0.7701***	0.7741***	0.7558***
Real Activity	0.0058	0.1546***	0.0217	0.2623***	0.0215	0.2443***
Net Exports	0.5737***	0.4920***	0.5768***	0.4833***	0.6150***	0.4489***
Prices	−0.2975***	−0.2289***	−0.3013***	−0.1515***	−0.3108***	−0.1417***
H_0: $\lambda_{s1}^{por} = \lambda_{s2}^{por} = \lambda_{s3}^{por} = 0$ (F-statistic)	10.53***	12.58***	11.32***	13.32***	12.82***	11.92***
	European Announcement, $\lambda_{sp_{ecb}}^{por}$					
ECB benchmark refinancing rate	−0.0910**	−0.0163	−0.0685**	−0.0560	−0.0765**	−0.0539
	US Announcements, $\lambda_{sp_{us}}^{por}$					
Real Activity	0.0399	−0.0292	0.0399	−0.0225	0.0411	−0.0219
Consumption	0.1967*	−0.2320**	0.1935*	−0.1863*	0.1940*	−0.1827*
Investment	0.1429*	0.0188	0.1372*	0.0232	0.1402*	0.0278
Government Purchases	0.3094	0.0499	0.2902	0.0457	0.2928	0.0549
Net Exports	0.0431	−0.1774	0.0516	−0.1355	0.0402	−0.1420
Prices	−0.0578	0.1256	−0.0385	0.0948	−0.0369	0.0974
Forward-Looking	0.1615**	0.1132*	0.1655**	0.1331**	0.1647**	0.1317**
Target Federal Funds Rate	−1.3058***	−0.8551***	−1.3209***	−0.8765***	−1.3085***	−0.8664***
Initial Unemployment Claims	−0.1216**	−0.0300	−0.1248**	−0.0429	−0.1177**	−0.0383
H_0 : $\lambda_{s1}^{por} = \cdots = \lambda_{s9}^{por} = 0$ (F-statistic)	6.93***	3.30***	6.98***	3.12***	6.86***	3.07***
Adjusted-R^2	0.1652	0.2270	0.1670	0.2335	0.1621	0.2328

Consistent with the US market results in Table 4, Table 5 also provides evidence that strongly supports the informed-trading hypothesis and to a lesser extent evidence in favor of small inventory effects. The estimated contemporaneous correlation between unanticipated order flow and price changes (λ_{p0}^{por} and λ_0^{por}) are positive and significant (at the 1 percent level). The first order lagged unanticipated order flow (λ_{p1}^{por} and λ_1^{por}) is negative and statistically significant at the 1% significance level, however its magnitude is 9.7 times smaller on announcement days (λ_{p1}^{por}) and 4.36 times smaller on non-announcements days (λ_1^{por}) than the contemporaneous coefficient. Furthermore, the third and higher order lagged unanticipated order flow effects are statistically insignificant at all significance levels for announcement and non-announcement days (not shown).

Opposite to the US market, liquidity during macroeconomic news announcement days is statistically significantly lower than liquidity on non-announcement days. One explanation for this unexpected behavior of liquidity is that Portuguese macroeconomic news necessitate more analysis to be useful, leading to the entry into the market of a different class of informed investors (see Kim and Verrecchia, 1994).

In untabulated results we note that, in contrast with the US, Portuguese stock market volatility is lower during announcement days of real activity. However, and consistent with the evidence for the US, daily stock market volatility is strongly positively correlated with the number of transactions as in Jones et al. (1994). There is also a significant volatility spillover from the US market into the Portuguese market.

6.3 IMPACT OF PORTUGUESE EARNINGS ANNOUNCEMENTS ON PORTUGUESE AND US CO-MOVEMENT

We now examine the impact of country specific news (section 4.6) on the US-Portuguese stock market correlations. Similar to the previous specification, we replace D_t^{por} in equation (20) with D_t^{epor}, an indicator function for Portuguese earnings announcement release dates. According to the model, we expect that cross-country return correlations are unchanged with earnings announcements, i.e., $\beta_0^{epor} - \beta_{p0}^{epor} = 0$. In column 4 of Table 5 we find evidence to strongly support this claim. One standard deviation shock to the value weighted DJ 30 Industrial index return (1.83 percent) increases Portuguese returns by about 0.42 percent during non-announcement and announcement days – the difference is not statistically significant.

Otherwise, the signs and significance of the coefficients associated with the Portuguese macroeconomic news announcements, earnings news announcements, ECB benchmark interest rates and US macroeconomic news announcements are very similar to those in the previous section.

6.4 IMPACT OF US NEWS ON PORTUGUESE AND US CO-MOVEMENT

Finally, we examine the impact of US macroeconomic public news surprises on the US-Portuguese stock market co-movement. We replace D_t^{por} in equation (20) with D_t^{us}, an indicator function for US macroeconomic announcement release dates. We expect that cross-country return correlations remain unchanged across US macroeconomic announcement days and non-announcement days, i.e., $\beta_0^{us} - \beta_{p0}^{us} = 0$. In the last column of Table 5 we find evidence to strongly support this claim. In particular, one standard deviation shock to the value weighted DJ 30 Industrial index return increases Portuguese returns by about 0.4% in announcement as well as non-announcement days.

Consistent with the model the sign of $\lambda_0 - \lambda_{p0} > 0$ meaning that at announcements liquidity increases. This difference is statistically significant; US macroeconomic news announcements significantly reduce adverse selection costs in the Portuguese stock market at the daily frequency. Finally, the results in the last two columns are broadly consistent with those in columns one through four for Portuguese Macroeconomic and earnings news announcements.

6.5 ROBUSTNESS CHECKS

Since some of the macroeconomic announcements listed in Table 3A and Table 3B do not significantly affect stock market returns, our definition of announcement days might bias the results presented above towards not finding any change in the cross-country stock market correlation across days. In other words, we may be comparing non-announcements days with "essentially non-announcement days" (days when insignificant macroeconomic news are released). Also, it is conceivable that the more relevant US macro announcements carry with them more analysis by informed investors and that the precision of US informed investors is therefore higher. We conjecture that such change in precision occurring at the same time as some macro news are released generates a change in the correlation between stock markets according to our model as the information content of US returns increases. To explore this possibility we re-estimate equation (20) using only significant US and Portuguese macroeconomic news announcements. For comparison, we report in Table 6 the coefficient estimates of equation (18), when we don't aggregate the US announcements. We can observe that only 50% of the macroeconomic news announcements listed in Table 3B are statistically significant, hence our previous results could be biased. In the first two columns of Table 7 we report the coefficient estimates of equation (20) redefining our indicator function for announcement days to be equal to days when a statistically significant Portuguese macroeconomic announcement is released (6 out of the 8 announcements listed in Table 3A are statistically significant). The coefficient estimates for the Portuguese-US stock

Table 6 Influence of US Disaggregate Macroeconomic Announcements on US Returns

This table reports coefficient estimates of the following equation:

$$r_{it}^{us} = a + \lambda_{sp_{eus}} S_{ip_{eus}t} + \lambda_{sp_{ecb}} S_{p_{ecb}t} + \sum_{p_{us}=1}^{25} \lambda_{sp_{us}} S_{p_{us}t} + \sum_{j=0}^{J} \lambda_j \Omega_{it-j}^{us} \left(1 - D_t^{us}\right)$$
$$+ \sum_{j=0}^{J} \lambda_{pj} \Omega_{it-j}^{us} D_t^{us} + \sum_{j=1}^{J} \beta_j r_{it-j}^{us} \left(1 - D_t^{us}\right) + \sum_{j=1}^{J} \beta_{pj} r_{it-j}^{us} D_t^{us} + \varepsilon_{it},$$

where r_{it}^{us} is the daily stock return for $i = 1, \ldots, 30$ DJ 30 individual stocks, Ω_{it}^{us} is the daily US unanticipated order flow for stock i (defined in Section 6), D_t^{us} is an indicator function equal to one if a US public announcement (earnings or macroeconomic news) is released on date $t S_{ip_{eus}t}$ is the standardized earnings news surprise for stock return $i S_{p_{ecb}t}$ is the standardized ECB benchmark refinancing rate news surprise, and $S_{p_{us}t}$ is the disaggregate standardized US macroeconomic news surprise for $p_{us} = 1, \ldots, 25$ (defined in Section 4.2 and listed in Table 3B). The t-statistics are estimated using the GARCH(1,1)-X model (equation (19)) to correct for heteroskedasticity and autocorrelation. We mark the coefficients and F-statistics with a " * ", " ** ", or " *** " to indicate significance at the 10%, 5%, or 1% level, respectively.

	Coefficient	t-statistic
	Contemporaneous Order Flow	
Non-Announcement, λ_0	0.0105	20.65***
Announcement, λ_{p0}	0.0084	22.25***
H_0: $\lambda_0 - \lambda_{p0} = 0$ (F-statistic)	0.0021	11.18***
	European Announcement	
ECB benchmark refinancing rate	−0.1613	−2.92***
	US Announcements	
Earnings	0.4906	3.89***
GDP Advance	−0.5452	−3.71***
GDP Preliminary	−0.0370	−0.25
GDP Final	0.1142	0.47
Nonfarm Payroll	0.1573	0.32
Retail Sales	−0.0227	−0.18
Industrial Production	−0.1628	−0.48
Capacity Utilization	1.1817	3.67***
Personal Income	1.2411	4.28***
Consumer Credit	0.1778	2.01**
New Home Sales	−0.6252	−4.8***
Personal Consumption Expenditures	1.9291	10.7***
Durable Goods Orders	0.3076	2.51**
Factory Orders	0.0839	0.64
Construction Spending	0.2049	0.57
Business Inventories	−0.1039	−0.55
Government Budget	0.1917	0.88

Table 6 Influence of US Disaggregate Macroeconomic Announcements on US Returns (continued)

	Coefficient	t-statistic
	US Announcements	
Trade Balance	0.4005	3.61***
Producer Price Index	0.0090	0.06
Consumer Price Index	−0.1917	−1.33
Consumer Confidence Index	0.0064	0.06
NAPM Index	−0.5410	−1.88*
Housing Starts	−1.1441	−6.17***
Index of Leading Indicators	0.4112	3.48***
Initial Unemployment Claims	−0.1128	−2.56**
Target Federal Funds Rate	−0.9267	−4.73***
Adjusted-R^2	0.1763	

market correlations are qualitatively the same as those in Table 5 (column 1 and 2). Interestingly, all the US announcements that are significant in Table 7 (column 1, 3, and 5) when the US value weighted return is not included in equation (20) remain significant in Table 6 (with the exception of the business inventories). This means that the Portuguese stock market only reacts to those US macroeconomic announcements that affect the US stock market. As previously shown, many of the US macroeconomic announcements become insignificant when the value weighted US return is included in the regression. Similarly, the results in Table 7, column 4 and 6, report that the Portuguese-US stock market correlation is the same during US significant announcement days and non-announcement days (including days when insignificant announcements are released). Hence, our results are robust to different announcement day definitions.

We test for predictable patterns in the Portuguese-US stock market correlation in the same spirit as Karolyi and Stulz (1996) and Bae, Karolyi and Stulz (2003). In particular, we replace D_t^{por} in equation (20) with D_t^{LARGE}, an indicator function equal to one if the US value weighted DJ 30 index experiences a top 10% jump in absolute value on day t and there were no announcements released on that day, and with day-of-the week indicator functions $\{D_t^{Monday}, D_t^{Tuesday}, D_t^{Wednesday}, D_t^{Tuesday}\}$. In the first specification we test the hypothesis that the Portuguese stock market “overreacts” to any US stock market shock. In the second specification, we consider the possibility of predictable patterns in the cross-country stock market correlation, that cannot be explained with our model. In Table 8 we show that, in contrast to Karolyi and Stulz (1996), the Portuguese stock market does not react significantly to large shocks to the US stock market (i.e., $\beta_{0\,LARGE}^{por}$ is insignificant) and there is no evidence of day-of-the week effects (only the Thursday correlation is slightly significantly lower at 10% significance level). The finding that $\beta_{0\,LARGE}^{por}$ is insignificant is consistent with Bekaert, Harvey and Ng (2005) who found that there is no contagion between US

Table 7 Influence of Statistically Significant Disaggregate Announcements on US-Portuguese stock Market co-movement

This table reports coefficient estimates of the following equation:

$$r_{it}^{por} = a^{por} + \lambda_{sp_{epor}}^{por} S_{ip_{epor}t} + \lambda_{sp_{ecb}}^{por} S_{p_{ecb}t} + \sum_{p_{por}=1}^{P_{por}} \lambda_{sp_{por}}^{por} S_{p_{por}t} + \sum_{p_{us}=1}^{P_{us}} \lambda_{sp_{us}}^{por} S_{p_{us}t} + \sum_{j=0}^{J} \lambda_{j}^{por} \Omega_{it-j}^{por}(1-D_t)$$

$$+ \sum_{j=0}^{J} \lambda_{pj}^{por} \Omega_{it-j}^{por} D_t + \sum_{j=0}^{J} \beta_{j}^{por} r_{t-j}^{us}(1-D_t) + \sum_{j=0}^{J} \beta_{pj}^{por} r_{t-j}^{us} D_t + \sum_{j=1}^{J} \beta_{porj}^{por} r_{it-j}^{por} + \varepsilon_{it}^{por},$$

where r_{it}^{por} is the daily return for stock $i = 1, \ldots, 20$ of the PSI-20 Index, Ω_{it}^{por} is the daily Portuguese unanticipated order flow for stock i (defined in Section 6), $D_t = \{D_t^{por}, D_t^{epor}, D_t^{us}\}$ is an indicator function equal to one if a statistically significant Portuguese macroeconomic announcement, Portuguese earnings announcement, and a statistically significant US macroeconomic annoucement is released, respectively, on date t $S_{p_{ecb}t}$ is the standardized ECB benchmark refinancing rate news surprise, $S_{ip_{epor}t}$ is the Portuguese standardized earnings news surprise for stock i, and $S_{p_{us}t}$ is the disaggregate standardized US macroeconomic news surprise for statistically significant news $p_{us} = 1, \ldots, p_{us}$ and $S_{p_{por}t}$ is the disaggregate Portuguese standardized macroeconomic news surprise for statistically significant news $p_{por} = 1, \ldots, P_{por}$. The coefficients in column one and two correspond to the equation estimates when $D_t = D_t^{por}$, the coefficients in column three and four correspond to the equation estimates when $D_t = D_t^{epor}$, and the coefficients in the last two columns correspond to the equation estimates when $D_t = D_t^{us}$. The t-statistics are estimated using the GARCH(1,1)-X model (equation (21)) to correct for heteroskedasticity and autocorrelation. We mark the coefficients and F-statistics with a " * ", " ** ", or " *** " to indicate significance at the 10%, 5%, or 1% level, respectively.

	Portuguese Macroeconomic Ann.		Portuguese Earnings Ann.		US Macroeconomic Ann.	
	Contemporaneous Order Flow					
Non-Announcement, λ_0^{por}	0.0151***	0.0139***	0.0150***	0.0144***	0.0144***	0.0137***
Announcement, λ_{p0}^{por}	0.0148***	0.0156***	0.0112**	0.0112**	0.0153***	0.0150***
H_0: $\lambda_0^{por} - \lambda_{p0}^{por} = 0$ (F-statistic)	0.0003	−0.0017**	0.0038	0.0032	−0.0009*	−0.0013**

	US Value Weighted Return					
Non-Announcement, β_0^{por}		0.2287***		0.2065***		0.2151***
Announcement, β_{0p}^{por}		0.0889**		0.2077		0.1962***
H_0: $\beta_0^{por} - \beta_{0p}^{por} = 0$ (F-statistic)		0.1398***		−0.0012		0.0189
	Portuguese Announcements					
Earnings	0.7721***	0.7461***	0.7783***	0.7512***	0.7742***	0.7530***
GDP	0.0090***	0.0101***	0.0087***	0.0102***	0.0093***	0.0109***
Industrial Sales	0.1964*	−0.01823	0.2052**	−0.1897***	0.1859*	−0.1788**
Trade Balance	0.4853***	0.4724***	0.5017***	0.4377***	0.4956***	0.4297***
Consumer Price Index	−0.5303***	−0.3630***	−0.5301***	−0.2791**	−0.5284***	−0.2727**
Producer Price Index	−0.2089***	−0.1400**	−0.2125***	−0.1100	−0.2147***	−0.1092
	European Announcement					
ECB benchmark refinancing rate	−0.1048**	−0.0662*	−0.1062***	−0.0733**	−0.1045***	−0.0714**
	US Announcements					
Personal Income	0.9951***	0.3847*	0.9938***	0.4684**	0.9854***	0.4614**
Consumer Credit	−0.1270**	−0.2304***	−0.1226**	−0.2020***	−0.1217**	−0.1995***
Personal Consumption Expenditures	0.9212***	0.0817	0.9129***	0.0867	0.9158***	0.0941
Business Inventories	−0.7147***	−0.3485**	−0.7179***	−0.3221**	−0.7115***	−0.3178**
Housing Starts	−0.5527**	−0.2369	−0.5487**	−0.2370	−0.5331**	−0.2274
Index of Leading Indicators	0.2867**	0.1698	0.2896**	0.1830	0.2873**	0.1817
Initial Unemployment Claims	−0.1259**	−0.0211	−0.1289**	−0.0256	−0.1284**	−0.0269
Target Federal Funds Rate	−1.3169***	−0.8166***	−1.3280***	−0.8282***	−1.3267***	−0.8353***
Adjusted-R^2	0.1887	0.2393	0.1857	0.2355	0.1861	0.2367

Table 8 Day of the Week Effects and Large US Returns

This table reports coefficient estimates of the following equation:

$$r_{it}^{por} = a^{por} + \lambda_{sp_{epor}}^{por} S_{ip_{epor}t} + \lambda_{sp_{ecb}}^{por} S_{p_{ecb}t} + \sum_{p_{por}=1}^{3} \lambda_{sp_{por}}^{por} S_{p_{por}t} + \sum_{p_{us}=1}^{9} \lambda_{sp_{us}}^{por} S_{p_{us}t} + \sum_{j=0}^{J} \lambda_j^{por} \Omega_{it-j}^{por}$$
$$+ \sum_{j=0}^{J} \beta_j^{por} r_{t-j}^{us} + \sum_{j=0}^{J} \beta_{pj}^{por} r_{t-j}^{us} D_t + \sum_{j=1}^{J} \beta_{porj}^{por} r_{it-j}^{por} + \varepsilon_{it}^{por},$$

where r_{it}^{por} is the daily return for stock $i = 1, \ldots, 20$ of the PSI−20 Index, Ω_{it}^{por} is the daily Portuguese unanticipated order flow for stock i (defined in Section 6), $D_t = \{D_t^{LARGE}, \{D_t^{Monday}, D_t^{Tuesday}, D_t^{Wednesday}, D_t^{Tuesday}\}\}$ where D_t^{LARGE} is an indicator function equal to one if the US value weighted DJ 30 index experiences a top 10% jump in absolute value on day t and there were no announcement releases, and $\{D_t^{Monday}, D_t^{Tuesday}, D_t^{Wednesday}, D_t^{Tuesday}\}$ are day-of-the week indicator functions, $S_{p_{ecb}t}$ is the standardized ECB benchmark refinancing rate news surprise, $S_{ip_{epor}t}$ is the Portuguese standardized earnings news surprise for stock i, and $S_{p_{us}t}$ is the aggregate standardized US macroeconomic news surprise $p_{us} = 1, \ldots, 9$ and $S_{p_{por}t}$ is the aggregate Portuguese standardized macroeconomic news surprise $p_{por} = 1, 2, 3$. The t-statistics are estimated using the GARCH(1,1)-X model (equation (21)) to correct for heteroskedasticity and autocorrelation. We mark the coefficients and F-statistics with a “ * ”, “ ** ”, or “ *** ” to indicate significance at the 10%, 5%, or 1% level, respectively.

	Coefficient	t-statistic	Coefficient	t-statistic
	Contemporaneous Order Flow			
λ_0^{por}	0.0136	43.45***	0.0134	40.90***
	Lagged Order Flow			
λ_1^{por}	−0.0032	−6.70***	−0.0030	−5.83***
λ_2^{por}	−0.0016	−3.24***	−0.0014	−2.58***
λ_3^{por}	−0.0014	−2.62***	−0.0016	−2.65***
	US Value Weighted Return			
β_0^{por}	0.2200	10.58***	0.2551	10.44***
β_{LARGE0}^{por}	0.0251	0.99		
Monday, $\beta_{monday0}^{por}$			0.0114	0.30
Tuesday, $\beta_{tuesday0}^{por}$			−0.0413	−1.11
Wednesday, $\beta_{wednesday0}^{por}$			−0.0170	−0.37
Thursday, $\beta_{thrusday0}^{por}$			−0.0647	−1.72*

and Portugal based on residuals from a two-factor asset pricing model. We conclude our model explains the time-varying properties of the US-Portuguese stock market correlation better than day-of-week and large-return patterns previously found in the literature.

Table 8 Day of the Week Effects and Large US Returns (continued)

	Coefficient	t-statistic	Coefficient	t-statistic
	Portuguese Announcements			
Earnings	0.7457	5.92***	0.7920	7.06***
Real Activity	0.2277	4.05***	0.2156	4.17***
Net Exports	0.4785	3.87***	0.4859	2.63***
Prices	−0.1799	−3.26***	−0.1258	−2.23**
F-statistic		10.12***		13.43***
	European Announcement			
ECB benchmark refinancing rate	−0.0578	−1.72*	−0.0503	−1.37
	US Announcements			
Real Activity	−0.0117	−0.3	−0.0214	−0.54
Consumption	−0.1953	−1.81*	−0.1780	−1.56
Investment	0.0334	0.47	0.0307	0.43
Government Purchases	0.1057	0.41	0.0500	0.19
Net Exports	−0.1132	−0.97	−0.1520	−1.26
Prices	0.0803	0.93	0.0869	0.99
Forward-Looking	0.1383	2.07**	0.1254	1.87*
Target Federal Funds Rate	−0.8698	−4.26***	−0.8777	−4.24***
Initial Unemployment Claims	−0.0350	−0.62	−0.0409	−0.71
F-statistic		2.62***		2.60***
Adjusted-R^2	0.2334		0.2321	

Finally, to further distinguish our hypothesis from the portfolio rebalancing hypothesis posed by Kodres and Pritsker (2002) we re-estimate (20) excluding from our sample Portuguese firms that are also traded in the US as ADRs during our sample: EDP, PORTUCEL and PT. US investors are more likely to buy Portuguese ADRs than Portuguese stocks not listed in the US. Hence the mechanism described in Kodres and Pritsker (2002) is more likely to work on an ADR sample than on a non-ADR sample. In untabulated results we show that the co-movement across markets drops from $\beta_0^{por} = 0.14$ on days of no Portuguese macroeconomic news to $\beta_{p0}^{por} = 0.02$ on days of Portuguese macro news. This finding deserves two comments. First, the result that there is lower co-movement on days of macroeconomic news announcements in Portugal is robust. Second, compared to the coefficients reported in Table 7, column 2 ($\beta_0^{por} = 0.23$ and $\beta_{p0}^{por} = 0.08$) there is a significant overall drop in correlations. This drop is consistent with ADRs being larger firms with greater correlation to global factors and with Ji's (2005) finding that once a stock is listed in the NYSE, its correlation with the US stock market increases. Continuing with our exercise with the non-ADR sample we find new estimates for co-movement changes during Portuguese earnings announcement days and US macroeconomic announcement days: $\beta_0^{epor} = 0.15$, $\beta_{p0}^{epor} = 0.13$, $\beta_0^{us} = 0.13$, and $\beta_{p0}^{us} = 0.18$, respectively. Consistent with the model and our previous evidence, the differences across announcement and non-announcement days are not statistically significant.

7 Conclusion

The main goal of this paper is to deepen our understanding of cross-country correlations and the price discovery process after public news releases. To that end, we theoretically identify and empirically document public news and order flow effects in the US and Portuguese stock markets. To guide our analysis, we develop a parsimonious model of speculative trading in the presence of short-lived private and public information about future dividends. We then test its equilibrium implications by studying the relation between daily US and Portuguese stock market returns, order flow and real-time macroeconomic news releases.

Our evidence suggests that cross-country stock market return co-movement is unchanged when US news are released. However, co-movement decreases when Portuguese news are released, unless the news are country-specific in which case there is no statistically significant change in co-movement. Our theory suggests that these effects arise from the way different news in Portugal and the US affect the informativeness of US returns to Portuguese investors.

Also, US public information affects Portuguese stock market returns, but this effect is smaller when US stock market returns are included in the regression. We document that this is due to a delayed response of the Portuguese stock market to US news and interpret the finding as evidence that Portuguese investors use the US return to filter out US investors' private information, in a sense free riding on US investors' efforts at analyzing the new information. We find evidence which contradicts the contagion view as an explanation to this delayed response.

Finally, we show that adverse selection costs decrease on days of news announcements in the US market, and that the effect of news on the Portuguese stock market depends on the nature of the news.

Appendix

The appendix gives the full details for the results presented in the paper.

The Large Economy with no News

We start with the large economy and compute the equilibrium on days of no news. The market maker sets a price $\tilde{P}_t^* = V_t^* + \lambda^* \tilde{\omega}_t^*$, and the informed investors' problem is

$$\max E\left[\tilde{P}^*_{t+1} - \tilde{P}^*_t\right] x^*_{it} = \max E\left[\tilde{v}^*_{t+1} - \lambda^* \sum_{j=1}^{n} \tilde{x}^*_{jt}\right] x^*_{it},$$

with first order necessary and sufficient condition (with conjecture that $\tilde{x}^*_{jt} = \tilde{x}^*_{it}$):

$$0 = E\left[\tilde{v}^*_{t+1} - \lambda^* \sum_{j=1}^{n} \tilde{x}^*_{jt} | s^*_t\right] - \lambda^* x^*_{it}.$$

Because $E[\tilde{v}^*_{t+1}|s^*_t] = \frac{\delta^*}{\delta^*+\phi^*} s^*_t$ we can solve for

$$x^*_{it} = \frac{1}{\lambda^*(n^*+1)} \frac{\delta^*}{\delta^*+\phi^*} s^*_t.$$

The market maker's problem is

$$\begin{aligned} 0 &= E[\tilde{P}^*_{t+1} - \tilde{P}^*_t]\omega^*_t \\ &= E[\tilde{v}^*_{t+1}|\omega^*_t] - \lambda^* \omega^*_t. \end{aligned}$$

With $\tilde{\omega}^*_t = \frac{n^*}{\lambda^*(n^*+1)} \frac{\delta^*}{\delta^*+\phi^*} \tilde{s}^*_t + \tilde{z}^*_t = \beta^* \tilde{s}^*_t + \tilde{z}^*_t$ we obtain $E[\tilde{v}^*_{t+1}|\omega^*_t] = \frac{\beta^*\delta^*}{\beta^{*2}(\delta^*+\phi^*)+\zeta^*}\omega^*_t$. Replacing in the market maker's optimality condition we get the equilibrium solution for prices and quantities:

$$\lambda^* = \frac{\delta^*}{n^*+1}\sqrt{\frac{n^*}{\zeta^*\left(\delta^*+\phi^*\right)}},$$

$$x^*_{it} = \sqrt{\frac{\zeta^*}{n^*\left(\delta^*+\phi^*\right)}} s^*_t.$$

The Large Economy with News

Consider a day of news in the foreign economy. Prices are $\tilde{P}^*_t = V^*_t + \lambda^* \tilde{\omega}^*_t + \sigma^* \tilde{U}^*_t$. The informed investors' problem yields:

$$\max E\left[\tilde{P}^*_{t+1} - \tilde{P}^*_t\right] x^*_{it} = \max E\left[\tilde{v}^*_{t+1} - \lambda^* \sum_{j=1}^{n} \tilde{x}^*_{jt} - \sigma^* \tilde{U}^*_t | \tilde{s}^*_t, \tilde{U}^*_t\right] x^*_{it}.$$

The solution to this problem (after appropriately computing conditional expectations) is:

$$x^*_{it} = \frac{1}{\lambda^*(n^*+1)}\left[\frac{\delta^*\kappa^*}{\Delta_5} s^*_t + \left(\frac{\delta^*\phi^*}{\Delta_5} - \sigma^*\right) U^*_t\right],$$

with $\Delta_5 = \delta^*\kappa^* + \phi^*\delta^* + \phi^*\kappa^*$.

The market maker's problem is to find λ^* and σ^* such that:

$$\begin{aligned}0 &= E\left[\tilde{P}^*_{t+1} - \tilde{P}^*_t\right] \omega^*_t \\ &= E\left[\tilde{v}^*_{t+1} | \omega^*_t, U^*_t\right] - \lambda^* \omega^*_t - \sigma^* U^*_t.\end{aligned}$$

Using the fact that total order flow is a function of investors' private information, the available public information and uninformed investors' trading we obtain $E[\tilde{v}^*_{t+1}|\omega^*_t, U^*_t]$ which then gives a solution for

$$\begin{aligned}\lambda^{*2} &= \frac{n^*}{\zeta^*\left(\delta^* + \kappa^*\right)\left(n^* + 1\right)^2} \frac{\left(\delta^*\kappa^*\right)^2}{\left(\delta^*\phi^* + \kappa^*\delta^* + \kappa^*\phi^*\right)}, \\ \sigma^* &= \frac{\delta^*}{\delta^* + \kappa^*}.\end{aligned}$$

Proof of Proposition 1. In the foreign market news lead to an increase in liquidity as the adverse selection is reduced $\lambda^*_A < \lambda^*_{NA}$:

$$\begin{aligned}\lambda^*_A &= \frac{\delta^*\kappa^*}{n^* + 1}\sqrt{\frac{n^*}{\zeta^*\left(\delta^* + \kappa^*\right)\left[\left(\delta^* + \kappa^*\right)\left(\phi^* + \delta^*\right) - \delta^{*2}\right]}} \\ &< \frac{\delta^*}{n^* + 1}\sqrt{\frac{n^*}{\zeta^*\left(\delta^* + \phi^*\right)}} = \lambda^*_{NA},\end{aligned}$$

because

$$0 < \delta^*\kappa^* + (\delta^* + \kappa^*)\phi^* + \phi^*\kappa^*.$$

■

The Small Economy with No News

On a day of no news, equilibrium in the small market requires $\tilde{P}_t = V_t + \lambda\tilde{\omega}_t + \eta\omega^*_t$ because the foreign order flow contains useful information for local investors. The informed investors' problem is

$$\max_{x_{it}} E[\tilde{P}_{t+1} - \tilde{P}_t | s_t, \tilde{\omega}^*_t] x_{it} = \max_{x_{it}} E\left[\tilde{v}_{t+1} - \lambda\sum_{j=1}^{n}\tilde{x}_{jt} - \lambda\tilde{z}_t - \eta\tilde{\omega}^*_t | s_t, \tilde{\omega}^*_t\right] x_{it}.$$

In order to solve this problem we need to find $E[\tilde{v}_{t+1}|s_t, \tilde{\omega}^*_t]$. To do this, first note that

$$\Sigma = Var\begin{bmatrix}\tilde{v}_{t+1} \\ s_t \\ \tilde{\omega}^*_t\end{bmatrix} = \begin{bmatrix}\delta & \delta & \beta^*\psi \\ & \delta + \phi & \beta^*\psi \\ & & (n^* + 1)\zeta^*\end{bmatrix}.$$

Defining $\Sigma_{12} = [Cov(\tilde{v}_{t+1}, s_t), Cov(\tilde{v}_{t+1}, \tilde{\omega}_t^*)]$ and $\Sigma_{22} = Var([s_t, \tilde{\omega}_t^*])$ we get:

$$\begin{aligned}
E\left[\tilde{v}_{t+1} | s_t, \tilde{\omega}_t^*\right] &= \Sigma_{12}\Sigma_{22}^{-1}\begin{bmatrix} s_t \\ \tilde{\omega}_t^* \end{bmatrix} \\
&= \frac{1}{\Delta_1}\begin{bmatrix} \delta & \beta^*\psi \end{bmatrix}\begin{bmatrix} (n^*+1)\zeta^* & -\beta^*\psi \\ -\beta^*\psi & \delta+\phi \end{bmatrix}\begin{bmatrix} s_t \\ \tilde{\omega}_t^* \end{bmatrix} \\
&= a_0 s_t + a_1\tilde{\omega}_t^*
\end{aligned}$$

where

$$\Delta_1 = (n^*+1)\zeta^*(\delta+\phi) - \beta^{*2}\psi^2$$

and

$$\begin{aligned}
a_0 &= \frac{\delta(n^*+1)\zeta^* - \beta^{*2}\psi^2}{(n^*+1)\zeta^*(\delta+\phi) - \beta^{*2}\psi^2} \\
a_1 &= \frac{\beta^*\psi\phi}{(n^*+1)\zeta^*(\delta+\phi) - \beta^{*2}\psi^2}.
\end{aligned}$$

Therefore, solving the first order necessary condition we find

$$\tilde{x}_{it} = \frac{1}{\lambda(n+1)}[a_0 s_t + (a_1 - \eta)\tilde{\omega}_t^*].$$

Given that $\tilde{P}_t = V_t + \lambda\tilde{\omega}_t + \eta\omega_t^*$ and $E[\tilde{P}_{t+1}|\omega_t, \omega_t^*] = E[V_t + \tilde{v}_{t+1}|\omega_t, \omega_t^*]$, the market maker solves:

$$\begin{aligned}
0 &= E[\tilde{P}_{t+1} - \tilde{P}_t]\omega_t \\
&= E[\tilde{v}_{t+1}|\omega_t, \omega_t^*] - \lambda\omega_t - \eta\omega_t^*.
\end{aligned}$$

We can show that

$$Var\begin{bmatrix} \tilde{v}_{t+1} \\ \tilde{\omega}_t \\ \tilde{\omega}_t^* \end{bmatrix} = \begin{bmatrix} \delta & \frac{n}{\lambda(n+1)}[a_0\delta + (a_1-\eta)\beta^*\psi] & \beta^*\psi \\ & E\left[\tilde{\omega}_t^2\right] & \frac{n}{\lambda(n+1)}[a_0\beta^*\psi + (a_1-\eta)(n^*+1)\zeta^*] \\ & & (n^*+1)\zeta^* \end{bmatrix},$$

with

$$E\left[\tilde{\omega}_t^2\right] = \left(\frac{n}{\lambda(n+1)}\right)^2\left[a_0^2(\delta+\phi) + (a_1-\eta)^2(n^*+1)\zeta^* + 2a_0(a_1-\eta)\beta^*\psi\right] + \zeta.$$

Abusing notation let $\Sigma = Var[\,\tilde{v}_{t+1}\ \tilde{\omega}_t\ \tilde{\omega}_t^*\,]'$. Define $\Sigma_{12} = [Cov(\tilde{v}_{t+1}, \tilde{\omega}_t), Cov(\tilde{v}_{t+1}, \tilde{\omega}_t^*)]$ and $\Sigma_{22} = Var([\tilde{\omega}_t, \tilde{\omega}_t^*])$. After tedious algebra we can find $E[\tilde{v}_{t+1}|\omega_t, \tilde{\omega}_t^*] = \Sigma_{12}\Sigma_{22}^{-1}[\,\tilde{\omega}_t\ \tilde{\omega}_t^*\,]'$ and show that the market maker's efficiency condition is satisfied with

$$\lambda^2 = \frac{1}{\zeta(n^*+1)\zeta^*}\frac{n}{(n+1)^2}\frac{[\delta(n^*+1)\zeta^* - \beta^{*2}\psi^2]^2}{(n^*+1)\zeta^*(\delta+\phi) - \beta^{*2}\psi^2},$$
$$\eta = \frac{\beta^*\psi}{(n^*+1)\zeta^*}.$$

Proof of Proposition 2. The equilibrium return regression when there are no public announcements in either economy is

$$\tilde{P}_t - V_t = \lambda\tilde{\omega}_t + \frac{\psi}{\delta^*}(P_t^* - V_t^*)$$

because $\eta\lambda^{*-1} = \frac{\psi}{\delta^*}$:

$$\eta\lambda^{*-1} = \frac{\sqrt{\frac{n^*\zeta^*}{\delta^*+\phi^*}}\psi}{(n^*+1)\zeta^*}\frac{1}{\frac{\delta^*}{n^*+1}\sqrt{\frac{n^*}{\zeta^*(\delta^*+\phi^*)}}} = \frac{\psi}{\delta^*}.$$

■

The small Economy with Local Macro News

Consider now a day of news in the small, local economy $\tilde{U}_t = \tilde{v}_{t+1} + \tilde{\mu}_t$, with $E[\tilde{\mu}_t^2] = \kappa$. The market maker is assumed to choose the following price function $\tilde{P}_t = V_t + \lambda\tilde{\omega}_t + \eta\tilde{\omega}_t^* + \sigma U_t$. The informed investors' problem is

$$\begin{aligned}
&\max E[\tilde{P}_{t+1} - \tilde{P}_t|\tilde{\omega}_t^*, U_t, \tilde{s}_t]x_{it} \\
&\quad = \max E\left[\tilde{v}_{t+1} - \lambda\sum_{j=1}^{n}\tilde{x}_{jt} - \lambda\tilde{z}_t - \eta\omega_t^* - \sigma U_t|\tilde{\omega}_t^*, U_t, \tilde{s}_t\right]x_{it}.
\end{aligned}$$

The solution to this problem is to trade:

$$\tilde{x}_{it} = \frac{1}{\lambda(n+1)}\left[a_0 s_t + (a_1-\eta)\,\omega_t^* + (a_2-\sigma)\,U_t\right],$$

where (abusing notation):

$$a_0 = \frac{\kappa[\delta(n^*+1)\zeta^* - \beta^{*2}\psi^2]}{(\delta\kappa+\phi\delta+\phi\kappa)(n^*+1)\zeta^* - (\phi+\kappa)\beta^{*2}\psi^2} = a_2\frac{\kappa}{\phi},$$
$$a_1 = \frac{\beta^*\psi\phi\kappa}{(\delta\kappa+\phi\delta+\phi\kappa)(n^*+1)\zeta^* - (\phi+\kappa)\beta^{*2}\psi^2}.$$

The auxiliary constants a_0, a_1 and a_2 are the solutions to

$$[a_0, a_1, a_2]' = \Sigma_{12}\Sigma_{22}^{-1}\left[s_t, \tilde{\omega}_t^*, U_t\right]'$$

where (abusing notation):

$$\Sigma = Var\begin{bmatrix} \tilde{v}_{t+1} \\ s_t \\ \tilde{\omega}_t^* \\ U_t \end{bmatrix} = \begin{bmatrix} \delta & \delta & \beta^*\psi & \delta \\ & \delta+\phi & \beta^*\psi & \delta \\ & \beta^*\psi & (n^*+1)\zeta^* & \beta^*\psi \\ & \delta & \beta^*\psi & \delta+\kappa \end{bmatrix},$$

and $\Sigma_{12} = [Cov(\tilde{v}_{t+1}, s_t), Cov(\tilde{v}_{t+1}, \tilde{\omega}_t^*), Cov(\tilde{v}_{t+1}, U_t)]$ and $\Sigma_{22} = Var([s_t, \tilde{\omega}_t^*, U_t])$.

The market maker's problem is

$$0 = E[\tilde{P}_{t+1} - \tilde{P}_t]\omega_t = E[\tilde{v}_{t+1}|\omega_t, \omega_t^*, U_t] - \lambda\omega_t - \eta\omega_t^* - \sigma U_t.$$

Again, we solve for $E[\tilde{v}_{t+1}|\omega_t, \omega_t^*, U_t]$. First note that (abusing notation on Σ),

$$\Sigma = Var\begin{bmatrix} \tilde{v}_{t+1} \\ \tilde{\omega}_t \\ \tilde{\omega}_t^* \\ U_t \end{bmatrix} = \begin{bmatrix} \delta & E[v_{t+1}\tilde{\omega}_t] & \beta^*\psi & \delta \\ & E\left[\tilde{\omega}_t^2\right] & E[\tilde{\omega}_t\tilde{\omega}_t^*] & E[\tilde{\omega}_t U_t] \\ & & (n^*+1)\zeta^* & \beta^*\psi \\ & & & \delta+\kappa \end{bmatrix},$$

where

$$E[v_{t+1}\tilde{\omega}_t] = \frac{n}{\lambda(n+1)}[a_0\delta + (a_1-\eta)\beta^*\psi + (a_2-\sigma)\delta],$$

$$E[\tilde{\omega}_t U_t] = \frac{n}{\lambda(n+1)}[a_0\delta + (a_1-\eta)\beta^*\psi + (a_2-\sigma)(\delta+\kappa)],$$

$$E\left[\tilde{\omega}_t\tilde{\omega}_t^*\right] = \frac{n}{\lambda(n+1)}[a_0\beta^*\psi + (a_1-\eta)(n^*+1)\zeta^* + (a_2-\sigma)\beta^*\psi],$$

$$E[\tilde{\omega}_t^2] = \left(\frac{n}{\lambda(n+1)}\right)^2 \left[a_0^2(\delta+\phi) + (a_1-\eta)^2(n^*+1)\zeta^* + (a_2-\sigma)^2(\delta+\kappa) + 2a_0(a_1-\eta)\beta^*\psi + 2a_0(a_2-\sigma)\delta + 2(a_1-\eta)(a_2-\sigma)\beta^*\psi\right] + \zeta.$$

Define $\Sigma_{12} = [Cov(\tilde{v}_{t+1}, \tilde{\omega}_t), Cov(\tilde{v}_{t+1}, \tilde{\omega}_t^*), Cov(\tilde{v}_{t+1}, U_t)]$ and $\Sigma_{22} = Var([\tilde{\omega}_t, \tilde{\omega}_t^*, U_t])$. After some algebra, to solve for the matrices in $E[\tilde{v}_{t+1}|\omega_t, \omega_t^*, U_t] = \Sigma_{12}\Sigma_{22}^{-1}[\omega_t, \omega_t^*, U_t]'$, we find the parameters that satisfy the market maker's zero profit condition:

$$\lambda = \frac{var\left(\tilde{v}_{t+1}|\tilde{\omega}_t^*, \tilde{U}_t\right)}{n+1}\sqrt{\frac{n}{\zeta var\left(\tilde{s}_t|\tilde{\omega}_t^*, \tilde{U}_t\right)}},$$

$$\eta = \frac{\kappa}{var\left(\tilde{U}_t|\tilde{\omega}_t^*\right)}\frac{var\left(\tilde{v}_{t+1}^*\right)}{n^*+1}\sqrt{\frac{n^*}{\zeta^* var\left(\tilde{s}_t^*\right)}}\frac{\psi}{\delta^*},$$

$$\sigma = \frac{var\left(\tilde{v}_{t+1}|\tilde{\omega}_t^*\right)}{var\left(\tilde{U}_t|\tilde{\omega}_t^*\right)},$$

where $var(\tilde{s}|\tilde{\omega}^*, \tilde{U}) = [(\delta\kappa + \phi\delta + \phi\kappa) - (\kappa + \phi)\frac{n^*}{(n^*+1)(\delta^*+\phi^*)}\psi^2]/[(\delta + \kappa) - \frac{n^*}{(n^*+1)(\delta^*+\phi^*)}\psi^2]$.

Proof of Proposition 3. Price correlation across markets is given by

$$\begin{aligned}\eta\lambda^{*-1} &= \frac{\kappa\beta^*\psi}{(n^*+1)\zeta^*(\delta+\kappa) - \beta^{*2}\psi^2}\lambda^{*-1} \\ &= \frac{\kappa}{(\delta+\kappa)[1 - Corr(\tilde{\omega}_t^*, \tilde{U}_t)^2]}\frac{\psi}{\delta^*} = \frac{\kappa}{var(\tilde{U}_t|\tilde{\omega}_t^*)}\frac{\psi}{\delta^*}.\end{aligned}$$

The slope $\eta\lambda^{*-1}$

$$\frac{d\log(\eta\lambda^{*-1})}{d\kappa} = \frac{var(\tilde{\upsilon}_{t+1}|\omega_t^*)}{\kappa var(\tilde{U}_t|\omega_t^*)} > 0.$$

Noting that as $\kappa \to \infty$, $\eta\lambda^{*-1} \to \frac{\psi}{\delta^*}$ and because $d\log(\eta\lambda^{*-1})/d\kappa > 0$ it must be that $\eta\lambda^{*-1} < \frac{\psi}{\delta^*}$ for finite κ. ∎

Proof of Proposition 5. What are the liquidity effects on days of news relative to no news? Compare

$$\lambda^2_{No\_A} = \frac{1}{\zeta(n^*+1)\zeta^*}\frac{n}{(n+1)^2}\frac{\left[\delta(n^*+1)\zeta^* - \beta^{*2}\psi^2\right]^2}{(n^*+1)\zeta^*(\delta+\phi) - \beta^{*2}\psi^2}$$

with

$$\begin{aligned}\lambda^2_{A,POR} &= \frac{n}{(n+1)^2}\frac{\kappa^2[\delta(n^*+1)\zeta^* - \beta^{*2}\psi^2]^2}{(\delta\kappa+\phi\delta+\phi\kappa)(n^*+1)\zeta^* - (\phi+\kappa)\beta^{*2}\psi^2} \\ &\quad\times\frac{1}{\zeta[(n^*+1)\zeta^*(\delta+\kappa) - \beta^{*2}\psi^2]}.\end{aligned}$$

If liquidity increases in news days then $\lambda^2_{A,POR} < \lambda^2_{No\_A}$ or

$$\kappa^2 < \left[(\delta\kappa+\phi\delta+\phi\kappa) - \frac{(\phi+\kappa)}{(n^*+1)}\frac{n^*}{\delta^*+\phi^*}\psi^2\right]\frac{\delta+\kappa - \frac{n^*}{(n^*+1)(\delta^*+\phi^*)}\psi^2}{\delta+\phi - \frac{n^*}{(n^*+1)(\delta^*+\phi^*)}\psi^2}.$$

The right hand side of this inequality can be written as

$$\kappa^2 + \kappa var(\tilde{\upsilon}_{t+1}|\tilde{\omega}_t^*)\left[1 + \frac{\phi}{var(\tilde{s}_t|\tilde{\omega}_t^*)}\right] + \phi\frac{var\left(\tilde{\upsilon}_{t+1}|\tilde{\omega}_t^*\right)^2}{var(\tilde{s}_t|\tilde{\omega}_t^*)}.$$

Therefore we get that $\lambda^2_{A,POR} < \lambda^2_{No\_A}$. ∎

The Small Economy with Foreign News

There is also price discovery in the small country after news in the large economy. The market maker is assumed to choose the following price function:

$$\tilde{P}_t = V_t + \lambda\tilde{\omega}_t + \eta \underbrace{[\tilde{\omega}_t^* - \beta_1^* U_t^*]}_{w_t^* = \beta_0^* s_t^* + z_t^*} + \sigma U_t^*.$$

Following the same steps as above we can show that

$$\tilde{x}_{it} = \frac{1}{\lambda(n+1)}\left[a_0 s_t + (a_1 - \eta)\, w_t^* + (a_2 - \sigma)\, U_t^*\right],$$

with

$$\begin{aligned}
a_0 &= \frac{[(\delta(\delta^* + \kappa^*) - \psi^2)E[\tilde{w}_t^{*2}] - \delta\beta_0^{*2}\delta^{*2} - \beta_0^{*2}\psi^2(\kappa^* - \delta^*)]}{(\delta + \phi)[(\delta^* + \kappa^*)E[\tilde{w}_t^{*2}] - \beta_0^{*2}\delta^{*2}] + \psi^2[(\delta^* - \kappa^*)\beta_0^{*2} - E[\tilde{w}_t^{*2}]]}\\
a_1 &= \frac{\phi\kappa^*\beta_0^*\psi}{(\delta + \phi)\left[(\delta^* + \kappa^*)\, E\left[\tilde{w}_t^{*2}\right] - \beta_0^{*2}\delta^{*2}\right] + \psi^2\left[(\delta^* - \kappa^*)\,\beta_0^{*2} - E\left[\tilde{w}_t^{*2}\right]\right]}\\
a_2 &= \frac{\left[-\beta_0^{*2}\delta^* + E\left[\tilde{w}_t^{*2}\right]\right]\psi\phi}{(\delta + \phi)\left[(\delta^* + \kappa^*)\, E\left[\tilde{w}_t^{*2}\right] - \beta_0^{*2}\delta^{*2}\right] + \psi^2\left[(\delta^* - \kappa^*)\,\beta_0^{*2} - E\left[\tilde{w}_t^{*2}\right]\right]}.
\end{aligned}$$

These auxiliary constans are the coefficients in the vector $\Sigma_{12}\Sigma_{22}^{-1}$ where the matrix Σ is

$$\Sigma = Var\begin{bmatrix}\tilde{v}_{t+1}\\ s_t\\ \tilde{w}_t^*\\ U_t^*\end{bmatrix} = \begin{bmatrix}\delta & \delta & \beta^*\psi & \psi\\ & \delta + \phi & \beta^*\psi & \psi\\ & \beta^*\psi & E\left[\tilde{w}_t^{*2}\right] & \beta^*\delta^*\\ & \psi & \beta^*\delta^* & \delta^* + \kappa^*\end{bmatrix},$$

where

$$E\left[\tilde{\omega}_t^{*2}\right] = \frac{\zeta^*(\delta^* + \kappa^*)n^*}{\delta^*\kappa^* + \phi^*\kappa^* + \phi^*\delta^*}(\delta^* + \phi^*) + \zeta^*,$$

and $\Sigma_{12} = [Cov(\tilde{v}_{t+1}, s_t), Cov(\tilde{v}_{t+1}, \tilde{\omega}_t^*), Cov(\tilde{v}_{t+1}, U_t^*)]$ and $\Sigma_{22} = Var([s_t, \tilde{\omega}_t^*, U_t^*])$.

The market maker's problem is to determine the constants $[\lambda, \eta, \sigma]'$ that solve (abusing notation for Σ)

$$E\left[\tilde{v}_{t+1}|\omega_t, w_t^*, U_t^*\right] = \Sigma_{12}\Sigma_{22}^{-1}\left[\omega_t, w_t^*, U_t^*\right]',$$

where

$$\Sigma = Var\begin{bmatrix}\tilde{v}_{t+1}\\ \tilde{\omega}_t\\ \tilde{w}_t^*\\ U_t^*\end{bmatrix} = \begin{bmatrix}\delta & E\left[v_{t+1}\tilde{w}_t\right] & \beta^*\psi & \psi\\ & E\left[\tilde{\omega}_t^2\right] & E\left[\tilde{\omega}_t\tilde{w}_t^*\right] & E\left[\tilde{\omega}_t U_t^*\right]\\ & & E\left[\tilde{w}_t^{*2}\right] & \beta^*\delta^*\\ & & & \delta^*+\kappa^*\end{bmatrix},$$

$\Sigma_{12} = [Cov(\tilde{v}_{t+1}, \tilde{\omega}_t), Cov(\tilde{v}_{t+1}, \tilde{\omega}_t^*), Cov(\tilde{v}_{t+1}, U_t^*)]$ and $\Sigma_{22} = Var([\tilde{\omega}_t, \tilde{\omega}_t^*, U_t^*])$, and where

$$E[v_{t+1}\tilde{\omega}_t] = \frac{n}{\lambda(n+1)}[a_0\delta + (a_1-\eta)\beta^*\psi + (a_2-\sigma)\psi],$$

$$E[\tilde{\omega}_t U_t^*] = \frac{n}{\lambda(n+1)}[a_0\psi + (a_1-\eta)\beta^*\delta^* + (a_2-\sigma)(\delta^*+\kappa^*)],$$

$$E[\tilde{\omega}_t w_t^*] = \frac{n}{\lambda(n+1)}[a_0\beta^*\psi + (a_1-\eta)E[\tilde{w}_t^{*2}] + (a_2-\sigma)\beta^*\delta^*],$$

$$E[\tilde{w}_t^{*2}] = \frac{\zeta^*(\delta^*+\kappa^*)n^*}{\delta^*\kappa^*+\phi^*\kappa^*+\phi^*\delta^*}(\delta^*+\phi^*)+\zeta^*,$$

$$E[\tilde{w}_t^2] = \left(\frac{n}{\lambda(n+1)}\right)^2\Big[a_0^2(\delta+\phi) + (a_1-\eta)^2E\big[\tilde{w}_t^{*2}\big] + (a_2-\sigma)^2(\delta^*+\kappa^*)$$
$$+ 2a_0(a_1-\eta)\beta^*\psi + 2a_0(a_2-\sigma)\psi + 2(a_1-\eta)(a_2-\sigma)\beta^*\delta^*\Big] + \zeta.$$

After much algebra we get:

$$\lambda^2 = \left\{\frac{n}{\zeta(n+1)^2}\left[\beta_0^{*2}(\psi^2(\delta^*-\kappa^*)-\delta\delta^{*2}) + E\left[\tilde{w}_t^{*2}\right](\delta(\delta^*+\kappa^*)-\psi^2)\right]^2\right\}\Big/$$
$$\left\{\left[E\left[\tilde{w}_t^{*2}\right](\delta^*+\kappa^*)-\beta_0^{*2}\delta^{*2}\right]\left[[(\delta+\phi)(\delta^*+\kappa^*)-\psi^2]E\left[\tilde{w}_t^{*2}\right]\right.\right.$$
$$\left.\left.+\ \beta_0^{*2}[\psi^2(\delta^*-\kappa^*)-\delta^{*2}(\delta+\phi)]\right]\right\},$$

$$\eta = \frac{\beta_0^*\psi\kappa^*}{E\left[\tilde{w}_t^{*2}\right](\delta^*+\kappa^*)-\beta_0^{*2}\delta^{*2}},$$

$$\sigma = \frac{\psi\left[E\left[\tilde{w}_t^{*2}\right]-\beta_0^{*2}\delta^*\right]}{E\left[\tilde{w}_t^{*2}\right](\delta^*+\kappa^*)-\beta_0^{*2}\delta^{*2}}.$$

Proof of Proposition 6. The regression of returns in the small economy on returns in the large economy conditional on local order flow and the available public information yields a slope on the foreign return of

$$\eta\lambda^{*-1} = \frac{\psi}{E\left[\tilde{w}_t^{*2}\right](\delta^*+\kappa^*)-\beta_0^{*2}\delta^{*2}}\,\frac{\zeta^*(\delta^*+\kappa^*)(n^*+1)}{\delta^*} = \frac{\psi}{\delta^*}$$

since $\beta_0^* = \sqrt{\frac{n^*\zeta^*(\delta^*+\kappa^*)}{\delta^*\kappa^*+\phi^*\delta^*+\phi^*\kappa^*}}$. We also need to show that the coefficient on foreign news is zero. To see this note that

$$\begin{aligned}\tilde{P}_t - V_t &= \lambda\tilde{\omega}_t + \eta\left[\tilde{\omega}_t^* - \beta_1 U_t^*\right] + \sigma U_t^* \\ &= \lambda\tilde{\omega}_t + \eta\lambda^{*-1}\left(\tilde{P}_t^* - V_t^*\right) - \left[\eta\left(\lambda^{*-1}\sigma^* + \beta_1^*\right) - \sigma\right]\tilde{U}_t^*.\end{aligned}$$

But, $\eta\lambda^{*-1}\sigma^* = \frac{\psi}{\delta^*+\kappa^*}$, and

$$\begin{aligned}\eta\beta_1^* &= \eta\frac{n^*}{\lambda^*(n^*+1)}\left(\frac{\delta^*\phi^*}{\delta^*\kappa^* + \phi^*\delta^* + \phi^*\kappa^*} - \sigma^*\right) \\ &= -\frac{\psi}{\delta^*+\kappa^*}\frac{n^*}{(n^*+1)}\frac{\delta^*\kappa^*}{\delta^*\kappa^* + \phi^*\delta^* + \phi^*\kappa^*}.\end{aligned}$$

Therefore we obtain $\eta\,(\lambda^{*-1}\sigma^* + \beta_1^*) - \sigma = 0$. ■

The Small Economy with Local Country-specific News

Finally, we consider country-specific news in the local, small economy. The price function is $\tilde{P}_t = V_t + \lambda\tilde{\omega}_t + \eta\tilde{\omega}_t^* + \sigma U_t$. The informed investors' problem is

$$\begin{aligned}&\max E[\tilde{P}_{t+1} - \tilde{P}_t | s_t, \omega_t^*, U_t]x_{it} \\ &\quad = \max E\left[\tilde{v}_{t+1} - \lambda\sum_{j=1}^{n}\tilde{x}_{jt} - \lambda\tilde{z}_t - \eta\omega_t^* - \sigma U_t | s_t, \omega_t^*, U_t\right]x_{it},\end{aligned}$$

with first order condition:

$$\lambda(n+1)\tilde{x}_{it} = E[\tilde{v}_{t+1}|s_t, \omega_t^*, U_t] - \eta\omega_t^* - \sigma U_t.$$

To compute the conditional expectation note that (abusing notation Σ):

$$\Sigma = Var\begin{bmatrix}\tilde{v}_{t+1} \\ s_t \\ \tilde{\omega}_t^* \\ U_t\end{bmatrix} = \begin{bmatrix}\delta & \delta_1 & \beta^*\psi & \delta_2 \\ & \delta_1 + \phi & \beta^*\psi & 0 \\ & & \beta^*\psi \quad (n^*+1)\zeta^* & 0 \\ & & 0 \quad\quad 0 & \delta_2 + \kappa\end{bmatrix}.$$

Define $\Sigma_{12} = [Cov(\tilde{v}_{t+1}, s_t), Cov(\tilde{v}_{t+1}, \tilde{\omega}_t^*), Cov(\tilde{v}_{t+1}, U_t)]$ and $\Sigma_{22} = Var([s_t, \tilde{\omega}_t^*, U_t])$. Denoting by $[a_0, a_1, a_2]' = \Sigma_{12}\ \Sigma_{22}^{-1}$ we show that informed investors' trading is

$$\tilde{x}_{it} = \frac{1}{\lambda(n+1)}[a_0 s_t + (a_1 - \eta)\omega_t^* + (a_2 - \sigma)U_t],$$

with

$$a_0 = \frac{\delta_1 (n^* + 1)\zeta^* - \beta^{*2}\psi^2}{(n^* + 1)\zeta^* (\delta_1 + \phi) - \beta^{*2}\psi^2} = \frac{\delta_1 (n^* + 1)\zeta^* - \beta^{*2}\psi^2}{\beta^* \psi \phi} a_1,$$
$$a_2 = \frac{\delta_2}{\delta_2 + \kappa}.$$

The market maker's problem is

$$\begin{aligned} 0 &= E[\tilde{P}_{t+1} - \tilde{P}_t | \omega_t, \omega_t^*, U_t]\omega_t \\ &= E[\tilde{v}_{t+1} | \omega_t, \omega_t^*, U_t] - \lambda\omega_t - \eta\omega_t^* - \sigma U_t. \end{aligned}$$

Compute,

$$\Sigma = Var \begin{bmatrix} \tilde{v}_{t+1} \\ \tilde{\omega}_t \\ \tilde{\omega}_t^* \\ U_t \end{bmatrix} = \begin{bmatrix} \delta & E\left[v_{t+1}\tilde{\omega}_t\right] & \beta^*\psi & \delta_2 \\ & E\left[\tilde{\omega}_t^2\right] & E\left[\tilde{\omega}_t \tilde{\omega}_t^*\right] & E\left[\tilde{\omega}_t U_t\right] \\ & & (n^* + 1)\zeta^* & 0 \\ & & & \delta_2 + \kappa \end{bmatrix},$$

where

$$\begin{aligned} E\left[\tilde{\omega}_t U_t\right] &= \frac{n}{\lambda(n+1)} (a_2 - \sigma)(\delta_2 + \kappa), \\ E\left[v_{t+1}\tilde{\omega}_t\right] &= \frac{n}{\lambda(n+1)} \left[a_0\delta_1 + (a_1 - \eta)\beta^*\psi + (a_2 - \sigma)\delta_2\right], \\ E\left[\tilde{\omega}_t\tilde{\omega}_t^*\right] &= \frac{n}{\lambda(n+1)} \left[a_0\beta^*\psi + (a_1 - \eta)(n^* + 1)\zeta^*\right], \\ E\left[\tilde{\omega}_t^2\right] &= \left(\frac{n}{\lambda(n+1)}\right)^2 \left[a_0^2(\delta_1 + \phi) + (a_1 - \eta)^2 (n^* + 1)\zeta^* \right. \\ &\quad \left. + (a_2 - \sigma)^2(\delta_2 + \kappa) + 2a_0(a_1 - \eta)\beta^*\psi\right] + \zeta. \end{aligned}$$

Define $\Sigma_{12} = [Cov(\tilde{v}_{t+1}, \tilde{\omega}_t), Cov(\tilde{v}_{t+1}, \tilde{\omega}_t^*), Cov(\tilde{v}_{t+1}, U_t)]$ and $\Sigma_{22} = Var([\tilde{\omega}_t, \tilde{\omega}_t^*, U_t])$. We can then show that $[\lambda, \eta, \sigma]' = \Sigma_{12}\, \Sigma_{22}^{-1}$ or that

$$\lambda^2 = \frac{1}{\zeta(n^* + 1)\zeta^*} \frac{n}{(n+1)^2} \frac{\left[\delta_1(n^* + 1)\zeta^* - \sqrt{\frac{n^*\zeta^*}{\delta^* + \phi^*}}\psi^2\right]^2}{(n^* + 1)\zeta^*(\delta_1 + \phi) - \sqrt{\frac{n^*\zeta^*}{\delta^* + \phi^*}}\psi^2},$$
$$\eta = \frac{\delta^*}{n^* + 1}\sqrt{\frac{n^*}{\zeta^*(\delta^* + \phi^*)}}\frac{\psi}{\delta^*},$$
$$\sigma = \frac{\delta_2}{\delta_2 + \kappa}.$$

Proof of Proposition 7. Regressing prices in the local economy on local order flow, local country-specific news and foreign returns yields a coefficient on foreign returns of

$$\eta\lambda^{*-1} = \frac{\psi}{\delta^*}.$$

Country-specific news in the local economy do not change conditional correlations. ■

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