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STOCK MARKET: ECONOMIC NEWS  
AND CO-MOVEMENT**

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***FINANCIAL ECONOMICS and  
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## ABSTRACT

### Asymmetric Information in the Stock Market: Economic News and Co-movement\*

We analyze the effect that real-time domestic and foreign news about fundamentals have on the correlation of stock returns of a small open economy, Portugal, and a large open economy, the U.S. We also study the role of public and private information in the price formation process in the U.S. and Portuguese stock markets. First, and consistent with our theoretical model, we find that U.S. macroeconomic news and Portuguese earnings news do not affect the cross-country stock market correlation, whereas Portuguese macroeconomic news lowers the cross-country stock market correlation. Second, we find that U.S. public information affects Portuguese stock market returns, but this effect is diminished when U.S. stock market returns are included in the regression; we provide evidence in the paper that this effect does not derive from contagion as commonly accepted. Finally, public information news in the U.S. is associated with increased liquidity, while the effect in Portugal depends on the type of news releases.

JEL Classification: F3, G12, G14 and G15

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# 1 Introduction

What drives the cross-country correlation of stock returns? This question, central to many topics in international finance, is deeply associated with another fundamental question: what is the role of public and private information in the price formation process? Under market efficiency, information about future stock prices in one market spreads to other markets where it can also be used to forecast local prices. Cross-country stock return correlations thus arise from correlated fundamentals. However, the empirical link between economic fundamentals and cross-country correlations has by and large eluded researchers, leading some to explore contagion as the main driver of stock market correlations. This paper revisits theoretically and empirically the link between cross-country correlations and fundamentals and the price discovery process.

The standard view in the literature is that shocks to global factors increase the conditional stock return correlations as they move the value of firms around the globe in the same direction.<sup>1</sup> Under this view, any cross-correlation of returns is spurious as it is driven by the dependence of each country's return on global factors. It is then puzzling to find, as previous studies have found, that U.S. macroeconomic news surprises lose some or all of their statistical significance when the U.S. daily return is also included in a regression explaining local returns. Also, under the standard view it is puzzling to find, as studies have, that the cross-country correlation of returns is the same on U.S. news announcement days and non-announcement days.<sup>2</sup> The favored alternative in the literature that accounts for these facts is contagion.

We conduct our empirical analysis studying comovement between Portugal and the U.S. First, we show that the two stylized facts presented above are borne in our data as well. Second, we reassess the conclusions drawn from the stylized facts by using high frequency data and a model. To address the first fact – that the U.S. return subsumes the information contained in U.S. news announcements in explaining local returns – we analyze the high frequency response of local returns to U.S. news. We show that in response to U.S. news about output or investment, which can be viewed as positive shocks to a global factor, both the U.S. and Portuguese stock markets appreciate, with the Portuguese market response *following* the U.S. response within 5 to 15 minutes. This pattern is particularly striking with U.S. news released at 8:30 am EST, at which time the Portuguese market is open and the U.S. market is closed. This delayed response does not appear to be evidence of contagion or rebalancing, however, as U.S. news about net-exports and inflation, which can be viewed as shocks to competitive factors à la Karolyi and Stulz (1996), lead to opposite responses in each market, but again with the Portuguese market following the U.S. response.<sup>3</sup> Given this *high frequency* delayed response in the local market it

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<sup>1</sup>To be more specific shocks to global factors lead to increases in the conditional variance of U.S. returns (e.g., à la Ross (1989)) and hence in conditional correlations (see Connolly and Wang (2003)). Karolyi and Stulz (1996) note that this link depends on the size of global shocks relative to competitive shocks, which they argue drive correlations down.

<sup>2</sup>We review the related literature below.

<sup>3</sup>Unexpected improvements in U.S. net-exports generate U.S. stock price hikes and lower Portuguese stock

is then not surprising to see that in regressions of *daily* local returns, the inclusion of the U.S. return removes explanatory power from U.S. news surprises. In contrast to the contagion view, we stress the informational role of U.S. returns. Our interpretation, and that of our model, is that U.S. returns are a summary statistic for public news *and* private information used by U.S. investors. Intuitively, Portuguese investors free-ride on U.S. investors' analysis and private information on the relevance of the news about the latter's economy.

While U.S. macroeconomic news affect Portuguese returns, these news do not affect the correlation of stock returns across the two countries – the second stylized fact noted above. We show that the same is true for Portuguese earnings announcements. However, we also document that in days of Portuguese macroeconomic news there is significantly lower comovement in daily returns among the two countries. These last two observations add to our empirical knowledge of comovement of returns as most other studies have focused on news from the U.S. alone. They also add complexity to the pattern of time-varying correlations that needs to be explained from an equilibrium model.

We present a simple model of stock trading, which draws on the work of Kyle (1985) and King and Wadhvani (1990). While there is no built-in time variation in cross-country correlation of fundamentals, the model *endogenously* displays time variation in cross-country return correlations that rationalizes the observed, puzzling patterns. In the model there is one large, foreign country, and one small, local country. For simplicity of exposition let the large country be the U.S. and the small country be Portugal. The U.S. dividend is driven by a global factor and the Portuguese dividend is driven by two factors, a global factor and a country-specific factor. Each country is independently populated with informed investors, noise traders, and a competitive market maker. Stock return comovement arises as a result of market efficiency: investors in Portugal use U.S. returns to infer the private information of U.S. informed investors about the global factor. In days of positive private information about U.S. assets, U.S. net order flow is positive and so are U.S. returns. Since fundamentals are correlated across countries, this information is good news for the Portuguese stock market and prices rise locally as well. Thus, Portuguese and U.S. stock market returns move together even in the absence of public announcements.

Consistent with empirical evidence, the model predicts that this baseline return comovement should not change in days of U.S. public news announcements. The model makes the new predictions that the effect of Portuguese news on comovement depends on the content of the news: if the Portuguese news are correlated with U.S. fundamentals, then comovement declines on news days, but if the Portuguese news are country-specific, then there is no change in comovement. To generate these results the model relies on two main features. First, we *assume* that

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prices. Similarly, all else equal, unexpectedly high U.S. inflation leads to, among other things, an unexpected real USD appreciation to which the U.S. stock market responds negatively, but the Portuguese market responds positively. Further evidence against the portfolio rebalancing and contagion mechanisms is (i) that our results are robust to excluding Portuguese ADRs from our sample and (ii) that controlling for U.S. macroeconomic news surprises, Portuguese stock market returns do not react to “extreme” U.S. stock market moves.

there is an asymmetric response to Portuguese news by investors: U.S. public news generates price discovery in both U.S. and Portuguese markets, whereas Portuguese news generates price discovery in the local market only.<sup>4</sup> Second, our model shows that the *equilibrium* cross-country conditional return correlation is directly affected by the information content in U.S. returns. Since the U.S. return serves as a summary statistic for both U.S. public news and U.S. private information, the information content of the U.S. return is not affected by the presence of news in the U.S. The information content of the U.S. return is lower in days of Portuguese news, only if these news have information, even if very noisy, about the global factor that could have been used by U.S. investors. This is the case for Portuguese macroeconomic news, but not for Portuguese earnings news.<sup>5</sup>

Finally, the model predicts that market liquidity should increase in response to any news announcements. The reason is that in a Kyle (1985) model the public news ‘destroys’ some of the value of the private information making the market maker less concerned about adverse selection. Empirically, we show that public information news in the U.S. increases liquidity in the U.S. market and the same is true for earnings announcements 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 useful, leading to the entry into the market of a different class of informed investors (see Kim and Verrecchia (1994)).

We use Portuguese stock market data for two main reasons. First, the globalization of the world economy and in particular the process of European integration means that the Portuguese stock market is increasingly more vulnerable to external shocks. However, given the relative sizes of the U.S. and Portuguese economies, shocks to the Portuguese economy are not likely to affect the U.S. This makes it an interesting research laboratory to study how the Portuguese stock market responds to economic news at home and abroad by avoiding the endogeneity problem which plagues the comovement literature.

Second, a unique feature of the Portuguese data is that it contains signed trades.<sup>6</sup> We can thus conduct our exercise conditioning on public as well as private information, which is a

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<sup>4</sup>U.S. investors might recognize its value, but in the spirit of Grossman and Stiglitz (1980) it is assumed that the costs of processing this information (and that originating from many other countries) outweigh the benefits, and the information is not used. Our data and the data in other papers cited below strongly supports this assumption.

<sup>5</sup>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 information about country-specific factors. Borrowing Poterba’s (1990) terminology, earnings announcements are “nearly” country-specific.

<sup>6</sup>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.

novelty of our study and is required by our model. Having signed trades in particular means that there is no need to rely on artificial algorithms which add measurement error to estimated order flow imbalances.

In testing our hypotheses we use real-time U.S. 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 avoid problems related to the existence of non-synchronous trading periods between countries (Karolyi and Stulz, 1996); *(ii)* we measure more accurately the effect that macroeconomic news announcements have on U.S. and Portuguese prices (Andersen et al., 2003) by focusing on episodes where the source of price revisions is well identified, thus leading to a high signal-to-noise ratio; *(iii)* we are able to test the theoretical assumption that foreign news are first incorporated into foreign stock prices and only then into local stock prices; *(iv)* we measure unanticipated order flow which proxies for private information-based trading and are thus able to analyze the effects of public news conditional on private information.

We proceed as follows. Next we give a brief literature review. In Sections 3 and 4, we construct and solve a model of trading to guide our empirical analysis and the interpretation of the results. Section 5 describes the data. In Sections 6 and 7, we present the empirical results and Section 8 concludes. The appendix contains the proofs of the model propositions.

## 2 Related Literature

Our paper is most closely related to two areas of research. The first examines international asset market linkages 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 international information spillovers and order flow are important in the price discovery process. We briefly discuss these research areas in turn.

One approach to studying international asset market linkages is to assess the effect of macroeconomic news announcements on asset returns around the world. Becker, Finnerty and Friedman (1995) use high-frequency futures data from 1986 to 1990 and document that the U.K. stock market reacts to U.S. and U.K. macroeconomic news, while the U.S. stock market only reacts to U.S. own news. Wongswan (2005) uses high-frequency return volatility and trading data from 1995 to 2000 to show that there is evidence of transmission of information from the U.S. and Japan to the equity markets in Korea and Thailand. Ebrahimann and Fratzscher (2003) model the degree of interdependence of the U.S. and European interest rate markets by focusing on the reaction of these markets to macroeconomic news and monetary policy announcements. They show that the connection of the Euro area and the U.S. money markets has steadily increased over time, with the spillover effects from the U.S. to the Euro area being somewhat stronger than in the opposite direction. Gande and Parsley (2005) document 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 U.S. macroeconomic news, but the U.S. does not react to Portuguese news. Our study is novel in that it looks at information spillovers in the conditional mean (and not the volatility) of stock returns (and not of other assets).

In the context of stock markets some authors argue that the relevance of foreign news to local returns discussed above is to a large extent subsumed in the foreign return itself. King, Sentana and Wadhvani (1995) construct a factor model of 16 national stock market monthly returns and examine the influence of 10 key macroeconomic variables. They show that the surprise component of these observable variables contributes little to world stock market variation after conditioning on the common factor that is unrelated to 10 macro variables they study. Connolly and Wang (2003) analyze the U.S., U.K. and Japan equity markets from 1985 to 1996 and separate the influence of the foreign markets on domestic markets into news about economic fundamentals and the foreign market return. They find that the macro news effect is too small to account for any economically sizeable part of the return comovement among the three national equity markets. While these authors interpret their results as indicative that contagion – not economic fundamentals – explains stock market linkages, in our rational asset pricing model price discovery implies that there is no role for foreign news in explaining local returns once we condition on foreign returns, because foreign returns summarize both private and public information. In addition, in our paper 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 U.S. and Japanese stock markets and test how much of that correlation is explained by the presence of U.S. news. Recognizing that different shocks can lead to opposite movements in stock return correlations (thus biasing the results to not finding any association), Karolyi and Stulz allow for international linkages to be driven by global shocks as well as competitive shocks: ‘global shocks’ affect the value of all firms (domestic and foreign) in the same direction, whereas ‘competitive shocks’ increase or decrease the value of firms in one country relative to the firms in another country.<sup>7</sup> Relative to their results, we also find that ‘global shocks’—identified in our paper and in theirs as U.S. news—do not change the cross-country correlation of returns. However, we find that Portuguese macroeconomic news lower the cross-correlation of returns. We also provide a model that can explain these apparently puzzling patterns.<sup>8</sup>

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<sup>7</sup>Karolyi and Stulz (1996) use U.S. macro announcements and asset prices (foreign exchange rates, U.S. Treasury bill futures, the Nikkei and Standard and Poor’s 500 index returns) to identify global and competitive shocks in the U.S. and Japan. They consider U.S. macro announcements, shocks to the indexes and interest rates to be global and shocks to the Yen/Dollar exchange rates to be competitive.

<sup>8</sup>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 Mei (1994), 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 (see also Campbell, Koedijk, and Kofman (2002), Campbell, Forbes, Koedijk, and Kofman (2003), and

In our theoretical model there are no contagion effects.<sup>9</sup> As in King and Wadhvani (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 in 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 à la Kyle (1985) whereas King and Wadhvani (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 effects in international stock return comovement which had not been previously addressed. Finally, our model generates time-varying return correlations while their model does not.

Several recent studies have highlighted the role of order flow in the price formation process (e.g., Brandt and Kavaiecz (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, Elton and Green (2001), Green (2004), and Andersen, Bollerslev, Diebold and Vega (2003, 2004)). Typically, however, the roles of order flow and public information are examined in isolation. Some notable exceptions are Green (2004), Pasquariello and Vega (2005), 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 Model

There is a local, small economy and a foreign, large economy.<sup>10</sup> Each economy has its own stock market where a single stock is traded (the market index) and a distinct 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  $t = 1, 2, \dots, T$  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 the

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Longin and Solnik (2001)).

<sup>9</sup>See Claessens, Dornbusch, and Park (2001) for a comprehensive review of the contagion literature.

<sup>10</sup>We have in mind that the U.S. is the foreign economy and a country such as Portugal the small economy.

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  $\tilde{v}_t$  is  $\delta$ . It is assumed that the local asset's fundamental value is affected by a global factor that drives the returns in the foreign, large economy, i.e.  $E[\tilde{v}_t \tilde{v}_t^*] = \psi$ .<sup>11</sup>

Before trading, informed investors observe a private information signal  $\tilde{s}_t = \tilde{v}_{t+1} + \tilde{\varepsilon}_t$  about next period's incremental valuation,  $\tilde{v}_{t+1}$ , where the variance of  $\tilde{\varepsilon}_t$  is  $\phi$ . In some periods, and also before trading takes place, market participants receive local or foreign public news about local or foreign asset values, respectively.<sup>12</sup> News are modeled by the random variable  $\tilde{U}_t = \tilde{v}_{t+1} + \tilde{\mu}_t$ , with the variance of  $\tilde{\mu}_t$  equal to  $\kappa$ . 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 assumed to be independently distributed.<sup>13</sup> We stress that there is no built-in time-variation in conditional correlations and that any time-variation in conditional correlations that is generated is endogenous.

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

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

with the convention that  $\tilde{P}_T = \tilde{V}_T$ . Uninformed investors trade the random quantity  $\tilde{z}_t$  in period  $t$ , where  $\tilde{z}_t$  has variance  $\zeta$ . 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 on their respective markets. This 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 (even perfectly so) which would be the case if, for example, foreign investors also traded on the small economy's market and vice-versa.

The market maker chooses prices to maximize

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

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<sup>11</sup>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 U.S. real GDP growth.

<sup>12</sup>Whether news come at known dates or not does not affect the equilibrium we study.

<sup>13</sup>The model developed here does not allow for time-variation in stock return correlations. This is not critical as we also do not model any time variation in the volatility of fundamentals (see Forbes and Rigobon (2002)).

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  $\omega_t$  and any available public news.

#### *Discussion of Model Assumptions*

We describe the behavior of the different investors and the equilibrium prices in periods with and without public news announcements. We make 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. The general framework we have in mind is one where foreign investors are aware of news from many smaller markets. While these news contain information regarding valuations in their own market, the costs of having to process all the little pieces of dispersed information outweigh the benefits (in the spirit of Grossman and Stiglitz (1980)). This assumption leads to what we believe is a realistic asymmetric treatment of news: while news in the large, foreign economy lead to price discovery in both markets, news in the local, small economy only lead to price discovery in the local stock market. This asymmetry is critical to our results and has been noted before *even between developed economies*; see section 2 above for evidence that U.S. news are used in the U.K., Thailand and Korea, but not the opposite. This asymmetry is also present in our data, as U.S. returns do not respond to Portuguese news.

Second, in the same spirit as King and Wadhvani (1990), informed investors and the market maker in the local economy see the period  $t$  stock price in the foreign economy  $P_t^*$  before they make their decisions. This second assumption is particularly realistic in our setting with a large, foreign economy and a small, local economy where local investors respond to news announced in the foreign economy. Casual observation suggests that investors in small markets like Portugal wait to see how investors in the U.S. respond to public U.S. news before they trade on that information, perhaps trusting U.S. investors' better interpretation of the news. Even in the absence of news, large upward or downward price movements in the U.S. are analyzed by local investors trying to learn about the nature of the price change. Confirming our assumption, section 6 below discusses evidence of a high lagged cross-correlation of stock returns at very high frequency. Finally, we believe that the mechanisms we describe here would still be present in a richer model that does not rely on our timing convention so long as (i) past price movements contain information that can be useful to forecast future local returns and (ii) different investors face different costs of inferring valuations from public news. In effect, in such a model, Portuguese investors would free-ride on price discovery in the U.S.

Implicit in our assumption of distinct investors populating each market is the assumption of no trading across markets. In contrast to King and Wadhvani (1990) this assumption is unnecessary to our results but again makes the analysis easier. Assuming the private information signals of informed investors in different markets to be correlated implicitly allows some of the informed investors to be the same.

Finally, while the model shares many similar features to King and Wadhvani (1990) (such as

the ones discussed in the two previous paragraphs) we differ in the equilibrium concept. There a rational expectations equilibrium concept is used. Here investors act strategically on their private information and hence order flow is a noisy measure of that private information. This feature allows us to determine theoretically and empirically the effects of public news controlling for private information. It also allows us to study liquidity effects around announcements as additional predictions from our model in contrast to their model of contagion which is silent along this dimension of trading.

## 4 Equilibrium

This section describes the equilibrium prices and trades that result in days with and without news. Before we start we note that because private information is short lived the problems (1) and (2) are equivalent to solving the sequence of single period problems

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

and

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

respectively. In the foreign market, informed investors and the market maker solve identical problems.

### 4.1 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  $\mathcal{I}_t^{I*} = \{V_t^*, s_t^*\}$ . In a period of no news 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 not, of public news in the foreign economy: if there are news announcements at  $t + 1$  the price displays a different liquidity parameter  $\lambda^*$  and depends on the public news released (see below). In equilibrium, because private information is short lived and uninformative of future payoffs  $E \left[ \tilde{P}_{t+1}^* | \mathcal{I}_t^{I*} \right] = V_t^* + E \left[ \tilde{v}_{t+1}^* | \mathcal{I}_t^{I*} \right]$ , independently of the type of news at  $t + 1$ . 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

$$0 = E \left[ \tilde{v}_{t+1}^* | \omega_t^* \right] - \lambda^* \omega_t^*,$$

where  $\lambda^*$  measures the information content of order flow. It is well known (see Kyle (1985)) that the solution to this static problem entails

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

and

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

From (6), informed investors are more aggressive in exploring their private information when they can better use their information monopoly: the signal is very informative ( $\phi^*$  is low); there are fewer of them ( $n^*$  is low); there are many uninformed investors ( $\zeta^*$  is large). In contrast, the market maker, fearing more informed trading, responds by reducing liquidity (i.e.,  $\lambda^*$  increases) when the signal is very informative ( $\phi^*$  is low) or there are fewer informed investors ( $n^*$  is low) (see 5).

## 4.2 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,<sup>14</sup>

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

Note that it is the unexpected part of the order flow,  $\tilde{\omega}_t^* - \beta^* \tilde{U}_t^*$ , that is relevant to the market maker to learn about informed investors' private information (with  $\beta^*$  determined in equilibrium). With this price conjecture, the information set  $\mathcal{I}_t^* = \{V_t^*, s_t^*, U_t^*\}$ , and the equilibrium property that  $E[\tilde{P}_{t+1}^* | \mathcal{I}_t^*] = V_t^* + E[\tilde{v}_{t+1}^* | \mathcal{I}_t^*]$ , 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:

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

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

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<sup>14</sup>The parameter  $\lambda^*$  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.

with  $\sigma^* = \hat{\sigma}^* + \lambda^* \beta^*$ ,<sup>15</sup>  $\text{var}(\tilde{v}_{t+1}^* | \tilde{U}_t^*) = \frac{\delta^* \kappa^*}{\delta^* + \kappa^*}$  and  $\text{var}(\tilde{s}_t^* | \tilde{U}_t^*) = \frac{\delta^* \kappa^* + \phi^* \delta^* + \phi^* \kappa^*}{\delta^* + \kappa^*}$  and the asset demand is

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

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

Adding public information has two conflicting implications for trading by informed investors (see (8) and (6)). On the one hand, the ‘amount’ of private information is reduced to the unforecastable part of informed investors’ private information,  $s_t^* - E(\tilde{s}_t^* | U_t^*) = s_t^* - \hat{\sigma}^* U_t^*$ , making informed investors trade less. On the other hand, the public news reduces the conditional variance of the private information to  $\text{var}(\tilde{s}_t^* | \tilde{U}_t^*) = \frac{\delta^* \kappa^* + \phi^* \delta^* + \phi^* \kappa^*}{\delta^* + \kappa^*}$  from  $\text{var}(\tilde{s}_t^*) = \delta^* + \phi^*$ . This makes informed investors more aggressive in acting upon their private information. Both of the forces affecting the order flow of informed investors also affect the liquidity parameter  $\lambda^*$  in the pricing function in opposing ways. However, it can be show that the former effect is stronger and that:

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

### 4.3 Local Market, No Local or Foreign News

Investors in the local stock market observe the time  $t$  price of the foreign stock asset  $P_t^*$  and use this knowledge to infer the private information of informed investors in that market:

$$\omega_t^* = \lambda^{*-1} (P_t^* - V_t^*).$$

Because stock fundamentals are correlated  $\omega_t^*$  is also informative about the local stock market. With this additional information, the local economy’s informed investors conjecture a pricing function for the current period  $t$  of

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

This pricing function implies that returns in both markets are correlated, with the conditional correlation given by  $\eta \lambda^{*-1}$ . Cross-country correlation of returns arises because fundamental

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<sup>15</sup>We also get that in the price function,

$$\beta^* = -\delta^* \sqrt{\frac{n^* \zeta^*}{(\delta^* \kappa^* + \phi^* \delta^* + \phi^* \kappa^*) (\delta^* + \kappa^*)}}.$$

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 (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 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 (4). The time  $t$  equilibrium is described by:

$$\begin{aligned}\lambda &= \frac{\text{var}(\tilde{v}_{t+1}|\omega_t^*)}{n+1} \sqrt{\frac{n}{\zeta \text{var}(\tilde{s}_t|\omega_t^*)}}, \\ \eta &= \frac{\psi}{n^*+1} \sqrt{\frac{n^*}{\zeta^*(\delta^* + \phi^*)}},\end{aligned}\tag{10}$$

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

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

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 (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*

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

The slope coefficient of regressing local returns on foreign returns on no news days is the ratio of the covariance of valuations  $\psi$  to the variance of the foreign asset value  $\delta^*$ . On average the correlation of stock returns reflects the correlation on fundamentals.

#### 4.4 Local Market with Local News, No Foreign News

Suppose now that period  $t$  has a public news announcement in the small, 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 (where again only the unexpected local order flow contains useful information to the market maker):

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

The appendix gives the solution to the informed investors' problem given the information set  $\mathcal{I}_t^I = \{V_t, s_t, U_t, \omega_t^*\}$ . With the solution to this problem and the uninformed trades we construct the local aggregate order flow and solve the market maker's problem of finding the  $P_t$  which ensures zero profits, given  $\mathcal{I}_t^M = \{V_t, U_t, \omega_t, \omega_t^*\}$ . The equilibrium trading at  $t$  is characterized by:

$$\begin{aligned} \lambda &= \frac{\text{var}(\tilde{v}_{t+1} | \tilde{\omega}_t^*, \tilde{U}_t)}{n+1} \sqrt{\frac{n}{\zeta \text{var}(\tilde{s}_t | \tilde{\omega}_t^*, \tilde{U}_t)}}, \\ \eta &= \frac{\kappa}{\text{var}(\tilde{U}_t | \tilde{\omega}_t^*)} \frac{\text{var}(\tilde{v}_{t+1}^*)}{n^*+1} \sqrt{\frac{n^*}{\zeta^* \text{var}(\tilde{s}_t^*)} \frac{\psi}{\delta^*}}, \\ \sigma &= \frac{\text{var}(\tilde{v}_{t+1} | \tilde{\omega}_t^*)}{\text{var}(\tilde{U}_t | \tilde{\omega}_t^*)}. \end{aligned}$$

The equilibrium asset trades of informed investors are given by

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

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

Again  $\eta$  and  $\sigma$  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: informed investors trade on the unexpected component of their private information  $\tilde{s}_t - E[\tilde{s}_t | \tilde{\omega}_t^*, \tilde{U}_t] = s_t - \eta \omega_t^* - \sigma U_t$ . Note that adding  $\omega_t$  does not affect the values of  $\eta$  and  $\sigma$  because the private information that goes into the local net order flow already 'subtracts' the information contained in  $\tilde{\omega}_t^*$ , and  $\tilde{U}_t$ . The price coefficient  $\eta$  contains three parts. One is an adjustment for how useful the foreign net order flow is given the local public news ( $\kappa / \text{var}(\tilde{U}_t | \tilde{\omega}_t^*)$ ).

The second accounts for liquidity in the foreign market (recall that  $\lambda^* = \frac{\text{var}(\tilde{v}_{t+1}^*)}{n^*+1} \sqrt{\frac{n^*}{\zeta^* \text{var}(\tilde{s}_t^*)}}$ ) and, finally, the last part measures ex-ante covariation between incremental dividends,  $\psi / \delta^*$ .

We are now ready to give our second 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

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

The slope  $\eta\lambda^{*-1}$  increases with the noise in the public news,  $\kappa$ , and  $\eta\lambda^{*-1} \rightarrow \frac{\psi}{\delta^*}$  if  $\kappa \rightarrow \infty$ .

Note that if the local public news are uninformative and  $\kappa \rightarrow \infty$ , we recover a correlation of stock 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  $\kappa$ , 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.*

In days of news in the local market, local prices respond less to foreign prices because some of the information contained in the foreign order flow is now provided via the local public news. This is true unless the 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 always increases in 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  $\lambda$ . This effect is outweighed by the fact that public news reduces the amount of private information that informed investors trade on (see 8).

#### 4.5 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 cares not about the total order flow, but only that component of the order flow that is unrelated to news,  $w_t^* = \tilde{\omega}_t^* - \beta U_t^*$  (and similarly for the local order flow). Informed investors conjecture that the time  $t$  equilibrium price function is:

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

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 parameters  $\lambda$ ,  $\eta$  and  $\sigma$  are the coefficients on the linear projection of  $\tilde{v}_{t+1}$  on  $\omega_t, w_t^*, U_t^*$ , respectively and are given in 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*

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

The proposition shows that in days of foreign news the return correlation does not change from that in 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. On the other hand, local investors' knowledge of their own private information cannot improve upon the information content of the foreign return any more than it did in days of no news. This means that a regression of local returns on local order flow, foreign returns and foreign news should produce a zero coefficient on foreign news.

The proposition can explain the evidence in Karolyi and Stulz (1996) that correlations between stock returns in U.S. and Japan do not vary with news announcements in the U.S., if, as it is reasonable, one takes the Japanese market as a follower to the U.S. market in the presence of U.S. news. While such lack of connection between fundamentals and international return correlations has often been viewed as evidence of contagion through the form of investor sentiment or noise trading, in our model it occurs because investors in the 'follower' market know that they cannot use the U.S. public news to help them filter the private information of U.S. investors contained in the U.S. 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. Obviously, if we omit the foreign return as an explanatory variable of local prices, foreign news will have explanatory power, but as the model suggests foreign returns are an all encompassing variable 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 Wadhvani (1995), Connolly and Wang (2003) and ours below where foreign news have no explanatory power over local returns over and above that implied by foreign returns.

## 4.6 Country-Specific News

So far we have treated news in the small, local economy as also being informative of the foreign valuations. Consider now that valuations in the small economy are given by

$$v_{t+1} = v_{1t+1} + v_{2t+1},$$

with  $E[\tilde{v}_{1t+1}\tilde{v}_{t+1}^*] = \psi$  and  $E[\tilde{v}_{2t+1}\tilde{v}_{t+1}^*] = 0$ . We maintain the normalization that  $E[\tilde{v}_{t+1}^2] = \delta$  so that  $E[\tilde{v}_{1t+1}^2] = \delta_1$ ,  $E[\tilde{v}_{2t+1}^2] = \delta_2$  and  $\delta = \delta_1 + \delta_2$ . We wish to characterize the equilibrium

in the presence of local country-specific news:

$$\tilde{U}_t = \tilde{v}_{2t+1} + \tilde{\mu}_t,$$

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 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 there should not be any change in correlation. The intuition is quite 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 are the news, 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 news as given by earnings announcements.

Finally we have:

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

## 5 Data Description

We test the implications of the model presented in the previous section using Portuguese and U.S. stock market data and Portuguese and U.S. earnings and macroeconomic announcements. As mentioned in the Introduction, this choice is motivated not only by the quality and availability of high frequency Portuguese stock market data, but because Portugal is a small emerging market economy vulnerable to U.S. news announcements, while there is relative immunity of the U.S. economy to Portuguese shocks. The data are novel in several respects, such as the simultaneous high frequency data in the U.S. and Portuguese stock markets and the availability of signed trades in the Portuguese stock market. Here we describe them in detail.

## 5.1 Portuguese and U.S. 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.<sup>16</sup> Our sample period is determined by the availability of high frequency stock market data from Euronext Lisbon and it is comparable with most studies that make use of very high-frequency data.<sup>17</sup> 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. This allow us to observe the number of buyer-initiated and seller-initiated trades and 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 comovement between the U.S. 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 U.S. we use Trades and Quotes (TAQ) data, which contains bid quotes, ask quotes and transaction prices from stocks traded in different U.S. 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.<sup>18</sup> 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 comovement is the existence of non-synchronous trading periods around the globe (e.g., Karolyi and Stulz 1996). In general, studies use closing market prices to estimate daily returns. Since stock markets around the world close at different times, these studies are not measuring contemporaneous stock market correlations. In this paper, we avoid this problem by using high frequency data and estimating daily returns using 11:30 EST prices, which correspond to Portuguese stock market closing prices as shown in Table 2.<sup>19</sup> An advantage of using 11:30 EST prices is that the U.S. stock market has been open for two hours and most U.S. macroeconomic news announcements are released at 8:30 and 10:00 EST. Hence, using prices close to these announcement release times allows us to measure more accurately the news effect on U.S. and Portuguese prices (Andersen et al. 2003). While we note that our qualitative results do not depend on using 11:30 EST prices, the results do depend on measuring synchronous returns between the two countries.

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<sup>16</sup>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.

<sup>17</sup>On February 6, 2002 the Bolsa de Valores de Lisboa e Porto (BVLPL) changed its name to Euronext Lisbon.

<sup>18</sup>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.

<sup>19</sup>Karolyi and Stulz (1996) and Craig, Dravid and Richardson (1995) use different ways to overcome the same problem.

In Table 3A and 3B we show descriptive statistics for the Portuguese and U.S. 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 is twenty six times higher, measured by the bid-ask spread divided by the average daily price in the sample, in the U.S. market compared to the Portuguese market, but daily return volatility is 1.5 times larger in the U.S. market than in the Portuguese market.

In our theory, it is only the unexpected portion of aggregate order flow that affects the equilibrium prices. Furthermore, order flow in both countries is assumed to depend only on informed and liquidity trading. Yet, in reality, many additional microstructure imperfections can cause lagged effects in the observed order flow (see Hasbrouck, 2004). Therefore, to implement our model, we estimate  $\Omega_t^{por}$  and  $\Omega_t^{us}$ , the unanticipated portion of aggregate local and foreign order flow, respectively. For that purpose, we use the linear autoregressive model of Hasbrouck (1991),

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

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

where  $x_{it_{in}}^{por}$  ( $x_{it_{in}}^{us}$ ) is the transaction by transaction net order flow for local (foreign) asset  $i$  for time interval  $t_{in}$ ,  $r_{it_{in}}^{por}$  ( $r_{it_{in}}^{us}$ ) is the quote revision changes for local (foreign) asset  $i$  for time interval  $t_{in}$ , 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 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.

In Section 7, we focus on daily horizons; broader intervals lead to less powerful tests of market comovement (Karolyi and Stulz 1996) and of the influence of macroeconomic fundamentals (Andersen et al. 2003, and 2005). For that analysis, we compute aggregate unanticipated (or “abnormal”) net order flow over each day  $t$ ,  $\Omega_t^{por}$  and  $\Omega_t^{us}$ , by summing the residuals of Eq. (13) (Eq. (14)) within each day. Consistent with the daily return definition we aggregate order flow from 11:30 EST the previous day to 11:30 EST today.

## 5.2 Macroeconomic and Earnings Data

To estimate news surprises for the U.S. and Portugal, we require 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. We use one-month Euribor futures data from Bloomberg to estimate the ECB interest rate market expectation, following the method described in Kuttner (2001),

Cochrane and Piazzesi (2002), Rigobon and Sack (2002), among others, who use the current month federal funds futures contract, one-month Eurodollar deposit rate and three-month Eurodollar futures 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 U.S. macroeconomic announcement), but we include this variable in all of our estimates. Foreshadowing subsequent results, the U.S. stock market does not react to any of the Portuguese announcements, except for the ECB announcement.

Since Bloomberg only reports professional forecasts for the Portuguese CPI, we construct our own forecast for the remaining series listed in Table 4A. In untabulated results, we show that a seasonal random walk describes the data well.<sup>20</sup> In other words, the optimal forecast of this month's or quarter's announcement is last year's announcement about the corresponding month or quarter, and this is the proxy we use for the market expectation.

We use MMS real-time data on the realizations of 25 of the most relevant U.S. macroeconomic announcements. Consistent with our estimate of the ECB interest rate market expectation, we use one-month Eurodollar futures deposit rate data from Bloomberg to estimate the market expectation of the federal funds target rate.<sup>21</sup> For the remaining 24 U.S. macroeconomic announcements listed in Table 4B, we use the MMS median forecast, which is better than our own univariate forecasts.<sup>22</sup> Table 4A and Table 4B provide a brief description of the most salient characteristics of these U.S. and Portuguese macroeconomic news announcements: the total number of observations in our sample, the agency reporting each announcement, and the time of the announcement release. The only announcement with uncertain release time is the ECB's announcement. The Governing Council of the ECB announces the interest rate level at 7:45 EST every month of the year, and the president of the council holds a press conference that ends anytime between 8:50 EST and 10:00 EST. Since ECB interest rate announcement surprises are very few, the market focuses on the president's statement and the future trajectory of interest rates rather than on the actual announcement. The evidence in Section 6.1 further supports this view.

Finally, we use the individual stock's earnings announcements to analyze the effect Por-

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<sup>20</sup>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.

<sup>21</sup>We also used the current month Federal funds futures contract, since Gürkaynak, Sack and Swanson (2002) find that this instrument outperforms the one-month Eurodollar futures deposit rate's one-month ahead forecasting power. We note, that our conclusions do not depend on whether we use the one-month Eurodollar futures deposit rate or the current month Federal funds futures contract.

<sup>22</sup>For a more detailed description of the MMS data we refer the reader to Andersen, Bollerslev, Diebold, and Vega (2003).

tuguese country specific news have on the US-Portuguese stock market comovement (Section 4.6) and to control for non-global U.S. public announcements. We use IBES and Reuters data to measure the U.S. 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.<sup>23</sup>

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  $j$  at time  $t$  is therefore computed as

$$S_{jt} = \frac{A_{jt} - E_{jt}}{\hat{\sigma}_j}, \quad (15)$$

where  $A_{jt}$  is the announced value of indicator  $j$ ,  $E_{jt}$  is the MMS median forecast for U.S. macroeconomic data, the IBES median forecast for U.S. earnings data, the Eurodollar implied forecast for the federal funds rate, Bloomberg median forecast for Portuguese CPI, last year’s announcement for the remaining Portuguese macroeconomic announcements, Reuters data for Portuguese earnings, and the Euribor implied forecast for the ECB benchmark interest rate.<sup>24</sup> The denominator,  $\hat{\sigma}_j$ , is the sample standard deviation of  $A_{jt} - E_{jt}$  estimated using the full sample period of expectations and announcements. Equation (15) facilitates the aggregation of news described below and it facilitates meaningful comparisons of responses of different stock price changes to different pieces of news. Operationally, we estimate the responses by regressing stock price changes on news. Because  $\hat{\sigma}_j$  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 4A and 4B we show the sample mean and standard deviation of each news announcement surprise for the United States and Portugal between January 4, 2002 and October 15, 2002, respectively. Note that the standardized variables show a standard deviation that is not equal to one, because the standard deviation we use was obtained in the full sample, with the purpose of more accurately measuring the standard deviation of the surprises in a larger sample.

To keep the analysis parsimonious, we aggregate the macroeconomic announcements into seven groups as shown in Table 4A and Table 4B: real activity, each of the GDP components (i.e., consumption, investment, government purchases and net exports), prices, and forward-looking announcements. For example, U.S. real activity surprises are defined as the sum of GDP Advance, GDP Preliminary, GDP Final, Nonfarm Payroll, Retail Sales, Industrial Production, Capacity Utilization, Personal Income and Consumer Credit standardized surprises (according to equation (15)); while Portuguese real activity surprises are defined as the sum of GDP, the

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<sup>23</sup>Reuters collects data 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 stocks: COFINA, IBERSOL, IMPRESA, NB, PARAREDE, PORTUCEL, PTM, SAG, SEMAPA, SONAE and TD.

<sup>24</sup>As mentioned before, since Reuters does not collect data for all Portuguese stocks, we use the previous year’s earnings when the forecast is not available.

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 above described categories and weekly announcements are more volatile than quarterly and monthly announcements. The aggregation does not affect the conclusions of the paper, as we show in Section 6.7, but it is solely done for expositional purposes. Summary statistics for these aggregated macroeconomic surprises are shown in Table 5 and will be used to calculate the economic significance of these announcements. We denote Portuguese macroeconomic news by  $S_{pport}$ , Portuguese firm-specific earnings by  $S_{peport}$ , U.S. macroeconomic news by  $S_{pust}$ , U.S. firm-specific earnings by  $S_{peust}$  and ECB public news surprises by  $S_{p ECB}$ .

## 6 The High-Frequency Flow of Information

We start by analyzing the high-frequency response in the local and foreign stock markets to U.S. news surprises. This is critical for the examination of the first stylized fact described in the introduction – that the U.S. return subsumes the information contained in U.S. news announcements in explaining local returns – and is also important as a justification of the model’s timing assumption.

We calculate cumulative 5-minute responses of the Portuguese and U.S. stock market returns to foreign public news in three different scenarios: (i) the Portuguese stock market is open, but the U.S. stock market is not (Figure 2A and 2B), (ii) the Portuguese and U.S. stock markets are both open (Figure 3A and 3B), and (iii) the U.S. stock market is open, but the Portuguese stock market is not (Figure 4A and 4B). In particular, we estimate the following contemporaneous stock market response:

$$r_{it_n}^{por} = a^{por} + \sum_{p_{us}=7}^{15} \lambda_{np_{us}}^{por} S_{p_{ust}t_n} + \lambda_{np_{ecb}}^{por} S_{p_{ecb}t_n} + \varepsilon_{it_n}, \quad (16)$$

$$r_{it_n}^{us} = a + \sum_{p_{us}=7}^{15} \lambda_{np_{us}} S_{p_{ust}t_n} + \lambda_{np_{ecb}} S_{p_{ecb}t_n} + \varepsilon_{it_n}, \quad (17)$$

where  $r_{it_n}^{por} = (\ln(P_{it_{in}+n}^{por}) - \ln(P_{it_{in}}^{por})) \times 100$  is the  $n$ -minute individual stock return for Portuguese firm  $i = 1, \dots, 20$ , and  $r_{it_n}^{us} = (\ln(P_{it_{in}+n}^{us}) - \ln(P_{it_{in}}^{us})) \times 100$  is the  $n$ -minute individual stock return for U.S. firm  $i = 1, \dots, 30$ . The return is measured from just before an announcement takes place to  $n$ -minutes after the announcement is made, where  $n = 5 - \text{minutes}, 10 - \text{minutes}, \dots$ . Therefore, note that the response coefficients  $\lambda_n$  are indexed by  $n$  to indicate that they vary as we extend the return horizon. The variable  $S_{p_{ust}t_n}$  is the standardized news surprise corresponding to announcement  $p_{us}$  ( $p_{us} = 7, \dots, 15$ ) listed in Table 5, and  $S_{p_{ecb}t_n}$  is the standardized ECB benchmark interest rate news surprise made at time  $t_n$ . Since we estimate equation (16) and (17) using only those observations ( $r_{it_n}^{por}, r_{it_n}^{us}, S_{p_{ust}t_n}$ ) such that an announcement was made at time  $t_n$ , there is no need to control for heteroskedasticity (see equation (3) in

Andersen et al., 2002). Estimating the above equations is equivalent to regressing the n-minute return of an equal weighted portfolio comprised of the 20 individual stocks in the PSI-20 index and the 30 individual stocks in the DJI-30 index, respectively, on U.S. macroeconomic news announcements and the ECB benchmark interest rate news surprise. The results we describe below are robust to using a value-weighted portfolio instead.

*U.S. News Released When the U.S. Market is Closed and the Portuguese Market is Open*

Focusing first on the response to public announcements when the Portuguese stock market is open, but the U.S. stock market is not, we estimate the reaction to the 8:30 and 9:15 EST U.S. macroeconomic announcements and the 7:45 EST ECB announcement. In each panel of Figure 2A we plot  $\lambda_{np}^{por}$ , the cumulative return response following the announcement. The first tick (counting from the left) 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 7:50 EST and the return is measured from just before 7:45 EST to 7:50 EST. The second tick indicates 7:55 EST and the return is measured from just before 7:45 EST to 7:55 EST. In Figure 2A the vertical line indicates 9:30 EST when the U.S. market opens.

The first panel of Figure 2A shows that the Portuguese stock market does not react to the ECB announcement until 9:30 EST when the U.S. stock market opens. It seems thus that price discovery takes place first in the U.S. stock market and then in the Portuguese stock market,<sup>25</sup> even though the benchmark interest rate from the European Central Bank is the primary instrument of monetary policy for Portugal. One possible explanation is that price discovery takes place first in the most liquid market, the U.S. stock market (see Hasbrouck (2003)). Another explanation is that the opening of the U.S. market coincides with the end of the press conference of the ECB (scheduled to start at 8:30 am EST in Frankfurt) and Reuters release of the ECB's press conference, so the response of the Portuguese stock market is tied to the latter fact not the former. None of these fully explain the phenomenon. We have redone our analysis for the FTSE-100 futures index and the DJ Stoxx 50 futures and found that the FTSE-100 futures index reacts 55 minutes before the U.S. stock market opens and the DJ Stoxx 50 futures index reacts 25 minutes before the U.S. stock market opens (results are available upon request). It is possible then that the Portuguese investors still look for the U.S. market for further confirmation of the significance of these news for the world economy.

For the U.S. real activity, consumption, investment, net-exports and price announcements, the Portuguese stock market reacts from 15 minutes before 9:30 (45 minutes after the announcement) to 20 minutes after 9:30 (1 hour and 20 minutes after the announcement). For the remaining 8:30 and 9:15 EST announcements, there is no significant response. To the best of our knowledge, this is the first paper that finds direct evidence of delayed response to U.S. macroeconomic announcements in foreign markets, which coincides with the U.S. stock market

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<sup>25</sup>Ehramann and Fratzscher (2003) show that ECB monetary policy surprises affect U.S. interest rate markets. Perhaps not surprisingly then we observe that they also affect U.S. stock market returns.

open.<sup>26</sup> This evidence suggests that Portugal reacts more to New York’s assessment of U.S. announcements than to the news themselves. We interpret this finding of a delayed response in light of our model assumption that Portuguese investors free ride on U.S. investors’ analysis of the news announcement. Arguably, though, this finding could also be interpreted as evidence of contagion: the Portuguese investors might not even know that news have been released in the U.S. but see that the U.S. return is going up and respond by bidding prices up in their local market as well. However, we note that the response by the Portuguese market to U.S. net-exports and inflation surprise announcements *is a delayed version in the opposite direction* of the response by the U.S. market. Because net-exports and inflation are the two announcements in our data that could signal different things for the two countries, we conclude against the contagion view.<sup>27</sup>

We have also redone our analysis using S&P500 futures (results available upon request). Strikingly, this market shows no detectable response to any of the announcements studied in Figure 2A. One explanation for this finding is that individual firms react differently to macroeconomic news surprises (Michael and Ehrman, 2004). The significance of this is that Portuguese investors cannot anticipate the stock market response to the news when it opens by looking at the futures market; Portuguese investors learn more from observing the disaggregate price discovery that takes place in the spot market than the aggregate price response to macroeconomic news surprises reflected in the S&P500 futures price. This explanation is also consistent with the empirical stylized fact that stock market volatility in other countries increases following the NYSE market opening time.

In all panels of Figure 2A, it is apparent that volatility increases around 9:30 EST (i.e., at 9:30 EST the standard error bands widen substantially), consistent with the empirical evidence in King and Wadhvani (1990) for the U.K. and the U.S. They document that volatility in the FTSE-100 index is lower from 8:30 to 9:30 EST than from 9:45 to 10:15 EST, after the New York’s stock market opens. The difference between their results and ours, is that (i) we focus on the conditional mean, not the conditional variance of returns, and (ii) we estimate the stock market response to news surprises, not the response to announcements. They interpret this increased volatility as evidence of contagion across equity markets.<sup>28</sup> In contrast, we interpret our results as evidence of price discovery taking place in the U.S. first and then in Portugal, with Portuguese investors letting the better informed U.S. market first figure out the significance of the U.S. news and then react to such interpretation of the news.

In Figure 2B we show the U.S. response to the same 8:30 and 9:15 EST U.S. macroeconomic announcements and the 7:45 EST ECB announcement. Since the U.S. stock market is not yet open, the first interval in all panels on the  $x$ -axis captures the U.S. stock market response from

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<sup>26</sup>The evidence discussed in section 7.5 below where we use a sample of non-ADR Portuguese firms gives even stronger evidence on this delayed response.

<sup>27</sup>Note that all else equal, unexpectedly high U.S. inflation leads to, an unexpected real USD appreciation. This is generally viewed as good for Portuguese exporters, but bad for U.S. firms.

<sup>28</sup>Becker et al. (1995) however present evidence that the U.K. market does respond immediately to U.S. news.

the previous day's close to 9:35 EST, the second interval captures the cumulative response from the previous day's close to 9:40 EST, and so on. The last interval captures the response from the previous day's close to 11:30 EST. In the first panel, we can observe that the U.S. market response to ECB announcements is immediate. There is some overshooting, since the immediate effect of -0.5 is reversed 20 minutes later to +0.1, but settles 30 minutes later to -0.2 (a typical unanticipated rate hike of 25 basis points in the ECB rate is associated with a decrease of roughly 0.2 percent in the level of stock market prices, compared with Kuttner and Bernanke's (2005) estimate of 1 percent for an unanticipated hike of 25 basis points in the Fed funds rate). 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 EST – 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.

Naturally, in the face of the predictability of Portuguese returns associated with the delayed response to U.S. news a question arises about the ability to generate profits from arbitraging the costs of information flow. Inspection of Table 3A reveals that the percentage spread on the Portuguese stocks is quite large and that it would swamp any profits present in Figure 2A. Another issue that a careful reader might notice is that the time of the release the news in the U.S. is close to lunch time in Portugal. However, by 9:30 EST when the U.S. market opens the Portuguese traders are more than done with their 'picnic'. Finally, 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. We do not think that this is a valid explanation because there does not appear to be a liquidity problem anymore once the U.S. market opens.

*U.S. News Released When both Market are Open*

In Figure 3A and 3B, we report the contemporaneous 5-minute cumulative response to the 10:00 EST announcements, when both markets are open. Though these results are not fully satisfying because the most "important" U.S. announcements are at 8:30 EST rather than 10:00 EST, they have the advantage of being generated when both markets are open. The Portuguese stock market significantly reacts to the consumption announcement 15 minutes after they are released (panel 1 in Figure 3A), this reaction temporarily reverses itself, and 45 minutes later it becomes stable. In contrast, the U.S. stock market also reacts 15 minutes later to this announcement (panel 1 in Figure 3B), and 40 minutes later it becomes stable. The Portuguese stock market does not react to the investment announcement (panel 2 in Figure 3A), while the U.S. stock market (panel 2 in Figure 3B) has an immediate reaction which becomes insignificant by 11:30 EST. Finally, the Portuguese stock market reacts to forward-looking announcements 15 minutes after they are released (panel 3 in Figure 3A), whereas the U.S. stock market

(panel 3 in Figure 3B) incorporates the information in these announcements immediately. 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 U.S. announcements.

*U.S. News Released When the U.S. Market is Open and the Portuguese Market is Closed*

Finally, Figure 4A and 4B reports the local and foreign stock market response to U.S. news when the U.S. market is open, but the Portuguese market is not (14:00, 14:15 and 15:00 EST macroeconomic announcements). The first panel in Figure 4A shows that the Portuguese reaction to the previous day’s U.S. government budget deficit surprise is incorporated into Portuguese stock market returns within 20 minutes of the market open in Portugal (at 3:30 EST the next day). However, this news becomes statistically insignificant by 11:30 EST, so it does not have a “permanent” effect on Portuguese stock market prices. This is not surprising, because the U.S. stock market (panel 1 Figure 4B) does not react strongly to this announcement either. In contrast, the federal funds rate surprise is important to both markets. It is incorporated into the Portuguese stock price as soon as the market opens (panel 2 Figure 4A), though it experiences a small reversal in the next 10 minutes, and it becomes stable within two hours of market open. This apparently ‘quick reaction’ is in contrast to those in Figure 3A, but we recall that by construction the response is occurring about 12 hours after the federal funds rate announcement. Surprisingly, the federal funds rate affects Portuguese stock market prices more than the ECB interest rate, since a typical unanticipated rate hike of 25 basis points in the federal funds rate (or one standard deviation shock to the standardized surprise variable) is associated with a decrease of roughly 0.5 ( $-0.8 \times 0.6$  std. dev.) percent in the level of Portuguese stock market prices, compared with a decrease of 0.2 percent associated with the ECB rate announcement. However, we caution on inferring too much from these differences in response to domestic and foreign monetary policy because 2002 was not a particularly active monetary policy year for the ECB. The U.S. stock market (panel 2 Figure 4B) reacts within 5-minutes of the announcement and it has a permanent effect; an unanticipated rate hike of 25 basis points in the federal funds rate is associated with a decrease of roughly 1.2 percent ( $-2 \times 0.6$ ) in the level of U.S. stock market prices, compared with 1 percent estimated by Bernanke and Kuttner (2005) using the NYSE-AMEX-NASDAQ value weighted index and data from June 1989 to December 2002. Finally, the U.S. consumer credit surprise is incorporated into Portuguese stock market prices (panel 3 Figure 4A) within one hour and 15 minutes of market open.

*‘Following’ Behavior of the Portuguese Market in the Absence of U.S. News*

In our model the timing assumption that price discovery takes place first in the U.S. and then in Portugal is not only relevant during announcement days, but also during non-announcement days. To further explore this assumption during non-announcement days we conduct 5-minute Granger causality tests. In untabulated results, we show that the U.S. value weighted and equal weighted stock market returns granger cause the Portuguese value weighted and equal weighted

stock market returns, respectively. But the Portuguese stock market return does not Granger cause the U.S. stock market return. We also show that the coefficient in front of the first lagged value is higher than the contemporaneous coefficient, specially so for the equal weighted portfolio.

Taken together, the empirical evidence presented in Figures 2, 3, 4 and the Granger causality tests support the model’s timing assumption that Portuguese investors wait for news (public or private) to be incorporated in the U.S. before acting on them. Also, the *high frequency* delayed response by the Portuguese stock market can explain why researchers have found that in regressions of *daily* local returns, the inclusion of the U.S. return takes explanatory power away from the U.S. news surprises (see below for these regressions with Portuguese data).

We next turn to estimate the impact of unanticipated U.S. order flow and U.S. public news surprises on daily U.S. price changes, to test the predictions of the model outlined in Section 4.2.

## 7 The Effect of News on Comovement

We now turn to testing directly the implications from the model of Sections 3 and 4.

### 7.1 Impact of U.S. News on U.S. Returns

For the remainder of the analysis we focus on daily returns. Our choice is motivated by the many finance applications of asset allocation and benchmarking that rely on daily frequencies. Given the results in the previous subsection, and our model, we expect that comovement across U.S. and Portuguese stock markets at a daily frequency is partly driven by the existence of a delayed response of Portuguese returns to US returns within the trading day. Going to even lower frequencies is problematic as the effect of news becomes harder to detect empirically.

We translate the equilibrium prices in Section 4.2 into the following estimable equation:

$$\begin{aligned}
 r_{it}^{us} = & a + \lambda_{sp_{eus}} S_{ip_{eus}t} + \lambda_{sp_{ecb}} S_{p_{ecb}t} + \sum_{p_{us}=7}^{15} \lambda_{sp_{us}} S_{p_{us}t} + \sum_{j=0}^J \lambda_j \Omega_{it-j}^{us} (1 - D_t^{us}) + \\
 & \sum_{j=0}^J \lambda_{pj} \Omega_{it-j}^{us} D_t^{us} + \sum_{j=1}^J \beta_j r_{it-j}^{us} (1 - D_t^{us}) + \sum_{j=1}^J \beta_{pj} r_{it-j}^{us} D_t^{us} + \varepsilon_{it}, \quad (18)
 \end{aligned}$$

where  $D_t^{us}$  is an indicator function for U.S. 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  $i = 1, \dots, 30$ , in the DJ 30 Index,  $S_{p_{us}t}$  is the standardized news corresponding to announcement  $p_{us}$  ( $p_{us} = 7, \dots, 15$ ) listed in Table 5,  $S_{p_{ecb}t}$  is the standardized ECB benchmark interest rate news surprise made at day  $t$ , and  $\Omega_{it}^{us}$  is the daily U.S. 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 U.S. returns. However, the ECB Governing Council news on its benchmark interest rate is known to influence the U.S. markets (Ehrmann and Fratzscher, 2003).<sup>29</sup> 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).<sup>30</sup> 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. (2002)). Hence, positive and significant contemporaneous estimates for  $\lambda_0$  and  $\lambda_{p0}$  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  $\lambda_0$  and  $\lambda_{p0}$  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  $\varepsilon_{it}$  as follows:

$$\sigma_{it}^2 = \omega + \beta_\sigma \sigma_{it-1}^2 + \beta_\varepsilon \varepsilon_{it-1}^2 + \phi T_{it-1} + \psi_{p_{eus}} D_t^{p_{eus}} + \psi_{p_{ecb}} D_t^{p_{ecb}} + \sum_{p_{us}=7}^{15} \psi_{p_{us}} D_t^{p_{us}}, \quad (19)$$

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 U.S. 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 U.S. macroeconomic announcement indicator  $p_{us}$  is released.<sup>31</sup>

In Table 6 we show that news on U.S. macroeconomic fundamentals exert a significant influence in the U.S. 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.

<sup>29</sup>Consistent with our expectation, the U.S. stock market does not respond to Portuguese macroeconomic surprises. Previous studies have found similar results with, for example, United Kingdom macro surprises (Becker, Finnerty and Friedman, 1995) and German surprises (Andersen, Bollerslev, Diebold, Vega, 2003).

<sup>30</sup>The order of the lagged polynomial,  $J$ , is set to assess 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.

<sup>31</sup>The index in the announcement dummies is  $t$  because the announcement date is known in advance.

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 U.S.<sup>32</sup> This claim is further supported by the statistical insignificance of the inflationary shocks (PPI and CPI surprises).

Table 6 shows that a one standard deviation unexpected increase in the federal funds target rate decreases stock market returns by 0.5 percent ( $-0.73 \times 0.6$ ) by the end of the announcement day. The magnitude of this response is much lower than the response we obtained in Figure 4B. The main reason for this discrepancy is that we use daily returns to estimate the response shown in Table 6. This response is noisier than the cumulative 5-minute return response depicted in Figure 4B due to the higher intraday signal-to-noise ratio, see Andersen et al. (2002). Similarly, a one standard deviation unexpected increase in the ECB benchmark rate decreases stock market returns by 0.16 percent.

The results in Table 6 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 ( $\lambda_{p0}$  and  $\lambda_0$ ) are positive and significant (at the 1% level). First order lagged unanticipated order flow ( $\lambda_{p1}$  and  $\lambda_1$ ) 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 is statistically insignificant at all significance levels. In other words, we find evidence that the contemporaneous impact of unanticipated U.S. 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 a larger informational order flow effect studied in the model.

According to our model, we expect  $\lambda_0 - \lambda_{p0} > 0$ , 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 6 shows that we fail to reject this null hypothesis at 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 U.S. liquidity decreases at earnings announcements and other unanticipated firm events.

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<sup>32</sup>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).

In untabulated results and consistent with Andersen and Bollerslev (1998) we find that volatility is higher during announcement days. Previous literature found that daily stock market volatility is positively correlated with the number of transactions (e.g., Jones et al., 1994). However, we found that the number of transactions becomes insignificant when including the announcement dummies. Since the number of transactions is a proxy for investors' dispersion of beliefs, the results suggest that the announcement dummies might more accurately measure this dispersion of beliefs.

## 7.2 Impact of Portuguese Macroeconomic News on Portuguese and U.S. Comovement

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

$$\begin{aligned}
r_{it}^{por} &= a^{por} + \lambda_{spepor}^{por} S_{ipeport} + \lambda_{specb}^{por} S_{pecbt} + \sum_{p_{por}=2}^4 \lambda_{sp_{por}}^{por} S_{p_{por}t} + \sum_{p_{us}=7}^{15} \lambda_{sp_{us}}^{por} S_{p_{us}t} + \\
&\sum_{j=0}^J \lambda_j^{por} \Omega_{it-j}^{por} (1 - D_t^{por}) + \sum_{j=0}^J \lambda_{pj}^{por} \Omega_{it-j}^{por} D_t^{por} + \sum_{j=0}^J \beta_j^{por} r_{t-j}^{us} (1 - D_t^{por}) \\
&+ \sum_{j=0}^J \beta_{pj}^{por} r_{t-j}^{us} D_t^{por} + \sum_{j=1}^J \beta_{porj}^{por} r_{it-j}^{por} + \varepsilon_{it}^{por}, \tag{20}
\end{aligned}$$

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  $i = 1, \dots, 20$ , 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,  $S_{ipeport}$  is the standardized news corresponding to Portuguese earnings announcement for firm  $i = 1, \dots, 20$ ,  $S_{p_{por}t}$  is the standardized news corresponding to Portuguese announcement  $p_{por}$  ( $p_{por} = 2, 3, 4$ ) listed in Table 5,  $S_{pecbt}$  is the standardized ECB benchmark interest rate news surprise,  $S_{p_{us}t}$  is the standardized news corresponding to announcement  $p_{us}$  ( $p_{us} = 7, \dots, 15$ ) listed in Table 5, and  $\Omega_{it}^{por}$  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  $\varepsilon_{it}^{por}$  as follows:

$$\begin{aligned}
\sigma_{it}^{por2} &= \omega^{por} + \beta_{\sigma}^{por} \sigma_{it-1}^{por2} + \beta_{\varepsilon}^{por} \varepsilon_{it-1}^{por2} + \phi^{por} T_{it-1} + \psi_{pepor}^{por} D_t^{pepor} \\
&+ \psi_{pecb}^{por} D_t^{pecb} + \sum_{p_{por}=2}^4 \psi_{p_{por}}^{por} D_t^{p_{por}} + \sum_{p_{us}=7}^{15} \psi_{p_{us}}^{por} D_t^{p_{us}} + \beta_{\varepsilon_{us}}^{por} r_{t-1}^{us2}, \tag{21}
\end{aligned}$$

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

According to the model, we expect that stock return correlations fall on public macroeconomic news announcement days,  $\beta_0^{por} - \beta_{p0}^{por} > 0$ . In the first two columns of Table 7 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 U.S. market results presented above. The only exception is that Portuguese inflationary shocks have a strong negative effect on Portuguese stock market returns, while U.S. inflationary shocks had no significant effect on U.S. stock market returns during the U.S. recession period. Interestingly, the U.S. macro news announcements slightly gain statistical significance when we drop the value weighted DJ 30 Industrial Index return from equation (20). This means that part of the comovement between the U.S. and Portugal is due to the effect U.S. macroeconomic fundamentals have on the Portuguese stock market and is consistent with the evidence shown in section 6 on a delayed high-frequency response by the Portuguese market to U.S. macro news surprises.

Consistent with the U.S. market results in Table 6, Table 7 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 ( $\lambda_{p0}^{por}$  and  $\lambda_0^{por}$ ) are positive and significant (at the 1 percent level). First order lagged unanticipated order flow ( $\lambda_{p1}^{por}$  and  $\lambda_1^{por}$ ) is negative and statistically significant at the 1% significance level, however its magnitude is 9.7 times smaller on announcement days ( $\lambda_{p1}^{por}$ ) and 4.36 times smaller on non-announcements days ( $\lambda_1^{por}$ ) 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 U.S. 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 U.S., Portuguese stock market volatility is lower during announcement days of real activity. However, and in contrast with the evidence for the U.S., 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 U.S. market into the Portuguese market.

### 7.3 Impact of Portuguese Earnings Announcements on Portuguese and U.S. Comovement

Now, we examine the impact of country specific news (section 4.6) on the U.S.-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,  $\beta_0^{epor} - \beta_{p0}^{epor} = 0$ . In columns 3 and 4 of Table 7 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 U.S. macroeconomic news announcements are very similar to those in the previous section.

### 7.4 Impact of U.S. News on Portuguese and U.S. Comovement

Finally, we examine the impact of U.S. macroeconomic public news surprises on the U.S.-Portuguese stock market comovement. We replace  $D_t^{por}$  in equation (20) with  $D_t^{us}$ , an indicator function for U.S. macroeconomic announcement release dates. We expect that cross-country return correlations remain unchanged across U.S. macroeconomic announcement days and non-announcement days, i.e.,  $\beta_0^{us} - \beta_{p0}^{us} = 0$ . In the last two columns of Table 7 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; U.S. 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.

### 7.5 Robustness Checks

Since some of the macroeconomic announcements listed in Table 4A and Table 4B 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 U.S. macro announcements carry with them more analysis by informed investors and that the precision of U.S. 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 U.S. returns increases. To explore this possibility we re-estimate equation (20) using only significant U.S. and Portuguese macroeconomic news announcements. For comparison, we report in Table 8 the coefficient estimates of equation (18), when we don't aggregate the U.S. announcements. We can observe that only 50% of the macroeconomic news announcements listed in Table 4B are statistically significant, hence our previous results could be biased. In the first two columns of Table 9 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 4A are statistically significant). The coefficient estimates for the Portuguese-U.S. stock market correlations are qualitatively the same as those in Table 7 (column 1 and 2). Interestingly, all the U.S. announcements that are significant in Table 9 (column 1, 3, and 5) when the U.S. value weighted return is not included in equation (20) remain significant in Table 8 (with the exception of the business inventories). This means that the Portuguese stock market only reacts to those U.S. macroeconomic announcements that affect the U.S. stock market. As previously shown, many of the U.S. macroeconomic announcements become insignificant when the value weighted U.S. return is included in the regression. Similarly, the results in Table 9, column 4 and 6, report that the Portuguese-U.S. stock market correlation is the same during U.S. 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-U.S. 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 U.S. value weighted DJ 30 index experiences a top 10% jump in absolute value on day  $t$ , and with day-of-the week indicator functions  $\{D_t^{Monday}, D_t^{Tuesday}, D_t^{Wednesday}, D_t^{Thursday}\}$ . In the first specification we test the hypothesis that the Portuguese stock market “overreacts” to any U.S. 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 10 we show that, in contrast to Karolyi and Stulz (1996), the Portuguese stock market does not react significantly to large shocks to the U.S. stock market (i.e.,  $\beta_{OLARGE}^{por}$  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  $\beta_{OLARGE}^{por}$  is insignificant is consistent with Bekaert, Harvey and Ng (2005) who found that there is no contagion between US and Portugal based on residuals from a two-factor asset pricing model. We conclude our model explains the time-varying properties of the U.S.-Portuguese stock market correlation better than day-of-week and large-return patterns previously found in the literature.

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 U.S. as ADRs: EDP, PORTUCEL and PT.<sup>33</sup> U.S. investors are more likely to buy Portuguese ADRs than Portuguese stocks not listed in the U.S. 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 comovement across markets drops from  $\beta_0^{por} = 0.14$  in days of no Portuguese macroeconomic news to  $\beta_{p0}^{por} = 0.02$  in days of Portuguese Macro news. This finding deserves two comments. First, the result that there is lower comovement in days of Macro announcements in Portugal is robust. Second, compared to the coefficients reported in Table 9 ( $\beta_0^{por} = 0.23$  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 U.S. stock market increases. Continuing with our exercise with the non-ADR sample we find new estimates for comovement changes during Portuguese earnings announcement days and U.S. macroeconomic announcements 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.

## 8 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 important public news and order flow effects in the U.S. 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 U.S. and Portuguese stock market returns, order flow and real-time macroeconomic news releases.

Our evidence suggests that cross-country stock market return correlations are unchanged when U.S. news is released, however this correlation decreases when Portuguese news is released, so long as the news are not country-specific. Our theory suggests that these effects arise from the way different news in Portugal or the U.S. affect the informativeness of U.S. returns to Portuguese investors and price discovery in Portugal.

Also, U.S. public information affects Portuguese stock market returns, but this effect is diminished when U.S. stock market returns are included in the regression. We document that this is due to a delayed response of the Portuguese stock market to U.S. news in that Portuguese investors free ride – by looking at U.S. returns – on U.S. investors' efforts at analyzing the new information. We find evidence which contradicts the contagion view as an explanation to this

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<sup>33</sup>There is also a BRISA-ADR, but it started trading on March 14, 2005. Since our sample period ends in 2002, we do not drop this stock from our analysis.

delayed response.

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

## A 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 in 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  $E \left[ \tilde{v}_{t+1}^* | s_t^* \right] = \frac{\delta^*}{\delta^* + \phi^*} s_t^*$  we can solve for

$$x_{it}^* = \frac{1}{\lambda^* (n^* + 1)} \frac{\delta^*}{\delta^* + \phi^*} s_t^*.$$

The market maker's problem is

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

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

$$\begin{aligned} \lambda^* &= \frac{\delta^*}{n^* + 1} \sqrt{\frac{n^*}{\zeta^* (\delta^* + \phi^*)}}, \\ x_{it}^* &= \sqrt{\frac{\zeta^*}{n^* (\delta^* + \phi^*)}} s_t^*. \end{aligned}$$

### *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:

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

The solution to this problem (after appropriately computing 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  $\lambda^*$  and  $\sigma^*$  such that:

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

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

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

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

$$\lambda_A^* = \frac{\delta^* \kappa^*}{n^* + 1} \sqrt{\frac{n^*}{\zeta^* (\delta^* + \kappa^*) [(\delta^* + \kappa^*) (\phi^* + \delta^*) - \delta^{*2}]}} < \frac{\delta^*}{n^* + 1} \sqrt{\frac{n^*}{\zeta^* (\delta^* + \phi^*)}} = \lambda_{NA}^*,$$

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

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

It can be checked that  $E \left[ \tilde{v}_{t+1} | s_t, \tilde{\omega}_t^* \right] = a_0 s_t + a_1 \tilde{\omega}_t^*$  with

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

and

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

The market maker solves

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

After tedious algebra we can find  $E[\tilde{v}_{t+1} | \omega_t, \omega_t^*]$  and show that the market maker's efficiency condition is satisfied with

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

**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

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

The solution to this problem is to trade:

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

where (abusing notation)

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

The market maker's problem is

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

Again, we solve for  $E \left[ \tilde{v}_{t+1} | \omega_t, \omega_t^*, U_t \right]$  and, after much algebra, find the parameters that satisfy the market maker's zero profit condition:

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

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

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

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

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

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

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

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

with

$$\lambda_{A,POR}^2 = \frac{n}{(n+1)^2} \frac{\kappa^2 \left[ \delta (n^* + 1) \zeta^* - \beta^{*2} \psi^2 \right]^2}{(\delta \kappa + \phi \delta + \phi \kappa) (n^* + 1) \zeta^* - (\phi + \kappa) \beta^{*2} \psi^2} \frac{1}{\zeta \left[ (n^* + 1) \zeta^* (\delta + \kappa) - \beta^{*2} \psi^2 \right]}.$$

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

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

The right hand side of this inequality can be written as

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

Therefore we get that  $\lambda_{A,POR}^2 < \lambda_{No\_A}^2$ . ■

*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

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

with

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

The market maker's problem yields:

$$\begin{aligned} \lambda^2 &= \frac{\frac{n}{\zeta(n+1)^2} [\beta_0^{*2} (\psi^2 (\delta^* - \kappa^*) - \delta\delta^{*2}) + E[\tilde{w}_t^{*2}] (\delta(\delta^* + \kappa^*) - \psi^2)]^2}{[E[\tilde{w}_t^{*2}] (\delta^* + \kappa^*) - \beta_0^{*2}\delta^{*2}] [(\delta + \phi) (\delta^* + \kappa^*) - \psi^2] E[\tilde{w}_t^{*2}] + \beta_0^{*2} [\psi^2 (\delta^* - \kappa^*) - \delta^{*2} (\delta + \phi)]}, \\ \eta &= \frac{\beta_0^*\psi\kappa^*}{E[\tilde{w}_t^{*2}] (\delta^* + \kappa^*) - \beta_0^{*2}\delta^{*2}}, \\ \sigma &= \frac{\psi [E[\tilde{w}_t^{*2}] - \beta_0^{*2}\delta^*]}{E[\tilde{w}_t^{*2}] (\delta^* + \kappa^*) - \beta_0^{*2}\delta^{*2}}. \end{aligned}$$

**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

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

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

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

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  $\tilde{P}_t = V_t + \lambda \tilde{\omega}_t + \eta \tilde{\omega}_t^* + \sigma U_t$ . Following the same steps as above 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

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

The market maker's problem yields

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

**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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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 market capitalization to smallest 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

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

This table lists the U.S. 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 market capitalization to smallest 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

Table 2. Portuguese and U.S. Stock Market Trading Hours

This table presents the Portuguese and U.S. stock market open and close. GMT is Greenwich Mean Time and is Lisbon time.

Portuguese Market Open			Portuguese Market Close				
GMT	8:30	↔	14:30	↔	16:30	↔	21:00
			U.S. Market Open				U.S. Market Close
EST	3:30	↔	9:30	↔	11:30	↔	16:00

Table 3A. 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 EST today to 11:30 EST 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

Table 3B. DJ 30 Industrial Index Summary Statistics

This table presents daily descriptive statistics for the individual components of the U.S. 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 EST today to 11:30 EST 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

Table 4A. 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 <sup>1</sup>	Obs <sup>2</sup>	Source	Time <sup>3</sup>	Mean	Std. Dev.	DOW <sup>4</sup>
<b>Real Activity</b>						
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 <sup>5</sup>	0.009	0.765	Varies
4- Industrial Sales	10	INE	6:00 <sup>6</sup>	-0.089	1.079	Varies
5- Retail Sales	10	INE	6:00 <sup>7</sup>	-0.050	0.796	Varies
<b>Net Exports</b>						
6- Trade Balance	7	INE	Varies	0.006	0.536	Varies
<b>Prices</b>						
7- Consumer Price Index	9	INE	6:00	-0.125	0.936	Varies
8- Producer Price Index	9	INE	6:00 <sup>8</sup>	-0.402	1.126	Varies
European Announcements						
9- ECB benchmark refinancing rate	8	ECB	7:45 <sup>9</sup>	-2.773	0.928	Varies

Footnotes:

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 announcement is usually released in.

5. Industrial Production was released at 10:00 EST on January 8, 2002, at 11:00 EST on March 13, 2002 and at 5:00 EST on April 5, 2002.

6. Industrial Sales was released at 10:00 EST on January 16, 2002.

7. Retail Sales was released at 10:00 EST on June 11, 2002.

8. Producer Price Index was released at 10:00 EST on January 25, 2002.

9. The ECB announces the benchmark interest rate at 7:45 EST, and the President of the ECB, Willem F. Duisenberg, holds a press conference that ends anytime between 8:50 to 10:00 EST.

Table 4B. U.S. Macroeconomic News Announcements

Announcements	Obs <sup>1</sup>	Source <sup>2</sup>	Time <sup>3</sup>	Mean	Std. Dev.	DOW <sup>4</sup>
<b>Real Activity</b>						
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 <sup>5</sup>
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
<b>Consumption</b>						
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
<b>Investment</b>						
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
<b>Government Purchases</b>						
16- Government Budget	9	FMO	14:00	-0.129	0.510	Varies
<b>Net Exports</b>						
17- Trade Balance	9	BEA	8:30	-0.168	1.118	Varies
<b>Prices</b>						
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
<b>Forward-Looking</b>						
20- Consumer Confidence Index	9	CB	10:00	0.083	1.062	Tuesday <sup>6</sup>
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
Six-Week Announcements						
24- Target Federal Funds Rate	6	FRB	14:15	-0.525	0.605	Tuesday <sup>7</sup>
Weekly Announcements						
25- Initial Unemployment Claims	40	ETA	8:30	0.139	1.045	Thursday

## Notes to Table 4B

U.S. 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 U.S. 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).

Footnotes:

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 announcement is usually released in.
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.

Table 5. Aggregate Portuguese and U.S. Macroeconomic News Announcements

This table reports estimates of the aggregate Portuguese and U.S. News. We aggregate announcements into seven groups as shown in Table 4A and Table 4B: real activity, each of the GDP components (i.e., consumption, investment, government purchases and net exports), prices, and forward-looking announcements. The six-week and weekly announcements are not aggregated. For example, U.S. real activity surprises are defined as the sum of GDP Advance, GDP Preliminary, GDP Final, Nonfarm Payroll, Retail Sales, Industrial Production, Capacity Utilization, Personal Income and Consumer Credit standardized surprises (according to equation (15)), while Portuguese real activity surprises are defined as the sum of GDP, the Employment Report, Industrial Production and Industrial Sales standardized surprises.

Announcements	Obs	Mean	Std. Dev.
Portuguese Announcements			
1- Earnings	60	0.094	1.206
2- Real Activity	35	-0.127	0.939
3- Net Exports	7	0.006	0.536
4- Prices	18	-0.264	1.014
European Announcements			
5- ECB benchmark refinancing rate	8	-2.773	0.928
U.S. Announcements			
6- Earnings	83	0.891	1.345
7- Real Activity	55	0.257	1.254
8- Consumption	17	0.070	0.882
9- Investment	38	0.027	0.888
10- Government Purchases	9	-0.129	0.510
11- Net Exports	9	-0.168	1.118
12- Prices	19	-0.466	0.921
13- Forward-Looking	36	0.111	0.982
14- Target Federal Funds Rate	6	-0.525	0.605
15- Initial Unemployment Claims	40	0.139	1.045

Table 6. Influence of U.S. Public Announcements on U.S. Returns

This table reports coefficient estimates of the following equation:

$$r_{it}^{us} = a + \lambda_{sp_{eus}} S_{ip_{eus}t} + \lambda_{sp_{ecb}} S_{p_{ecb}t} + \sum_{p_{us}=7}^{15} \lambda_{sp_{us}} S_{p_{us}t} + \sum_{j=0}^J \lambda_j \Omega_{it-j}^{us} (1 - D_t^{us}) + \sum_{j=0}^J \lambda_{pj} \Omega_{it-j}^{us} D_t^{us} + \sum_{j=1}^J \beta_j r_{it-j}^{us} (1 - D_t^{us}) + \sum_{j=1}^J \beta_{pj} r_{it-j}^{us} D_t^{us} + \varepsilon_{it},$$

where  $r_{it}^{us}$  is the daily stock return for  $i = 1, \dots, 30$  DJ 30 individual stocks,  $\Omega_{it}^{us}$  is the unanticipated order flow (defined in Section 6),  $D_t^{us}$  is an indicator function equal to one if a U.S. 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 U.S. macroeconomic news surprise for  $p_{us} = 7, \dots, 15$  (defined in Section 4.2 and listed in Table 5). 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, $\lambda_0$	0.0102	19.39***
Announcement, $\lambda_{p0}$	0.0084	23.08***
$H_0: \lambda_0 - \lambda_{p0} = 0$ (F-statistic)	0.0018	8.59***
Lagged Order Flow		
Non-Announcement, $\lambda_1$	-0.0029	-5.11***
Non-Announcement, $\lambda_2$	-0.0010	-1.61
Announcement, $\lambda_{p1}$	-0.0016	-3.86***
Announcement, $\lambda_{p2}$	-0.0011	-2.78***
European Announcement, $\lambda_{sp_{ecb}}$		
ECB benchmark refinancing rate	-0.1703	-3.44***
U.S. 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**
$H_0: \lambda_{s7} = \dots = \lambda_{s15} = 0$ (F-statistic)		13.42***
Adjusted- $R^2$		0.1665

Table 7. Influence of News Announcements on US-Portuguese Stock Market Comovement

	Portuguese Macroeconomic Ann.		Portuguese Earnings Ann.		U.S. Macroeconomic Ann.	
Contemporaneous Order Flow						
Non-Announcement, $\lambda_0^{por}$	0.0182***	0.0186***	0.0193***	0.0141***	0.0235***	0.0165***
Announcement, $\lambda_{p0}^{por}$	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, $\lambda_1^{por}$	-0.0038***	-0.0048***	-0.0036***	-0.0033***	-0.0060**	-0.0045***
Non-Announcement, $\lambda_2^{por}$	-0.0027**	-0.0020*	-0.0023**	-0.0015**	-0.0050**	-0.0016
Announcement, $\lambda_{p1}^{por}$	-0.0051*	-0.0044	-0.0025	-0.0034	-0.0036**	-0.0033***
Announcement, $\lambda_{p2}^{por}$	-0.0012	-0.0001	-0.0050*	-0.0022*	-0.0013	-0.0013**
U.S. Value Weighted Return						
Non-Announcement, $\beta_0^{por}$		0.2515***		0.2289***		0.2278***
Announcement, $\beta_{0p}^{por}$		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, $\lambda_{spepor}^{por}, \lambda_{sppor}^{por}$						
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***
$H_0 : \lambda_{s2}^{por} = \lambda_{s3}^{por} = \lambda_{s4}^{por} = 0$ (F-statistic)	10.53***	12.58***	11.32***	13.32***	12.82***	11.92***
European Announcement, $\lambda_{specb}^{por}$						
ECB benchmark refinancing rate	-0.0910**	-0.0163	-0.0685**	-0.0560	-0.0765**	-0.0539
U.S. Announcements, $\lambda_{spus}^{por}$						
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
$H_0 : \lambda_{s7}^{por} = \dots = \lambda_{s15}^{por} = 0$ (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

## Notes to Table 7

This table reports coefficient estimates of the following equation:

$$\begin{aligned}
 r_{it}^{por} = & a^{por} + \lambda_{sp_{epor}}^{por} S_{i_{p_{epor}t}} + \lambda_{sp_{ecb}}^{por} S_{p_{ecb}t} + \sum_{p_{por}=2}^4 \lambda_{sp_{por}}^{por} S_{p_{por}t} + \sum_{p_{us}=7}^{15} \lambda_{sp_{us}}^{por} S_{p_{us}t} + \sum_{j=0}^J \lambda_j^{por} \Omega_{it-j}^{por} (1 - D_t) + \\
 & \sum_{j=0}^J \lambda_{pj}^{por} \Omega_{it-j}^{por} D_t + \sum_{j=0}^J \beta_j^{por} r_{t-j}^{us} (1 - D_t) + \sum_{j=0}^J \beta_{pj}^{por} r_{t-j}^{us} D_t + \sum_{j=1}^J \beta_{porj}^{por} r_{it-j}^{por} + \varepsilon_{it}^{por},
 \end{aligned}$$

where  $r_{it}^{por}$  is the daily return for stock  $i = 1, \dots, 20$  of the PSI-20 Index,  $\Omega_{it}^{por}$  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 U.S. macroeconomic announcement is released, respectively, on date  $t$ ,  $S_{p_{ecb}t}$  is the standardized ECB benchmark refinancing rate news surprise,  $S_{i_{p_{epor}t}}$  is the Portuguese standardized earnings news surprise for stock  $i$ , and  $S_{p_{us}t}$  is the aggregate standardized U.S. macroeconomic news surprise for  $p_{us} = 7, \dots, 15$  and  $S_{p_{por}t}$  is the aggregate Portuguese standardized macroeconomic news surprise for  $p_{por} = 2, 3, 4$  (both of which are defined in Section 4.2 and listed in Table 5). 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.

Table 8. Influence of U.S. Disaggregate Macroeconomic Announcements on U.S. Returns

	Coefficient	t-statistic
	Contemporaneous Order Flow	
Non-Announcement, $\lambda_0$	0.0105	20.65***
Announcement, $\lambda_{p0}$	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***
	U.S. 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
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	

## Notes to Table 8

This table reports coefficient estimates of the following equation:

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

where  $r_{it}^{us}$  is the daily stock return for  $i = 1, \dots, 30$  DJ 30 individual stocks,  $\Omega_{it}^{us}$  is the daily U.S. unanticipated order flow for stock  $i$  (defined in Section 6),  $D_t^{us}$  is an indicator function equal to one if a U.S. 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 U.S. macroeconomic news surprise for  $p_{us} = 1, \dots, 25$  (defined in Section 4.2 and listed in Table 4B). 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.

Table 9. Influence of Statistically Significant Disaggregate Announcements on US-Portuguese stock Market Comovement

	Portuguese Macroeconomic Ann.		Portuguese Earnings Ann.		U.S. Macroeconomic Ann.	
	Contemporaneous Order Flow					
Non-Announcement, $\lambda_0^{por}$	0.0151***	0.0139***	0.0150***	0.0144***	0.0144***	0.0137***
Announcement, $\lambda_{p0}^{por}$	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**
	U.S. Value Weighted Return					
Non-Announcement, $\beta_0^{por}$		0.2287***		0.2065***		0.2151***
Announcement, $\beta_{0p}^{por}$		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**
	U.S. 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

## Notes to Table 9

This table reports coefficient estimates of the following equation:

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

where  $r_{it}^{por}$  is the daily return for stock  $i = 1, \dots, 20$  of the PSI-20 Index,  $\Omega_{it}^{por}$  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 U.S. macroeconomic announcement is released, respectively, on date  $t$ ,  $S_{p_{ecb} t}$  is the standardized ECB benchmark refinancing rate news surprise,  $S_{i p_{epor} t}$  is the Portuguese standardized earnings news surprise for stock  $i$ , and  $S_{p_{us} t}$  is the disaggregate standardized U.S. macroeconomic news surprise for statistically significant news  $p_{us} = 1, \dots, P_{us}$  and  $S_{p_{por} t}$  is the disaggregate Portuguese standardized macroeconomic news surprise for statistically significant news  $p_{por} = 1, \dots, P_{por}$ . 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.

Table 10. Day of the Week Effects and Large U.S. Returns

	Coefficient	t-statistic	Coefficient	t-statistic
	Contemporaneous Order Flow			
$\lambda_0^{por}$	0.0136	43.45***	0.0134	40.90***
	Lagged Order Flow			
$\lambda_1^{por}$	-0.0032	-6.70***	-0.0030	-5.83***
$\lambda_2^{por}$	-0.0016	-3.24***	-0.0014	-2.58***
$\lambda_3^{por}$	-0.0014	-2.62***	-0.0016	-2.65***
	U.S. Value Weighted Return			
$\beta_0^{por}$	0.2200	10.58***	0.2551	10.44***
$\beta_{0LARGE}^{por}$	0.0251	0.99		
Monday, $\beta_0^{por}$			0.0114	0.30
Tuesday, $\beta_0^{por}$			-0.0413	-1.11
Wednesday, $\beta_0^{por}$			-0.0170	-0.37
Thursday, $\beta_0^{por}$			-0.0647	-1.72*
	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
	U.S. 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	

Notes to Table 10

This table reports coefficient estimates of the following equation:

$$r_{it}^{por} = a^{por} + \lambda_{sp_{eport}}^{por} S_{i p_{eport}} + \lambda_{sp_{ecbt}}^{por} S_{p_{ecbt}} + \sum_{p_{por}=1}^{P_{por}} \lambda_{sp_{por}}^{por} S_{p_{por}t} + \sum_{p_{us}=1}^{P_{us}} \lambda_{sp_{us}}^{por} S_{p_{us}t} + \sum_{j=0}^J \lambda_j^{por} \Omega_{it-j}^{por} (1 - D_t) + \sum_{j=0}^J \lambda_{pj}^{por} \Omega_{it-j}^{por} D_t + \sum_{j=0}^J \beta_j^{por,us} r_{t-j}^{us} (1 - D_t) + \sum_{j=0}^J \beta_{pj}^{por,us} r_{t-j}^{us} D_t + \sum_{j=1}^J \beta_{porj}^{por} r_{it-j}^{por} + \varepsilon_{it}^{por},$$

where  $r_{it}^{por}$  is the daily return for stock  $i = 1, \dots, 20$  of the PSI-20 Index,  $\Omega_{it}^{por}$  is the daily Portuguese unanticipated order flow for stock  $i$  (defined in Section 6),  $D_t = \{D_t^{LARGE}, \{D_t^{Monday}, D_t^{Tuesday}, D_t^{Wednesday}, D_t^{Thursday}\}\}$  where  $D_t^{LARGE}$  is an indicator function equal to one if the U.S. value weighted DJ 30 index experiences a top 10% jump in absolute value on day  $t$ , and  $\{D_t^{Monday}, D_t^{Tuesday}, D_t^{Wednesday}, D_t^{Thursday}\}$  are day-of-the-week indicator functions,  $S_{p_{ecbt}}$  is the standardized ECB benchmark refinancing rate news surprise,  $S_{i p_{eport}}$  is the Portuguese standardized earnings news surprise for stock  $i$ , and  $S_{p_{us}t}$  is the aggregate standardized U.S. macroeconomic news surprise  $p_{us} = 2, \dots, 7$  and  $S_{p_{por}t}$  is the aggregate Portuguese standardized macroeconomic news surprise  $p_{por} = 2, 3, 4$ . 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

Figure 1. Timeline of Events

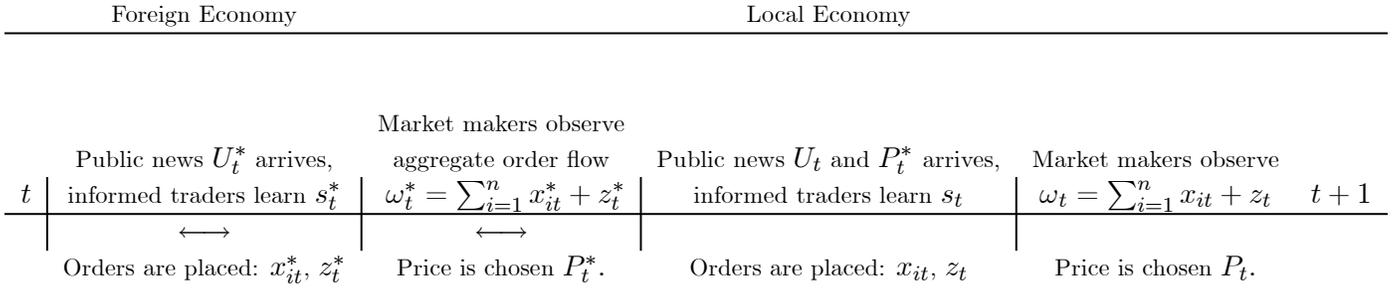


Figure 2A. Portuguese Response to 7:45 ECB announcement, 8:30 and 9:15 EST U.S. Macroeconomic Announcements

We plot  $\lambda_{np}^{por}$  (equation (16)), the cumulative Portuguese response to 8:30 and 9:15 EST U.S. macroeconomic announcements, and the 7:45 EST ECB announcement. The left hand side 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 7:50 EST and the return is measured from just before 7:45 EST to 7:50 EST. The second tick indicates 7:55 EST and the return is measured from just before 7:45 EST to 7:55 EST. The vertical line corresponds to 9:30 EST when the U.S. stock market opens. The last tick captures the response from the time indicated in the title of the plot to 11:30 EST.

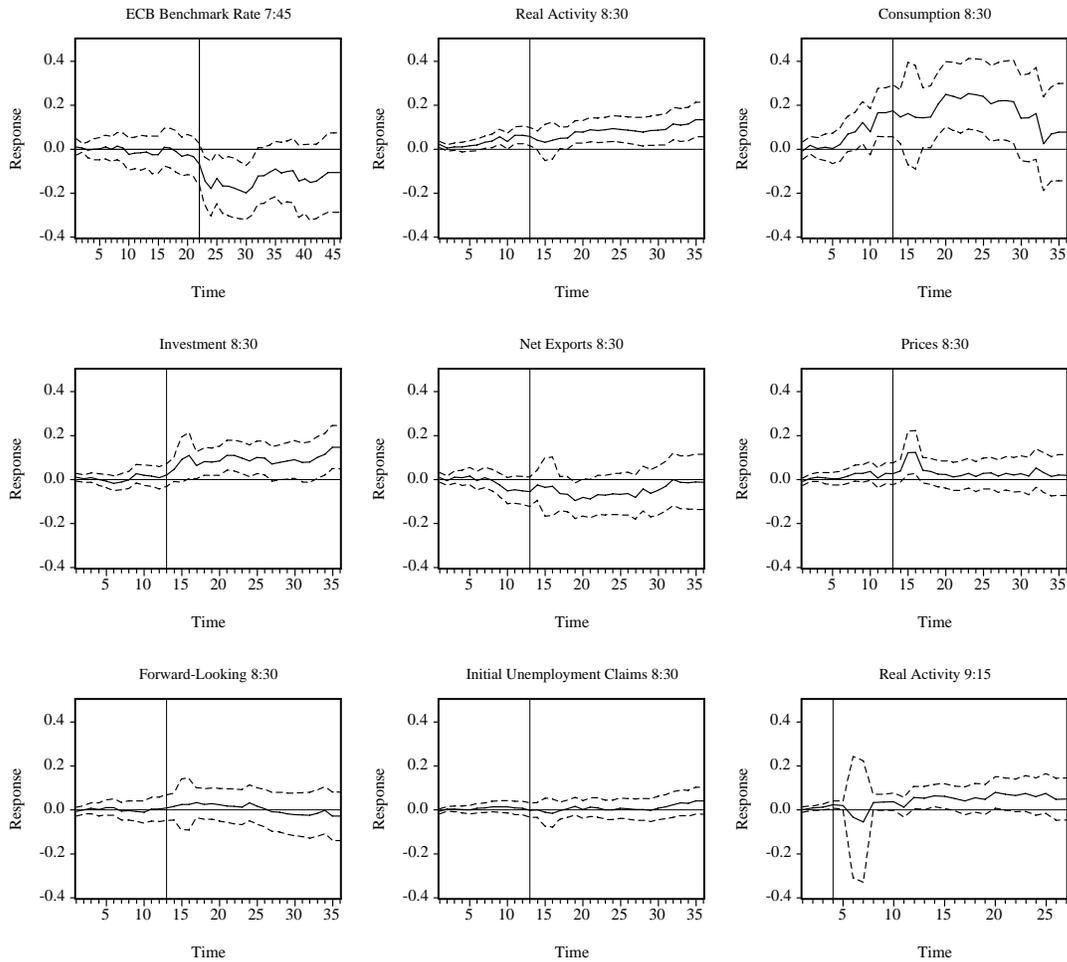


Figure 2B. U.S. Response to 7:45 ECB announcement, 8:30 and 9:15 EST U.S. Macroeconomic Announcements

We plot  $\lambda_{np}$  (equation (16)), the cumulative U.S. response to 8:30 and 9:15 EST U.S. macroeconomic announcements, and the 7:45 EST ECB announcement. Since the U.S. stock market is not yet open, the first tick in all panels on the  $x$ -axis captures the U.S. stock market response from the previous day's close to 9:35 EST, the second tick captures the cumulative response from the previous day's close to 9:40 EST, and so on. The last tick captures the response from the previous day's close to 11:30 EST.

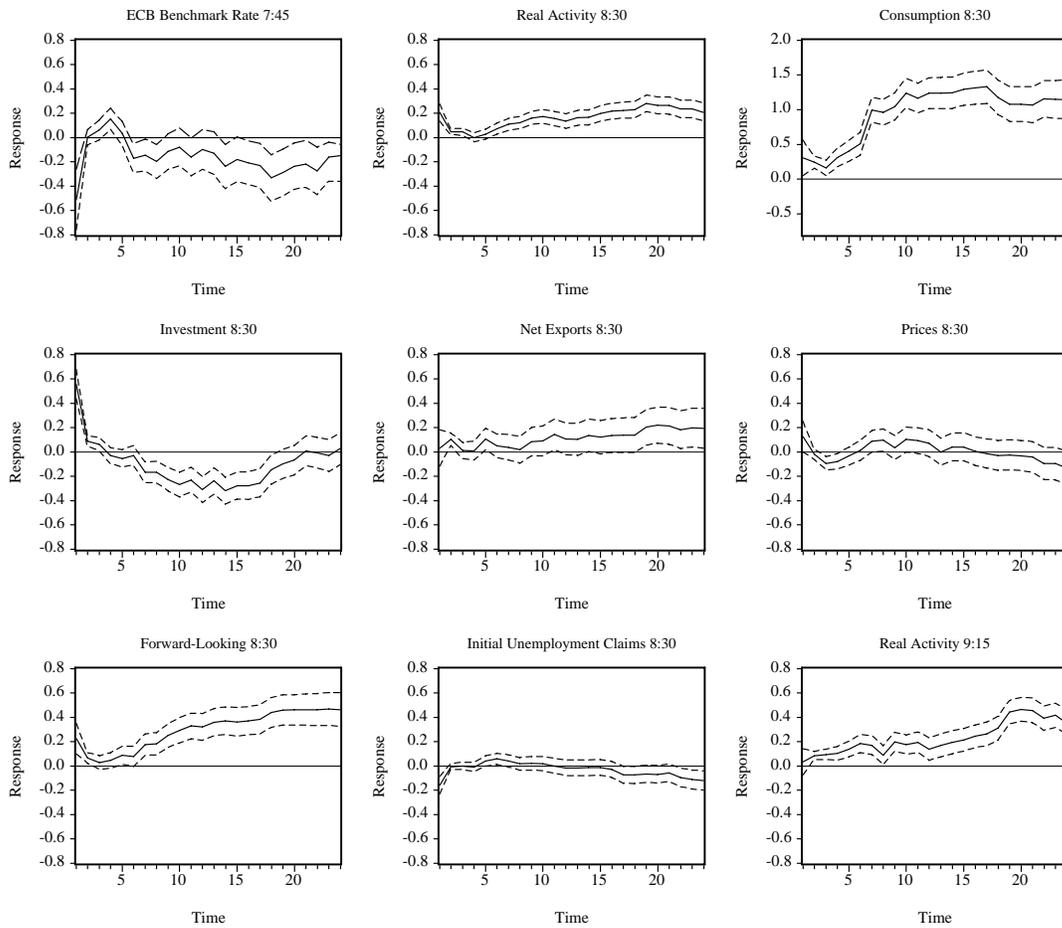


Figure 3A. Portuguese Response to 10:00 EST U.S. Macroeconomic Announcements

We plot  $\lambda_{np}^{por}$  (equation (16)), the cumulative Portuguese response to 10:00 EST U.S. macroeconomic announcements. The first tick in all panels on the  $x$ -axis captures the Portuguese stock market response from 10:00 to 10:05 EST, the second tick captures the cumulative response from 10:00 to 10:10 EST, and so on. The last tick captures the response from 10:00 to 11:30 EST.

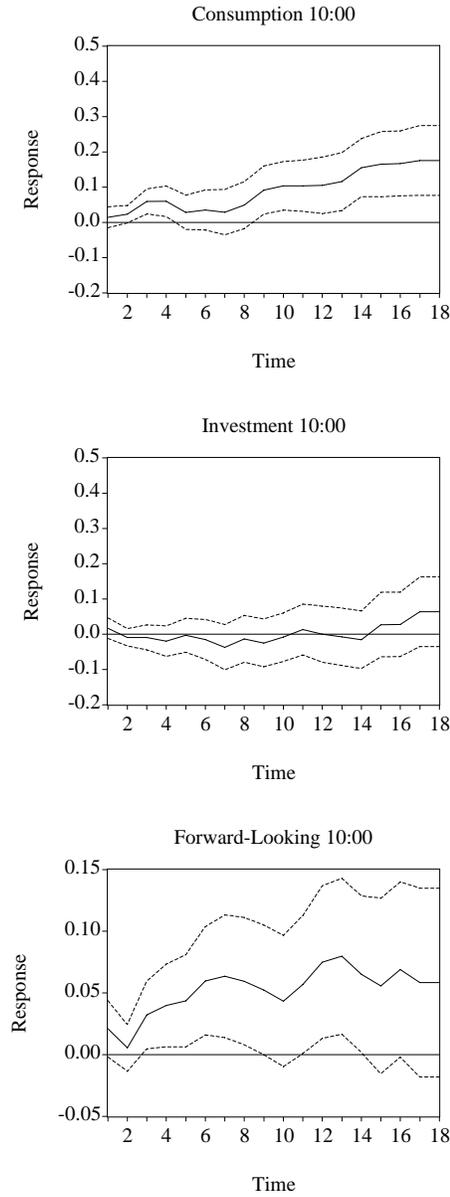


Figure 3B. U.S. Response to 10:00 EST U.S. Macroeconomic Announcements

We plot  $\lambda_{np}$  (equation (16)), the cumulative U.S. response to 10:00 EST U.S. macroeconomic announcements. The first tick in all panels on the  $x$ -axis captures the U.S. stock market response from 10:00 to 10:05 EST, the second tick captures the cumulative response from 10:00 to 10:10 EST, and so on. The last tick captures the response from 10:00 to 11:30 EST.

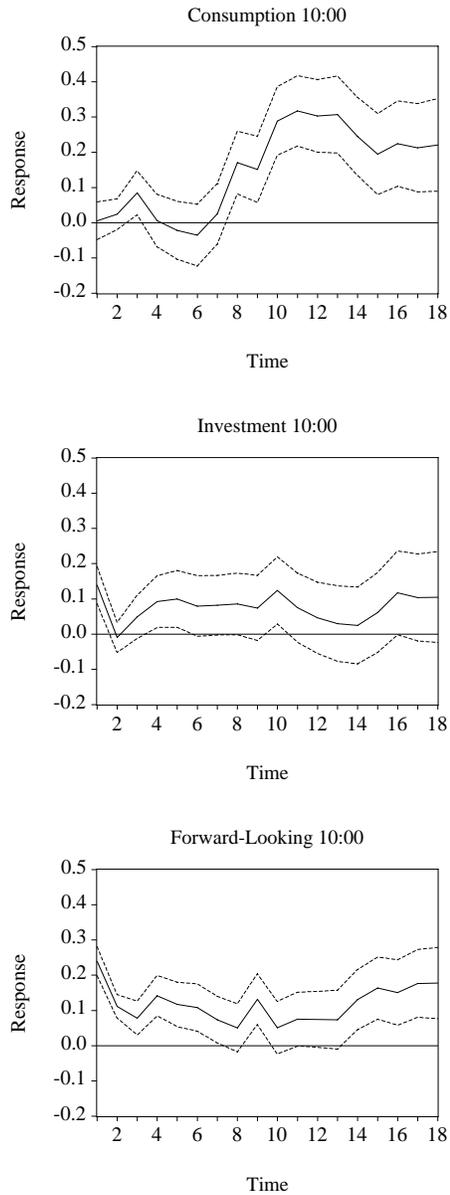


Figure 4A. Portuguese Response to 14:00, 14:15 and 15:00 EST U.S. Macroeconomic Announcements

We plot  $\lambda_{np}^{por}$  (equation (16)), the cumulative Portuguese response to 14:00, 14:05 and 15:00 EST U.S. macroeconomic announcements. Since the Portuguese stock market is not open, the first tick in all panels on the  $x$ -axis captures the Portuguese stock market response from this day's close to 3:35 EST the next day, the second tick captures the cumulative response from this day's close to 3:40 EST the next day, and so on. The last tick captures the response from this day's close to 11:30 EST.

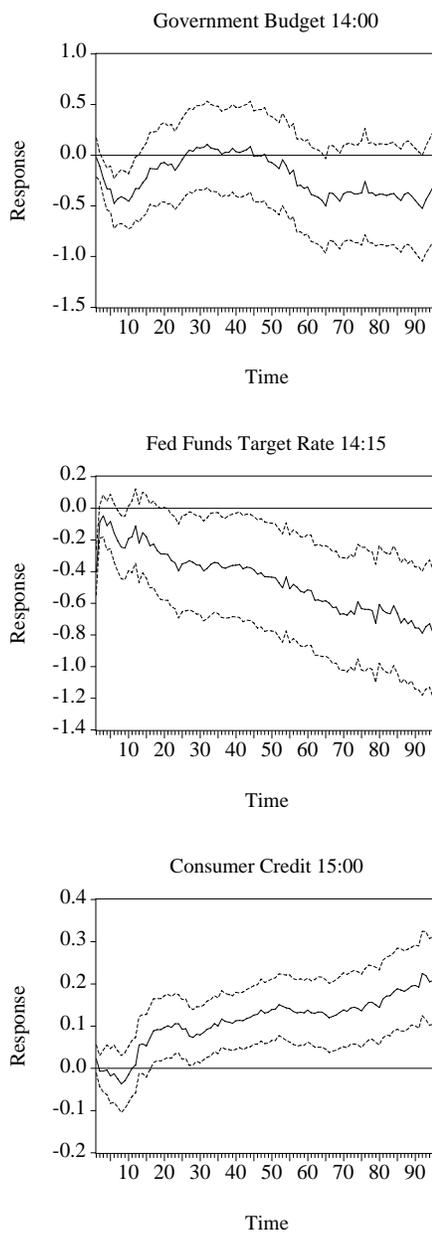


Figure 4B. U.S. Response to 14:00, 14:15 and 15:00 EST U.S. Macroeconomic Announcements

We plot  $\lambda_{np}$  (equation (16)), the cumulative U.S. response to 14:00, 14:15 and 15:00 EST U.S. macroeconomic announcements. The left hand side 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 plot the first tick indicates 14:00 EST and the return is measured from just before 14:00 EST to 14:05 EST. The second tick indicates 14:10 EST and the return is measured from just before 14:00 EST to 14:10 EST, and so on. The last tick captures the response from the time indicated in the title of the plot to 11:30 EST.

