Real-Time Price Discovery in Stock, Bond and Foreign Exchange Markets*

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Abstract: We characterize the response of U.S., German and British stock, bond and foreign exchange markets to real-time U.S. macroeconomic news. Our analysis is based on a unique data set of high-frequency futures returns for each of the markets. We find that news surprises produce conditional mean jumps; hence high-frequency stock, bond and exchange rate dynamics *are* linked to fundamentals. The details of the linkages are particularly intriguing as regards equity markets. We show that equity markets react differently to the same news depending on the state of the economy, with bad news having a *positive* impact during expansions and the traditionally-expected negative impact during recessions. We rationalize this by temporal variation in the competing "cash flow" and "discount rate" effects for equity valuation. This finding helps explain the time-varying correlation between stock and bond returns, and the relatively small equity market news effect when averaged across expansions and recessions. Lastly, relying on the pronounced heteroskedasticity in the high-frequency data, we document important contemporaneous linkages across all markets and countries over-and-above the direct news announcement effects.

Key Words: Asset Pricing; Macroeconomic News Announcements; Financial Market Linkages; Market Microstructure; High-Frequency Data; Survey Data; Asset Return Volatility; Forecasting.

JEL Codes: F3, F4, G1, C5

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1. Introduction

How do markets arrive at prices? There is perhaps no question more central to economics. This paper focuses on understanding the behavior of prices in financial markets, where the following question looms especially large: How, if at all, is news about macroeconomic fundamentals incorporated into stock prices, bond prices and foreign exchange rates?

The process of price discovery in financial markets remains poorly understood. Traditional "efficient markets" thinking suggests that asset prices should completely and instantaneously reflect movements in underlying fundamentals. Conversely, several influential authors have recently gone as far as to assert that asset prices and fundamentals may be largely and routinely disconnected. Experiences such as the late 1990s U.S. technology-driven market bubble would seem to support that view, yet simultaneously it seems clear that financial market participants pay a great deal of attention to data on underlying economic fundamentals. The notable difficulty of empirically mapping the links between economic fundamentals and asset prices is indeed striking.

We seek to better understand the links between asset prices and fundamentals by simultaneously combining: (1) high-quality and ultra-high frequency asset price data across markets and countries, which allows us to study price movements in (near) continuous time; (2) synchronized survey data on market participants' expectations, which allow us to infer "surprises" or "innovations" when news is announced; and (3) advances in statistical theory of volatility modeling, which facilitate efficient inference. This in turn allows us to probe of the workings of the marketplace in powerful ways, focusing on episodes where the source of price revisions is well identified, leading to a high signal-to-noise ratio.

The central question posed above – how do financial asset prices respond to news about underlying fundamental economic conditions – has many dimensions and nuances, which include, but are not limited to, the following. How quickly, and with what patterns, do adjustments to news occur? Does announcement timing matter? Are the magnitudes of effects similar for good news and bad news, or, for example, do markets react more vigorously to bad news than to good news? Quite apart from the direct effect of news on assets prices, what is its effect on financial market volatility? Do the effects of news on prices and volatility vary across assets and countries, and what are the links? Are there readily identifiable herd behavior and/or contagion effects? Do news effects vary over the business cycle?

Just as the central question of price discovery has many dimensions, nuances, and sub-questions, so too does a full answer. In this paper we progress by characterizing the simultaneous response of foreign exchange markets, and domestic and foreign stock and bond markets, to real-time U.S. macroeconomic news. Such a joint, multimarket analysis enables examination of both the robustness of earlier results and the study of cross-market movements and interactions.

We proceed as follows. In Section 2 we provide background by situating our paper in the existing literature. In Section 3 we sketch a stylized multi-country monetary model that provides a simple theoretical benchmark and useful guidance for interpreting our empirical results. In Section 4 we describe our data, and in Section 5 we present our new empirical findings. We conclude in section 6.

2. Background and Related Literature

Our work speaks to three related but distinct literatures. The first examines the links between asset prices and macroeconomic fundamentals as embodied in news announcement effects, the second examines the links among domestic asset markets, and the third examines the link among various domestic and foreign asset markets. We set the stage by discussing selected aspects of each.

Asset Prices and Macroeconomic Announcement Effects

The literature contains many empirical studies seeking to link the effects of macroeconomic announcements to movements in stock, bond and foreign exchange returns. While the first generation studies relied on daily, or even weekly or monthly data, the more recent literature has moved toward the use of finer sampled high-frequency intraday data. Typically, however, each market is examined in isolation. Recent examples include Fleming and Remolona (1997, 1999), Balduzzi, Elton and Green (2001), Bollerslev, Cai and Song (2000), Green (2004), Hautsch and Hess (2002), Kuttner (2001), Li and Engle (1998) who study bond markets; Bernanke and Kuttner (2004), Bomfim (2003), Boyd, Jagannathan and Hu (2001), Goto and Valkanov (2002), and Flannery and Protopapadakis (2002) and who study equity markets; and Andersen and Bollerslev (1998), Andersen, Bollerselev, Diebold and Vega (henceforth ABDV, 2003), Almeida, Goodhart and Payne (1998), and Galati and Ho (2003) who study foreign exchange markets.[1]

Most theories predict an unambiguous link between macroeconomic fundamentals and the bond market, with unexpected increases in real activity and inflation raising bond yields (lowering prices), as in the simple model sketched in Section 3 below. Empirical analyses generally confirm these theoretical predictions. For example, Balduzzi, Elton and Green (2001) find using 1990s data that both positive real shocks and positive inflation shocks affect bond prices negatively, and moreover, that the absolute size of news effects generally increases with the maturity of the instrument.

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[1] Two recent notable exceptions to this single market approach are Fair (2003) who examines the joint movements in stock, bond and equity markets around big market moves, typically associated with macroeconomic announcements, and Faust, Rogers, Wang and Wright (2003) who, in concurrent work with the present paper, estimate the response of different maturity interest rates, exchange rates, and deviations from uncovered interest rate parity (UIP) to macroeconomic news surprises.

The nature of the link between macroeconomic fundamentals and the stock market is less clear. Stock prices depend on expected cash flows, the discount rate, and the risk premium. Holding the risk premium constant, a positive macroeconomic shock increases expected cash flows, which increases the stock price, ceteris paribus, but it also increases the discount rate, which decreases the stock price, ceteris paribus, so the final result depends on which effect dominates.

Theoretical considerations concerning the effect of news on foreign exchange markets generally predict that good domestic news (e.g., brisk real activity, low inflation) should strengthen the domestic currency, although an expected deterioration in the future terms of trade could have the opposite effect. Nonetheless, as discussed for example in ABDV (2003), most existing empirical studies tend to support the good news hypothesis, subject to various subtleties, such as announcement timing, asymmetries, and sign effects.

Within-Country Asset Markets Links

An extensive empirical literature has explored the relationship between stock and bond returns, but little consensus has emerged. For example, using a dynamic present value model and a long sample of annual U.S. data, Shiller and Beltratti (1992) report a strong positive correlation between stock and long-term bond prices, while Campbell and Ammer (1993) on employing a similar variance decomposition framework document a relatively low average correlation with a more recent sample of monthly stock and bond returns.

While these and many other related studies implicitly assume constancy of the covariance structures, much of the subsequent literature has sought to relax that potentially binding constraint.[2] Barsky (1989) shows theoretically, for example, that stock and bond comovement is in general state-dependent. This idea is supported by further theoretical arguments and related empirical evidence in Connolly, Stivers and Sun (2004), David and Veronesi (2001), Fleming, Kirby and Ostdiek (1998), Guidolin and Timmermann (2003), Li (2002), Ribeiro and Veronesi (2002), Rigobon and Sack (2002, 2003b), and Scruggs and Glabadanidis (2003), among others.

Perhaps most directly related to the new empirical results presented below is the recent work of Boyd, Jagannathan and Hu (2001) who argue for a time-varying stock-market effect of the unemployment report, with surprise increases in unemployment serving as "good news" during expansions and "bad news" during recessions. One interpretation, which we subsequently discuss in detail, is that the cash flow effect dominates during contractions, while the discount rate effect is more important during

[2] Many of the recent developments in the burgeoning ARCH/GARCH literature have been explicitly concerned with modeling temporal dependencies in the correlations of asset returns; see, e.g., the discussion in Engle (2002).

expansions, thus resulting in positively correlated stock returns and bond yields in contractions and lower, perhaps even negative, correlations during expansions. Another noteworthy precedent is the earlier work by McQueen and Roley (1993). They study the impact of macroeconomic news using daily data covering 1977-1988 and conclude that the stock market responses tend to be asymmetric across the business cycle. Especially, good real economic news is bad for the equity markets in good times. However, they do not find any significant response of the stock market to positive real economic news during bad times. This contrasts sharply with our findings of very strong positive responses to positive news during recessions. Compared to these studies we consider a broader set of announcements, many more markets and asset classes, and we perform more powerful tests due to the improved signal-to-noise ratio in intraday high-frequency data.

Cross-Country Asset Market Links

A number of studies have focused on the transmission of information across international equity markets. Early empirical papers include Hamao, Masulis and Ng (1990) who examine spillover effects in the returns and volatilities of daily price changes for the Japanese, U.K., and U.S. equity markets, along with Lin, Engle and Ito (1994) who employ a similar GARCH-based approach but finer sampled data. Generally, only weak evidence of transmission from the U.S. to other markets, and none the other way around, has been found, although "contagion" effects, or increased correlations, have been documented during periods of financial crises such as the 1987 crash; e.g., King and Wadhwani (1990).[3]

With a sample of five-years of high-frequency data, Becker, Finnerty and Friedman (1995) relate the U.S. - U.K. equity market linkages to the reactions of foreign traders to public information originating from the U.S.[4] In a related context, Connolly and Wang (2003) analyze U.S., U.K. and Japanese equity markets and separate the influence of the foreign markets on domestic markets into two components: one driven primarily by economic fundamentals and the other, a so-called contagion factor, by foreign market returns. They conclude that although statistically significant, the macro news effect is too small to account for any sizeable part of the return comovement among the three markets.

Less work has been done on cross-country bond market linkages. However, recent results of Ehrmann and Fratzscher (2003), who model the degree of interdependence between the U.S. and European bond markets, suggest that the linkage between the markets has gradually increased, with the

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[3] A recent literature has argued for the existence of even more pronounced "contagion" effects in developed stock markets during periods of financial crises. However, as shown by Forbes and Rigobon (2002), these results need to be carefully interpreted when the overall level of volatility is also changing through time.

[4] Using high-frequency data from 1995 to 2000, Wongswan (2003) also finds evidence of macroeconomic news announcements in Japan and the U.S. affecting the Korean and Thai equity markets.

spillover effects from the U.S. to the Euro area being somewhat stronger than in the opposite direction. In addition, Christie-David, Chaudhry and Khan (2002) and Goldberg and Leonard (2003) demonstrate significant international bond market movement in response to the release of U.S. macroeconomic news.

Different exchange rates for the same currency are, of course, naturally linked through their joint dependence on the same underlying fundamental economic influences. Several empirical papers have studied the dynamic dependencies in the correlations among different exchange rates as well as inter-market dependencies in the volatilities of different rates within the same day. For instance, Engle, Ito and Lin (1990, 1992) report strong evidence of volatility spillovers, or so-called "meteor shower" effects, from the U.S. to the Japanese, to the European, to the U.S. trading areas, but little, or no, evidence of area specific "heat wave" effects.

Set against this backdrop, we next turn to a brief description of a simple stylized model which provides a framework for better understanding the empirical results.

3. Theory: Prices and Fundamentals in Foreign Exchange, Bond and Stock Markets

How do macroeconomic fundamentals affect foreign exchange rates, bond prices and stock prices? Lucas' (1982) two-country general equilibrium model, in which asset prices are directly determined by monetary and real shocks, helps to illuminate the different linkages, and provides a natural setting for discerning the directional impact of specific macroeconomic news announcements.[5] The model consists of a home and a foreign country, each of which produces a single good. A representative agent in each of the two countries trades in and consumes the two goods, and intertemporal substitution proceeds via the stock and bond markets.

<u>Foreign Exchange</u>

Shocks are propagated across the two countries through the foreign exchange market. For concreteness, we refer to the home currency as the Dollar and the foreign currency as the Euro. The first order equilibrium condition for the nominal Dollar/Euro exchange rate S_t may be expressed as

$$S_t \;=\; \frac{u_y(c_{xt}, c_{yt})\; M_t\, y_t}{u_x(c_{xt}, c_{yt})\; N_t\, x_t}\;, \tag{3.1}$$

where $u_x(\,.\,,.\,)$ and $u_y(\,.\,,.\,)$ refer to the derivatives of the representative domestic consumer's utility

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[5] Our discussion of the discrete-time Lucas model is adapted from Mark (2001). A more elaborate continuous-time version of the model, in which *real* exchange rates, stock and bond prices are jointly determined has recently been developed in contemporaneous and independent work by Pavlova and Rigobon (2003). As will be clear, however, our paper is not at all intended as a direct "test" of the Lucas model. Instead, we use the model to provide rough guidance in assessing the directional influences of various macroeconomic announcements.

function with respect to the consumption of the home good, c_{xt}, and the foreign good, c_{yt}, respectively, M_t (N_t) refers to the Dollars (Euros) in circulation, and x_t (y_t) denotes domestic (foreign) output.

It follows readily that other things equal, a positive domestic money supply shock, $M_{t+1} - M_t > 0$, depreciates the Dollar. Similarly, a positive foreign money supply shock, $N_{t+1} - N_t > 0$, depreciates the Euro. This is directly in line with the standard monetary approach to exchange rate determination (e.g., Mark, 2001), as well as competing models involving a central bank reaction function that embodies a preference for low inflation (e.g., Taylor, 1993).

The effect of real shocks will generally depend upon the exact form of the utility function and the corresponding cross-country substitution effects. To illustrate, suppose that the utility function for the representative domestic consumer takes the form,

$$u(c_{xt}, c_{yt}) = \frac{c_{xt}^{1-\gamma_x}}{1-\gamma_x} + \frac{c_{yt}^{1-\gamma_y}}{1-\gamma_y}, \tag{3.2}$$

where $\gamma_x > 0$ and $\gamma_y > 0$. Solving for the equilibrium,

$$S_t = 2^{\gamma_y - \gamma_x} \frac{y_t^{1-\gamma_y}}{x_t^{1-\gamma_x}} \frac{M_t}{N_t}. \tag{3.3}$$

Hence a positive domestic real shock may appreciate or depreciate the nominal exchange rate depending on the value of the risk aversion parameter, γ_x. In particular, everything else equal, an increase in domestic output, $x_{t+1} - x_t > 0$, appreciates the Dollar provided that $\gamma_x < 1$. Again, this accords directly with the implications of the standard monetary models and central bank reaction function models.[6]

Domestic Bonds

Following the standard consumption-based approach to asset pricing, the equilibrium nominal price of a one-period domestic bond with a one-Dollar payoff is conveniently expressed as

[6] It is also consistent with the earlier empirical evidence in ABDV (2003), who report evidence of significant Dollar appreciation in response to better than expected payroll and industrial production figures. This particular utility representation leads, however, to an equilibrium exchange rate of the form (3.3) that is inconsistent with the levels of relative risk aversion – greater than one – necessary to accommodate the so-called equity-premium puzzle.

$$b_t = E_t[SD_{t+1}], \tag{3.4}$$

where

$$SD_{t+1} \equiv \beta \frac{u_x(c_{xt+1}, c_{yt+1})}{u_x(c_{xt}, c_{yt})} \frac{P_t}{P_{t+1}} \tag{3.5}$$

is the stochastic discount factor, P_t denote the nominal price of domestic output, and β is the discount rate. The bond price is, of course, inversely related to the nominal risk free rate, $b_t = 1/(1+r_{ft})$.

Inflationary shocks trivially lower bond prices and raise interest rates. To appreciate the likely impact of a real shock, consider again the representative utility function in equation (3.2). In this case the equilibrium price simplifies to

$$b_t = \beta E_t\left[\left(\frac{x_{t+1}}{x_t}\right)^{-\gamma_x} \frac{P_t}{P_{t+1}}\right]. \tag{3.6}$$

Thus, in this situation we would expect positive domestic real shocks, $x_{t+1} - x_t > 0$, to affect bond prices negatively.[7]

<u>Domestic Stock Market</u>

The equilibrium nominal price of equity claims solves the standard recursive asset pricing equation,

$$e_t = b_t E_t[P_t x_t + e_{t+1}] + Cov_t(SD_{t+1}, e_{t+1}). \tag{3.7}$$

This highlights the three separate influences determining stock prices: the risk-free interest rate, $b_t = 1/(1+r_{ft})$, expected future cash flows, $E_t[P_t x_t + e_{t+1}]$, and the equity risk premium, $Cov_t(SD_{t+1}, e_{t+1})$.

As discussed above, a positive real shock, $x_{t+1} - x_t > 0$, will generally affect bond prices negatively, implying a decrease in the price of equity coming from the first term. This same real shock, however, affects the expected rate of growth positively, and hence implies an increase in stock prices coming from the second term. It is not clear how a positive real shock would affect the covariance, or risk premium, term. As such, this renders the overall effect on equity prices of real domestic shocks elusive; see also the related discussion in Campbell and Mei (1993). Similarly, the inflation rate, P_{t+1}/P_t,

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[7] This accords both with the earlier empirical evidence cited above, and with popular financial press explanations of bond market reactions to news. Quoting from Balduzzi, Elton and Green (2001): "the financial press explains the reaction of the bond market to economic news mainly in terms of revisions of inflationary expectations, where, in accord with a Phillips curve view, inflation is perceived to be positively correlated with economic activity. So procyclical variables and inflationary pressures have a negative impact on bond prices."

will affect nominal stock prices in different directions through the three separate channels, leaving the dominant effect of inflationary shocks an empirical question.

There is also the possibility that the relative importance of the different effects, and hence the impact of macroeconomic announcements, changes over the stage of the business cycle. In particular, Boyd, Jagannathan and Hu (2001) argue that information about interest rates (i.e., the first term) may be dominant during expansions (i.e., positive real shocks are bad news for stocks during good times), while information about future corporate dividends and/or the equity risk premium (i.e., the second and third term) may be dominant during contractions. We will examine this issue in detail in the empirical analysis below.

Foreign Bond and Stock Markets

The foreign exchange market links the equilibrium nominal price of a one-period nominal foreign bond with a one-Euro payoff to the price of a domestic bond with a Dollar payoff,

$$b_t^* \;=\; E_t\left[SD_{t+1} \frac{S_{t+1}}{S_t} \right]. \tag{3.8}$$

The impact of a shock will therefore again depend upon the form of the utility function and the risk premium implied by the corresponding stochastic discount factor. Assuming that the risk premium stays approximately constant, however, a shock which appreciates (depreciates) the Dollar should lower (increase) the price of the foreign bond, increasing (decreasing) the nominal foreign interest rate, $b_t^* = 1/(1+r_{ft}^*)$.[8]

By direct analogy to the pricing equation for domestic stocks, the equilibrium nominal foreign equity price satisfies,

$$e_t^* \;=\; b_t^* E_t(P_t^* y_t + e_{t+1}^*) \;+\; Cov_t(SD_{t+1}^*, e_{t+1}^*), \tag{3.9}$$

where P_t^* denotes the foreign (Euro) price level, and the foreign nominal stochastic discount factor is defined by

$$SD_{t+1}^* \;\equiv\; \beta \frac{u_y(c_{xt+1}, c_{yt+1})}{u_y(c_{xt}, c_{yt})} \frac{P_t^*}{P_{t+1}^*}. \tag{3.10}$$

[8] In interesting concurrent work, Faust, Rogers, Wang and Wright (2003) exploit the uncovered interest parity relation and data on bonds of different maturity to infer changes in risk premiums for holding foreign currency in response to various macroeconomic news announcements.

As discussed above, positive domestic inflationary or real shocks will generally result in lower foreign bond prices, b_t^*. Assuming in addition that domestic and foreign growth are positively correlated, these same shocks will enhance the expected future nominal payoff, $E_t[P_t^* y_t + e_{t+1}^*]$. Thus, regardless of the covariance or risk premium term, $Cov_t(SD_{t+1}^*, e_{t+1}^*)$, the overall directional impact of a U.S. domestic shock for foreign stock prices remains ambiguous. Moreover, it is possible that the magnitude of the different effects, and hence the impact of the shocks, will vary with the phase of the business cycle.

We next turn to a discussion of the data used in our empirical assessment of this question and the other macroeconomic news announcement effects and linkages discussed above.[9]

4. High-Frequency Return and News Announcement Data

We explore the impact of twenty-five U.S. macroeconomic news announcements using high-frequency futures returns for foreign exchange, and domestic and foreign stock and bond markets. We begin by discussing the data sources and salient features of the returns data.

Futures Market Return Data

We use futures market data for several reasons. First, futures prices are readily available on a tick-by-tick basis. Second, some of the most important U.S. macroeconomic announcements are made at 8:30 Eastern Standard Time (EST) when the futures markets are open, but the domestic spot markets for bonds and stocks are closed. Third, transaction costs are much lower in the futures markets, and all of the contracts that we analyze are very actively traded. Indeed, numerous studies find that futures markets generally lead the cash markets in terms of price discovery.[10] This is particularly important as we are interested in price adjustments measured over very short time intervals.

Table 1 provides a brief overview of the specific contracts, the exchanges on which they trade, and their respective EST trading hours, along with the average number of contracts traded daily. The S&P500, $/Pound, $/Yen and $/Euro futures contracts are all listed on the Chicago Mercantile Exchange (CME).[11] Regular trading in the foreign exchange contracts starts at 8:20 EST, while the regular trading

[9] Of course, in addition to these direct economic channels, the news may indirectly affect the markets' reactions through changes in beliefs about the U.S. Federal Reserve and other central banks' likely conduct of monetary policy. For instance, Rigobon and Sack (2003a) find that an increase in U.S. stock prices significantly increases the likelihood of monetary tightening by the FED.

[10] See, for example, Hasbrouck (2003).

[11] The returns for the $/Euro are based on the $/DM contract prior to June 1, 1999. Both contracts traded actively before and after this date, but the liquidity started to switch from the $/DM to the $/Euro around that time.

hours for the S&P500 are 9:30 to 16:15 EST. Starting January 2, 1994, however, GLOBEX has offered automated pre-market trading in the S&P500 futures contract, and we use transactions data from this market to augment the trading-day for the S&P500 to 8:20 EST. Our data for the 30-Year U.S. Treasury Bond futures contract comes from the Chicago Board of Trade (CBOT). The trading hours for the CBOT coincide with those of the CME. The FTSE 100 and the British Long Gilt futures contracts trade on the London International Financial Futures Exchange (LIFFE). The FTSE 100 index is based on the one-hundred largest U.K. companies, while the contract for the Long Gilt is based on the British 10-Year Treasury note. Trading on LIFFE opens at 8:00 GMT, or 3:00 EST. Our last two contracts, the DJ Euro Stoxx 50 (DJE) and the Euro Bobl futures, both trade on the European Exchange (EUREX). The DJE index is composed of the fifty largest blue-chip market sector leaders in the Euro-zone countries. The Euro Bobl is based on the German 5-Year Treasury note.

We obtained raw tick-by-tick transaction prices for all contracts from Tick Data Inc. The sample for the foreign exchange rates and the U.S. Treasury Bond contracts spans January 2, 1992 through December 31, 2002. Because of the need for pre-market GLOBEX data to augment the trading day, our sample for the S&P500 starts two years later on January 2, 1994. Data on the four European contracts are only available from July 1, 1998 through December 31, 2002.

All of our empirical results reported below are based on five-minute local currency continuously compounded returns, $\log(p_t/p_{t-1})$, where p_t denotes the price of the last trade in the t'th five-minute interval.[12] If no trade occurs in a given five-minute interval, we use the price from the previous interval, as long as the previous price was quoted within the last half-hour. We include only the days where there were at least one trade every half-hour. We always use the most actively traded nearest-to-maturity contract, switching to the next-maturity contract five days before expiration.

Table 2 reports the standard set of summary statistics for each of the five-minute return series. To facilitate comparison across the different markets and with our subsequent model estimates, we restrict the sample for all contracts to the July 1, 1998 to December 31, 2002, period available for the European markets. Moreover, because our news announcement regressions are based on the five-minute returns ranging from ten minutes before to one-and-a-half hours after an announcement, we report the summary statistics for this set of five-minute returns surrounding the scheduled announcements. As discussed further below, this leaves us with a total of 15,764 five-minute returns.

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[12] Five-minute returns strike a reasonable balance between confounding market microstructure effects when sampling too frequently and blurring the specific price reactions when disaggregating to coarser time intervals; see e.g., the related discussions in ABDV (2003), Bandi and Russell (2003), Dacorogna et al. (2001), Hansen and Lunde (2004), and Aït-Sahalia, Mykland and Zhang (2003) among others.

The average five-minute returns for each of the nine markets are, of course, extremely close to zero. However, the (absolute) sizes of the lowest and highest five-minute returns are large, with the values for the S&P500 and the DJE both exceeding two percent. Moreover, for all markets the extreme return event is more than ten standard deviations removed from the sample mean. This immediately suggests that the macroeconomic announcements *do* move the markets.[13] The summary statistics confirm the usual rank ordering in terms of volatility among the different markets, with the three stock markets being the most volatile, followed by the foreign exchange rates, and then the fixed income markets. The only exception to this rule is the U.S. T-Bond market, for which the unconditional standard deviation actually exceeds the standard deviations for the three exchange rates. However, as discussed further below, the T-Bond market also reacts most strongly of all of the markets to the macroeconomic announcements.

To highlight important comovements among the different markets during announcement times, Table 3 reports the unconditional sample correlations. All of the correlations within each of the three different asset classes are positive. For instance, the stock market correlations range from a low of 0.42 between the S&P500 and the FTSE 100, to a high of 0.54 for the FTSE 100 and the DJE. Similarly, the correlation between the returns for the U.S. T-Bond and the British Long Gilt is 0.53, while the Gilt and German Euro Bobl correlation is 0.61. The positive cross bond market correlations during U.S. macroeconomic announcement times are directly in line with the implications from the basic Lucas model discussed in the previous section. The positive equity market cross-correlations are also consistent with the model, as long as domestic and foreign real output shocks are positively correlated.[14]

The cross correlations between the different asset types are generally much smaller than the cross correlations for the same type of asset across different countries. Given our exchange rate convention, the negative correlations between the S&P500 and each of the exchange rates is consistent with U.S. macroeconomic news affecting the Dollar and the stock market in the same direction. Additional suggestive evidence that U.S. macroeconomic fundamentals exert a dominant effect during the announcement period comes from the fact that a Dollar appreciation is similarly positively linked with

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[13] This is consistent with Fair (2002), who finds that most of the large moves in high-frequency S&P500 returns are readily identified with U.S. macroeconomic news announcements. Similar results for the DM/$ foreign exchange market are reported in Andersen and Bollerslev (1998).

[14] Although the high positive contemporaneous correlation across countries may be explained by the common response to U.S. macroeconomic news, a number of other influences, including market microstructure, contagion, and cross-market hedging effects, as discussed in Fleming, Kirby and Ostdiek (1998), could also account for the high-frequency correlations. It is generally difficult to identify the effects separately, but in the empirical analysis below we will attempt to estimate directly the effects of news by measuring the surprise components.

stock market increases abroad, despite the fact that one would naturally expect the Pound (Euro) to appreciate against the Dollar when FTSE 100 (DJE) prices are rising.

Foreshadowing some of our subsequent empirical results, the news announcement effects appear fairly stable for the bond markets, while for the equity markets they appear to change with the business cycle. Consequently, the stock-bond market correlations might be expected to change as well. To illustrate, the last two panels in Table 3 separately report the unconditional correlations for the expansion period from July 1998 through February 2001 and the recession period from March 2001 through December 2002.[15] All of the correlations are generally higher during the recession period. Most notably, however, there is a distinct change in the stock-bond market correlations. During the expansion period, all of the stock-bond correlations are *positive* albeit small, while during the recession period the correlations are strong and *negative*. We can hardly claim this as a general pattern, as we only have data for one expansion and one recession. Still, in the context of the Lucas model discussed above, one possible explanation is that the discount term dominates during expansions, whereas the cash flow effect dominates during recessions. Hence, stock and bond prices will be negatively correlated during recessions, as the prices respond to news in opposite directions.

Similarly, while the correlations between bonds and exchange rates are positive on average, the correlations are much larger for the recession period. This may again be explained by time-variation in the magnitude of the impact of changes in macroeconomic fundamentals across the business cycle. All of these conjectures will be tested more thoroughly in the empirical section below.

News Announcement Data

We use the International Money Market Services (MMS) real-time data on expected and realized U.S. macroeconomic fundamentals, defining "news" as the difference between the survey expectations and the subsequent realizations, or announcements. The MMS sample covers the period from January 1, 1992 through December 31, 2002. Table 4 provides a brief description of the most salient features of the announcements, including the total number of observations in our sample, the agency reporting the news, and the time of the announcement release.[16]

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[15] We define recessions as beginning when there are three consecutive monthly declines in nonfarm payroll employment, and ending when there are three consecutive monthly increases in nonfarm payroll employment. Recessionary periods so-determined match closely those designated by the NBER over the postwar period. The recession dates in our sample, moreover, remain unchanged if adopt an alternative criterion of three consecutive monthly declines in industrial production.

[16] With the exception of money supply figures, which are released at 16:30 EST after the futures markets have closed, the indicators listed in Table 4 include all of the regularly-scheduled major U.S. macroeconomic announcements. For a more detailed description of the MMS data, including a discussion of the properties of the

The units of measurement obviously differ across the announcements. Hence, to facilitate meaningful comparisons of the estimated news response coefficients across different assets and types of announcements, we follow ABDV (2003) and Balduzzi, Elton and Green (2001) in their use of "standardized news." Specifically, we divide the surprise by its sample standard deviation, defining the standardized news associated with indicator k at time t as

$$S_{kt} = \frac{A_{kt} - E_{kt}}{\hat{\sigma}_k},$$

where A_{kt} denotes the announced value of indicator k, E_{kt} refers to the market's expectation of indicator k as distilled in the MMS median forecast, and $\hat{\sigma}_k$ is equal to the sample standard deviation of the surprise component, $A_{kt}-E_{kt}$. Because $\hat{\sigma}_k$ is constant for any indicator k, this standardization affects neither the statistical significance of the estimated response coefficients nor the fit of the regressions compared to the results based on the "raw" surprises.

We now turn to a discussion of our high-frequency estimation results based on the above-described news announcement indicators.

5. Empirical Results

In this section, we characterize both the immediate impact and the dynamic effects of U.S. macroeconomic news announcements for each of the markets in Table 1. In addition to estimating average responses across the full sample, we also estimate the effects and cross market linkages separately in expansions and recessions. We start by discussing the impact effects for each of the individual markets.

Impact Effects of News

To focus directly on the importance of news at the time of the announcements, we begin by estimating the simple regression model,

$$R_t^h = \alpha_k^h + \beta_k^h S_{kt} + \epsilon_t^h, \tag{5.1}$$

where $R_t^h = \log(p_t^h / p_{t-1}^h)$ denotes the five-minute futures return corresponding to asset h (h = \$/BP, \$/Yen, \$/Euro, S&P500, T-Bond, Gilt, Bobl, FTSE, and DJE) from time t to time $t+1$, S_{kt} refers to the standardized news for announcement k (k=1,...,25) at time t, and the estimates are based on only those

median expectations, see ABDV (2003).

observations (R_t^h, S_{kt}) such that an announcement was made at time t. In addition to the full-sample regression results reported in Table 5A, we report separate estimates for expansion and recession periods in Tables 5B and 5C. Following the discussion in the previous section, we define the expansion period from the beginning of each sample until February 28, 2001, while the recession period extends from March 1, 2001 until the end of our sample, or December 31, 2002.[17]

The results in the first three sets of columns in Table 5A show that many of the news announcements exert a significant influence on the currency futures returns. The actual coefficient estimates accord well with the earlier findings in ABDV (2003) based on five-minute spot currency returns over a different sample.[18] The directional effects are generally consistent with the implications of the standard monetary approach to exchange rate determination as embedded in the stylized Lucas model. A comparison of the full-sample results of Table 5A to the expansion and recession samples of Tables 5B and 5C reveals that there is no qualitative difference between the overall response coefficients for the exchange rates and those estimated separately for the expansion and contraction samples.

The next six sets of columns in the tables give the results for the domestic and foreign stock and bond markets. Consider first the bond returns. Consistent with the findings reported in the existing news announcement literature, U.S. T-Bond prices respond very significantly to U.S. macroeconomic news. Many of the coefficient estimates for the Gilt and the Bobl are also highly significant and of the same sign as those for the T-Bond market. This is again directly in line with the implications from the simple two-country Lucas model. Comparing the full-sample estimates across the different markets, the effects of news on bond returns appear noticeably stronger than for any of the other markets. As for currencies, splitting the sample into expansion and recession does not materially affect any of the estimated response coefficients.

Now consider the results for the three stock markets. The full-sample estimates in Table 5A suggest that macroeconomic news announcements have much less impact on stock market returns. Indeed, only the release of new figures on nonfarm payroll employment, PPI, CPI, new home sales, net exports, and the fed funds rate significantly affect the S&P500. Moreover, the estimated effects for the five-minute S&P500 returns are much smaller than for the T-Bonds, despite the fact that the equity

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[17] Because high-frequency data for the U.S. markets ($/Pound, $/Yen, $/Euro, T-Bond, and S&P500) are available over a longer time span, the results and statistical significance of the estimated coefficients for the full and expansion samples are not directly comparable to those for the European markets (Gilt, Bobl, FTSE 100, and DJE).

[18] We adopt the American terms quotation convention ($/Foreign Currency), so negative coefficients are associated with a Dollar appreciation.

market is generally much more volatile. This relatively weak effect for the stock market is, of course, entirely consistent with the presence of opposing effects across the business cycle, to which we have alluded.

Indeed, separating the data into the expansion and recession periods in Tables 5B and 5C reveals a very different story: for all of the stock markets, whether U.S. or foreign, U.S. macroeconomic news announcements have statistically significant and economically important effects. However, the news impact switches sign with the business cycle. Consequently, news effects look weak when averaged across regimes, when in fact the within-regime effects can be quite strong. In particular, "good" economic news on real activity raises stock prices during recessions, but lower prices during expansions; that is "good news" is "bad news" for stocks in expansions. In the context of the Lucas model, we find that the discount rate effect dominates during economic expansions, as the Federal Reserve is more likely to tighten monetary policy to ward off inflation in response to good news, while the cash flow effect dominates during economic contractions, when the central bank does not have the same inflation-fighting incentives. This central bank policy interpretation is further supported by the strong and significant negative effect that inflationary shocks (positive PPI and CPI surprises) have on all of the three stock markets during the expansion period, while these same inflationary shocks are insignificant for the recession sample. This, of course, also helps explain why most previous studies have typically been unable to detect any strong linkages between the stock market and macroeconomic fundamentals when estimated over long historical samples.[19]

<u>Dynamic Effects of News</u>

In order to analyze the dynamic effects of the news ion more depth, we also estimate a system of equations using the two five-minute returns directly preceding and the eighteen five-minute returns directly following each announcement.[20] Because this requires the data to be available for all of the markets simultaneously, these estimates are based on the shorter common sample from July 1, 1998 through December 31, 2002, with the corresponding sub-samples reflecting the expansion and recession

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[19] As previously mentioned, McQueen and Roley (1993) is a noteworthy exception. Using daily data, that paper produces evidence suggestive of an asymmetric stock market response to scheduled macroeconomic announcements over the business cycle. Our broader coverage of announcements and asset markets, and the inherently more powerful tests based on intraday data, provide stronger evidence and also show, contrary to the McQueen-Roley findings, that the announcement effects are highly significant in both expansions and recessions but, of course, with opposite signs.

[20] Hence the post-announcement window is one and one-half hours. Some preliminary experimentation revealed that our chosen pre- and post-event windows were more than adequate to capture the systematic news responses.

periods based on the observations before and after February 28, 2001, respectively.[21] All-in-all, this leaves us with a full sample of $T = 15{,}764 = 544*20 + 40*29 + 98*38$ five-minute return observations, reflecting 544 days with only one macroeconomic announcement released on that day (20 observations per day), 40 days with two macroeconomic announcements, one at 8:30 EST and the other one at 9:15 EST (29 observations per day), and 98 days with two macroeconomic announcements, one at 8:30 EST and the other at 10:00 EST (38 observations per day). The expansion sample is comprised of the first 9,301 observations, while the last 6,463 observations constitute the recession sample.

To allow explicitly for cross-market linkages and dynamic announcement effects, we model the conditional mean of the five-minute return for asset h, R_t^h, as a linear function of I lags of all the returns, together with J lags of each of the K news announcements; that is,

$$R_t^h = \beta_0^h + \sum_{h'=1}^{H} \sum_{i=1}^{I} \beta_{hi}^{h'} R_{t-i}^{h'} + \sum_{k=1}^{K} \sum_{j=0}^{J} \beta_{kj}^h S_{k,t-j} + \varepsilon_t^h, \qquad t = 1, ..., T, \tag{5.2}$$

where $H = 9$ corresponds to the nine different assets. Because the consumer credit, government budget, and federal funds rate figures are released in the afternoon, when LIFFE and EUREX are closed, we have a total of $K=22$ announcements. Guided by the Schwarz and Akaike information criteria, we uniformly fix the two lag lengths at $I=2$ and $J=3$, resulting in a total of 107 regression coefficients to be estimated for each of the nine assets.

Although ordinary least squares (OLS) would be consistent for the parameters in (5.2), the disturbance terms for the five-minute return regressions are clearly heteroskedastic. Thus, to enhance the efficiency of the coefficient estimates, we use a two-step weighted least squares (WLS) procedure. We first estimate the conditional mean model by OLS. We then use the absolute value of the regression residuals, $|\hat{\varepsilon}_t^h|$, to estimate a time-varying volatility function, which we then subsequently use to perform weighted least squares estimation of (5.2). We approximate the temporal variation in the five-minute return volatility around the announcement times by the relatively simple regression model,

$$|\hat{\varepsilon}_t^h| = \sum_{i=1}^{I'} \beta_{hi} |\hat{\varepsilon}_{t-i}^h| + \sum_{d=1}^{D} \gamma_d D_d + \sum_{k=1}^{K_d} \sum_{j'=0}^{J'} \gamma_{kj'}^h D_{k,t-j'} + u_t^h. \tag{5.3}$$

[21] As such, the full and expansion sample point estimates for the U.S. markets are not directly comparable to those reported in Tables 5A and 5B.

The $I' = 9$ own lags of the absolute value of the residuals captures serial correlation, or ARCH effects. The next term involves $D = 38$ dummy variables for each of the five-minute intraday intervals. This term directly accounts for the well-documented intradaily volatility patterns; see, e.g., the discussion and references in Andersen and Bollerslev (1998). The last summation reflects dummy variables for each of the announcement surprises, $D_{k,t}$, up to a lag length of $J' = 14$. There are only $K_d = 20$ such dummies as capital utilization and industrial production, and personal consumption expenditures and personal income are announced at the same time.[22]

Because the model in (5.2) contains so many variables and lags, it would prove counterproductive to simply report all of the parameter estimates.[23] Instead, in Figures 1A-1C we present graphically the point estimates for the news response coefficients, $\beta_{kj}^{h}, \quad j = 0, \ldots, 3$, for some of the key indicators at the time of the news releases and fifteen-minutes thereafter (dots), along with corresponding robust ninety-percent confidence bands (dashes). Figure 1A covers the full sample, while the results for the expansion and recession periods appear in Figures 1B and 1C. All figures contain three panels; the first displays the news responses for the domestic and foreign bond markets, the second focuses on the foreign exchange markets, and the last reports the results for the domestic and foreign equity markets.

Consider first the bond market responses. The immediate responses to the representative announcements are qualitatively similar to those discussed earlier for the domestic bond market over the longer eleven-year sample. Regardless of the stage of the business cycle, positive real shocks and inflationary shocks both produce lower bond prices, or increases in yields. Not surprisingly, the effects are clearly the strongest for the U.S. market, but many of the U.S. macroeconomic fundamentals significantly impact the foreign bond markets, and in the same direction. This is, of course, broadly consistent with our basic theoretical predictions. It is noteworthy that, almost invariably, only the simultaneous effect is significant, reflecting a very quick price discovery process.

This is true for all of the markets. Any systematic effect of the news announcements is almost

[22] We also experimented with other lag lengths and alternative volatility specifications, directly including the absolute value of the surprise component, $|S_{k,t}|$, instead of the news announcement dummies, $D_{k,t}$. However, the fit was generally the best for the model in equation (5.3), although the corresponding estimates for the mean parameters in (5.2) essentially remained the same. This is consistent with our earlier empirical results for the spot foreign exchange market in ABDV (2003) that the mere presence of an announcement, quite apart for the size of the corresponding surprise, tend to boost volatility; see also the discussion in Rich and Tracy (2003).

[23] Details concerning all of the parameter estimates, including the coefficients in the volatility equation, are available upon request.

exclusively restricted to the five-minute interval immediately following the release. This explains why previous empirical studies relying on daily, or coarser, observations have typically failed to uncover any systematic linkages between asset market returns and innovations to macroeconomic fundamentals – the responses occur almost instantaneously and "drown" in the day-to-day movements.

Turning to the specific results for the foreign exchange market, the immediate impact is again directly in line with the estimated coefficients from the simultaneous regressions reported in Table 5A earlier.[24] News about the U.S. inflation rate doesn't seem to systematically affect any of the foreign exchange rates, while positive domestic real shocks lead to an appreciation of the Dollar against the other currencies, particularly during the recent recession regime.

The findings for the equity markets are again quite striking. The full-sample results in Figure 1A reveal almost no significant responses, but once we split the sample into the expansion and recession periods, we see the negative responses to positive real economic shocks in expansions and positive responses to positive shocks in recessions. As discussed previously, this pattern, which is the same for the domestic and foreign markets, is suggestive of positively correlated real economic shocks across the regions along with pronounced business cycle variation in the importance of the discount factor versus cash flow components in the pricing of equities. This is further corroborated by the apparent asymmetric effect of the PPI shocks over the business cycle. The marked negative impact of inflation surprises during expansions directly suggests the presence of stronger anti-inflationary monetary policies, in turn strengthening the influence of the discount factor component in "good" times.

Within-Country and Cross-Country Asset Market Links

We have argued that the movements in asset returns across markets and countries documented above are driven by the common exposure to exogenous U.S. macroeconomic shocks. This contrasts with previous studies that also document important spillover effects and market interdependencies, but little (if any) role for macroeconomic fundamentals in explaining the comovements between markets. Our positive results can be attributed to our focus on synchronous high-frequency data – all assets are actively traded during announcement times, so we observe the immediate news reaction of all assets – which mitigates potentially important omitted variables biases.

To further investigate the extent of cross-market and cross-country linkages in the high-frequency data over-and-above the direct influence of the macroeconomic announcement effects, consider the

[24] The somewhat weaker statical significance in Figure 1A is due to the shorter sample size. Although a few of the lagged coefficients for the asset market responses are outside the confidence bands in Figure 1A, the effects do not appear to be systematic.

simultaneous equation model,

$$R_t^h \;=\; \beta_0^h \;+\; \sum_{h'\neq h} \beta_{h0}^{h'} R_t^{h'} \;+\; \sum_{h'=1}^{H}\sum_{i=1}^{I} \beta_{hi}^{h'} R_{t-i}^{h'} \;+\; \sum_{k=1}^{K}\sum_{j=0}^{J} \beta_{kj}^{h} S_{k,t-j} \;+\; \eta_t^h, \qquad t=1,\ldots,T. \tag{5.4}$$

Except for the inclusion of the contemporaneous asset returns on the right-hand side, the model is identical to the reduced form representation in (5.2). As in equation (5.2), the β_{k0}^{h} coefficients directly capture the U.S. macroeconomic announcement effects, while the $\beta_{h0}^{h'}$ account for any contemporaneous cross-asset linkages and/or spillovers that are not explained by news announcements. This could include the reaction to other fundamental information, but also incorporates non-fundamental market microstructure, contagion, and cross-hedging effects. The problem from an econometric perspective, of course, is that without any additional restrictions or modeling assumptions, the contemporaneous coefficients in $\beta_{h0}^{h'}$ are not identified.

To overcome this problem, we follow the approach in the recent series of papers by Rigobon (2003), Rigobon and Sack (2002, 2003a,b), and Sentana and Fiorentini (2001) of using the conditional heteroskedasticity in the high-frequency data to identify the contemporaneous coefficients. The idea is straightforward. Assuming that the "structural" form innovations in (5.4) are conditionally uncorrelated but heteroskedastic – as indicated by our previous estimation results for (5.3) – the conditional *covariances* of the implied reduced-form innovations in (5.2) will then move in proportion to the conditional heteroskedasticity in the individual structural innovations, with the factors of proportionality determined by the elements in $\beta_{h0}^{h'}$. This proportionality in turn, allows for the identification and estimation of the contemporaneous coefficients.[25]

In the results reported here we follow Rigobon and Sack (2003b), in estimating the elements of $\beta_{h0}^{h'}$ by applying Gaussian quasi-maximum likelihood estimation (QMLE) techniques to the multivariate "structural GARCH" model implied by the univariate GARCH models for each of the individual

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[25] Formally, consider the matrix representation of (5.4), $\Psi R_t = \Phi X_{t-1} + \eta_t$, where the "structural shocks" to each of the equations, η_t^h, are assumed to be heteroskedastic, but serially uncorrelated and uncorrelated across equations. The corresponding reduced-form representation, $R_t = \Psi^{-1}\Phi X_{t-1} + \Psi^{-1}\eta_t$, uniquely determines the distributional properties of the system. However, the non-zero off-diagonal elements of the time-varying conditional covariance matrix for the reduced form shocks, $\varepsilon_t \equiv \Psi^{-1}\eta_t$, depend directly on Ψ^{-1}, thus ensuring identification of the elements of Ψ through the heteroskedasticity in the data.

equations in (5.4).[26] To facilitate the implementation of the multivariate GARCH model, we treat the residuals from the first-stage estimation of (5.2) as directly observable. Also, for tractability, we estimate the model for three markets at a time, but the same idea could in principle be applied to any number of assets.

Focusing first on the trivariate domestic system consisting of U.S. T-Bond, S&P500, and $/Euro returns, we obtain the following estimates for the contemporaneous linkages among the three markets for the July 1, 1998 through February 28, 2001 expansion period based on the 9,301 five-minute returns described earlier:

$$R_t^{TBond} = -\underset{(-9.41)}{0.026} R_t^{S\&P} + \underset{(3.34)}{0.020} R_t^{\$/Euro} + \beta_0^h + \sum_{h'=1}^{H} \sum_{i=1}^{I} \beta_{hi}^{h'} R_{t-i}^{h'} + \sum_{k=1}^{K} \sum_{j=0}^{J} \beta_{kj}^{h} S_{k,t-j} + \eta_t^h \tag{5.5}$$

$$R_t^{S\&P} = \underset{(25.33)}{0.204} R_t^{TBond} + \underset{(14.88)}{0.120} R_t^{\$/Euro} + \beta_0^h + \sum_{h'=1}^{H} \sum_{i=1}^{I} \beta_{hi}^{h'} R_{t-i}^{h'} + \sum_{k=1}^{K} \sum_{j=0}^{J} \beta_{kj}^{h} S_{k,t-j} + \eta_t^h \tag{5.6}$$

$$R_t^{\$/Euro} = \underset{(12.53)}{0.030} R_t^{TBond} - \underset{(-2.39)}{0.002} R_t^{S\&P} + \beta_0^h + \sum_{h'=1}^{H} \sum_{i=1}^{I} \beta_{hi}^{h'} R_{t-i}^{h'} + \sum_{k=1}^{K} \sum_{j=0}^{J} \beta_{kj}^{h} S_{k,t-j} + \eta_t^h, \tag{5.7}$$

where the numbers in parenthesis refer to robust t-statistics.[27] Interpreting an increase in stock prices and a Dollar appreciation (decrease in $/Euro prices) as a signal of positive real activity or an inflationary shock, equation (5.5) is entirely consistent with the negative implication of both shocks on bond prices in the context of the Lucas model. Equation (5.6) is also directly in line with our aforementioned discussion of the dominance of the "discount" factor component in the evaluation of stock prices during economic expansions, whereby higher bond prices (lower discount rates) are good for the stock market in good

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[26] To economize on the number of parameters, we only include those macroeconomic news announcement dummies that were statistically significant at the five-percent level in the estimation of equation (5.3). We also employ a more parsimonious GARCH(1,1) specification, $E_{t-1}[(\eta_t^h)^2] \equiv (\sigma_t^h)^2 = \omega_h + \beta_h(\sigma_{t-1}^h)^2 + \lambda_h(\eta_{t-1}^h)^2 + \sum_{k=1}^{K} \gamma_{h,k} D_{k,t}$, as opposed to the ARCH(9) model implicit in (5.3). Further details of the estimation results are available upon request.

[27] The reported t-statistics do not formally account for the first-stage conditional mean parameter estimation error, but this effect is almost surely negligible in the present context.

times. Similarly, Dollar depreciation (interpreted as a deflationary shock) results in higher stock prices. Notice also that while the unconditional correlation between bond and stock prices for the expansion period reported in Table 3 is positive, the estimation method underlying equations (5.5)-(5.7) allows us to disentangle two opposing effects: bond prices affect stock prices positively, but stock prices affect bond prices negatively.[28]

Estimating the same set of equations over the more recent March 1, 2001 through December 31, 2002 recession period, based on the 6,463 five-minute returns described earlier, produces the following results:

$$R_t^{TBond} = \underset{(-6.26)}{-0.033 R_t^{S\&P}} + \underset{(0.47)}{0.010 R_t^{\$/Euro}} + \beta_0^h + \sum_{h'=1}^{H}\sum_{i=1}^{I}\beta_{hi}^{h'} R_{t-i}^{h'} + \sum_{k=1}^{K}\sum_{j=0}^{J}\beta_{kj}^{h} S_{k,t-j} + \eta_t^h \tag{5.8}$$

$$R_t^{S\&P} = \underset{(-3.88)}{-0.192 R_t^{TBond}} - \underset{(-1.97)}{0.090 R_t^{\$/Euro}} + \beta_0^h + \sum_{h'=1}^{H}\sum_{i=1}^{I}\beta_{hi}^{h'} R_{t-i}^{h'} + \sum_{k=1}^{K}\sum_{j=0}^{J}\beta_{kj}^{h} S_{k,t-j} + \eta_t^h \tag{5.9}$$

$$R_t^{\$/Euro} = \underset{(2.70)}{0.033 R_t^{TBond}} - \underset{(-4.28)}{0.011 R_t^{S\&P}} + \beta_0^h + \sum_{h'=1}^{H}\sum_{i=1}^{I}\beta_{hi}^{h'} R_{t-i}^{h'} + \sum_{k=1}^{K}\sum_{j=0}^{J}\beta_{kj}^{h} S_{k,t-j} + \eta_t^h. \tag{5.10}$$

The difference in the estimates for equations (5.6) and (5.9) are striking. The sign of the contemporaneous linkages between the stock market and the bond and foreign exchange markets changes between the two periods. Again, we see that "good news" during expansions is "bad news" for stocks, but "good news" during recessions is good for the stock market, as the cash-flow effect dominates. Interestingly, the \$/Euro coefficients in equations (5.8) and (5.9) are both insignificant. This is again consistent with our previous findings for the macroeconomic news announcement effects – inflationary shocks are generally insignificant for the more recent recession sample.

Finally, we use the same "structural GARCH" approach to estimate the contemporaneous

[28] Our results for the high-frequency data in equations (5.5) and (5.6) agree with the findings reported in Rigobon and Sack (2003b) based on daily stock and bond market returns from November 1985 to March 2001. Of course, this is predominantly an expansionary period, so it is not surprising that the directional effects coincide.

interdependence among the three national stock markets beyond the linkages explained by the U.S. macroeconomic news announcements. Again, dividing the sample in two, our estimates for the expansion period are:

$$R_t^{S\&P} = \underset{(5.83)}{0.028 R_t^{FTSE}} + \underset{(2.00)}{0.007 R_t^{DJE}} + \beta_0^h + \sum_{h'=1}^{H}\sum_{i=1}^{I}\beta_{hi}^{h'}R_{t-i}^{h'} + \sum_{k=1}^{K}\sum_{j=0}^{J}\beta_{kj}^{h}S_{k,t-j} + \eta_t^h \tag{5.11}$$

$$R_t^{FTSE} = \underset{(2.73)}{0.014 R_t^{S\&P}} + \underset{(9.57)}{0.015 R_t^{DJE}} + \beta_0^h + \sum_{h'=1}^{H}\sum_{i=1}^{I}\beta_{hi}^{h'}R_{t-i}^{h'} + \sum_{k=1}^{K}\sum_{j=0}^{J}\beta_{kj}^{h}S_{k,t-j} + \eta_t^h \tag{5.12}$$

$$R_t^{DJE} = \underset{(13.26)}{0.089 R_t^{S\&P}} + \underset{(0.23)}{0.001 R_t^{FTSE}} + \beta_0^h + \sum_{h'=1}^{H}\sum_{i=1}^{I}\beta_{hi}^{h'}R_{t-i}^{h'} + \sum_{k=1}^{K}\sum_{j=0}^{J}\beta_{kj}^{h}S_{k,t-j} + \eta_t^h. \tag{5.13}$$

Not surprisingly, all of the estimated coefficients are positive, indicating important cross-country linkages not directly explained by the U.S. news. Whether these high-frequency international market linkages are due to common reaction to worldwide fundamental news, or manifest non-synchronous trading, cross-market hedging or other non-fundamental contagion effects is difficult to ascertain based on these results.

Estimating the same relations over the more recent recession period suggests even stronger contemporaneous cross-country linkages,

$$R_t^{S\&P} = \underset{(17.80)}{0.447 R_t^{FTSE}} + \underset{(14.98)}{0.210 R_t^{DJE}} + \beta_0^h + \sum_{h'=1}^{H}\sum_{i=1}^{I}\beta_{hi}^{h'}R_{t-i}^{h'} + \sum_{k=1}^{K}\sum_{j=0}^{J}\beta_{kj}^{h}S_{k,t-j} + \eta_t^h \tag{5.14}$$

$$R_t^{FTSE} = \underset{(11.44)}{0.074 R_t^{S\&P}} + \underset{(9.88)}{0.085 R_t^{DJE}} + \beta_0^h + \sum_{h'=1}^{H}\sum_{i=1}^{I}\beta_{hi}^{h'}R_{t-i}^{h'} + \sum_{k=1}^{K}\sum_{j=0}^{J}\beta_{kj}^{h}S_{k,t-j} + \eta_t^h \tag{5.15}$$

$$R_t^{DJE} = \underset{(10.49)}{0.073 R_t^{S\&P}} + \underset{(8.74)}{0.115 R_t^{FTSE}} + \beta_0^h + \sum_{h'=1}^{H}\sum_{i=1}^{I}\beta_{hi}^{h'}R_{t-i}^{h'} + \sum_{k=1}^{K}\sum_{j=0}^{J}\beta_{kj}^{h}S_{k,t-j} + \eta_t^h. \tag{5.16}$$

These results accord directly with the findings of stronger international stock market cross-correlations in down markets reported in the recent asset pricing literature.[29] Importantly, however, our results help explain the origins of the linkages. In particular, movements in the DJE and the FTSE both strongly influence the U.S. market. This contrasts with previous studies, which report significant spillover effects from the U.S. stock market to foreign markets, but not necessarily the other way around.

6. Concluding Remarks

We have characterized the real-time responses of U.S., German and British stock, bond and foreign exchange markets to regularly-scheduled U.S. macroeconomic news announcements. We found that announcement surprises produce conditional mean jumps; hence high-frequency stock, bond and exchange rate dynamics *are* linked to fundamentals. This contrasts with many previous studies that find asset price movements and comovements to be driven primarily by private information and contagion effects rather than public information. Our positive results can be attributed to the use of synchronous high-frequency futures data, which lets us observe the immediate reaction of some of the most actively traded financial assets during and immediately following announcement times. Our results are particularly intriguing as regards stock market responses to news, which display distinct state dependence. In particular, *bad* macroeconomic news has the traditionally-expected negative impact during recessions, but influences stock prices *positively* during expansions. This explains the small stock market news reaction effect when averaged across expansions and recessions reported in the exiting literature. Using a "structural GARCH" estimation approach, we also documented highly significant contemporaneous cross-market and cross-country linkages not directly explained by the macroeconomic announcement effects.

Among the many possible directions for future work, we are particularly intrigued by the idea of using high-frequency data to quantify the three separate channels of private information, contagion, and public information that link the markets. Several recent studies have highlighted the role of order flow in the price formation process; e.g., Brandt and Kavajecz (2004), Cao, Lyons and Evans (2004), Evans and Lyons (2003), and Underwood (2003). It would be interesting to exploit the information in order flow and other liquidity measures in concert with the new statistical procedures and rich high-frequency return and news announcement data employed here to help shed more light on the price discovery process and cross-market linkages.

[29] The theoretical model in Ribeiro and Veronesi (2002), in which news is more informative about the true state of the economy in recessions, resulting in higher cross-market correlations, provides one possible explanation for the findings.

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Table 1
Futures Contracts

Futures Contract[1]	Exchange[2]	Trading Hours[3]	Sample[4]	Liquidity[5]
$/Pound	CME	8:20-15:00	01/92-12/02	160.73
$/Yen	CME	8:20-15:00	01/92-12/02	202.26
$/Euro[6]	CME	8:20-15:00	01/92-12/02	216.01
S&P 500	CME/GLOBEX	8:20-16:15[7]	01/94-12/02	231.10
30-Year U.S. Treasury Bond	CBOT	8:20-15:00	01/92-12/02	228.27
British Long Gilt[8]	LIFFE	3:00-13:00	07/98-12/02	200.59
Euro Bobl[9]	EUREX	2:00-13:00	07/98-12/02	234.97
FTSE 100[10]	LIFFE	3:00-12:30	07/98-12/02	235.65
DJ Euro Stoxx 50[11]	EUREX	3:00-14:00[12]	07/98-12/02	169.20

Footnotes to Table 1:

1. The delivery months for all of the contracts are March, June, September and December. We always use the contract closest to expiration - which is generally the most actively traded - switching to the next-maturity contract five days before expiration.
2. Chicago Mercantile Exchange (CME), Chicago Board of Trade (CBOT), London International Financial Futures Exchange (LIFFE), European Exchange (EUREX).
3. Open auction regular trading hours, Eastern Standard Time.
4. Starting and ending dates of our data sample.
5. Average number of daily transactions in the common sample 07/98 to 12/02, 8:20 to 12:30 EST.
6. Prior to June 1, 1999, we use $/DM futures.
7. The S&P500 data from 8:20 to 9:30 comes from GLOBEX.
8. The British Long Gilt contract is based on the British 10-Year Treasury Note.
9. The Euro Bobl contract is based on the German 5-Year Treasury Note.
10. The FTSE 100 index is constructed from the 100 largest U.K. companies.
11. The DJ Euro Stoxx 50 index is composed of the 50 largest blue-chip market sector leaders in continental Europe. In July 2003 the index was composed of one Belgian, twelve German, five Spanish, one Finish, seventeen French, seven Italian and seven Dutch companies.
12. EUREX extended the DJ Euro Stoxx 50 trading hours from 4:00-11:00 EST to 3:00-11:00 EST on October 18, 1999, again from 3:00-11:00 EST to 3:00-11:30 EST on January 24, 2000, and yet again from 3:00-11:30 EST to 3:00-14:00 EST on January 2, 2002.

Table 2
Summary Statistics for Five-Minute Stock, Bond and Forex Returns

	Mean	Maximum	Minimum	Std. Dev.	Skewness	Kurtosis
$/Pound	0.00063	0.535	-0.460	0.048	0.025	7.499
$/Yen	0.00022	0.615	-1.111	0.067	-0.464	19.443
$/Euro	-0.00043	0.824	-0.587	0.066	-0.055	11.018
S&P 500	-0.00131	2.103	-2.437	0.171	-0.183	26.115
FTSE 100	-0.00187	1.785	-1.516	0.138	0.284	25.745
DJ Euro Stoxx 50	-0.00118	2.203	-2.037	0.175	-0.081	17.507
30-Year Treasury Bond	0.00063	1.319	-0.917	0.081	0.141	15.583
British Long Gilt	0.00005	0.470	-0.366	0.040	0.087	11.217
German Euro Bobl	0.00010	0.261	-0.257	0.023	-0.168	13.258

Notes to Table 2: See the notes to Table 1 for a description of the different contracts. The summary statistics for each of the different contracts are based on the 15,764 five-minute returns ten minutes before and one-and-a-half hours after the release of each of the U.S. macroeconomic announcements described in Table 4. The full common sample for all of the contracts used in the calculations spans July 1, 1998 through December 31, 2002.

Table 3
Unconditional Correlation Matrix for Five-Minute Stock, Bond and Forex Returns

	$/Pound	$/Yen	$/Euro	S&P 500	FTSE 100	DJ Euro Stoxx 50	30-Year Treasury Bond	British Long Gilt	German Euro Bobl
Full Sample									
$/Pound	1.000	0.267	0.582	-0.152	-0.166	-0.181	0.101	0.087	0.135
$/Yen		1.000	0.367	-0.123	-0.124	-0.149	0.052	0.040	0.061
$/Euro			1.000	-0.227	-0.215	-0.253	0.127	0.114	0.187
S&P 500				1.000	0.420	0.502	-0.129	-0.119	-0.178
FTSE 100					1.000	0.544	-0.123	-0.127	-0.182
DJ Euro Stoxx 50						1.000	-0.174	-0.169	-0.250
30-Year Treasury Bond							1.000	0.526	0.583
British Long Gilt								1.000	0.614
German Euro Bobl									1.000
Expansion Sample									
$/Pound	1.000	0.230	0.547	-0.124	-0.107	-0.118	0.024	0.021	0.049
$/Yen		1.000	0.326	-0.101	-0.077	-0.114	-0.014	-0.009	-0.011
$/Euro			1.000	-0.218	-0.151	-0.182	0.020	0.029	0.085
S&P 500				1.000	0.439	0.518	0.071	0.023	0.003
FTSE 100					1.000	0.407	0.056	0.015	0.004
DJ Euro Stoxx 50						1.000	0.063	0.022	0.019
30-Year Treasury Bond							1.000	0.505	0.555
British Long Gilt								1.000	0.575
German Euro Bobl									1.000
Recession Sample									
$/Pound	1.000	0.345	0.637	-0.184	-0.249	-0.251	0.196	0.204	0.237
$/Yen		1.000	0.453	-0.166	-0.214	-0.212	0.161	0.154	0.175
$/Euro			1.000	-0.248	-0.313	-0.342	0.272	0.277	0.319
S&P 500				1.000	0.417	0.492	-0.300	-0.303	-0.324
FTSE 100					1.000	0.698	-0.345	-0.379	-0.399
DJ Euro Stoxx 50						1.000	-0.393	-0.431	-0.483
30-Year Treasury Bond							1.000	0.578	0.612
British Long Gilt								1.000	0.703
German Euro Bobl									1.000

Notes to Table 3: See the notes to Table 1 for a description of the different contracts. The unconditional cross correlations are based on the 15,764 five-minute returns ten minutes before and one-and-a-half hours after the release of each of the U.S. macroeconomic announcements described in Table 4. The full common sample spans July 1, 1998 through December 31, 2002. The expansion covers July 1, 1998 through February 28, 2001, for a total of 9,301 five-minute returns. The recession goes from March 1 to December 31, 2002, for a total of 6,463 five-minute returns.

Table 4
U.S. News Announcements

Announcement	Obs.[1]	Source[2]	Dates[3]	Announcement Time[4]
Quarterly Announcements				
1- GDP Advance	51	BEA	01/92-12/02	8:30
2- GDP Preliminary	50	BEA	01/92-12/02	8:30
3- GDP Final	51	BEA	01/92-12/02	8:30
Monthly Announcements				
Real Activity				
4- Nonfarm Payroll Employment	194	BLS	01/92-12/02 [5]	8:30
5- Retail Sales	193	BC	01/92-12/02	8:30
6- Industrial Production	193	FRB	01/92-12/02	9:15
7- Capacity Utilization	177	FRB	01/92-12/02	9:15
8- Personal Income	192	BEA	01/92-12/02 [6]	10:00/8:30 [7]
9- Consumer Credit	178	FRB	01/92-12/02	15:00[8]
Consumption				
10- New Home Sales	167	BC	01/92-12/02	10:00
11- Personal Consumption Expenditures	192	BEA	01/92-12/02 [9]	10:00/8:30[10]
Investment				
12- Durable Goods Orders	237	BC	01/92-12/02 [11]	8:30/9:00/10:00[12]
13- Factory Orders	178	BC	01/92-12/02 [13]	10:00
14- Construction Spending	177	BC	01/92-12/02 [14]	10:00
15- Business Inventories	177	BC	01/92-12/02	10:00/8:30[15]
Government Purchases				
16- Government Budget	175	FMS	01/92-12/02 [16]	14:00
Net Exports				
17- Trade Balance	192	BEA	01/92-12/02	8:30
Prices				
18- Producer Price Index	193	BLS	01/92-12/02	8:30
19- Consumer Price Index	275	BLS	01/92-12/02	8:30
Forward-Looking				
20- Consumer Confidence Index	138	CB	01/92-12/02	10:00
21- NAPM Index	156	NAPM	01/92-12/02	10:00
22- Housing Starts	269	BC	01/92-12/02	8:30
23- Index of Leading Indicators	275	CB	01/92-12/02	8:30
Six-Week Announcements				
FOMC				
24- Target Federal Funds Rate	175	FRB	01/92-12/02	14:15[17]
Weekly Announcements				
25- Initial Unemployment Claims	600	ETA	01/92-12/02	8:30

Notes to Table 4: We partition the U.S. monthly news announcements into seven groups: real activity, GDP constituents (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.

Footnotes to Table 4:

1. Total number of observations in our announcements and expectations data sample.
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. Starting and ending dates of our announcements and expectations data sample.
4. Eastern Standard Time. Daylight savings time starts on the first Sunday of April and ends on the last Sunday of October.
5. 10/98 is a missing observation.
6. 11/95, 2/96 and 03/97 are missing observations.
7. In 01/94, the personal income announcement time moved from 10:00 EST to 8:30 EST.
8. Beginning in 01/96, consumer credit was released regularly at 15:00 EST. Prior to this date the release times varied.
9. 11/95 and 2/96 are missing observations.
10. In 12/93, the personal consumption expenditures announcement time moved from 10:00 EST to 8:30 EST.
11. 03/96 is a missing observation.
12. Whenever GDP is released on the same day as durable goods orders, the durable goods orders announcement is moved to 10:00 EST. On 07/96 the durable goods orders announcement was released at 9:00 EST.
13. 10/98 is a missing observation.
14. 01/96 is a missing observation.
15. In 01/97, the business inventory announcement was moved from 10:00 EST to 8:30 EST.
16. 05/88, 06/88, 11/98, 12/89 and 01/96 are missing observations.
17. Beginning in 3/28/94, the fed funds rate was released regularly at 14:15 EST. Prior to this date the release times varied.

Table 5A
Contemporaneous News Response Coefficients
U.S. Markets, Full Sample

Announcement	\$/Pound β_k	\$/Pound R^2	\$/Yen β_k	\$/Yen R^2	\$/Euro β_k	\$/Euro R^2	S&P 500 β_k	S&P 500 R^2	30-Year Treasury Bond β_k	30-Year Treasury Bond R^2
Quarterly Announcements										
1- GDP Advance	-0.054**	0.220	-0.048**	0.154	-0.119**	0.418	0.118	0.063	-0.095**	0.097
2- GDP Preliminary	-0.022	0.035	-0.026*	0.074	-0.050**	0.118	-0.029	0.024	-0.030	0.030
3- GDP Final	-0.011	0.018	-0.014	0.034	-0.010	0.012	0.005	0.002	-0.017	0.031
Monthly Announcements										
Real Activity										
4- Nonfarm Payroll Employment	-0.098**	0.160	-0.078**	0.177	-0.153**	0.218	-0.151**	0.075	-0.325**	0.360
5- Retail Sales	-0.042**	0.152	-0.026**	0.086	-0.056**	0.134	0.004	0.000	-0.097**	0.110
6- Industrial Production	-0.022**	0.060	-0.016**	0.045	-0.032**	0.094	-0.002	0.001	-0.062**	0.194
7- Capacity Utilization	-0.014	0.024	-0.011	0.020	-0.025**	0.058	0.006	0.004	-0.076**	0.281
8- Personal Income	-0.016**	0.053	-0.005	0.005	-0.014	0.024	0.000	0.000	-0.017	0.013
9- Consumer Credit	0.000	0.000	0.000	0.001	0.001	0.011	0.018	0.025	-0.002	0.009
Consumption										
10- New Home Sales	-0.011	0.022	-0.015**	0.038	-0.014	0.018	-0.031*	0.027	-0.077**	0.244
11- Personal Consumption Expend.	-0.002	0.001	-0.003	0.002	-0.009	0.009	-0.031	0.040	-0.009	0.004
Investment										
12- Durable Goods Orders	-0.038**	0.167	-0.028**	0.099	-0.070**	0.264	-0.019	0.007	-0.098**	0.210
13- Factory Orders	-0.018**	0.056	-0.014**	0.029	-0.028**	0.053	0.023	0.009	-0.015	0.005
14- Construction Spending	-0.015*	0.043	-0.002	0.001	-0.016	0.024	0.013	0.005	-0.029**	0.061
15- Business Inventories	0.006	0.007	-0.002	0.001	-0.004	0.002	-0.020	0.007	0.022	0.013
Government Purchases										
16- Government Budget	-0.006**	0.032	-0.005	0.021	-0.009**	0.064	0.010	0.010	0.006	0.011
Trade Balance										
17- Net Exports	-0.049**	0.164	-0.059**	0.111	-0.078**	0.196	0.040**	0.099	0.018*	0.026
Prices										
18- Producer Price Index	0.002	0.000	0.012	0.017	0.004	0.001	-0.094**	0.100	-0.115**	0.154
19- Consumer Price Index	-0.014	0.031	0.003	0.002	-0.017*	0.025	-0.110**	0.139	-0.110**	0.166
Forward Looking										
20- Consumer Confidence Index	-0.044**	0.189	-0.036**	0.203	-0.077**	0.277	0.034	0.020	-0.088**	0.361
21- NAPM Index	-0.035**	0.201	-0.017**	0.045	-0.049**	0.140	-0.011	0.002	-0.153**	0.388
22- Housing Starts	-0.011	0.020	-0.009*	0.020	-0.015*	0.023	-0.014	0.011	-0.064**	0.193
23- Index of Leading Indicators	-0.004	0.002	0.003	0.001	-0.006	0.003	-0.006	0.006	-0.005	0.001
Six-Week Announcements										
24- Target Federal Funds Rate	-0.033*	0.116	-0.019*	0.024	-0.026*	0.037	-0.174*	0.131	-0.025*	0.048
Weekly Announcements										
25- Initial Unemployment Claims	0.017**	0.036	0.013**	0.021	0.026**	0.047	0.002	0.000	0.048**	0.074

Table 5A (continued)
Contemporaneous News Response Coefficients
European Markets, Full Sample

Announcement	British Long Gilt β_k	British Long Gilt R^2	Euro Bobl β_k	Euro Bobl R^2	FTSE 100 β_k	FTSE 100 R^2	DJ Euro Stoxx 50 β_k	DJ Euro Stoxx 50 R^2
Quarterly Announcements								
1- GDP Advance	-0.042**	0.159	-0.034**	0.225	0.072	0.054	0.332**	0.306
2- GDP Preliminary	-0.031**	0.262	-0.017	0.196	-0.034	0.033	0.091	0.042
3- GDP Final	-0.024	0.171	-0.007	0.068	0.018	0.033	-0.015	0.007
Monthly Announcements								
Real Activity								
4- Nonfarm Payroll Employment	-0.071**	0.142	-0.032**	0.138	-0.117**	0.086	-0.030	0.001
5- Retail Sales	-0.029**	0.165	-0.032**	0.346	-0.007	0.001	0.087**	0.100
6- Industrial Production	-0.021**	0.293	-0.018**	0.390	0.051	0.035	0.063	0.086
7- Capacity Utilization	-0.023**	0.247	-0.019**	0.370	0.007	0.001	0.063	0.056
8- Personal Income	-0.006	0.019	-0.002	0.005	0.005	0.001	-0.027	0.027
Consumption								
10- New Home Sales	-0.013*	0.087	-0.012**	0.147	-0.022*	0.026	-0.017	0.007
11- Personal Consumption Expend.	-0.001	0.000	-0.002	0.006	-0.016	0.017	-0.017	0.017
Investment								
12- Durable Goods Orders	-0.029**	0.323	-0.021**	0.285	0.015	0.007	0.091	0.084
13- Construction Spending	-0.010	0.011	-0.007	0.017	0.023	0.013	0.096*	0.057
14- Factory Orders	-0.016**	0.074	-0.007**	0.049	0.008	0.001	0.070**	0.051
15- Business Inventories	0.008	0.013	0.002	0.001	-0.026	0.017	-0.012	0.001
Trade Balance								
17- Net Exports	0.001	0.000	0.003	0.015	0.037**	0.087	0.045	0.075
Prices								
18- Producer Price Index	-0.028**	0.160	-0.017**	0.148	-0.092**	0.135	-0.034	0.013
19- Consumer Price Index	-0.029*	0.111	-0.010*	0.060	-0.084**	0.185	-0.139**	0.223
Forward Looking								
20- Consumer Confidence Index	-0.032**	0.253	-0.026**	0.283	0.029	0.019	0.162**	0.097
21- NAPM Index	-0.069**	0.450	-0.043**	0.439	-0.025	0.013	0.143*	0.102
22- Housing Starts	-0.004	0.002	-0.009**	0.083	-0.015	0.018	0.012	0.003
23- Index of Leading Indicators	0.000	0.000	0.001	0.001	0.006	0.004	-0.009	0.006
Weekly Announcements								
25- Initial Unemployment Claims	0.010**	0.037	0.008**	0.060	0.003	0.000	-0.032**	0.018

Notes to Table 5A: We report $\hat{\beta}_k$ and R^2 from the contemporaneous news response regression, $R_t^h = \alpha_k^h + \beta_k^h S_{kt} + \epsilon_t^h$, where R_t^h denotes the five-minute return from t to $t+1$, and S_{kt} refers to the standardized news announcement, for nine asset returns, h, and twenty-five news announcements, k. The model is estimated using only those observations (R_t^h, S_{kt}) such that an announcement was made at time t. Two asterisks denote statistical significance at the five-percent level, and one asterisk denotes statistical significance at the ten-percent level, where we assess significance with asymptotic t-statistics constructed using heteroskedasticity and autocorrelation consistent standard errors. The sample for the exchange rates and the U.S. Treasury bond goes from January 2, 1992 through December 31, 2002. The results for the S&P500 are based on the slightly shorter sample starting January 2, 1994. Data for the European stock and bond contracts are only available from July 1, 1998 through December 31, 2002. We do not estimate the consumer credit, government budget and federal funds rate responses (announcements 9, 16 and 24) for the European markets, because LIFFE and EUREX are not open after 14:00 EST when the announcements are made.

Table 5B
Contemporaneous News Response Coefficients
U.S. Markets, Expansion Sample

	$/Pound		$/Yen		$/Euro		S&P 500		30-Year Treasury Bond	
Announcement	β_k	R^2	β_k	R^2	β_k	R^2	β_k	R^2	β_k	R^2
Quarterly Announcements										
1- GDP Advance	-0.054**	0.217	-0.048**	0.142	-0.118**	0.405	0.049	0.010	-0.089**	0.072
2- GDP Preliminary	-0.017	0.019	-0.026*	0.074	-0.050*	0.112	-0.064**	0.166	-0.017	0.009
3- GDP Final	-0.017	0.048	-0.017	0.046	-0.013	0.021	-0.009	0.011	-0.010	0.013
Monthly Announcements										
Real Activity										
4- Nonfarm Payroll Employment	-0.098**	0.162	-0.077**	0.180	-0.148**	0.220	-0.220**	0.200	-0.330**	0.372
5- Retail Sales	-0.076**	0.188	-0.023	0.029	-0.089**	0.135	-0.131**	0.069	-0.213**	0.218
6- Industrial Production	-0.025**	0.062	-0.022**	0.067	-0.034**	0.087	-0.001	0.000	-0.068**	0.187
7- Capacity Utilization	-0.016	0.026	-0.014	0.028	-0.027**	0.060	0.009	0.005	-0.083**	0.297
8- Personal Income	-0.020**	0.085	-0.007	0.014	-0.018	0.038	0.000	0.000	-0.018	0.014
9- Consumer Credit	0.000	0.000	-0.001	0.001	0.002	0.018	-0.009	0.006	-0.003	0.015
Consumption										
10- New Home Sales	-0.010	0.020	-0.011	0.031	-0.013	0.016	-0.042**	0.055	-0.082**	0.263
11- Personal Consumption Expend.	-0.006	0.006	-0.006	0.009	-0.013	0.015	-0.033	0.033	-0.024	0.017
Investment										
12- Durable Goods Orders	-0.047**	0.201	-0.028**	0.085	-0.077**	0.261	-0.090**	0.181	-0.117**	0.237
13- Factory Orders	-0.016**	0.051	-0.012**	0.029	-0.029**	0.063	-0.001	0.000	-0.009	0.002
14- Construction Spending	-0.015*	0.044	0.000	0.000	-0.016	0.030	-0.011	0.004	-0.026*	0.047
15- Business Inventories	0.005	0.003	-0.001	0.000	-0.006	0.003	-0.020	0.006	0.009	0.002
Government Purchases										
16- Government Budget	-0.007**	0.034	-0.006	0.018	-0.005	0.019	0.004	0.001	0.004	0.005
Trade Balance										
17- Net Exports	-0.063**	0.210	-0.076*	0.142	-0.100**	0.246	0.033*	0.046	0.019	0.025
Prices										
18- Producer Price Index	0.000	0.000	0.016	0.022	0.004	0.000	-0.165**	0.204	-0.174**	0.234
19- Consumer Price Index	-0.017	0.039	0.005	0.004	-0.015	0.017	-0.140**	0.177	-0.135**	0.215
Forward Looking										
20- Consumer Confidence Index	-0.043**	0.160	-0.029**	0.129	-0.066**	0.219	-0.035**	0.047	-0.076**	0.301
21- NAPM Index	-0.030**	0.160	-0.014*	0.033	-0.040**	0.104	-0.076**	0.097	-0.159**	0.405
22- Housing Starts	-0.010	0.014	-0.010	0.019	-0.016	0.022	-0.027**	0.040	-0.072**	0.216
23- Index of Leading Indicators	-0.007	0.004	0.001	0.000	-0.019	0.013	-0.010	0.012	-0.011	0.003
Six-Week Announcements										
24- Target Federal Funds Rate	-0.075**	0.245	-0.083*	0.168	-0.078**	0.148	-0.130*	0.054	-0.080**	0.189
Weekly Announcements										
25- Initial Unemployment Claims	0.018**	0.034	0.014**	0.018	0.027**	0.041	0.018*	0.008	0.054**	0.072

Table 5B (continued)
Contemporaneous News Response Coefficients
European Markets, Expansion Sample

	British Long Gilt		Euro Bobl		FTSE 100		DJ Euro Stoxx 50	
Announcement	β_k	R^2	β_k	R^2	β_k	R^2	β_k	R^2
				Quarterly Announcements				
1- GDP Advance	-0.017	0.026	-0.012	0.058	0.029	0.009	0.173*	0.156
2- GDP Preliminary	-0.040	0.280	-0.004	0.018	-0.050**	0.116	-0.141**	0.161
3- GDP Final	-0.022	0.088	-0.008	0.082	0.002	0.000	-0.09*	0.261
				Monthly Announcements				
Real Activity								
4- Nonfarm Payroll Employment	-0.060**	0.122	-0.028**	0.180	-0.156**	0.174	-0.178	0.052
5- Retail Sales	-0.078**	0.179	-0.038**	0.169	-0.095**	0.095	-0.215*	0.176
6- Industrial Production	-0.017**	0.214	-0.013**	0.337	0.028	0.009	-0.034*	0.070
7- Capacity Utilization	-0.025**	0.246	-0.015**	0.404	-0.019	0.005	-0.086**	0.244
8- Personal Income	-0.007	0.033	-0.004	0.032	0.007	0.004	-0.039**	0.070
Consumption								
10- New Home Sales	-0.010	0.072	-0.008**	0.097	-0.028**	0.049	-0.052**	0.117
11- Personal Consumption Expend.	-0.003	0.004	-0.001	0.002	-0.014	0.011	-0.085**	0.171
Investment								
12- Durable Goods Orders	-0.036**	0.470	-0.020**	0.317	-0.045**	0.098	-0.073**	0.250
13- Construction Spending	-0.007	0.005	-0.004	0.008	0.006	0.001	0.034	0.019
14- Factory Orders	-0.020**	0.087	-0.006	0.042	-0.023	0.015	0.008	0.002
15- Business Inventories	0.001	0.000	-0.007	0.015	-0.027	0.015	-0.006	0.000
Trade Balance								
17- Net Exports	-0.002	0.003	0.001	0.003	0.040*	0.084	0.099**	0.154
Prices								
18- Producer Price Index	-0.057**	0.285	-0.028**	0.256	-0.155**	0.280	-0.191**	0.253
19- Consumer Price Index	-0.048*	0.213	-0.013	0.088	-0.098**	0.224	-0.208**	0.346
Forward Looking								
20- Consumer Confidence Index	-0.025**	0.254	-0.013**	0.270	-0.024**	0.035	-0.044	0.021
21- NAPM Index	-0.081**	0.444	-0.041**	0.457	-0.076**	0.142	-0.131**	0.163
22- Housing Starts	0.002	0.000	-0.006	0.033	-0.033**	0.079	-0.015	0.004
23- Index of Leading Indicators	0.001	0.001	-0.003	0.030	0.014	0.020	-0.006	0.003
				Weekly Announcements				
25- Initial Unemployment Claims	0.007	0.011	0.007**	0.039	0.016**	0.008	-0.011	0.002

Notes to Table 5B: See the notes to Table 5A. The expansion sample for the U.S. markets goes from January 2, 1992 through February 28, 2001, except for the S&P500 results which are based on the slightly shorter sample starting January 2, 1994. The expansion data for the European markets covers July 1, 1998 through February 28, 2001.

Table 5C
Contemporaneous News Response Coefficients
U.S. Markets, Recession Sample

	$/Pound		$/Yen		$/Euro		S&P 500		30-Year Treasury Bond	
Announcement	β_k	R^2	β_k	R^2	β_k	R^2	β_k	R^2	β_k	R^2
Quarterly Announcements										
1- GDP Advance	-0.060**	0.325	-0.046	0.269	-0.128**	0.584	0.388**	0.814	-0.131**	0.850
2- GDP Preliminary	-0.044	0.309	-0.020	0.068	-0.052	0.174	0.088	0.142	-0.084*	0.296
3- GDP Final	0.041	0.232	0.013	0.058	0.025	0.102	0.080	0.162	-0.059	0.169
Monthly Announcements										
Real Activity										
4- Nonfarm Payroll Employment	-0.107**	0.136	-0.072**	0.099	-0.209**	0.202	0.415**	0.180	-0.298**	0.247
5- Retail Sales	-0.023**	0.323	-0.027**	0.322	-0.038**	0.275	0.056*	0.134	-0.031	0.046
6- Industrial Production	-0.014	0.091	-0.008	0.035	-0.028**	0.186	-0.010	0.015	-0.044**	0.242
7- Capacity Utilization	-0.007	0.018	-0.004	0.006	-0.017	0.058	0.013	0.028	-0.044**	0.216
8- Personal Income	0.033*	0.161	0.020	0.026	0.029	0.059	0.006	0.001	-0.006	0.002
9- Consumer Credit	0.000	0.000	0.000	0.000	0.000	0.000	0.063**	0.441	0.000	0.000
Consumption										
10- New Home Sales	-0.020	0.052	-0.051**	0.126	-0.024	0.040	0.038	0.025	-0.042	0.112
11- Personal Consumption Expend.	0.004	0.014	0.004	0.005	0.001	0.000	-0.028*	0.127	0.020	0.076
Investment										
12- Durable Goods Orders	-0.015	0.088	-0.027	0.152	-0.052*	0.328	0.116*	0.197	-0.053	0.163
13- Factory Orders	-0.030*	0.093	-0.022	0.034	-0.020	0.016	0.199**	0.213	-0.062*	0.047
14- Construction Spending	-0.022	0.070	-0.008	0.018	-0.023	0.040	0.106**	0.152	-0.042*	0.131
15- Business Inventories	0.008	0.088	-0.006	0.017	-0.001	0.001	-0.024	0.076	0.056	0.217
Government Purchases										
16- Government Budget	-0.002	0.007	-0.004	0.022	-0.015**	0.218	0.018**	0.050	0.011	0.053
Trade Balance										
17- Net Exports	-0.013	0.050	-0.011	0.029	-0.018	0.057	0.052**	0.358	0.010	0.021
Prices										
18- Producer Price Index	0.003	0.005	0.006	0.014	0.004	0.004	-0.020	0.024	-0.022	0.030
19- Consumer Price Index	-0.001	0.001	-0.006	0.030	-0.026**	0.270	-0.022	0.046	-0.004	0.001
Forward Looking										
20- Consumer Confidence Index	-0.046**	0.286	-0.059**	0.492	-0.107**	0.435	0.208**	0.322	-0.121**	0.509
21- NAPM Index	-0.048**	0.350	-0.025*	0.071	-0.071**	0.276	0.248**	0.471	-0.131**	0.317
22- Housing Starts	-0.016*	0.126	-0.010	0.034	-0.015	0.056	0.034	0.096	-0.030	0.094
23- Index of Leading Indicators	0.001	0.002	0.005	0.016	0.009	0.038	-0.006	0.006	-0.002	0.001
Six-Week Announcements										
24- Target Federal Funds Rate	-0.011	0.039	0.009	0.036	-0.006	0.004	-0.203	0.183	-0.008	0.009
Weekly Announcements										
25- Initial Unemployment Claims	0.012**	0.066	0.011**	0.049	0.022**	0.105	-0.023	0.023	0.036**	0.110

Table 5C (continued)
Contemporaneous News Response Coefficients
European Markets, Recession Sample

Announcement	British Long Gilt β_k	British Long Gilt R^2	Euro Bobl β_k	Euro Bobl R^2	FTSE 100 β_k	FTSE 100 R^2	DJ Euro Stoxx 50 β_k	DJ Euro Stoxx 50 R^2
Quarterly Announcements								
1- GDP Advance	-0.095**	0.763	-0.099**	0.881	0.278**	0.839	0.683**	0.683
2- GDP Preliminary	-0.025	0.258	-0.030**	0.485	0.222	0.206	0.238*	0.237
3- GDP Final	-0.027**	0.537	-0.004	0.023	0.114**	0.513	0.068	0.184
Monthly Announcements								
Real Activity								
4- Nonfarm Payroll Employment	-0.121**	0.261	-0.068**	0.170	0.274**	0.181	0.386**	0.102
5- Retail Sales	-0.024**	0.239	-0.031**	0.442	0.040	0.116	0.115*	0.234
6- Industrial Production	-0.026**	0.417	-0.028**	0.527	0.146**	0.455	0.222**	0.502
7- Capacity Utilization	-0.022**	0.248	-0.025**	0.386	0.111**	0.233	0.212**	0.406
8- Personal Income	0.002	0.001	0.005	0.023	-0.009	0.002	0.016	0.005
Consumption								
10- New Home Sales	-0.016	0.105	-0.021**	0.265	0.047**	0.056	0.055	0.038
11- Personal Consumption Expend.	0.001	0.001	-0.002	0.014	-0.018	0.037	0.005	0.003
Investment								
12- Durable Goods Orders	-0.022	0.190	-0.021	0.250	0.159*	0.441	0.281**	0.424
13- Construction Spending	-0.020	0.039	-0.018**	0.047	0.147*	0.198	0.271**	0.180
14- Factory Orders	-0.012*	0.065	-0.012*	0.093	0.122**	0.199	0.152**	0.142
15- Business Inventories	0.014	0.158	0.011	0.121	-0.026*	0.138	-0.019	0.024
Trade Balance								
17- Net Exports	0.002	0.019	0.002	0.019	0.029*	0.159	0.020	0.035
Prices								
18- Producer Price Index	-0.008	0.050	-0.004	0.019	0.003	0.001	0.031	0.016
19- Consumer Price Index	0.000	0.000	-0.005	0.019	-0.028	0.059	-0.035	0.054
Forward Looking								
20- Consumer Confidence Index	-0.035**	0.253	-0.038**	0.344	0.190**	0.259	0.286**	0.213
21- NAPM Index	-0.060**	0.464	-0.046**	0.420	0.174**	0.399	0.380**	0.498
22- Housing Starts	-0.01*	0.100	-0.013**	0.262	0.057**	0.230	0.048	0.074
23- Index of Leading Indicators	0.000	0.000	0.002	0.015	-0.007	0.008	-0.015	0.015
Weekly Announcements								
25- Initial Unemployment Claims	0.011**	0.082	0.008**	0.086	-0.023*	0.029	-0.043**	0.038

Notes to Table 5C: See the notes to Table 5A. The recession sample for all of the markets goes from March 1, 2001 through December 31, 2002.

Figure 1A
Bond Market News Announcement Responses, Full Sample

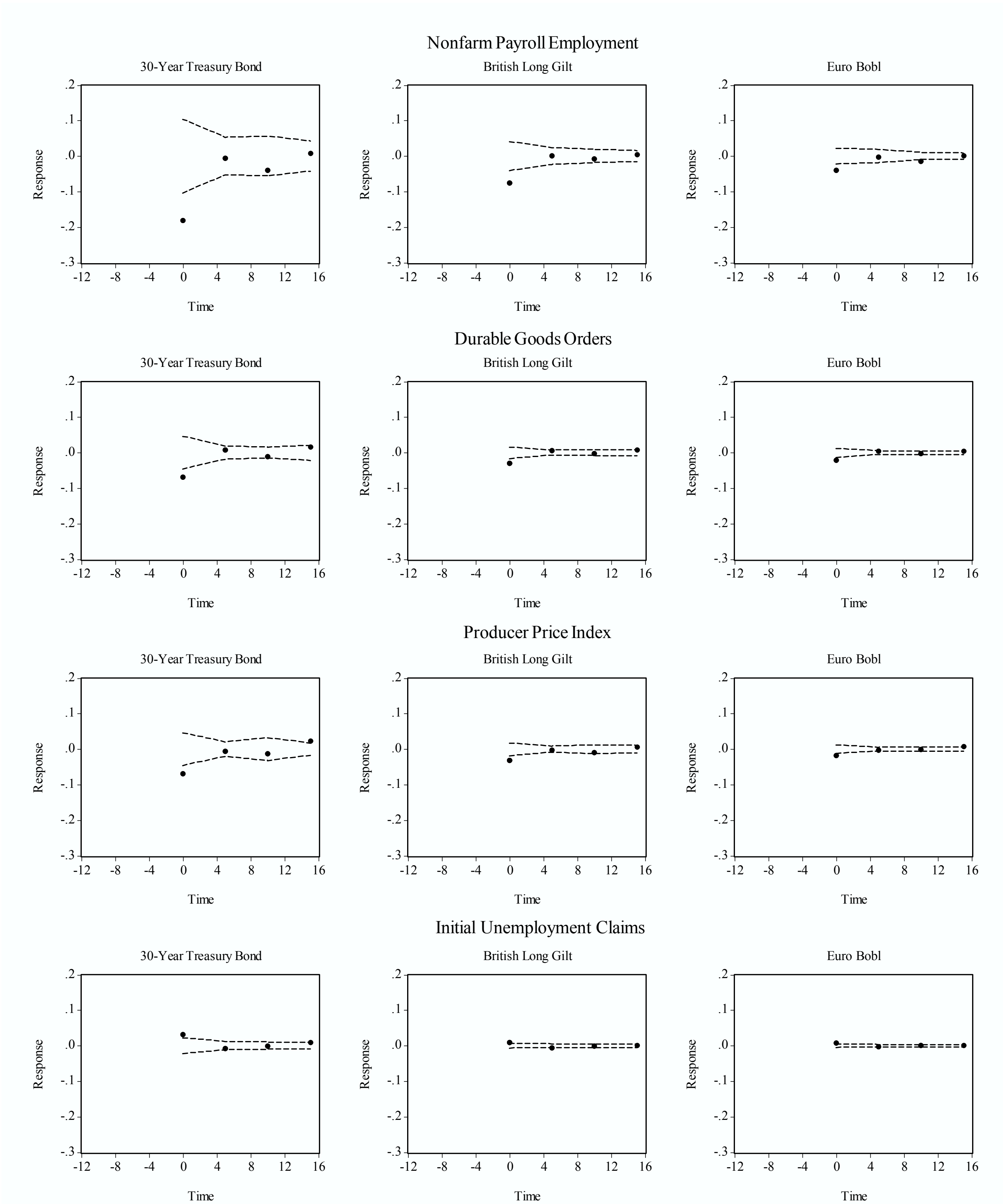


Figure 1A (continued)
Foreign Exchange Market News Announcement Responses, Full Sample

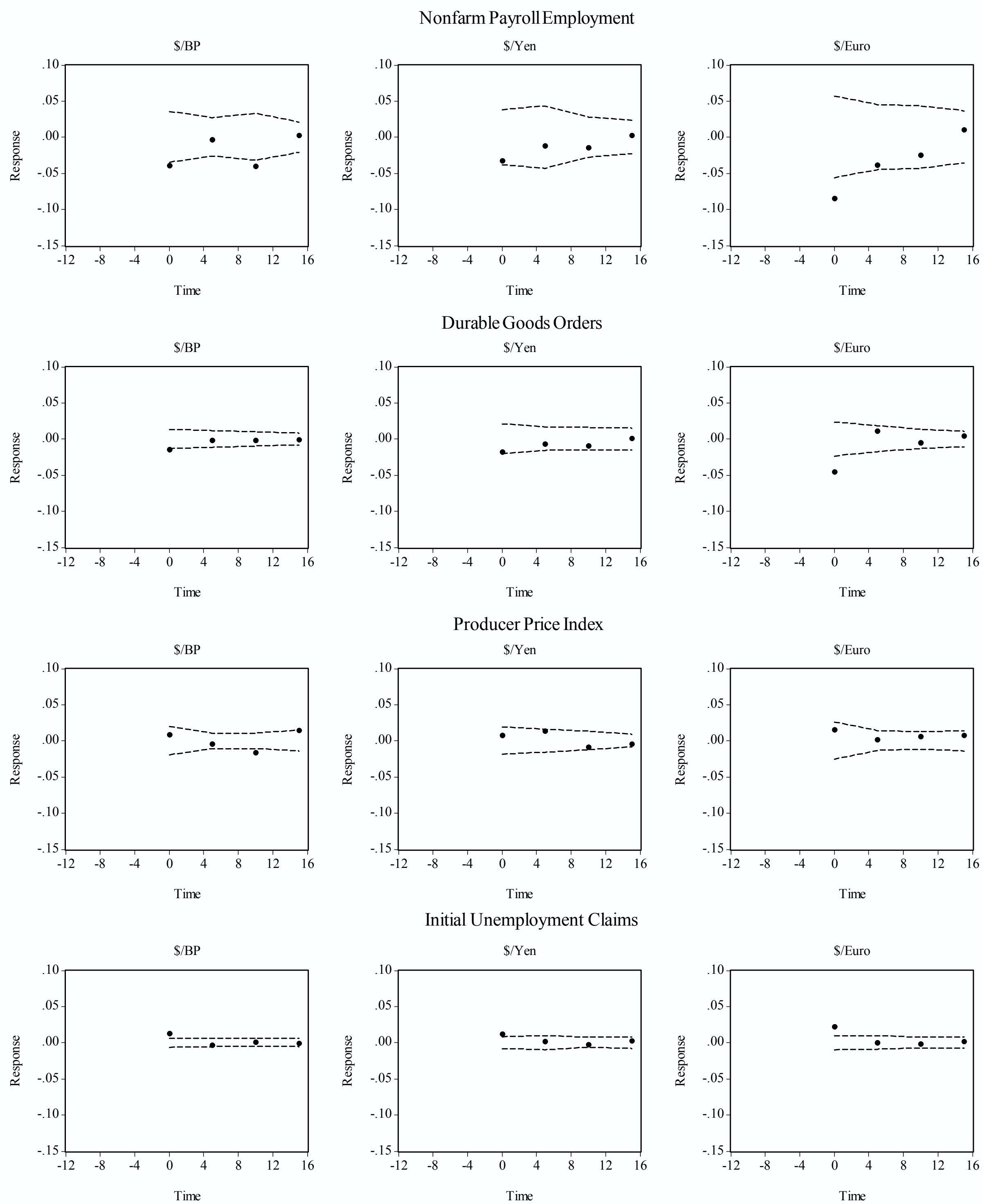


Figure 1A (continued)
Stock Market News Announcement Responses, Full Sample

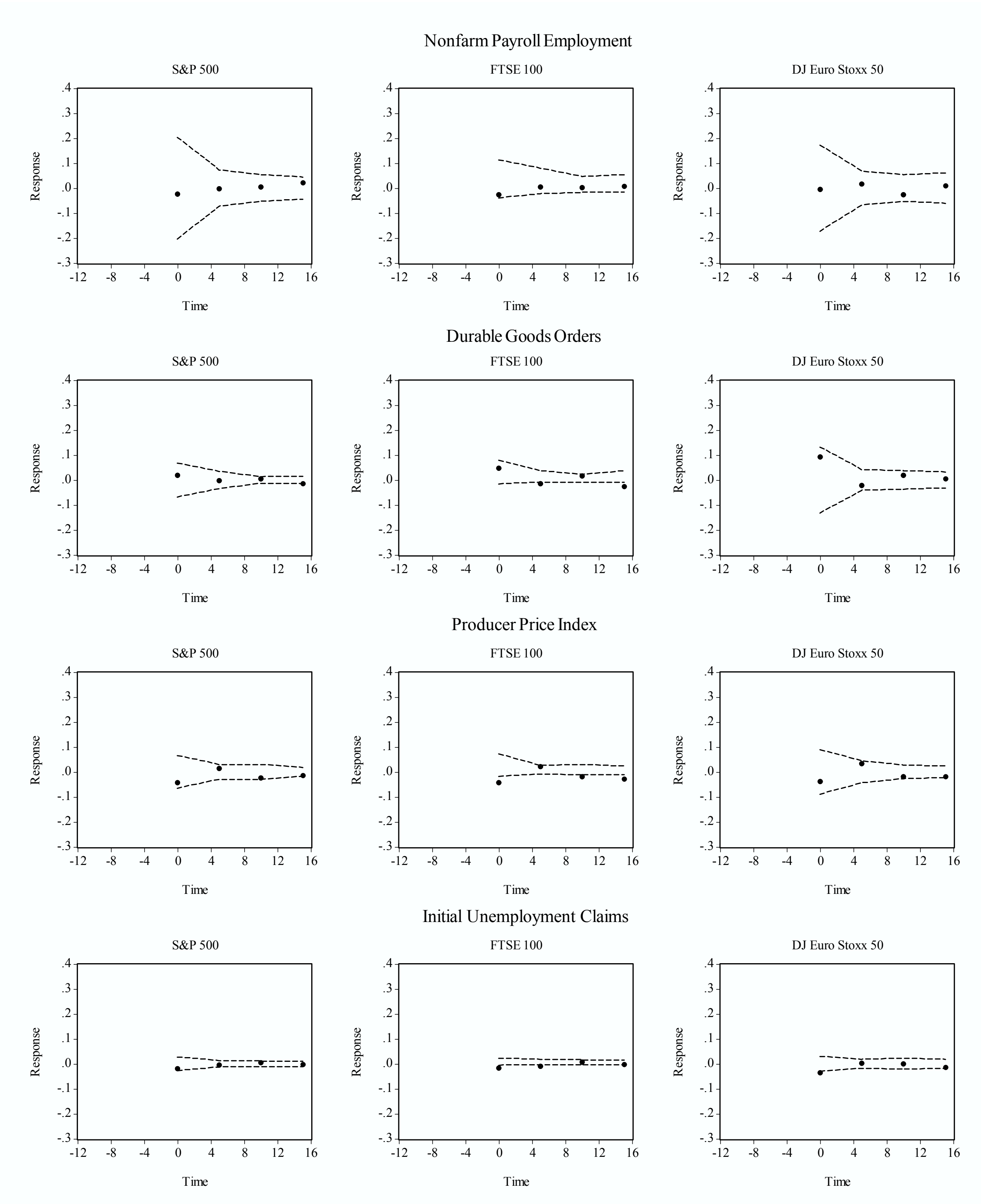


Figure 1B
Bond Market News Announcement Responses, Expansion Sample

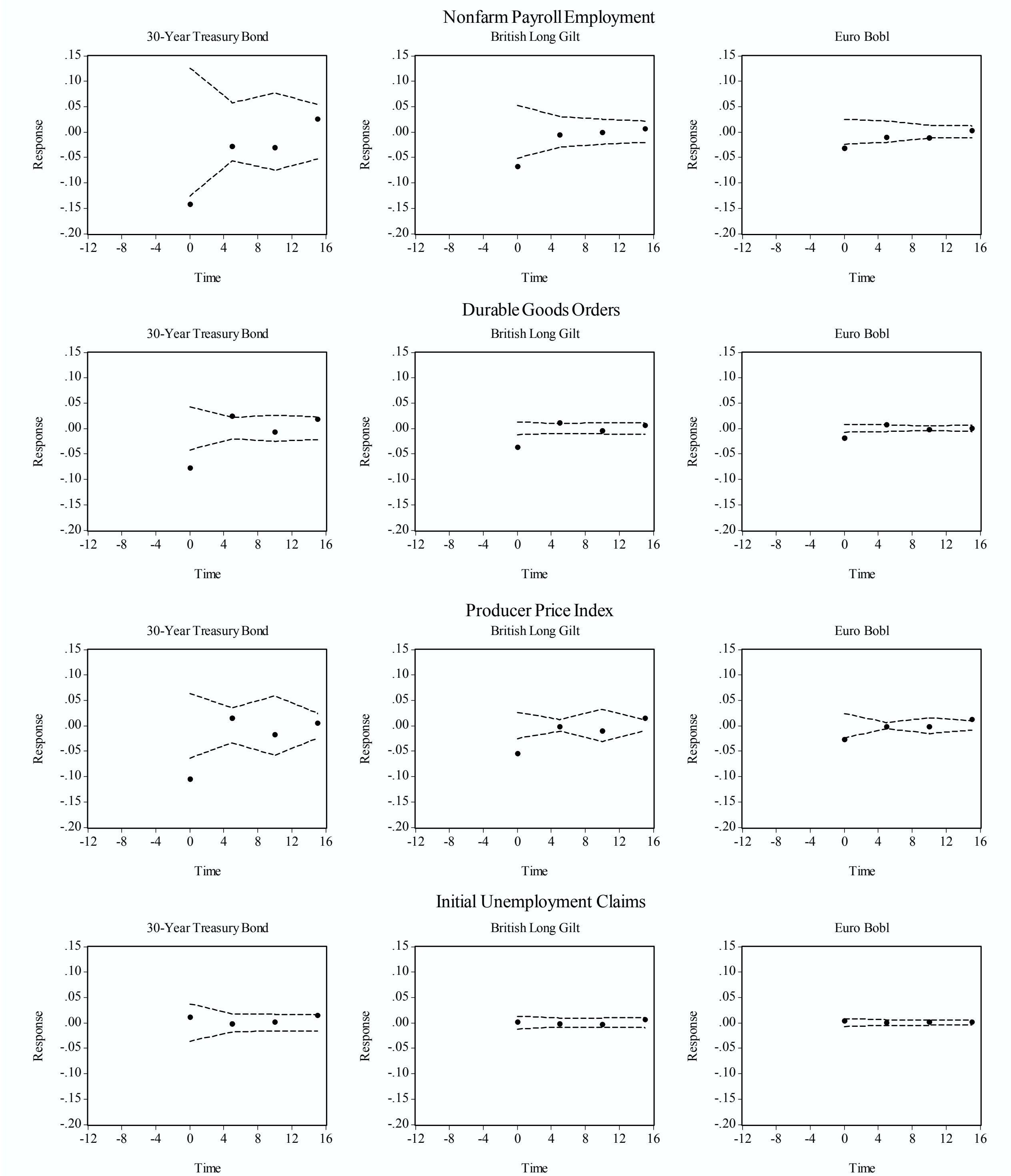


Figure 1B (continued)
Foreign Exchange Market News Announcement Responses, Expansion Sample

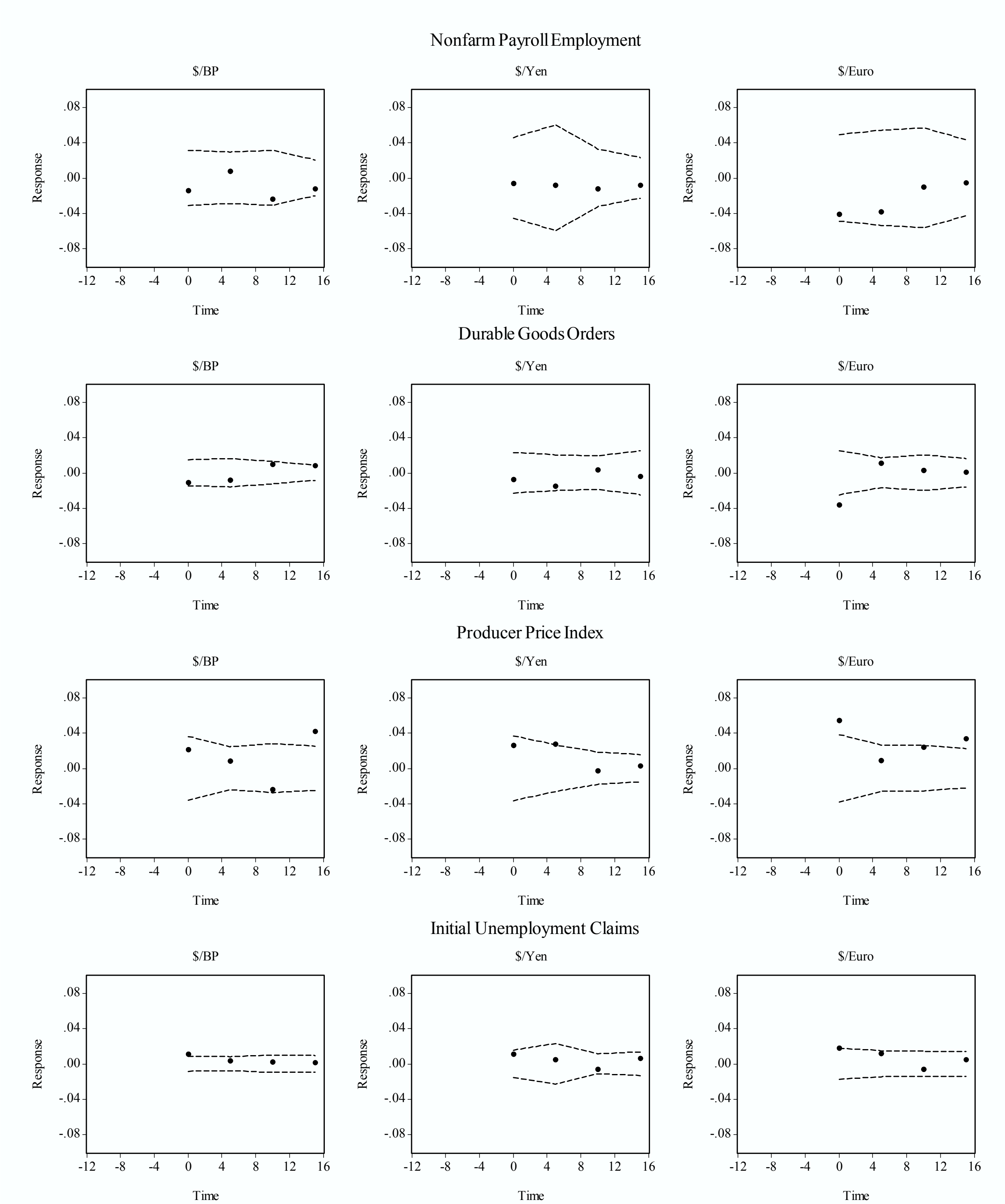


Figure 1B (continued)
Stock Market News Announcement Responses, Expansion Sample

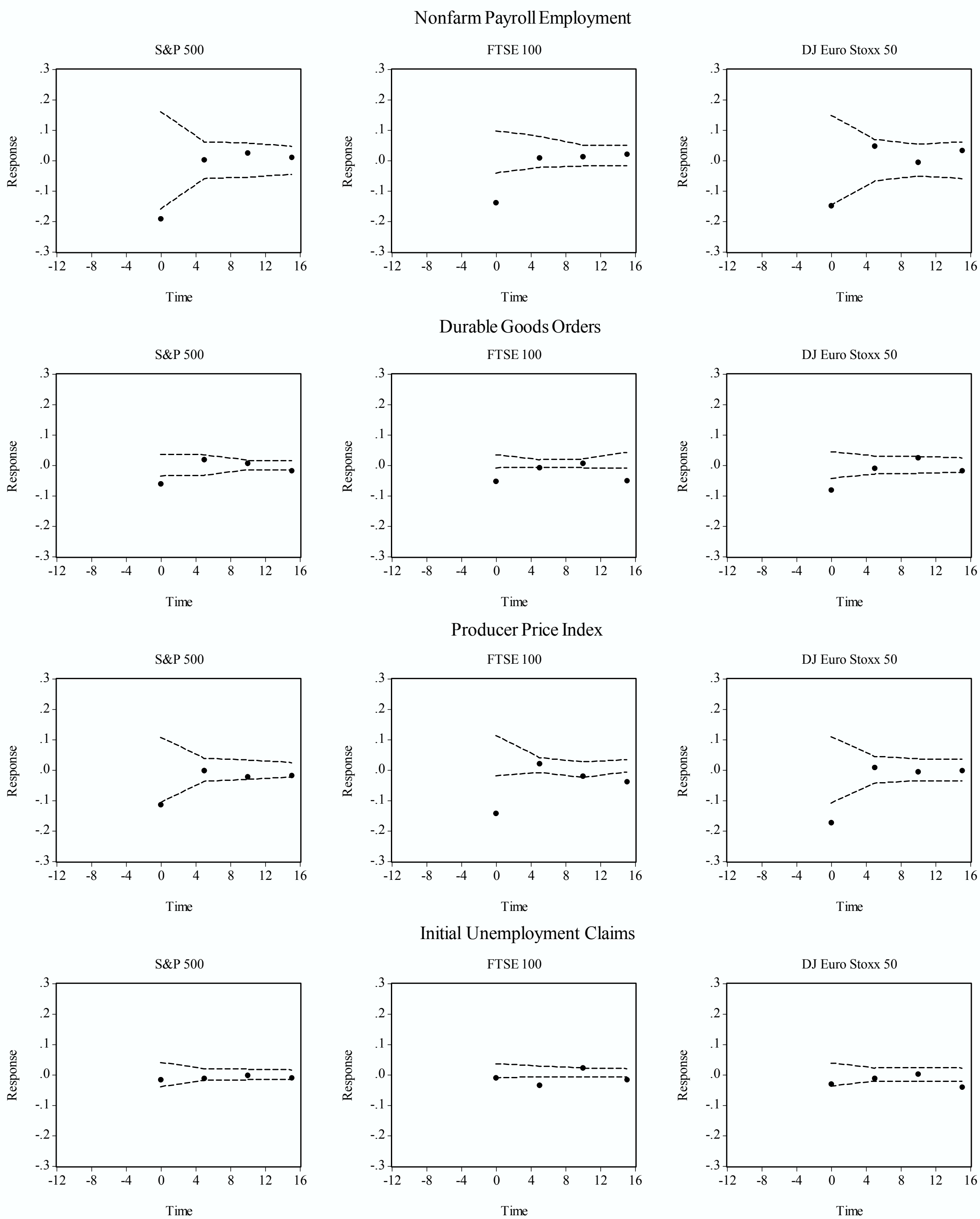


Figure 1C
Bond Market News Announcement Responses, Recession Sample

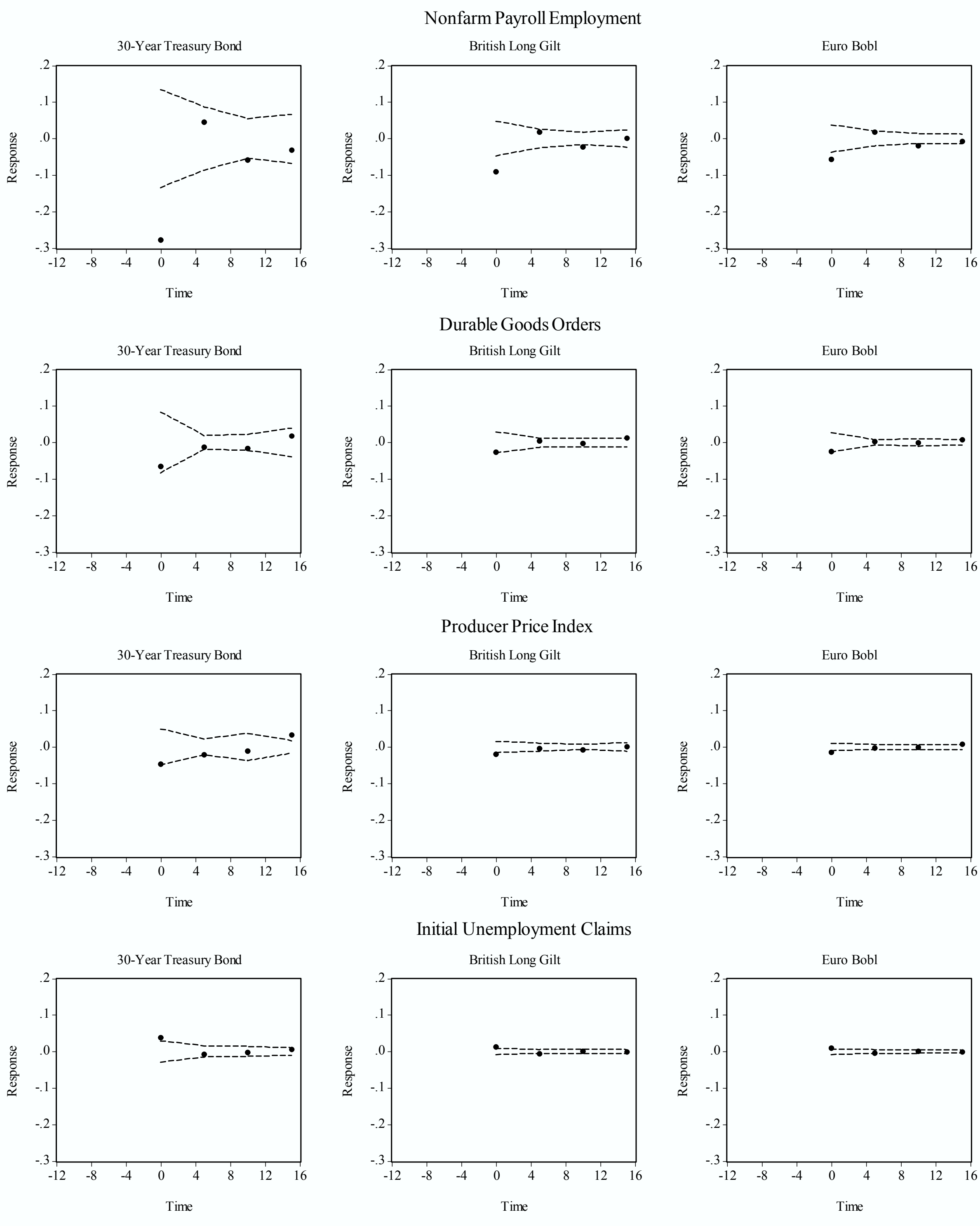


Figure 1C (continued)
Foreign Exchange Market News Announcement Responses, Recession Sample

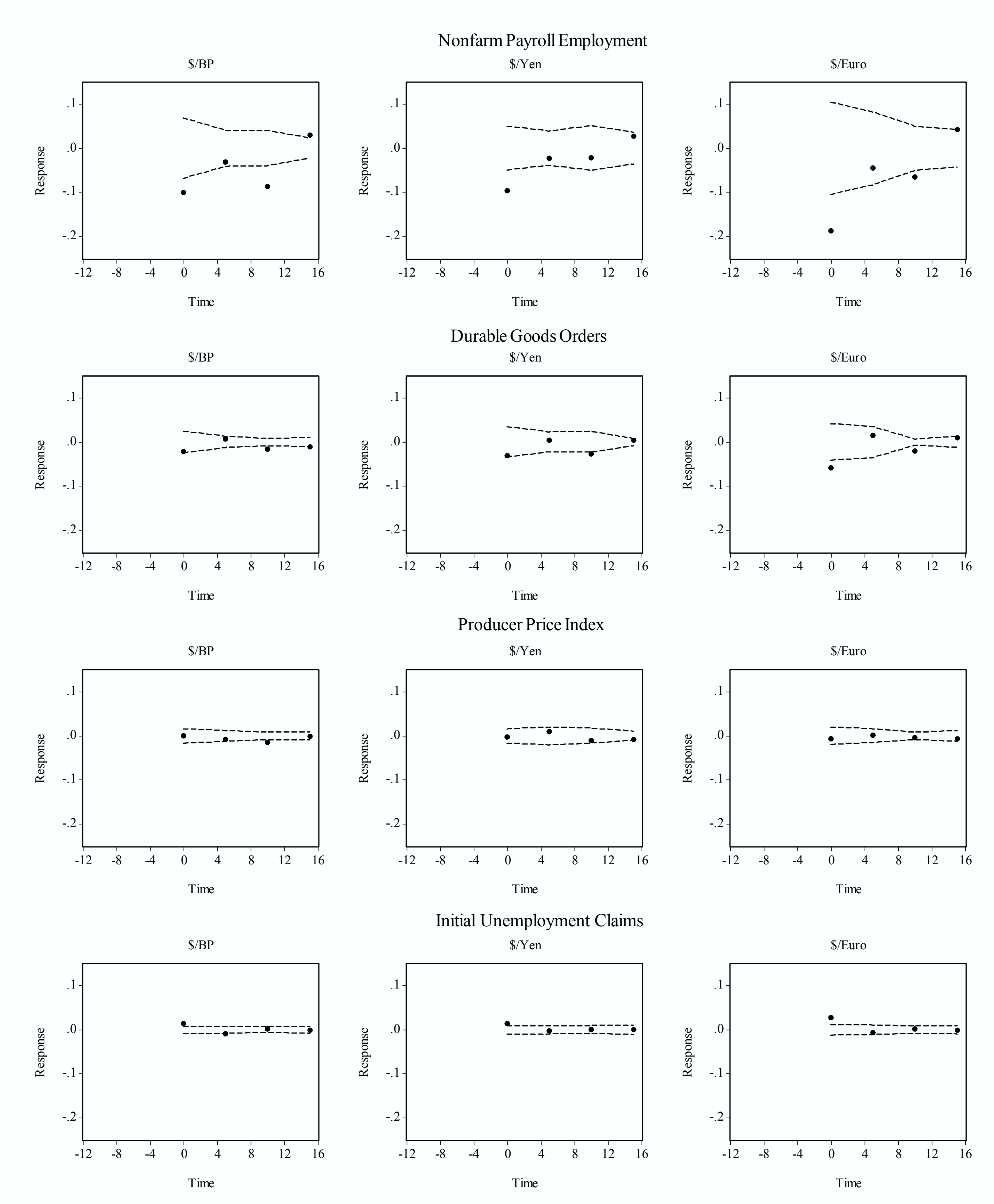
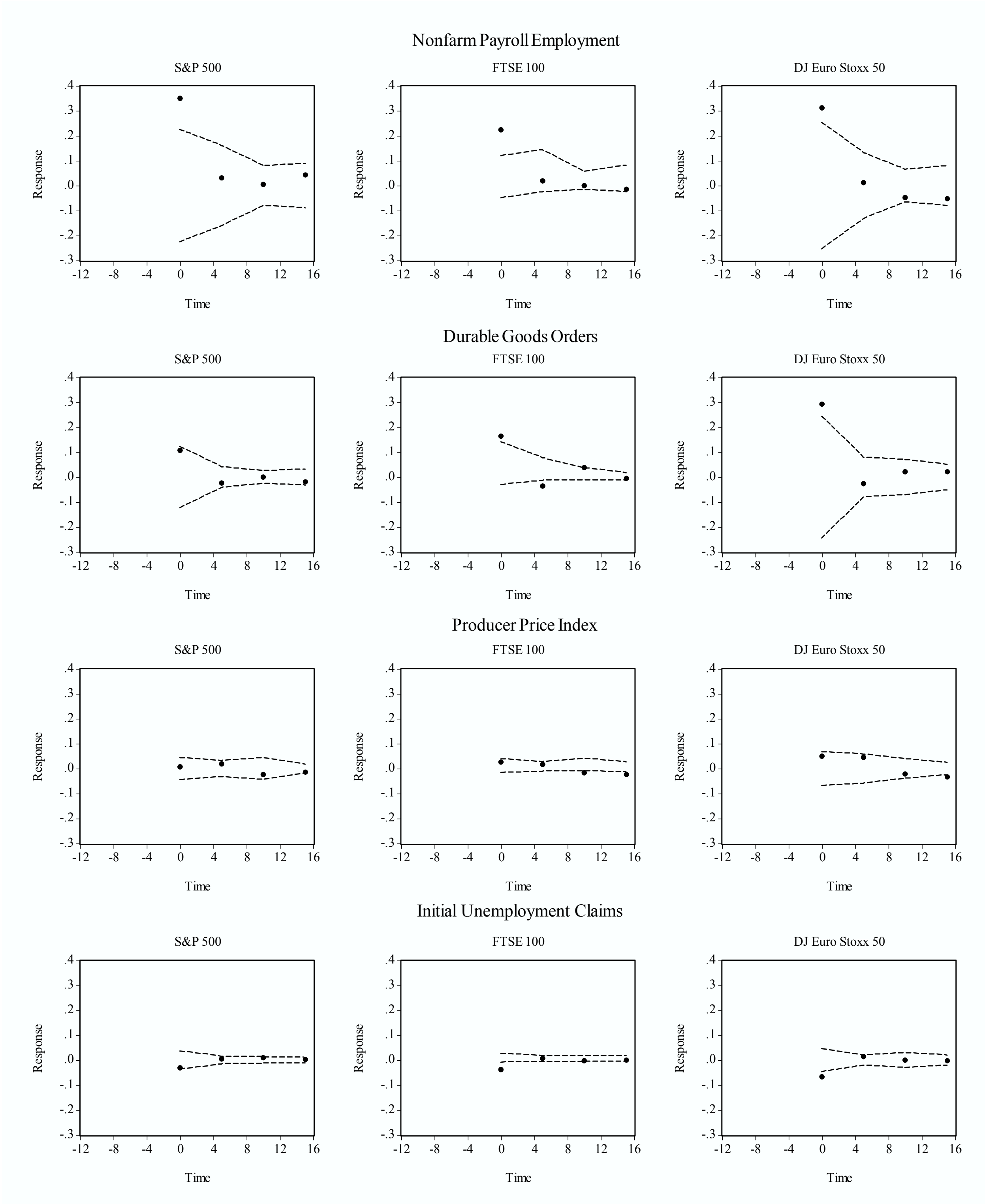


Figure 1C (continued)
Stock Market News Announcement Responses, Recession Sample



Notes to Figures 1A, 1B and 1C: We graph the news announcement response coefficients from the weighted least squares estimation of equation (5.2), corresponding to the responses at the announcement time, and five-, ten-, and fifteen-minutes after the announcement. We also show two standard error bands under the null hypothesis of a zero response. The common full sample goes from July 1, 1998 through December 31, 2002. The expansion sample covers July 1, 1998 to February 28, 2001. The recession sample goes from March 1, 2001 to December 31, 2002.