Journal of
Risk and Financial Management

Article

Assessing the Impact of the ECB's Unconventional Monetary Policy on the European Stock Markets

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Abstract: This study assesses the effects of the European Central Bank's (ECB) unconventional monetary policy (UMP) on the prices of selected European stock market indices during the European sovereign debt (2010–2012) and the COVID-19 pandemic (2020–2022) crises interventions. This research employs the instrumental variables (IV) two-stage least squares (2SLS) model approach to evaluate the effects of changes in the size of the ECB's balance sheet on the pricing of key equity market indices in Europe. The results of this study suggest that the ECB's asset value expansion had the opposite statistically significant effects on the European stock market indices' prices between the interventions. That is, an increase in the ECB's balance sheet size was associated with a decrease in the prices of the indices during the sovereign debt crisis and with a rise during the COVID-19 pandemic. This research pinpoints the price sensitivity of each of the European equity indices to the ECB's UMP and determines the different outcomes of the ECB's quantitative easing policy between the interventions.

Keywords: ECB's balance sheet; quantitative easing; sovereign debt crisis; European stock indices; COVID-19 pandemic crisis

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Citation: Rincon, Carlos J., and Anastasiia V. Petrova. 2024. Assessing the Impact of the ECB's Unconventional Monetary Policy on the European Stock Markets. *Journal of Risk and Financial Management* 17: 425. https://doi.org/10.3390/jrfm17090425

Academic Editor: Marius Sikveland

Received: 25 August 2024
Revised: 17 September 2024
Accepted: 18 September 2024
Published: 23 September 2024

1. Introduction

The COVID-19 pandemic, which erupted in late 2019, triggered a global financial crisis that forced government authorities all over the world to take measures for stabilizing financial markets and maintaining economic activity. During this crisis, the central banks and governments responded by implementing monetary and fiscal policies, respectively. Both policies aimed at reducing the systemic risk, maintaining liquidity, and achieving the stability of the financial markets. The global nature of this economic crisis implied that the regulatory authorities in different countries faced similar challenges and provided significant measures that considered the specific conditions of certain economies and financial systems. In this article, we focus on the European case, as the European financial markets were highly impacted by the COVID-19 pandemic from its early stage.

In Europe, the European Central Bank's (ECB) main functions include maintaining a low and stable level of inflation, supervising the banks of the EU, issuing the euro banknotes, and supporting the financial stability in the euro area. In periods of a financial crisis, when economic instability causes uncertainty, the banks hesitate to lend excess funds to other financial institutions, and the money supply in the interbank credit system decreases significantly (Morelli and Seghezza 2021). Hence, the cost of overnight borrowing rises, and the spread between the ECB's interest rate and the overnight interbank rate is expected to increase (Cassola et al. 2013). In this instance, stabilizing the economy through the changes in the key interest rate alone is insufficient, as the financial markets do not function properly and have a limited response to the central bank's policy (Mishkin 2009). For the purpose of efficient intervention during the unprecedented economic conditions of the Great Financial Crisis, the European sovereign debt crisis, and the COVID-19 crisis, the ECB implemented unconventional monetary policy (UMP) measures (European Central Bank 2020a, 2020b, 2020c, 2020d, 2020e). Figure 1 shows the evolution of the ECB's balance sheet size, the German 10-year government bond yield, and the European short-term rate. The figure suggests that during the sovereign debt crisis in Europe, the value of the ECB's assets and the German bond yields exhibit opposite directions, whereas during the crisis caused by the coronavirus outbreak, this relationship may be somewhat unclear.

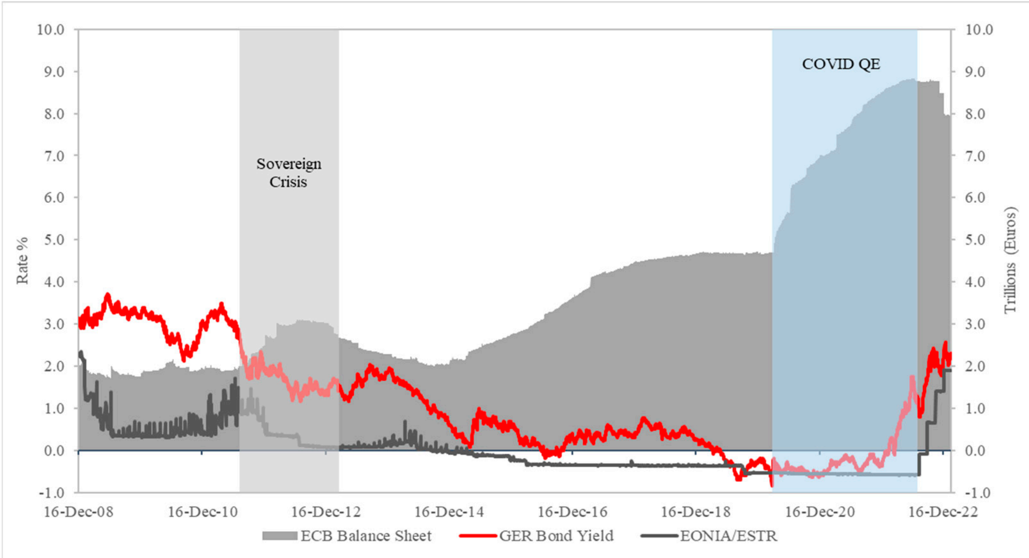

Figure 1. ECB's balance sheet, German 10-year government bond yield, and European short-term rate.

Figure 1 reveals a key motivation of this research. The large growth of the ECB's balance sheet during the COVID-19 period makes the response to the sovereign debt crisis look considerably small. Thus, in terms of scale and impact, the COVID-19 pandemic signals a more severe impact on the economy and financial markets than the sovereign debt crisis (Lane 2012) and the global financial crisis itself (Choi 2020).

The trends of the major European stock market indices (STOXX50, STOXX600, Euronext100, MSCI Europe Small Cap) prices for the same period are displayed in Figure 2.

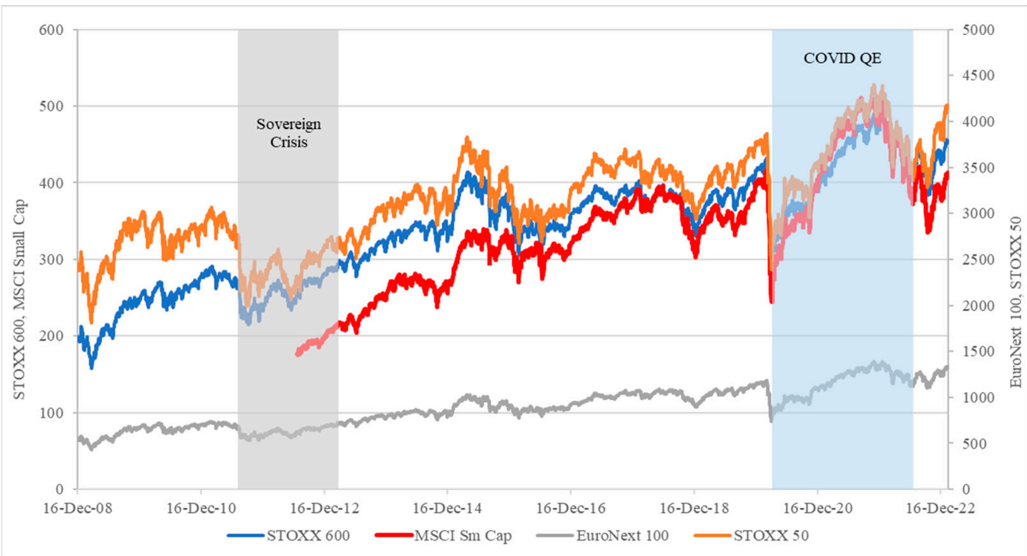

Figure 2. Major European stock market indices' prices.

The indices' prices in Figure 2 exhibit notably similar general trends, yet the extents of the reactions to the financial crises and the ECB's measures differ. For instance, the STOXX50, STOXX600, and MSCI Europe Small Cap indices are more volatile than Euronext100 and experience more dramatic drops in price at the beginning of both the European sovereign debt and the COVID-19 crises.

The figures presented above suggest that the ECB's asset purchase programs during the sovereign debt crisis and the COVID-19 crisis had different effects on the long-term government bond yields. Moreover, even though the European stock market indices' prices resembled identical trends, the magnitudes of the changes differed among the indices. The aim of this study is to determine the effects of the European Central Bank's securities purchases on the major European stock market indices. Hence, the following questions are addressed: Do large-scale purchases of government securities interventions in the European credit markets impact the equity markets' pricing? And if they do, in what proportion? The results of this paper can benefit the investment public holding European assets in their portfolios. As we progress in our analysis, we anticipate to determine the sensitivities of the most crucial EU indices to the changes in the central bank's securities purchasing programs. As each stock market index includes underlying assets with different characteristics, knowing the elasticities of each index, investors can have clearer expectations about the performance of their specific portfolios during the financial crises to come.

Recent literature explores specific cases to assess the effects of central bank UMPs transmission on the financial markets, including during the COVID-19 crisis, such as on large-cap banking stocks listed in the U.S., Europe, and China (O'Donnell et al. 2024), stock indices in India (Rao and Kumar 2023), and financial markets subsets for a large sample of countries (Wei and Han 2021). Particularly, these studies focus on recent datasets and share the event–study methods for their empirical strategy. The empirical research of this study is limited to the European Union during the European sovereign debt crisis and the COVID-19 pandemic. The data collected contain the daily prices of the crucial indices in the euro area, namely, STOXX50, STOXX600, Euronext100, MSCI Europe Small Cap, and the size of the ECB's balance sheet, and cover the period from 2 April 2007 to 1 February 2023. Moreover, the data include the yields on the German government bonds and relevant macroeconomic indicators, i.e., the euro to dollar exchange rate, consumer price index as a measure of inflation, and oil prices. To identify the impact of the ECB's policy on the stock market, the two-stage least squares (2SLS) regression model was run, and the results of the estimations were found to be robust by the generalized method of moments (GMM) for IV analysis. In short, our research strategy helps fill a gap in terms of market specifics, data extent, and methodology. This paper is organized as follows: this introduction, literature review, methodology and data, results and discussion, implications, and conclusions.

2. Literature Review

The impact of the government's monetary policy on stock market pricing has been a subject of interest in macroeconomics and finance for decades (Chen 2007). However, the estimation of effects of the economic policy on the financial markets remains a challenge because both interest rates regulated by the central banks and the asset prices are affected by several different variables (Samuelson 1954). Moreover, scholars face the problem of simultaneity, which means that the causal relationship between the asset prices and the interest rates can run in both directions (Rigobon and Sack 2003), and, therefore, this endogeneity should be accounted for by using specific, suitable methodology.

Most studies on the government interventions' impact on asset pricing have considered the short-term interbank interest rate as the key instrument of the central bank's policy since the seminal paper of Bernanke and Blinder (1992). Patelis (1997) demonstrates a significant effect of the changes in the interest rates on the stock market returns in the United States: an increase in the federal funds rate corresponds to a decline in the stock returns in the short run and a rise in the stock returns in the long run.

It is important to consider the expectations of the economic agents when studying the government's policy impact on some economic variables. Bernanke and Kuttner (2005) examine the reaction of the stock prices to the unexpected changes in the federal funds rate. They find that an unanticipated decrease of the interest rate by 25 basis points leads to an approximate 1 percent rise in the stock prices. Similar results were obtained by Rigobon and Sack (2004). According to their study, an increase in the short-term interest rates corresponds to a fall in the stock prices and to a yield curve upward shift, which decreases as the assets' maturity rises. The authors also conclude that a change in the interest rates has a larger effect on the government bond yields than on the stock prices.

The monetary policy of the economic authorities also impacts the equity premium, i.e., the excess return earned on the assets over a risk-free return, namely, the return on the government bonds. Fama and French (2002) examine the U.S. stock market and show that the period of the declining interest rates set by the Federal Reserve System is associated with the increasing average stock returns. Therefore, the lowering of the interest rates by the central bank implies higher equity premiums and larger capital gains by the investors in the financial markets (Cochrane 2005; Sharpe 1964).

During the global financial crisis of 2008, the level of interest rates set by the monetary authorities worldwide declined significantly as a result of the central banks' actions aimed at providing the funding to the banks and maintaining the liquidity in the financial markets. As the economic situation deteriorated quickly after the collapse of Lehman Brothers in September 2008, the standard monetary policy measures appeared to be insufficient (Joyce et al. 2012). Hence, the largest central banks (e.g., the Federal Reserve System, the European Central Bank, the Bank of Japan, and the Bank of England) introduced unconventional measures to support households and the financial institutions. Quantitative easing (QE) policy became a crucial instrument of the governments during the Great Recession. This policy implied large-scale purchases of assets, mainly long-term government bonds, by the central bank (Dell'Ariccia et al. 2018). Gagnon et al. (2011) demonstrated that quantitative easing of the Federal Reserve had an economically meaningful and long-lasting negative effect on the longer-term interest rates on the securities. In consequence, such a decline in the interest rate led to lower equity risk premiums not only on the assets purchased by the central bank but also on the securities that were not included in the government's purchase programs.

In the beginning stages of the global financial crisis, high levels of financial uncertainty led to extreme spreads of short-term interest rates worldwide and in Europe. The ECB immediately reacted to the economic deterioration by gradually cutting the key interest rate by a total of 325 basis points, reaching a euro area historical minimum of 1 percent in May 2009 (European Central Bank 2010). In contrast to the Federal Reserve, which started to implement the quantitative easing policy in November 2008, the ECB's reaction to the crisis began with the standard refinancing operations and resorted to asset purchases only in May 2009. Trichet (2009) explains this by the differences in the funding structure of corporations between the European Union and the United States. In detail, the companies of the euro area rely more on bank financing, which constitutes about 70 percent of the external funding sources, whereas American firms prefer to fund their needs by issuing corporate bonds, which compose around 80 percent of the external funding (Cour-Thimann 2013). Moreover, Geanakoplos and Wang (2020) state that the quantitative easing policy in Europe differs from the United States one because countries in the European Union have different levels of government debt and not every state issues, bonds which are eligible as collateral. Other relevant cases of UMP actions include those of Japan. Montgomery and Volz (2019) state that the Bank of Japan's (BOJ) UMP worked in spite of negative interest rates thanks to an efficient bank lending transmission channel in the Japanese banking system. In our methodology, we take into account the presence of negative data in the European case, similar to the Japanese case, yet different to the U.S., where yields and interest rates have not crossed the zero lower bound (ZLB).

The effects of the monetary policy of a particular central bank can also affect international financial markets. For instance, Yildirim and Ivrendi (2021) assessed the transmission of the U.S. unconventional monetary policy to the emerging and advanced economies. They claim that the Federal Reserve's policy measures influence investors' risk premiums all over the world. In addition, Fratzscher et al. (2016) studied the ECB's nonstandard policy spillover effects of the interest and exchange rates, risk and yield changes, and the flows of capital. Although the authors obtained significant results indicating the presence of the effect of the ECB's monetary policy on the international equity markets, this effect was not as large as in the case of the Federal Reserve. The reasons supporting such findings include the U.S. dollar being the key currency worldwide and the international trend of switching from bank funding to the issue of bonds, which were a more popular funding instrument for American companies rather than the European ones prior to the crisis. On this matter, Inoue and Rossi (2019) suggest that monetary policy easing leads to significant exchange rate changes during both conventional and unconventional periods.

One of the main goals of the central bank as a monetary authority is to keep the price level and inflation stable. Hence, when introducing the new directions of economic policy in times of crises, governments must consider the impact of their actions on inflation. Moessner (2015) did not find the significant relationship between the high level of inflation and expansions of the ECB's balance sheet. However, Boeckx et al. (2017) conclude that without the introduction of the long-term refinancing operations in response to the sovereign debt crisis, the inflation in Europe would be 1 percent lower in 2012. Perera et al. (2013) found that inflation and the value of the assets purchased by the central bank are negatively associated. That is, the more aggressive the quantitative easing policy of the government is, the lower the level of inflation. In line with this, Cochrane (2018) suggests that when nominal interest rates are close to zero, inflation can be low and stable even with a large value of assets on the central bank's balance sheet.

As economic conditions started to improve after the Great Recession, the quantitative easing policy was replaced with tapering—a gradual reduction in the measures supporting the economy, namely, the asset purchase program. Albu et al. (2016) suggest that this tapering policy had an impact on stock market indices. Moreover, Chari et al. (2017) affirm that the Federal Reserve's tapering had even larger effects on interest rates, asset returns, and equity premiums both domestically and internationally in comparison with the effects of the quantitative easing.

Although there is a generous amount of research devoted to the effects of the large-scale purchases of Treasury securities by the ECB as a response to financial crises before the COVID-19 pandemic, the limited literature available during the pandemic mostly examines the expected effects on macroeconomic variables, such as GDP and employment (Aguilar et al. 2020; Aktar et al. 2021; Choi 2020; Li et al. 2021). While some studies only focus on the justification of the ECB's reaction to the crisis (Morelli and Seghezza 2021), others focus on the effects on the stocks in a specific sector (O'Donnell et al. 2024), countries (Rao and Kumar 2023), or financial market subsets (Wei and Han 2021), employing the event-study methods as their identification strategy. Our research is expected to contribute to narrowing the research gap by focusing on the effects on the main stock indices in Europe using the instrumental variables approach to determine the quantitative effects on the trends of those indices.

3. Methodology and Data

While having an impact on the price of the stock market, the yield on the government bonds is, in turn, influenced by the asset purchase programs implemented by the central bank as a part of its monetary policy. The ECB implemented the securities purchasing programs during the European sovereign debt crisis and the COVID-19 pandemic crisis. The ECB expanded its balance sheet size by buying the euro area government bonds, and as a result, the prices of those bonds rose and the bond yields declined. This study examines the effect of the ECB's balance sheet size on the European stock market indices through its impact on government bond yields. Hence, based on the described economic intuition, this paper proposes the following hypotheses:

H1. *Liquidity excesses from the ECB's UMP interventions influence the pricing of European equity assets.*

H2. *European debt market pricing is directly affected by the size of the ECB's balance sheet.*

H3. *European debt market pricing, which may be affected by the ECB's interventions, influences the pricing of equity securities in the long run.*

H4. *European equity indices, as measures of stock market performance, have different sensitivities to the size of the ECB's balance sheet.*

H5. *European stock market indices' sensitivities vary by the ECB's asset purchasing programs.*

3.1. Empirical Model

Grounded on the described relationships, this paper employs the instrumental variables approach as its identification strategy. Considering that in any time t, the government bond yields, $GerYld_t$, can influence the prices of the stock market indices, $index_t$, and are also impacted by the central bank's balance sheet size itself, $ECBbs_t$, a simultaneity of processes was followed. The 10-year German government bond yields were used as a proxy for government bond yields data due to their high liquidity (Hill and Bruno 2024). Further, as endogeneity issues within the variables must be considered, the two-stage least squares (2SLS) method best captures the simultaneity and endogeneity aspects of this process (Hausman 1983). As the aim of this study is to estimate the expected changes in the index, the suggested model will compute the expected change in the price of the index at predicted changes in the yields given the changes in the central bank's balance sheet size. The log–log model can be formally described as the following system of two simultaneous equations:

$$\textit{Stage } 1\text{: } ln(GerYld_t) = \alpha + \beta_1 ln(ECBbs_t) + \Sigma\beta_i Z_{i,t} + \epsilon_t \quad (1)$$

$$\textit{Stage } 2\text{: } ln(index_t) = \mu + \lambda_1 ln(GerYld_t) + \lambda_2 ln(Estr_t) + \lambda_3 ln(Hicp_t) + \lambda_4 ln(EurUsd_t) + \lambda_5 ln(Wti_t) + v_t \quad (2)$$

where, ln represents the natural logarithm of the variables, α and μ are intercepts, β_1, β_i, λ_1, λ_2, λ_3, λ_4, are coefficients, $Z_{i,t}$ are the vectors of covariates in (2), and ϵ_t and v_t are error terms.

The principal equation of this model, represented by the second stage specification, estimates the predicted change of the index price, the dependent variable $index_t$, as a function of the variable of interest, the predicted change in the yield of the 10-year German government bonds, $GerYld_t$. The other variables in this equation, namely, the European short-term rate, $Estr_t$, the harmonized index of consumer prices, $Hicp_t$, the euro to U.S. dollar exchange rate, $EurUsd_t$, and the WTI crude oil spot price, Wti_t, are included as control variables. At the same time, in the first-stage equation, the variable of interest is instrumented by the size of the ECB's balance sheet, $ECBbs_t$. In short, this 2SLS log-log model specification calculates the European equity indices' price elasticities of government yields, the yield elasticity of the ECB's balance sheet, and ultimately, the European equity indices' price elasticities of the ECB's balance sheet altogether.

This study initially considered alternative empirical settings, such as three-stage least squares (3SLS) regression (Sargan 1964; Zellner and Theil 1962) and vector auto-regressive (VAR) models (Stock and Watson 2001). According to Krugman and Obstfeld (2003), the government bond yields are influenced by the central bank's balance sheet value in the money market directly. Simultaneously, these bond yields are influenced by the currency rate determined in the foreign exchange market. Hence, the 3SLS model follows the

Krugman and Obstfeld (2003) simultaneous money market and foreign exchange market equilibrium modeling identified by the following system of three simultaneous equations:

$$Stage\ 1\text{: } ln(GerYld_t) = \alpha + \beta_1 ln(ECBbs_t) + \Sigma\beta_i Z_{i,t} + \epsilon_t \quad (3)$$

$$Stage\ 2\text{: } ln(EurUsd_t) = \delta + \gamma_1 ln(GerYld_t) + \gamma_2 ln(Wti_t) + \Sigma\ \gamma_i Z_{i,t} + \theta_t \quad (4)$$

$$Stage\ 3\text{: } ln(index_t) = \mu + \lambda_1 ln(GerYld_t) + \lambda_2 ln(Estr_t) + \lambda_3 ln(Hicp_t) + \lambda_4 ln(EurUsd_t) + \upsilon_t \quad (5)$$

where, ln represents the natural logarithm, δ is an intercept, γ_1, γ_2, are coefficients, and θ_t is an error term.

Equations (3) and (4) of the 3SLS model resolve the endogeneity problem between the government bond yield, the central bank's assets value, and the exchange rate. However, Krugman and Obstfeld's (2003) modeling fits well for the U.S. market, yet not as accurately for the European markets. The results of our 3SLS model specification with the European market data showed low quality expressed in relatively small R-squared values. Thus, Equation (4) is removed from the model setting, and the exchange rate was kept as a control variable in the principal Equation (2) of the 2SLS model, obtaining higher statistical power.

The VAR model, which was also considered for this study, drew weak significance from the lagged variables. VAR models may provide estimates for short-term impulse reactions of the variables to their previous values, but this trait is less relevant in this study because such specification does not correspond to the goal of this research, which is to examine the long-term trends of stock market prices that are influenced by government interventions. Moreover, long-term monetary policies such as large-scale security purchases are not regarded as surprise shocks, and given that monetary policy rules change over time, constant parameter structural VARs that miss this instability tend to be incorrectly identified (Stock and Watson 1996).

3.2. Data Description

This study uses the daily data of the prices of the four major European stock market indices (STOXX50, STOXX600, Euronext100, and MSCI Europe Small Cap), the ECB's balance sheet size, the yield on the 10-year German government bonds, the European short-term rate, the Harmonized Index of Consumer Prices, the euro to U.S. dollar exchange rate, and the WTI crude oil spot price. All data have been obtained from online databases (Investing.com, Yahoo Finance) and the ECB's Statistical Data Warehouse. The dataset covers the period from 2 April 2007 to 1 February 2023, and includes the ECB's quantitative easing policy during the European sovereign debt crisis and the COVID-19 pandemic crisis. To analyze these interventions separately, the data are divided into two subsets according to Table 1.

Table 1. ECB's intervention timeline.

Crisis	ECB's Asset Purchase Program	Announcement Date	Start Date	End Date
Sovereign Debt Crisis	Securities Markets Program (SMP)	9 May 2010	10 May 2010	6 September 2012
COVID-19 crisis	Pandemic Emergency Purchase Program (PEPP)	18 March 2020	26 March 2020	31 March 2022

Source: compiled by authors.

The summary statistics of all variables for the entire period are provided in Table 2. A crucial distinctive fact to account for in the European case is that interest rates (government bond yields and the ECB's discount rate) turned negative at some points during this data period, for which transformations of these datasets were conducted in order to properly apply logarithms to them. Thus, before coming with the summary statistics in Table 2, the raw data indicated negative values in some of the variables, such as yields on the

10-year German government bonds, the European short-term rate, the Harmonized Index of Consumer Prices, and the WTI crude oil spot prices. This becomes a problem when applying logarithms to the dataset as the logarithms of negative values become undetermined, and the ones below 1 become negative. In such cases, the data has been adjusted adding a constant as per: $Adj(X_t) = (\alpha + 1) + X_t$, where the constant $\alpha > |\min(X_t)|$. Table A1 in Appendix A shows the minimum values of α used to transform these datasets. Lastly, the number of observations for the MSCI Europe Small Cap index is significantly lower than for other variables due to data unavailability. As the data for this index start from 9 July 2012, the results are only estimated for the COVID-19 pandemic crisis period.

Table 2. Summary statistics of the variables assessed in this study (from 2 April 2007 to 1 February 2023).

Variable	Obs	Mean	Std. Dev.	Variance	Min	Max	Skewness	Kurtosis
lnStx50	3972	8.06238	0.17854	0.03188	7.50107	8.42455	−0.26466	2.62957
lnStx600	3973	5.79983	0.22119	0.04893	5.06241	6.20324	−0.62515	2.79377
lnNxt100	3986	6.76383	0.24795	0.06148	6.07445	7.23568	−0.26728	2.23331
lnMsciEU	2655	5.79552	0.23637	0.05587	5.16644	6.23499	−0.53809	2.95258
lnECBbs	3986	14.95346	0.55999	0.31359	13.96180	15.99434	0.32454	2.11142
lnGerYld *	3980	1.07355	0.47044	0.22131	0.00000	1.87809	−0.04185	1.87765
lnESTR *	3986	0.55527	0.49784	0.24785	0.00000	1.82358	1.17205	3.56157
lnHICP *	3986	1.13279	0.49762	0.24762	0.00000	2.50144	0.42495	3.44399
lnEurUsd	3986	0.80609	0.06058	0.00367	0.67254	0.95505	0.24991	2.11707
lnWTI *	3952	4.52403	0.19043	0.03627	0.00029	5.02278	−3.51998	82.78193

Note(s): * Data series underwent the following transformations: $Adj(GerYld_t) = 0.854 + 1 + GerYld_t$; $Adj(ESTR_t) = 0.593 + 1 + ESTR_t$; $Adj(HICP_t) = 0.6 + 1 + HICP_t$; $Adj(WTI_t) = 34.644 + 1 + WTI_t$. Source: ECB datasets (https://data.ecb.europa.eu/data/datasets, accessed on 28 December 2023); Yahoo Finance (https://finance.yahoo.com/, accessed on 28 December 2023); Author's calculations.

4. Results and Discussion

4.1. Correlation Analysis

The correlation matrix for all time-series data are presented in Table 3. The results support the hypothesis of a negative correlation between the size of the ECB's balance sheet and the German government bond yields. The statistically significant correlation coefficient of −0.7634 confirms that the value of the ECB's assets is a relevant instrumental variable for the German bond yield. Besides, each of the considered European stock market indices is positively statistically significantly correlated with the ECB's balance sheet size. The STOXX50 shows the lowest correlation of 0.3346, and the MSCI Europe Small Cap index has the highest coefficient of 0.7735. Moreover, the stock market indices' correlations with the German government bond yield are negative and statistically significant, which is consistent with the theoretical framework and the empirical model setting. Lastly, the control variables, except for the WTI crude oil spot price, also have statistically significant correlations with the indices and, therefore, are justified to be included in the model.

4.2. Regression Results

The coefficient estimates obtained from the 2SLS model on the dataset for the entire period are presented in Table 4. In the first-stage regression, the yield on the 10-year German government bonds is instrumented by the size of the ECB's balance sheet and the control variables. The results show high values of R-squared, implying that more than 85 percent of the dependent variable's variance is explained by the considered instrumental variables.

Moreover, the estimated coefficients are mostly highly statistically significant at the 0.1 percent level, including the coefficient on the value of the ECB's balance sheet, which is the main focus of this paper. In detail, a negative coefficient on the ECB's balance sheet size indicates that its increase is associated with a decline in the government bond yields.

Naturally, by buying the debt securities, the ECB raises its demand, and this leads to a decrease in the yields in acceptance of H2.

Table 3. Correlation matrix (from 2 April 2007 to 1 February 2023).

	lnStx50	**lnStx600**	**lnNxt100**	**lnMsciEU**	**lnECBbs**	**lnGerYld**	**lnESTR**	**lnHICP**	**lnEurUsd**	**lnWTI**
lnStx50	1.0000									
lnStx600	0.8809 *	1.0000								
	0.0000									
lnNxt100	0.9043 *	0.9823 *	1.000							
	0.0000	0.0000								
lnMsciEU	0.9252 *	0.9618 *	0.9717 *	1.000						
	0.0000	0.0000	0.0000							
lnECBbs	0.3346 *	0.6371 *	0.6733 *	0.7735 *	1.0000					
	0.0000	0.0000	0.0000	0.0000						
lnGerYld	−0.2819 *	−0.6153 *	−0.5897 *	−0.5601 *	−0.7634 *	1.0000				
	0.0000	0.0000	0.0000	0.0000	0.0000					
lnESTR	0.0687 *	−0.4456 *	−0.4087 *	−0.5558 *	−0.7445 *	0.8631 *	1.0000			
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000				
lnHICP	0.2225 *	0.1801 *	0.2348 *	0.3235 *	0.2601 *	0.2826 *	0.2726 *	1.0000		
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000			
lnEurUsd	−0.2860 *	−0.6079 *	−0.5959 *	−0.5551 *	−0.7596 *	0.7476 *	0.6967 *	−0.0152	1.0000	
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.3389		
lnWTI	0.0399	0.0199	0.0040	−0.0890 *	−0.0209	0.3851 *	0.2275 *	0.6459 *	0.2714 *	1.0000
	0.0122	0.2122	0.8032	0.0000	0.1895	0.0000	0.0000	0.0000	0.0000	

Note(s): * denotes coefficients are significant at 0.1%. Source: author's calculations.

Table 4. Regression results (from 2 April 2007 to 1 February 2023).

First-stage regression				
	lnStx50	**lnStx600**	**lnNxt100**	**lnMsciEU**
lnGerYld				
lnESTR	0.2573 ***	0.2579 ***	0.2571 ***	0.5338 ***
lnWTI	0.1939 ***	0.1953 ***	0.1948 ***	0.1011
lnHICP	0.2855 ***	0.2849 ***	0.2852 ***	0.3842 ***
lnEurUsd	1.0533 ***	1.0522 ***	1.0504 ***	0.9076 ***
lnECBbs	−0.4494 ***	−0.4490 ***	−0.4495 ***	−0.4142 ***
_const	5.6020 ***	5.5901 ***	5.6016 ***	5.3892 ***
R-squared	0.8588	0.8588	0.8590	0.8571
F	4783.90	4784.67	4799.53	3172.08
Prob > F	0.0000	0.0000	0.0000	0.0000
Instrumental Variables (2SLS) regression				
Variable	**lnStx50**	**lnStx600**	**lnNxt100**	**lnMsciEU**
lnGerYld	−0.4742 ***	−0.5175 ***	−0.7709 ***	−0.8428 ***
lnESTR	0.3477 ***	0.2630 ***	0.4081 ***	0.2546 ***
lnWTI	0.1878 ***	0.3368 ***	0.3094 **	0.2279 ***
lnHICP	0.0654 ***	0.0616 ***	0.1356 ***	0.2278 ***
lnEurUsd	−0.2332 ***	−0.9975 ***	−0.5454 ***	−0.5146 ***
_const	7.6425 ***	5.4202 ***	6.2520 ***	5.5301 ***
R-squared	0.2764	0.5776	0.5266	0.5420
Wald chi2	1162.88	4408.55	4295.71	4002.66
Prob > chi2	0.0000	0.0000	0.0000	0.0000

Note(s): The models considered are the instrumental variables two-stage least squares (IV2SLS) using the central bank balance sheet size as the main control variable tested for the entire data period (from 2 April 2007 to 1 February 2023). ***, ** Coefficients are significant at the 1%, 5% level. Source: authors' estimations.

The second-stage regression provides the results for the relationship between the European stock market index price and the German bond yield estimations from the first-stage equation. The values of R-squared suggest that this model fits the STOXX600 index the best and the STOXX50 index the least. However, most of the estimated coefficients are highly statistically significant. Specifically, according to the model, a negative change in the German government bond yields is associated with an increase in the price of all four considered European stock market indices. Taking into account the relationship between the ECB's balance sheet size and the yield on the long-term German government bonds obtained in the first-stage equation, one can conclude that when the ECB launches the quantitative easing policy and expands its asset purchases, the prices of the European stock indices are expected to rise, in support of H3. As the main objective of such an unconventional ECB measure is to stimulate the economy during the period of economic distress, these results are consistent with the assumption that the liquidity provided by the ECB reflects increasing demand in the stock market, supporting H1.

4.3. Intervention Comparison

The data related to the European sovereign debt crisis cover the period from 10 May 2010 to 6 September 2012, which aligns with the ECB's official announcements about the start and the end of the assets purchase program (outlined in Table 1). The correlation results (see Table A2 in Appendix A) on the main variables of interest are ambiguous and differ from the results presented for the entire period in Table 3. As in the previous case, the correlation between the ECB's balance sheet size and the bond yield is negative and statistically significant. However, the prices of all four indices are positively correlated with the German government bond yield. Moreover, the indices' prices are negatively correlated with the value of the ECB's assets. Table 5 shows the 2SLS regression results for the sovereign debt crisis. The first-stage equation provides expected and statistically significant results of the negative relationship between the ECB's balance sheet and the German bond yield for the STOXX50, STOXX600, and Euronext100. Moreover, these models exhibit a high explanatory power with R-squared values greater than 85 percent, except for the MSCI Europe Small Cap index, which displays low statistical significance of the model and its estimates due to the low number of observations available about this index for this particular period.

The second-stage regression demonstrates that an increase in the German 10-year government bond yield is associated with a positive statistically significant change in the price of the STOXX50, Stoxx600, and Euronext100 indices. Considering the relationship obtained between the variables in the first stage, when the ECB expanded its asset value by purchasing government securities during the sovereign debt crisis, the yield on the bonds decreased, and the European stock market indices' prices declined, too. Therefore, the effect of the ECB's interventions on the stock market pricing during the European sovereign debt crisis was negative. The ECB's attempts to stimulate the economy during the financial distress through the unconventional policy instruments were somewhat discouraging to the investment public in the European equity markets.

The correlations between the variables during the COVID-19 crisis are presented in Table A3 of Appendix A. The results are different from both of the previously discussed cases. Firstly, in contrast to the results for the entire period and the sovereign debt crisis, the ECB's balance sheet size has a positive statistically significant correlation coefficient with the German government bond yield. Secondly, the prices of the four stock market indices are positively correlated with both the German bond yield and the ECB's assets value. The correlations of the stock indices' prices and the ECB's balance sheet size are very high, exceeding 92 percent. These results suggest that even though similar monetary policy measures were realized by the ECB during the sovereign debt crisis and the COVID-19 crisis, the effects on the stock market and the transmission mechanisms differed.

Table 6 shows the 2SLS regression results for the COVID-19 crisis period from 26 March 2020 to 31 March 2022 (outlined in Table 1). The first-stage equation also provides expected and statistically significant results of the negative relationship between the ECB's balance sheet and the German bond yield for all four indices. The R-squared results are greater than 67 percent in all cases.

Table 5. Regression results (sovereign debt crisis).

First-stage regression				
	lnStx50	**lnStx600**	**lnNxt100**	**lnMsciEU**
lnGerYld				
lnESTR	0.0381	0.0380	0.0381	0.3314
lnWTI	1.0327 ***	1.0326 ***	1.0325 ***	0.4536
lnHICP	−0.1837 ***	−0.1833 ***	−0.1836 ***	0.8657 **
lnEurUsd	−0.2425	−0.2412	−0.2430	−0.1383
lnECBbs	−0.9095 ***	−0.9094 ***	−0.9094 ***	2.0318
_const	10.3650 ***	10.3621 ***	10.3656 ***	−32.6200
R-squared	0.8630	0.8629	0.8633	0.5750
F	719.39	717.76	722.38	9.74
Prob > F	0.0000	0.0000	0.0000	0.0000
Instrumental Variables (2SLS) regression				
Variable	**lnStx50**	**lnStx600**	**lnNxt100**	**lnMsciEU**
lnGerYld	0.5675 ***	0.2336 ***	0.3466 ***	1.6945
lnESTR	−0.1848 ***	−0.1736 ***	−0.1856 ***	−0.4292
lnWTI	0.4148 ***	0.5430 ***	0.4332 ***	−0.0881
lnHICP	−0.4086 ***	−0.2369 ***	−0.3166 ***	−1.2662
lnEurUsd	1.1814 ***	0.9700 ***	1.2025 ***	0.8021
_const	4.8227	2.3413 **	3.5287	5.0221
R-squared	0.8410	0.6068	0.7125	-
Wald chi2	2750.56	771.74	1256.99	12.69
Prob > chi2	0.0000	0.0000	0.0000	0.0265

Note(s): The models considered are the instrumental variables two-stage least squares (IV2SLS) using the central bank balance sheet size as main control variable tested for the sovereign debt crisis data period (from 10 May 2010 to 6 September 2012). ***, ** Coefficients are significant at the 1%, 5% level. Source: authors' estimations.

Table 6. Regression results (COVID-19 crisis).

First-stage regression				
	lnStx50	**lnStx600**	**lnNxt100**	**lnMsciEU**
lnGerYld				
lnESTR	−3.1636 **	−3.1636 **	−3.1636 **	−3.1636 **
lnWTI	0.0882 ***	0.0882 ***	0.0882 ***	0.0882 ***
lnHICP	0.1659 ***	0.1659 ***	0.1659 ***	0.1659 ***
lnEurUsd	−0.7082 *	0.7082 *	0.7082 *	0.7082 *
lnECBbs	−0.3224 ***	−0.3224 ***	−0.3224 ***	−0.3224 ***
_const	5.5766 ***	5.5766 ***	5.5766 ***	5.5766 ***
R-squared	0.6751	0.6751	0.6751	0.6751
F	209.83	209.83	209.83	209.83
Prob > F	0.0000	0.0000	0.0000	0.0000
Instrumental Variables (2SLS) regression				
Variable	**lnStx50**	**lnStx600**	**lnNxt100**	**lnMsciEU**
lnGerYld	−1.3725 ***	−1.3703 ***	−1.6344 ***	−1.5724 ***
lnESTR	−3.1410 ***	−3.5363 ***	−4.0634 ***	−4.3581 ***
lnWTI	0.1066 **	0.1059 **	0.1281 **	0.1154 **
lnHICP	0.3443 ***	0.3354 ***	0.3946 ***	0.4111 ***
lnEurUsd	1.4953 **	0.7746	1.0000	2.6085 ***
_const	6.8713 ***	5.2672 ***	6.0692 ***	3.8415 ***
R-squared	0.2203	0.2048	0.1369	0.4667
Wald chi2	599.34	602.97	557.33	895.85
Prob > chi2	0.0000	0.0000	0.0000	0.0000

Note(s): The models considered are the instrumental variables two-stage least squares (IV2SLS) using the central bank balance sheet size as main control variable tested for the COVID-19 Crisis data period (from 26 March 2020 to 31 March 2022). ***, **, * Coefficients are significant at the 1%, 5%, 10% level. Source: authors' estimations.

The results of the second-stage regression, however, imply that an increase in the German 10-year government bond yield is associated with a negative statistically significant change in the price of all four indices. Considering the relationship obtained between the variables in the first stage, when the ECB expanded its assets value by purchasing government securities during the COVID-19 crisis, the yield on the bonds decreased, and the European stock market indices' prices increased. This result is inverted from the previous intervention results. That is, the effect of the ECB's interventions on the stock market pricing during the COVID-19 crisis was clearly positive.

4.4. Results Discussion

The results of the IV 2SLS approach enable us to examine the sensitivities of each of the top European stock market indices' prices to the changes in the ECB's balance sheet size, by first determining the effect of the latter on the German 10-year bond yields. In the case of the sovereign debt crisis, a one percent increase in the value of the ECB's balance sheet would lower the German bond yields by 0.9094 percent, while a one percent drop in the yields would lower the STOXX50, STOXX600, and Euronext100 prices by 0.5675, 0.2336, and 0.3466 percent, respectively. By definition, $lnX_t = \Delta X_t / X_t$ and $lnY_t = \Delta Y_t / Y_t$, then

$$\frac{lnX_t}{lnY_t} = \frac{\Delta X_t / X_t}{\Delta Y_t / Y_t} = \frac{\partial X_t}{\partial Y_t} \tag{6}$$

is the first derivative of X_t with respect to Y_t; then, the cross-elasticity with $lnZ_t = \Delta Z_t / Z_t$ would be

$$\frac{lnX_t}{lnZ_t} = \frac{\partial X_t}{\partial Y_t} \times \frac{\partial Y_t}{\partial Z_t} = \frac{\partial X_t}{\partial Z_t} \tag{7}$$

Hence, the cross-elasticity of the indices with respect to the central bank's balance sheet is as follows:

$$\frac{\partial index_t}{\partial ECBbs_t} = \frac{\partial GerYld_t}{\partial ECBbs_t} \times \frac{\partial index_t}{\partial GerYld_t} \tag{8}$$

Substituting with the regressions coefficients in Table 5, results in

$$\begin{aligned} \tfrac{\partial Stx50_t}{\partial ECBbs_t} &= (-0.9095) \times (0.5675) = -0.5161 \\ \tfrac{\partial Stx600_t}{\partial ECBbs_t} &= (-0.9094) \times (0.2336) = -0.2124 \\ \tfrac{\partial Nxt100_t}{\partial ECBbs_t} &= (-0.9094) \times (0.3466) = -0.3152 \end{aligned} \tag{9}$$

That is, a one percent increase in the ECB's balance sheet size during the sovereign debt crisis is associated with expected drops in the STOXX50, STOXX600, and Euronext100 prices by 0.5161, 0.2124, and 0.3152 percent, respectively. Translated into values, a one percent increase in the value of the ECB's balance sheet from its mean value of 2.299 trillion euros of about 23 billion euros lowers the German bond yield by 2.1 basis points from 2.320 to 2.299 percent. Consequently, this drop in the German yield is associated with a 0.5161, 0.2124, and 0.3152 percent decrease in the prices of STOXX50, STOXX600, and Euronext100, respectively. Table 7 summarizes the indices' price sensitivities to the value of the ECB's assets during the European sovereign debt crisis.

Table 7. Effect of the ECB's balance sheet size change on the European stock market indices' prices during sovereign debt crisis.

	ECB's Balance Sheet (mil. eur)	**GerYld (%)**	**Stx50 Price (eur)**	**Stx600 Price (eur)**	**Nxt100 Price (eur)**	**MsciEU Price (eur)**
Value in t_0	2,299,761	2.320	2269.41	257.580	646.412	-
Value in t_1	2,322,759	2.299	2257.70	257.030	644.370	-
ΔChange	22,998	−0.021	−0.5161%	−0.2124%	−0.3152%	-

Note(s): MsciEU was omitted as its data was not complete during the sovereign debt crisis. This table shows the expected percentage change in the value of the main European indices given a hypothetical one percent expansion of the ECB's balance sheet during the sovereign debt crisis. Source: authors' calculations.

In the case of the COVID-19 crisis, a one percent increase in the value of the ECB's balance sheet would lower the German bond yields by 0.3224 percent, while a one percent drop in the yields would lower the STOXX50, STOXX600, Euronext100, and MSCI Europe Small Cap prices by 1.3725, 1.3705, 1.6344, and 1.5724 percent, respectively. Recalling Equation (8) for the cross-elasticity of the index with respect to changes in the ECB's balance sheet and substituting with the regression coefficients in Table 6 result in

$$\begin{aligned}\frac{\partial Stx50_t}{\partial ECBbs_t} &= (-0.3224) \times (-1.3725) = 0.4425 \\ \frac{\partial Stx600_t}{\partial ECBbs_t} &= (-0.3224) \times (-1.3705) = 0.4419 \\ \frac{\partial Nxt100_t}{\partial ECBbs_t} &= (-0.3224) \times (-1.6344) = 0.5269 \\ \frac{\partial MsciEU_t}{\partial ECBbs_t} &= (-0.3224) \times (-1.5724) = 0.5069\end{aligned} \tag{10}$$

In other words, a one percent increase in the ECB's balance sheet size during the COVID-19 crisis is associated with expected surges in the STOXX50, STOXX600, Euronext100, and MSCI Europe Small Cap prices by 0.4425, 0.4419, 0.5269, and 0.5069 percent, respectively.

The effects of the expansion of the ECB's balance sheet on the prices of the European stock market indices during the COVID-19 crisis are presented in Table 8. Firstly, a one percent expansion in the value of the ECB's balance sheet from its mean value of 7.316 trillion euros by 73.167 billion euros is associated with a drop in the German bond yield of 0.1 basis points, from −0.319 to −0.320 percent. In turn, this decline in the German yield in response to the central bank balance sheet expansion is associated with an increase in the prices of the STOXX50, STOXX600, Euronext100 and, MSCI Europe Small Cap indices by 0.4425, 0.4419, 0.5269, and 0.5069 percent, respectively. Secondly, although the basis points drop in the yields is remarkably smaller than during the sovereign debt crisis, the expected rise in the value of all four indices is consistent during the COVID-19 crisis. These two facts may suggest the relevance of the yield levels in the effects obtained from one crisis to the other; while yield levels were still in black numbers during the sovereign debt crisis, they were negative through most of the COVID-19 crisis.

Table 8. Effect of the ECB's balance sheet size change on the European stock market indices' prices during the COVID-19 pandemic crisis.

	ECB's Balance Sheet (mil. eur)	GerYld (%)	Stx50 Price (eur)	Stx600 Price (eur)	Nxt100 Price (eur)	MsciEU Price (eur)
Value in t_0	7,316,740	−0.319	3715.76	417.990	1154.653	423.127
Value in t_1	7,389,907	−0.320	3732.20	419.840	1160.740	425.270
ΔChange	73,167	−0.001	0.4425%	0.4419%	0.5269%	0.5069%

Note(s): This table shows the expected percentage change in the value of the main European indices given a hypothetical one percent expansion of the ECB's balance sheet during the COVID-19 crisis. Source: authors' calculations.

4.5. Instrumental Variables Tests

To verify whether there are endogeneity problems between a stock index value and the variables considered in the models, the statistics for the Durbin–Wu–Hausman test (Hausman et al. 1987), which evaluates the consistency of estimators, for the STOXX600 as a plausible example are shown in Table 9. The p-values for the entire period and for each intervention are equal or close to zero. Hence, the null hypothesis of exogeneity is rejected at all standard significance levels. Therefore, there is an endogeneity problem among the variables, and the instrumental variables 2SLS approach is appropriate for this study.

Table 10 provides the results of the weak identification test for the STOXX600 index. The F statistic values exceed the critical values in the first two time periods. Therefore, the null hypothesis of weak instruments is rejected at all standard significance levels, proving high relevance of the chosen instruments (Stock and Yogo 2002). Although the Cragg–Donald Wald F statistic dropped considerably for the data during the COVID-19 crisis, the weak identification test for the longest data period is preferred to determine the strength of the instruments used in the models. Moreover, due to the fact that the last crisis was caused by a highly exogenous shock, the non-inclusion of such variable may weaken the instruments selected for the model specification in that particular period.

Table 9. Durbin–Wu–Hausman test for the STOXX600 index.

Tests of endogeneity H0: variables are exogenous		
Entire Period (from 2 April 2007 to 1 February 2023)		
Durbin (score) chi2(1)	15.2143	(p = 0.0001)
Wu-Hausman F(1,3932)	15.2461	(p = 0.0001)
Sovereign Debt Crisis (from 10 May 2010 to 6 September 2012)		
Durbin (score) chi2(1)	10.569	(p = 0.0012)
Wu-Hausman F(1,569)	10.6357	(p = 0.0012)
COVID-19 Crisis (from 26 March 2020 to 31 March 2022)		
Durbin (score) chi2(1)	98.0027	(p = 0.0000)
Wu-Hausman F(1,504))	119.597	(p = 0.0000)

Note(s): This table shows presence of endogeneity in the variables included in the models. The null hypothesis that all variables in the models are exogenous is rejected if there are large Chi2 and F values. Zero p-values indicate variables are endogenous. The models use the balance sheet as a control variable. Source: authors' estimations.

Table 10. Weak identification test for STOXX600.

Entire Period (from 2 April 2007 to 1 February 2023)		
Cragg–Donald Wald F statistic:		1291.361
Stock–Yogo weak ID test critical values	10% maximal IV size	16.38
	15% maximal IV size	8.96
	20% maximal IV size	6.66
	25% maximal IV size	5.53
Sovereign Debt Crisis (from 10 May 2010 to 6 September 2012)		
Cragg–Donald Wald F statistic:		1041.725
Stock–Yogo weak ID test critical values	10% maximal IV size	16.38
	15% maximal IV size	8.96
	20% maximal IV size	6.66
	25% maximal IV size	5.53
COVID-19 Crisis (from 26 March 2020 to 31 March 2022)		
Cragg–Donald Wald F statistic:		9.480
Stock–Yogo weak ID test critical values	10% maximal IV size	16.38
	15% maximal IV size	8.96
	20% maximal IV size	6.66
	25% maximal IV size	5.53

Note(s): This table shows lower S-Y weak ID test critical values than the C-D Wald F statistics in all intervention periods. Thus, rejecting the null hypothesis that the instruments used in the models are weak. If any of the C–D Wald F values are lower than S–Y critical values, there would be at least one weak instrument in the models for that period data. Source: authors' estimations.

4.6. Robustness Tests

The results of this study are robust to the inclusion of the generalized method of moments (GMM) for IV analysis. Tables 11 and 12 show the results of the GMM estimations during the sovereign debt and the COVID-19 crises, respectively. The results confirm that even though the robust standard errors for the GMM estimations are higher, the p-values are still highly statistically significant for the relevant instruments, such as the ECB's balance sheet to the German yields in the first stage regression and for the German yields to the selected index in the principal stage regression.

Table 11. Robustness test for STOXX600 (sovereign debt crisis).

First-stage regression						
	2SLS	**Std. Err.**	**P > |t|**	**GMM**	**Robust Std. Err.**	**P > |t|**
lnGerYld						
lnESTR	0.0380	0.0326	0.245	0.0380	0.0340	0.265
lnWTI	1.0326	0.0545	0.000	1.0326	0.0542	0.000
lnHICP	−0.1833	0.0437	0.000	−0.1833	0.0481	0.000
lnEurUsd	−0.2412	0.1723	0.162	−0.2412	0.1764	0.172
lnECBbs	−0.9094	0.0281	0.000	−0.9094	0.0265	0.000
_const	10.3621	0.4855	0.000	10.3621	0.4947	0.000
R-squared			0.8629			0.8629
F			717.76			831.50
Prob > F			0.0000			0.0000
Instrumental Variables (2SLS) and (GMM) regression GMM weight matrix: Robust						
	2SLS	**Std. Err.**	**P > |t|**	**GMM**	**Robust Std. Err.**	**P > |t|**
lnGerYld	0.2336	0.0229	0.000	0.2336	0.0216	0.000
lnESTR	−0.1736	0.0245	0.000	−0.1736	0.0254	0.000
lnWTI	0.5430	0.0430	0.000	0.5430	0.0377	0.000
lnHICP	−0.2369	0.0352	0.000	−0.2369	0.0330	0.000
lnEurUsd	0.9700	0.1246	0.000	0.9700	0.1374	0.000
_const	2.3413	0.1908	0.000	2.3413	0.1553	0.000
R-squared			0.6068			0.6068
Wald chi2			771.74			1336.02
Prob > chi2			0.0000			0.0000

Note(s): The models considered are the instrumental variables two-stage least squares (IV2SLS) and the generalized method of moments (GMM) using the central bank balance sheet size as main control variable tested for the sovereign debt crisis data period (from 10 May 2010 to 6 September 2012). Source: authors' estimations.

Table 12. Robustness test for STOXX600 (COVID-19 crisis).

First-stage regression						
	2SLS	**Std. Err.**	**P > |t|**	**GMM**	**Robust Std. Err.**	**P > |t|**
lnGerYld						
lnESTR	−3.1636	1.1568	0.006	−3.1636	1.1949	0.008
lnWTI	0.0882	0.0190	0.000	0.0882	0.0729	0.227
lnHICP	0.1659	0.0155	0.000	0.1659	0.0144	0.000
lnEurUsd	−0.7082	0.2991	0.018	−0.7082	0.3255	0.030
lnECBbs	−0.3224	0.1047	0.002	−0.3224	0.1041	0.002
_const	5.5766	1.5740	0.000	5.5766	1.4916	0.000
R-squared			0.6751			0.6751
F			209.83			192.78
Prob > F			0.0000			0.0000
Instrumental Variables (2SLS) and (GMM) regression GMM weight matrix: Robust						
	2SLS	**Std. Err.**	**P > |t|**	**GMM**	**Robust Std. Err.**	**P > |t|**
lnGerYld	−1.3703	0.4263	0.001	−1.3703	0.4549	0.003
lnESTR	−3.5363	0.9929	0.000	−3.5363	1.3188	0.007
lnWTI	0.1059	0.0408	0.009	0.1059	0.0809	0.191
lnHICP	0.3354	0.0645	0.000	0.3354	0.0771	0.000
lnEurUsd	0.7746	0.5909	0.190	0.7746	0.6400	0.226
_const	5.2672	0.4601	0.000	5.2672	0.6792	0.000
R-squared			0.2048			0.2048
Wald chi2			602.97			772.30
Prob > chi2			0.0000			0.0000

Note(s): The models considered are the instrumental variables two-stage least squares (IV2SLS) and the generalized method of moments (GMM) using the central bank balance sheet size as main control variable tested for the COVID-19 crisis data period (from 26 March 2020 to 31 March 2022). Source: authors' estimations.

5. Implications and Conclusions

Despite the same direction of the ECB's balance sheet's size effects on the German government bond yield during both the sovereign debt crisis and the COVID-19 crisis, the magnitude of these effects differed between interventions, supporting H4. In particular, during the sovereign debt crisis, this effect was larger but was associated with the negative changes in the prices of all three indices studied. On the contrary, the COVID-19 crisis showed a very small effect of the ECB's interventions on the German bond yields. However, the corresponding change in the bond yield was associated with the positive dynamics of the European stock market indices' prices. One possible explanation for this difference in effects is the level of the yields. Since yield levels in Europe were negative during the COVID-19 crisis, the European investors would have disregarded the Treasury securities as the opportunity cost of investing in risky securities such as stocks, a case that has not happened in the U.S. market yet. Besides this possible reason, other explanations based on rational expectations in relation to the theory of economic policy also emerge (Sargent and Wallace 1976; Shiller 1978). Under this reasoning, as the origin of the COVID-19 crisis was rather exogenous, expectations of changes in the monetary rules raised investors' awareness. Thus, investors may have taken the excess liquidity injected by the monetary authority through the debt markets (and subsequently available in the banking system) and invested it in the stock markets rather than supporting the real economy.

As for the indices sensitivities, the Euronext100 index experienced the highest price growth rate, followed by the MSCI Europe Small Cap index during the COVID-19 pandemic. The STOXX600 index's price had the lowest sensitivity to the ECB's UMP measures. During the sovereign debt crisis, STOXX50's price was the most sensitive to the ECB's balance sheet expansion, followed by Euronext100. Similar to the COVID-19 crisis period, the STOXX600 was the least affected by the ECB's interventions. These differences in the indices' sensitivities to the ECB's balance sheet then support H5.

Overall, the effects of the ECB's asset purchases were statistically significant but quite low during both considered crises. In other words, the ECB's expectations and goals to stimulate the economy in times of financial distress did not convert into large effects of the stock market in either interventions.

The empirical results show that increases in the ECB balance sheet as a consequence of large-scale purchases of government securities in Europe have mixed effects on the valuation of the major European stock indices. Although this research has proved that pricing in the debt market is directly affected by the size of the ECB balance sheet, it also validates that pricings in the debt market influence the pricing of equity securities in the long run, at least under the 2SLS for time-series analysis performed on the four most prominent European equity markets' benchmarks. Liquidity excesses from the ECB's interventions influence the pricing of European equity assets, as stated in H1.

The results also prove that European equity indices, as measures of stock market performance, have different sensitivities to the size of the ECB's balance sheet, and these sensitivities vary among the ECB's asset purchasing programs. That is, while the effects during the sovereign crisis were negative, those were positive during the COVID-19 pandemic crisis. Moreover, those effects ranged from -0.2124 percent for the STOXX600 to -0.5161 for the STOXX50 for each one percent change in the ECB's balance sheet expansion in the first intervention, while the effects had a narrow range during the COVID-19 response intervention, going from 0.4419 percent for the STOXX600 to 0.5269 percent for the Euronext100 index. Given the size and scale of the COVID-19 response intervention, these results are largely relevant.

Some limitations of this study stem from the fact that this work focuses on identifying the effects on the trends of a particular market, such as the European market. The integration of other relevant markets (e.g., the U.S. and Asia) would considerably help decompose the effects identified here. Future research should focus on the understanding of the effects of such interventions by economic sector or by industry in Europe.

This research contributes to the understanding of financial asset valuations under unconventional monetary policies by investors within some financial markets, especially during exogenous crises resulting from pandemics such as the COVID-19 outbreak.

Author Contributions: Conceptualization, C.J.R. and A.V.P.; methodology, C.J.R.; software, C.J.R.; validation, C.J.R. and A.V.P.; formal analysis, C.J.R. and A.V.P.; investigation, A.V.P.; resources, C.J.R.; data curation, A.V.P.; writing—original draft preparation, A.V.P.; writing—review and editing, C.J.R.; visualization, C.J.R.; supervision, C.J.R.; project administration, C.J.R. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Informed Consent Statement: Not applicable.

Data Availability Statement: The data that support the findings of this study are available from the European Central Bank (ECB) datasets website https://data.ecb.europa.eu/data/datasets (accessed on 28 December 2023) and monetary policy website https://www.ecb.europa.eu/mopo/html/index.en.html (accessed on 28 December 2023).

Conflicts of Interest: The authors declare no conflicts of interest.

Appendix A

Table A1. Raw data summary statistics (from 2 April 2007 to 1 February 2023).

Variable	Obs	Mean	Std. Dev.	Variance	Min	Max	Skewness	Kurtosis
Stx50	3972	3222.931	564.207	318,329.70	1809.98	4557.57	0.144	2.536
Stx600	3973	338.033	70.105	4914.64	158.00	494.35	−0.186	2.330
Nxt100	3986	892.272	214.224	45,892.06	434.61	1388.09	0.159	2.205
MsciEU	2655	337.738	75.663	5724.90	175.29	510.30	0.052	2.714
ECBbs *	3986	3,668,832	2,199,969	4.84×10^{12}	1,157,534	8,835,987	1.088	3.066
GerYld	3980	1.405	1.492	2.23	−0.854	4.687	0.536	2.103
ESTR	3986	0.427	1.333	1.78	−0.593	4.601	1.945	5.618
HICP	3986	1.947	2.114	4.47	−0.600	10.60	2.144	8.075
EurUsd	3986	1.243	0.137	0.019	0.959	1.599	0.347	2.214
WTI	3952	58.075	16.445	270.441	−34.644	116.19	0.267	3.211

* In millions of euros. Source: ECB datasets (https://data.ecb.europa.eu/data/datasets, accessed on 28 December 2023); Yahoo Finance (https://finance.yahoo.com/, accessed on 28 December 2023); author's calculations.

Table A2. Correlation matrix (sovereign debt crisis).

	lnStx50	lnStx600	lnNxt100	lnMsciEU	lnECBbs	lnGerYld	lnESTR	lnHICP	lnEurUsd	lnWTI
lnStx50	1.0000									
lnStx600	0.8396 *	1.0000								
	0.0000									
lnNxt100	0.9582 *	0.9444 *	1.000							
	0.0000	0.0000								
lnMsciEU	0.9256 *	0.9360 *	0.9336 *	1.000						
	0.0000	0.0000	0.0000							
lnECBbs	−0.6995 *	−0.2797 *	−0.5408 *	−0.0238	1.0000					
	0.0000	0.0000	0.0000	0.8796						
lnGerYld	0.8492 *	0.5447 *	0.7322 *	0.7104 *	−0.8730 *	1.0000				
	0.0000	0.0000	0.0000	0.0000	0.0000					
lnESTR	0.2044 *	−0.0284	0.1139	−0.3955	−0.5986 *	0.5098 *	1.0000			
	0.0000	0.4925	0.0055	0.0087	0.0000	0.0000				
lnHICP	−0.3715 *	−0.1012	−0.2710 *	0.7722 *	0.3292 *	−0.2174 *	0.3368 *	1.0000		
	0.0000	0.0141	0.0000	0.0000	0.0000	0.0000	0.0000			
lnEurUsd	0.3658 *	0.2389 *	0.3343 *	0.6924 *	−0.5760 *	0.5526 *	0.7983 *	0.4318 *	1.0000	
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000		
lnWTI	−0.1694 *	0.2460 *	−0.0184	0.8501 *	0.5915 *	−0.2757 *	−0.2289 *	0.6254 *	−0.0235 *	1.0000
	0.0000	0.0000	0.6595	0.0000	0.0000	0.0000	0.0000	0.0000	0.5731	

Note(s): * denotes coefficients significant at 0.1%. Source: own calculations.

Table A3. Correlation matrix (COVID-19 crisis).

	lnStx50	**lnStx600**	**lnNxt100**	**lnMsciEU**	**lnECBbs**	**lnGerYld**	**lnESTR**	**lnHICP**	**lnEurUsd**	**lnWTI**
lnStx50	1.0000									
lnStx600	0.9920 *	1.0000								
	0.0000									
lnNxt100	0.9925 *	0.9975 *	1.000							
	0.0000	0.0000								
lnMsciEU	0.9844 *	0.9836 *	0.9841 *	1.000						
	0.0000	0.0000	0.0000							
lnECBbs	0.9241 *	0.9452 *	0.9464 *	0.9265 *	1.0000					
	0.0000	0.0000	0.0000	0.8625						
lnGerYld	0.5617 *	0.6007 *	0.5982 *	0.5181 *	0.6290 *	1.0000				
	0.0000	0.0000	0.0000	0.0000	0.0000					
lnESTR	−0.8825 *	−0.9080 *	−0.9073 *	−0.8878 *	−0.9609 *	−0.6479 *	1.0000			
	0.0000	0.9498	0.0010	0.0095	0.0000	0.0000				
lnHICP	0.7934 *	0.8443 *	0.8353 *	0.7715 *	0.8242 *	0.8056 *	−0.8188 *	1.0000		
	0.0000	0.0061	0.0000	0.0000	0.0000	0.0000	0.0000			
lnEurUsd	0.2842 *	0.2041 *	0.2251 *	0.3405 *	0.1823	−0.2928 *	−0.1409	−0.2617 *	1.0000	
	0.0000	0.0001	0.0000	0.0000	0.0108	0.0000	0.0012	0.0000		
lnWTI	0.6912 *	0.7119 *	0.7121 *	0.6856 *	0.7548 *	0.6060 *	−0.7332 *	0.6835 *	0.0645	1.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.1452	

Note(s): * denotes coefficients significant at 0.1%. Source: own calculations.

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