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Assessing the Impact of Federal Reserve Policies on Equity Market Valuations: An Instrumental Variables Approach

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Abstract: This study investigates the impact of Central Bank interventions on the pricing dynamics of select stock markets. The research utilizes the instrumental variables three-stage least square (3SLS) model approach. It analyses the effects of variations in the Federal Reserve's balance sheet size across three distinct intervention scenarios: the 2008–2013 Great Recession, the 2020–2021 COVID-19 pandemic periods, and an overarching analysis spanning these timelines. Our methodology includes estimations of the Seemingly Unrelated Regression Equations (SURE), and the results are robust under the two-step Generalized Method of Moments (GMM). Our findings indicate that changes in the size of the Fed's balance sheet correlate significantly with the pricing of principal U.S. equity market indices. This correlation reflects a time-dependent effect emanating from the Fed's balance sheet expansion, marking a growing divergence between the adaptability of pricing mechanisms in equity and debt markets. Notably, the Federal Reserve's interventions during the COVID-19 crisis are associated with an increase of approximately 0.0403 basis points per billion in treasury yields. This research makes a significant contribution to the understanding of financial asset pricing, particularly by elucidating the extent to which interventions in government debt securities engender price distortions in certain equity markets.

Keywords: Fed's balance sheet; great recession; instrumental variables; quantitative easing; tapering; COVID-19

JEL Classification: E50; G12; G18; H12

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1. Introduction

In response to the 2007 financial crisis, the Federal Reserve (Fed) implemented a number of programs, including policies to uphold liquidity of financial institutions and the stability of financial markets (Federal Reserve 2021a). Although these crisis-response programs have ended, the Fed continues to take action to meet relevant monetary policy objectives such as high employment and price stability. Many of these actions have involved substantial purchases of long-term securities over recent years, with the objective of maintaining long-term interest rates as low as possible and facilitating overall financial conditions. The immediate response to the crisis started with the implementation of programs that provided short-term liquidity to financial institutions, as well as programs that provided liquidity directly to borrowers and investors in key credit markets, for the first few years that followed the crisis. Then, afterwards, in addition to those programs, the Fed expanded its open market operations monetary tool to bolster credit markets' activity in order to maintain long-term interest rates as low as possible, and to help make broader financial conditions more stable through the purchase of long-term securities. That is when, in late

November 2008, the Federal Reserve started buying USD 600 billion in mortgage-backed securities (MBS). By March 2009, it held USD 1.75 trillion of bank debt, mortgage-backed, and Treasury securities, reaching a height of USD 2.1 trillion by June 2010. In November 2010, the Fed announced a second round of quantitative easing (QE)[1], buying USD 600 billion of Treasury securities by mid-2011. Nonetheless, starting in September 2012, the Federal Open Market Committee (FOMC) increased the Fed's purchases of agency-guaranteed MBS at a pace of USD 40 billion per month in order to support a stronger economic recovery, but most specially, to help ensure price stability over time. Then, starting in January 2013, the monthly purchase of long-term Treasury securities increased to USD 45 billion, in addition to the MBS purchases, for a total of USD 85 billion monthly. However, starting in January 2014, following signs of economic recovery, the FOMC started gradually reducing the pace of those asset purchases, at a rate of USD 10 billion per month, and finally ending them by October 2014 (Federal Reserve 2021b).

The Fed started to intervene in the U.S. credit markets again in the spring of 2020 in response to the financial distress caused by the outbreak of COVID-19. The central bank implemented actions to stimulate the economy by intervening in the debt markets, understanding their crucial role in the credit flow within the economy as major sources of liquidity. The Fed then started the large-scale purchases of debt securities again, a tool heavily employed during the Great Recession. That is when, in March of 2020, the Fed announced the purchase of at least USD 500 billion in Treasury securities and USD 200 billion in government-guaranteed MBS over the months that followed, a decision that was changed shortly after to monthly amounts as required to support smooth market operations (Federal Reserve 2020). In June 2020, the Fed set the amount of these purchases to at least USD 80 billion per month in Treasuries and USD 40 billion in mortgage-backed securities, conditional on the progress of the economy with regard to the Fed's goals of price stability and minimum unemployment.

On 3 November 2021, the Fed announced cuts of USD 15 billion per month, USD 10 billion in Treasuries, and USD 5 billion in MBS from the monthly USD 120 billion that the Fed was buying at the time, expecting to end them by July 2022 (Cox 2021). This decision was the result of observing the recovery of economic activity and employment figures in the U.S. economy, as well as progress on the COVID-19 vaccinations after the breakout of the virus in February of 2020 (Federal Reserve 2021c). At the time of this decision, the federal funds rate was at its lowest level of 0.25 percent and the 10-year treasuries were trading at yields near 1.5 percent throughout 2021, for which the continuation of the central bank's active intervention was no longer required. Moreover, the stock market indices showed solid proof of recovery from the bottom levels of 2020 at the midst of the pandemic outbreak. While the Dow Jones Industrial Average (DJIA) and NASDAQ composites had completely cleared all losses from the pandemic, the S&P 500 was quoting at its maximum historical levels. However, in December 2021, the Fed accelerated the tapering by reducing its purchases by USD 20 billion and USD 10 billion, respectively, as signs of rising inflation emerged (Federal Reserve 2021d).

Although the 2021 tapering had begun, market health indicators continued to improve, reminding us of the times after the first tapering employed to support the economy during the Great Recession. However, this time would be different, as unexpected side effects developed such as the inflation outbreak. While a lack of inflation was a concern to investors back in 2013–2015, the Fed was now facing rising inflation to levels not seen in the last forty years. Figure 1 shows the performance of the 10-year treasury yields as the main indicator of the effects in the credit market interest rates in direct connection to the securities purchased by the central bank. The Fed's purchases increased its balance sheet, maintaining the yields lower than 1 percent while also lowering the federal funds rate to 0.25 percent in the spring of 2020. The figure also shows how the U.S. Consumer Price Index CPI escalated through the COVID-19 QE program in comparison to the various QE programs implemented in connection to the previous credit crisis. While high inflation was not a concern in 2013 at the beginning of the first tapering with this rate well below 2 percent, inflation reached levels of 8.5 percent in early April of 2022. Perhaps the size of the last QE may explain such a rise in such a short period. However, with a much larger debt market size, larger securities purchases were required in order to keep pressure away from treasury yields, which was, indeed, well accomplished by the Fed.

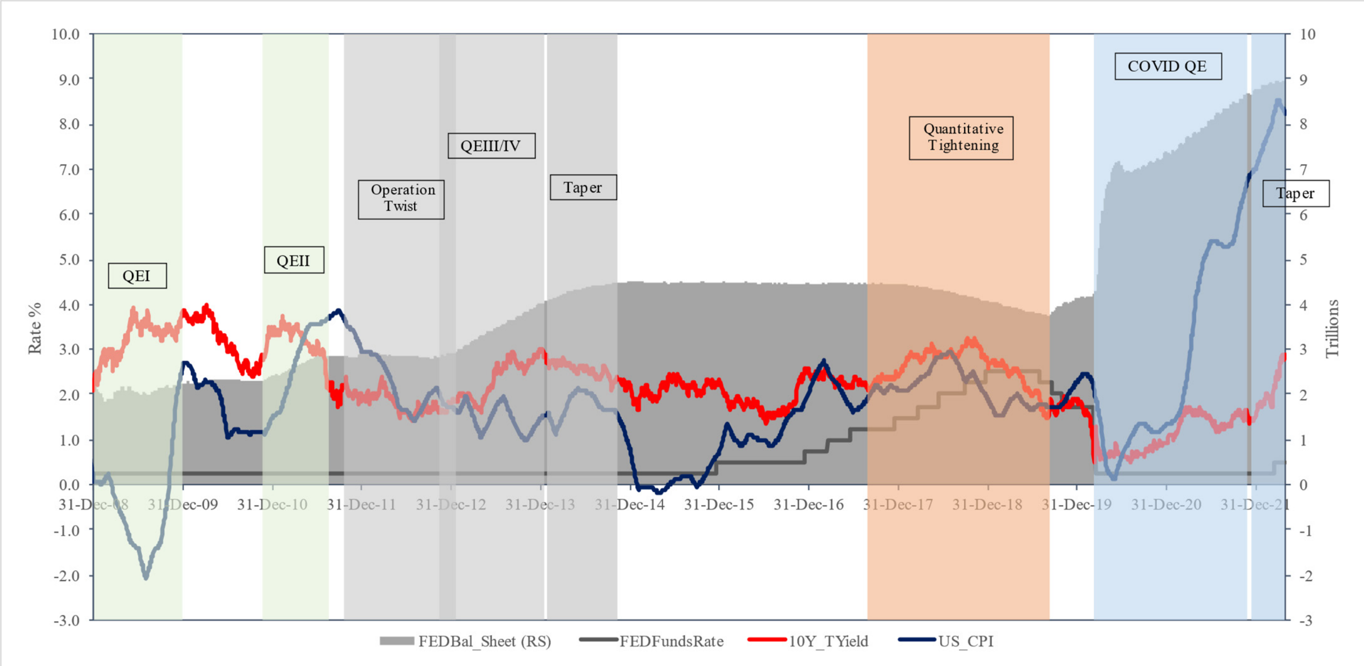

Figure 1. Fed balance sheet, interest rates, and inflation (from 16 December 2008 to 29 April 2022). Source: author's work based on the EIKON Refinitiv database.

While the credit market was being stimulated, so were the equity markets. It is commonly expected that as lower costs of funds are available to businesses, economic activity flourishes. The investment public views this as better future prospects for businesses, hence the higher value of the companies. This rationale is typically reflected in the performance of the stock market indices. Figure 2 shows the performance of the four major U.S. indices: the Dow Jones Industrial Average (DJIA), the NASDAQ, S&P 500, and the Russell Small Cap 2000 (the SMLCAP 2000) from 16 December 2008 until 29 April 2022. Although all four indices display trends alike, they are not identical. For instance, while the DJIA and the S&P 500 mimic each other, the SMLCAP 2000 and NASDAQ differ slightly in the past QEs. Moreover, although all four indices completely recovered all losses from the COVID-19 correction, the first two slightly diverged in the summer of 2021, and the other two tended to match in early 2021, however they diverged again thereafter.

Key recent moments in the indices' trajectories are worth analyzing. Take the S&P 500, for example, it quoted its maximum historical value of 4796.56 on 2 January 2022, returning some 42 percent before the COVID-19 correction when it traded at 3386.15 on 19 February 2020, and at 114 percent from 2237.4 at the bottom of the pandemic crisis on 23 March 2020. Even though, the difference in the performance of each index relies on the way each index is constructed (that is, the number, type, and size of firms that constitute each index), it is reasonable to conclude that the stock market came out stronger from both crises under analysis in this research.

Figure 3 shows the performance of the S&P 500 in comparison to the evolution of the Fed's balance sheet. Peculiarly, the trajectory of the S&P 500 suggests mimicking that of the Fed's balance sheet. Moreover, this relationship grows over time. By measuring the difference between the index level and that of the Fed's balance sheet at the beginning of the tapering of 2013 and the COVID-19 tapering of 2021 using an exponential regression analysis of both series, the dotted lines show that the spread widens over time. This visualization suggests a possible cumulative effect of the central bank balance sheet growth on the index valuation. Hence, it is possible to infer that the index valuation may have been priced at levels far different from its fundamental values, had the Fed's balance sheet remained unused.

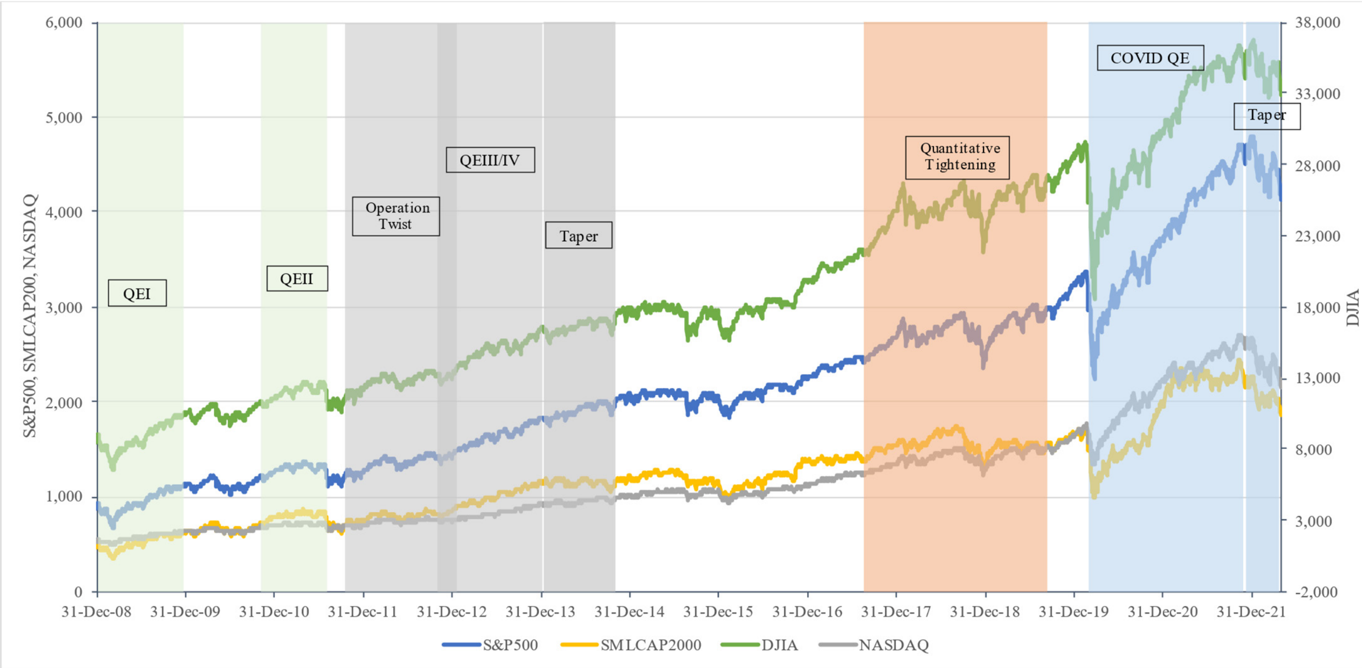

Figure 2. Performance of main U.S. indices (from 16 December 2008 to 29 April 2022). Source: author's work based on the EIKON Refinitiv database.

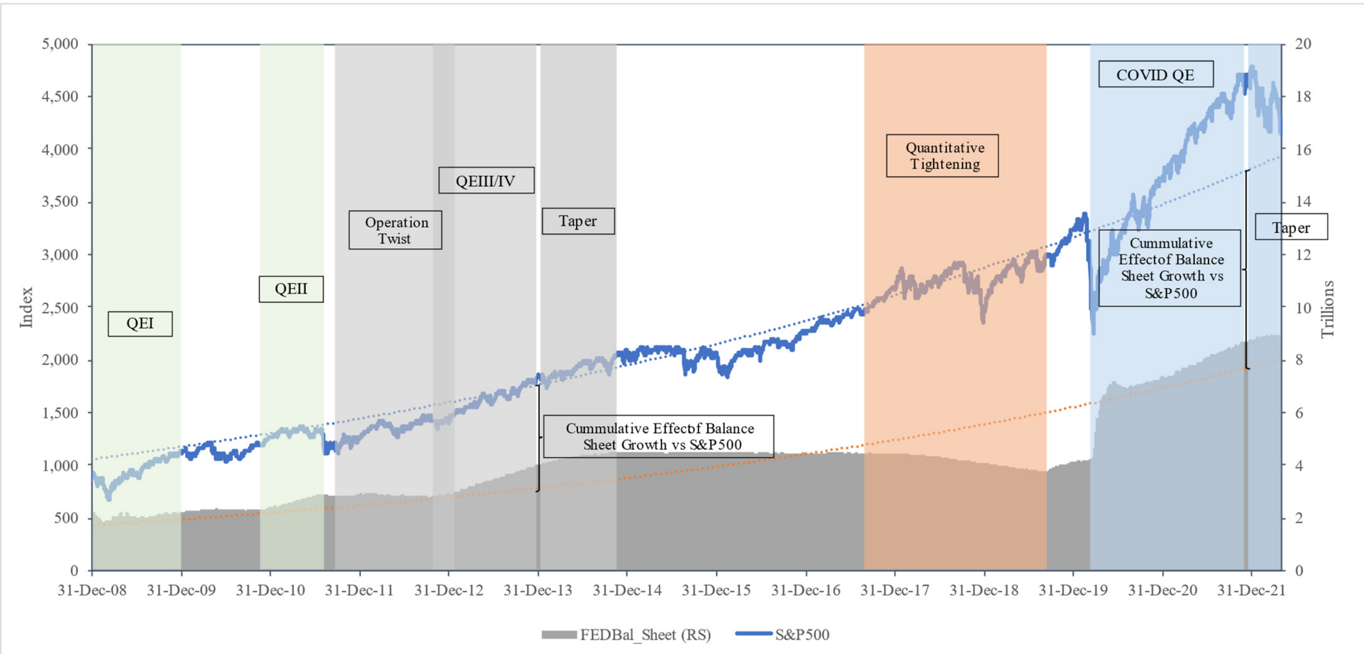

Figure 3. Fed balance sheet and S&P 500 index (from 16 December 2008 to 29 April 2022). Source: author's work based on the EIKON Refinitiv database.

Price distortions in financial assets pricing refer to mark-to-market prices substantially far from a plausible range of the economic values of those assets. Similar to market failures, price distortions derive from the mispricing of financial assets relative to their fundamental value (Vukovic et al. 2021). In the context of this study, we identify that the

Fed's intervention on the credit market via the purchase of government debt securities in the 2008–2013 and the 2020–2021 periods made the value of the majority of stocks in the U.S. equity market to be priced at levels significantly different from their fundamental values.

The goal of this research is to ascertain the influence of the Federal Reserve's purchases of government securities on the pricing of stocks within major U.S. indices. This study investigates the extent of any resultant price distortions and their magnitudes. Utilizing the credit market interventions of 2008–2013 and 2020–2021 in the U.S. as a quasi-natural experiment, our paper explores the potential impact of government interventions in credit markets on the pricing of equity securities. The analysis incorporates daily trading data from the DJIA, S&P 500, the NASDAQ, and the SMLCAP 2000 indices in the U.S. equity market, spanning from 16 December 2008 to 29 April 2022. This period encompasses the Great Recession and the COVID-19 crises. The research addresses crucial questions: Do central bank interventions, such as QE or its tapering, in government securities within the credit markets affect the pricing of equity securities? If so, what is the significance of these effects?

To respond to these inquiries, the study employs the Instrumental Variables (IV) Three-Stage Least Squares (3SLS) method. Findings from this research may carry policy implications, suggesting that when policymakers seek to reduce financing costs in capital markets during financial distress through market interventions, the investment public considers the enduring effects on the pricing of financial assets, including those not directly targeted by the interventions. This could have implications for the efficient allocation of resources in the future.

Consequently, the novelty of our study lies in identifying the structural, long-term effects of such interventions, as opposed to the existing literature's focus on short-term, impulse-response analyses. That is, our study identifies the trends rather than the instant effects of the variables involved in the valuation of equity indices in the U.S. market. To achieve this, the study utilizes advanced long-term identification models like the IV 3SLS, corroborated further by Seemingly Unrelated Regression Equations (SURE) and the Two-Step Iterated Generalized Method of Moments (GMM) to estimate trends instead of short-term impulse-response estimations of other methods such as structural VAR. Hence, our estimations aim to go a step further than short-term valuations. Our research makes a significant contribution by thoroughly examining the influence of central bank interventions in government debt securities amidst major economic downturns. This investigation reveals pronounced price distortions within principal U.S. equity markets. It unveils novel insights regarding the discrepancy in adaptability between equity market pricing and the dynamics of the debt market, underscoring the ongoing impact of central bank policies on the valuations of equity over time. Furthermore, this study provides imperative policy implications. It underscores the necessity for policymakers and the investment public to acknowledge the long-term consequences on the pricing of financial assets. This consideration is crucial to mitigate the risk of fostering inefficient valuations in assets during future implementations of market interventions.

This paper is divided into seven sections, including this introduction. In Section 2, we review the existing literature related to the key factors and variables to consider in the proposed methodology of the study, develop its theoretical framework and hypotheses. In Section 3, we develop the methodological framework and its empirical models, relying on the instrumental variables approach. In Section 4 we present the empirical results, and a thorough discussion about the key results of our modeling are outlined in Section 5. In Section 6, we discuss the results one step further and develop several key implications regarding the dynamics of these results. Finally, in Section 7, we draw the conclusions of our study.

2. Literature Review

2.1. Complex Dynamics of Government Interventions: Monetary Policy Impacts on Asset Prices and Financial Markets

The task of estimating the effects of government interventions (Samuelson 1954), via changes in monetary policy, on asset prices may be rather complex due to the endogeneity of policy implementations, on the one hand, and because interest rates and asset prices are influenced by multiple other variables on the other. Rigobon and Sack (2004) have indicated that an increase in short-term interest rates generates a decline in stock prices and an upward shift in the yield curve. However, that shift becomes smaller for longer maturities. Their findings also suggest that, due to some biases, the estimated effects on treasury yields are rather large, while too small on stock prices. Moreover, Bernanke and Kuttner (2005) have shown that, on average, an unexpected 25 basis points cut in the Fed funds target rate may be associated with an approximate 1% rise in stock market indices. They also found that the effects of unforeseen monetary policy actions on expected excess returns may add to most of the stock price response.

Regarding the study of equity premiums, the work of Fama and French (2002) pointed out that the average stock return for the period 1951 to 2000 was much higher than expected as their evidence suggested that the high average return for that period was due to declining discount rates that produced large, unexpected capital gains. In agreement with this view, this brings us to believe that any actions by the central bank that help steadily reduce the interest rate levels should translate into a larger equity premium (Cochrane 2005; Sharpe 1964).

Since the midst of the great recession (end of 2008), the target federal funds rate, the Fed's conventional policy instrument, had been at its lowest levels ever. As the economic prospects deteriorated, in an attempt to further ease its monetary policy, the Fed implemented an unconventional monetary policy (UMP) which primarily included a program of massive purchases of assets of medium and long maturities. Gagnon et al. (2011) presented evidence that those purchases led to economically meaningful and long-lasting reductions in longer-term interest rates on a range of securities, including securities that were not included in the purchase programs. In turn, those interest rate reductions reflected lower risk premiums in the fixed income markets, including long-term premiums. Consequently, Khemraj and Yu (2015) found evidence that QE stimulated the level of aggregate investment via the interest rate channel by narrowing the corporate bond spread to benchmark. In short, they found that the Fed's purchases of MBS had a high statistical significance effect on aggregate private investment.

Interestingly, Yildirim and Ivrendi (2021) found that U.S. UMP highly affects the financial conditions in emerging and advanced economies by modifying investors' risk premiums. This finding suggests that the risk-taking venue plays a crucial role in transferring the effects of these policies to the rest of the world. QE measures such as security purchases that lower the US mortgage spread translate into more significant spillover effects on international financial markets than those that reduce the US term spread.

Further works on government interventions have researched the effects of the discontinuation of such interventions on asset prices. Albu et al. (2016) suggested that both the QE policy and the gradual reduction of it ("Tapering") had relevant effects in terms of the volatility of the indices they analyzed. Furthermore, Chari et al. (2017) analyzed the impact of U.S. UMP on capital flows and asset prices in emerging markets. They found that U.S. monetary policy shocks represent revisions to the expected trajectory of short-term interest rates and the required risk compensation, with this risk compensation factor becoming especially important during UMP periods. They also suggested that the relative effects of U.S. monetary policy shocks are larger for emerging markets asset returns in relation to physical capital flows, and are larger for emerging equity markets relative to fixed income markets. Surprisingly, they found that these effects were larger when the Fed implemented a "tapering" or reduction of its asset purchase program.

Other academic literature has disputed the effects of central bank's balance sheet expansions on inflation. Moessner (2015) found no strong evidence that announcements about expansions of the European Central Bank (ECB) balance sheet lead to higher inflation expectations. However, Boeckx et al. (2014) affirmed that inflation in Europe could have been 1 percent lower in 2012, had the LTRO programs not been implemented by the ECB. Perera et al. (2013), on the other hand, found that inflation and central bank's balance sheet size were negatively associated, especially in the presence of other determinants of inflation in their modeling. In line with this, Cochrane (2018) suggested that inflation could be low and stable when nominal interest rates are near zero, to the extent that a larger interest-paying balance sheet can be maintained indefinitely.

Other studies, however, reveal links between interest rates and exchange rates. Moreover, further research has suggested ties of both rates to oil prices. For instance, Krugman and Obstfeld (2006) indicated that increases in a country's money supply cause its currency to weaken in the foreign exchange market, as the former decreases the interest paid on deposits of that currency. Also, Krugman (1980) suggested that the short- and long-term effects of oil price changes on currency may go in opposite directions. That is, oil price increases will initially lead to a dollar appreciation and eventually depreciate. While Amano and van Norden (1995) pointed out that oil prices best capture exogenous terms-of-trade shocks that are crucial in currency price determination in the long run, and Beckmann et al. (2020) confirmed that links between exchange rates and oil prices are strong, however these links are frequently observed over the long-run.

Curiously, Fratzscher et al. (2013) revealed that the U.S. dollar, oil prices, and equity market returns are strongly linked mostly due to the rising use of oil as a financial asset. Moreover, Mokni (2020) found evidence of country time-varying reactions of stock returns to oil shocks. In general, oil demand shocks impact positively on the oil-exporting stock returns and negatively on oil-importing countries. In addition, stock returns react more to demand-side oil shocks over supply-side shocks, with a positive effect on almost all stock returns in the first, while negative and modest in the latter case. Degiannakis et al. (2018) found that the effect of oil prices on stock prices is merely in terms of volatility. That is, as volatility in the oil prices increases, so would the stock prices' volatility.

Another aspect to consider are market structures, price levels, and liquidity issues that may condition the magnitude and direction of the above-discussed effects in the financial markets. For example, Rocheteau et al. (2018) stated that injecting money via open market operations is different than transfers form fiscal policy, and that under various market structure specifications and asset liquidity, negative nominal yields and liquidity traps can emerge. Hommes et al. (2019) revealed adaptive learning effects of interest rates near the zero lower bound turning monetary policy alone not enough to prevent liquidity traps. Duly, Cochrane (2017), Guerrieri and Lorenzoni (2017), and Korinek and Simsek (2016) share the finding that liquidity traps are often present when interest rates are near the zero lower bound. Nonetheless, Acharya and Bengui (2018) asserted that capital flows reduce inefficient fluctuations of asset prices by adjusting the exchange rate, for which restricting capital mobility curbs such an adjustment. Moreover, terms-of-trade manipulations drive countries to inefficiently restrict capital flows, causing price distortions.

Several studies have assessed the UMPs' transmission effects on financial markets. Their methodologies rely mostly on Vector Autoregressive (VAR), pooled Ordinary Least Squares (OLS), and event-study approaches, including during the COVID-19 crisis for the U.S., Europe, China (D'Amico and Seida 2024; Herradi and Leroy 2023; O'Donnell et al. 2024), India (Rao and Kumar 2023), and Thailand (Schrank 2024). In order to find evidence that supports the hypotheses of this study, the instrumental variables approach was employed. Different strategies may be used under this approach, though. Jiang (2019) and Vukovic et al. (2021) used this approach under the two-stage least squares (2SLS) method to estimate the effects of government and currency dis-interventions on the risk premiums in the fixed income markets. However, given the complexity and how highly interconnected financial markets have become, resemble simultaneity of estimations in different markets at once. Hence, a 3SLS method, first proposed by Zellner and Theil (1962), and further developed by (Fisher 1970) and Hausman et al. (1987), provides appropriate solutions for tackling biases and endogeneity issues, but specially the simultaneity in causalities, allowing us to link several market clearings at the same time in different moments.

Although further academic research has been devoted to the effects of the large-scale purchases of treasury securities by the Fed, these effects revolve around the pricing of debt securities and interest rates. Prominent contributions in this area come from D'Amico and King (2010), D'Amico et al. (2012), Doh (2010), and Hamilton and Wu (2012), among others. The literature linking these effects to the equity markets' pricing, however, is rather tangential to the present day, especially given how recently the last crisis took place. Vukovic et al. (2019) found changing effects on the bond pricing dynamics before and after the economic crisis in the European market for the 2005–2017 period that may give hints of probable changing effects on the pricing of bond securities during the COVID-19 crisis as well (Chen et al. 2021). This research not only pursues the findings of such links and effects, but also tests the empirical methods available and contribute to filling the research gap in these spheres.

2.2. Theoretical Framework

Structurally speaking, the value of a given equity index is influenced by the quotations of the stocks that compose the index. Hence, the performance of the holdings within the index will determine the trends of it. As the companies weighted within the index prosper, so would the performance of its stock. Most firms depend highly on low-cost funding to carry on with their business objectives to become more profitable. Accordingly, as lower cost funds are made available to firms, the more able they are to reinvest them into their activity, thus creating higher value for the company, which in turn is reflected in a higher value of its stock, and ultimately contributes to a higher value of the index of which they are part. Moreover, as low-cost funds become available through the banking system, the faster the transmission of those funds to the firms is. These arguments, and based on the literature discussed above, lead a conclusion about the relevance of the treasury yields (*t_yield*) and the Federal Funds rate (*Fed_FRate*) on the index's expected performance. Moreover, the value of key commodities such as oil and gas, as well as of other inputs, aggravate the costs of most enterprises (Peersman et al. 2021). Furthermore, imported inputs add to the list of costs that may expand with a weaker local currency. Consequently, price indicators such as oil prices (*wti_spot*), consumer price indices (*us_cpi*), and exchange rates (*usd_eur*) must be considered in the index performance analysis. Finally, measures of risk for investing in risky assets must be considered as well, as signs of unexpected risks in the markets tend to make investors reduce their positions in assets within the index, driving it down. This last factor is best captured by volatility indices such as the (*vix*). Accounting for all these factors in a time series setting, the value of a given equity index function (1) can be expressed as follows:

$$Index_t = f\,(t\_yield_t,\ Fed\_FRate_t,\ wti\_spot_t,\ us\_cpi_t,\ usd\_eur_t,\ vix_t) \tag{1}$$

Throughout the period under analysis, as learnt from the literature, the treasury yield rate is influenced by the size of the central bank balance sheet, as it expands as the treasury securities are purchased by the Fed. Additionally, given the size of the U.S. treasuries market, changes in the treasury rate drives the value of its currency as well. In this study we describe how the dynamics of an equity index in the U.S. are influenced by the dynamics in the central bank balance sheet through its impact on the treasury yields. Moreover, the dynamics of its currency value are influenced by those of treasury yields and the oil prices due to the large international exchange of this commodity (Amano and van Norden 1995; Beckmann et al. 2020; Fratzscher et al. 2013; Krugman 1980; Mokni 2020).

In particular, following Krugman and Obstfeld (2006), the relationship between the treasury yields and the central bank's balance sheet may be described by a function with a negative slope in the money market, such as that displayed on the left-hand side of Figure 4.

In this figure, the yields are shown on the vertical axis, and the size of the balance sheet is located on the horizontal axis on the left-hand side, where a rise in the Fed's balance sheet from B-S_0 to B-S_1 is associated with a drop in yields from Y_0 to Y_1.

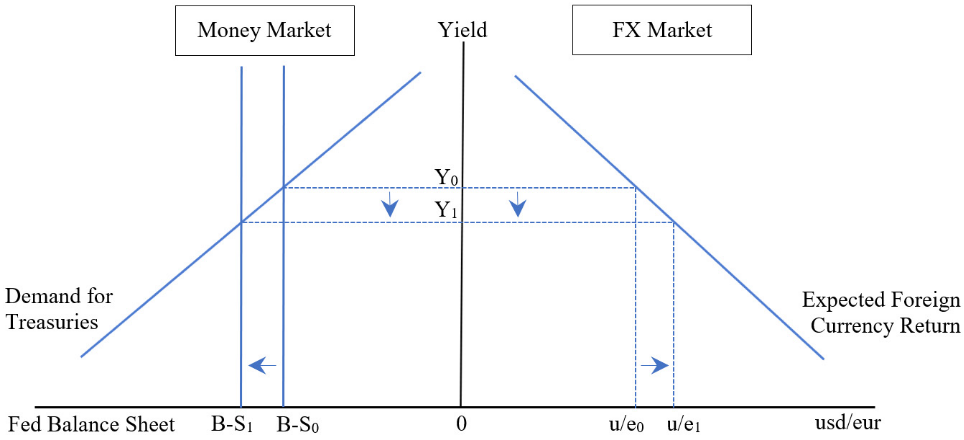

Figure 4. Treasury yields and dollar/euro exchange rate as a function of Fed's balance sheet. Source: own estimations.

Simultaneously, as foreign investors add to a portion of the demand for treasuries, the foreign capital flows of arbitrage pressure the currency price to maintain the interest rate parity (Krugman and Obstfeld 2006). Hence, a function of expected foreign currency returns against yields with a negative slope in the foreign exchange market is also supported, such as that displayed on the right-hand side of Figure 4. In this chart, the yields are also shown on the vertical axis, and the currency price is shown on the horizontal axis, where the drop in the yields from Y_0 to Y_1 is associated with a rise in the currency price from u/e_0 to u/e_1.

Under the above assumptions and mechanisms, the following hypotheses emerge, on which this paper will offer evidence:

H1: *Excess liquidity from interventions leads to the overpricing of equity assets. The results of our regressions will show that, although the estimations of long periods of data are quite reliable, there is a larger effect as the data periods become much larger (Brana and Prat 2016).*

H2: *The pricing in the debt market is directly affected by the size of the Federal Reserve's balance sheet. In line with Krugman and Obstfeld (2006), our models show the exact effects of the Fed's UMP on the treasury yields, a necessary condition (not sufficient) to prove H1.*

H3: *The pricing in both the debt market and currency market, potentially influenced by Federal Reserve interventions, affects the pricing of equity securities in the long run.Also in line with Krugman and Obstfeld (2006), our models show the simultaneous effects of the Fed's UMP on the treasury yields and the currency exchange rate, necessary conditions to prove H1.*

H4: *There exists a divergence in adaptability between equity pricing and debt market pricing. Although the links among the four variables discussed in H1, H2, and H3 are identified, the adaptability of each market differs as the agents in each react differently.*

H5: *Although similar types of monetary interventions were implemented in two different crisis periods, different effects were observed. That is, our results identify opposite effects even though the same monetary tools were used during the great recession compared to the COVID-19 crisis.*

3. Methodological Framework

3.1. The Data

This study employs daily data from major financial indices—the DJIA, S&P 500, NASDAQ, and the SMLCAP 2000—as well as the Federal Reserve's balance sheet size, the federal funds interest rate, and the yields of 10-year treasury bonds. Additionally, it incorporates other pertinent data, including the USD/EUR currency exchange rate, WTI oil spot prices, the Volatility Index (VIX), and the Consumer Price Index (CPI) for inflation. We employ VIX to forecast the anticipated market volatility over the ensuing 30-day period. This index is computed by the Chicago Board Options Exchange, and it derives its calculation from the implied volatilities of numerous options within the S&P 500 index. The temporal scope of the data extends from 16 December 2008 to 29 April 2022, encompassing periods of both central bank interventions and dis-interventions. All data have been sourced from the EIKON Refinitiv (2022) database. A comprehensive summary of the statistics for all data variables is presented in Table 1.

Table 1. Summary descriptive statistics for all variables (from 16 December 2008 to 29 April 2022).

Variable	Obs	Mean	Std.Dev.	Min	Max	Variance	Skewness	Kurtosis
SP500	3366	2210.98	981.02	676.53	4796.56	962,396.9	0.77631	2.91983
DJIA	3366	19,267.45	7585.67	6547.05	36,799.65	57,500,000	0.53529	2.31663
NASDAQ	3366	5869.56	3670.72	1268.64	16,057.44	13,500,000	1.11896	3.39836
SMLCAP 2000	3366	1220.94	472.38	343.26	2442.74	223,147.1	0.51269	2.71154
Fed_BalSht	3366	4.2554	1.7627	1.8434	8.9650	3.106988	1.12002	3.68414
lag1d_Bal_Sh	3365	4.2540	1.7611	1.8434	8.9650	3.101389	1.12016	3.68722
lag1w_Bal_Sh	3361	4.2484	1.7547	1.8434	8.9650	3.078825	1.12061	3.69917
Fed_FRate	3366	0.6326	0.6877	0.250	2.500	0.472965	1.64255	4.22399
t_yield	3366	2.2673	0.7317	0.499	3.994	0.535385	−0.06953	2.71556
usd_eur	3366	0.81961	0.07531	0.6605	0.9627	0.005672	−0.15913	1.74796
wti_spot	3366	68.8356	23.1513	7.79	126.47	535.981	−0.08693	2.23274
us_cpi	3366	1.9182	1.6700	−2.10	8.56	2.788834	1.36117	6.63550
vix	3366	19.3887	8.2991	9.140	82.690	68.875	2.04447	9.36145

Note(s): This table presents the dataset key statistics. Symmetric distributions for coefficient of skewness zero, negative coefficients skewed left, and positive skewed right. Smaller kurtosis coefficients for flatter distributions (fat tails), assuming normal distributions have a coefficient of kurtosis of 3. Source: own estimations.

It is noteworthy that the model excludes certain variables or controls for the sake of simplicity, aligning with the study's aim which does not include testing the robustness of the proposed model. Additional note: the Fed's balance sheet shows a mean of around 4 trillion, with very little variance, indicating relative stability during the observed period. The VIX has a mean of 19.3887, and its high maximum value of 82.690 suggests periods of significant market stress.

3.2. Empirical Model

In order to establish the above stated causalities and linkages, the first identification strategy that comes to mind is the use of vector autoregression models (VAR). Chen et al. (2014) and Broadstock and Filis (2014) used this approach for estimating the effects of oil price shocks on stock market returns using a structural VAR model as an extension of the work by Kilian (2009). Moreover, Stock and Watson (2001) tested the effects on inflation and unemployment of a surprise increase of 100 bps in the federal funds rate, proving this approach to be a good tool for showing the impulse responses of those two variables to monetary policy shocks. However, for longer-term monetary policies such as large-scale security purchases, these would not be regarded as surprise shocks, and given that monetary policy rules change over time, constant parameter structural VARs that miss this instability tend to be improperly identified (Stock and Watson 1996).

As the type of policy analyzed in this paper is not a surprise while it is being executed, we suggest the use of the instrumental variables approach as the identification strategy of this research. Given that we assume that the index value may be explained in part by the treasury yield and the currency levels, both of which are explained by the balance sheet and oil price levels, respectively, a 3SLS method proposed by Zellner and Theil (1962) can be used to solve the endogeneity issue between treasury yields and the central bank balance sheet levels, and between the currency, treasury yield, and oil price values. The causalities, thus, are best characterized by the following three simultaneous equations system[2]:

$$\text{Stage 1: } t\_yield_t = \pi_0 + \pi_1 Fed\_BalSht_t + \Sigma \pi_i Z_{i,t} + v_t \tag{2}$$

$$\text{Stage 2: } usd\_eur_t = \delta_0 + \delta_1 t\_yield_t + \delta_2 wti\_spot_t + \Sigma \delta_i Z_{i,t} + e_t \tag{3}$$

$$\text{Stage 3: } Index_t = \beta_0 + \beta_1 t\_yield_t + \beta_2 usd\_eur_t + \beta_3 Fed\_FRate_t + \beta_4 us\_cpi_t + u_t \tag{4}$$

In the first equation of the system, the variable Fed_BalSht_t represents how the endogenous variable t_yield_t is affected by the Fed's balance sheet level, so that here the control variable is Fed_BalSht_t. In the second equation, the usd_eur_t dependent variable is affected by t_yield_t, determined by the former equation, and by wti_spot_t, an exogenous variable, the price of which is determined by the international oil market. Conversely, in the third, or principal, equation, the $Index_t$ variable is dependent upon the levels of the federal funds rate, Fed_FRate_t, of the general price levels, us_cpi_t, t_yield_t, and usd_eur_t, from the first and second equations. $Z_{i,t}$ are the vectors of covariates in (4). The solution of this model system can be found in Appendix A.

Although alternative empirical approaches may be used to support the formulated hypotheses, the 3SLS approach is preferred to the full information maximum likelihood (FIML) and the two-stage least squares (2SLS) method as it is less complicated to compute on the one hand, and it goes one step further, on the other, as Zellner and Theil (1962) thoroughly validated. This further step covers two critical aspects in this research. First, it uses the moment matrix of the structural disturbances of the 2SLS to estimate all the coefficients of the whole system simultaneously, and, second, the estimation of the coefficients of any identifiable equation becomes even more efficient upon other over-identified equations, should the moment matrix of the structural disturbances have non-zero simultaneous covariances. This last aspect will be crucial for the interpretation of the validity of instrument tests performed later in this paper. While computation of the 3SLS estimates by Narayanan (1969) and Hausman (1983) proved the goodness of this approach in these two aspects, Wooldridge (2002) gave attention to the identification issues of choosing the right estimator. That is, for just-identified equations, the 2SLS and the 3SLS estimations coincide, in which case the latter would not offer added efficiency.

A key feature of the simultaneous equations approach proposed here is that, although every equation is specified to be linear, the relationships among the variables considered are presumed non-linear. That is, there will typically be non-linear identities connecting the variables in the different equations of the system (Fisher 1970). This non-linearity is essential in our study, as we have visualized in Figure 3 a non-linear divergence between the size of the Fed's balance sheet and the case of the S&P 500 index trajectory, and although the functions shown in Figure 4 are originally described as non-linear by Krugman and Obstfeld (2006), a linear adaptation has been made to fit the empirical model broken down by the different moments of intervention.

In order to calculate the estimations of the proposed instrumental variables system of simultaneous equations, we begin by employing the 3SLS for time series strategy on the S&P 500 index as a case analysis, and then replicate this method on the remaining indices.

4. Empirical Results

4.1. Correlations Results

From the results displayed in Table 2, it is possible to verify our expectations about a high negative correlation between the levels of the Fed's balance sheet and the treasury yields, as well as the high positive correlation of the balance sheet with the value of the foreign exchange rate and inflation. This is in line with the fact that the higher demand from the central bank for treasuries lowers their yield, while weakening its currency and increasing the value of the CPI. Note in the fifth column the high correlation between the balance sheet instrument *Fed_BalSht*, and the *t_yield* (−0.6140), the *usd_eur* (0.5391), and the us_cpi_t (0.5439). Moreover, the results confirm the significant negative correlations between the yields and the currency prices, and the latter with the oil prices of −0.4978 and −0.6676, respectively. Another key finding in this table is the high positive correlations of the balance sheet with the four indices, ranging from 0.8830 in the case of the DJIA to 0.9342 for the NASDAQ, as displayed in the fourth row. Also note that, since the open market purchases are reported weekly, lags in the balance sheet level series have been calculated for one-day and one-week delays (*lag1d_Bal_Sh* and *lag1w_Bal_Sh*), showing similar correlation results with the index. Moreover, the high positive correlations of the indices with the currency value and the CPI (ranging from 0.5551 to 0.6318, and from 0.5450 to 0.5742, respectively) imply that a weakening of the currency, as well as increases in the price of the products sold, may drive the index up.

Finally, although there is a lower negative correlation (ranging from −0.2483 to −0.3043) between the indices and the oil prices, all the above-mentioned results suggest that, for the data used in this study, this set of variables are relevant as instruments for our estimations. In contrast, although the volatility index *vix* displays a negative correlation with all the indices, these are weak correlations, ranging from −0.0639 in the case of the NASDAQ and −0.2800 for the SMLCAP 2000, with this last a logical result as small capitalization companies are more sensitive to market instability.

4.2. Regressions Results

The regression results, estimated by the three stage least squares approach for the S&P 500 index, as a case analysis, are shown in Table 3. In this model, the variable *Fed_BalSht* was used as instrument in the first equation for the endogeneity of the treasury yield variable, *t_yield*. In turn, the treasury yield variable, *t_yield*, was used as instrument in the second equation for the endogeneity of the currency variable, *usd_eur*. The regression results of the simultaneous equations show high statistical significance for most variables. Then, using the coefficients in this table, it is possible to conclude that the Fed's intervention by expanding its balance sheet through the purchase of treasury securities causes the treasury yields to drop while weakening its currency, which supports the high negative correlation between the currency price and the treasury yields shown in the ninth column of Table 2, and in Krugman and Obstfeld's diagram in Figure 4.

As for the principal equation, the results show that the S&P 500 index increases are associated with raises in the Federal Funds Rate, *Fed_FRate*, as shown by its positive coefficient, and drops in the index are associated with cuts in this rate. Intuitively, this tells us that increases in the *Fed_FRate* usually happen when the economy is booming, and cuts of this rate usually happen when the firms that compose the index are underperforming, which in turn corresponds to corrections in the index. Moreover, the coefficients of the oil prices, *wti_spot*, and price index, *us_cpi*, coincide with our expectations that increases in the oil prices and in the price levels in the economy drive the index to drop and rise, respectively, with the former via the weakening of the currency.

Table 2. Correlation results (from 16 December 2008 to 29 April 2022).

	SP500	DJIA	NASDAQ	SMLCAP2000	Fed_ BalSht	lag1d_ Bal_Sh	lag1w_ Bal_Sh	Fed_ FRate	t_yield	usd_eur	wti_spot	us_cpi	vix
SP500	1												
DJIA	0.9925 *	1											
	0.0000												
NASDAQ	0.9893 *	0.9731 *	1										
	0.0000	0.0000											
SMLCAP2000	0.9771 *	0.9803 *	0.9546 *	1									
	0.0000	0.0000	0.0000										
Fed_BalSht	0.9255 *	0.8830 *	0.9342 *	0.8857 *	1								
	0.0000	0.0000	0.0000	0.0000									
lag1d_Bal_Sh	0.9257 *	0.8832 *	0.9343 *	0.8860 *	0.9999 *	1							
	0.0000	0.0000	0.0000	0.0000	0.0000								
lag1w_Bal_Sh	0.9262 *	0.8838 *	0.9345 *	0.8875 *	0.9996 *	0.9997 *	1						
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							
Fed_FRate	0.3128 *	0.4120 *	0.2373 *	0.3602 *	−0.0184	−0.0178	−0.0156	1					
	0.0000	0.0000	0.0000	0.0000	0.2866	0.3014	0.3672						
t_yield	−0.5405 *	−0.5189 *	−0.5578 *	−0.4742 *	−0.6140 *	−0.6134 *	−0.6111 *	0.0951 *	1				
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000					
usd_eur	0.6167 *	0.6318 *	0.5551 *	0.6078 *	0.5391 *	0.5390 *	0.5388 *	0.4339 *	−0.4978 *	1			
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000				
wti_spot	−0.2946 *	−0.3043 *	−0.2948 *	−0.2483 *	−0.2748 *	−0.2750 *	−0.2760 *	−0.2653 *	0.4104 *	−0.6676 *	1		
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000			
us_cpi	0.5742 *	0.5522 *	0.5703 *	0.5450 *	0.5439 *	0.5440 *	0.5446 *	0.0587 *	−0.1449 *	0.1221 *	0.3675 *	1	
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0007	0.0000	0.0000	0.0000		
vix	−0.1522 *	−0.1887 *	−0.0639 *	−0.2800 *	−0.0488	−0.0493	−0.0511	−0.2569 *	−0.0962 *	−0.1629 *	−0.2224 *	−0.0715 *	1
	0.0000	0.0000	0.0002	0.0000	0.0046	0.0042	0.0031	0.0000	0.0000	0.0000	0.0000	0.0000	

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

Table 3. Regression results for the S&P 500 Index (from 16 December 2008 to 29 April 2022).

Three-stage least-squares regressions						
Panel A: Composition of effects *without* balance sheet weekly lag						
Equation	Obs	Parms	RMSE	R-sq	chi2	P
SP500	3366	2	754.896	0.4077	2411.66	0.0000
t_yield	3366	1	0.57864	0.3744	1778.33	0.0000
usd_eur	3366	2	0.05447	0.4767	4490.07	0.0000
	Coef.	Std.Err.	z	P>∣z∣	[95% Conf. Interval]	
SP500						
Fed_FRate	384.9307	18.65331	20.64	0.0000	348.3709	421.4906
us_cpi	333.8543	7.72019	43.24	0.0000	318.7230	348.9856
_cons	1327.1010	22.51226	58.95	0.0000	1282.9780	1371.2240
t_yield						
Fed_BalSht	−0.2337	0.00554	−42.17	0.0000	−0.24458	−0.22286
lag1w_Bal_Sh	-	-	-	-	-	-
_cons	3.2618	0.02560	127.42	0.0000	3.21166	3.31201
usd_eur						
t_yield	−0.0450	0.00232	−19.35	0.0000	−0.04954	−0.04043
wti_spot	−0.0018	0.00005	−39.31	0.0000	−0.00193	−0.00174
_cons	1.0480	0.00430	243.84	0.0000	1.03955	1.05640
Endogenous variables:	SP500 t_yield usd_eur					
Exogenous variables:	Fed_FRate us_cpi Fed_BalSht wti_spot					
Panel B: Composition of effects *with* balance sheet weekly lag						
Equation	Obs	Parms	RMSE	R-sq	chi2	P
SP500	3361	2	754.981	0.4068	2385.72	0.0000
t_yield	3361	2	0.57194	0.3897	1862.02	0.0000
usd_eur	3361	2	0.05369	0.4907	4345.55	0.0000
	Coef.	Std.Err.	z	P>∣z∣	[95% Conf. Interval]	
SP500						
Fed_FRate	382.3947	18.67625	20.47	0.0000	345.7899	418.9995
us_cpi	332.7607	7.72852	43.06	0.0000	317.6131	347.9084
_cons	1331.8390	22.55758	59.04	0.0000	1287.6270	1376.0510
t_yield						
Fed_BalSht	−1.4081	0.18828	−7.48	0.0000	−1.7772	−1.0391
lag1w_Bal_Sh	1.1790	0.18893	6.24	0.0000	0.8087	1.5493
_cons	3.2549	0.02532	128.56	0.0000	3.2053	3.3046
usd_eur						
t_yield	−0.0422	0.00227	−18.6	0.0000	−0.0467	−0.0378
wti_spot	−0.0018	0.00005	−39.52	0.0000	−0.0019	−0.0018
_cons	1.0427	0.00423	246.52	0.0000	1.0344	1.0510
Endogenous variables:	SP500 t_yield usd_eur					
Exogenous variables:	Fed_FRate us_cpi lag1w_Bal_Sh Fed_BalSht wti_spot					

Note(s): This table displays the coefficients of the variables in the models proposed for the S&P 500 index. The models considered are the instrumental variables three stage least squares (IV3SLS) for time series *with* and *without* one week lag in the central bank balance sheet size tested for the entire data period (16 December 2008–29 April 2022). Both models use the size of the Fed's balance sheet as control variables. Source: own estimations.

Panels A and B of Table 3 show the composition of the effects of the balance sheet growth on the treasury yields without and with a weekly lag. That is, although we have established that an increase in the Fed's balance sheet explains the drop in the yields, this change is about 23.37 basis points (bps) for each trillion added to the Fed's balance sheet, as shown in Panel A. This, however, is a result of netting a sharp drop of about 140.81 (Panel B) bps in the yields as the purchases are executed in the current week (*Fed_BalSht*), but subsequently the yields rise through the week as the liquidity is absorbed by the market in about 117.90 (Panel B) bps (*lag1w_BalSht*), for a net drop of about 22.91 bps per trillion. From these findings, Equation (2) has been re-specified to derive the results on Panel B as:

$$\text{Stage 1}': t\_yield_t = \pi_0 + \pi_1 Fed\_BalSht_t + \pi_2 lag1w\_BalSht_t + \Sigma\pi_i Z_{i,t} + v_t \quad (5)$$

The regression results help identify the magnitudes and changes in the main instrumental variable per week and how the effects are distributed. That is, the expansion of the Fed's balance sheet seems to shave a cumulative portion of the yields that gets transmitted into the index, meaning that as the treasury yields drop slightly further each week while the central bank is executing the securities purchase, the index does not adapt in the same manner, continuing its trend instead. This effect is also noticeable in the other indices, per the results displayed in Appendix B, where all coefficients and equation significances coincide with those for the S&P 500.

Finally, the R-squares for each of the three equations are displayed in the first section of Table 3. Since the simultaneous equations approach is being used in this research, we do not aim to maximize the R-squares in any of the simultaneous equations (Fisher 1970). However, the results register plausible enough R-squares in each equation, as well as high chi-square values.

Appendix B also shows the equation significances for the other indices in line with those for the S&P 500. Although the estimates from the 3SLS are assumed to be robust, they can be verified by the results obtained via the generalized method of moments (GMM) for the S&P 500 case provided in Appendix C.

To assess the validity of the specified equations of the system, we performed the Breusch–Pagan test of independence of errors using the seemingly unrelated regression (SUR) approach introduced by Zellner (1962). The Breusch and Pagan (1980) for the SUR is a Lagrange Multiplier (LM) statistic calculated as:

$$\lambda = T\sum_{m=1}^{M}\sum_{n=1}^{m-1} r_{mn}^2$$

where T is the number of observations and r_{mn} is the estimated correlation between the residuals of the M equations. The LM is distributed as χ^2 with $M\ (M-1)/2$ degrees of freedom. Table 4 displays the correlation matrix of errors across the three equations and the Breusch–Pagan test of independence of the errors.

Table 4. Test of independence of errors for the S&P 500 Index (from 16 December 2008 to 29 April 2022).

Panel A: Correlation Matrix of Residuals (*Without* Balance Sheet Weekly Lag):				Panel B: Correlation Matrix of Residuals (*With* Balance Sheet Weekly Lag):			
	SP500	t_yield	usd_eur		SP500	t_yield	usd_eur
SP500	1			SP500	1		
t_yield	−0.1666	1		t_yield	−0.1631	1	
usd_eur	0.1094	0.2443	1	usd_eur	0.1042	0.2207	1
Breusch–Pagan test of independence:				Breusch–Pagan test of independence:			
chi2(3) = 334.467,			Pr = 0.0000	chi2(3) = 289.651,			Pr = 0.0000

Note(s): This table displays the correlation matrix of errors across the three equations and the Breusch–Pagan test of independence of errors. High χ2 indicate that the three correlation coefficients are jointly significant. Source: own estimations.

The results of the Breusch–Pagan test of independence, displayed in Table 4, indicate that the three correlation coefficients are jointly significant with χ^2 of 334.467 and 289.651 for the S&P 500 without and with the one-week balance sheet lag equations, respectively. As the results of these tests indicate, the pricing in both the treasury yields and the currency is highly influenced by the central bank balance sheet, and this affects the pricing of equity securities, supporting H2 and H3. The LM results for the remaining indices are provided in Appendix D. Furthermore, Appendix E summarizes the 3SLS, SUR, and 2-step GMM for 3SLS estimators for all indices without and with one-week lag balance sheet size.

4.3. Correlation Analysis of Intervention Effects

The correlation results during the interventions under analysis, displayed in Appendices F and G, are somewhat mixed. For instance, in the first intervention, the high negative correlation between the size of the Fed's balance sheet and the treasury yields still holds (−0.4962), while for the second intervention this correlation turns highly positive (0.8121). This last result is explained by the extremely low level (near the zero bound) of the treasury yields at the time of the implementation of the second intervention. That is, in March of 2020, the treasury yields were quoting just below 0.5 percent as these assets became the top global safe haven destination for investors shifting out of risky assets during the global financial downturn caused by the COVID-19 pandemic, while back in 2008 the treasury yields were quoting above 2%, with a high pressure to increase as expectations of further deterioration of the economy increased, driving the yields to almost 4% in the spring of 2009. Hence, even meager increases in the treasury yields during the second intervention would be considered high, for which a rise of 50 bps would double the yield rate, while it would be a rise of a much lesser proportion in the first intervention.

A correlation switching also happens between the balance sheet size and the value of the foreign exchange rate. This correlation, although rather low at 0.1938 in the first intervention, turned negative (−0.0833) during the second intervention, transitorily strengthening the currency as a side effect of the above-described process, in which the demand for dollars increased to purchase the world's safest treasuries. However, there is an increase in the positive correlation of the balance sheet with inflation, passing from 0.4016 in the first intervention to a shocking 0.8838 in the second intervention.

Despite the mixed results in the interventions correlations, the strong correlations of the balance sheet with the four indices also hold, maintaining the highest positive correlation of all four indices in both periods consistently (ranging from 0.9322 to 0.9427, and from 0.8818 to 0.9395 in the first and second interventions, respectively), as well as the lagged balance sheet size variable. Moreover, the high positive correlations of the indices with the CPI accelerated from the first intervention to the second (from a range of 0.3866 to 0.4392 to a startling range of 0.6746 to 0.8725), implying a pronounced upward drive in the indices. Finally, although a low negative correlation of −0.2946 between the S&P 500 and the oil prices was stated from the results of Table 2, this correlation is specially high during both intervention periods (0.8186 to 0.8385 and 0.8231 to 0.9011), leading us to determine that the index performance, although ignored the 2014–2016 oil crisis (where there was no government intervention), was highly sensitive to the oil prices during times of interventionism due to added risks in the financial markets, in agreement with Degiannakis et al. (2018).

4.4. Results of Regression Analysis by Interventions

The next step consists of running the same methods on the data solely in the periods under the intervention by the central bank in order to estimate the changes in the coefficients of the equations presented. In turn, after running the specified 3SLS model for the period from 16 December 2008 to 31 December 2013 for the first intervention, and for the period from 18 March 2020 to 29 March 2022 for the second intervention, yielded the sets of coefficients for the S& P500 case presented in Table 5.

Table 5. Coefficients of regression results by interventions for the S&P 500 Index.

Three-stage least-squares regressions by government intervention						
Intervention	(2008–2013)		(2020–2022)		(2008–2022)	
Variable	SP5003SLS	SP5003SLSlg	SP5003SLS	SP5003SLSlg	SP5003SLS	SP5003SLSlg
SP500						
Fed_FRate	(omitted)	(omitted)	−899.4386 ***	−934.4934 ***	384.9307 ***	382.3947 ***
us_cpi	71.7047 ***	70.8901 ***	209.6201 ***	198.2083 ***	333.8543 ***	332.7607 ***
_cons	1159.469 ***	1161.948 ***	3379.689 ***	3440.396 ***	1327.101 ***	1331.839 ***
t_yield						
Fed_BalSht	−0.79619 ***	2.22881 ***	0.40251 ***	1.47007 ***	−0.23372 ***	−1.40813 ***
lag1w_Bal_Sh	–	−3.06200 ***	–	−0.97657 ***	–	1.17898 ***
_cons	4.80692 ***	4.88872 ***	−1.87952 ***	−2.63439 ***	3.26183 ***	3.25493 ***
usd_eur						
t_yield	−0.03082 ***	−0.03388 ***	0.29521 ***	0.11085 ***	−0.04498 ***	−0.04222 ***
wti_spot	−0.00047 ***	−0.00056 ***	−0.00382 ***	−0.00107 ***	−0.00184 ***	−0.00185 ***
_cons	0.86651 ***	0.88257 ***	0.71070 ***	0.78379 ***	1.04797 ***	1.04269 ***
note: Fed_FRate omitted because of collinearity				legend: * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$		

Note(s): This table displays the coefficients of the variables in the models proposed for the S&P 500 index during the two interventions and the entire period under analysis. The models are the Instrumental Variables Three Stage Least Squares (IV3SLS) for time series with and without one-week lag (labeled SP5003SLSlg and SP5003SLS) in the central bank balance sheet size tested during the great recession (2008–2013) and the COVID-19 (2020–2022) intervention periods, and the entire data period (2008–2022). All approaches use the size of the Fed's balance sheet as control variables. ***, **, * Coefficients are significant at the 1%, 5%, and 10% levels. Source: own estimations.

The first two columns of Table 5 display the coefficients under the first intervention, while the next two columns are the resulting coefficients under the second intervention. Furthermore, the last two columns in Table 5 include the coefficients for the entire period, per the results in Table 3, to facilitate the analysis that follows.

First, the coefficients under the first intervention suggest that the Fed's intervention via the expansion of its balance sheet through the purchase of treasury securities leads the treasury yields to drop, and this drop is followed by a weakening of the currency, in line with the results obtained for the entire 2008–2022 period. However, the opposite happens to the yields during the second intervention, turning the yield-to-balance-sheet coefficient positive (0.4025) in the first equation of the system. That is, although the balance sheet size increased abruptly in the spring of 2020, the treasury yields did not continue to drop as they were already at their historically lowest levels, instead moderately rising to levels below those before the start of the first intervention. Moreover, its one-week lagging adaptability inverted. For instance, the yields did, indeed, drop in the week prior to each purchase, yet rose higher in the week of the purchase, acting as though the investment public had identified an opportunity to sell to the Fed at much lower yields each time they anticipated the Fed's purchases. In other words, the Fed fell into a liquidity trap, turning the second intervention rather ineffective in its goal of keeping the yields at least lower than at the start of its intervention. This switching is confirmed by the −0.9766 and 1.4700 coefficients for the one-week lagged (*lag1w_Bal_Sh*) and the actual (*Fed_BalSht*) balance sheet size in the fourth column of Table 5.

Note also that the currency-to-yields coefficient has also switched in the second equation of the second intervention, explained by the foreign flight-to-quality inflows (among other possible factors), hence strengthening the currency while the yields went up. These results indicate that the pricing of the equity index should have adjusted matching the effects of the expansion of the central bank balance sheet on the treasury yields and the currency rate, yet the index continued into an overvaluation trend, in support of H1.

As for the third stage equation, the results show that the S&P 500 index no longer increases by the Federal Funds Rate, *Fed_FRate*. Instead, this rate was omitted by our model in the first intervention, as it stayed constant at the lowest level possible throughout that intervention. Furthermore, the index fell at the end of the second intervention as the Fed had to raise its rate to tackle the inflation outbreak in early 2021. This is shown by the −899.4386 and −934.4934 coefficients in the third and fourth columns of Table 5. Finally, the coefficients of the price index, *us_cpi*, and the constant terms, both expanded threefold, from 71.70466 and 70.89005 to 209.6201 and 198.2083, and 1159.469 and 1161.948 to 3379.689 and 3440.396, respectively. These results indicate that the inflation component on the index remains the same on both interventions, and that the value of the index tripled in the second intervention from the first one, and so did the size of the Fed's balance sheet. The regression results for all four indices are shown in Appendix H, in which the above findings are confirmed by the two twelve equations systems for each intervention, displayed in panels A and B, for the first and second interventions, respectively.

4.5. Instrumental Variables Tests

In order to verify whether there are endogeneity concerns between the value of the indices and the variables included in the models, the Durbin-Wu-Hausman test was performed for each model in each intervention period. Table 6 shows the results of the endogenous tests for the S&P 500 index models, while Appendix I shows the test results for the other three indices. Based on the higher efficiency of the 3SLS estimators in comparison to those of the 2SLS modeling proved by Zellner and Theil (1962), the Durwin-Wu-Hausman tests were performed using the more constrained 2SLS approach, only merging the first two equations of the 3SLS models. The results in Table 6 and Appendix I exhibit large chi2, and zero *p*-values in all periods, being the largest for the longer period models. Hence, these results strongly reject the null hypothesis that all independent variables are exogenous for the models in the intervention periods under analysis.

Table 6. Instrumental variables tests by interventions for the S&P 500 Index.

Durwin-Wu-Hausman Test			
Tests of endogeneity Ho: variables are exogenous			
Intervention Period:		(2008–2013)	
SP5002SLS	Durwin (score) Wu-Hausman	chi2(1) = 302.04 F(1,1265) = 395.136	(p = 0.0000) (p = 0.0000)
SP5002SLS1Wlg	Durwin (score) Wu-Hausman	chi2(1) = 303.938 F(1,260) = 398.892	(p = 0.0000) (p = 0.0000)
Intervention Period:		(2020–2022)	
SP5002SLS	Durwin (score) Wu-Hausman	chi2(1) = 71.3761 F(1,508) = 82.104	(p = 0.0000) (p = 0.0000)
SP5002SLS1Wlg	Durwin (score) Wu-Hausman	chi2(1) = 95.9886 F(1,503) = 117.187	(p = 0.0000) (p = 0.0000)
Period:		(2008–2022)	
SP5002SLS	Durwin (score) Wu-Hausman	chi2(1) = 2292.5 F(1,3361) = 7177.51	(p = 0.0000) (p = 0.0000)
SP5002SLS1Wlg	Durwin (score) Wu-Hausman	chi2(1) = 2203.08 F(1,3356) = 6385.18	(p = 0.0000) (p = 0.0000)

Note(s): This table shows the presence of endogeneity in the variables included in the models selected. The null hypothesis that all variables in the models are exogenous is rejected if Chi^2 and F values are large. Zero p-values indicate variables are endogenous. All models use the balance sheet as control variable. Source: own estimations.

4.6. First Stage Regression Results

The explanatory power of the instrumental variables is verifiable by running the correlation test of the first stage regression. Table 7 displays the results of such a test on the S&P 500 case per model by intervention period. The Robust *F* values in all the models are sufficiently large to reject the null hypothesis that the coefficients of the instrumental variables are zero. A lower than 10 *F* statistic would suggest weak instruments. In the case of the S&P 500 index these values are much higher than 10 in each intervention period. Appendix J shows identical results for the other three indices with identical first stage equations.

Table 7. First-stage regression summary statistics by interventions for the S&P 500 Index.

Model	Variable	*R*-sq.	Adjusted *R*-sq.	Partial *R*-sq.	Robust *F* Value		Prob > *F*
Intervention Period:				(2008–2013)			
SP5002SLS	*t_yield*	0.4688	0.4671	0.4138	F(3,1264):	330.169	0.0000
SP5002SLS1Wlg	*t_yield*	0.4787	0.4766	0.4236	F(4,1258):	253.755	0.0000
Intervention Period:				(2020–2022)			
SP5002SLS	*t_yield*	0.8623	0.8609	0.4426	F(3,507):	132.534	0.0000
SP5002SLS1Wlg	*t_yield*	0.8677	0.8662	0.4637	F(4,501):	118.595	0.0000
Period:				(2008–2022)			
SP5002SLS	*t_yield*	0.4883	0.4875	0.4715	F(3,3360):	957.066	0.0000
SP5002SLS1Wlg	*t_yield*	0.4987	0.4978	0.4823	F(4,3354):	871.693	0.0000

Note(s): This table shows the Robust F statistic for the significance of the instrument coefficients. If the F statistic is not significant, the instruments have no significant explanatory power for *t_yield* after controlling for the effect of *Fed_BalSht*, *lag1w_Bal_Sh*, *usd_eur*, and *wti_spot*. Source: own estimations.

4.7. The Identification of Instrumental Variables

To determine whether fewer instrumental variables than endogenous ones are being used in these models, the Anderson Lagrangian Multiplier test was performed. Table 8 shows that this statistic is large enough to strongly reject the null hypothesis that the models may be under-identified. Furthermore, the Sargan (1964) test on the right-hand side of this table confirms that there is an overidentification of instruments in the models, as expected from the second aspect previously mentioned about the benefits of the 3SLS estimation.

Table 8. Instrumental variables identification tests by interventions for the S&P 500 Index.

	Underidentification test (Anderson canon. corr. LM statistic): Ho: underidentification of instrumental variables		Sargan statistic (overidentification test of all instruments): Ho: overderidentification of instrumental variables	
Intervention Period:		(2008–2013)		
SP5002SLS	525.118	Chi-sq(3) P-val = 0.0000	639.396	Chi-sq(2) P-val = 0.0000
SP5002SLS1Wlg	535.438	Chi-sq(4) P-val = 0.0000	638.456	Chi-sq(3) P-val = 0.0000
Intervention Period:		(2020–2022)		
SP5002SLS	227.03	Chi-sq(3) P-val = 0.0000	287.492	Chi-sq(2) P-val = 0.0000
SP5002SLS1Wlg	235.56	Chi-sq(4) P-val = 0.0000	242.494	Chi-sq(3) P-val = 0.0000
Period:		(2008–2022)		
SP5002SLS	1586.973	Chi-sq(3) P-val = 0.0000	443.641	Chi-sq(2) P-val = 0.0000
SP5002SLS1Wlg	1620.904	Chi-sq(4) P-val = 0.0000	508.681	Chi-sq(3) P-val = 0.0000

Note(s): This table shows high Chi2 values in the Instrumental Variables Underidentification test. These reject the null hypothesis of less relevant instruments in the models than endogenous variables. The zero *p*-values suggest no underidentification of instruments. In the Overidentification test, large Chi2 values and zero *p*-values detect overidentification of instruments. That is, there is one endogenous variable *t_yield*, but more than one valid instrument in addition to *Fed_BalSht*, which are (2): *usd_eur* and *wti_spot* in the simple models, and (3): plus *lag1w_Bal_Sh*, in the lagged models. Source: own estimations.

The number in brackets next to the Chi2 detect the possibility of more than one instrument for the endogenous variable *t_yield*, which could be the currency (*usd_eur*) and the oil prices (wti_spot), in addition to the balance sheet instruments (Fed_BalSht and lag1w_Bal_Sh) for the simple and lagged models, and in turn the currency (*usd_eur*) may also be endogenous. Hence, recalling Wooldridge (2002), the 3SLS strategy is preferred over the 2SLS approach. Accordingly, inclusion of the Fed's balance sheet variable is plausible according to the first test, however, the other variables may also be valid instruments, according to the results of the second test. Appendix K exhibits identical results by intervention period on the first test and, although not identical, high chi2 values on the second test for the remaining indices.

4.8. Results on the Relevance of Instrumental Variables

Table 9 confirms that none of the instruments used in this study is weak in any of the indices' models in all intervention periods. None of the Stock-Yogo (Stock and Yogo 2005) critical values is near the Cragg-Donald Wald *F* statistic (Cragg and Donald 1993), in line with the correlation results which indicated that the variables included in the models are relevant as instruments. Weak instruments draw low μ^2 values and derive low *F* values, which instead here are large enough for all twenty-four models. Moreover, the results of the Montiel–Pflueger robust weak instrument test (Olea and Pflueger 2013; Pflueger and Wang 2015) show that the TSLS and LIML critical values for τ = 5% are still low compared to the C-D Wald *F* statistic.

Table 9. Weak instrumental variables tests by index per intervention.

Weak identification test (Cragg–Donald Wald F statistic):								
Intervention Period	Model				Model			
	SP500	DJIA	NASDAQ	SMCP2K	SP500 1WLg	DJIA 1WLg	NASDAQ 1WLg	SMCP2K 1WLg
2008–2013	297.426	297.426	297.426	297.426	231.134	231.134	231.134	231.134
2020–2022	134.169	134.169	134.169	134.169	108.295	108.295	108.295	108.295
2008–2022	999.091	999.091	999.091	999.091	781.065	781.065	781.065	781.065
Stock–Yogo weak ID test critical values:								
		5% maximal IV relative		13.91		5% maximal IV relative		16.85
		10% maximal IV relative		9.08		10% maximal IV relative		10.27
		20% maximal IV relative		6.46		20% maximal IV relative		6.71
		30% maximal IV relative		5.39		30% maximal IV relative		5.34
		10% maximal IV size		22.3		10% maximal IV size		24.58
		15% maximal IV size		12.83		15% maximal IV size		13.96
		20% maximal IV size		9.54		20% maximal IV size		10.26
		25% maximal IV size		7.8		25% maximal IV size		8.31
Montiel–Pflueger robust weak instrument test								
Critical Values:			TSLS	LIML	Critical Values:		TSLS	LIML
% of Worst Case Bias					% of Worst Case Bias			
tau = 5%			13.253	13.253	tau = 5%		16.720	10.231
tau = 10%			8.525	8.525	tau = 10%		10.231	6.701
tau = 20%			5.898	5.898	tau = 20%		6.701	4.749
tau = 30%			4.930	4.930	tau = 30%		5.421	4.035

Note(s): This table shows lower S–Y weak ID test critical values than the C–D Wald F statistics in all intervention periods. The Montiel–Pflueger robust test for weak instruments also shows that neither the TSLS nor LIML critical values for threshold values $\tau \in$ (5%, 10%, 20%, 30%) exceed the F statistics in any intervention period, thus, rejecting the null hypothesis that the instruments used in the models are weak. Had any of the S-Y and Montiel–Pflueger TSLS and LIML critical values been larger than the C–D Wald F values, there would have been at least one weak instrument in the models. Source: own estimations.

5. Discussion

Based on the results displayed in Table 3, although there is a positive relation between the value of the SP500 and the size of the Fed balance sheet, there is no evidence from the model used in this research that Central Bank interventions via the expansion of the balance sheet cause inflation. This clarifies the assumption of this variable as exogenous within this model. Moreover, even though there is a positive relationship between the SP&500 index value and the consumer price index, the model system used here had to be re-specified as the R-square results of the second equation turned negative, meaning low significance of that equation in the specification of the model in such a way. This fact is in agreement with what Bernanke (2020) suggested about the effects of the lower bound, in which it would be fair to moderately allow the inflation rate target to increase.

However, from the results in Table 5, it is possible to identify that, as the sources of both financial crises were different, the normal flows of liquidity assumed from the first intervention may be altered. For instance, while during the 2008–2013 intervention period the lack of liquidity from the investment public called for the additional liquidity provided by the Fed and lowered the yields some 0.0796 bps for each billion of securities purchases, in the 2020–2022 intervention massive flows of liquidity from the global investors went directly to the purchase of U.S. treasuries, pushing their yields to extremely low levels never seen before nearing the zero bound, though with the help of the Fed's involvement they would not lower further, and instead rose some 0.0403 bps per billion of purchases as the crisis progressed. Hence, the second intervention proved to be rather ineffective for the Fed's goal of lowering the yields further, for which opposite results were attained, despite the same type of stimulation was implemented, supporting H5.

Special attention is given to the currency-to-yields coefficient switching in the second equation of the second intervention, showing the strengthening of the currency as a key effect of the flight-to-quality flows while the yields caught an upward trend. In agreement with Engel (2016), this particular puzzle goes in contradiction to the foreign exchange premium and interest rate differentials relationship. This outcome also provides proof that, although the same type of stimulation was applied in different periods under crisis, opposite results were achieved.

Additionally, the results show that, in the second intervention, the S&P 500 index no longer increases alongside the Federal Funds Rate, instead the index falls at the end of the second intervention as the Fed had to raise its rate to halt the inflation outbreak of early 2022. This last fact may contradict Cochrane (2018), though only for a short period. Furthermore, regarding the large growth in the coefficients of the inflation and the constant terms of the S&P 500 equation, although the inflation proportion on the index remains constant in both interventions, this suggests long-term growth accumulated during the 2014–2019 dis-intervention period as the value of the index tripled in the second intervention from the first one. This conclusion is made possible as the size of the Fed's balance sheet also tripled as of the end of the second intervention.

6. Implications

The results in this research have important policy implications. First, as the Fed's balance sheet expands during its intervention, a cumulative portion of the effect it has on the treasury yields remains on the valuation of the selected U.S. indices on a weekly basis. Although each week the Fed's balance sheet expands, causing a drop in the yield, then after that drop there is a smooth adjustment of the yields in preparation for the following week's purchases by the Fed. Even though this dynamic is happening in the treasuries market, the equity indices continue their trends for which the weekly adjustment does not materialize. As there is no adjustment in the index, the rise of the index continues, revealing a divergence between the pricing in the equity markets and that of the debt market, supporting H4. That is, while the investors in the stock market make their investment decisions on a long-term basis, the traders in the fixed income market do so on a short-term basis. Moreover, while stock prices follow random walks (Fama 1965), yields follow a diffusion process (Vasicek 1977).

Figure 5 shows the dynamics in the treasury yields in response to the Fed's weekly purchases based on the results displayed in Table 3. While there is a sharp drop upon each new purchase by the Fed executed each week, there is a smooth rise throughout the prior week in anticipation of the following week's Fed purchases. To better illustrate this effect, the expected drop in the yields for each billion of central bank purchases worth of treasuries would be 0.14081 bps on average, from a prior week rise of 0.11789 bps[3].

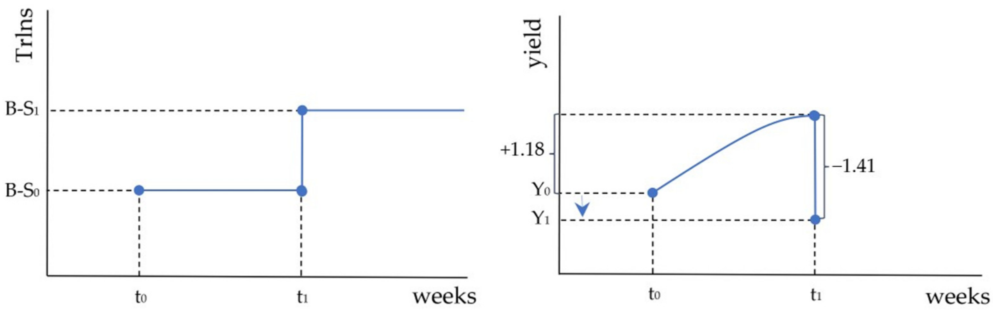

Figure 5. Yield net drops as result of Fed purchases (2008–2022). Source: own calculations.

Figures 6 and 7 show the dynamics in the treasury yields in response to the 2008–2013 and 2020–2022 Fed interventions, per the results shown in Table 5. While there is a confirmation of the yield dynamics in the first intervention displayed in Figure 6, it differs in the second intervention, as shown in Figure 7. That is, while there is a drop in the yields in the week prior to each week's execution of the Fed's purchases, a larger rise in the week of the actual purchases follows, in anticipation of each week's intervention purchases. As the Fed expected the debt markets to behave according to the 2008–2013 intervention, when the effect was a drop of 0.30620 and a rise 0.22288 for a net drop of 0.079 bps per billion dollars, they implemented the same approach to face the COVID-19 crisis of 2020. However, the results in Table 5 proved this policy ineffective, as the yields rose some 0.0403 bps per billion instead, despite an aggressive expansion of the Fed's balance sheet in a shorter period.

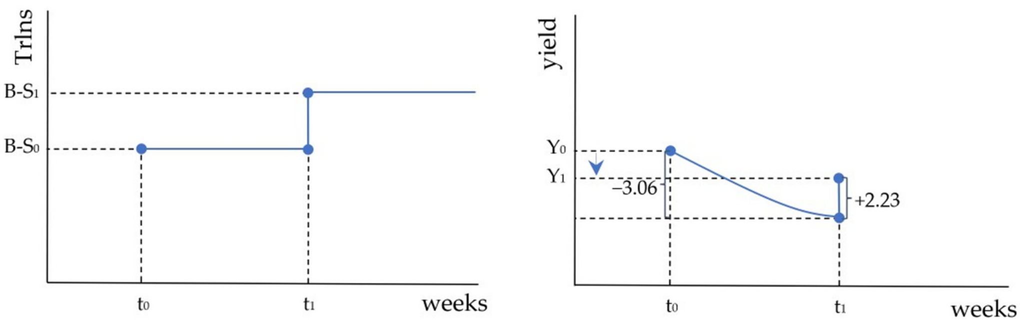

Figure 6. Yield net drops as result of Fed purchases, (2008–2013) intervention. Source: own calculations.

In short, the effects of the size of the central bank's balance sheet on the treasury yields are transmitted into each index valuation equations in different proportions. Hence the level of price distortion on each market is determined by these effects. For instance, while the drop in the yields from the expansion of the balance sheet for the DJIA index is about 0.07390 bps per billion dollars, it is about 0.08747 bps for the Russell index. This explains to some degree why the stocks in the Russell index underperformed in comparison to those in the other indices during the first intervention period. Although the under-valuation would remain for the Russell during the COVID-19 intervention, the S&P 500 would overvalue compared to the other two indices with effects of 0.03774 and 0.04025, respectively.

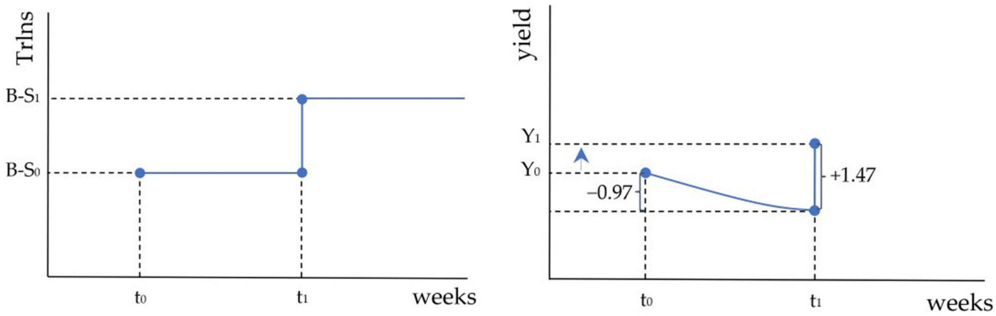

Figure 7. Yield net rises as result of Fed purchases (2020–2022) intervention. Source: own calculations.

In addition to the switching of the balance sheet size against the yields coefficient in the second intervention, the currency-to-yields coefficient has also switched in the second equation, in opposition to Krugman and Obstfeld (2006) premise, accordingly. Figure 8 shows the Figure 4 diagram again, however, in it the demand for treasuries and the expected foreign currency return functions have positive slopes. Nonetheless, the regression results for this intervention estimate a lower elasticity of the expected foreign currency return function compared to that of the demand for treasuries function. In short, for a given amount of Fed purchases in billions of dollars, the rise in the yields is much higher than the strengthening of the dollar against the euro, as a result of the near zero bound yield levels (Doh 2010) and the higher demand for the dollar, respectively, under times of excess liquidity and increased uncertainty. Henceforth, as excess liquidity finds extremely low yields in the debt market and a more costly currency, flows steer into the equity markets in search of much higher returns. Although this effect is identified from the positive performance of the four main indices during the second intervention, it is best described by the different effects, or price distortions, shown in Appendix H for each of the selected indices, once again strongly supporting H5.

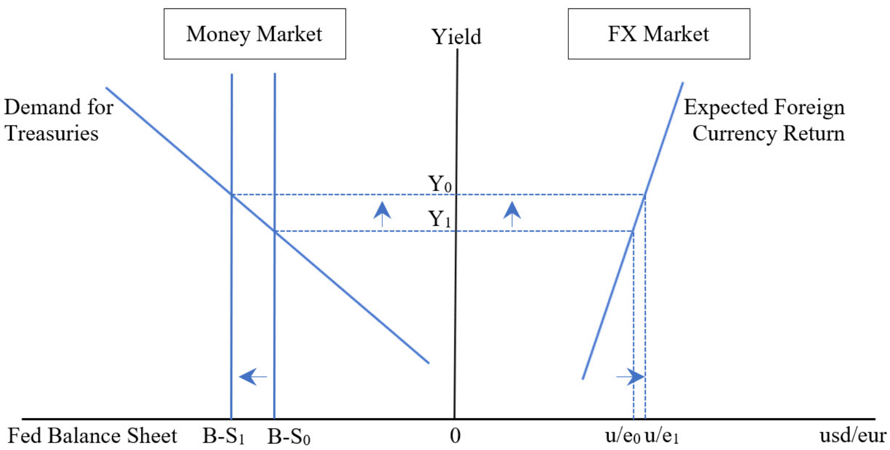

Figure 8. Treasury yields and dollar/euro exchange rate as a function of Fed's balance sheet in 2020–2022 intervention. Source: own estimations.

7. Conclusions

This study uses the interventions of the credit market in the U.S. in response to the credit crisis of 2007 and the response to the COVID-19 crisis as quasi-natural experiments to explore whether interventions in the credit markets such as QE (or tapering) impact some key industry and financial asset prices.

The empirical results show that increases in the Fed's balance sheet, as a consequence of large-scale purchases of treasuries and MBS in the last fourteen years, have impacted the valuation of the four main U.S. equity indices positively. Moreover, this effect seems to add a residual factor that accumulated through the years as the performance of the equity indices continued its upward trend, even during times of dis-interventions, mostly explained by an adaptability divergence between equity pricing and the debt market pricing. Furthermore, liquidity excesses from interventions in the debt market contribute to the overpricing of equity assets.

Although this research has proved that pricing in the debt market is directly affected by the size of the Fed's balance sheet, it also validates that pricings in the debt and currency markets that may be affected by the Fed's interventions influence the pricing of equity securities in the long run, at least under the simultaneous equations time-series analysis performed on the four most prominent equity markets' benchmarks.

Based on the above conclusions, this study may suggest that if policymakers aim to reduce the relative cost of financing in the capital markets in times of financial distress via market interventions, long-run effects on the pricing of financial assets are to be considered. Such effects include changes in the trends of key macroeconomic series that hint at the overvaluation of financial assets and, thus, inefficient asset valuations in the future. Moreover, the sources of each financial crisis differ, hence different interventions may be implemented. The 2007 crisis originated within the U.S., making it an internal crisis that later spread out to the rest of the world. However, the 2020 crisis originated globally, catching the U.S. as the soundest at that time, to which unprecedented flows of liquidity migrated to help keep the U.S. treasury yields at the lowest historical levels, for which the already known QE mechanism may have been unnecessary for maintaining low yields. The question would be whether the excess liquidity provided by the Fed boosted the valuation of the equity and the consumer price indices at the same time. Moreover, as Cox et al. (1985) mentioned, changes in preferences in the debt market explain the switching in the money and foreign exchange markets' pricing. This may be a limitation of our study as the methods used are unable to capture how the liquidity flows circulate among markets.

Another limitation is the fact that this work focused on identifying the effects on the trends of a particular market such as that of the U.S., for which integration of other relevant markets (e.g., the European and Asian ones) would help break down the effects identified here considerably.

Future research calls for the understanding of the effects on the market as a whole, suggesting the use of panel data modeling that includes the four indices. This may help determine the presence of market segmentations by obtaining fixed effects by index as a result of the interventions studied. Moreover, the different effects shown in Appendix H, which we have referred to as price distortions, may indicate those fixed effects in panel data modeling worth exploring in future research. The methodology may also be useful for estimating the effects by economic sector or by industry.

This research contributes to the understanding of financial asset valuations under particular interventions by central planners in some financial markets.

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Data Availability Statement: The data that support the findings of this study are available from the Federal Reserve Bank of St. Louis (FRED) datasets website https://fred.stlouisfed.org/categories/ (accessed on 29 April 2022) and monetary policy website https://www.federalreserve.gov/monetarypolicy.htm (accessed on 29 April 2022).

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

Appendix A. Simultaneous Equations by Stages System Index Solution

Given the system:

$$\text{Stage 1: } t\_yield_t = \pi_0 + \pi_1 Fed\_BalSht_t + v_t \tag{A1}$$

$$\text{Stage 2: } usd\_eur_t = \delta_0 + \delta_1 t\_yield_t + \delta_2 wti\_spot_t + e_t \tag{A2}$$

$$\text{Stage 3: } Index_t = \beta_0 + \beta_1 t\_yield_t + \beta_2 usd\_eur_t + \beta_3 Fed\_FRate_t + \beta_4 us\_cpi_t + u_t \tag{A3}$$

By substitution of Equations (2) and (3) into (4):

$$\begin{gathered} Index_t = \beta_0 + \beta_1(\pi_0 + \pi_1 Fed\_BalSht_t + v_t) + \beta_2(\delta_0 + \delta_1(\pi_0 + \pi_1 Fed\_BalSht_t + v_t) + \delta_2 wti\_spot_t + e_t) + \\ \beta_3 Fed\_FRate_t + \beta_4 us\_cpi_t + u_t \\ Index_t = \zeta_0 + \zeta_1 Fed\_BalSht_t + \zeta_2 wti\_spot_t + \zeta_3 Fed\_FRate_t + \zeta_4 us\_cpi_t + \epsilon_t \end{gathered} \tag{A4}$$

Notice that the variables *t_yield* and *usd_eur* have disappeared from the expression (A4), as they are both the endogenous variables in the system. Hence, the system is finally dependent on the exogenous variables (or instruments) *Fed_BalSht, wti_spot, Fed_FRate and us_cpi*.

Appendix B. Regression Results by Index (from 16 December 2008 to 29 April 2022)

Three-Stage Least-Squares Regressions by Index

	(1)		(2)		(3)		(4)	
Variable	**SP500**	**SP500 1WLg**	**DJIA**	**DJIA 1WLg**	**NASDAQ**	**NASDAQ 1WLg**	**SMCP2K**	**SMCP2K 1WLg**
Fed_FRate	384.9307	382.3947	4137.8340	4119.3300	1183.6030	1174.2210	208.4120	206.6854
us_cpi	333.8543	332.7607	2469.4850	2462.0310	1292.0510	1289.9160	146.9944	146.2313
_cons	1327.1010	1331.8390	11913.1100	11947.2600	2642.4890	2655.5140	807.1451	810.3717
R^2	0.4077	0.4068	0.4494	0.4486	0.3657	0.3649	0.4044	0.4034
χ	2411.66	2385.72	2903.65	2873.31	2230.06	2210.86	2187.3	2161.54
P-Value	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
t_yield								
Fed_BalSht	−0.233722	−1.408131	−0.228948	−1.372496	−0.233966	−1.360477	−0.253249	−1.543998
lag1w_Bal_Sh	-	1.178981	-	1.147626	-	1.130360	-	1.298019
_cons	3.261833	3.25493	3.241519	3.236392	3.262874	3.258566	3.344931	3.327776
R^2	0.3744	0.3897	0.3731	0.3883	0.3745	0.3895	0.377	0.3929
χ	1778.33	1862.02	1714.78	1800.21	1783.27	1871.68	2060.26	2123.75
P-Value	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
usd_eur								
t_yield	−0.044983	−0.042221	−0.046512	−0.043667	−0.051962	−0.049034	−0.038969	−0.036551
wti_spot	−0.001836	−0.001847	−0.001832	−0.001844	−0.001836	−0.001849	−0.001878	−0.001882
_cons	1.047974	1.042690	1.051195	1.045825	1.063766	1.058340	1.037202	1.032244
R^2	0.4767	0.4907	0.4716	0.4865	0.4490	0.4669	0.4918	0.5026
χ	4490.07	4345.55	4565.02	4419.63	4910.79	4763.24	4309.16	4164.75
P-Value	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Endogenous variables:	SP500 DJIA NASDAQ		SMCP2K t_yield usd_eur					
Exogenous variables:	Fed_FRate us_cpi		lag1w_Bal_Sh Fed_BalSht wti_spot					

Source: own estimations.

Appendix C. Robust Estimates S&P 500 Index (from 16 December 2008 to 29 April 2022)

Two Step GMM Estimation Results						
Step 1						
Iteration 0:	GMM criterion Q (b) = 5828325.5					
Iteration 1:	GMM criterion Q (b) = 540042.39					
Iteration 2:	GMM criterion Q (b) = 540042.39					
Step 2						
Iteration 0:	GMM criterion Q (b) = 1.2128526					
Iteration 1:	GMM criterion Q (b) = 1.1949021					
Iteration 2:	GMM criterion Q (b) = 1.1949021					
GMM estimation						
Number of parameters = 9						
Number of moments = 18						
Initial weight matrix:		Unadjusted		Number of obs = 3,361		
GMM weight matrix:		Unadjusted				
	Coef.	Std. Err.	z	P > z	[95% Conf. Interval]	
SP500						
Fed_FRate	397.817	18.69296	21.28	0.0000	361.179	434.455
us_cpi	335.843	7.73227	43.43	0.0000	320.688	350.998
_cons	1316.156	22.57053	58.31	0.0000	1271.919	1360.394
t_yield						
lag1w_Bal_Sh	1.536262	0.196165	7.83	0.0000	1.15179	1.920738
Fed_BalSht	−1.752991	0.195403	−8.97	0.0000	−2.135973	−1.370008
_cons	3.20559	0.025438	126.02	0.0000	3.15573	3.255447
usd_eur						
t_yield	−0.043461	0.003145	−13.82	0.0000	−0.049626	−0.037297
wti_spot	−0.001838	0.000067	−27.58	0.0000	−0.001968	−0.001707
_cons	1.04489	0.005873	177.9	0.0000	1.03337	1.056397
Instruments for equation eq1:		Fed_FRate us_cpi		lag1w_Bal_Sh Fed_BalSht wti_spot _cons		
Instruments for equation eq2:		Fed_FRate us_cpi		lag1w_Bal_Sh Fed_BalSht wti_spot _cons		
Instruments for equation eq3:		Fed_FRate us_cpi		lag1w_Bal_Sh Fed_BalSht wti_spot _cons		

Source: own calculations.

Appendix D. Test of Independence of Errors by Index (from 16 December 2008 to 29 April 2022)

Panel A: Correlation matrix of residuals (*without* Balance Sheet Weekly Lag):				Panel B: Correlation matrix of residuals (*with* Balance Sheet Weekly Lag):			
	SP500	t_yield	usd_eur		SP500	t_yield	usd_eur
SP500	1			SP500	1		
t_yield	−0.1666	1		t_yield	−0.1631	1	
usd_eur	0.1094	0.2443	1	usd_eur	0.1042	0.2207	1
Breusch–Pagan test of independence:				Breusch–Pagan test of independence:			
chi2(3) = 334.467,			Pr = 0.0000	chi2(3) = 289.651,			Pr = 0.0000
Correlation matrix of residuals:				Correlation matrix of residuals:			
	DJIA	t_yield	usd_eur		DJIA	t_yield	usd_eur
DJIA	1			DJIA	1		
t_yield	−0.1859	1		t_yield	−0.1813	1	
usd_eur	0.0984	0.2443	1	usd_eur	0.0931	0.2207	1
Breusch–Pagan test of independence:				Breusch–Pagan test of independence:			
chi2(3) = 349.718,			Pr = 0.0000	chi2(3) = 303.367,			Pr = 0.0000
Correlation matrix of residuals:				Correlation matrix of residuals:			
	NASDAQ	t_yield	usd_eur		NASDAQ	t_yield	usd_eur
NASDAQ	1			NASDAQ	1		
t_yield	−0.1702	1		t_yield	−0.1649	1	
usd_eur	0.029	0.2443	1	usd_eur	0.0238	0.2207	1
Breusch–Pagan test of independence:				Breusch–Pagan test of independence:			
chi2(3) = 301.150,			Pr = 0.0000	chi2(3) = 257.073,			Pr = 0.0000
Correlation matrix of residuals:				Correlation matrix of residuals:			
	SMCP2K	t_yield	usd_eur		SMCP2K	t_yield	usd_eur
SMCP2K	1			SMCP2K	1		
t_yield	−0.0943	1		t_yield	−0.0981	1	
usd_eur	0.162	0.2443	1	usd_eur	0.1568	0.2207	1
Breusch–Pagan test of independence:				Breusch–Pagan test of independence:			
chi2(3) = 319.167,			Pr = 0.0000	chi2(3) = 278.725,			Pr = 0.0000

Note(s): This table displays the correlation matrix of errors across the three equations and the Breusch–Pagan test of independence of the errors for each of the indices. High χ^2 indicate that the three correlation coefficients are jointly significant. Source: own estimations.

Appendix E. 3SLS, SUR and 2 Step GMM Estimators for All Indices (2008–2022)

Three-Stage Least-Squares, Seemingly Unrelated, and Two Step GMM Regressions Estimation Results by Index (from 16 December 2008 to 29 April 2022)

Index	S&P500						DJIA					
Model	3SLS	3SLS1Wlg	SUR	SUR1Wlg	Robust	Robust1Wlg	3SLS	3SLS1Wlg	SUR	SUR1Wlg	Robust	Robust1Wlg
Variable												
Fed_FRate	384.9307	382.3947	341.8748	343.2947	404.6229	397.8169	4137.8341	4119.3297	3813.1064	3823.4318	4350.7396	4308.5433
us_cpi	333.8543	332.7608	320.0322	319.9994	337.4309	335.8427	2469.4851	2462.0312	2362.0200	2362.6059	2502.5455	2494.4704
_cons	1327.1010	1331.8388	1380.8500	1381.1001	1307.7838	1316.1561	11913.1050	11947.2620	12324.6550	12325.5320	11715.0120	11765.1700
t_yield												
Fed_BalSht	−0.2337	−1.4081	−0.2225	−1.7064	−0.2202	−1.7530	−0.2289	−1.3725	−0.2182	−1.6731	−0.2067	−2.1008
lag1w_Bal_Sh		1.1790		1.4893		1.5363		1.1476		1.4598		1.9005
_cons	3.2618	3.2549	3.2141	3.2070	3.2042	3.2056	3.2415	3.2364	3.1956	3.1901	3.1468	3.1391
usd_eur												
t_yield	−0.0450	−0.0422	−0.0391	−0.0375	−0.0472	−0.0435	−0.0465	−0.0437	−0.0393	−0.0377	−0.0502	−0.0461
wti_spot	−0.0018	−0.0018	−0.0017	−0.0017	−0.0018	−0.0018	−0.0018	−0.0018	−0.0017	−0.0017	−0.0018	−0.0018
_cons	1.0480	1.0427	1.0234	1.0217	1.0519	1.0449	1.0512	1.0458	1.0248	1.0231	1.0576	1.0500
Index	NASDAQ						SMCP2K					
Model	3SLS	3SLS1Wlg	SUR	SUR1Wlg	Robust	Robust1Wlg	3SLS	3SLS1Wlg	SUR	SUR1Wlg	Robust	Robust1Wlg
Variable												
Fed_FRate	1183.6028	1174.2210	1026.3398	1031.1730	1164.4119	1145.8599	208.4120	206.6854	186.2845	186.9564	212.6758	209.6973
us_cpi	1292.0513	1289.9159	1243.1496	1244.3260	1275.7923	1272.5377	146.9944	146.2313	140.5160	140.3782	148.0706	147.0385
_cons	2642.4893	2655.5136	2835.7710	2833.6290	2685.8162	2706.8413	807.1451	810.3717	833.5691	834.1026	802.3836	806.9149
t_yield												
Fed_BalSht	−0.2340	−1.3605	−0.2260	−1.6988	−0.2122	−2.0778	−0.2532	−1.5440	−0.2403	−1.8271	−0.2490	−1.6239
lag1w_Bal_Sh		1.1304		1.4781		1.8716		1.2980		1.5945		1.3810
_cons	3.2629	3.2586	3.2289	3.2219	3.1702	3.1642	3.3449	3.3278	3.2897	3.2735	3.3270	3.3154
usd_eur												
t_yield	−0.0520	−0.0490	−0.0411	−0.0395	−0.0555	−0.0513	−0.0390	−0.0366	−0.0374	−0.0359	−0.0397	−0.0369
wti_spot	−0.0018	−0.0018	−0.0017	−0.0018	−0.0018	−0.0018	−0.0019	−0.0019	−0.0017	−0.0017	−0.0019	−0.0019
_cons	1.0638	1.0583	1.0324	1.0308	1.0699	1.0623	1.0372	1.0322	1.0200	1.0182	1.0384	1.0328
Endogenous variables:	SP500 DJIA NASDAQ SMCP2K t_yield usd_eur											
Exogenous variables:	Fed_FRate us_cpi Fed_BalSht lag1w_Bal_Sh wti_spot											

Source: Own Estimations.

Appendix F. Correlation Results (2008–2013)

	SP500	DJIA	NASDAQ	SMLCAP2000	Fed_ BalSht	lag1d_ Bal_Sh	lag1w_ Bal_Sh	Fed_ FRate	t_yield	usd_eur	wti_spot	us_cpi	vix
SP500	1												
DJIA	0.9956 *	1											
	0.0000												
NASDAQ	0.9950 *	0.9900 *	1										
	0.0000	0.0000											
SMLCAP2000	0.9914 *	0.9844 *	0.9896 *	1									
	0.0000	0.0000	0.0000										
Fed_BalSht	0.9391 *	0.9391 *	0.9427 *	0.9322 *	1								
	0.0000	0.0000	0.0000	0.0000									
lag1d_Bal_Sh	0.9386 *	0.9388 *	0.9425 *	0.9316 *	0.9996 *	1							
	0.0000	0.0000	0.0000	0.0000	0.0000								
lag1w_Bal_Sh	0.9368 *	0.9374 *	0.9418 *	0.9293 *	0.9982 *	0.9986 *	1						
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							
Fed_FRate	.	.	.	.	.	.	.	.					
t_yield	−0.4187 *	−0.4707 *	−0.4211 *	−0.3546 *	−0.4962 *	−0.4979 *	−0.5067 *	.	1				
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	.					
usd_eur	0.1716 *	0.1940 *	0.1821 *	0.1411 *	0.1938 *	0.1946 *	0.1976 *	.	−0.5324 *	1			
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	.	0.0000				
wti_spot	0.8186 *	0.8385 *	0.8342 *	0.8335 *	0.7295 *	0.7291 *	0.7290 *	.	−0.2902 *	0.0066	1		
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	.	0.0000	0.8146			
us_cpi	0.3866 *	0.4392 *	0.4068 *	0.4032 *	0.4016 *	0.4016 *	0.4017 *	.	−0.3064 *	0.0608	0.6168 *	1	
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	.	0.0000	0.0304	0.0000		
vix	−0.7913 *	−0.7824 *	−0.7808 *	−0.7846 *	−0.5779 *	−0.5768 *	−0.5706 *	.	0.1325 *	−0.0258	−0.7765 *	−0.2480 *	1
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	.	0.0000	0.3578	0.0000	0.0000	

(*) denotes coefficients significant at the 10% level. Source: Own calculations.

Appendix G. Correlation Results (2020–2022)

	SP500	DJIA	NASDAQ	SMLCAP 2000	Fed_ BalSht	lag1d_ Bal_Sh	lag1w_ Bal_Sh	Fed_ FRate	t_yield	usd_eur	wti_spot	us_cpi	vix
SP500	1												
DJIA	0.9909 *	1											
	0.0000												
NASDAQ	0.9783 *	0.9762 *	1										
	0.0000	0.0000											
SMLCAP2000	0.9176 *	0.9454 *	0.9530 *	1									
	0.0000	0.0000	0.0000										
Fed_BalSht	0.9395 *	0.9169 *	0.8818 *	0.7923 *	1								
	0.0000	0.0000	0.0000	0.0000									
lag1d_Bal_Sh	0.9387 *	0.9156 *	0.8808 *	0.7897 *	0.9985 *	1							
	0.0000	0.0000	0.0000	0.0000	0.0000								
lag1w_Bal_Sh	0.9329 *	0.9074 *	0.8758 *	0.7799 *	0.9942 *	0.9952 *	1						
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							
Fed_FRate	0.137	0.1129	0.0779	0.0518	0.1998 *	0.2005 *	0.2003 *	1					
	0.0019	0.0105	0.0778	0.2416	0.0000	0.0000	0.0000						
t_yield	0.8249 *	0.8272 *	0.7448 *	0.7776 *	0.8121 *	0.8190 *	0.8280 *	0.3310 *	1				
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000					
usd_eur	−0.2720 *	−0.3581 *	−0.4108 *	−0.5149 *	−0.0833	−0.0792	−0.0457	0.2030 *	−0.048	1			
	0.0000	0.0000	0.0000	0.0000	0.0594	0.0736	0.3043	0.0000	0.2774				
wti_spot	0.9011 *	0.8884 *	0.8441 *	0.8231 *	0.8783 *	0.8786 *	0.8812 *	0.2782 *	0.9232 *	−0.1361	1		
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0020			
us_cpi	0.8725 *	0.8317 *	0.7680 *	0.6746 *	0.8822 *	0.8838 *	0.8902 *	0.2509 *	0.8595 *	0.1269	0.9073 *	1	
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0040	0.0000		
vix	−0.7263 *	−0.7686 *	−0.7784 *	−0.7670 *	−0.6650 *	−0.6608 *	−0.6358 *	−0.0351	−0.4254 *	0.5730 *	−0.4900 *	−0.3888 *	1
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.4280	0.0000	0.0000	0.0000	0.0000	

(*) denotes coeficients signifcant at the 10% level. Source: Own calculations.

Appendix H. Regression Results by Index per Intervention

Three-Stage Least-Squares Regressions by Index per Intervention

Panel A: Regressions Results 1st Intervention (2008–2013)

Variable	SP500	SP500 1WLg	DJIA	DJIA 1WLg	NASDAQ	NASDAQ 1WLg	SMCP2K	SMCP2K 1WLg
Index	(1)		(2)		(3)		(4)	
Fed_FRate	(omitted)	(omitted)	(omitted)	(omitted)	(omitted)	(omitted)	(omitted)	(omitted)
us_cpi	71.7047	70.8900	707.6381	700.8915	185.9111	183.6030	52.0364	51.4864
_cons	1159.4691	1161.9480	10754.6280	10774.7960	2373.3875	2380.5885	671.6842	673.4021
P-Value	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
t_yield	(5)		(6)		(7)		(8)	
Fed_BalSht	−0.7962	2.2288	−0.7390	2.3320	−0.7995	2.2430	−0.8747	2.0488
lag1w_Bal_Sh	-	−3.0620	-	−3.1103	-	−3.0796	-	−2.9574
_cons	4.8069	4.8887	4.6529	4.7403	4.8159	4.8980	5.0185	5.0925
P-Value	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
usd_eur	(9)		(10)		(11)		(12)	
t_yield	−0.0308	−0.0339	−0.0311	−0.0342	−0.0304	−0.0334	−0.0303	−0.0332
wti_spot	−0.0005	−0.0006	−0.0005	−0.0006	−0.0005	−0.0006	−0.0005	−0.0006
_cons	0.8665	0.8826	0.8673	0.8833	0.8665	0.8825	0.8663	0.8823
P-Value	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

Panel B: Regressions Results 2nd Intervention (2020–2022)

Variable	SP500	SP500 1WLg	DJIA	DJIA 1WLg	NASDAQ	NASDAQ 1WLg	SMCP2K	SMCP2K 1WLg
Index	(13)		(14)		(15)		(16)	
Fed_FRate	−899.4386	−934.4934	−8372.9004	−9421.7857	−5603.9925	−5440.0177	−1481.5871	−1570.1119
us_cpi	209.6201	198.2083	1343.0482	1263.4306	682.0166	631.6812	94.3413	89.6114
_cons	3379.6891	3440.3962	28658.1660	29297.2660	11841.9870	12023.1460	1979.4897	2026.0396
P-Value	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
t_yield	(17)		(18)		(19)		(20)	
Fed_BalSht	0.4025	1.4701	0.3935	1.5285	0.3993	1.5056	0.3774	1.6158
lag1w_Bal_Sh	-	−0.9766	-	−1.0390	-	−1.0100	-	−1.1297
_cons	−1.8795	−2.6344	−1.8098	−2.6064	−1.8549	−2.6521	−1.6859	−2.5842
P-Value	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
usd_eur	(21)		(22)		(23)		(24)	
t_yield	0.2952	0.1108	0.2637	0.0964	0.3541	0.1165	0.3205	0.1128
wti_spot	−0.0038	−0.0011	−0.0032	−0.0008	−0.0048	−0.0012	−0.0041	−0.0011
_cons	0.7107	0.7838	0.7175	0.7862	0.6925	0.7836	0.6966	0.7802
P-Value	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

Endogenous variables: SMCP2K t_yield usd_eur
Exogenous variables: lag1w_Bal_Sh wti_spot

Source: own calculations.

Appendix I. Instrumental Variables Tests by Index per Intervention

Durwin-Wu-Hausman Test			
Tests of endogeneity			
Ho: variables are exogenous			
Intervention Period:		(2008–2013)	
DJIA2SLS	Durwin (score) Wu-Hausman	chi2(1) = 287.229 F(1,1265) = 370.091	(p = 0.0000) (p = 0.0000)
DJIA2SLS_1Wlg	Durwin (score) Wu-Hausman	chi2(1) = 290.807 F(1,260) = 376.51	(p = 0.0000) (p = 0.0000)
NASDAQ2SLS	Durwin (score) Wu-Hausman	chi2(1) = 317.109 F(1,1265) = 421.417	(p = 0.0000) (p = 0.0000)
NASDAQ2SLS_1Wlg	Durwin (score) Wu-Hausman	chi2(1) = 320.922 F(1,260) = 428.768	(p = 0.0000) (p = 0.0000)
SMCP2K2SLS	Durwin (score) Wu-Hausman	chi2(1) = 287.229 F(1,1265) = 370.091	(p = 0.0000) (p = 0.0000)
SMCP2K2SLS_1Wlg	Durwin (score) Wu-Hausman	chi2(1) = 315.581 F(1,260) = 418.713	(p = 0.0000) (p = 0.0000)
Intervention Period:		(2020–2022)	
DJIA2SLS	Durwin (score) Wu-Hausman	chi2(1) = 62.7963 F(1,508) = 70.858	(p = 0.0000) (p = 0.0000)
DJIA2SLS_1Wlg	Durwin (score) Wu-Hausman	chi2(1) = 80.1503 F(1,503) = 94.2284	(p = 0.0000) (p = 0.0000)
NASDAQ2SLS	Durwin (score) Wu-Hausman	chi2(1) = 95.4257 F(1,508) = 116.09	(p = 0.0000) (p = 0.0000)
NASDAQ2SLS_1Wlg	Durwin (score) Wu-Hausman	chi2(1) = 121.784 F(1,503) = 158.609	(p = 0.0000) (p = 0.0000)
SMCP2K2SLS	Durwin (score) Wu-Hausman	chi2(1) = 100.157 F(1,508) = 123.242	(p = 0.0000) (p = 0.0000)
SMCP2K2SLS_1Wlg	Durwin (score) Wu-Hausman	chi2(1) = 120.088 F(1,503) = 155.717	(p = 0.0000) (p = 0.0000)
Period:		(2008–2022)	
DJIA2SLS	Durwin (score) Wu-Hausman	chi2(1) = 2157.66 F(1,3361) = 6001.52	(p = 0.0000) (p = 0.0000)
DJIA2SLS_1Wlg	Durwin (score) Wu-Hausman	chi2(1) = 2083.34 F(1,3356) = 5472.27	(p = 0.0000) (p = 0.0000)
NASDAQ2SLS	Durwin (score) Wu-Hausman	chi2(1) = 2001.14 F(1,3361) = 4927.87	(p = 0.0000) (p = 0.0000)
NASDAQ2SLS_1Wlg	Durwin (score) Wu-Hausman	chi2(1) = 1920.89 F(1,3356) = 4476.4	(p = 0.0000) (p = 0.0000)
SMCP2K2SLS	Durwin (score) Wu-Hausman	chi2(1) = 1971.55 F(1,3361) = 4751.98	(p = 0.0000) (p = 0.0000)
SMCP2K2SLS_1Wlg	Durwin (score) Wu-Hausman	chi2(1) = 1863.77 F(1,3356) = 4177.57	(p = 0.0000) (p = 0.0000)

Note(s): This table shows presence of endogeneity in the variables included in the models selected. The null hypothesis that all variables in the models are exogenous is rejected if Chi^2 and F values are large. Zero p-values indicate variables are endogenous. All models use the balance sheet as a control variable. Source: own estimations.

Appendix J. First-Stage Regression Summary Statistics by Index per Intervention

Model	Variable	R-sq.	Adjusted R-sq.	Partial R-sq.	Robust F Value		Prob > F
Intervention Period:				(2008–2013)			
DJIA2SLS	*t_yield*	0.4688	0.4671	0.4138	F(3,1264):	330.169	0.0000
DJIA2SLS_1Wlg	*t_yield*	0.4787	0.4766	0.4236	F(4,1258):	253.755	0.0000
NASDAQ2SLS	*t_yield*	0.4688	0.4671	0.4138	F(3,1264):	330.169	0.0000
NASDAQ2SLS_1Wlg	*t_yield*	0.4787	0.4766	0.4236	F(4,1258):	253.755	0.0000
SMCP2K2SLS	*t_yield*	0.4688	0.4671	0.4138	F(3,1264):	330.169	0.0000
SMCP2K2SLS_1Wlg	*t_yield*	0.4787	0.4766	0.4236	F(4,1258):	253.755	0.0000
Intervention Period:				(2020–2022)			
DJIA2SLS	*t_yield*	0.8623	0.8609	0.4426	F(3,507):	132.534	0.0000
DJIA2SLS_1Wlg	*t_yield*	0.8677	0.8662	0.4637	F(4,501):	118.595	0.0000
NASDAQ2SLS	*t_yield*	0.8623	0.8609	0.4426	F(3,507):	132.534	0.0000
NASDAQ2SLS_1Wlg	*t_yield*	0.8677	0.8662	0.4637	F(4,501):	118.595	0.0000
SMCP2K2SLS	*t_yield*	0.8623	0.8609	0.4426	F(3,507):	132.534	0.0000
SMCP2K2SLS_1Wlg	*t_yield*	0.8677	0.8662	0.4637	F(4,501):	118.595	0.0000
Period:				(2008–2022)			
DJIA2SLS	*t_yield*	0.4883	0.4875	0.4715	F(3,3360):	957.066	0.0000
DJIA2SLS_1Wlg	*t_yield*	0.4987	0.4978	0.4823	F(4,3354):	871.693	0.0000
NASDAQ2SLS	*t_yield*	0.4883	0.4875	0.4715	F(3,3360):	957.066	0.0000
NASDAQ2SLS_1Wlg	*t_yield*	0.4987	0.4978	0.4823	F(4,3354):	871.693	0.0000
SMCP2K2SLS	*t_yield*	0.4883	0.4875	0.4715	F(3,3360):	957.066	0.0000
SMCP2K2SLS_1Wlg	*t_yield*	0.4987	0.4978	0.4823	F(4,3354):	871.693	0.0000

Note(s): This table shows the Robust F statistic for the significance of the instrument coefficients. If the F statistic is not significant, the instruments have no significant explanatory power for *t_yield* after controlling for the effect of *Fed_BalSht*, *lag1w_Bal_Sh*, *usd_eur*, and *wti_spot*. Source: own estimations.

Appendix K. Instrumental Variables Identification Tests by Index per Intervention

	Underidentification test (Anderson canon. corr. LM statistic): Ho: underidentification of instrumental variables		Sargan statistic (overidentification test of all instruments): Ho: overderidentification of instrumental variables	
Intervention Period:		(2008–2013)		
DJIA2SLS	525.118	Chi-sq(3) P-val = 0.0000	658.841	Chi-sq(2) P-val = 0.0000
DJIA2SLS1Wlg	535.438	Chi-sq(4) P-val = 0.0000	655.72	Chi-sq(3) P-val = 0.0000
NASDAQ2SLS	525.118	Chi-sq(3) P-val = 0.0000	636.342	Chi-sq(2) P-val = 0.0000
NASDAQ2SLS1Wlg	535.438	Chi-sq(4) P-val = 0.0000	633.039	Chi-sq(3) P-val = 0.0000
SMCP2K2SLS	525.118	Chi-sq(3) P-val = 0.0000	631.205	Chi-sq(2) P-val = 0.0000
SMCP2K2SLS1Wlg	535.438	Chi-sq(4) P-val = 0.0000	630.598	Chi-sq(3) P-val = 0.0000
Intervention Period:		(2020–2022)		
DJIA2SLS	227.03	Chi-sq(3) P-val = 0.0000	317.99	Chi-sq(2) P-val = 0.0000
DJIA2SLS1Wlg	235.56	Chi-sq(4) P-val = 0.0000	277.335	Chi-sq(3) P-val = 0.0000
NASDAQ2SLS	227.03	Chi-sq(3) P-val = 0.0000	236.747	Chi-sq(2) P-val = 0.0000
NASDAQ2SLS1Wlg	235.56	Chi-sq(4) P-val = 0.0000	202.537	Chi-sq(3) P-val = 0.0000
SMCP2K2SLS	227.03	Chi-sq(3) P-val = 0.0000	212.14	Chi-sq(2) P-val = 0.0000
SMCP2K2SLS1Wlg	235.56	Chi-sq(4) P-val = 0.0000	186.43	Chi-sq(3) P-val = 0.0000
Period:		(2008–2022)		
DJIA2SLS	1586.973	Chi-sq(3) P-val = 0.0000	510.89	Chi-sq(2) P-val = 0.0000
DJIA2SLS1Wlg	1620.904	Chi-sq(4) P-val = 0.0000	569.035	Chi-sq(3) P-val = 0.0000
NASDAQ2SLS	1586.973	Chi-sq(3) P-val = 0.0000	553.352	Chi-sq(2) P-val = 0.0000
NASDAQ2SLS1Wlg	1620.904	Chi-sq(4) P-val = 0.0000	618.657	Chi-sq(3) P-val = 0.0000

SMCP2K2SLS	1586.973	Chi-sq(3) P-val = 0.0000	537.662	Chi-sq(2) P-val = 0.0000
SMCP2K2SLS1Wlg	1620.904	Chi-sq(4) P-val = 0.0000	624.028	Chi-sq(3) P-val = 0.0000

Note(s): This table shows high Chi2 values in the Instrumental Variables Underidentification test. These reject the null hypothesis of less relevant instruments in the models as endogenous variables. The zero *p*-values suggest no underidentification of instruments. In the Overidentification test, large Chi2 values and zero *p*-values detect overidentification of instruments. That is, there is one endogenous variable *t_yield*, but more than one valid instrument in addition to *Fed_BalSht*, which are (2): *usd_eur* and *wti_spot* in the simple models and (3): plus *lag1w_Bal_Sh*, in the lagged models. Source: own estimations.

Notes

1 Quantitative Easing (QE) is a form of monetary policy used by central banks as a method of increasing the domestic money supply and stimulating economic activity. QEs consist of large-scale purchases of long-term government bond and other types of financial assets.

2 Note that variable vix_t has been omitted from the system due to its low significance in the model estimations.

3 As of December 2013, the Fed monthly treasury and government backed MBS purchases were USD 45 and USD 40 billion. Should these amounts be multiplied by 0.00141 and 0.00118, the average expected monthly drop and rise of prior week in the yields would be 11.985 bps and 10.021 bps, respectively. Multiplying the difference of these amounts times 60 months (of intervention), the average expected net drop in the yields would be 117.84 bps for the entire first intervention.

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