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Abstract

Most advanced economy central banks cut their policy rates and introduced asset purchase programs (APPs) to weather the impacts of the Covid-19 pandemic on their economies and financial systems. Similar to their advanced economy counterparts, a number of emerging market (EM) central banks also initiated APPs during the Covid-19 pandemic. In this paper, we analyze the effects of these EM APPs on financial market variables such as sovereign bond yields, nominal exchange rates vis-à-vis US dollar, and stock market indices by using a novel causal inference approach. We utilize the local projections (LP) methodology of Jordà (2005) and estimate the average treatment effect (ATE) of EM APPs by applying the augmented inverse probability weighting (AIPW) estimator that addresses the selection bias and endogeneity problems inherent in the statistical analysis of quantitative easing (QE) policies. Our empirical findings suggest that QE policies adopted by EM central banks played an instrumental role in lowering sovereign bond yields and supporting exchange rates and equity markets during Covid-19 pandemic. This suggests that QE policies may complement traditional monetary policies in EM countries especially during periods of elevated market stress and uncertainty.

Keywords: Covid-19, Quantitative Easing, Asset Purchase Program, Central Banks, Emerging Markets, Local Projections, Augmented Inverse Probability Weighting Estimation.

JEL Codes: E5, F3, G1.

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Non-technical Summary

At the height of Covid-19 pandemic, several advanced economy central banks initiated quantitative easing (QE) policies mainly in the form of asset purchases. Unlike previous financial crisis periods when only advanced countries implemented QE policies, this time some of the emerging market (EM) central banks also adopted asset purchase programs and bought government bonds in relatively sizable amounts.

In this paper, we study the effects of EM asset purchase programs implemented during Covid-19 pandemic on the financial markets. Different from most of the recent papers relying on event study methodology, we utilize the local projections approach and estimate the causal effects of these programs on local currency government bond yields, nominal exchange rates, and stock market indices using a six-month analysis horizon.

We use the actual monthly bond purchases as a proxy for asset purchase programs rather than their announcements, which are frequently used in the papers examining EM quantitative easing policies. The underlying assumption in our analysis is that actual bond purchase operations contain information that can be critical for the markets. Our sample is determined based on data availability and includes 19 EM economies covering the period between January 2020 and May 2021.

Our findings suggest that the asset purchase programs adopted by EM central banks were instrumental in lowering sovereign bond yields. The impacts of these programs on sovereign bond yields range from 10 to 40 basis points, with changes in the 5- and 10-year bond yields being relatively larger than those in 2-year bond yields. The asset purchases also led to a slight appreciation of local currencies against the US dollar, by approximately 1% in the six-month period following the first bond purchases. Furthermore, EM asset purchase programs supported equity indices with their impact reaching 4%. The results suggest that asset purchases can complement traditional monetary policies especially during periods of elevated market stress and uncertainty.

1. Introduction

The financial market stress triggered by the Covid-19 pandemic resulted in a massive market sell-off in the spring of 2020. Bond yields and risk premiums jumped, stock markets plummeted across the board, and most emerging market currencies depreciated against the US dollar and other safe haven currencies. A set of policy measures were introduced in an effort to address the market dislocations, restore the risk appetite, and bolster the economic activities that were severely hurt by heightened uncertainty and the fall in mobility caused by lockdowns. The policy response was multifaceted and, in most cases, included fiscal, monetary, and financial policies. Large, advanced economy central banks initiated asset purchase programs (APPs) similar to their responses during the global financial crisis.[1] The main goals of the APPs were to provide monetary accommodation and to address the market dysfunctionality caused by risk aversion. Unlike previous crisis episodes when only advanced countries implemented QE policies, this time several emerging and developing country central banks also started to purchase government and corporate bonds as well as mortgage-backed securities. As per the stated goals, these programs mainly sought to stabilize local bond markets, ensure proper functioning of financial markets, support the monetary transmission mechanism, and in some cases ease the financial conditions (Table 1). The bond purchases peaked during the height of market turbulence and were halted by mid-2020 except for a few countries such as Hungary, Poland, India, and Indonesia. Table 2 shows that the bond purchases by emerging market central banks reached sizable volumes but remained low compared to the magnitude of the asset purchase programs carried out by the Federal Reserve (Fed) and European Central Bank (ECB) that stood at 23 and 14 percent of GDP, respectively.

This paper analyzes the effects of emerging market (EM) quantitative easing (QE) policies on the domestic financial markets. Unlike most of the recent papers relying on event study methodology, we utilize the local projections (LP) approach proposed by Jordà (2005) and estimate the average treatment effect (ATE) of APPs. The augmented inverse probability weighting (AIPW) estimator, which re-randomizes the sample based on propensity scores, is used to address the possible selection bias problem, which might stem from the differences between the QE-implementing and non-implementing emerging market countries. Thus, we account for the endogeneity usually inherent in monetary policy including QE programs.

In the spirit of Fratzscher et al. (2016) and Beck et al. (2019), we use the actual bond purchases as a QE proxy rather than QE program announcements, which are frequently used in the papers examining EM quantitative easing policies. The underlying assumption in our analysis is that actual bond purchase operations contain information that can be critical for the markets, especially in the case of EM APPs.

[1] The term "asset purchase program" is used interchangeably with "quantitative easing" hereafter.

Our sample is determined based on data availability and includes 19 EM economies covering the period between January 2020 and May 2021. We include both QE-implementing and non-implementing emerging market countries as policy and control groups, respectively.

The empirical results suggest that the APPs adopted by emerging market central banks were instrumental in lowering sovereign bond yields. The impacts of APPs on sovereign bond yields range between 10 to 40 basis points (bp) with changes in the 5- and 10-year bond yields being relatively larger than in short-term bond yields. QE policies also led to a slight appreciation of local currencies against the US dollar, by approximately 1% in the six-month period following the first bond purchases. Furthermore, EM QE programs supported equity indices with their impact reaching 4%. The results suggest that QE policies can complement traditional monetary policies especially during periods of elevated market stress and uncertainty. That being said, there are certain caveats that need to be considered while assessing these empirical findings. First of all, while we use the EM central banks' government bond purchase dates as a proxy for QE policies, there might be alternative proxies or definitions. For instance, a number of studies include government, corporate, and other security purchases in their analysis. Secondly, as we rely on low frequency data, our analysis does not specifically control for the announcement effects or relevant policy guidance provided by the central banks as well as macro-prudential measures due to data unavailability. Lastly, QE policies may have different economic and financial effects during different times. It should be noted that our analysis only applies to the Covid-19 pandemic period.

The rest of paper is organized as follows. Section 1 provides a brief overview of the main strands of research on quantitative easing policies and recent studies examining the APPs introduced during the Covid-19 pandemic. Section 2 presents the empirical methodology and the data used. Section 3 discusses statistical results showing the impacts of APPs on domestic financial markets. Section 4 concludes.

2. Literature Review

In this section, we briefly discuss the theoretical background of quantitative easing policies and present some of the studies examining the APPs adopted by advanced and emerging market central banks.

2.1. Quantitative Easing

QE in general includes large-scale long-term government bond and other asset purchases to reduce long-term yields and ease financial conditions. In addition to security purchases, central banks can change collateral requirements and adjust the composition of their balance sheets. Such policy measures, dubbed unconventional monetary policy, have been mostly used by advanced economy

central banks with policy rates at or around the zero lower bound. However, the policy experiments of EM central banks during the pandemic constitute an exception to such a generalization.

The asset purchases of a central bank can affect portfolio decisions and asset prices through several channels such as the signaling channel, the portfolio balance channel, the liquidity channel, the duration risk channel, and the safety premium channel (Krishnamurthy and Vissing-Jorgensen, 2011). For the purposes of brevity, we single out three of these channels: the portfolio balance, signaling, and liquidity premia.

i) *Portfolio balance channel:* A central bank's asset purchases lower the available supply to investors, change the mix of financial assets held by the public, and bid up the financial asset prices. Treasury bond purchases by a central bank would bolster the prices of long-term bonds more due to the duration and trigger a portfolio rebalancing (Fratzscher et al. 2016). Investors would be inclined to search for securities offering higher yields as the Treasury bond yields fall in response to the central bank purchases. Gagnon et al. (2011) show that the 10-year Treasury bond term premium declined by 71 bp in response to the Fed's large-scale asset purchases.

ii) *Signaling channel:* Asset purchases can provide signals about the future path of policy rates, which can alter investor expectations. The signaling channel effects bond interest rates but it is likely to exert a larger impact on bonds with intermediate maturity compared to long maturity bonds. Bauer and Rudebusch (2014) argue that Fed's large-scale asset purchases affected the bond yields not only through portfolio rebalancing but also through the signaling channel.

iii) *Liquidity premia:* Central bank liquidity supports the functioning of markets in times of turmoil, improves the liquidity conditions, and lowers the required liquidity risk premia. De Pooter et al. (2018) estimate the impacts of the ECB's securities markets program on sovereign bond markets and show that official purchases improved the bond market liquidity and reduced the liquidity premia sought by investors.

The Bank of Japan (BoJ), which is the first central bank to adopt QE measures as an alternative monetary policy framework, introduced its QE policies in March 2001 to manage deflationary pressures. Under its new policy framework, the BoJ provided ample liquidity and purchased long-term Japanese government bonds (JGBs) as well as asset-backed securities. As a result of these asset purchases, the BoJ's JGB holdings reached 63 trillion yen as of end-2005 and consumer price indices registered positive growth in late-2005. Several empirical analyses of the effects of the BoJ's QE

suggest that these policy steps averted funding concerns and supported accommodative policies (Ugai, 2006).

Other advanced economy central banks followed the footsteps of the BoJ during and after the global financial crisis. Some policymakers responded to the crisis by slashing their policy rates and introducing new set of policy tools including asset purchases in an effort to ease the financial conditions and bolster the stagnant economic activity. The Fed, ECB, BoJ, and Bank of England purchased billions of dollars of government bonds and private sector debt securities. As a result of the asset purchases central bank balance sheets expanded significantly and their composition changed dramatically.

2.2. Prior Results

Unconventional monetary policies and in particular quantitative easing measures attracted attention over the years and their propagation channels, impacts on financial conditions, markets, and economies have been thoroughly analyzed. There is ample empirical evidence of the effectiveness of QE policies and their impacts on bond yields, equity indices, output, and inflation. Gagnon et al. (2011) find that the Fed's first QE helped reduce the US term premium by between 0.3 percent and 1.5 percent at different maturities. The authors also show that positive spillovers were not limited to government bond yields as corporate bond yields registered a decline in response to these policy steps. Similarly, Vissing-Jorgensen and Krishnamurthy (2011) study the impacts of the Fed's QE1 and QE2 and find that the yields of mortgage-based securities (MBS) declined following the Fed's MBS purchases. On the ECB's securities markets program, Eser and Schwaab (2016) document large announcement effects and find several basis points falls in core and periphery European bond yields.

There is also strand of work that studies the international spillovers of QE measures. Neely (2011) reports statistically significant declines in Japanese, German, and Canadian government bond yields in response to the Fed's first QE program. Chen et al. (2012) use a global error correction model to estimate the impacts of the Fed's quantitative easing measures on global financial markets. Their empirical findings suggest that the US QE had limited impacts on other advanced economies but significant effects on the emerging market economies and especially on the inflation rate.

Some researchers remain skeptical about QE measures' success in reaching their stated goals and raised concerns about earlier studies. For instance, Greenlaw et al. (2018) argue that QE events may be confused with other unconventional monetary policies and the Fed's QE announcements in fact did not exert major impact on bond yields. Martin and Milas (2012) question the validity of the event study approach employed in most studies and argue that effects of QE measures may be short-lived if yields are already low.

Currently, there are only a few papers that study the impacts of APPs adopted by emerging market economies during the Covid-19 crisis. Hartley and Rebucci (2020) examine the yield impacts of APPs both in advanced and emerging market economies by using event study analysis of 24 QE announcements during the early stages of the pandemic. The authors show that 10-year government bond yields of emerging market economies declined by 0.28 percent over a one-day window, which is significantly higher compared to the response of advanced economy bond yields. Arslan et al. (2020) use a similar setting and look into the responses of bond yields and exchange rates to QE announcements. The authors select APP announcements that do not coincide with policy rate decisions and find that 10-year bond yields declined by 10 bp on the day of the policy announcement followed by a subsequent fall of 50 bp in the following five days. They argue that the announcement effect subsides to 25 bp if the regression models incorporate factors that can affect the yields. According to their high frequency data analysis, the announcements led to the appreciation of the currency against the US dollar and had significant impacts on the bond yields.

The studies that are closely related to ours are Sever et al. (2020), World Bank (2021), and Arena et al. (2021). Sever et al. (2020) use high frequency financial data and employ both event study and the local projections approach of Jordà (2005). The authors find that 10-year bond yields fell by 35 bp in response to the QE announcements while the stock market and exchange rate responses were rather muted. Chapter 4 of the World Bank's flagship report Global Economic Prospects conducts a similar analysis on the impacts of asset purchase program announcements and provides an overview of QE measures employed by emerging market economies. The authors argue that the effects of QE announcements on bond yields and equity indices have been larger than those of conventional monetary policy announcements. They also show that 10-year bond yields fell by 34 bp and equity indices rose by 1.9 percent within two days of the announcements. Similar to Sever et al. (2020) the authors do not find significant impacts on the currencies. Arena et al. (2021) focus on a subset of emerging market economies in Europe and show that the bid-ask spread in the government bond markets narrowed significantly and the yield curve flattened following the APP announcements. The authors find that the median stock market index rose by 2 percent on the fourth day after the QE announcement while the exchange rate remained broadly constant.

Compared to Sever et al. (2020), World Bank (2021), and Arena et al. (2021) we use the LP approach with a slightly different specification to deal with the selection bias. We also take into account not only global but also country specific macroeconomic and financial factors that can have a bearing on local financial variables. Furthermore, instead of focusing on the QE announcements, we consider the actual government bond purchases conducted each month and use low frequency data to disentangle their implications on the local financial markets.

3. Empirical Methodology and Data

In this section, we discuss the statistical methodology employed in this paper and then elaborate on the data.

3.1. Empirical Methodology

The main challenge associated with analyzing the effects of central bank APPs on financial markets is to select an appropriate empirical approach. The literature frequently employed event-study analysis to study the implications of QE announcements and central bank asset purchases. Although this method is effective for estimating the initial impacts of the QE announcements on financial markets, it falls short of providing an estimate of the medium-term effects of these policies as the initial effects may be transitory. An alternative and frequently chosen methodology in the monetary policy literature is vector autoregression (VAR). There are several papers that utilize VAR models to estimate the longer-term effects of monetary policy shocks including QE policies (see Baumeister and Benati, 2013; Gambacorta et al., 2014; Meinusch and Tillmann, 2016). However, making causal inferences based on VAR models would be bold as this method does not address the "selection bias", which might be considerable in the case of possibly endogenous QE policies. In other words, the countries implementing QE measures may be endogenously different from non-QE countries and their macroeconomic and financial characteristics might explain why they adopted QE policies in the first place. Moreover, these countries might have been responding to changes in macroeconomic and financial variables, which QE policies are supposed to affect. There are several papers employing the instrumental variable (IV) method in macroeconomics to deal with endogeneity problems (Mertens and Ravn, 2013; Owyang et al., 2013). However, it is usually quite difficult to find a valid IV especially for policy decisions in monetary and fiscal policy.

As per the scientific tradition, in order to evaluate the effects of any kind of treatment, it is necessary to separate the sample into treatment and control groups with the treatment applied randomly. This strategy is effectively used via randomized control trials in the fields of medicine, epidemiology, and biostatistics. Economists, mainly on the micro side, adopt this empirical strategy in empirical studies. However, as the randomization through experiments is not possible for observational macroeconomic data, macroeconomic studies have mostly ignored this method. Jordà and Taylor (2016) introduced this kind of statistical intuition into macroeconomics. By considering the fiscal consolidation as a treatment, the authors estimate the causal effects of fiscal adjustment through re-randomization of treatment by using the propensity scores. They employ the selection-on-observables assumption of Rosenbaum and Rubin (1983) and calculate the propensity scores of fiscal consolidations given

controls. In the last step, they determine the effects of fiscal policy consolidation through LP using the AIPW estimator.

In this paper, we look into the cross-country dimension of EM policies in a panel data setting. Due to the possible endogeneity, we assess the impacts of EM QE policies through LPs and using the AIPW estimator. The local projections approach with the AIPW provides a flexible semi-parametric regression control strategy to estimate the dynamic average treatment effect. Similar to Jordà and Taylor (2016), we first calculate the propensity scores for introducing QE measures through a logit model. In the second step, by estimating the LPs through the AIPW estimator we calculate the effects of EM APPs on some of the financial market variables, namely government bond yields, stock indices, and bilateral exchange rates.

3.2. Data

Our sample, which is determined by data availability, includes 19 emerging market countries. One of the challenges with data compilation was the limited availability of information about the EM central banks' responses to the turmoil in 2020. While some central banks provided a clear framework and announced bond purchase auctions, most did not transparently disclose details of their asset purchase operations. Therefore, we rely on information from several sources such as central banks, the IMF, World Bank, BIS, and JP Morgan and do not consider countries for which there is no reliable QE data. We manage to include most of the emerging market countries conducting APPs during the Covid-19 pandemic and also take their non-QE implementing peers into account in order to have a more or less similar control group.

We use monthly frequency data mainly for two reasons. Firstly, the daily bond purchase information is not available for most of the emerging market central banks in our sample. Secondly, as part of our empirical strategy we need to control country specific macroeconomic and financial variables that are only available in monthly frequency.

Our sample covers the period between January 2020 and May 2021. There are two reasons for this choice. Firstly, by only focusing on the Covid-19 pandemic period, we avoid the risk of over-determining the propensity scores for QE. This is mainly because no emerging market country adopted QE before the Covid-19 pandemic.[2] Although our sample size decreases with the sample period choice, over-determining the QE probabilities would be problematic for the AIPW estimator. Secondly, we conduct our analysis for an extraordinary period that would be more or less similar for all countries.

[2] In the pre-Covid19 era, QE was considered as a policy tool for central banks with policy rates at or near the zero-lower bound. Therefore, QE policies were out of the question for EM economies.

We need to identify the QE episodes in order to proceed with our statistical strategy. There is no universally agreed definition of QE policies. While QE measures are generally defined as the purchase of government bonds by central banks, there are several central banks that bought securities such as corporate bonds, mortgage-backed securities, and securities issued by state-owned enterprises. During the Covid-19 pandemic, several EM central banks included corporate and mortgage bonds in their APPs.[3] For the sake of homogeneity and due to data availability, we consider only government bond purchases as our QE proxy.[4] Table 3 shows the details of EM APPs.

Using the monthly government bond purchases of EM central banks, we create a treatment dummy variable "*QE"* that takes the value of one if a central bank purchases government bonds in a given month, and zero otherwise. At this stage, it should be noted that all central banks hold government bonds for open market operations (OMO) and purchase government bonds from time to time to replenish their OMO portfolios. These purchases are often conducted at very low amounts and target non-benchmark bonds in order not to affect prices and expectations. As data permits, we do not consider government bond purchases for OMO purposes as QE and focus only on the extraordinary purchases under EM asset purchase programs.[5] Lastly, as a robustness check, we create an alternative treatment dummy variable "*QE_permanent"* that takes the value of one for all months throughout the duration of officially announced asset purchase programs and zero if the country does not implement QE or ends its QE officially. This is done because some EM countries skipped several months without officially ending their QE programs.[6] As suggested in the literature, the effects of QE programs may continue as long as the program is not officially ended due to the expectation effects. It is likely that this alternative QE dummy might capture lasting effects of QE for these countries.

We use 2, 5, and 10-year sovereign bond yields, stock market indices, and nominal exchange rates against the US Dollar as dependent variables. End of month values for each variable are taken in order to capture the effects of APPs conducted each month. The exchange rates vis-à-vis US dollar and stock market indices are normalized (January 2020=100) for comparability purposes.

[3] Central banks such as the Banco de la República Colombia and Magyar Nemzeti Bank purchased corporate bonds in addition to sovereign bonds as part of their APPs.

[4] We do not include Mexico and Serbia in our analysis as these central banks used repurchase agreements rather than direct government bond purchases.

[5] There is specific QE data available for Hungary, Israel, Poland, India, Indonesia, and Türkiye. We use monthly changes in the government bond holdings of Colombian, Philippines, and South African central banks. For the latter group of countries, the monthly changes in government bond holdings that we consider as QE are significantly larger than earlier periods. While these figures may include traditional OMO purchases and some valuation effects, we remain confident that the majority of these bond purchases were conducted for purposes beyond OMO operations. On the other hand, we do not include countries such as Malaysia in our analysis since we could not distinguish their bond purchases from OMO purchases.

[6] Philippines central bank indicated that the "QE window was set to remain open between April - June 2020, or until market conditions returned to normal". After that, no official announcements have been made concerning the continuation or the end of their program. Thus, we consider their QE windows remained open only for that period.

A broad set of domestic and global covariates that may affect the treatment and dependent variables are included in our regressions. It should be noted that we use variables only at the monthly frequency and do not consider some potentially important covariates as they are available at quarterly or yearly frequencies.[7] In order to make sure that the treatment effects stem from bond purchases in the context of QE measures, we control for central bank policy interest rates and inflation on the monetary policy side. We account for economic activity by including the unemployment rate as well as industrial production and real credit growth rates. Fiscal policy stance and changes in the external balance are also controlled with the inclusion of budget balance to GDP, trade balance to GDP, and trade openness to GDP ratios. In order to capture external vulnerability/resilience we also use foreign exchange reserves to GDP ratio. Moreover, the Oxford Stringency Index is used to control for the extraordinary measures taken by governments during the Covid-19 pandemic.[8] Lastly, we capture global shocks through crude oil prices and the VIX index (see Table 4 for variable definitions and sources, Table 5 for a list of countries, and Table 6 for the descriptive statistics).

4. Statistical Analysis

In this section we discuss our empirical approach and present the impacts of EM APPs on government bond yields, stock market indices, and nominal exchange rates.

4.1. Baseline Analysis

Treatment allocation to the treatment and control groups is not usually random in observational macroeconomic data. For this reason, the decision to adopt QE measures may be endogenous. In the spirit of Jordà and Taylor (2016), we first estimate the propensity scores for the QE treatment via a logit model. This empirical approach depends on the selection-on-observables assumption, which states that treatment-control allocation is independent of potential outcomes, given controls (Rosenbaum and Robin, 1983). In other words, we calculate the probability of receiving the treatment, which in our case is to implement QE policies, given a set of covariates that might be related with our dependent (outcome) and treatment variables. We control for global factors and major available macroeconomic variables that can determine the probability of a central bank conducting asset purchases. We take the lagged values of covariates except for the VIX in order to address the simultaneity problem that might be inherent between the dependent and control variables.

[7] For a detailed discussion of determinants of bond yields and exchange rates, see survey papers such as Maltritz and Molchanov (2013), Fidora, Giordano, and Schmitz (2018).

[8] The index records the strictness of "lockdown style" policies that primarily restrict people's behavior. It is calculated using all ordinal containment and closure policy indicators, plus an indicator recording public information campaigns.

The coefficient estimates for both treatment variables, namely *"QE"* and *"QE_permanent"*, are presented in Table 8.[9] We find that an increase in the central bank policy rate is associated with higher probability of adopting QE policies, which shows that QE is not a zero-lower bound phenomenon for the EM economies. As expected, an increase in the inflation rate, real credit growth, and reserves to GDP ratio lowers the probability of conducting APPs. However, only reserves to GDP ratio among these variables has a statistically significant coefficient. While being statistically insignificant, an improvement in the budget and trade balance to GDP ratios decreases the QE probability, as expected. The trade openness ratio is associated with greater probability of applying QE measures. The stringency index coefficient is statistically significant and contributes positively to QE probability. Among the global factors included in our regression models, the volatility index (VIX) is positively associated with higher probability of undertaking APPs, while oil prices are negatively related with asset purchases, as expected. Lastly, the coefficients for industrial production growth and unemployment do not have the expected signs.

Based on the empirical results, it can be argued that most of the domestic macroeconomic variables that could determine the probability of adopting QE policies are statistically insignificant. On the other hand, global factors and the stringency index are important for the implementation of EM QE policies. The results for the *"QE_permanent"* treatment specification are broadly similar to our baseline estimations. However, VIX and stringency index coefficients become insignificant in this alternative specification. This finding, in our view, underlines the fact that QE measures were introduced to address the short-term and extraordinary challenges faced during the financial turmoil in 2020.

The relatively low R-squared figures from our logit models suggest that the decision to undertake QE policies does not significantly depend on macroeconomic variables but is mostly a by-product of the Covid-19 pandemic. However, Figures 1 and 2 show that the distributions of propensity scores for QE-implementing EM countries (treatment group) and non-QE implementing countries (control group) are still dissimilar and underline some endogenous aspect of these policies. Therefore, analyzing QE-implementing countries alone or simply comparing QE and non-QE countries via traditional estimation methods would not yield unbiased estimates for QE policies' impacts.

In order to assess the ATE of QE policies on our dependent variables, we estimate the following LP model with the AIPW estimator:

[9] The amount of bond purchases as a percent of national income could be used as the main explanatory variable. However, the methodology used in this paper requires the usage of dummies as the treatment variable to find the average treatment effect (ATE).

$$Y_{i,t+h} = \alpha_i + \varphi_i + \rho_h Y_{i,t-1} + \beta_h D_{i,t} + \gamma_h X_{i,t-1} + \varepsilon_{i,t+h} \quad (1)$$

where Y stands for the dependent variable, D is the treatment variable, X is a vector of covariates, ρ, β and γ are the corresponding coefficients. i and t are the indices for country and time, and h denotes the horizon. α and φ are the country and time fixed effects, respectively, and finally ε is the error term.

Our dependent variables are sovereign bond yields, bilateral exchange rates vis-à-vis the US dollar, and stock market indices. We use two treatment variables, namely "*QE"* and "*QE_permanent"* and estimate their impacts in different regressions. The same control variables from the logit model are included in equation 1 for the purposes of simplicity and their lagged values are used to mitigate the simultaneity problem between dependent and control variables.[10] Lastly, country and time-fixed effects are included in the LPs in order to capture the country specific and global factors that could not be controlled for. The AIPW estimator re-randomizes the sample and under-weights countries and episodes with a high propensity score for treated observations and over-weights countries and episodes with a low propensity score for non-treated observations.[11] This mitigates the endogeneity problem inherent in the models.

We estimate the local projections up to six months due to limited number of observations in our sample. Figure 3 plots the impulse responses. The results presented in Table 9 suggest that after controlling for other factors, government bond yields fall across all maturities and almost all months in response to the QE policies, which indicates that effects are quite persistent. Two-year bond yields decline (in absolute terms) more than 5 and 10-year bond yields in the first two months following the implementation of QE policies. However, starting from the fourth month falls in the long-term bond yields become larger, reaching approximately 40 bp in the last month of the estimation period. The latter result is in line with literature suggesting that APPs target longer maturity bonds and as a result the yield curve flattens (World Bank, 2021).

Similar to Arslan et al. (2020), who analyze the announcement effects of EM APPs, we find that domestic currencies appreciate against the US dollar in response to the APPs. The average currency appreciation in the first two months is approximately 0.7 percent while the effects are not as persistent as in the case of sovereign bond yields. In addition, the exchange rate response is not statistically

[10] The AIPW estimator used by Jordà and Taylor (2016) is a doubly-robust estimator. Consistency of the estimated ATE only requires either the LP model or the propensity score model to be correctly specified. Thus, the results for ATE are unbiased as long as one of the models is specified correctly.

[11] Beck et al. (2019) stated that the AIPW estimator is valid only if the treatment affects the treated unit, and not the other units. This means that for our results to be valid EM QE policies should not have spillover effects on other EM countries.

significant after the second month except for the last month. Lastly, our findings suggest that equity indices responded positively to the APPs only after the third month with statistically significant and positive impacts observed in the last three months.

4.2. Robustness Checks

We estimate several alternatives in order to check the robustness of our baseline results. Firstly, we estimate the LP model (1) with an alternative treatment variable "*QE_permanent"* and report the results in Table 10 and Figure 4. The results are quite similar to the baseline model, especially for the bond yields. The estimated positive impact in nominal exchange rates is augmented for this treatment variable. The slight differences could stem from the QE definition used for the alternative treatment. To be more specific, for this dummy variable we include months when there are no asset purchases, but the QE program is not officially ended (see Table 3). Therefore, this choice might have altered the estimated impacts of QE policies.

Secondly, we estimate the LP model in equation 1 with ordinary least squares (OLS) instead of the AIPW estimator. The results for OLS estimations with our baseline and alternative dummy variables are presented in Tables 11 and 12. According to these results, the impacts of QE policies on 5 and 10-year bonds and equity indices are still significant at the end of the six-month period after the first bond purchases. On the other hand, impacts on short-term bond yields and nominal exchange rates are statistically insignificant. However, it should be noted that the OLS estimator does not re-randomize the sample based on propensity scores. As a result, OLS does not necessarily address the endogeneity problem even though we control for country and time-fixed effects.

Lastly, as Sever et al. (2020) indicated, APPs may coincide with periods of high government bond issuance. Our baseline analysis does not control for the government bond supply as data is not available for all of the countries in our sample. However, we include government bond supply to GDP ratio as an additional explanatory variable and estimate alternative LP regressions for bond yields using 14 countries for which bond supply data is available. The results are broadly similar and do not materially impact our conclusions based on the baseline regression results (Tables 13 and 14).

5. Conclusion

In this paper, we analyze the impacts of APPs introduced by EM central banks during the Covid-19 pandemic on sovereign government bond yields, nominal exchange rates, and stock market indices. Compared to earlier studies on EM APPs, we use a novel causal inference approach proposed by Jordà and Taylor (2016) to control for possible endogeneity problems inherent in QE measures. Our empirical results suggest that bond yields, especially with long-term maturities, responded favorably to the

central banks' bond purchases and the currencies appreciated against the US dollar though the impact was rather muted. The initial stock market response to the bond purchases reversed after the fourth month and remained significantly positive throughout the rest of the analysis horizon. Several robustness checks confirm that our results are relatively robust to alternative specifications and estimations.

Our analysis is subject to a number of caveats. First of all, we consider EM central banks' government bond purchase dates as a proxy for QE policies. Some countries only purchased corporate bonds and other securities as part of their APPs, which may indirectly affect government bond yields. However, these purchases were made by a few countries and in small amounts. Secondly, we do not take into account the announcement effects or central bank policy guidance but instead focus on the actual implementation of APPs. Furthermore, some EM countries sterilized their bond purchases, which may have affected the impacts of APPs especially on exchange rates. Likewise, we also could not specifically control for macro-prudential policies since data unavailability limited the scope for the inclusion of such variables in our analysis. Lastly, the analysis in this paper is limited to the Covid-19 era and empirical results should be treated within the context of extraordinary conditions imposed by the pandemic.

Quantitative easing policies played a role in alleviating the market dysfunction during the early stages of the pandemic without stoking fiscal dominance concerns or hurting central bank credibility. It is safe to conclude that QE measures reached their goals. That being said, QE is still unchartered territory for emerging market economies. The costs and benefits of continued reliance on unconventional policies during normal times would warrant careful consideration and further analysis. Lastly, EM QE programs in general have been less transparent than their advanced economy counterparts and such a drawback may hinder these measures' effectiveness. As suggested by World Bank (2021) and Arena et al. (2021) the EM central banks should clearly communicate the objectives as well as the operational details should they decide to continue or expand their bond purchases. With central banks continuing to implement unconventional monetary policies, EM APPs will be an interesting avenue of further research.

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Appendix

Table 1

Stated Goals of EM APPs and Major Announcement Dates in 2020

Country	Main Goals	Date
Colombia	"In its extraordinary session on 23 March 2020, the Board of Directors of the Central Bank decided to inject permanent liquidity to the economy in order to ensure the proper operation of financial markets."	March 23
Croatia	"The CNB has also started purchasing Republic of Croatia bonds with an aim of maintaining stability in the market of government securities."	March 13
Hungary	"The Monetary Council also decided to launch a government security purchase programme in the secondary market to restore the stable liquidity position of the government securities market, and to relaunch its mortgage bond purchase programme to improve the long-term supply of funding to the banking sector."	March 24 April 7 & 28
India	"The RBI's endeavor is to ensure that all markets segments function normally with adequate liquidity and turnover."	March 20 April 23
Indonesia	The central bank to purchase government bonds in the primary market and announced the "optimization" of intervention in the secondary market for government bonds. In July, it was announced that the central bank would purchase IDR 397 trillion of primary issuance for public goods funding under the national economic recovery program.	March 2 April 1 July 7
Israel	"The bond purchases will enable the Bank of Israel to influence bond yields in the market along the entire unindexed and indexed curves, and to lower the costs of longer-term credit for firms and households, as a complementary tool to the short-term interest rate policy. In addition, the bond purchasing program will enable the Bank of Israel to moderate serious volatility in bond yields that is caused by the lack of liquidity in the financial markets, and to work toward stabilizing the markets. In view of the crisis continuing to impact Israel and the world, the Committee decided to increase the government-bond purchase program by NIS 35 billion and thus continue to support financing ability in the economy, in view of the strengthening of the coronavirus crisis and its economic effects."	March 23 October 22
Philippines	"The measure was aimed at reassuring market participants of demand for GS should they need to liquidate their holdings, thus encouraging participation in the primary GS auctions. The window was set to remain open until June 2020, or until market conditions returned to normal."	March 24
Poland	"NBP will also purchase government bonds on the secondary market as part of the structural operations that change the long-term liquidity structure in the banking sector and contribute to maintaining the liquidity in the government bond secondary market."	March 17 April 8

South Africa	"As a further measure to add liquidity to the market, the SARB will commence a programme of purchasing government securities in the secondary market. The purchases will be conducted across the yield curve. In addition to providing liquidity and promoting the smooth functioning of domestic financial markets, this will allow the SARB to enhance its Monetary Policy Portfolio (MPP)"	March 25
Thailand	"Even though the Thai financial system remains strong, with commercial banks holding healthy levels of capital and liquidity reserves, the liquidity stress and the resulting irregularity in the global financial market have begun to affect the Thai financial market. The Bank of Thailand (BOT) has alleviated the situation through government bond purchase program amounting more than 100 billion baht during 13-20 March 2020"	March 22
Türkiye	"Outright purchase operations under the Open Market Operations (OMO) portfolio, which are conducted within the limits identified at the Monetary and Exchange Rate Policy for 2020 text, can be carried out in a front-loaded manner and these limits may be revised depending on the market conditions. These operations are intended to enhance the effectiveness of the monetary transmission mechanism via increasing the market depth, enabling sound asset pricing and providing banks with flexibility in liquidity management."	March 31 April 17

Table 2

EM Central Banks' Sovereign Bond Purchases and Leading Macroeconomic Indicators

Country	Market	Start & End of APPs	Bond Purchases/GDP (%)*	Budget Deficit/GDP (%)	Public Debt/GDP (%)	Inflation (%)**	Unemployment (%)	Current Account Balance/GDP (%)
Colombia	Secondary	03.2020/04.2020	0.21	-6.9	62.8	1.6	16.1	-3.3
Croatia	Secondary	03.2020/06.2020	4.4	-8.0	87.2	0.1	9.2	-3.5
Hungary	Secondary	05.2020/Still on as of 05.2021	4.7	-8.5	81.2	2.7	4.1	-0.2
India	Secondary	05.2020/Still on as of 05.2021	2.3	-12.3	89.6	4.9	-	1.0
Indonesia	Primary, Secondary	03.2020/Still on as of 05.2021	4.0	-5.9	36.6	1.7	7.1	-0.4
Israel	Secondary	03.2020/Still on as of 05.2021	4.5	-11.8	73.0	-0.7	4.3	4.9
Philippines	Primary, Secondary	05.2020/06.2020	3.6 ***	-5.5	47.1	3.5	10.4	3.2
Poland	Secondary	03.2020/Still on as of 05.2021	3.2 ****	-8.2	57.7	2.4	3.2	3.5
South Africa	Secondary	03.2020/Still on as of 05.2021	0.6	-12.2	77.1	3.2	29.2	2.2
Thailand	Secondary	03.2020/03.2020	0.5	-4.7	49.6	-0.3	2.0	3.3
Türkiye	Secondary	05.2020/07.2020	0.5	-5.4	36.8	14.6	13.1	-5.1

Source: Respective central banks, Datastream, JP Morgan Global EM QE Tracker, Authors' estimates

* Through May 2021, % of 2020 GDP. ** Year-end CPI, y-o-y % change. *** Excludes central bank bonds. **** Excludes purchases of securities issued by the state-owned enterprises.

Table 3

EM Central Banks' Sovereign Bond Purchases (Billion Local Currency)

	03.2020	04.2020	05.2020	06.2020	07.2020	08.2020	09.2020	10.2020	11.2020	12.2020	01.2021	02.2021	03.2021	04.2021	05.2021
Colombia*	1.9	0.837	-	-	-	-	-	-	-	-	-	-	-	-	-
Hungary	-	-	148.9	-	10	75	200	190	200	170	205	240	300	240	246
Israel	8.5	4.7	6	4.2	0.5	6	3.7	3.4	4.6	4.6	4	4	4	3	3
Poland	18.80	31.38	0.15	0.47	0.94	0.36	0.56	0.17	0.21	1.66	0.57	1.03	2.22	9.71	7.69
South Africa	1.1	11.4	10.2	5.1	2.5	0.4	0.6	0.4	1.3	0.8	0.3	-	-	0.7	1.5
Türkiye	-	20.7	1.6	3.2	3.1	-	-	-	-	-	-	-	-	-	-
India	430	910.1	295	-	36.8	17	225.3	463.1	328.3	100	129	517	112	572	393
Indonesia*	75.9	14.2	3.2	4	5.9	101.6	85.5	80.8	50.8	102.7	31	19	34	20	-
Philippines	-	96.2	156.7	411.5	-	-	-	-	-	-	-	-	-	-	-
Thailand	82.176	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Croatia	4.287	9.529	-	4.069	-	-	-	-	-	-	-	-	-	-	-

Source: Respective central banks, Datastream, JP Morgan Global EM QE Tracker, Authors' estimates

* In trillion local currency.

Table 4

List of Variables

Variable	Explanation	Source
Sovereign bond yields	2, 5 and 10-year local currency sovereign bond yields (%)	Datastream
Nominal exchange rates	Nominal exchange rates vis-à-vis US dollar (Jan-2020= 100)	Bloomberg
Stock indices	Major stock index (Jan-2020= 100)	Bloomberg
Central bank policy rates	Policy rates of EM central banks (%)	BIS
Inflation	Annual percent change in consumer price index	Datastream, National Statistical Offices
Unemployment	The number of unemployed persons as a percentage of the labor force (%)	Datastream, National Statistical Offices
Industrial production growth*	Annual growth in industrial production index (%)	Datastream, National Statistical Offices
Real credit growth	Annual private credit growth (real, %)	Datastream, BIS, National Statistical Offices
Reserves/GDP	Official central bank reserves (% of GDP)	Datastream, National Statistical Offices
Budget balance/GDP	General government balance (% of GDP)	Datastream, National Statistical Offices
Trade balance/GDP	Trade balance (% of GDP)	Datastream, National Statistical Offices
Trade openness/GDP	Sum of exports and imports (% of GDP)	Datastream, IMF, National Central Banks
Stringency index	Composite measure based on nine response indicators including school closures, workplace closures, and travel bans 0 to 100 (100 = strictest)	Oxford University
VIX	Volatility index of S&P500	Bloomberg
Crude oil price	Brent crude oil (US dollars per barrel)	Bloomberg

* Industrial GDP figures are used for Indonesia since its industrial production data is discontinued after March 2020.

Table 5
Country List

Brazil	Hungary*	Poland*
Chile	India*	Russia
China (Mainland)	Indonesia*	South Africa*
Colombia*	Israel*	Taiwan
Croatia*	Peru	Thailand*
Czechia	Philippines*	Türkiye*
Hong Kong		

*APP implementing countries

Table 6
Summary Statistics

Variables	Obs	Mean	Standard Deviation	Min	Max
2-year gov. bond yield	323	2.72	3.24	0.01	18.32
5-year gov. bond yield	323	3.42	3.37	0.19	18.22
10-year gov. bond yield	323	3.98	3.57	-0.65	18.08
Nominal FX rate (vs $)	323	103.86	9.85	88.74	141.93
Stock index	323	96.04	12.23	64.19	126.12
Inflation	323	2.95	3.19	-3.38	17.28
Policy rate	323	2.49	3.03	0.10	19.00
Stringency index	323	58.02	23.91	0.00	100.00
Unemployment	323	8.99	6.58	1.03	34.70
Budget balance/GDP	323	-6.67	6.35	-45.79	1.37
Trade balance/GDP	323	-0.64	6.69	-17.85	9.92
Industrial prod. (growth)	323	1.35	26.15	-78.43	239.57
Reserves/GDP	323	36.10	28.41	10.73	143.01
Real credit growth	323	6.87	8.98	-8.24	45.59
VIX	323	26.83	9.86	13.94	57.74
Crude oil price (in logs)	323	3.86	0.27	3.28	4.22
Trade openness/GDP	323	71.57	64.88	21.52	333.29

Table 7

	Summary Statistics (Treatment Group)					Summary Statistics (Control Group)				
Variables	**Obs**	**Mean**	**Standard Deviation**	**Min**	**Max**	**Obs**	**Mean**	**Standard Deviation**	**Min**	**Max**
2-year gov. bond yield	187	3.32	3.79	0.01	18.32	136	1.88	2.00	0.02	7.41
5-year gov. bond yield	187	4.03	3.89	0.21	18.22	136	2.58	2.25	0.19	8.14
10-year gov. bond yield	187	4.72	3.93	0.58	18.08	136	2.97	2.71	-0.65	9.14
Nominal FX rate (vs $)	187	103.51	9.03	91.41	141.93	136	104.33	10.88	88.74	134.14
Stock index	187	93.93	11.50	72.52	123.95	136	98.94	12.64	64.19	126.12
Inflation	187	3.38	3.84	-3.38	17.28	136	2.36	1.83	-2.41	8.15
Policy rate	187	2.90	3.66	0.10	19.00	136	1.93	1.70	0.25	6.25
Stringency index	187	56.76	25.27	0.00	100.00	136	59.75	21.87	0.00	95.43
Unemployment	187	10.04	7.72	1.03	34.70	136	7.55	4.20	2.80	16.27
Budget balance/GDP	187	5.48	3.02	-12.49	0.30	136	8.32	8.88	-45.79	1.37
Trade balance/GDP	187	2.99	6.00	-17.85	7.24	136	2.59	6.24	-15.49	9.92
Industrial prod. (growth)	187	0.55	31.18	-78.43	239.57	136	2.45	17.03	-51.29	113.11
Reserves/GDP	187	25.53	11.13	10.73	51.40	136	50.64	37.24	12.93	143.01
Real credit growth	187	5.23	8.04	-8.24	33.78	136	9.12	9.73	-5.06	45.59
VIX	187	26.83	9.88	13.94	57.74	136	26.83	9.89	13.94	57.74
Crude oil price (in logs)	187	3.86	0.27	3.28	4.22	136	3.86	0.27	3.28	4.22
Trade openness/GDP	187	59.37	36.32	24.77	166.13	136	88.35	87.93	21.52	333.29

Table 8
Logit Regressions for Estimating Propensity Scores

Variables	QE	QE_Permanent
Inflation (-1)	-0.098	-0.141
	(0.190)	(0.205)
Policy rate (-1)	0.025	0.053
	(0.231)	(0.246)
Unemployment (-1)	-0.028	-0.011
	(0.069)	(0.069)
Industrial production growth (-1)	0.018***	0.018***
	(0.006)	(0.006)
Budget balance/GDP (-1)	-0.058	-0.066
	(0.050)	(0.051)
Trade balance/GDP (-1)	-0.084	-0.090
	0.062	(0.062)
Trade openness/GDP (-1)	0.023	0.027
	(0.019)	(0.020)
Reserves/GDP (-1)	-0.107***	-0.117***
	(0.041)	(0.045)
Real credit growth (-1)	-0.082	-0.090
	(0.067)	(0.069)
Stringency index (-1)	0.020*	0.018
	(0.011)	(0.011)
Log of Oil Price (-1)	-1.680**	-1.894**
	(0.746)	(0.752)
VIX	0.030**	0.028
	(0.018)	(0.018)
Constant	5.784*	6.782***
	(3.291)	(3.308)
Pseudo R-square	0.279	0.304
Observations	323	323

Note: Robust standard errors in parenthesis. Sample period covers January 2020 – May 2021. * p<0.10, ** p<0.05, *** p<0.01.

Table 9

Dynamic Average Treatment Effects of QE Policies, AIPW Estimations, Treatment QE

Variables	Month 1	Month 2	Month 3	Month 4	Month 5	Month 6
2-year government bond yields	-0.155***	-0.157**	-0.074	-0.106*	-0.154***	-0.098***
	(0.05)	(0.05)	(0.05)	(0.05)	(0.04)	(0.04)
5-year government bond yields	-0.094***	-0.143***	-0.036	-0.174***	-0.358***	-0.358***
	(0.04)	(0.04)	(0.05)	(0.05)	(0.05)	(0.04)
10-year government bond yields	0.044	-0.059	-0.006	-0.218***	-0.366***	-0.408***
	(0.04)	(0.04)	(0.04)	(0.05)	(0.05)	(0.05)
Equity indices (Jan-2020 indexed to 100)	-0.562**	-0.525*	0.164	0.816*	3.663***	4.463***
	(0.44)	(0.45)	(0.44)	(0.39)	(0.43)	(0.44)
Nominal exchange rate vs. USD (Jan-2020 indexed to 100)	-0.557***	-0.745***	0.155	0.49	-0.319	-1.114***
	(0.29)	(0.29)	(0.33)	(0.29)	(0.27)	(0.29)
Observations	304	285	266	247	228	209

Note: Robust standard errors in parenthesis. Country and time fixed effects are included. Sample period covers January 2020 – May 2021. * p<0.10, ** p<0.05, *** p<0.01.

Table 10

Dynamic Average Treatment Effects of QE Policies, AIPW Estimations, Treatment QE_Permanent

Variables	Month 1	Month 2	Month 3	Month 4	Month 5	Month 6
2-year government bond yields	-0.162***	-0.168***	-0.024	-0.055	-0.117***	-0.091***
	(0.05)	(0.05)	(0.05)	(0.05)	(0.04)	(0.04)
5-year government bond yields	-0.066	-0.119**	0.025	-0.132***	-0.340***	-0.370***
	(0.04)	(0.04)	(0.05)	(0.05)	(0.05)	(0.05)
10-year government bond yields	0.132***	-0.019	0.044	-0.183***	-0.322***	-0.400***
	(0.04)	(0.04)	(0.04)	(0.05)	(0.05)	(0.05)
Equity indices (Jan-2020 indexed to 100)	-0.887***	-0.642*	0.262	1.241***	4.100***	4.922***
	(0.44)	(0.46)	(0.46)	(0.39)	(0.42)	(0.44)
Nominal exchange rate vs. USD (Jan-2020 indexed to 100)	-1.070***	-1.615***	-0.246	0.561	-0.435	-1.211***
	(0.28)	(0.29)	(0.35)	(0.28)	(0.26)	(0.29)
Observations	304	285	266	247	228	209

Note: Robust standard errors in parenthesis. Country and time fixed effects are included. Sample period covers January 2020 – May 2021. * p<0.10, ** p<0.05, *** p<0.01.

Table 11

Coefficient Estimates Using OLS, Treatment QE

Variables	Month 1	Month 2	Month 3	Month 4	Month 5	Month 6
2-year government bond yields	-0.120	-0.169	-0.110	-0.145	-0.186	-0.132
	(-0.17)	(-0.22)	(-0.27)	(-0.25)	(-0.16)	(-0.13)
5-year government bond yields	-0.102	-0.176	-0.103	-0.25	-0.409**	-0.402**
	(-0.16)	(-0.2)	(-0.24)	(-0.2)	(-0.17)	(-0.18)
10-year government bond yields	0.04	-0.061	-0.009	-0.236	-0.392*	-0.450*
	(-0.16)	(-0.19)	(-0.22)	(-0.18)	(-0.19)	(-0.23)
Equity indices (Jan-2020 indexed to 100)	-0.946	-1.227	1.395	0.289	2.874**	3.966***
	(-0.84)	(-1.25)	(-1.78)	(-1.85)	(-1.11)	(-1.37)
Nominal exchange rate vs. USD (Jan-2020 indexed to 100)	-0.353	-0.61	-0.068	-0.026	-0.47	-0.866
	(-0.87)	(-0.90)	(-0.89)	(-1.38)	(-1.26)	(-1.08)
Observations	304	285	266	247	228	209

Note: Robust standard errors in parenthesis. Country and time fixed effects are included. Sample period covers January 2020 – May 2021. * p<0.10, ** p<0.05, *** p<0.01.

Table 12

Coefficient Estimates using OLS, Treatment QE_Permanent

Variables	Month 1	Month 2	Month 3	Month 4	Month 5	Month 6
2-year government bond yields	-0.127	-0.195	0.089	0.109	0.162	0.127
	(-0.2)	(-0.24)	(-0.27)	(-0.25)	(-0.16)	(-0.14)
5-year government bond yields	-0.094	-0.18	-0.084	-0.231	-0.399**	-0.411**
	(-0.21)	(-0.25)	(-0.26)	(-0.21)	(-0.17)	(-0.18)
10-year government bond yields	0.102	-0.041	0.013	-0.215	-0.362*	-0.451*
	(-0.19)	(-0.23)	(-0.24)	(-0.2)	(-0.19)	(-0.24)
Equity indices (Jan-2020 indexed to 100)	-1.257	-1.566	-1.801	-0.116	3.079**	4.251**
	(-1.17)	(-1.42)	(-1.87)	(-1.82)	(-1.34)	(-1.55)
Nominal exchange rate vs. USD (Jan-2020 indexed to 100)	-1.05	-1.738	0.78	0.155	0.561	0.843
	(-1.05)	(-1.25)	(-1.26)	(-1.48)	(-1.37)	(-1.2)
Observations	304	285	266	247	228	209

Note: Robust standard errors in parenthesis. Country and time fixed effects are included. Sample period covers January 2020 – May 2021. * p<0.10, ** p<0.05, *** p<0.01.

Table 13

Dynamic Average Treatment Effects of QE Policies, AIPW Estimations, Treatment QE

Variables	**Month 1**	**Month 2**	**Month 3**	**Month 4**	**Month 5**	**Month 6**
2-year government bond yields	-0.257***	-0.300***	-0.231**	-0.290***	-0.313***	-0.219***
	(0.06)	(0.06)	(0.06)	(0.06)	(0.05)	(0.05)
5-year government bond yields	-0.134***	-0.178***	-0.046	-0.181***	-0.371***	-0.392***
	(0.05)	(0.05)	(0.05)	(0.06)	(0.06)	(0.05)
10-year government bond yields	0.024	-0.105**	-0.028	-0.244***	-0.367***	-0.455***
	(0.04)	(0.04)	(0.04)	(0.05)	(0.06)	(0.06)
Observations	224	210	196	182	168	154

Note: Robust standard errors in parenthesis. Government bond supply to GDP ratio, country and time fixed effects are included.* p<0.10, ** p<0.05, *** p<0.01.

Table 14

Dynamic Average Treatment Effects of QE Policies, AIPW Estimations, Treatment QE_Permanent

Variables	**Month 1**	**Month 2**	**Month 3**	**Month 4**	**Month 5**	**Month 6**
2-year government bond yields	-0.306***	-0.363***	-0.215**	-0.253***	-0.297***	-0.211***
	(0.06)	(0.06)	(0.06)	(0.06)	(0.05)	(0.05)
5-year government bond yields	-0.139***	-0.201***	-0.015	-0.158***	-0.395***	-0.430***
	(0.05)	(0.05)	(0.05)	(0.06)	(0.06)	(0.05)
10-year government bond yields	0.066	-0.116**	-0.017	-0.246***	-0.383***	-0.498***
	(0.04)	(0.04)	(0.04)	(0.06)	(0.06)	(0.06)
Observations	224	210	196	182	168	154

Note: Robust standard errors in parenthesis. Government bond supply to GDP ratio, country and time fixed effects are included.* p<0.10, ** p<0.05, *** p<0.01.

Figure 1

Distribution of Propensity Scores for Treatment QE

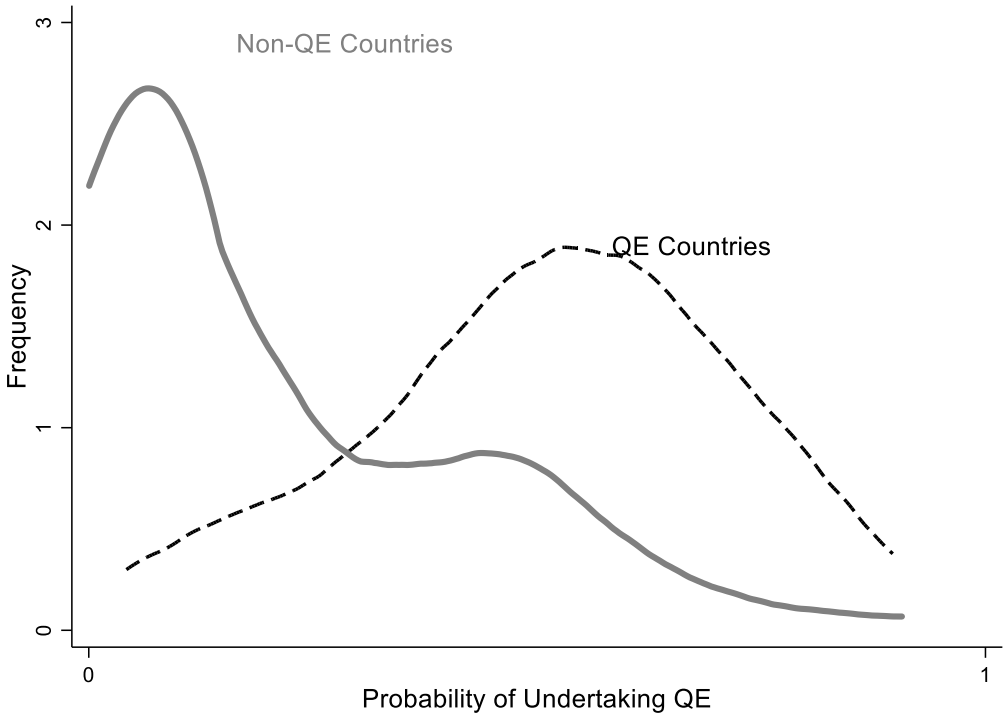


Figure 2

Distribution of Propensity Scores for Treatment QE_Permanent

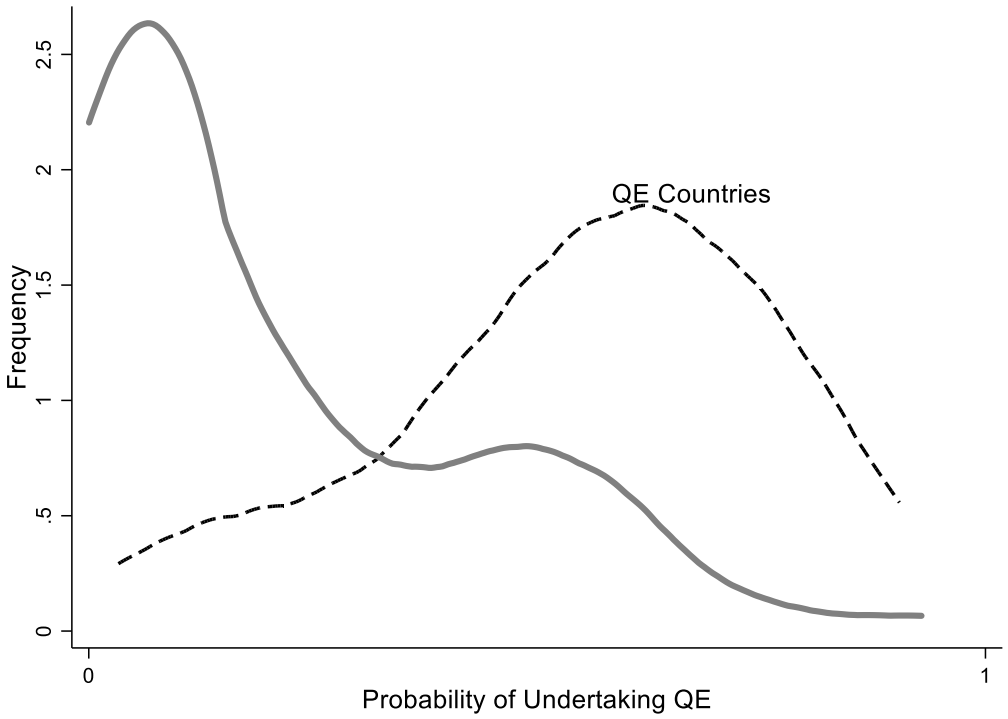
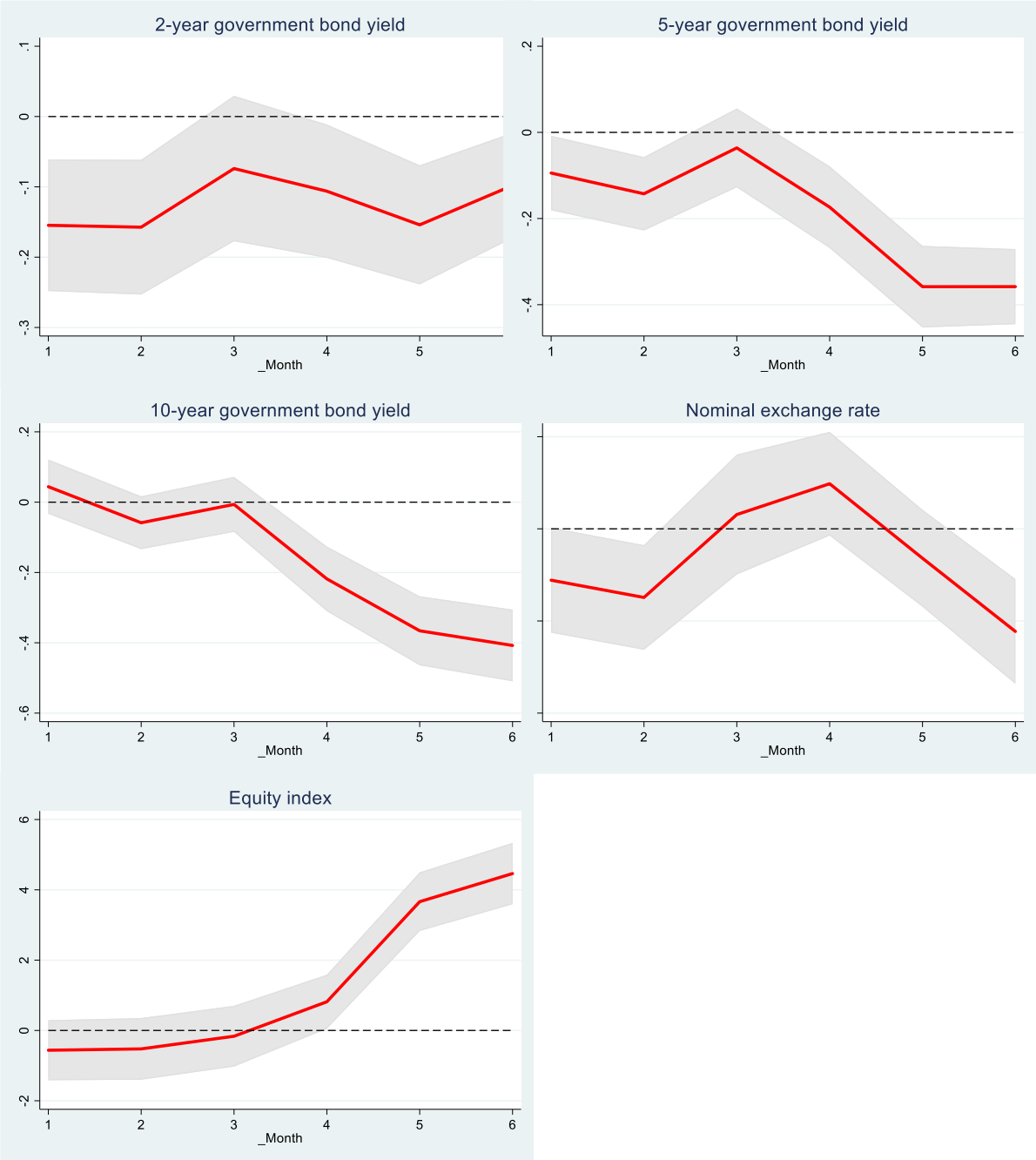


Figure 3

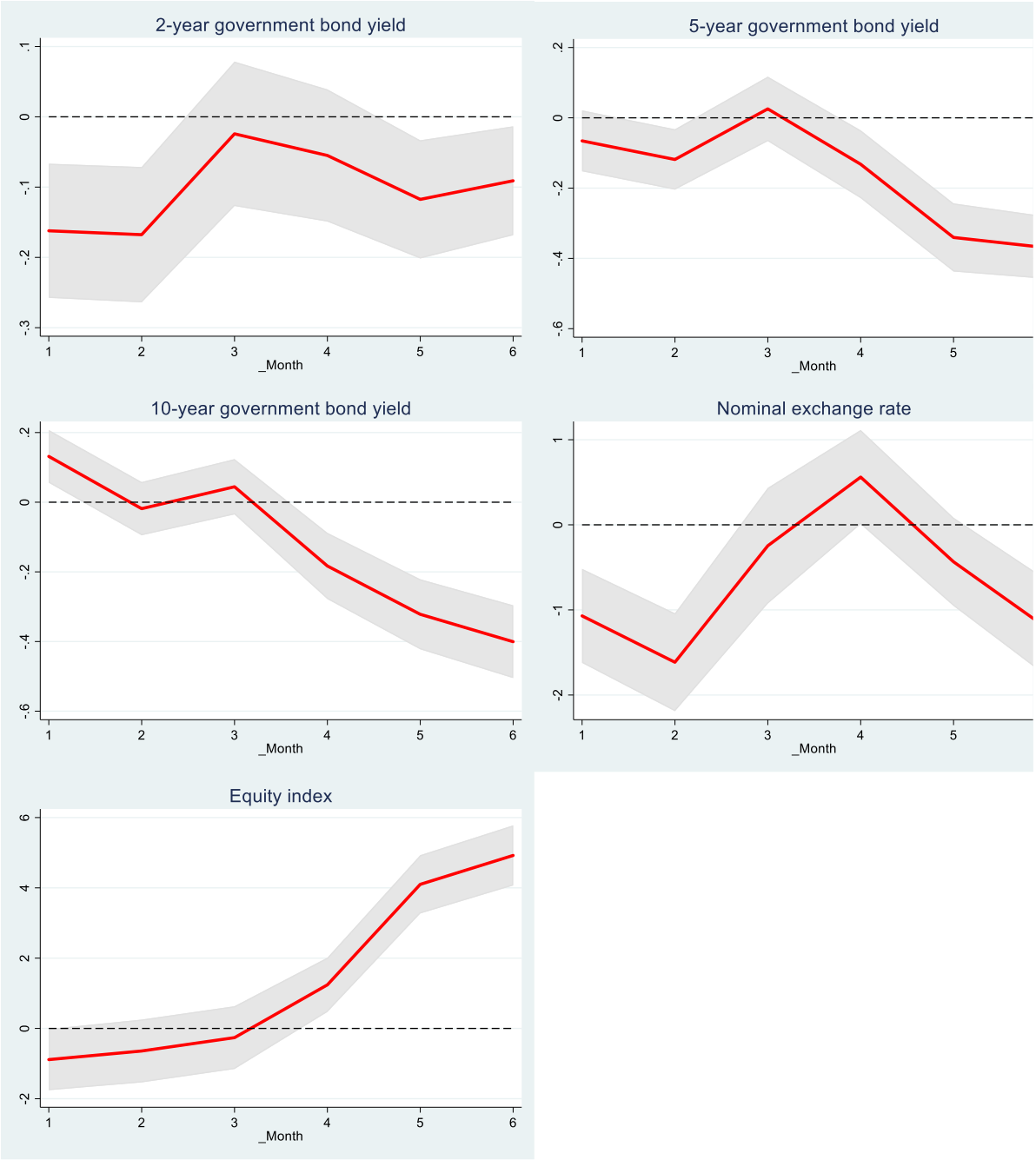
Impulse-Responses to Treatment QE



Note: Shaded areas correspond to 10% confidence intervals.

Figure 4

Impulse-Responses to Treatment QE_Permanent



Note: Shaded areas correspond to 10% confidence intervals.

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