



# The COVID-19 pandemic and financial markets in Central Europe: Macroeconomic measures and international policy spillovers

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## ABSTRACT

This paper investigates the effects of macroeconomic policy announcements on financial markets in three Central European economies: Czechia, Hungary, and Poland (CE-3). We focus on the unprecedented stabilisation policies implemented from March to December 2020 during the COVID-19 pandemic, including unconventional monetary measures and large stimulus programs. Detailed categories of monetary and fiscal measures are introduced into vector autoregressions with exogenous regressors and dynamic conditional correlations, which we estimate using daily data. This allows us to control for policy spillovers from abroad, as well as global risk factors and pandemic-related variables. We find that, in general, macroeconomic policy measures implemented in the CE-3 countries played an important role in stabilising financial markets during the pandemic. We uncover several notable patterns in the reaction of markets to anti-crisis measures across the region. The impact of the monetary policy announcements on 10-year sovereign bond yields was more substantial than on stock market returns and exchange rate returns. The communication of the unconventional tools proved effective in lowering the bond yields. Interestingly, we document that the effects of non-standard measures for some variables, such as the exchange rate, can be qualitatively different from those resulting from a conventional monetary expansion. Even though the domestic monetary events became more important than the fiscal ones, the latter proved relevant for financial market returns, especially when large-scale immediate fiscal measures and tax deferrals were introduced. We also show that the CE-3 economies were subject to the cross-border transmission of policy announcement effects from the Euro Area and the US, although the magnitude of these effects was smaller than expected and varied across the CE-3 countries.

## 1. Introduction

The macroeconomic policy response to the COVID-19 pandemic was genuinely global. Unlike during the global financial crisis (GFC) and its aftermath, when the major advanced economies (AEs) led in the use of unconventional monetary policies and large fiscal stimulus programs, this time, emerging market economies (EMEs) quickly caught up and deployed various anti-crisis measures. This change was also observed in Central European economies, including Czechia, Hungary, and Poland (henceforth: CE-3). Early empirical

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evidence suggests that their monetary policy interventions had an immediate, stimulating impact on financial markets, but also that the effects of quantitative easing announcements turned out to be systematically different than in AEs and varied across the CE–3 countries (Arslan et al., 2020). On the other hand, few studies have examined the effects of fiscal announcements on financial markets in EMEs, despite the fact that their fiscal responses to the pandemic were unprecedented (Alberola-Ila et al., 2020). Similarly, while considerable work has been devoted to financial contagion among various asset classes during the COVID-19 crisis (e.g., Okorie and Lin, 2021; Papadamou et al., 2021; Sharif et al., 2020), the research on cross-border policy spillovers remains limited (Rebucci et al., 2021).

The effectiveness of anti-crisis policy measures adopted in the CE–3 economies raises a series of pressing research questions, considering the challenges that these economies faced during the pandemic. First, as small, open economies highly integrated with the EU and the global economy, the CE–3 markets are vulnerable to external shocks and financial contagion (Horvath and Petrovski, 2013; Beck and Stanek, 2019; Das et al., 2018). Hence, it is natural to ask whether policy interventions proved sufficient to curb the turbulent trends in international financial markets, such as capital outflows from the region and excessive reductions in asset prices. Second, in the past, the CE–3 had experienced considerable cross-border spillovers from policies implemented in the AEs, for instance from the unconventional measures of the European Central Bank (ECB; cf. Falagiarda and Reitz, 2015; Horvath and Voslarova, 2017; Janus, 2020). For this reason, an assessment of anti-COVID-19 policies should consider the interplay between domestic and foreign policy measures. Additionally, the CE–3 countries had relatively little experience with some of the stabilisation tools they launched during the pandemic. To give an example, with the exception of Hungary, asset purchase programmes (APPs) had never been used by the countries in question. In this context, additional evidence for or against the effectiveness of such novel policy instruments is in high demand.

This paper examines the effects of macroeconomic policies on financial markets in the CE–3 economies during the COVID-19 pandemic. We investigate the monetary and fiscal policy announcements, which we further break down into several detailed categories. The analysis spans from March to December 2020.<sup>1</sup> Policy announcement variables are introduced into vector autoregressions with exogenous regressors and dynamic conditional correlations, which we estimate using daily data. Our basic aim is to quantify and compare the reaction of sovereign bond, stock, and foreign exchange markets across the region to various policy events in one- to six-day windows. At the same time, this framework allows us to simultaneously account for financial and policy spillovers from the Euro Area (EA), including the EU-wide anti-crisis policies, and the US, for instance the Fed's unconventional actions. Additionally, we control for a set of global risk factors and COVID-19-related variables, reflecting the pandemic situation in the countries analysed (e.g., domestic stringency measures).

Our findings indicate that, in general, the macroeconomic policy measures implemented in the CE–3 countries played an important role in stabilising financial markets during the COVID-19 pandemic. We uncover several notable patterns in the market reactions to anti-crisis measures across the region. In particular, the impact of the monetary policy announcements on 10-year government bond yields was more profound and clear-cut than on stock market returns and exchange rate returns. The communication in Hungary and Poland of the new, unconventional programmes proved effective in lowering the bond yields. Interestingly, we document that the effects of non-standard measures on some variables, such as the exchange rate, can be qualitatively different than in the effects of conventional monetary expansion. Even though the domestic monetary events turned out to be more important than the fiscal ones, the latter proved relevant for financial market returns, especially when large-scale immediate fiscal measures and tax deferrals were introduced. We also show that the CE–3 economies were subject to some cross-border transmission of policy announcements from two large economies, the EA and the US, although the distribution of these effects was smaller than expected, given the scale of policy interventions in these economies, and varied across the CE–3 countries. In particular, we find surprisingly scarce evidence for spillovers from the ECB policies.

The contribution of this paper is threefold. First, we gather a comprehensive dataset on policy announcements, which are further divided into detailed categories, which allow us to handle simultaneous and potentially confounded policy events. As opposed to most other recent studies, we supplement our examination of monetary policy actions by including fiscal announcements. The latter tend to be more difficult to extract and label than the monetary ones due to oftentimes informal or general communication by fiscal authorities. Second, in our analysis, we go beyond the onset of the COVID-19 crisis (March and April 2020) to include the measures adopted during the second wave of the pandemic (Autumn 2020), which in the case of the CE–3 countries proved to be more severe in terms of the number of cases and deaths, consequently triggering relatively longer lockdowns and further policy responses. Third, to the best of our knowledge, we are the first to investigate the impact of the COVID-19-related policy announcements in both the EA and in the US on the financial markets of the CE–3 countries. Hence, we also add to a broader literature on the international transmission of shocks from global financial centres to small open economies during financial turmoil.

The rest of the paper is structured as follows. The next section discusses the literature on macroeconomic policy interventions during the pandemic in the context of the CE–3 economies. Section 3 lays down the methodology and estimation procedures we use in this paper and introduces the datasets of policy events. In Section 4, we present empirical results for the CE–3 economies and discuss our findings. Section 5 contains robustness checks on our baseline results using an alternative set of financial variables. The last section concludes and identifies issues for further research.

<sup>1</sup> To be precise, we account for policy measures taken since the pandemic-induced crisis, i.e., since March 2020. At the same time, due to the estimation procedure, we prolong the financial time-series to include the dates from the beginning of January 2019 onwards.

## 2. Literature review

This paper adds to the incipient body of literature exploring the effects of macroeconomic policy interventions on financial markets during the COVID-19 pandemic. In the literature review, we first focus on comparative studies of monetary policy effects in various economies during the pandemic, particularly those covering EMEs. Next, we turn to the research on international, cross-border effects of monetary policies. Finally, we review the evidence on the impact of fiscal policy measures on financial markets during this period.

One of the leading themes in recent research on the global response to the pandemic is that the central banks' actions in EMEs were vastly different than during previous periods of financial stress in the world economy, such as the GFC or the taper tantrum of 2013. This time, EMEs launched highly expansionary, countercyclical monetary policies, even though their economies faced the effects of increased risk aversion, capital outflows, and currency depreciation pressures (Aguilar and Cantú, 2020; Sever et al., 2020). Numerous EMEs resorted to unconventional monetary policies, similar to those used previously by AEs post-2007 (Fratto et al., 2021). During the second half of March 2020, central banks in more than 20 EMEs announced asset purchase programs of government and commercial bonds (quantitative easing), liquidity-enhancement measures, or long-term lending facilities.

Aguilar and Cantú (2020) show that the main reason for this shift in EMEs' monetary policies was the fact that due to the abrupt output contraction and drop in inflation rates, business cycles in EMEs entered a phase similar to the one prevailing in AEs. They also argue that a more aggressive response to the pandemic crisis was facilitated by an improved institutional position of EME central banks, anchored inflation expectations, lowered inflation persistence, and small exchange-rate pass-through effects on their economies. At the same time, Arslan et al. (2020) show that the entire monetary toolbox – interest rate policy, liquidity operations, or outright asset purchases – was used in EMEs in a different way than in AEs. The instruments were deployed primarily to address global risk aversion and restore confidence in markets rather than provide additional monetary accommodation and alleviate the lower bound on interest rates. However, Benmelech and Tzur-Ilan (2020) show that countries with lower interest rate levels before the crisis were more likely to resort to various unconventional tools or relax macroprudential regulations.

Given the novelty of the reaction of EMEs central banks to the crisis, there are numerous questions concerning the effectiveness of these policies. Sever et al. (2020) study the impact of APP announcements on bond yields, exchange rates, and equity markets in EMEs. Using event studies and local projections, they measure the announcement effects in 10 EMEs, including Hungary and Poland. Their findings show that APP announcements had strong effects on long-term bond yields, which fell by between 20 and 60 basis points for up to six days after the announcement. The effects were less pronounced for the US dollar exchange rates and equity markets, which is explained by the larger role of global risk factors in driving those markets. Additionally, asset purchases by the Fed helped to bring down bond yields in EMEs. However, their effects on exchange rates were detectable but much weaker. In line with these results, Arslan et al. (2020) also find that domestic APP announcements had significant effects on local currency bonds in 13 EMEs, both immediately and for several days after the announcements. The response of the exchange rates was ambiguous, but their depreciation seems to have slowed down following the communication of APPs.

An interesting insight into new unconventional measures comes from the comparison of their effects between AEs and EMEs, especially given the voluminous literature on monetary policy event-studies in the former group of economies (e.g., Swanson, 2011; Szczerbowicz, 2015; Afonso et al., 2020). Some of these studies also cover the cross-border impact of policies implemented in AEs, mostly the Fed's quantitative easing, on EMEs. Beirne et al. (2020) investigate capital flows dynamics across 14 EMEs during the first phase of the COVID-19 crisis. They find that in March and April 2020, expansionary monetary policies implemented in AEs helped to stabilise capital outflows from EMEs, not only through quantitative easing programs but also via international swap lines, such as those introduced by the Fed. Also focusing on the first phase of the pandemic, Harjoto et al. (2020) study stock market reactions to two major events: the WHO's official announcement of the global COVID-19 epidemic in March and the Fed's announcement of massive lending programs in April, representing the shock and the stimulus, respectively. Their findings indicate that the impact of the COVID-19 shock on stock markets was stronger in emerging economies than in developed ones. They also conclude that the Fed's stimulus positively affected the US equity markets, but that its impact on stock markets in EMEs was negative.

Rebucci et al. (2021) provide an investigation into 30 selected quantitative easing announcements made by 21 central banks at the onset of the COVID-19 pandemic. Using both a high-frequency event-study analysis and a multivariate Global Vector Autoregressive Model (GVAR), they capture the reaction of bond and FX markets to central bank communication. The study finds that in narrow event windows (one to three days), the announcements successfully compressed sovereign bond yields, both in AEs and EMEs. Interestingly, this effect was stronger and more persistent in EMEs. Such a result may be explained by a larger degree of surprise generated by the EME central banks' policy decisions. It also confirms that country-specific quantitative easing programs launched by EMEs brought about additional effects beyond those coming from the "global QE" by the major central banks, such as the Fed or the ECB. On the other hand, Rebucci et al. (2021) document a more divergent reaction of the FX markets in EMEs to the announcements, with an uncertain direction of impact on the dollar exchange rate. The impact of domestic APPs on the exchange rates in EMEs was different than in AEs as well, possibly due to a stronger interaction between the flight to safety from EMEs and depreciation of their currencies during the COVID-19 shock. By stepping into the bonds markets with APPs, some of the central banks in EMEs were able not only to alleviate the fire sales of local bonds but also to reduce the depreciation pressure on domestic currencies.

Covering a longer timespan (March to August 2020), Fratto et al. (2021) put forward an event study on unconventional monetary policies in EMEs and small AEs. They provide a more detailed classification of unconventional programs and control for announcements made on the same day by other monetary authorities. Unconventional policy measures are categorised according to the goal and size of an individual program. Agreeing with previous research, the study indicates that APPs proved to be generally effective in lowering bond yields. However, the magnitude of these effects depended on the character of a program: quantity-based tools (i.e., programs with a pre-defined amount of assets to be purchased) and programs focused on government securities turned out to be more

effective. On aggregate, their effects on exchange rates were insignificant. Interestingly, some of the “usual suspects”, such as the exchange rate regime or capital account openness, seem not to have any influence on the outcomes of APPs. However, central bank credibility and a low share of non-resident holdings of sovereign bonds tend to improve the effectiveness of anti-crisis policies. The authors also argue that the transmission of unconventional policy announcements across the sovereign yield curve is stronger than the effects of standard interest-rate policy.

Because this paper studies the CE-3 in detail, an important benchmark for our analysis comes from research on COVID-19-related policy events conducted at the European level. [Klose and Tillmann \(2020\)](#) examine the responses of stock prices and sovereign bond yields to the monetary, fiscal, and European fiscal events of 29 European countries from February to April 2020. The results of their panel model indicate that monetary policy was effective in supporting the stock market and easing the pressure on public finances. In particular, announcements of APPs raised stock returns and decreased bond yields. [Fendel et al. \(2021\)](#) use an event study approach to investigate the impact of COVID-19-related announcements on 10-year sovereign bond yields of several EA members in the period January–July 2020. Overall, they consider 20 announcements, which are later divided into monetary policy (i.e., related to the ECB's measures) and fiscal policy (i.e., related to the measures of the European Commission). They find that the yields of more solvent countries (like Austria, Germany, or the Netherlands) were more strongly affected by the announcements. In particular, the fiscal policy announcements had a positive impact on the yields of these countries. The authors view this finding in the context of the future fiscal burden to be carried by more solvent countries within the Euro Area. At the same time, they provide evidence that a decline in spreads (vis-à-vis German yields) of high-debt countries did not stem from their more favourable financing conditions but rather from an increase in the yields of less indebted economies.

In a related study, [Delatte and Guillaume \(2020\)](#) investigate the determinants of sovereign bond spreads (with regard to Germany) of 13 EA countries for the period 2 January–26 May 2020. The set of their explanatory variables includes public health, financial, and macroeconomic variables, as well as variables capturing the policy announcements pertaining to the European interventions, monetary policy, and fiscal policy measures. They employ a pooled OLS estimate and show that the countries' resilience to the pandemic shock depended on three preconditions: the condition of public finances, the robustness of the banking sector, and healthcare capacity. Regarding the impact of the anti-crisis measures, the authors provide evidence that the ECB's announcement of the pandemic emergency purchase programme in April 2020 significantly reduced bond yields. Additionally, the easing of collateral requirements exerted downward pressure on the Greek, Italian, and Portuguese spreads. The loan-based financial assistance turned out to have widened the spreads of heavily indebted countries.

In contrast to monetary policies, there is little systematic evidence on the impact of fiscal policy announcements on financial markets during the pandemic crisis. Using an event study approach, [Heyden and Heyden \(2021\)](#) analyse the short-term market reaction of the US and European stock markets to the arrival and containment of COVID-19. In particular, they demonstrate that the initial fiscal policy announcements had a negative impact on stock returns, whereas the monetary policy measures introduced at the beginning of the pandemic turned out to be effective in calming markets. [Beirne et al. \(2020\)](#) introduce a single fiscal policy dummy into their analysis on EMEs equity and bond flows. They find that fiscal measures were effective in stabilising equity flows in a broad group of 28 EMEs, where it was relatively more important than in AEs. At the same time, the impact of these measures on bond flows, bond yields, and effective exchange rates in EMEs was significantly weaker.

[D’Orazio and Dirks \(2020\)](#), in turn, focus not only on fiscal packages but also on lockdown policies and mobility restriction measures in Europe. They employ a panel regression approach to investigate the relationship between economic and COVID-19-related policies in a sample of 17 EA countries from January to May 2020. They provide evidence that the lockdown policies had a negative impact on stock market behaviour, while announcements related to the improvements in the health sector had opposite effects. Surprisingly, the authors find no significant effects of countercyclical fiscal policy announcements, such as an increase in government spending, deferred tax payments, or export guarantees, for stock and bond market returns.

Some recent studies have also been devoted to the problem of the fiscal space that dictates the possible scope of policy during the pandemic. [Benmelech and Tzur-Ilan \(2020\)](#) show that government expenses compared to GDP during the first phase of the COVID-19 crisis were lower, on average, in EMEs than in AEs and negatively correlated with a country's credit risk (as approximated by its credit rating) and the pre-COVID-19 interest rate. [Alberola-Ila et al. \(2020\)](#) compare AEs and EMEs' initial fiscal responses to the COVID-19 crisis. They find that the smaller value of fiscal packages in EMEs cannot be solely explained by their lower exposure to the COVID-19 shock. In fact, they argue that the limited fiscal space that EMEs could use to launch fiscal stimulus was further constrained by the impact of the pandemic on their financing conditions. The overall level of development, lower government bond yields, and higher sovereign debt ratings turn out to be the most important predictors of a country's ability to respond to the crisis with fiscal measures. These findings are confirmed by [Feyen et al. \(2020\)](#), who summarise the financial sector policy responses to the COVID-19 in more than 150 jurisdictions. They find that policy measures deployed to address the macro-financial impact of the pandemic (e.g., monetary, fiscal, and macroprudential ones) were more numerous in larger and more developed economies. This study, however, does not address the issue of the effectiveness of various anti-crisis measures.

### 3. Data and methodology

#### 3.1. Data

The study is conducted for the CE-3 countries, with the sample period running from January 2019 to December 2020. Particular attention is paid to macroeconomic policy measures that were launched as a response to the COVID-19-induced crisis throughout March–December 2020. The frequency of data is daily (for the five-day working week). In our regression analysis, we explain the

performance of the following financial variables:

- 1) daily changes in 10-year sovereign bond yields in Czechia, Hungary, and Poland (in percentage points),
- 2) daily rates of return on leading stock market indexes in the analysed countries, i.e., Prague Stock Exchange Index (PX), Budapest Stock Exchange Index (BUX), and Warsaw Stock Exchange WIG20 Index,
- 3) daily rates of return on the nominal effective (trade-weighted) Czech koruna (CZK), Hungarian forint (HUF), and Polish zloty (PLN) exchange rates.

All data series were drawn from the Refinitiv and Bank for International Settlements' databases. There are several reasons why we focus on the CE-3 economies out of all the countries in the region. First, unlike several economies in the region (e.g., Slovakia or the Baltic states), the CE-3 economies remain outside of the Eurozone and retain their own currencies and independent monetary policies. Second, their currency regimes may be classified as floating (during the period of the analysis, with occasional foreign-exchange interventions), which—apart from their structural similarities, such as strong international financial integration with the Eurozone and potential spillovers from abroad—renders them comparable in terms of their macroeconomic policy frameworks. Third, the CE-3 economies undertook strong and unprecedented macroeconomic policy measures in response to the COVID-19 crisis, including in particular unconventional monetary and fiscal stimulus packages, which are the main subject of the paper.

The focus on the response of the sovereign bond yields, exchange rates, and stock market indexes to policy events has been a common practice in the related literature (cf. Georgiadis and Gräß, 2016; Grabowski and Stawasz-Grabowska, 2021; Sever et al., 2020). The important difference we make is the use of the NEER instead of the nominal exchange rate vis-à-vis one of the global reserve currencies (usually the euro in the case of CE countries). This is because one of the aims of our study is to identify the impact of both European and US policy events on the CE-3 financial markets. Therefore, we believe that it is reasonable to opt for the NEER, which assigns the highest weight to the EUR and a relatively high weight to the USD in the basket of currencies for all countries in question.

The set of explanatory variables consists of three main categories, which are later subject to further separation:

- 1) variables reflecting domestic monetary and fiscal stimulus,
- 2) variables associated with monetary and fiscal response undertaken in the US or at the European level, i.e., by the ECB or the European Commission (EC),
- 3) control variables tracking the course of the pandemic in the CE-3 countries, approximating global risk aversion and reflecting performance of financial markets in the EU and US.

### 3.2. Policy event dataset

Starting with the dominant category of domestic measures, each type of policy event is coded in binary variables, taking the value of 1 on the day of the policy announcement and 0 otherwise. The lists of monetary and fiscal events, which we include in the study, are presented in Appendix A, together with their descriptions and the announcement dates (cf. Tables A.1 through A.6). Given that the monetary policy expansions of the Czech National Bank (CNB), the National Bank of Hungary (MNB), and the National Bank of Poland (NBP) comprised interest rate cuts, liquidity enhancing measures, macroprudential tools, and the APPs, we create four corresponding variables, namely *dom\_MP\_rate*, *dom\_MP\_liquidity*, *dom\_MP\_macropru*, and *dom\_MP\_purchase*. That way, for example, the *dom\_MP\_rate* variable for Czechia adopts the value of 1 on 16 March, 26 March, and 7 May, the dates when the CNB lowered its two-week repo rate, and 0 otherwise.

For domestic fiscal policy, we initially adopted three categories: immediate fiscal impulse, deferrals, and other liquidity provisions and guarantees, following Bruegel's classification.<sup>2</sup> Nonetheless, it turned out that the announcement dates of the measures falling into the first and the second category largely coincided, causing the potential problem of multicollinearity. Hence the two categories were merged into the single variable *dom\_FP\_core*. Other liquidity provisions and guarantees are captured by the binary variable *dom\_FP\_other*.

All monetary policy announcements were gathered from press releases available on the official websites of the CNB, MNB, and NBP. For the fiscal policy announcements, the process of data collection was more complex. This is due to the fact that only the Czech government informs the public about its response to the COVID-19 pandemic in the form of regularly published press releases, which are also available in English. Hence, in the cases of Hungary and Poland, we had to resort to other sources. The first choice was to use a database that tracks fiscal measures adopted at the national level and allows for international comparisons. However, the available databases proved to be incomplete for the needs of our study. For example, Bruegel's dataset, which lists country-specific measures of the EU members, includes only Hungary from the CE region, while the Refinitiv's Macro Vitals provides information on selective policies, mainly from the first wave of the pandemic. As a result, we compiled lists of fiscal events for Hungary and Poland, using various sources and cross-checking the information available therein. For Poland, these were: the official websites of the Government and the President of the Republic of Poland, the IMF's Policy Tracker database, and the KPMG's reports on COVID-19-related economic stimulus measures, while for Hungary we relied on Bruegel's and the IMF's databases.

Even though the data collection on fiscal policies in Hungary and Poland was meticulous, we are aware of the limitations of these

<sup>2</sup> Bruegel's datasets, The fiscal response to the economic fallout from the coronavirus, <https://www.bruegel.org/publications/datasets/covid-national-dataset/>; retrieved on 20 March 2021.

datasets. More specifically, the binary fiscal variables created for these two countries adopt the value of 1 on the dates of official announcements of the included fiscal measures, by which we understand, for example, their adoption by a national parliament (as in the case of the six “Anti-Crisis Shields” adopted by the Polish legislature). Unlike for Czechia, we are not, however, able to add the announcements of the planned stimulus actions, and therefore fully capture the “surprise effects”, if there were any.

Altogether, we include 36 monetary and 47 fiscal events. A detailed breakdown according to countries and the above-distinguished categories of measures is presented in Table 1.

The second category of explanatory variables is associated with the monetary and fiscal policies undertaken by the European and US authorities. It is also composed of dummy variables taking on a value of 1 for every announcement date and 0 otherwise. Regarding European policies, the response of the ECB to the COVID-19 pandemic was based on unconventional measures. Hence, we introduce two variables, *ECB\_liquidity* and *ECB\_purchase*, reflecting, respectively, the introduction of measures aiming to facilitate the banking sector’s access to central bank liquidity at favourable terms and the launch as well as the extension of the ECB’s APPs. Regarding the EU actions from the fiscal policy scope, we pool the key announcements of the EC (including, inter alia, the temporary suspension of the Stability and Growth Pact and the adoption of the EU’s employment-support loan facility, SURE) and create a variable – *EU\_FP\_measures*. At the same time, we believe that the EU deal on the Recovery and Resilience Facility (RRF) is not only a critical response to the COVID-19 challenges that lie ahead of the EU, but also that it constitutes an unprecedented step in the process of European integration, especially given the scale of the Facility as well as the fact that the EU will borrow from capital markets for the first time in history. Therefore, we have decided to mark out the Facility by introducing a separate variable *EU\_FP\_RRF*, which takes the value of 1 on days when decisions regarding its adoption were made and 0 otherwise. For US policies, we proceed in a similar way. Interest-rate cuts and unconventional monetary policy measures launched by the Fed are reflected by *Fed\_rate*, *Fed\_liquidity*, and *Fed\_purchase* variables, while the subset of US fiscal policy variables is composed of *US\_FP\_core* and *US\_FP\_other*.

The European monetary and fiscal announcements were collected from the official websites of the ECB and the EC. Similarly, the primary sources for the US policy announcements were the official websites of the Fed and the US government. Altogether we include 33 European and 25 US policy events. A detailed breakdown is presented in Table 2. The dates of the announcements, along with their descriptions, are provided in Appendix A (Tables A.7 through A.10).

Finally, the third group of explanatory variables consists of categories reflecting the level of global risk aversion as well as the pandemic situation in each of the CE–3 countries. The variable *VIX* reflects the implied volatility of the S&P500 index and is used as a proxy for global risk aversion. To capture the course of the pandemic in individual countries, we introduce two COVID-19-related variables. The first of them,  $\Delta Stringency$ , measures the change of the level of stringency of epidemic restrictions adopted by each government, while the second one, the  $\Delta Deaths$  variable, measures the daily change in the number of COVID-19-related deaths. To account for the performance of the EA and US financial markets, we employ rates of return on EUROSTOXX50 and S&P500, as well as daily changes in German (for the EA) and US sovereign bond yields, and introduce  $r^{EUROSTOXX50}$ ,  $r^{S\&P500}$ ,  $\Delta I^{DE}$ ,  $\Delta I^{US}$  variables.<sup>3</sup> The respective time series were sourced from the Refinitiv database.

Appendix B presents the list of the variables used in this study, along with short descriptions of their construction and sources. Appendix C provides some graphical illustrations.

### 3.3. Model specification

We analyse the impact of the announcements of fiscal and monetary policy measures on changes in sovereign bond yields as well as stock market and currency market returns. We consider the effects of those measures in different window lengths. We define the following variables, measuring the impact of measures on changes of prices in 1–, 3–, and 6–day windows. Variables reflecting the impact of measures in 3– and 6–day windows are defined in the following way:

$$x.W3_t^{cc} = \max(x_t^{cc}, x_{t-1}^{cc}, x_{t-2}^{cc}) \tag{1}$$

$$x.W6_t^{cc} = \max(x_t^{cc}, x_{t-1}^{cc}, x_{t-2}^{cc}, x_{t-3}^{cc}, x_{t-4}^{cc}, x_{t-5}^{cc}) \tag{2}$$

where  $x_t^{cc}$  is a binary variable taking the value of 1 on day  $t$  if a measure was announced (or introduced) in the country  $cc$  on day  $t-1$ . Such specification of binary variables, reflecting the impact of measures in 3- and 6-day windows, is typically used in event studies (MacKinlay, 1997). Coefficients are short-run parameters, and their estimates provide information about the average daily impact of a measure on market returns for event windows of three (six) days.

In order to evaluate the impact of the announcements of fiscal and monetary policy measures on daily stock market returns, daily currency market returns, and changes in sovereign bond yields, we propose the estimation of the parameters of the following VARX-AGDCC-GARCH model (Cappiello et al., 2006), an autoregressive system with external regressors and asymmetric generalized dynamic conditional correlations:

<sup>3</sup> It should be noted that lagged rates of return and lagged changes in yields for the EA and US are used in the VARX-AGDCC-GARCH model. This is due to the diluted impact of major markets on emerging ones. Moreover, the time delay in the US market vis-à-vis the European markets excludes considering rates of return on the S&P500 without a delay.

**Table 1**  
Number of monetary and fiscal policy events.

|                 |                         | Czechia | Hungary | Poland |
|-----------------|-------------------------|---------|---------|--------|
| Monetary policy | <i>dom_MP_rate</i>      | 3       | 3       | 3      |
|                 | <i>dom_MP_liquidity</i> | 2       | 7       | 1      |
|                 | <i>dom_MP_macropru</i>  | 4       | 2       | 3      |
|                 | <i>dom_MP_purchase</i>  | –       | 6       | 2      |
| Fiscal policy   | <i>dom_FP_core</i>      | 18      | 5       | 7      |
|                 | <i>dom_FP_other</i>     | 10      | 3       | 4      |

Source: Authors' compilation.

**Table 2**  
Number of key European and US monetary and fiscal events.

| European events       |            | US events            |            |
|-----------------------|------------|----------------------|------------|
| Variable              | Occurrence | Variable             | Occurrence |
| <i>ECB_liquidity</i>  | 9          | <i>Fed_liquidity</i> | 8          |
| <i>ECB_purchase</i>   | 4          | <i>Fed_purchase</i>  | 5          |
| <i>EU_FP_measures</i> | 17         | <i>Fed_rate</i>      | 2          |
| <i>EU_FP_RRF</i>      | 3          | <i>US_FP_core</i>    | 6          |
|                       |            | <i>US_FP_other</i>   | 4          |

Source: Authors' compilation.

$$y_t^m = \sum_{p=1}^p \Pi_p y_{t-p}^m + [\Psi \Lambda] \begin{bmatrix} cv_t \\ mfm_t \end{bmatrix} + \epsilon_t^m \tag{3}$$

The use of the Vector Autoregressive Model with External Regressors (VARX) allows us to measure the impact of policy measures on market returns and consider dynamic relations among markets in different countries. Moreover, the use of the Asymmetric Generalized Dynamic Conditional Correlation (AGDCC) specification of the covariance matrix enables modelling the asymmetric impact of shocks on correlations between them and variability of these correlations in time. Volatility clustering, which is present in particular in high-frequency data, justifies the use of the Generalized Autoregressive Conditional Heteroscedasticity (GARCH) Model to explain the performance of variances of shocks.

In the model (3),  $y_t^m$  consists of changes in levels for the  $m$ -th market.  $m = 1$  denotes sovereign bond markets in the CE–3 economies,  $y_t^1 = [\Delta I_t^{CZ} \Delta I_t^{HU} \Delta I_t^{PL}]^T$ , and the elements of this vector denote daily changes in 10-year sovereign bond yields for Czechia, Hungary, and Poland.  $m = 2$  denotes the stock market,  $y_t^2 = [r_t^{PX} r_t^{BUX} r_t^{WIG20}]^T$ ;  $r_t^{PX}$  is a daily rate of return on PX,  $r_t^{BUX}$  is a daily rate of return on BUX, and  $r_t^{WIG20}$  is a daily rate of return on WIG20.  $m = 3$  denotes the currency market and  $y_t^3 = [r_t^{NEER.CZ} r_t^{NEER.HU} r_t^{NEER.PL}]^T$ , where elements of this vector denote rates of return on the NEER for Czechia, Hungary, and Poland respectively.  $mfm_t$  denotes the vector of monetary policy and fiscal policy measures, while control variables are included in the vector  $cv_t$ . In this vector, variables tracking the course of the pandemic in the CE–3 countries and approximating global risk aversion are included. Moreover, categories reflecting the performance of financial markets in the EU and US are included in this vector. For example, if  $m = 1$ ,  $cv_t$  consists additionally of changes in sovereign bond yields for Germany and the US. If  $m = 2$ ,  $cv_t$  additionally consists of rates of return on EUROSTOXX50 and S&P500.  $\Psi$  contains parameters reflecting the impact of control variables on the elements of the vector  $y_t^m$ . In turn, the effects of fiscal and monetary policy announcements are measured by parameters of the matrix  $\Lambda$ . It must be noted that the estimated parameters reflect the short-run impact of particular policies in a given market and hence allow us to assess their respective effects.

Estimation of the parameters of the vector autoregressive model, as well as inclusion of variables reflecting performance of financial markets in major world economies arise for two reasons. First, there are strong linkages among CE stock, bond and currency markets, especially during medium- and high-volatility periods (Csontó, 2014). Second, interdependence between financial markets in the analysed countries and highly-developed economies grew significantly after the former's accession to the EU in 2004 (e.g., Brzeszczynski and Welfe, 2007; Hanousek et al., 2009; Égert and Kočenda, 2007; Bubák et al., 2011; Kouretas and Syllignakis, 2012).

In the case of the vector  $\epsilon_t^m$  from Eq. (3), it is assumed that:

$$E(\epsilon_t^m (\epsilon_t^m)^T) = H_t \tag{4}$$

where  $H_t$  is the matrix of covariances between shocks. It is decomposed as follows:

$$H_t = D_t R_t D_t \tag{5}$$

where the matrix  $D_t$  consists of standard deviations of shocks, while the matrix  $R_t$  consists of correlations between shocks.

The matrix  $D_t$  is defined as follows:

$$D_t = diag\left\{ \left[ \sqrt{h_{1,t}} \quad \sqrt{h_{2,t}} \quad \sqrt{h_{3,t}} \right] \right\} \tag{6}$$

For example, if research concerns stock markets, then  $h_{1,t} = h_{r^{MIC20}}$ ,  $h_{2,t} = h_{r^{BUX}}$  and  $h_{3,t} = h_{r^{PX}}$ .

Due to the use of high-frequency data, the assumption about variability in time of these variances seems to be justified. Because—in times of crisis in particular—negative shocks may exert a stronger impact on volatilities than positive ones, variances are modelled using the asymmetric GJR–GARCH(1,1) model:

$$h_{n,t} = \alpha_{0n} + \alpha_{1n}\varepsilon_{n,t-1}^2 + \gamma_{1n}\varepsilon_{n,t-1}^2 I\{\varepsilon_{n,t-1} < 0\} + \beta_{1n}h_{n,t-1} \tag{7}$$

for  $n = 1, 2, 3$ .

The validity of the assumption about asymmetric impact of shocks on volatilities is tested ( $\gamma_{1n} = 0$ ). The matrix  $R_t$  consists of correlations between shocks. Elements of this matrix are time-varying and depend on positive and negative shocks:

$$R_t = (\text{diag}(Q_t))^{(-1/2)} Q_t (\text{diag}(Q_t))^{(-1/2)} \tag{8}$$

$$Q_t = (1 - \alpha_1 - \beta_1) \underline{Q} + \gamma_1 (\underline{Q} - \underline{Q}^-) + \alpha_1 \mathbf{u}_{t-1} \mathbf{u}_{t-1}^T + \beta_1 Q_{t-1} + \gamma_1 \mathbf{u}_{t-1}^- (\mathbf{u}_{t-1}^-)^T \tag{9}$$

The elements of the vector  $\mathbf{u}_t$  are defined as follows:

$$u_{n,t} = \frac{\varepsilon_{n,t}}{\sqrt{h_{n,t}}} \tag{10}$$

Moreover,  $\mathbf{u}_{t-1}^-$  consists of zero–threshold standardized errors, while  $\underline{Q}$  and  $\underline{Q}^-$  are the unconditional covariance matrices of vectors  $\mathbf{u}_{t-1}$  and  $\mathbf{u}_{t-1}^-$ , respectively. Considering asymmetry is due to the fact that—in times of crisis in particular—negative shocks may more strongly affect market returns volatilities, as well as linkages between markets. Similarly, as in the case of the GJR-GARCH(1,1) model (Eq. 7), the validity of the assumption about the asymmetric impact of shocks on correlations between them is tested ( $\gamma_1 = 0$ ).

The proposed model seems to be an appropriate empirical specification when daily data are used. It enables the inclusion of variables reflecting domestic monetary policy and fiscal stimulus, categories associated with monetary and fiscal response undertaken at the European level and in the US, as well as variables tracking the course of the pandemic in the CE–3 countries and approximating global risk aversion.<sup>4</sup>

Given that we deal with many policy-related variables, we need an efficient strategy to choose a proper model specification for each economy and asset class. To perform the model selection process, we employ the “from general to specific” strategy, proposed by Hendry and Krolzig (2004). This approach allows us to obtain models appropriately reduced into parsimonious encompassing, congruent representations by beginning with the entire set of policy measures and incrementally reducing the number of covariates in a model by removing the insignificant ones. Appendix D (Tables D.1 through D.3) provides the estimates of the full models for bond, stock and foreign-exchange markets—the starting points for our baseline model selection.

### 3.4. Descriptive statistics and stationarity tests

Table 3 presents descriptive statistics for the daily changes in 10-year sovereign bond yields, as well as the rates of return on stock and foreign exchange markets. As can be seen, in the period under analysis slight decreases in sovereign bond yields were observed (the largest in Poland and the smallest in Czechia). Results in Table 3 indicate that the average rate of return on the Polish stock market was negative. For Czechia and Hungary, a slightly positive average rate of return was recorded. The nominal effective exchange rate of the Polish zloty and Hungarian forint slightly depreciated in the analysed period, while the value of the Czech koruna increased marginally. For all countries and all markets, leptokurtic distributions are observed. In general, rates of return on stock and foreign exchange markets are characterised by negative skewness, while daily changes in sovereign bond yields in Czechia are positively skewed.

Time series of stock indices and exchange rates are generally realisations of stochastic processes integrated of order one. Analysis of long-run relationships between these categories requires cointegration methods (see, e.g., Grabowski and Welfe, 2020), while short-run relationships are estimated using differenced time series. In general, first differences are stationary; however in turbulent times, non-stationarity of rates of return may be identified (see, e.g., Homm and Breitung, 2012). Sovereign bond yields are likely integrated of order 1, in particular during turbulent times. To check whether rates of return on stock market indexes and exchange rates, as well as changes in sovereign bond yields, contain a unit root, we apply the ADF–GLS test (Elliott et al., 1996). Table 4 presents the ADF–GLS test statistic with critical values<sup>5</sup> at the 0.05 significance level and the decision for three countries and three markets.

The results of stationarity tests for rates of return as well as differences in 10–year sovereign bond yields indicate that these categories are stationary.

<sup>4</sup> The VARX-AGDCC-GARCH models estimated in the paper are used with the aim of capturing the interdependencies among financial markets and as a framework to perform the event-study analysis of monetary and fiscal policy effects while controlling for a broad set of CE-specific and external factors. Hence, we do not conduct a structural analysis (e.g., impulse-response functions) that would require additional identifying assumptions in the VAR systems.

<sup>5</sup> Variation in critical values may be due to different lag lengths. Optimal number of lag lengths was chosen on the basis of the Schwarz information criterion.

**Table 3**

Descriptive statistics for changes in sovereign bond yields, stock market returns, and NEER returns.

|          | 10-year sovereign bond yields (daily changes) |          |          | Stock market indices (daily returns) |          |          | NEER (daily returns) |         |          |
|----------|-----------------------------------------------|----------|----------|--------------------------------------|----------|----------|----------------------|---------|----------|
|          | Czechia                                       | Hungary  | Poland   | Czechia                              | Hungary  | Poland   | Czechia              | Hungary | Poland   |
| Mean     | -0.0011                                       | -0.0017  | -0.0031  | 0.0000                               | 0.0001   | -0.0003  | 0.0000               | -0.0002 | -0.0001  |
| St. Dev. | 0.0422                                        | 0.0825   | 0.0543   | 0.012                                | 0.015    | 0.016    | 0.0033               | 0.0041  | 0.0030   |
| Skewness | 0.85***                                       | 0.57     | -0.09    | -1.32***                             | -1.72*** | -1.49*** | -1.50***             | -0.09   | -0.35*** |
| Kurtosis | 21.93***                                      | 15.04*** | 22.70*** | 16.35***                             | 17.15*** | 17.46*** | 17.87***             | 7.74*** | 6.22***  |

**Table 4**

ADF-GLS unit root tests for stock market returns, NEER returns, and changes in sovereign bond yields.

|         | 10-year sovereign bond yields (daily changes) |                |              | Stock market indices (daily returns) |                |              | NEER (daily returns) |                |              |
|---------|-----------------------------------------------|----------------|--------------|--------------------------------------|----------------|--------------|----------------------|----------------|--------------|
|         | ADF-GLS statistic                             | Critical value | Decision     | ADF-GLS statistic                    | Critical value | Decision     | ADF-GLS statistic    | Critical value | Decision     |
| Czechia | -13.55                                        | -2.88          | Stationarity | -12.02                               | -2.88          | Stationarity | -9.37                | -2.87          | Stationarity |
| Hungary | -11.84                                        | -2.86          | Stationarity | -10.56                               | -2.87          | Stationarity | -13.38               | -2.88          | Stationarity |
| Poland  | -16.16                                        | -2.88          | Stationarity | -14.14                               | -2.88          | Stationarity | -11.81               | -2.88          | Stationarity |

In the first step, the lag order of the VARX was chosen on the basis of the information criteria. Selection of distribution of disturbances was based on multivariate extension of the Mann-Wolowitz test (see, [Friedman and Rafsky, 1979](#)). Results of selection of distribution of disturbances, as well as lag lengths on the basis of information criteria for all three markets, are available upon request.

**Table 5**

The impact of COVID-19-related policy announcements on sovereign bond yields.

|                          | Czechia              |                      |                      | Hungary              |                      |                      | Poland               |                      |                     |
|--------------------------|----------------------|----------------------|----------------------|----------------------|----------------------|----------------------|----------------------|----------------------|---------------------|
|                          | 1-day window         | 3-day window         | 6-day window         | 1-day window         | 3-day window         | 6-day window         | 1-day window         | 3-day window         | 6-day window        |
| <b>Domestic measures</b> |                      |                      |                      |                      |                      |                      |                      |                      |                     |
| <i>dom_MP_rate</i>       | -0.132***<br>(0.035) | -0.107***<br>(0.016) | -                    | -0.095***<br>(0.030) | -0.029*<br>(0.016)   | -                    | -0.156***<br>(0.040) | -0.067***<br>(0.021) | -0.036**<br>(0.017) |
| <i>dom_MP_purchase</i>   | -                    | -                    | -                    | -                    | -0.080***<br>(0.015) | -                    | -0.133***<br>(0.033) | -0.073**<br>(0.036)  | -                   |
| <i>dom_FP_core</i>       | -                    | -                    | -                    | -0.318***<br>(0.104) | -0.157**<br>(0.076)  | -                    | -                    | -                    | -                   |
| <i>dom_FP_other</i>      | -                    | -                    | -0.095***<br>(0.026) | -                    | -                    | -0.098***<br>(0.022) | -                    | -                    | -                   |
| <b>EU measures</b>       |                      |                      |                      |                      |                      |                      |                      |                      |                     |
| <i>ECB_liquidity</i>     | -                    | -                    | -                    | -                    | 0.047**<br>(0.021)   | -                    | -                    | -                    | -                   |
| <i>EU_FP_measures</i>    | -                    | 0.014**<br>(0.006)   | 0.009**<br>(0.004)   | 0.034**<br>(0.017)   | -                    | -                    | -                    | -                    | -                   |
| <b>US measures</b>       |                      |                      |                      |                      |                      |                      |                      |                      |                     |
| <i>Fed_rate</i>          | -                    | -                    | -                    | -                    | -                    | -                    | 0.197***<br>(0.049)  | 0.074**<br>(0.034)   | -                   |
| <b>Other variables</b>   |                      |                      |                      |                      |                      |                      |                      |                      |                     |
| $\Delta$ Stringency      | -                    | -                    | -                    | -0.009***<br>(0.003) | -                    | -                    | -0.007*<br>(0.004)   | -                    | -                   |
| VIX                      | 0.014**<br>(0.007)   | -                    | -                    | -                    | -                    | -                    | -                    | -                    | -                   |

Notes: The table presents only statistically significant parameter estimates for policy variables. Policy variables that turned out to be statistically insignificant are not included in the final specification (denoted with the symbol '-'). We use the "from general to specific" strategy of model selection. According to the approach proposed by [Hendry and Krolzig \(2004\)](#), we obtain models appropriately reduced to a parsimonious encompassing, congruent representation. Standard errors in parentheses; \*, \*\*, \*\*\* indicate statistical significance at 0.1, 0.05, and 0.01 levels, respectively; estimates of parameters on VIX,  $\Delta$ Deaths, and  $\Delta$ Stringency are almost identical across windows, and hence only 1-day window estimates are presented.

## 4. Results and discussion

### 4.1. Bond markets

For all CE-3 countries, we identify a significant impact of domestic monetary policy measures on sovereign bond yields (see Table 5). The decisions of the CNB, MNB, and NBP helped to reduce the yields; hence, they turned out to be effective in calming the markets. More specifically, the yields were particularly influenced by interest rate cuts, observed in 1- and 3-day windows in Hungary and Czechia and in 1-, 3-, and 6-day windows in Poland. For all three countries, the strongest reductions in yields were noted one day after the announcement and ranged from  $-0.156$  pp. in Poland to  $-0.095$  pp. in Hungary. Moreover, our results point to an important role of the QE announcements in lowering the yields. The effect is stronger in Poland than in Hungary, which may be attributable to the fact that the NBP had never resorted to APPs before the beginning of the pandemic. Our result aligns with previous research, which showed that the COVID-19-related APP announcements effectively lowered the refinancing costs for governments (cf. Arslan et al., 2020; Klose and Tillmann, 2020; Delatte and Guillaume, 2020). At the same time, relative to existing studies, we find slightly smaller impacts of monetary policy events. For example, Rebucci et al. (2021) identify a 1-day impact of  $-0.45\%$  for the NBP's announcement of 17 March 2020 and a  $-0.59\%$  3-day impact of the MNB's announcement of 28 April 2020, while Sever et al. (2020) find a decline of 35 bps for median bond yields after APP announcements in a group of 11 EMs, including Poland and Hungary. Finally, our results show that sovereign bond yields of the CE-3 countries were immune to the announcements of additional refinancing operations (or the easing of the conditions of the existing operations) and of macroprudential tools. The difference between our results and findings of cited papers may result from different empirical specifications. We consider a dynamic, multivariate model and consider the problem of volatility clustering, as well as an asymmetric impact of shocks, rather than conducting an isolated event study of policy announcements.

The impact of domestic fiscal policy announcements turned out to be weaker and more heterogeneous across the CE-3 countries. In particular, we identify no role of the fiscal events in determining Polish sovereign bond yields. The Hungarian yields were influenced

**Table 6**

The impact of COVID-19-related policy announcements on stock markets.

|                          | Czechia      |              |              | Hungary      |              |              | Poland       |              |              |
|--------------------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|
|                          | 1-day window | 3-day window | 6-day window | 1-day window | 3-day window | 6-day window | 1-day window | 3-day window | 6-day window |
| <b>Domestic measures</b> |              |              |              |              |              |              |              |              |              |
| <i>dom_MP_liquidity</i>  | -            | -            | -            | -            | 0.004*       | 0.004**      | 0.035*       | 0.061***     | 0.058**      |
|                          |              |              |              |              | (0.003)      | (0.002)      | (0.020)      | (0.019)      | (0.028)      |
| <i>dom_MP_rate</i>       | -            | -            | -0.004*      | -            | -            | -            | -            | -            | -            |
|                          |              |              | (0.002)      |              |              |              |              |              |              |
| <i>dom_MP_macropru</i>   | -0.013**     | -0.011***    | -            | -            | -            | -            | -            | -            | -            |
|                          | (0.006)      | (0.004)      |              |              |              |              |              |              |              |
| <i>dom_FP_core</i>       | 0.004*       | 0.004**      | 0.002**      | -            | -            | -            | 0.011**      | 0.010**      | 0.010**      |
|                          | (0.003)      | (0.002)      | (0.001)      |              |              |              | (0.005)      | (0.005)      | (0.004)      |
| <b>EU measures</b>       |              |              |              |              |              |              |              |              |              |
| <i>ECB_liquidity</i>     | -            | -            | -            | 0.008*       | 0.009***     | 0.003*       | -            | -            | -            |
|                          |              |              |              | (0.004)      | (0.003)      | (0.002)      |              |              |              |
| <i>EU_FP_RRF</i>         | -            | -            | -            | -            | -            | -            | 0.009**      | 0.005*       | 0.006**      |
|                          |              |              |              |              |              |              | (0.004)      | (0.003)      | (0.003)      |
| <b>US measures</b>       |              |              |              |              |              |              |              |              |              |
| <i>Fed_rate</i>          | -            | -            | -            | -            | -            | -            | -            | -            | 0.005*       |
|                          |              |              |              |              |              |              |              |              | (0.003)      |
| <i>Fed_liquidity</i>     | -            | -            | -            | -            | -0.005*      | -0.005**     | -            | -            | -            |
|                          |              |              |              |              | (0.003)      | (0.002)      |              |              |              |
| <i>US_FP_core</i>        | -            | -            | -            | -            | -            | -            | -            | -            | -0.018***    |
|                          |              |              |              |              |              |              |              |              | (0.005)      |
| <i>US_FP_other</i>       | -            | -            | -            | -            | -            | -            | -            | -            | 0.020***     |
|                          |              |              |              |              |              |              |              |              | (0.006)      |
| <b>Other variables</b>   |              |              |              |              |              |              |              |              |              |
| $\Delta Stringency$      | -0.051***    |              |              | -            |              |              | -            |              |              |
|                          | (0.016)      |              |              |              |              |              |              |              |              |

Notes: The table presents only statistically significant parameter estimates for policy variables. Policy variables that turned out to be statistically insignificant are not included in the final specification (denoted with the symbol '-'). We use the "from general to specific" strategy of model selection. According to the approach proposed by Hendry and Krolzig (2004), we obtain models appropriately reduced to a parsimonious encompassing, congruent representation. Standard errors in parentheses; \*, \*\*, \*\*\* indicate statistical significance at 0.1, 0.05, and 0.01 levels, respectively; estimates of parameters on *VIX*,  $\Delta Deaths$ , and  $\Delta Stringency$  are almost identical across windows, and hence only 1-day window estimates are presented.

by both core and other fiscal policy measures, and the Czech yields responded to the latter subcategory much as the Hungarian ones did. Interestingly, all the announcements for which we obtain statistical significance lowered the yields. This finding contrasts with the results from previous studies, which indicate that expansionary fiscal policy increased yields and view this relationship as a reflection of investors' fears of rising debt burdens (cf. Klose and Tillmann, 2020; Delatte and Guillaume, 2020). Nonetheless, those analyses are mainly devoted to the members of the EA, whose debt ratios are incomparably higher than those of the CE-3 countries. Hence, the relatively more sustainable condition of public finances might have worked to the advantage of the CE-3 countries and allowed investors to see the stimulating impact of the fiscal measures instead. In fact, Benmelech and Tzur-Ilan (2020) show that countries with liquid sovereign bonds and fairly low interest rates, such as the CE-3 economies, were more effective in deploying fiscal policy tools during the pandemic.

Surprisingly, the EU fiscal measures (excluding the RRF) exerted a positive, though relatively small, impact on sovereign bond yields in Czechia and Hungary. Hence, our results support the previous findings of Klose and Tillmann (2020). Nonetheless, we are cautious to interpret this result as a reflection of investors' awareness of the long-term budgetary consequences of stimulus announcements. As mentioned above, we do not analyse the highly-indebted EA economies but countries with relatively low sovereign debt burdens. Hence, the positive estimates may be viewed in the context of investor disappointment with regard to the scale of the European fiscal efforts.

We find little spillover effects from monetary policies of the ECB and the Fed. These are largely limited to the impact of the Fed's policy rate cuts on the Polish yields. The announcements in question give positive values, which means that the reductions in the federal funds rate triggered increases in Polish yields. The almost unidentifiable role of the ECB's and Fed's measures in determining the yields of the CE-3 countries comes as a surprise, given the global and regional significance of the US and Euro Area economies, and the results of studies from the GFC period which detected large international spillovers, particularly of unconventional monetary policies, to EMs (cf. Bauer and Neely, 2014; Chen et al., 2016; Fratzscher et al., 2016).

The first differences in COVID-19-related deaths turned out to be insignificant. At the same time, we find that the  $\Delta Stringency$  variable lowered Hungarian and Polish sovereign bond yields. An increase in global risk aversion, approximated by VIX, resulted in higher yields in Czechia.

#### 4.2. Stock markets

As to the response of the stock markets, we identify more heterogeneities across the CE-3 countries, though some similarities appear as well (see Table 6). The role of the domestic monetary policy announcements is less pronounced in comparison with their effects on the sovereign bond markets. The stock market returns in Hungary and Poland reacted only to the easing of liquidity-providing operations of the NBP and MNB. The respective coefficient estimates are positive, which is in line with economic intuition. We do not find any significant impact of the APPs launched by the two central banks. In that respect, our results support those of Sever et al. (2020), who provide evidence that domestic APP announcements had a weak impact on emerging market equities. Surprisingly, macroprudential events and, to a lesser extent, policy interest rate cuts put downward pressure on Czech stock returns. This finding may reflect investors' disappointment with the scale of the monetary policy accommodation of the CNB, which – unlike other central banks from the CE region (including not only the MNB and NBP, but also the Croatian and Romanian central banks) – did not resort to unconventional measures to support the economy.

We identify a significant impact from a subcategory of core fiscal impulse measures on stock returns in Poland and Czechia. The effect turns out to be positive and persistent, i.e. it is detectable across all window lengths. At the same time, Hungarian stock returns remained unaffected by the national fiscal policy response. In that way, our results are rather inconsistent with the existing studies, which either find almost no role of domestic fiscal policy in driving stock prices (Klose and Tillmann, 2020; D'Orazio and Dirks, 2020) or even point out that fiscal policy announcements adversely affected stock returns, adding to investor uncertainty (Heyden and Heyden, 2021). Again we believe that in view of the relatively stable conditions of the public finances of the CE-3 countries, their fiscal stimulus might have played an important role in calming market participants.

Our results indicate that the fiscal measures introduced at the EU level had almost no significant impact on stock returns in the CE-3 countries. The noticeable exception is the positive impact of the  $EU\_FP\_RRF$  variable on WIG20 stock returns across all window lengths. This finding comes as no surprise, given that Poland is expected to be one of the main beneficiaries of the Recovery and Resilience Facility, along with the Southern European countries. In particular, Poland is estimated to obtain grants amounting to around 7.1% of the total funds, which makes it the 5th largest recipient after Italy, Spain, France, and Germany (Darvas, 2020).

Regarding the international transmission of the ECB's monetary policy, we identify almost no spillover effects on the stock markets of the CE-3 countries. In particular, Czech and Polish stock returns remained unaffected by any of the ECB's announcements, including those pertaining to the APPs. In Hungary, the ECB's decisions on the liquidity-providing measures played some role in driving the returns, especially in the 3-day window.

Our results suggest that the Hungarian and Polish stock markets were somewhat influenced by US monetary events. At the same time, no clear pattern emerges, as the two markets responded differently to individual subcategories. The Fed's rate cuts had a positive, although not highly significant, impact on Polish stock market returns, while its liquidity refinancing operations had the reverse effect on Hungary. When it comes to US fiscal policy measures, the international spillover effects were only detected in Poland. In particular, two variables,  $US\_FP\_core$  and  $US\_FP\_other$ , have proved to be highly significant in the 6-day window. The magnitude of their impacts is also similar, though the direction differs. As with the EC's and the ECB's announcements, we find no spillovers from the US announcements on the stock returns in Czechia.

Finally, our findings indicate that the  $\Delta Stringency$  variable adversely affected the stock returns in Czechia. No other relationship

between the variables reflecting the course of the COVID-19 pandemic in the CE-3 countries and the stock returns has been identified. In this context, our findings differ from the results obtained in other studies (cf. Harjoto et al., 2020).

#### 4.3. Foreign exchange markets

Foreign exchange markets in the CE-3 economies display relatively diverse reactions to domestic monetary policies concerning both the interest-rate and non-standard measures (see Table 7). The estimated coefficients on the *dom\_MP\_rate* variable are negative for Czechia and Poland. This means that interest-rate cuts in both economies lowered the returns on their respective currencies. This result, however, does not apply to Hungary, which is not unexpected given that the MNB did not reduce its base interest rate in the first phase of the pandemic-induced crisis. When it comes to central bank liquidity measures, the effects are opposite to those expected for a conventional monetary expansion, as the return on Polish zloty and the Hungarian forint both increased following the announcements. Given the results that we obtain for the *dom\_MP\_rate* and stock markets, this outcome may indicate a positive impact of liquidity measures on market participants' expectations regarding the outlook for the Polish and Hungarian economies and the fact that these policies were aimed not only at providing further monetary stimulus but also directly at stabilising financial markets. At the same time, it is worth noting that the APPs launched by the MNB and the NBP did not produce any significant results for the FX returns (insignificant estimates; not reported in Table 7). Limited effects of domestic QE policies on currency markets are in-line with most recent studies on such measures implemented by EMEs (Arslan et al., 2020; Sever et al., 2020) and could reflect the central banks' attempts to sterilize the effects of assets purchases for the broad money supply.

Concerning domestic fiscal policies, we find generally weak evidence for the effects of anti-COVID-19 programs on the exchange-rate returns. Apart from the sole exception of the Hungarian case, the announcements of fiscal stimulus packages did not produce any reactions of the FX markets. In Hungary, however, the fiscal measures resulted in the depreciation of the HUF. This effect may be attributed to the perceived risk of a future increase in the inflation rate in Hungary, given that before the pandemic its public debt was considerably higher and economic growth was lower than in Czechia and Poland.

The liquidity programs of the ECB led to an appreciation of the Hungarian forint and the Czech koruna, although in the latter case, this effect was visibly weaker and detected only in the six-day event window. The returns on the Polish zloty remained unaffected by

**Table 7**  
The impact of COVID-19-related policy announcements on foreign exchange markets.

|                          | Czechia              |                      |                      | Hungary             |                     |                      | Poland               |                    |                    |
|--------------------------|----------------------|----------------------|----------------------|---------------------|---------------------|----------------------|----------------------|--------------------|--------------------|
|                          | 1-day window         | 3-day window         | 6-day window         | 1-day window        | 3-day window        | 6-day window         | 1-day window         | 3-day window       | 6-day window       |
| <b>Domestic measures</b> |                      |                      |                      |                     |                     |                      |                      |                    |                    |
| <i>dom_MP_liquidity</i>  | -                    | -                    | -                    | -                   | 0.004***<br>(0.001) | -                    | 0.017***<br>(0.004)  | -                  | -                  |
| <i>dom_MP_rate</i>       | -0.007***<br>(0.002) | -0.005***<br>(0.002) | -0.004***<br>(0.001) | -                   | -                   | -                    | -                    | -0.009*<br>(0.005) | -0.007*<br>(0.004) |
| <i>dom_FP_core</i>       | -                    | -                    | -                    | -                   | -0.005**<br>(0.003) | -0.005***<br>(0.002) | -                    | -                  | -                  |
| <b>EU measures</b>       |                      |                      |                      |                     |                     |                      |                      |                    |                    |
| <i>ECB_liquidity</i>     | -                    | -                    | 0.004*<br>(0.002)    | 0.005***<br>(0.001) | 0.005***<br>(0.001) | 0.002**<br>(0.001)   | -                    | -                  | -                  |
| <i>EU_FP_RRF</i>         | -                    | -                    | -                    | -                   | -                   | -                    | 0.003**<br>(0.001)   | 0.002**<br>(0.001) | -                  |
| <b>US measures</b>       |                      |                      |                      |                     |                     |                      |                      |                    |                    |
| <i>Fed_purchase</i>      | -                    | -                    | -                    | -                   | -                   | -                    | -0.008***<br>(0.002) | -0.002*<br>(0.001) | -                  |
| <i>US_FP_core</i>        | -                    | 0.001*<br>(0.001)    | 0.001*<br>(0.000)    | -                   | -                   | -                    | -                    | -                  | 0.002**<br>(0.001) |
| <b>Other variables</b>   |                      |                      |                      |                     |                     |                      |                      |                    |                    |
| <i>VIX</i>               | -                    | -                    | -                    | -0.006*<br>(0.004)  | -                   | -                    | -                    | -                  | -                  |
| $\Delta Deaths$          | -                    | -                    | -                    | -0.004*<br>(0.002)  | -                   | -                    | -                    | -                  | -                  |
| $\Delta Stringency$      | -                    | -                    | -                    | 0.012*<br>(0.007)   | -                   | -                    | -                    | -                  | -                  |

Notes: The table presents only statistically significant parameter estimates for policy variables. Policy variables that turned out to be statistically insignificant are not included in the final specification (denoted with the symbol '-'). We use the "from general to specific" strategy of model selection. According to the approach proposed by Hendry and Krolzig (2004), we obtain models appropriately reduced to a parsimonious encompassing, congruent representation. Standard errors in parentheses; \*, \*\*, \*\*\* indicate statistical significance at 0.1, 0.05, and 0.01 levels, respectively; estimates of parameters on *VIX*,  $\Delta Deaths$ , and  $\Delta Stringency$  are almost identical across windows, and hence only 1-day window estimates are presented.

monetary policy measures launched in the EA but did respond to the *EU\_FP\_RRF* variable. The resulting appreciation of the PLN in the 1- and 3-day windows confirms a positive reaction by the Polish financial markets to the announcement of the unprecedented EU recovery plan.

The impact of the US monetary and fiscal policies is noticeable for Polish and Czech and absent from Hungarian foreign exchange markets. The Fed's announcements of QE programs (the *US\_purchase* variable) led to a decline in the returns on the Polish zloty in 1- and 2-day windows. Such a finding may seem hard to reconcile with the majority of studies on the exchange rate channel of a central bank's balance sheet expansion (e.g., [Bhattarai et al., 2021](#); [Dedola et al., 2021](#)). However, as pointed out by [Rebucci et al. \(2021\)](#), the instantaneous nexus between the QE announcements and the broad dollar exchange rate in March 2020 may have been more complex due to a major shortage of dollar-denominated assets following a major shock to financial markets. Consequently, the initial impact of QE policies on exchange rates remains ambiguous. Turning to American fiscal policy, we find that the core fiscal measures had significant effects on the koruna and the zloty. The size of these effects, however, must be considered relatively small, especially in the Czech case, where the estimated coefficients are significant only at the 0.1 significance level.

Lastly, the Hungarian foreign exchange market turns out to be the only one among the CE-3 economies that responded to other variables included in the regressions. As expected, the Hungarian forint depreciated following an increase in the global appetite for risk, as approximated by VIX, but also due to a higher number of deaths ( $\Delta Deaths$ ) in the country during the pandemic. Conversely, the impact of stringency measures on the HUF returns was positive. At the same time, the Czech and Polish currency markets proved more resilient to VIX and COVID-19-related indicators.

#### 4.4. Robustness checks

We perform two sets of robustness checks for our baseline results. First, concerning the foreign exchange markets, we estimate the VARX-AGDCC-GARCH model parameters using rates of return on exchange rates of the CE-3 currencies against the euro (CZK/EUR, HUF/EUR, and PLN/EUR) and for rates of return against the US dollar (CZK/USD, HUF/USD, and PLN/USD), instead of synthetic but unobservable effective exchange rates. When rates of return on the CE-3 currencies against the euro are introduced into the model, variables associated with US fiscal and monetary policies are omitted. Analogously, when rates of return against the US dollar are modelled, we exclude variables associated with EU fiscal and monetary policies. The estimates of the parameters in the baseline model (rates of return on the NEER) vis-à-vis the alternative models (rates of return on exchange rates against the euro and the US dollar) are presented in [Table 8](#) and [Table 9](#). Second, as a robustness check for bond markets, parameters of the VARX-AGDCC-GARCH model are estimated for changes in 1-year sovereign bond yields. This check allows us to verify our initial results using yield at the shorter end of the treasury yield curve in each of the CE-3 economies. The estimates of the parameters in the baseline model (changes in 10-year sovereign bond yields) and the alternative model (changes in 1-year sovereign bond yields) are presented in [Table 10](#). The parameter estimates are consistent between the two empirical specifications. For some of the policy variables in Czechia and Hungary, the latter produces slightly larger standard errors and higher *p*-values. However, there are no event types in which the results of two model contradict each other.

To sum up, the results of the first robustness check indicate that when we substitute the effective exchange rate with the observable US dollar and euro exchange rates, similar explanatory variables turn out to be significant. This informs us that our baseline results hold in alternative model specifications and support our conclusions on the impact of specific policy events on financial markets in the

**Table 8**

Foreign exchange markets – robustness checks (1): rates of return on national currencies against the euro.

| Country | Variable                | 1-day window         |                                              | 3-day window         |                                              | 6-day window         |                                              |
|---------|-------------------------|----------------------|----------------------------------------------|----------------------|----------------------------------------------|----------------------|----------------------------------------------|
|         |                         | Basic model          | Rates of return on CZK/EUR, HUF/EUR, PLN/EUR | Basic model          | Rates of return on CZK/EUR, HUF/EUR, PLN/EUR | Basic model          | Rates of return on CZK/EUR, HUF/EUR, PLN/EUR |
| Czechia | <i>dom_MP_rate</i>      | -0.007***<br>(0.002) | -0.005***<br>(0.002)                         | -0.005***<br>(0.002) | -0.003***<br>(0.001)                         | -0.004***<br>(0.001) | -0.003***<br>(0.001)                         |
|         | <i>ECB_liquidity</i>    | –                    | –                                            | –                    | –                                            | 0.004*<br>(0.002)    | –                                            |
| Hungary | <i>dom_MP_liquidity</i> | –                    | –                                            | 0.004***<br>(0.001)  | 0.003**<br>(0.001)                           | –                    | –                                            |
|         | <i>dom_FP_core</i>      | –                    | –                                            | -0.005**<br>(0.003)  | –                                            | -0.005***<br>(0.002) | -0.003*<br>(0.002)                           |
|         | <i>ECB_liquidity</i>    | 0.005***<br>(0.001)  | 0.003*<br>(0.002)                            | 0.005***<br>(0.001)  | 0.003*<br>(0.002)                            | 0.002**<br>(0.001)   | 0.001*<br>(0.000)                            |
| Poland  | <i>dom_MP_liquidity</i> | 0.017***<br>(0.004)  | 0.015***<br>(0.004)                          | –                    | –                                            | –                    | –                                            |
|         | <i>dom_MP_rate</i>      | –                    | –                                            | -0.009*<br>(0.005)   | -0.010**<br>(0.004)                          | -0.007*<br>(0.004)   | -0.008**<br>(0.004)                          |
|         | <i>EU_FP_RRF</i>        | 0.003**<br>(0.001)   | 0.002*<br>(0.001)                            | 0.002**<br>(0.001)   | 0.002**<br>(0.001)                           | –                    | –                                            |

Notes: Standard errors in parentheses; \*, \*\*, \*\*\* denote significance at the 0.1, 0.05 and 0.01 level of significance, respectively; the symbol '–' denotes statistical insignificance.

**Table 9**

Foreign exchange markets – robustness checks (2): rates of return on national currencies against the US dollar.

| Country | Variable                | 1-day window         |                                              | 3-day window         |                                              | 6-day window         |                                              |
|---------|-------------------------|----------------------|----------------------------------------------|----------------------|----------------------------------------------|----------------------|----------------------------------------------|
|         |                         | Basic model          | Rates of return on CZK/USD, HUF/USD, PLN/USD | Basic model          | Rates of return on CZK/USD, HUF/USD, PLN/USD | Basic model          | Rates of return on CZK/USD, HUF/USD, PLN/USD |
| Czechia | <i>dom_MP_rate</i>      | -0.007***<br>(0.002) | -0.006***<br>(0.002)                         | -0.005***<br>(0.002) | -0.003***<br>(0.001)                         | -0.004***<br>(0.001) | -0.003***<br>(0.001)                         |
|         | <i>US_FP_core</i>       | –                    | –                                            | 0.001*<br>(0.001)    | 0.001*<br>(0.001)                            | 0.001*<br>(0.000)    | 0.001*<br>(0.001)                            |
| Hungary | <i>dom_MP_liquidity</i> | –                    | –                                            | 0.004***<br>(0.001)  | 0.002**<br>(0.001)                           | –                    | –                                            |
|         | <i>dom_FP_core</i>      | –                    | –                                            | -0.005**<br>(0.003)  | -0.003**<br>(0.002)                          | -0.005***<br>(0.002) | -0.002*<br>(0.001)                           |
| Poland  | <i>dom_MP_liquidity</i> | 0.017***<br>(0.004)  | 0.014***<br>(0.004)                          | –                    | –                                            | –                    | –                                            |
|         | <i>dom_MP_rate</i>      | –                    | –                                            | -0.009*<br>(0.005)   | -0.013***<br>(0.002)                         | -0.007*<br>(0.004)   | -0.009***<br>(0.003)                         |
|         | <i>Fed_purchase</i>     | -0.008***<br>(0.002) | -0.009***<br>(0.002)                         | -0.002*<br>(0.001)   | -0.004***<br>(0.001)                         | –                    | –                                            |
|         | <i>US_FP_core</i>       | –                    | –                                            | –                    | –                                            | 0.002**<br>(0.001)   | 0.003**<br>(0.001)                           |

Notes: Standard errors in parentheses; \*, \*\*, \*\*\* denote significance at the 0.1, 0.05 and 0.01 level of significance, respectively; the symbol ‘–’ denotes statistical insignificance.

**Table 10**

Bond markets – robustness checks: 1-year sovereign bond yields.

| Country | Variable               | 1-day window         |                                        | 3-day window         |                                        | 6-day window         |                                        |
|---------|------------------------|----------------------|----------------------------------------|----------------------|----------------------------------------|----------------------|----------------------------------------|
|         |                        | Baseline model       | Change in 1-year sovereign bond yields | Baseline model       | Change in 1-year sovereign bond yields | Baseline model       | Change in 1-year sovereign bond yields |
| Czechia | <i>dom_MP_rate</i>     | -0.132***<br>(0.035) | -0.098*<br>(0.058)                     | -0.107***<br>(0.016) | -0.069*<br>(0.040)                     | –                    | –                                      |
|         | <i>dom_FP_other</i>    | –                    | –                                      | –                    | –                                      | -0.095***<br>(0.026) | -0.071*<br>(0.042)                     |
|         | <i>EU_FP_measures</i>  | –                    | –                                      | 0.014**<br>(0.006)   | 0.010**<br>(0.005)                     | 0.009**<br>(0.004)   | 0.006*<br>(0.004)                      |
| Hungary | <i>dom_MP_rate</i>     | -0.095***<br>(0.030) | -0.071**<br>(0.035)                    | -0.029*<br>(0.016)   | –                                      | –                    | –                                      |
|         | <i>dom_MP_purchase</i> | –                    | –                                      | -0.080***<br>(0.015) | -0.045*<br>(0.026)                     | –                    | –                                      |
|         | <i>dom_FP_core</i>     | -0.318***<br>(0.104) | -0.221**<br>(0.109)                    | -0.157**<br>(0.076)  | -0.121*<br>(0.071)                     | –                    | –                                      |
|         | <i>dom_FP_other</i>    | –                    | –                                      | –                    | –                                      | -0.098***<br>(0.022) | -0.071*<br>(0.040)                     |
|         | <i>ECB_liquidity</i>   | –                    | –                                      | 0.047**<br>(0.021)   | 0.040**<br>(0.019)                     | –                    | –                                      |
| Poland  | <i>EU_FP_measures</i>  | 0.034**<br>(0.017)   | 0.030***<br>(0.010)                    | –                    | –                                      | –                    | –                                      |
|         | <i>dom_MP_rate</i>     | -0.156***<br>(0.040) | -0.081***<br>(0.023)                   | -0.067***<br>(0.021) | -0.055***<br>(0.016)                   | -0.036**<br>(0.017)  | -0.028**<br>(0.014)                    |
|         | <i>dom_MP_purchase</i> | -0.133***<br>(0.033) | -0.109***<br>(0.029)                   | -0.073**<br>(0.036)  | -0.057**<br>(0.028)                    | –                    | –                                      |
|         | <i>Fed_rate</i>        | 0.197***<br>(0.049)  | 0.091**<br>(0.044)                     | 0.074**<br>(0.034)   | 0.055**<br>(0.027)                     | –                    | –                                      |

Notes: Standard errors in parentheses; \*, \*\*, \*\*\* denote significance at the 0.1, 0.05 and 0.01 level of significance, respectively; the symbol ‘–’ denotes statistical insignificance.

CE–3 economies. The robustness of the obtained results was also confirmed for the model explaining sovereign bond yields.

## 5. Conclusions

The aim of this paper was to examine the effects of macroeconomic policy announcements on financial markets in Czechia, Hungary, and Poland during the COVID-19 pandemic. Overall, we show that major monetary and fiscal measures implemented in the CE–3 economies from March to December 2020 had a substantial impact on financial markets in the region. These effects hold in a multivariate setting, which allows us to control for a comprehensive set of risk factors and COVID-19-related variables as well as to

account for potentially confounding policy interventions conducted at the European level and in the US.

We detect several patterns in the reaction of the sovereign bond, stock, and foreign exchange markets to anti-crisis measures across the region. First, the impact of the monetary policy announcements on bond markets, including the communication of the QE programs, was more profound and clear-cut than on foreign exchange and stock markets. This indicates that the monetary policies of the CE-3 central banks have an important role in stabilising markets during market turmoil. Second, even though the domestic monetary events turned out to be more important than the fiscal ones, the latter proved relevant, especially when core fiscal measures (anti-crisis spending and tax deferrals) were implemented. Third, we show that the CE-3 economies were subject to the cross-border transmission of policy announcement effects from two large economies, the EA and the US, although the distribution of these effects varied across the region. On a methodological note, our results confirm that the financial markets in small open economies should not be investigated in isolation from international financial shocks, especially in periods when numerous governments and central banks intervene simultaneously.

At the same time, the effects of specific policies differed, across both the CE-3 countries and different markets. For example, impulses coming from the Fed's policies were generally stronger in Poland, the largest of the three economies, than in the two remaining countries. Additionally, several types of policies that we capture in the empirical models did not always lead to the outcomes we would expect from stabilisation policies. At times, their effects on stock and bond market returns, as well as the foreign exchange markets, are ambiguous. One possible reason for such a result is that, given the unusual depth of the COVID-19 crisis, the measures may have simply been insufficient to mitigate the market reaction to the pandemic.

The work on the effects of macroeconomic policies during the COVID-19 pandemic is far from over, and the results of this study may be extended in various ways, for both the CE-3 and other economies. We believe that the reactions of EMEs to the pandemic should be further investigated through the lens of financial globalization and its impact on the efficiency of macroeconomic policies across economies. It also seems necessary to take a closer look into the potential side effects of the extraordinary policy responses to the COVID-19 recession, from both economic and institutional points of view, including the central banks' independence and fiscal stability. The empirical framework presented in this paper may also be used to examine shifts in conditional correlations among financial variables and capture the spillover in-variance effects of anti-crisis policies. Finally, as time passes, the macroeconomic effects of various anti-crisis policies, such as their role in mitigating a pandemic-related decline in investment or economic growth, will come under the spotlight.

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### Author contribution statement

All authors have contributed equally to this study.

### Declaration of competing interest

None.

### Data availability

The dataset used in the study is available as supplementary material to the paper.

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### Appendix A. Monetary and fiscal policy announcements included in the study

**Table A.1**  
Major CNB announcements in 2020.

| Date | Event | Type of monetary policy measures |
|------|-------|----------------------------------|
|------|-------|----------------------------------|

(continued on next page)

**Table A.1** (continued)

| Date         | Event                                                                                                                                                                                                                                                                                                         | Type of monetary policy measures |
|--------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------|
| 16 Mar. 2020 | CNB cuts its key interest rates (2 W repo rate by 50 bps to 1.75%, the Lombard rate to 2.75%, and the discount rate to 0.75%), increases the number of liquidity-providing operations, and revises its earlier decision to increase the countercyclical capital buffer rate for exposures located in Czechia. | Rate, liquidity, macroprudential |
| 26 Mar. 2020 | CNB further cuts its key interest rates (2 W repo rate by 75 bps to 1.00%, the Lombard rate to 2.00%, and the discount rate to 0.05%) and lowers the countercyclical capital buffer rate.                                                                                                                     | Rate, macroprudential            |
| 1 Apr. 2020  | CNB relaxes its recommendation for the assessment of new mortgages, increases the LTV limit to 90% (from 80%), and increases the limit on the DSTI ratio from (45% to 50%).                                                                                                                                   | Macroprudential                  |
| 7 May 2020   | CNB further cuts its key interest rates (2 W rate by 75 bps to 0.25% and the Lombard rate to 1.00%), announces the broadening of the range of eligible collateral used in liquidity-providing operations, and introduces operations with 3-month maturity.                                                    | Rate, liquidity                  |
| 18 Jun. 2020 | CNB partially relaxes mortgage limits and lowers the countercyclical capital buffer rate.                                                                                                                                                                                                                     | Macroprudential                  |

Source: Authors' own compilation based on the CNB's press releases.

**Table A.2**

Major MNB announcements in 2020.

| Date         | Event                                                                                                                                                                                                                                                                   | Type of monetary policy measures |
|--------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------|
| 16 Mar. 2020 | MNB expands the range of eligible collateral to include corporate loans.                                                                                                                                                                                                | Liquidity                        |
| 18 Mar. 2020 | MNB considers restarting the mortgage bond purchase program, announces relief from maintenance of the systemic risk buffer, and suspends capital adequacy assessment.                                                                                                   | Purchase, macroprudential        |
| 24 Mar. 2020 | MNB expands the scope of collateral coverage and introduces additional one-week FX swap tenders.                                                                                                                                                                        | Liquidity                        |
| 30 Mar. 2020 | MNB maintains the 0 % countercyclical capital buffer "for longer".                                                                                                                                                                                                      | Macroprudential                  |
| 7 Apr. 2020  | MNB extends the interest rates corridor and launches QE, which involves purchases of government securities (in the secondary market) and mortgage bonds. It also launches two lending programs: Funding for Growth Scheme Go! and Bond Funding for Growth Scheme (BGS). | Rate, purchase, liquidity        |
| 28 Apr. 2020 | MNB announces details on the long-term assets purchase program. 1 trillion HUF government bonds; 300 billion HUF mortgage (corporate) bonds. Focus on securities with at least three years to maturity.                                                                 | Purchase                         |
| 4 May 2020   | QE operations are launched at the weekly level of HUF 100 bn.                                                                                                                                                                                                           | Purchase                         |
| 23 Jun. 2020 | MPC reduces the base rate by 15 bps to 0.75%.                                                                                                                                                                                                                           | Rate                             |
| 21 Jul. 2020 | MPC reduces the base rate by 15 bps to 0.60%.                                                                                                                                                                                                                           | Rate                             |
| 8 Sep. 2020  | Swap facility is added to the MNB's toolbox.                                                                                                                                                                                                                            | Liquidity                        |
| 22 Sep. 2020 | The scale of BGS is increased to HUF 750 bn.                                                                                                                                                                                                                            | Liquidity                        |
| 6 Oct. 2020  | MNB extends its QE program by increasing the maximum amount of purchased securities from 33% to 50% of available securities.                                                                                                                                            | Purchase                         |
| 3 Nov. 2020  | MNB extends the maturity range of assets purchased under its QE program, prepares for green QE, and raises the total amount of FGS Go! by HUF 1000 bn.                                                                                                                  | Purchase, liquidity              |
| 8 Dec. 2020  | MNB announces FX swap tenders providing euro liquidity.                                                                                                                                                                                                                 | Liquidity                        |

Source: Authors' own compilation based on the MNB's press releases.

**Table A.3**

Major NBP and FSC announcements in 2020.

| Date         | Event                                                                                                                                                                                                                                                                                                                              | Type of monetary policy measures     |
|--------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------|
| 16 Mar. 2020 | NBP introduces operations to supply banks with liquidity, large-scale purchase of Treasury bonds in the secondary market, and discount credit for banks. The FSC recommends an immediate repeal of the 3% systemic risk buffer for bank capital requirements.                                                                      | Liquidity, purchase, macroprudential |
| 17 Mar. 2020 | NBP cuts the reference rate by 0.5 pp. to 1.00%, decreases the required reserve ratio from 3.5% to 0.5%, and increases the remuneration of the required reserves from 0.5% to the reference rate level.                                                                                                                            | Rate                                 |
| 8 Apr. 2020  | NBP cuts interest rates by 0.50 pp. (the reference rate to 0.50%, Lombard rate to 1.00%, deposit rate to 0.00%, rediscount rate to 0.55%, discount rate to 0.60%). It expands the list of securities eligible for purchases in the secondary market to consist of government securities and government-guaranteed debt securities. | Rate, purchase                       |
| 28 May 2020  | NBP cuts interest rates (the reference rate to 0.10%, Lombard rate to 0.50%, rediscount rate to 0.11%, discount rate to 0.12%).                                                                                                                                                                                                    | Rate                                 |
| 15 Jun. 2020 | The FSC agrees with the request of the Chairman of the PFSA on the postponement of the implementation of Recommendation S on good practices with regard to managing mortgage-secured credit exposures until 30 June 2021.                                                                                                          | Macroprudential                      |

(continued on next page)

**Table A.3** (continued)

| Date            | Event                                                                                                                                                                                                                            | Type of monetary policy measures |
|-----------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------|
| 13 Jul.<br>2020 | The FSC recommends a reduction from 100% to 50% in the risk weights for exposures arising from loans secured on commercial property used for the borrower's own business and not generating rental income or profit on the sale. | Macroprudential                  |

Source: Authors' own compilation based on the CNB's press releases. FSC stands for Financial Stability Committee, which is the Polish macroprudential authority. The FSC comprises NBP, the Polish Financial Supervision Authority (PFSa), the Ministry of Finance, and the Bank Guarantee Fund.

**Table A.4**

Major Czech fiscal measures in response to the COVID-19 pandemic in 2020.

| Date            | Event                                                                                                                                                                                                                                                                                                                                                                                                                              | Type of fiscal policy measures |
|-----------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------|
| 16 Mar.<br>2020 | The Czech-Moravian Guarantee and Development Bank (ČMZRB) launches the national COVID loan program (COVID I program) with the aim of allowing SMEs to fund their operations in response to the crisis.                                                                                                                                                                                                                             | Other                          |
| 19 Mar.<br>2020 | The government agrees to extend the payment of care allowance during an emergency.                                                                                                                                                                                                                                                                                                                                                 | Core                           |
| 23 Mar.<br>2020 | The government announces the cancellation of compulsory pension insurance payments for six months for the self-employed, adopts a "liberation package" allowing for different tax reliefs, approves further steps within the "Antivirus" program, and approves aid for farmers affected by the pandemic.                                                                                                                           | Core, other                    |
| 26 Mar.<br>2020 | The government notes the announcement of "Care Allowance for the Self-Employed" – a subsidy program for self-employed persons who – due to school closures – had to stop their business in order to take care of children.                                                                                                                                                                                                         | Core                           |
| 31 Mar.<br>2020 | The government approves the final version of the employment support program ("Antivirus"), providing for wage or salary reimbursement for the COVID-19-stricken entities. It also approves one-time financial assistance of CZK 25,000 for self-employed persons and an expansion of the declared "Care Allowance for the Self-Employed" program to include self-employed from the field of agriculture and the forestry industry. | Core                           |
| 1 Apr.<br>2020  | The government proposes a draft act on certain loan repayment measures in connection with the COVID-19 pandemic providing for a moratorium on the repayment of loans and mortgages.                                                                                                                                                                                                                                                | Other                          |
| 2 Apr.<br>2020  | The ČMZRB starts accepting applications within the COVID II program, a follow-up to the COVID I program, aimed at increasing the scope of eligible entities to the self-employed and the smallest business owners.                                                                                                                                                                                                                 | Other                          |
| 9 Apr.<br>2020  | The government approves financial aid to cultural institutions which lost their income due to quarantine measures.                                                                                                                                                                                                                                                                                                                 | Core                           |
| 17 Apr.<br>2020 | The government increases the value of the care allowance.                                                                                                                                                                                                                                                                                                                                                                          | Core                           |
| 20 Apr.<br>2020 | The government proposes extending financial assistance to the self-employed through May. It also approves a state guarantee of CZK 150 bn on business loans to be provided by the ČMZRB.                                                                                                                                                                                                                                           | Core, other                    |
| 21 Apr.<br>2020 | The COVID Prague program is launched with the same conditions as the COVID II program, though aimed at Prague-based companies and the self-employed.                                                                                                                                                                                                                                                                               | Other                          |
| 27 Apr.<br>2020 | The government extends the "Antivirus" program to the end of May.                                                                                                                                                                                                                                                                                                                                                                  | Core                           |
| 4 May<br>2020   | The government proposes an extension of entities eligible for a compensation bonus to include the partners of small limited liability companies. It also puts forward an increase in subsidies provided to self-employed persons looking after children. Further, a subsidy program aimed at helping businesses to cover the rent of their premises is proposed.                                                                   | Core                           |
| 18 May<br>2020  | The government approves the COVID III guarantee program for firms with up to 500 employees. It also approves the release of up to CZK 2.5 bn to finance the Care-giver's Allowance for the self-employed persons subsidy program and the release of a further CZK 5 bn for the financing of the COVID – Rent program.                                                                                                              | Core, other                    |
| 25 May<br>2020  | The government proposes lowering the VAT rate on selected services (accommodation, sport, culture) from 15% to 10%. The proposal also contains a reduction of 25% on the road tax for vehicles above 3.5 t.                                                                                                                                                                                                                        | Core                           |
| 1 Jun.<br>2020  | The government announces the COVID – Sport subsidy program aimed at providing financial assistance to sports organizations.                                                                                                                                                                                                                                                                                                        | Core                           |
| 8 Jun.<br>2020  | The government announces a law mitigating the impact of lower tax revenues to villages to be put before the Parliament. It also decides to extend the Antivirus A program, and approves another liberation package and the Tourism Crisis Action Plan, which consists of 16 specific steps to help businesses in the sector.                                                                                                       | Core, other                    |
| 14 Oct.<br>2020 | The government announces the extension of the Covid – Culture program, the continuation of the Antivirus A program under the name Antivirus Plus, an extension and modification of the Covid – Rent subsidy program, the introduction of Covid – Bus program aimed at supporting businesses in irregular bus transportation, the Covid – Sport II subsidy program. Some tax reliefs are announced.                                 | Core                           |
| 16 Oct.<br>2020 | The government announces a bill on a compensation bonus for entrepreneurs to be put forward in Parliament. It also approves Care Allowance II for the self-employed program, announces a plan to introduce the AgroCovid Foodstuffs program aimed at supporting food producers, and the continuation of the Covid III Guarantee Program.                                                                                           | Core, other                    |
| 19 Oct.<br>2020 | The government agrees to financial support for small companies operating in the audio-visual industry and announces the Covid – Tourism promotion program to be designed by the Ministry of Regional Development.                                                                                                                                                                                                                  | Core                           |
| 26 Oct.<br>2020 | The government approves an extension of the Antivirus B aid program and announces further expansion of the liberation package.                                                                                                                                                                                                                                                                                                     | Core, other                    |
| 14 Dec.<br>2020 | The government announces an extension of the Covid – Accommodation program, the continuation of the Covid – Rent subsidy scheme, and the launch of a new subsidy program, Covid – Gastro. Further tax reliefs are approved.                                                                                                                                                                                                        | Core                           |

Source: Authors' own compilation based on press releases available on the official website of the Government of the Czech Republic.

**Table A.5**  
Major Hungarian fiscal measures in response to the COVID-19 pandemic in 2020.

| Date         | Event                                                                                                                                                                                                                                                                                                                           | Type of fiscal policy measures |
|--------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------|
| 17 Mar. 2020 | The government announces the cancellation of tax and social security, totaling HUF 142.5 bn (most affected sectors, small businesses), tourism development fee, and taxes for small enterprises, as well as a loan repayment moratorium for households and enterprises.                                                         | Core                           |
| 23 Mar. 2020 | The government announces the cancellation of tax and social security totaling HUF 35.6 bn, additional cancellation of taxes for small enterprises of HUF 16.3 bn, the cancellation of interest and fees and unpaid taxes.                                                                                                       | Core                           |
| 8 Apr. 2020  | The government launches the Anti-Epidemic Protection Fund and the Economy Protection Fund aimed at protecting and creating jobs (investment up to HUF 450 bn), support for priority sectors (tourism, health, logistics, etc.), subsidized and guaranteed credit facilities to Hungarian companies, and extra pension payments. | Core, other                    |
| 16 Apr. 2020 | Grants for exporting companies are introduced via Eximbank (a state-owned bank): preferential loans and guarantee and insurance schemes.                                                                                                                                                                                        | Other                          |
| 23 Apr. 2020 | HUF 1490 bn financial support for companies is announced: loans and guarantees, via MFB (a state-owned investment bank).                                                                                                                                                                                                        | Other                          |
| 7 May 2020   | The government announces the purchase program of bank bonds (HUF 150 bn) to support lending and maintain financial stability.                                                                                                                                                                                                   | Core                           |
| 20 May 2020  | The government introduces a wage subsidy for new hires under the condition that employment will last at least nine months.                                                                                                                                                                                                      | Core                           |

Source: Authors' own compilation based on IMF's Policy responses to COVID 19, <https://www.imf.org/en/Topics/imf-and-covid19/Policy-Responses-to-COVID-19> (access: 18 March 2021), and Bruegel's datasets, The fiscal response to the economic fallout from the coronavirus, <https://www.bruegel.org/publications/datasets/covid-national-dataset/> (access: 18 March 2021).

**Table A.6**  
Major Polish fiscal measures in response to the COVID-19 pandemic in 2020.

| Date         | Event                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | Type of fiscal policy measures |
|--------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------|
| 31 Mar. 2020 | The Parliament adopts the package of legislative laws, commonly referred to as the "Anti-Crisis Shield", including, inter alia, additional government spending (e.g., wage subsidies to keep people employed), the postponement or cancellation of certain taxes and social insurance contributions (e.g., 3-month exemption from ZUS contributions for micro-enterprises), additional loans for micro-enterprises, and liquidity guarantees for medium-sized and large companies.                                                                                                                                                                                                                                                      | Core, other                    |
| 17 Apr. 2020 | The Polish Sejm adopts the "Anti-Crisis Shield 2.0," extending previously enacted measures. The new regulations increased the availability of loans for micro-enterprises, extended the set of businesses eligible for ZUS contribution exemptions and the stoppage pay option. It also adopts the "Financial Shield" to be implemented by the Polish Development Fund (PDF). For SMEs, the Program envisaged returnable subsidies, with the possibility of redemption of up to 75%, whereas for large enterprises, the forms of financing were loans or bonds supporting financial liquidity, preferential financing, and investment in the form of equity instruments. The "Financial Shield" was approved by the EC on 11 June 2020. | Core, other                    |
| 30 Apr. 2020 | The Polish Sejm adopts the "Anti-Crisis Shield 3.0." which further increases government spending or foregone revenues, defers certain taxes, increases access to low-interest loans.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | Core, other                    |
| 19 Jun. 2020 | The Polish Sejm adopts the "Anti-Crisis Shield 4.0." introducing: anti-takeover laws aimed at protecting Polish companies against hostile takeovers by investors from outside Europe and the OECD, budgetary support for local governments, interest rate subsidies for credit granted to COVID-19-stricken enterprises, a credit holiday for individuals who have lost their employment or main source of income, and tax aids.                                                                                                                                                                                                                                                                                                        | Core, other                    |
| 22 Sep. 2020 | The President signs the "Anti-Crisis Shield 5.0." which provides support for certain entities from the tourism, stage arts, and exhibition industries.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | Core                           |
| 14 Dec. 2020 | The President signs "Anti-Crisis Shield 6.0." providing aid measures for industries particularly stricken by the COVID-19-induced crisis. The key measures are the subsidization of salaries, exemption from ZUS contributions, the extension of the list of industries eligible for a 3-month exemption for ZUS contribution, the extension of the groups of entities eligible for downtime benefit or additional one-off downtime benefit, and subsidies of up to PLN 5000 for micro- and small businesses.                                                                                                                                                                                                                           | Core                           |
| 23 Dec. 2020 | The EC approves the PLN 13 bn "Financial Shield for SME 2.0," which provides aid in the form of subsidies for micro- and aid in the form of support for uncovered fixed costs for small and medium-sized enterprises.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | Core                           |

Source: Authors' own compilation based on press releases available on the websites of the President of the Republic of Poland, the Government of Poland, and the European Commission, <https://home.kpmg/xx/en/home/insights/2020/04/poland-government-and-institution-measures-in-response-to-covid.html>.

**Table A.7**  
Major ECB announcements in 2020.

| Date         | Event                                                                                                                                                                                                                                                  | Type of monetary policy measures                |
|--------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------|
| 12 Mar. 2020 | The ECB announces additional LTROs, more favourable terms in TLTRO III, additional net asset purchases of EUR 120 bn.                                                                                                                                  | Purchase, liquidity                             |
| 15 Mar. 2020 | The ECB announces coordinated action of the BoC, BoE, BoJ, ECB, Fed, and SNB to enhance the provision of global US dollar liquidity (lowering the pricing of all US dollar operations, offering additional US dollar operations with 84-day maturity). | Liquidity                                       |
|              |                                                                                                                                                                                                                                                        | Purchase, liquidity<br>(continued on next page) |

**Table A.7** (continued)

| Date         | Event                                                                                                                                                                                                                                                                                                                   | Type of monetary policy measures |
|--------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------|
| 18 Mar. 2020 | The ECB announces the Pandemic Emergency Purchase Program (PEPP) of EUR 750 bn and some collateral easing measures.                                                                                                                                                                                                     |                                  |
| 20 Mar. 2020 | The ECB announces coordinated action of the BoC, BoE, BoJ, ECB, Fed, and SNB to further enhance the provision of global US dollar liquidity (an increase of the frequency of 7-day maturity operations from weekly to daily).                                                                                           | Liquidity                        |
| 7 Apr. 2020  | The ECB announces temporary collateral easing measures.                                                                                                                                                                                                                                                                 | Liquidity                        |
| 22 Apr. 2020 | The ECB announces further collateral easing measures, reinforcing the package announced on 7 April 2020.                                                                                                                                                                                                                | Liquidity                        |
| 30 Apr. 2020 | The ECB announces further easing of the conditions of TLTRO III operations, a new series of non-targeted pandemic emergency longer-term refinancing operations (PELTROs).                                                                                                                                               | Liquidity                        |
| 4 Jun. 2020  | The ECB announces PEPP expansion by EUR 600 bn to a total of EUR 1350 bn.                                                                                                                                                                                                                                               | Purchase                         |
| 17 Sep. 2020 | The ECB's Governing Council supports the exclusion of certain central bank exposures from the leverage ratio.                                                                                                                                                                                                           | Liquidity                        |
| 10 Dec. 2020 | The ECB announces PEPP expansion by EUR 500 bn to a total of EUR 1850 bn and the extension of the horizon for net purchases under the PEPP, further easing of the conditions for the TLTRO III, extending the duration of the set of collateral easing measures adopted on 7 and 22 April 2020, and additional PELTROs. | Purchase, liquidity              |

Source: Authors' own compilation based on the ECB's press releases. (T)LTROs – (targeted) longer-term refinancing operations. BoC, BoE, BoJ, SNB stand for the Bank of Canada, the Bank of England, the Bank of Japan, and the Swiss National Bank, respectively (accessed: 18 March 2021).

**Table A.8**

Major Fed announcements in 2020.

| Date         | Event                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | Type of monetary policy measures |
|--------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------|
| 3 Mar. 2020  | The Fed lowers its federal funds rate by 0.5 pp. to a target range of 1 to 1.25% + interest rate paid on required and excess reserve balances set at 1.10%                                                                                                                                                                                                                                                                                                                                                                                     | Rate                             |
| 15 Mar. 2020 | The Fed further lowers the target range for the federal funds rate to 0 to 0.25%. It cuts the primary credit rate by 1.5 pp. to 0.25%, introduces loans up to 90 days, and lowers reserve requirement ratios to 0%. Purchases of Treasuries and MBS under the QE program of 700 bn USD are introduced.                                                                                                                                                                                                                                         | Rate, liquidity, purchase        |
| 17 Mar. 2020 | Several new programs are announced: Primary Dealer Credit Facility (PDCF) consists of lending operations within the Commercial Paper Funding Facility (CPFF); an SPV buys short-term commercial papers with partial fiscal backing.                                                                                                                                                                                                                                                                                                            | Purchase, liquidity              |
| 18 Mar. 2020 | The Money Market Mutual Fund Liquidity Facility is announced: additional lending operations.                                                                                                                                                                                                                                                                                                                                                                                                                                                   | Liquidity                        |
| 22 Mar. 2020 | An interagency statement is issued: loan modification rules for financial institutions.                                                                                                                                                                                                                                                                                                                                                                                                                                                        | Macroprudential                  |
| 23 Mar. 2020 | The Fed announces the "unlimited" QE, treasury, and MBS purchases. Long-term lending within the Term Asset-Backed Securities Loan Facility (TALF) is introduced. The Fed launches new purchase programs: Primary Market Corporate Credit Facility (PMCCF), long-term asset purchases (corporate bonds and ETFs) with partial fiscal backing, and Secondary Market Corporate Credit Facility (SMCCF) long-term asset purchases with partial fiscal backing. Long-term lending to SMEs is launched using the Main Street Lending Program (MSLP). | Purchase, liquidity              |
| 26 Mar. 2020 | Regulatory reporting relief to small financial institutions during the COVID-19 pandemic is announced.                                                                                                                                                                                                                                                                                                                                                                                                                                         | Macroprudential                  |
| 31 Mar. 2020 | The Fed launches the Foreign and International Monetary Authorities Repo Facility (FIMA), which provides lending in the US dollar.                                                                                                                                                                                                                                                                                                                                                                                                             | Liquidity                        |
| 6 Apr. 2020  | The Fed announces the emerging lending facilities to implement the CARES Act, e.g., Paycheck Protection Program Liquidity Facility (PPPLF), which supports long-term lending to SMEs.                                                                                                                                                                                                                                                                                                                                                          | Liquidity                        |
| 7 Apr. 2020  | An interagency statement is issued: clarification on troubled debt restructuring rules.                                                                                                                                                                                                                                                                                                                                                                                                                                                        | Macroprudential                  |
| 9 Apr. 2020  | The Fed announces the Municipal Liquidity Facility (MLF), purchasing short-term state and local governments debt.                                                                                                                                                                                                                                                                                                                                                                                                                              | Purchase                         |
| 15 Jun. 2020 | Lending programs are extended: Update on MSLP and SMCCF. Two new facilities are created: Nonprofit Organization New Loan Facility (NONLF) and Nonprofit Organization Expanded Loan Facility (NOELF).                                                                                                                                                                                                                                                                                                                                           | Liquidity                        |
| 30 Nov. 2020 | Lending facilities CPFF, MMFLF, PDCF, PPPLF are extended to March 31, 2021.                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | Liquidity                        |
| 16 Dec. 2020 | The Fed announces the continuation of QE: monthly purchases of USD 80 bn of Treasuries and USD 40 bn of MBS debt.                                                                                                                                                                                                                                                                                                                                                                                                                              | Purchase                         |

Source: Authors' own compilation based on the Fed's press releases. Note: Weekend announcements adopt the value of one on the next working day.

**Table A.9**

Major US fiscal measures in response to the COVID-19 pandemic in 2020.

| Date        | Event                                                                                                                                                                | Type of fiscal policy measures |
|-------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------|
| 6 Mar. 2020 | The Coronavirus Preparedness and Response Supplemental Appropriations Act is enacted: emergency funding for public health agencies and coronavirus vaccine research. | Core                           |
|             |                                                                                                                                                                      | Core                           |

(continued on next page)

**Table A.9** (continued)

| Date         | Event                                                                                                                                                                                                                                                                                                                                          | Type of fiscal policy measures |
|--------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------|
| 18 Mar. 2020 | The Families First Coronavirus Response Act is signed into law: paid sick leave, tax credits, and free COVID-19 testing, expanded food assistance and unemployment benefits, along with an increase in Medicaid funding. The U.S. Treasury and Internal Revenue Service (IRS) announce non-corporate tax deferrals.                            |                                |
| 27 Mar. 2020 | The CARES Act (Coronavirus Aid, Relief and Economy Security Act) is signed by the president: direct payments to taxpayers, financial assistance to companies, an estimated USD 2.3 trillion in tax rebates, expanded unemployment benefits, financial support for hospitals, state and local authorities, and student loan payment suspension. | Core, other                    |
| 24 Apr. 2020 | The Paycheck Protection Program and Health Care Enhancement Act are signed into law: USD 383 billion in emergency lending (disaster loans) and guarantees for small businesses; USD 75 billion for hospitals, USD 25 billion for virus testing.                                                                                                | Core, other                    |
| 8 Aug. 2020  | An executive order of the President is issued: extension of previous programs, including Paycheck Protection Program, extra unemployment benefits, student loan payment relief, deferred social security taxes, and additional financial assistance for renters and homeowners.                                                                | Core, other                    |
| 21 Dec. 2020 | The Consolidated Appropriations Act is passed: another round of financial aid to small businesses, direct payments to taxpayers, unemployment benefits, and aid for schools and the healthcare system.                                                                                                                                         | Core, other                    |

Source: Authors' own compilation based on US government sources, IMF's Policy responses to COVID 19, <https://www.imf.org/en/Topics/imf-and-covid19/Policy-Responses-to-COVID-19> (access: 18 March 2021), and Bruegel's datasets, The fiscal response to the economic fallout from the coronavirus, <https://www.bruegel.org/publications/datasets/covid-national-dataset/> (access: 18 March 2021). Note: Weekend announcements adopt the value of one on the next working day.

**Table A.10**

Key announcements of the EC with regard to EU action in 2020.

| Date         | Event                                                                                                                                                                                                                                                                                        |
|--------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 10 Mar. 2020 | The EC announces the "Corona Response Investment Initiative" to fight the pandemic and its economic consequences.                                                                                                                                                                            |
| 13 Mar. 2020 | The EC proposes several fiscal measures to mitigate the economic impact of the pandemic (inter alia, via the use of EU State aid rules, European fiscal framework flexibility, and the EU budget).                                                                                           |
| 19 Mar. 2020 | The EC adopts a Temporary Framework for State aid measures to support member states' efforts in fighting the economic fallout from the pandemic.                                                                                                                                             |
| 20 Mar. 2020 | The EC proposes activating the general escape clause of the Stability and Growth Pact.                                                                                                                                                                                                       |
| 23 Mar. 2020 | EU ministers of finance agree with the EC that the conditions for using the general escape clause of the EU fiscal framework are met.                                                                                                                                                        |
| 2 Apr. 2020  | The EC proposes setting up a EUR 100 bn instrument "Support to mitigate Unemployment Risks in an Emergency" (SURE) aimed at protecting people's jobs.                                                                                                                                        |
| 3 Apr. 2020  | The EC announces the extension of the EU's State aid Temporary Framework.                                                                                                                                                                                                                    |
| 6 Apr. 2020  | The EC unlocks EUR 1 bn from the European Fund for Strategic Investments as a guarantee to the European Investment Fund (EIF). This was to allow the EIF to provide guarantees to financial intermediaries with a view of incentivizing lending to European small and medium-sized business. |
| 28 Apr. 2020 | The EC adopts a banking package to facilitate bank lending to households and businesses throughout the EU.                                                                                                                                                                                   |
| 8 May 2020   | The EC adopts a second amendment to extend the scope of the State Aid Temporary Framework.                                                                                                                                                                                                   |
| 27 May 2020  | The EC puts forward "Next Generation EU" of EUR 750 bn.                                                                                                                                                                                                                                      |
| 3 Jun. 2020  | The EC puts forward adjustments to its budget for 2020 to make EUR 11.5 bn available to support recovery.                                                                                                                                                                                    |
| 29 Jun. 2020 | The EC further extends the scope of the State aid Temporary Framework.                                                                                                                                                                                                                       |
| 21 Jul. 2020 | EU leaders come to an agreement on the recovery plan and multiannual financial framework for 2021–2027.                                                                                                                                                                                      |
| 24 Jul. 2020 | The EC adopts a Capital Markets Recovery Package.                                                                                                                                                                                                                                            |
| 24 Aug. 2020 | The EC proposes to grant financial support of EUR 81.4 bn to 15 member states under SURE.                                                                                                                                                                                                    |
| 25 Sep. 2020 | The Council approves EUR 87.4 bn of financial support to 16 member states in the form of EU loans under SURE.                                                                                                                                                                                |
| 10 Nov. 2020 | The European Parliament and EU member states in the Council reach an agreement on a EUR 1.8 tr package to rebuild a post-COVID-19 Europe.                                                                                                                                                    |
| 17 Dec. 2020 | The Council adopts the EU's long-term budget of EUR 1074.3 bn (in 2018 prices) for 2021–2027.                                                                                                                                                                                                |
| 18 Dec. 2020 | The Council and Parliament reach a political agreement on a EUR 672.5 bn Recovery and Resilience Facility.                                                                                                                                                                                   |

Source: Authors' own compilation based of the EC and ECB press releases.

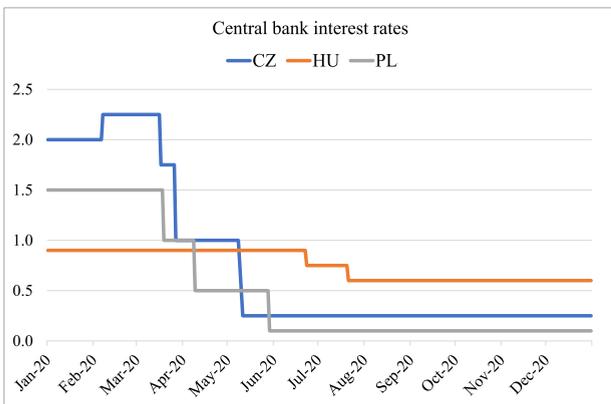
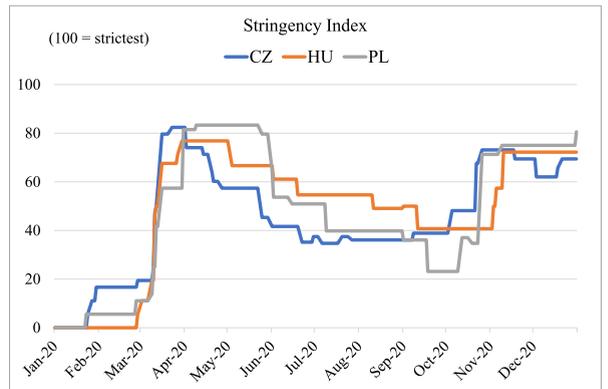
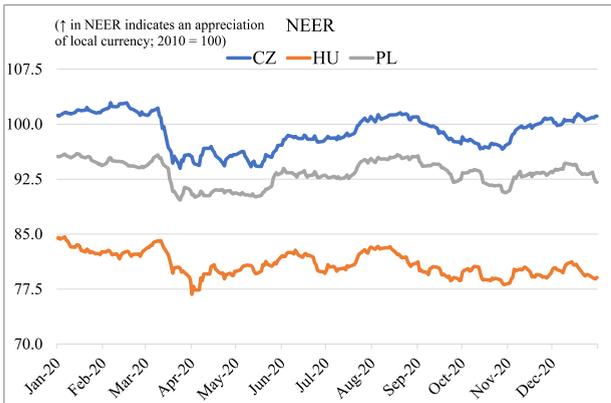
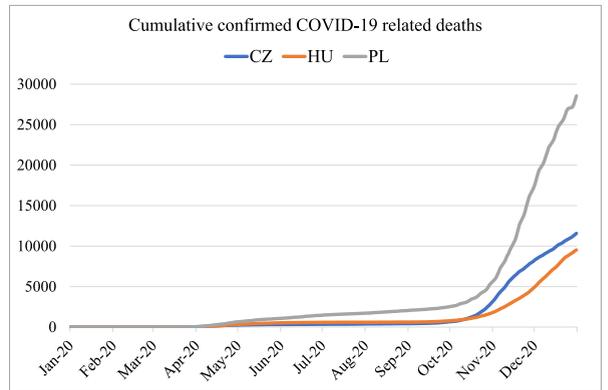
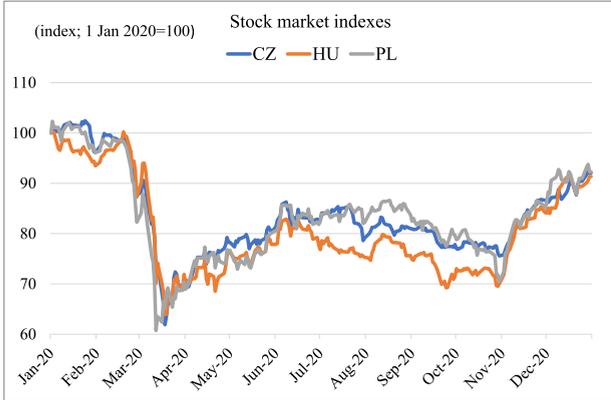
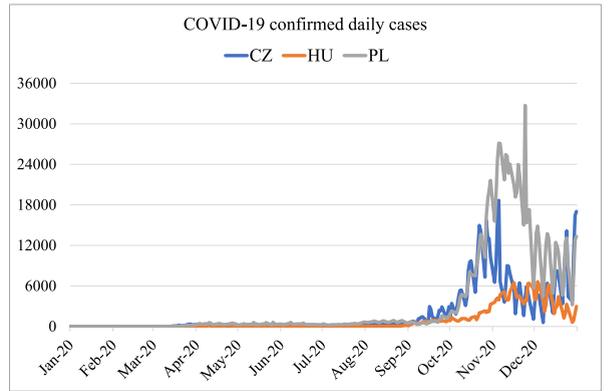
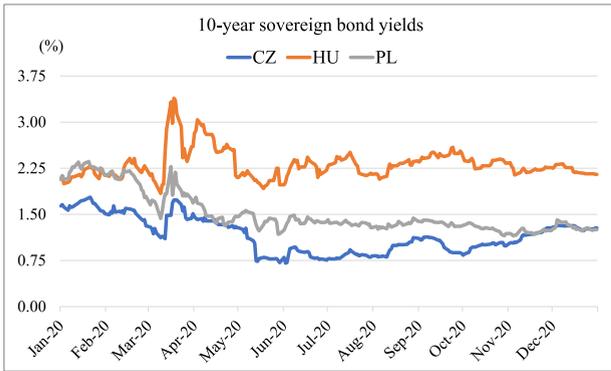
## Appendix B. Variables used in the study

**Table B.1**

The full set of variables used in the study.

| Name                                                | Description                                                                                                                                                                                        | Source                |
|-----------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------|
| <b>Financial variables</b>                          |                                                                                                                                                                                                    |                       |
| $\Delta I^{CZ}, \Delta I^{HU}, \Delta I^{PL}$       | Daily changes in 10-year sovereign bond yields of Czechia, Hungary and Poland                                                                                                                      | Refinitiv             |
| $r^{NEER,CZ}, r^{NEER,HU}, r^{NEER,PL}$             | Daily rates of return on the nominal effective CZK, HUF, and PLN exchange rates                                                                                                                    | BIS                   |
| $r_t^{PX}, r_t^{BUX}, r_t^{WIG20}$                  | Daily rates of return on the Prague Stock Exchange Index (PX), Budapest Stock Exchange Index (BUX), and Warsaw Stock Exchange WIG20 Index                                                          | Refinitiv             |
| <b>Domestic monetary and fiscal policy measures</b> |                                                                                                                                                                                                    |                       |
| <i>dom_MP_rate</i>                                  | Dummy variable taking the value of 1 if a domestic central bank cut its interest rates; 0 otherwise                                                                                                | Authors' calculations |
| <i>dom_MP_liquidity</i>                             | Dummy variable taking the value of 1 if a domestic central bank undertook liquidity enhancement measures; 0 otherwise                                                                              | Authors' calculations |
| <i>dom_MP_macropru</i>                              | Dummy variable taking the value of 1 if macroprudential policy easing was adopted by a domestic central bank or with its participation; 0 otherwise                                                | Authors' calculations |
| <i>dom_MP_purchase</i>                              | Dummy variable taking the value of 1 if a domestic central bank launched or extended its APP(s); 0 otherwise                                                                                       | Authors' calculations |
| <i>dom_FP_core</i>                                  | Dummy variable taking the value of 1 when immediate fiscal response or deferral measures were adopted at the national level; 0 otherwise                                                           | Authors' calculations |
| <i>dom_FP_other</i>                                 | Dummy variable taking on the value of 1 when liquidity provisions, guarantees or other fiscal measures not captured by <i>dom_FP_core</i> variable were adopted at the national level; 0 otherwise | Authors' calculations |
| <b>European and the US measures</b>                 |                                                                                                                                                                                                    |                       |
| <i>ECB_liquidity</i>                                | Dummy variable taking the value of 1 if the ECB undertook liquidity enhancement measures; 0 otherwise                                                                                              | Authors' calculations |
| <i>ECB_purchase</i>                                 | Dummy variable taking the value of 1 if the ECB launched or extended its APP(s); 0 otherwise                                                                                                       | Authors' calculations |
| <i>EU_FP_measures</i>                               | Dummy variable taking the value of 1 on the dates of announcements of key EU measures by the EC (excluding RRF announcements); 0 otherwise                                                         | Authors' calculations |
| <i>EU_FP_RRF</i>                                    | Dummy variable taking the value of 1 on the dates of RRF announcements; 0 otherwise                                                                                                                | Authors' calculations |
| <i>Fed_rate</i>                                     | Dummy variable taking the value of 1 if the Fed cut its interest rates; 0 otherwise                                                                                                                | Authors' calculations |
| <i>Fed_liquidity</i>                                | Dummy variable taking the value of 1 if the Fed undertook liquidity enhancement measures; 0 otherwise                                                                                              | Authors' calculations |
| <i>Fed_purchase</i>                                 | Dummy variable taking the value of 1 if the Fed launched or extended its APP(s); 0 otherwise                                                                                                       | Authors' calculations |
| <i>US_FP_core</i>                                   | Dummy variable taking the value of 1 when immediate fiscal response or deferral measures were adopted by the US government; 0 otherwise                                                            | Authors' calculations |
| <i>US_FP_other</i>                                  | Dummy variable taking the value of 1 when liquidity provisions, guarantees or other fiscal measures not captured by <i>US_FP_core</i> variable were adopted by the US government; 0 otherwise      | Authors' calculations |
| <b>Other variables</b>                              |                                                                                                                                                                                                    |                       |
| <i>EPU</i>                                          | European Economic Policy Uncertainty Index                                                                                                                                                         | Refinitiv             |
| <i>VIX</i>                                          | Chicago Board Options Exchange Market Volatility Index (Implied volatility of S&P 500 index options)                                                                                               | Refinitiv             |
| <i>Stringency</i>                                   | The level of stringency of epidemic restrictions adopted by each country                                                                                                                           | Refinitiv             |
| <i>Deaths</i>                                       | The number of COVID-19-related deaths                                                                                                                                                              | Refinitiv             |
| $r^{EUROSTOXX50}, r^{S\&P500}$                      | Daily rates of return on the EUROSTOXX50 and S&P500 indices                                                                                                                                        | Refinitiv             |
| $\Delta I^{DE}, \Delta I^{US}$                      | Daily changes in 10-year sovereign bond yields of Germany and the US                                                                                                                               | Refinitiv             |

## Appendix C. Time series used in the empirical analysis



## Appendix D. Additional estimation results - models with the entire set of policy measures

Table D.1

The impact of COVID-19-related policy announcements on sovereign bond yields: models with the entire set of policy measures.

|                          | Czechia              |                      |                     | Hungary              |                     |                      | Poland               |                    |                     |
|--------------------------|----------------------|----------------------|---------------------|----------------------|---------------------|----------------------|----------------------|--------------------|---------------------|
|                          | 1-day window         | 3-day window         | 6-day window        | 1-day window         | 3-day window        | 6-day window         | 1-day window         | 3-day window       | 6-day window        |
| <b>Domestic measures</b> |                      |                      |                     |                      |                     |                      |                      |                    |                     |
| <i>dom_MP_liquidity</i>  | 0.004<br>(0.053)     | 0.008<br>(0.048)     | 0.006<br>(0.005)    | 0.018<br>(0.015)     | -0.000<br>(0.013)   | 0.002<br>(0.010)     | 0.028<br>(0.027)     | 0.024<br>(0.115)   | 0.033<br>(0.079)    |
| <i>dom_MP_rate</i>       | -0.149***<br>(0.047) | -0.109***<br>(0.032) | -0.029<br>(0.025)   | -0.081***<br>(0.023) | -0.054*<br>(0.029)  | -0.017<br>(0.016)    | -0.176***<br>(0.040) | -0.062*<br>(0.037) | -0.027**<br>(0.013) |
| <i>dom_MP_purchase</i>   | X                    | X                    | X                   | -0.024<br>(0.029)    | -0.034**<br>(0.015) | -0.023<br>(0.021)    | -0.061**<br>(0.027)  | -0.048*<br>(0.026) | -0.003<br>(0.042)   |
| <i>dom_MP_macropru</i>   | -0.017<br>(0.012)    | -0.012<br>(0.009)    | -0.007<br>(0.007)   | 0.016<br>(0.012)     | 0.029<br>(0.038)    | 0.023<br>(0.030)     | 0.033<br>(0.029)     | 0.014<br>(0.010)   | 0.002<br>(0.008)    |
| <i>dom_FP_core</i>       | 0.008<br>(0.029)     | -0.011<br>(0.012)    | 0.005<br>(0.009)    | -0.255*<br>(0.151)   | -0.163**<br>(0.081) | -0.074<br>(0.077)    | 0.047<br>(0.040)     | 0.031<br>(0.022)   | 0.035<br>(0.026)    |
| <i>dom_FP_other</i>      | 0.003<br>(0.006)     | -0.002<br>(0.004)    | -0.078**<br>(0.037) | -0.018<br>(0.059)    | -0.007<br>(0.025)   | -0.094***<br>(0.022) | -0.041<br>(0.032)    | -0.023<br>(0.015)  | -0.032<br>(0.024)   |
| <b>EU measures</b>       |                      |                      |                     |                      |                     |                      |                      |                    |                     |
| <i>ECB_liquidity</i>     | -0.007<br>(0.012)    | -0.011<br>(0.010)    | -0.000<br>(0.007)   | -0.029<br>(0.031)    | -0.006<br>(0.022)   | -0.003<br>(0.021)    | -0.012<br>(0.022)    | -0.017<br>(0.023)  | 0.008<br>(0.013)    |
| <i>ECB_purchase</i>      | 0.020<br>(0.016)     | 0.016<br>(0.012)     | 0.001<br>(0.008)    | 0.012<br>(0.031)     | 0.014<br>(0.024)    | 0.014<br>(0.023)     | 0.029<br>(0.030)     | 0.014<br>(0.022)   | -0.009<br>(0.015)   |
| <i>EU_FP_measures</i>    | -0.001<br>(0.005)    | 0.008**<br>(0.004)   | 0.008**<br>(0.004)  | 0.038**<br>(0.017)   | 0.011<br>(0.011)    | 0.008<br>(0.008)     | -0.000<br>(0.008)    | 0.000<br>(0.005)   | 0.001<br>(0.004)    |
| <i>EU_FP_RRF</i>         | 0.009<br>(0.007)     | 0.014<br>(0.010)     | 0.006<br>(0.006)    | -0.030<br>(0.026)    | -0.032<br>(-0.021)  | -0.023<br>(0.019)    | -0.005<br>(0.012)    | -0.003<br>(0.010)  | 0.005<br>(0.008)    |
| <b>US measures</b>       |                      |                      |                     |                      |                     |                      |                      |                    |                     |
| <i>Fed_rate</i>          | 0.005<br>(0.025)     | 0.028<br>(0.056)     | 0.008<br>(0.018)    | 0.088<br>(0.063)     | 0.014<br>(0.061)    | 0.029<br>(0.030)     | 0.110**<br>(0.054)   | 0.067*<br>(0.038)  | -0.005<br>(0.033)   |
| <i>Fed_liquidity</i>     | -0.004<br>(0.008)    | -0.011<br>(0.010)    | -0.006<br>(0.005)   | -0.005<br>(0.020)    | -0.003<br>(0.015)   | -0.008<br>(0.012)    | -0.031<br>(0.022)    | -0.011<br>(0.013)  | -0.007<br>(0.011)   |
| <i>Fed_purchase</i>      | -0.008<br>(0.011)    | -0.011<br>(0.008)    | -0.004<br>(0.006)   | -0.020<br>(0.022)    | -0.014<br>(0.024)   | -0.007<br>(0.013)    | -0.028<br>(0.025)    | -0.000<br>(0.017)  | 0.013<br>(0.012)    |
| <i>US_FP_core</i>        | 0.021<br>(0.014)     | 0.018<br>(0.014)     | 0.016<br>(0.011)    | 0.018<br>(0.013)     | 0.026<br>(0.019)    | 0.029<br>(0.031)     | 0.018<br>(0.031)     | 0.001<br>(0.017)   | 0.002<br>(0.013)    |
| <i>US_FP_other</i>       | -0.034<br>(0.027)    | -0.012<br>(0.010)    | -0.005<br>(0.005)   | -0.155<br>(0.113)    | -0.032<br>(0.036)   | -0.027<br>(0.029)    | -0.016<br>(0.023)    | -0.003<br>(0.013)  | -0.001<br>(0.009)   |
| <b>Other variables</b>   |                      |                      |                     |                      |                     |                      |                      |                    |                     |
| <i>VIX</i>               | 0.006<br>(0.004)     |                      |                     | 0.001<br>(0.001)     |                     |                      | 0.001<br>(0.006)     |                    |                     |
| $\Delta$ Deaths          | 0.003<br>(0.002)     |                      |                     | -0.000<br>(0.001)    |                     |                      | 0.009<br>(0.007)     |                    |                     |
| $\Delta$ stringency      | -0.004<br>(0.005)    |                      |                     | -0.004***<br>(0.001) |                     |                      | -0.005*<br>(0.003)   |                    |                     |

Notes: Standard errors in parentheses; \*, \*\*, \*\*\* denote significance at the 0.1, 0.05, and 0.01 level of significance, respectively; 'X' indicates lack of a policy measure for a given country.

Table D.2

The impact of COVID-19-related policy announcements on stock markets: models with the entire set of policy measures.

|                          | Czechia           |                   |                    | Hungary          |                   |                    | Poland            |                    |                     |
|--------------------------|-------------------|-------------------|--------------------|------------------|-------------------|--------------------|-------------------|--------------------|---------------------|
|                          | 1-day window      | 3-day window      | 6-day window       | 1-day window     | 3-day window      | 6-day window       | 1-day window      | 3-day window       | 6-day window        |
| <b>Domestic measures</b> |                   |                   |                    |                  |                   |                    |                   |                    |                     |
| <i>dom_MP_liquidity</i>  | 0.005<br>(0.020)  | 0.001<br>(0.011)  | 0.001<br>(0.008)   | 0.004<br>(0.005) | 0.002*<br>(0.001) | 0.004**<br>(0.002) | 0.018*<br>(0.010) | 0.032**<br>(0.015) | 0.050***<br>(0.017) |
| <i>dom_MP_rate</i>       | -0.006<br>(0.018) | -0.009<br>(0.008) | -0.004*<br>(0.002) | 0.002<br>(0.005) | 0.002<br>(0.003)  | -0.002<br>(0.003)  | -0.004<br>(0.008) | 0.006<br>(0.007)   | -0.001<br>(0.004)   |
| <i>dom_MP_purchase</i>   | X                 | X                 | X                  |                  |                   |                    |                   |                    |                     |

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Table D.2 (continued)

|                        | Czechia              |                     |                    | Hungary           |                     |                     | Poland             |                     |                    |
|------------------------|----------------------|---------------------|--------------------|-------------------|---------------------|---------------------|--------------------|---------------------|--------------------|
|                        | 1-day window         | 3-day window        | 6-day window       | 1-day window      | 3-day window        | 6-day window        | 1-day window       | 3-day window        | 6-day window       |
|                        |                      |                     |                    | 0.002<br>(0.005)  | 0.003<br>(0.003)    | 0.002<br>(0.002)    | -0.001<br>(0.009)  | 0.001<br>(0.010)    | 0.005<br>(0.008)   |
| <i>dom_MP_macropru</i> | -0.008*<br>(0.005)   | -0.007**<br>(0.003) | -0.003<br>(0.025)  | -0.014<br>(0.009) | -0.001<br>(0.005)   | 0.000<br>(0.004)    | -0.009<br>(0.006)  | -0.005<br>(0.004)   | -0.001<br>(0.003)  |
| <i>dom_FP_core</i>     | 0.007*<br>(0.004)    | 0.003*<br>(0.002)   | 0.004**<br>(0.002) | 0.003<br>(0.018)  | -0.005<br>(0.009)   | -0.000<br>(0.009)   | 0.022**<br>(0.010) | 0.018***<br>(0.006) | 0.013**<br>(0.006) |
| <i>dom_FP_other</i>    | 0.001<br>(0.003)     | 0.004<br>(0.003)    | -0.001<br>(0.001)  | 0.003<br>(0.008)  | -0.000<br>(0.004)   | 0.005<br>(0.004)    | -0.014<br>(0.017)  | 0.003<br>(0.006)    | -0.010<br>(0.007)  |
| <b>EU measures</b>     |                      |                     |                    |                   |                     |                     |                    |                     |                    |
| <i>ECB_liquidity</i>   | -0.003<br>(0.006)    | 0.001<br>(0.011)    | 0.005<br>(0.003)   | 0.010*<br>(0.006) | 0.009***<br>(0.003) | 0.003*<br>(0.002)   | 0.002<br>(0.006)   | -0.003<br>(0.005)   | -0.003<br>(0.003)  |
| <i>ECB_purchase</i>    | -0.012<br>(0.008)    | -0.003<br>(0.004)   | -0.006<br>(0.004)  | -0.004<br>(0.006) | 0.000<br>(0.004)    | 0.001<br>(0.003)    | -0.000<br>(0.009)  | -0.004<br>(0.006)   | 0.007<br>(0.005)   |
| <i>EU_FP_measures</i>  | 0.002<br>(0.003)     | 0.002<br>(0.002)    | 0.001<br>(0.001)   | 0.004<br>(0.003)  | 0.001<br>(0.002)    | -0.001<br>(0.001)   | 0.004<br>(0.003)   | 0.003<br>(0.002)    | 0.002<br>(0.002)   |
| <i>EU_FP_RRF</i>       | 0.001<br>(0.004)     | -0.002<br>(0.003)   | -0.004<br>(0.003)  | -0.002<br>(0.005) | 0.001<br>(0.004)    | 0.003<br>(0.003)    | 0.010**<br>(0.005) | 0.005*<br>(0.003)   | 0.006**<br>(0.003) |
| <b>US measures</b>     |                      |                     |                    |                   |                     |                     |                    |                     |                    |
| <i>Fed_rate</i>        | 0.016<br>(0.011)     | -0.026<br>(0.020)   | -0.003<br>(0.005)  | 0.009<br>(0.023)  | -0.017<br>(0.013)   | -0.003<br>(0.008)   | 0.019<br>(0.014)   | 0.005<br>(0.013)    | -0.003<br>(0.009)  |
| <i>Fed_liquidity</i>   | -0.008<br>(0.006)    | -0.003<br>(0.003)   | -0.003<br>(0.002)  | -0.011<br>(0.008) | -0.006**<br>(0.003) | -0.004**<br>(0.002) | -0.004<br>(0.006)  | -0.002<br>(0.004)   | 0.002<br>(0.003)   |
| <i>Fed_purchase</i>    | 0.003<br>(0.005)     | 0.002<br>(0.003)    | 0.001<br>(0.003)   | -0.003<br>(0.007) | -0.004<br>(0.004)   | -0.007<br>(0.005)   | 0.010<br>(0.007)   | -0.004<br>(0.004)   | 0.002<br>(0.004)   |
| <i>US_FP_core</i>      | 0.008<br>(0.009)     | 0.007<br>(0.005)    | 0.004<br>(0.003)   | 0.002<br>(0.010)  | 0.006<br>(0.006)    | 0.002<br>(0.004)    | 0.017<br>(0.013)   | 0.007<br>(0.006)    | -0.001<br>(0.004)  |
| <i>US_FP_other</i>     | 0.001<br>(0.003)     | -0.001<br>(0.004)   | -0.003<br>(0.002)  | 0.004<br>(0.008)  | -0.002<br>(0.005)   | 0.001<br>(0.004)    | -0.012<br>(0.008)  | -0.006<br>(0.005)   | 0.004<br>(0.003)   |
| <b>Other variables</b> |                      |                     |                    |                   |                     |                     |                    |                     |                    |
| <i>VIX</i>             | -0.005<br>(0.007)    |                     |                    | -0.001<br>(0.002) |                     |                     | -0.005<br>(0.003)  |                     |                    |
| $\Delta$ Deaths        | -0.002<br>(0.002)    |                     |                    | -0.002<br>(0.002) |                     |                     | -0.006<br>(0.005)  |                     |                    |
| $\Delta$ Stringency    | -0.036***<br>(0.013) |                     |                    | -0.003<br>(0.003) |                     |                     | 0.000<br>(0.001)   |                     |                    |

Notes: Standard errors in parentheses; \*, \*\*, \*\*\* denote significance at the 0.1, 0.05, and 0.01 level of significance, respectively; 'X' indicates lack of a policy measure for a given country.

Table D.3

The impact of COVID-19-related policy announcements on foreign exchange markets: models with the entire set of policy measures.

|                          | Czechia            |                     |                     | Hungary            |                     |                    | Poland              |                    |                    |
|--------------------------|--------------------|---------------------|---------------------|--------------------|---------------------|--------------------|---------------------|--------------------|--------------------|
|                          | 1-day window       | 3-day window        | 6-day window        | 1-day window       | 3-day window        | 6-day window       | 1-day window        | 3-day window       | 6-day window       |
| <b>Domestic measures</b> |                    |                     |                     |                    |                     |                    |                     |                    |                    |
| <i>dom_MP_liquidity</i>  | -0.007<br>(0.006)  | -0.011<br>(0.009)   | -0.005<br>(0.004)   | -0.000<br>(0.002)  | 0.002**<br>(0.001)  | 0.001<br>(0.001)   | 0.011***<br>(0.003) | 0.004<br>(0.004)   | 0.009<br>(0.020)   |
| <i>dom_MP_rate</i>       | -0.007*<br>(0.004) | -0.004**<br>(0.002) | -0.003**<br>(0.001) | -0.001<br>(0.003)  | -0.001<br>(0.002)   | -0.002<br>(0.002)  | -0.003<br>(0.002)   | -0.008*<br>(0.005) | -0.007*<br>(0.004) |
| <i>dom_MP_purchase</i>   | X                  | X                   | X                   | 0.001<br>(0.001)   | 0.003<br>(0.002)    | 0.001<br>(0.001)   | -0.002<br>(0.002)   | 0.000<br>(0.003)   | 0.000<br>(0.002)   |
| <i>dom_MP_macropru</i>   | -0.003<br>(0.002)  | -0.002<br>(0.002)   | -0.002<br>(0.002)   | -0.007<br>(0.005)  | -0.005<br>(0.004)   | -0.002<br>(0.002)  | 0.000<br>(0.001)    | 0.001<br>(0.001)   | 0.001<br>(0.001)   |
| <i>dom_FP_core</i>       | -0.001<br>(0.002)  | -0.000<br>(0.002)   | -0.001<br>(0.001)   | -0.005<br>(0.004)  | -0.008**<br>(0.004) | -0.004*<br>(0.002) | 0.001<br>(0.001)    | 0.001<br>(0.001)   | -0.000<br>(0.001)  |
| <i>dom_FP_other</i>      | -0.002<br>(0.002)  | -0.000<br>(0.001)   | 0.001<br>(0.001)    | -0.004<br>(0.003)  | -0.002<br>(0.003)   | -0.000<br>(0.002)  | 0.000<br>(0.001)    | 0.000<br>(0.001)   | -0.001<br>(0.002)  |
| <b>EU measures</b>       |                    |                     |                     |                    |                     |                    |                     |                    |                    |
| <i>ECB_liquidity</i>     | -0.002<br>(0.002)  | -0.000<br>(0.001)   | 0.004*<br>(0.002)   | 0.004**<br>(0.002) | 0.003*<br>(0.002)   | 0.002*<br>(0.001)  | 0.003<br>(0.003)    | 0.001<br>(0.001)   | 0.000<br>(0.001)   |

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Table D.3 (continued)

|                        | Czechia           |                    |                    | Hungary            |                   |                   | Poland               |                     |                     |
|------------------------|-------------------|--------------------|--------------------|--------------------|-------------------|-------------------|----------------------|---------------------|---------------------|
|                        | 1-day window      | 3-day window       | 6-day window       | 1-day window       | 3-day window      | 6-day window      | 1-day window         | 3-day window        | 6-day window        |
| <i>ECB purchase</i>    | -0.001<br>(0.002) | -0.001<br>(0.001)  | -0.001<br>(0.001)  | -0.002<br>(0.002)  | -0.001<br>(0.002) | -0.001<br>(0.001) | -0.000<br>(0.002)    | -0.001<br>(-0.002)  | -0.001<br>(0.001)   |
| <i>EU_FP_measures</i>  | 0.000<br>(0.001)  | 0.000<br>(0.001)   | 0.000<br>(0.001)   | 0.000<br>(0.001)   | -0.000<br>(0.001) | 0.000<br>(0.001)  | -0.001<br>(0.001)    | -0.000<br>(0.001)   | 0.000<br>(0.001)    |
| <i>EU_FP_RRF</i>       | 0.001<br>(0.001)  | 0.003<br>(0.002)   | 0.003<br>(0.002)   | 0.001<br>(0.001)   | 0.004<br>(0.003)  | 0.005<br>(0.004)  | 0.003**<br>(0.001)   | 0.004***<br>(0.001) | 0.003<br>(0.002)    |
| <b>US measures</b>     |                   |                    |                    |                    |                   |                   |                      |                     |                     |
| <i>Fed_rate</i>        | 0.009<br>(0.007)  | 0.002<br>(0.002)   | 0.001<br>(0.001)   | -0.002<br>(0.002)  | -0.001<br>(0.002) | 0.000<br>(0.001)  | 0.000<br>(0.001)     | 0.001<br>(0.001)    | 0.002<br>(0.002)    |
| <i>Fed_liquidity</i>   | -0.002<br>(0.002) | -0.001<br>(0.001)  | 0.000<br>(0.001)   | 0.002<br>(0.002)   | 0.003<br>(0.002)  | 0.001<br>(0.001)  | 0.000<br>(0.002)     | 0.001<br>(0.001)    | 0.001<br>(0.001)    |
| <i>Fed_purchase</i>    | -0.001<br>(0.003) | 0.002<br>(0.002)   | -0.001<br>(0.001)  | -0.005<br>(0.004)  | -0.001<br>(0.002) | -0.001<br>(0.002) | -0.010***<br>(0.002) | -0.002*<br>(0.001)  | -0.001<br>(0.001)   |
| <i>US_FP_core</i>      | 0.003<br>(0.002)  | 0.003**<br>(0.001) | 0.003**<br>(0.001) | -0.003<br>(0.002)  | -0.001<br>(0.002) | -0.001<br>(0.002) | 0.001<br>(0.001)     | 0.001<br>(0.001)    | 0.003***<br>(0.001) |
| <i>US_FP_other</i>     | 0.002<br>(0.002)  | 0.001<br>(0.001)   | 0.001<br>(0.001)   | 0.001<br>(0.002)   | 0.000<br>(0.002)  | -0.001<br>(0.001) | 0.001<br>(0.002)     | -0.000<br>(0.001)   | -0.000<br>(0.002)   |
| <b>Other variables</b> |                   |                    |                    |                    |                   |                   |                      |                     |                     |
| <i>VIX</i>             | -0.004<br>(0.003) |                    |                    | -0.003*<br>(0.002) |                   |                   | -0.002<br>(0.004)    |                     |                     |
| $\Delta$ Deaths        | -0.002<br>(0.002) |                    |                    | -0.004*<br>(0.002) |                   |                   | -0.001<br>(0.001)    |                     |                     |
| $\Delta$ Stringency    | 0.005<br>(0.004)  |                    |                    | 0.006*<br>(0.004)  |                   |                   | 0.001<br>(0.004)     |                     |                     |

Notes: Standard errors in parentheses; \*, \*\*, \*\*\* denote significance at the 0.1, 0.05, and 0.01 level of significance, respectively; 'X' indicates lack of a policy measure for a given country.

## Appendix E. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.ememar.2022.100991>.

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