Journal of International Money and Finance 127 (2022) 102694

Contents lists available at ScienceDirect

Journal of International Money and Finance

journal homepage: www.elsevier.com/locate/jimf

Financial sector rescue programs: Domestic and cross border effects ☆

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ARTICLE INFO

Article history:
Available online 23 June 2022

JEL codes:
E58
E65
G14
G18
G28

Keywords:
Financial market stress
Spillovers and financial contagion
Policy interventions
Event study analysis
Interacted Bayesian VAR

ABSTRACT

We assess the effectiveness of the financial sector stabilisation measures taken by the Austrian authorities in the wake of the global financial crisis. Employing an event study methodology, we evaluate domestic and cross-border effects involving Central, Eastern and South-eastern European economies. We identify recapitalisations and public guarantees as the most effective sovereign interventions. Both mitigate financial market stress at home and abroad. However, a risk-shifting effect emerges at the sovereign's expense which undermines their effectiveness relative to monetary policy interventions. Moreover, in complement to the actual implementation, the mere announcement of interventions already mitigates financial market stress, underscoring the extent of policy credibility.

1. Introduction

When the global financial crisis erupted and advanced economies plunged into recession, devising appropriate policies to contain stress in financial markets quickly became a top priority for policy-makers. The first policy responses involved central banks solely (Aït-Sahalia et al., 2012; Moessner and Allen, 2013; Jäger and Grigoriadis, 2017). Their actions were designed to alleviate financial stress, however, investors continued their retreat from risky assets which aggravated the already elevated stress levels. In its Spring 2008 Global Financial Stability Report, the International Monetary Fund (IMF) estimated potential losses from U.S. securities at US-$945 billion, which was revised up to US-$2.7 trillion by April 2009 and totaled US-$4 trillion when assets from other mature markets were included. Against this background, the IMF then recommended the use of financial sector stabilisation measures by sovereigns (IMF, 2009). While the immediate objective of these measures was to restore confidence in the financial system, the ultimate aim was to help normalise credit conditions and thereby resume a sustainable economic development.

☆ Financial support from the Anniversary Fund (*Jubiläumsfonds*, project number: 2818) of the Austrian National Bank (Oesterreichische Nationalbank—OeNB) is gratefully acknowledged. The authors would like to thank the editor in charge of this paper (Kasper Roszbach), two anonymous referees, Fabian Eser, Serguei Kaniovski, Benjamin Klaus, Philipp Piribauer, Pascal Towbin and Edgar Vogel for valuable comments and helpful discussions. Excellent research assistance by Ursula Glauninger is gratefully acknowledged.

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https://doi.org/10.1016/j.jimonfin.2022.102694
0261-5606/

The present study assesses the success of financial sector stabilisation measures in achieving these objectives. This is important for at least two reasons. The first concerns the principle of efficient and prudent usage of public funds. The measures taken entailed exceptionally high sovereign costs. Since the use of public funds to support financial intermediaries is generally justified only in an environment where markets are significantly impaired, an assessment is needed. Second, these measures have negative side effects. In the context of financial markets these side effects result from moral hazard, adverse selection, and the delayed exit of insolvent financial intermediaries. Thus, the gain from restoring the smooth functioning of financial markets may be outweighed by induced behavioural changes, which provides another reason for an assessment of the success of the financial sector stabilisation measures.

We focus on a specific country in this respect for the following reasons: First, the publication of intervention data by public authorities is not uniform and the complexity of many transactions complicates a clear categorisation of all measures across countries. Second, some countries had not even published their intervention data by 2019 rendering cross country comparisons difficult (Igan et al., 2019). The specific country we focus on is Austria which is appealing in several respects. First, Austria has a bank-based economy (Allen and Gale, 2000) with a financial industry that strongly relies on the originate-to-hold business model. Hence, the credit channel should be particularly important, providing ample rationale for sovereign interventions for the purpose of restoring confidence in the financial system. Second, Austrian banks have built up sizeable cross-border claims in the magnitude of more than 90 percent of Austria's GDP against affiliated branches or through direct lending in the Central, Eastern and South-eastern European Economies (henceforth CESEE); with a market share of 20 percent, this was by far the largest exposure among Western European countries[1] (see Table 1). The high CESEE exposure comprises an interesting environment for assessing potential cross-border effects of stabilisation measures. Third, in their attempt to restore credibility in the financial system, the Austrian authorities utilised a multitude of policy measures. With an overall share of more than 40 percent of GDP, the magnitude of the implemented measures was large in comparison to other countries (Panetta et al., 2009).

Our contribution is threefold. First, we construct a daily database of financial sector stabilisation measures which ranges from 2006 to the end of 2016. We group the stabilisation measures into three categories of policy instruments: (1) recapitalisations, (2) public guarantees including decisions to expand deposit insurance schemes, and (3) ownership change. We build on existing work on the mitigating effect of ECB interventions on financial market stress (see Eser and Schwaab, 2016; Falagiarda and Reitz, 2015; Jäger and Grigoriadis, 2017, among others) and add conventional (interest rate changes) and unconventional measures (liquidity support) undertaken by the ECB as a fourth category. The inclusion of central bank actions serves to condition the results on monetary policy actions and allows to compare the size of effects emanating from sovereign interventions. Within the four categories we distinguish between the actual implementation and the mere announcement of policy instruments. All four policy instruments are specified as intervention dummy variables. Second, we utilise a particular event study approach that allows the response to stabilisation measures to vary along two dimensions: impact response and the degree of persistence. We do so by means of a Bayesian vector autoregressive (BVAR) model where the heterogeneity in the degree of persistence is captured by an interaction term. Third, we examine the success of policy measures by Austrian authorities in mitigating financial market stress in Austria and the CESEE, respectively. As Austrian banks had large exposures to this region, it is likely that measures taken by the Austrian authorities had an impact in these countries too. To this purpose, we construct daily financial market stress indicators for Austria and the CESEE, which are used jointly with the intervention dummy variables in the BVAR model. This allows us to compare the domestic effects to those arising abroad and embeds our results into the literature on financial contagion (Bordo and Murshid, 2006; Corsetti et al., 2005; Bowman et al., 2015). Consequently, our approach allows for a more comprehensive picture of the effectiveness of different financial sector stabilisation measures.

To preview some results, we find that the measures taken by the Austrian authorities mitigated (domestic) financial market stress. At the same time, however, we observe a risk-shifting effect: While the measures mitigate stress at the level of financial intermediaries, risks are transferred to the sovereign. This might explain the observation that the mitigation effects arising from ECB measures outweigh those of the Austrian authorities. Second, the mitigation effect in response to measures taken by Austrian authorities arises both from the actual implementation and the mere announcement. This underscores the extent of policy credibility. Third, measures taken by the Austrian authorities had large spillover effects into the CESEE, with the size of the effects increasing in the market share of Austrian banks in the host country. Fourth, the most effective sovereign measures were recapitalisations and liquidity guarantees, while the potential of ownership change appears limited. Moreover, the effects are significantly state-dependent: recapitalisations and liquidity guarantees had a particularly strong calming effect in times of acute financial market tensions. Ownership change policies, in turn, increase financial market stress in times of acute turbulence, whereas they alleviate stress during more normal periods.

Regarding previous work, while there is ample evidence of the effectiveness of monetary policy in reducing stress levels in financial markets (Brunetti et al., 2011), the contributions on the effectiveness of sovereign interventions are noticeably less numerous despite the huge sums of public funds involved.[2] The theoretical literature remains inconclusive regarding the adequacy of sovereign interventions. Acharya and Yorulmazer (2007); Bianchi (2016); Keister (2016); Chari and Kehoe (2016)

[1] Consequently, the IMF raised concerns about potential negative spillovers from host countries to Austria and vice versa as early as in its spring 2009 Global Financial Stability Report (box 1.2) and the ECB reiterated these worries after the European debt crisis unfolded (ECB, 2014).

[2] Igan et al. (2019) highlights that more than 1,100 financial intermediaries in 37 developed economies received state aid totalling to US-$ 1.6 trillion. Additionally, public guarantees to the extent of US-$ 1.9 trillion have been underwritten by governments or related public sector entities.

Table 1
Banks' Foreign Claims on CESEE at End-2008 by country of origin.

Austria	20	France	12	Sweden	7
Germany	16	Belgium	9	(Rest)	12
Italy	15	Netherlands	8	*Total*	*100*

Notes: All numbers are in percent and add up to one hundred. Source: Bank for International Settlements (BIS), consolidated banking statistics. See also Kavan and Wittenberger (2020).

present theoretical models motivating sovereign interventions in a severe crisis through their stabilising role for economic activity and the higher expected aggregate loss of a no-bailout alternative. However, Acharya et al. (2014); Cooper and Nikolov (2018); Farhi and Tirole (2018) highlight the risk of a doom loop. As the balance sheets of financial intermediaries and the sovereign are tightly linked, an increase in sovereign risk spills over to financial intermediaries through the recognition of losses on their holdings of sovereign bonds. While the empirical literature is scarce, it finds evidence for both. Panetta et al. (2009), for instance, show in a cross country sample that (i) sovereign interventions have been effective in reducing banks' default risk, and (ii) risk premia of particular financial intermediaries have shown a reduction once sovereign interventions were implemented, rather than just being announced. In contrast, Kizys et al. (2016) find that sovereign interventions in the European banking sector deteriorated sovereign credit risk, highlighting the presence of a doom loop.

Our contribution is also related to the literature on the international bank lending channel (see also Auer et al., 2019; Shim and Shin, 2021; Herman and Lozej, 2021). Under the free movement of capital across national borders, financial stress is not confined to the country where liquidity or solvency problems first surface, instead it will spill over to closely linked countries. Similarly, it is conceivable that the effects of sovereign interventions in stabilising financial markets are not limited to the home country, but are likely to be reflected in an equivalent form in financially closely connected countries. To the extent that Austrian banks had a large exposure to the CESEE, they imported risks from this area in the run-up to the global financial crisis. Thus, it is likely that the policy measures taken by the Austrian authorities will have had an impact in these countries as well.

The paper is structured as follows. Section 2 provides an overview of the Austrian banking sector, the financial sector stabilisation measures and provides details on the construction of the intervention dummy variables. The construction of the financial market stress indicators is presented in Section 3 and Section 4 examines the effects of the stabilisation measures on financial market stress. Finally, Section 5 concludes.

2. Economic environment, cross-border banking and crisis response

The onset of the global financial crisis can roughly be dated to the fourth quarter of 2006 and the first quarter of 2007. At that time, the first financial intermediaries specialising in sub-prime mortgages began to become insolvent due to increasing defaults on U.S.-mortgages. The Austrian financial system was affected with a significant delay. Once affected, however, financial turmoil was severe and lasted longer than in other countries. Reinhart and Rogoff (2009) note that Austria experienced peak-to-trough equity price declines far exceeding the average of their historical comparison group. While the crisis eventually caused default rates in Austria to rise, credit conditions for borrowers to become more restrictive and the demand for loans to shrink, this did not happen until the end of 2008 (OeNB, 2009). This is primarily due to the business model applied by Austrian banks: a strong reliance on retail banking, the dominant originate-to-hold business model, and a regional focus on Austria and the CESEE initially helped to retain financial market stress (Schürz et al., 2009; Ferstl and Seres, 2012).

2.1. The Austrian banking sector and its CESEE exposure

The Austrian banking sector is large compared to the size of the economy (consider the second subplot in Fig. 1). A key characteristic is its high exposure to the CESEE. After the collapse of the communist regimes in the CESEE and a series of banking crises, their banking sectors had to be rebuilt (Hubmer et al., 2001; Barisitz, 2009a,b; Temesvary and Banai, 2017). In this process, foreign banks were welcome with their financial and technical knowledge as well as their capital base and thus made a significant contribution to the creation of securities markets and the financing of companies, which contributed to economic development.[3] Already in the mid-1980s, Austrian banks followed their corporate customers into CESEE to provide banking services to their clients starting business in the region (Puhr et al., 2009). They early recognised the opportunity to expand from the low-margin home market into CESEE with a comparatively low degree of financial intermediation and high growth potential. Initially starting with greenfield operations and organic growth, most Austrian banks switched to large-scale acquisitions of state owned banks in the second half of the 1990s. Austrian banks were hence among the first Western banks to enter the CESEE region and achieved a clear starting advantage over other foreign banks, which is reflected in their high market shares to date. For Western banks that were more hesitant, market entry costs were already significantly higher.

[3] See Hubmer et al. (2001); Kavan and Wittenberger (2020) and Temesvary and Banai (2017) who provide an excellent overview in their Online Appendix.

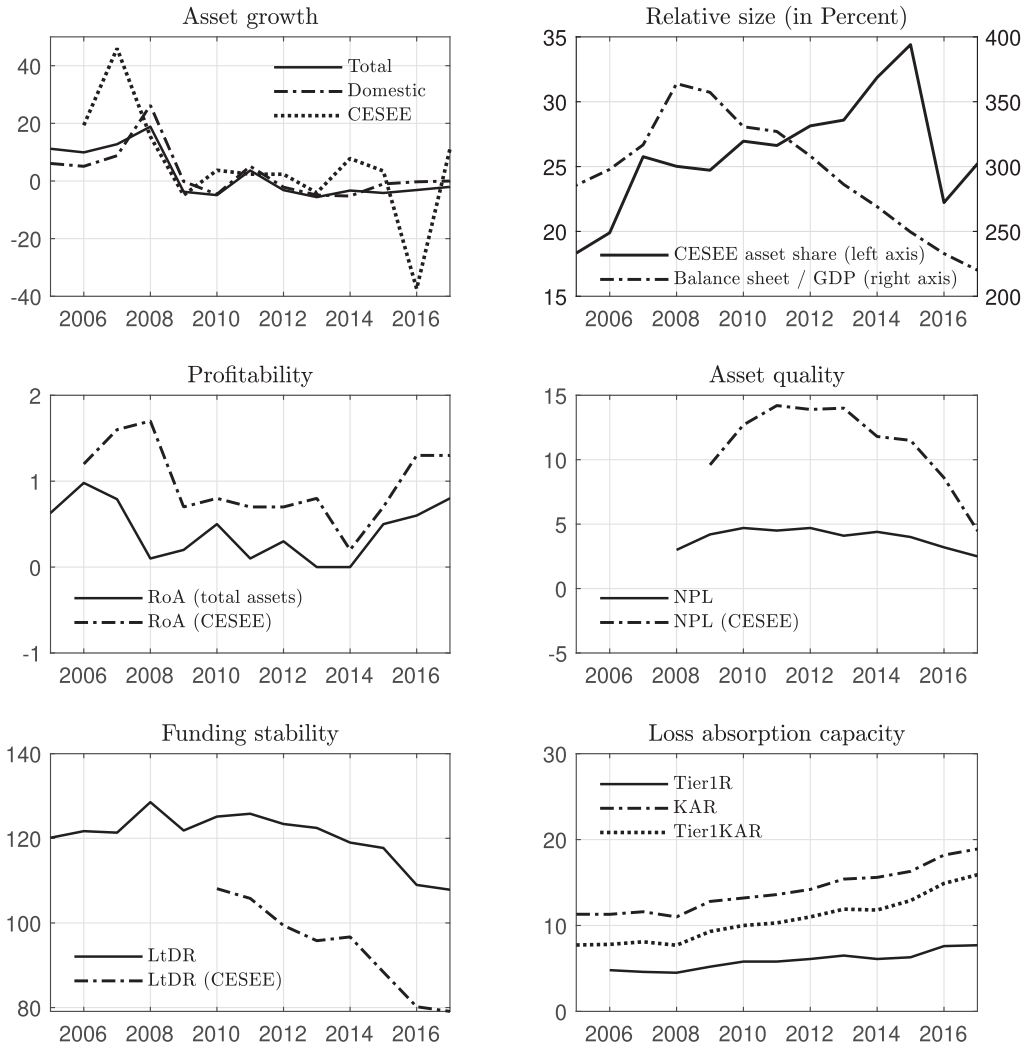

Fig. 1. Austrian banking sector: descriptive overview. Note: All numbers are in percent. Data are from the Austrian National Bank (OeNB). RoA: Return on average assets, consolidated (end-of-period result after tax in percent of average total assets and average tier 1 capital, respectively). RoA (CESEE): Return on average assets (end-of-period result expected for the full year after tax as a percentage of average total assets and average total tier 1 capital, respectively). *NPL:* Non-performing loan ratio. *Tier1R*: Leverage ratio. *KAR*: Capital ratio (regulatory capital). *Tier1KAR*: Capital ratio (regulatory tier 1 capital). *LtDR* and *LtDR (CESEE)*: Loan-to-deposit ratio for the Austrian banking sector as a whole and for foreign subsidiaries only. *CESEE asset share:* CESEE assets relative to total assets of Austrian banks.

The comparatively low level of competition in the early years allowed high profit margins: Few banks on the supply side were faced with a strong increase in credit demand. Foreign banks in particular succeeded in maintaining higher profit margins because, unlike domestic banks, they had lower refinancing costs, but also lower credit risk costs. The major advantage of CESEE business was therefore its earnings potential for Western banks.

On a more granular basis, Temesvary and Banai (2017) highlight that higher capital-to-asset ratios and lower non-performing loans (NPL) ratios at either the subsidiary or the parent bank significantly increased subsidiary lending growth before and during the global financial crisis. They also find firm evidence that the post-crisis CESEE engagement of Western banks depends on whether they participated in the *Vienna Initiative*.[4]

For some CESEE, Table 2 shows (i) the importance of a particular country portfolio for Austrian banks' foreign activities (first three columns) and (ii) the importance of Austrian banks within a particular host country (remaining three columns). On average, Austrian banks account for a high market share in the region (see Puhr et al., 2009, for further details). As shown in the second subplot in Fig. 1 the share of assets from the CESEE region in total assets increased steadily and peaked in 2015

[4] The *Vienna Initiative* offers a framework to enable the efficient coordination among European banks in safeguarding the financial stability of emerging Europe. The Initiative was launched at the height of the first wave of the global financial crisis in January, 2009. It brought together all the relevant public and private sector stakeholders of EU-based banks active in emerging Europe (De Haas et al., 2015).

Table 2
Foreign claims of Austrian banks: Exposure to Central, Eastern and South-eastern European Economies.

	Relative to Austrian banks' total volume of foreign claims[1]			Relative to country *i*'s total volume of foreign liabilities[2]		
	2008	2014	2018	2008	2014	2018
Slovakia	7.4	9.1	10.1	39.9	41.9	43.7
Croatia	4.6	6.6	5.2	29.0	37.8	39.1
Czech Rep.	10.8	15.2	22.9	32.8	31.3	35.4
Hungary	7.4	5.3	5.1	24.4	24.6	31.1
Poland	3.1	6.0	2.4	5.7	7.3	3.4
Romania	8.4	9.0	7.8	34.8	35.2	36.0

Notes: All numbers are in percent. Source: Bank for International Settlements (BIS), consolidated banking statistics.
[2] Austrian banks' foreign claims on an immediate counterparty basis in percent of country *i*'s total liabilities to foreign banks (consolidated position); i.e. Austrian banks' market share in country *i*.
[1] Austrian banks' foreign claims on an immediate counterparty basis in percent of Austrian banks' total foreign claims (consolidated position); i.e. country *i*'s importance for Austrian banks' foreign asset portfolio.

at a level close to 35 percent. Austrian banks continued to increase their overall exposure to the region even during and after the global financial crisis.

Austrian banks have been providing retail, investment banking and leasing services in CESEE to a broad type of borrowers. For a long time, non-financial corporations were the borrower type with the largest outstanding exposure. Since 2014, however, household loans comprise the largest lending segment. Within this segment, mortgage loans outweigh consumer loans and it was especially the former that had a significant share denominated in foreign currency (Pann et al., 2010). Some Austrian banks specialised in financing investment projects of public and quasi-public institutions in CESEE giving rise to a significant exposure to the public sector (which includes federal and local governments as well as certain public funds). Finally, a moderate share of lending is also provided to local credit institutes and insurance companies. Besides operating through their subsidiaries, Austrian banks also offer direct cross-border lending to non-banks and financial intermediaries. This business segment accounts for around one fifth of the total CESEE exposure (Puhr et al., 2009; Wittenberger, 2018).

2.2. The build-up of risk and its materialisation

While the CESEE exposure contributed strongly to Austrian banks' profitability (Fig. 1), it also led to the build-up of vulnerabilities and risks underneath a seemingly tranquil macroeconomic surface. These materialised with the global financial crisis. In many host countries, rapid credit expansion (Fig. 1) fuelled economic growth but also a domestic demand boom and large current account deficits. For instance, lending in some countries was not refinanced by local sources, but was driven by liquidity transfers from the respective Austrian parent bank. Strongly increased loan-deposit ratios (Fig. 1) were not only an indication of local lending in excess of local savings, but also of an increased risk of contagion for the (domestic) Austrian banking sector. In addition, lending was often denominated in foreign currencies, with Swiss franc and euro loans in particular entailing high exchange rate risks for households, which created vulnerabilities to currency depreciation and hence further fuelled risk accumulation.

After global money markets froze following the Lehman bankruptcy, the boom in the CESEE came to a halt, and Austrian banks faced both a liquidity squeeze and a deteriorating quality of their credit portfolio. This (spatial) concentration of risk determined the profitability profile of Austrian banks (Fig. 1), but also shaped the path of asset quality as illustrated by the non-performing loan ratio (Fig. 1). Hence, the experience of Austrian banks confirms the common conjecture of rapid credit growth giving rise to subsequent high NPL ratios (see for instance Gersl and Seidler, 2012; IMF, 2015).

While the aggregate balance sheet of Austrian CESEE subsidiaries has continued to expand after 2008, its composition has changed. This especially concerns liabilities: the loan-to-deposit ratio (LtDR) declined and this decrease was driven by a strong rise in deposits from non-banks giving rise to increased funding stability. Not least, the loss absorption capacity was also raised (Fig. 1).

2.3. Interventions during the Global Financial Crisis and its aftermath

When the crisis unfolded, government interventions were implemented to stabilise the banking system, to avoid a potential credit crunch in the domestic market, and to support aggregate demand. To achieve this, the Austrian authorities had to create a legal basis for all federal measures in line with the declaration of the European Council from October 12th 2008 (Posch et al., 2009). During the most acute phase of the crisis, in fall 2008, Austrian authorities quickly put forward a banking package. Further measures were implemented in the subsequent years, the last of which took place in 2016. In what follows we start with a brief description of the measures taken within the acute phase of the crisis and continue with follow-up interventions. We also discuss the extent to which these measures are likely to be relevant in curbing financial market stress beyond national borders.

2.3.1. The banking package

The banking package was introduced in autumn 2008. In addition to unlimited deposit protection for natural persons until the end of 2009, it provided public guarantees for new security issues by Austrian banks, the creation of the public Clearing Bank channelling short-term interbank lending through a public guarantee system, and means to recapitalise financial intermediaries with public funds. The latter came in various forms: Injection of participation capital (no voting rights), participation in capital increases, capital reductions and conversion of participation capital into regular equity (with voting rights).

All measures of the banking package together had a volume of € 100 billion. In order to not discriminate against non-participating banks, market-oriented fees and interest rates had to be paid. The banking package constituted state aid and was therefore subject to special considerations under the EU competition rules. The approval of the banking package by the European Commission was originally set to expire on the 30th of June, 2009. However, it was subsequently extended several times. With each extension, the European Commission tightened the conditions in order to render the measures of the banking package less attractive and thus gradually phase them out. Further measures required separate EU state aid assessments for compatibility with the internal market, as well as approval by the European Commission.

2.3.2. Second stage measures

The problems in the Austrian financial sector did not abate with the expiration of the banking package. In the course of the crisis, some banks got into such difficulties that further drastic measures were necessary. In the context of the implementation of the restructuring plan together with the Austrian authorities and the European Commission, numerous measures were taken until 2016. However, there was no need to create additional instruments; instead, using the existing instruments proved sufficient. The most important measures were (i) the creation of resolution units for insolvent banks, (ii) a debt cut for subordinated liabilities, (iii) a debt cut for eligible senior debt, (iv) the cancellation of interest payments, (v) and a standardisation of the maturities of all eligible liabilities. These measures, as well as the decision to transform insolvent banks or parts thereof into resolution units, were taken at different times, but they covered the period after the financial crisis up to 2016. Resolution units receive the non-performing assets of a financial institution, with the aim of ensuring an orderly, active and best-possible sale of impaired assets.

2.3.3. Discussion

While the proposed volume of the Austrian banking package already comprised around 35 percent of GDP[5] in 2008, the additional second-stage measures raised this number to above 40 percent. The magnitude of these actions was large in comparison to other countries. As highlighted in Panetta et al. (2009), the overall amount of resources committed by the eleven countries examined[6] totalled around 18 percent of GDP.

The public guarantees underwritten by the end of 2010 amounted to approximately € 23 billion at the end of 2010 (Rechnungshof, 2012).[7] This corresponded to a utilisation rate of 44 percent of the guarantee framework. As regards the recapitalisation efforts, the federal government injected a total of € 5.9 billion in participation capital into five Austrian banks.

The reason for sizeable contributions by the Austrian authorities was primarily the large cross-border CESEE exposure of commercial banks and fears of a potential credit crunch in the domestic market. By the end of 2010, seven Austrian banks (ERSTE Bank, HAAI, KA Finanz AG, Kommunalkredit, RZB, VBAG, and the newly established public Clearing Bank) used public guarantees. Notably, with the exception of the Clearing Bank all these banks had/have a high exposure in CESEE. A number of CESEE obtained support from international financial organisations and benefited from the *Vienna Initiative*, whereby foreign banks jointly committed to maintain their CESEE exposures. The contribution of the Austrian authorities is remarkable for at least two reasons. First, the sheer volume and second, interventions by Austrian authorities occurred at an early stage of the crisis.

The second-stage interventions were primarily targeted at the resolution of insolvent banks. Again, these measures only addressed banks with a high exposure to the CESEE. The failure of the Austrian parent bank would certainly have brought about the risk of increased financial market turmoil in the CESEE. It is therefore likely that the interventions by the Austrian authorities were also effective at alleviating financial market turbulences in these countries.

2.4. Event database construction

For the purpose of our analysis, we classify policy interventions into four broad categories of policy instruments. This renders feasible a bundling of interventions of a similar type into one sole category, thus approximating multiple draws from a policy instrument. Each category is represented by an intervention dummy variable, henceforth referred to as $\xi_{i,t}^{j}$ with $i \in \{RC, PG, OC, MP\}$ and $j \in \{A, I\}$. The four categories of policy instruments (i) are composed of actions by Austrian authorities: recapitalisations (RC), public guarantees and the decision to expand the deposit insurance scheme (PG), and changes in

[5] According to the European system of accounts (ESA) 1995.

[6] Australia, Canada, France, Germany, Italy, Japan, the Netherlands, Spain, Switzerland, the United Kingdom and the United States.

[7] General information on the statistical recording of these public measures can be found in Eurostat (2009); Eurostat (2012); Eurostat (2013) with details for the Austrian public sector provided by BMF (2015); Fiskalrat (2015); Fiskalrat (2016).

Table 3
Event database: Classification of events.

Financial sector stabilisation measures by the Austrian authorities	
Recapitalisation	Capital injection (common stock, preferred equity, etc.) by the Government or a consortium of banks
	Capital injection (subordinated debt)
Public guarantees	Expansion of deposit insurance
	Debt guarantees (all and/or new liabilities)
Ownership change	Purchases of impaired assets (individual assets, bank by bank, etc.)
	Acquisition and/or liquidation of a bank or parts thereof
Monetary policy and liquidity support measures by the ECB	
(Un-)Conventional measures	Reduction of interest rates
	Reduction of reserve requirements, longer funding terms, more auctions and/or higher credit lines
	Domestic system lender of last resort: broader set of eligible institutions, wider collateral rules, and/or eligible collateral
	Other liquidity support (e.g., support of money market funds)

bank ownership (OC); the final category (MP) concerns actions taken by the ECB involving conventional and unconventional measures. A similar classification was also used in IMF (2009); Panetta et al. (2009); Aït-Sahalia et al. (2012). The four categories of policy instruments are summarised in Table 3. Further details are provided in the Online Appendix.

The database contains policy interventions that concern crisis-related measures taken by the Austrian authorities, the accreditation thereof by the European Commission, and the interventions by the ECB within the years 2006 until 2016. Since the analysis is predicated on the determination of the immediate stress impact of policy interventions, our event study dataset contains the date of policy interventions. These are screened with respect to the prominence of their media coverage where we rely on official press releases and articles in major newspapers. Data from the media are complemented with information from official sources such as for instance the Austrian National Bank (OeNB), the federal ministries and alike.[8]

The policy interventions were screened and selected as to whether they aimed at mitigating financial market stress. This is straightforward in the case of those taken by the Austrian authorities; the opposite applies, however, to those taken by the ECB. Against this background, we confine the set of policy interventions taken by the ECB to those which align with the notion of expansionary policies.

Many measures were introduced by the Austrian authorities in the form of laws or decrees, without an immediate triggering event. The early introduction of a legal framework provided the basis for rapid implementations later on. On the one hand, this is in line with the principle of legality, but on the other hand, the political discussion in parliament can in itself exert a positive effect on financial market stability, thus shifting forward trust and stabilising market expectations without any actions actually being implemented. Against this background, we distinguish between two forms of policy modes (j): (1) the legal introduction of policy measures for possible use in the event of crisis (measures taken under precautionary motives), and (2) the explicit implementation of measures – that is, the intervention taken during an acute phase of financial market stress. In concrete terms, the first describes pure announcements of (optional) policy measures and the design of the legal framework to enable measures to be implemented quickly in the event of a crisis. The second relates to the implementation of one or more policy instruments in the event of a crisis. We refer to the first policy mode as *Announcement* (A) and to the second as *Implementation* (I).

The difference can be illustrated using the example of the banking package. While the banking package provides a framework for the legal setting, it does not yet give rise to particular policy interventions. We classify the date of passing the law in parliament as *Announcement*. Only if the instruments from this package were applied, for instance in the recapitalisation of a particular bank, would we consider this to be an *Implementation*. From a purely theoretical point of view, both forms of policy interventions could in principle have an impact on the financial markets.

Another aspect that motivates a distinction of policy interventions along announcement and implementation modes arises from the delay between legislation and administration. Legislative processes usually cause a time gap between the announcement and the implementation of a policy measure. Although both forms of interventions can already exert an effect on financial markets, it is nevertheless interesting to assess whether there are differences and, if so, along which dimension. These two modes of policy interventions apply to all four policy instruments (RC, PG, OC, MP). Table 4 provides an overview on the number of events for the policy instruments set by the Austrian authorities for both policy modes (A and I). The intervention dummy variables $\xi^{j}_{i,t}\ \forall i \in \{RC, PG, OC, MP\}$ and $\forall j \in \{A, I\}$ are specified as follows: Assume that a policy intervention for policy instrument i and policy mode j occurs at date t_0. This is replicated in the intervention dummy $\xi^{j}_{i,t}$ by

$$\xi^{j}_{i,t} = \begin{cases} 1, & \text{given an intervention of policy } i \text{ at } t = t_0 \\ 0, & \text{otherwise} \end{cases} \tag{1}$$

[8] Many of the measures taken by the European Central Bank are found in Jäger and Grigoriadis (2017) and Falagiarda and Reitz (2015) and the references mentioned therein.

Table 4
Event database: Number of events.

	Recapitalisation	Public guarantees	Ownership change
Whole period (2007–2016)			
Announcement	20	15	6
Implementation	17	21	9
Acute crisis period (September 2007–March 2009)			
Announcement	9	6	2
Implementation	7	12	4
Second stage period (from April 2009–2016)			
Announcement	11	9	4
Implementation	10	9	5

In words, a policy intervention at time t_0 is replicated by $\xi^j_{i,t_0} = 1$ and zero elsewhere. Hence, ξ^j_{i,t_0} is an ordinal measure of policy interventions. However, as various interventions of the same policy instrument and policy mode were implemented at different points in time, the individual dummy variables contain several unit-entries, where each unit-entry corresponds to the date of a particular policy intervention. We construct intervention dummy variables of this kind for both the announcements and the implementations (j) separately. This leaves us with a total of eight event dummy variables describing the events depicted in detail in the Online Appendix.

3. Measuring financial market stress

The intention of financial sector stabilisation measures is to attenuate financial markets in episodes of heightened distress. Since we are interested in the effects of policy interventions on the financial market as a whole, rather than on a particular market segment or asset class, we focus on a market-wide indicator to measure financial stress on a daily frequency. For this purpose, we use a multivariate approach at daily frequency because policy interventions occurred repeatedly on different days within a month or week, and financial markets respond quickly to news.

Let $\varsigma_{i,t}$ denote the (excess) return volatility or risk spread of asset $i \in \{1, \dots, N\}$ out of N observable variables at time t. We assume that it follows an approximate factor model with fixed exposure coefficient η_i, one common factor μ_t and an asset-specific return volatility $e_{i,t}$

$$\varsigma_{i,t} = \bar{\varsigma}_i + \eta_i \mu_t + \theta_i(L) e_{i,t} \quad \text{with} \quad e_{i,t} \sim N(0, \sigma_i^2) \quad \forall i \in \{1, \dots, N\} \tag{2}$$

$$\mu_t = \mu_{t-1} + u_t \quad \text{with} \quad u_t \sim N(0,1) \tag{3}$$

where $\theta_i(L)$ is a lag polynomial and the $\varsigma_{i,t}$ are standardised. We cast Eq. (2) into a state-space system and estimate the parameters and the unobserved state μ_t by relying on Bayesian Kalman filter methods[9] as proposed by Carter and Kohn (1994). We estimate Eqs. (2) and (3) across distinct market segments (foreign exchange market, government bond market, stock market and money market) for each country (c) individually and sample 10,000 draws (d) for the parameters and the common factor μ_t from the posterior distribution of which we keep $D = 8,000$ draws and discard the first 2,000. The subsequent analysis uses the posterior distribution of $\left\{\hat{\mu}^c_{t,d}\right\}_{d=1}^{D}$ as the financial market stress indicator for each country.

3.1. Variables for measuring financial market stress

We use a broad set of variables for $\varsigma_{i,t}$ to make sure that stress is captured across the whole financial market. We capture financial stress along the level of (I) financial intermediaries, (II) sovereigns and (III) the entire country. As regards the first, we consider money market indicators and individual financial intermediaries' stock returns. We capture stress in the money market by a country-equivalent of the US TED spread. This serves to assess the importance of liquidity provision by the Austrian parent banks for their CESEE subsidiaries either because local banks worry of an unexpected need for funds (liquidity risk) or because of heightened frictions in the local inter-bank market (counterparty risk) (Heider et al., 2010; Acharya and Skeie, 2011). We use the idiosyncratic volatility[10] of financial intermediaries' stock returns and the cross-section dispersion of these returns as further risk measures for financial intermediary stress. They serve to capture both uncertainty about the fundamental values of financial intermediaries' assets and uncertainty about the behaviour of investors and hence address the risk

[9] As regards the prior distributions, we closely follow Carter and Kohn (1994) and Blake and Mumtaz (2015) in particular for a practical implementation.
[10] All volatilities considered here are realised daily volatilities which are measured by estimating a GJR-GARCH model (Glosten et al., 1993). Further details are provided in the Online Appendix.

of a sudden liquidity squeeze (liquidity risk). Additionally, we also include the exchange rate volatilities (local currency to the euro in case of the Czech Republic, Hungary, Poland, Romania and Croatia and local currency to the Swiss franc in case of Austria and Slovakia) to capture the risk emanating from loans denominated in foreign currency (credit risk).[11]

We capture Austrian banks' risk-exposure to the sovereigns, which emanates from their domestic and CESEE activities, by focusing on sovereign stress. We measure sovereign stress by the yield spread between a country's 10-year bond rate and the German counterpart. We also consider 1-year and 5-year maturities and complement these yield spread series by measures of the domestic term structure (yield curve). These yield spread series capture tensions in bond markets which arise from changes in the sovereigns' riskiness and the sheer size allows for a quick spillover of sovereign stress into other market segments; thereby creating risks for the whole financial system. We also use yield spread volatilities in this respect which complement the information of interest rate spreads as regards their information on the extent of sovereign distress. Cieslak and Povala (2016) show that yield spreads reflect market expectations about the path of interest rates and their volatility captures the uncertainty surrounding that path. We employ three measures of spread volatilities of which two are cross-country based and one is local (consider the Online Appendix for further details).

The high share of loans provided by Austrian banks to non-financial corporations in the CESEE (especially prior to 2014) renders their asset portfolio sensitive to changing macroeconomic conditions. This in turn shapes banks' credit risk and hence their profitability. We capture banking sector's exposure to macroeconomic risk by measuring the cross-country dispersion of stock returns. This measure compares the idiosyncratic volatility of local stock market indices returns to the Eurostoxx50 and reflects the entire country risk.

Depending on data availability, which varies across countries, we have up to $N = 15$ individual observable series available (these also include individual bank stock return series) for computing the financial market stress indicators. Stress is interpreted as the amount of systemic risk which has already materialised. We apply the same procedure to all countries in our sample. By aggregating our financial market stress indicators from daily to monthly frequency we are able to compare them with stress indicators published by the ECB: the correlations are in the range between 0.85 and 0.95. Further details are provided in the Online Appendix.

3.2. Results

The left subplot in Fig. 2 shows the financial market stress indicator for Austria jointly with the log of the Vstoxx (implied volatility index for the Eurostoxx50). The latter is used as a daily proxy for financial market stress in the euro area. The two indices align well during the episodes surrounding the global financial crisis and the euro area government debt crisis. Beyond these, however, there are severe discrepancies, as for instance from 2013 onwards, when, in contrast to Austria, financial market stress in the euro area was still elevated. The opposite applies in the pre-crisis period where idiosyncratic events triggered an above-average level of financial market stress in Austria (see Eidenberger et al., 2013; Glocker and Kaniovski, 2014).

The right subplot in Fig. 2 shows two disaggregated versions of the financial market stress indicator for Austria, focusing either on sovereign bond market information or on information about financial intermediaries. Evidently, both indices comove strongly, but the sub-indicator for stress in the sovereign market shows a higher volatility, particularly during the euro area government debt crisis. Remarkably, the sub-indicator covering financial intermediary stress quickly returned to pre-crisis levels, although the sovereign stress level remained high in Austria and in European financial markets. This provides first informal evidence for risk shifting from financial intermediaries to the sovereign following early bailout activities by the Austrian authorities.

Using the same econometric procedure, Fig. 3 depicts daily financial market stress indicators for six of the CESEE (median of $\hat{\mu}^{c}_{t,d}$) jointly with the one for Austria (median of $\hat{\mu}^{AT}_{t,d}$). The figure highlights, first, that the global financial crisis triggered noteworthy distress in all countries besides Croatia, which was affected with a delay. Second, while elevated financial market stress arose in Austria during the euro area government debt crisis, the negative spillover effects to CESEE were mild. Third, the indicators highlight a few country specific events that eventually led to above average levels of financial stress.

4. Event study methodology and effect of financial sector rescue programmes

We now combine the event study database with the daily financial market stress indicators to assess the success of policy interventions in mitigating financial markets stress. The econometric framework builds upon the external instruments approach as used in Jarociński and Karadi (2020) extended for an interaction term as popularised by Towbin and Weber (2013); Sa et al. (2014). We define the vectors y^{G}_{t} and $\hat{y}^{C}_{t,d} = \left[\hat{\mu}^{AT}_{t,d}, \ldots, \hat{\mu}^{RO}_{t,d}\right]'$ to capture financial stress at the global and country level. All variables included in y^{G}_{t} and $\hat{y}^{C}_{t,d}$ are standardised. The model reads

[11] We also assessed the role of exchange rate volatility with respect to the Swiss franc for the Czech Republic, Hungary, Poland, Romania and Croatia, however, this variable's factor loading (η_i in Eq. (2)) always had a small value and was only border-line significant; we hence dropped it. This, however, aligns with the fact that among the loan volume denominated in foreign currency terms in these countries, those denominated in euro dominate relative to those denominated in Swiss Francs or other currencies.

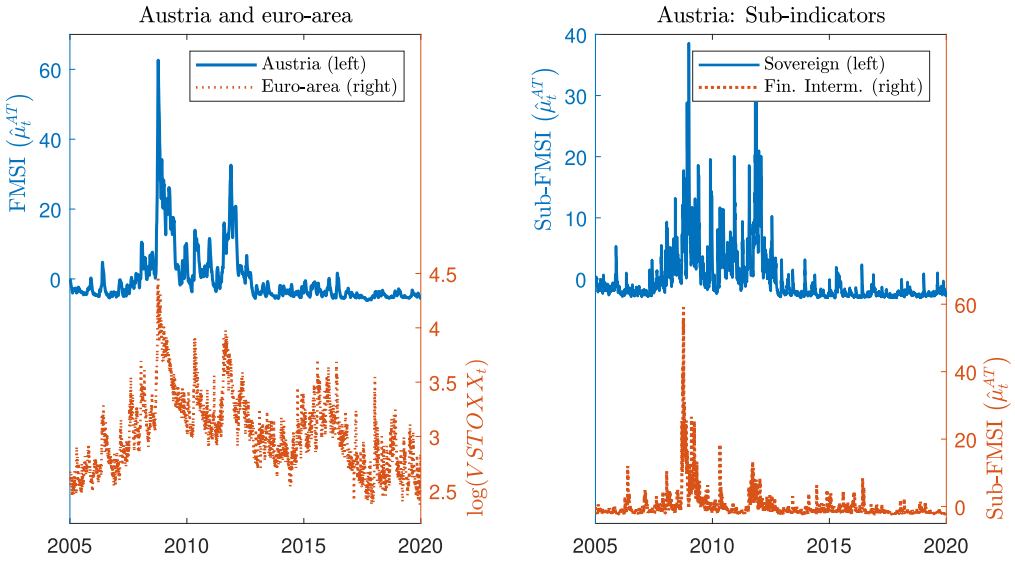

Fig. 2. A daily financial market stress indicator for Austria. Note: The figure shows the median of $\hat{\mu}_{t,d}^{AT}$ across the draws (d) based on a Bayesian Kalman filter estimation of a state space model for fourteen financial variables. The sample includes daily data from January 1, 2005 through December 31, 2019.

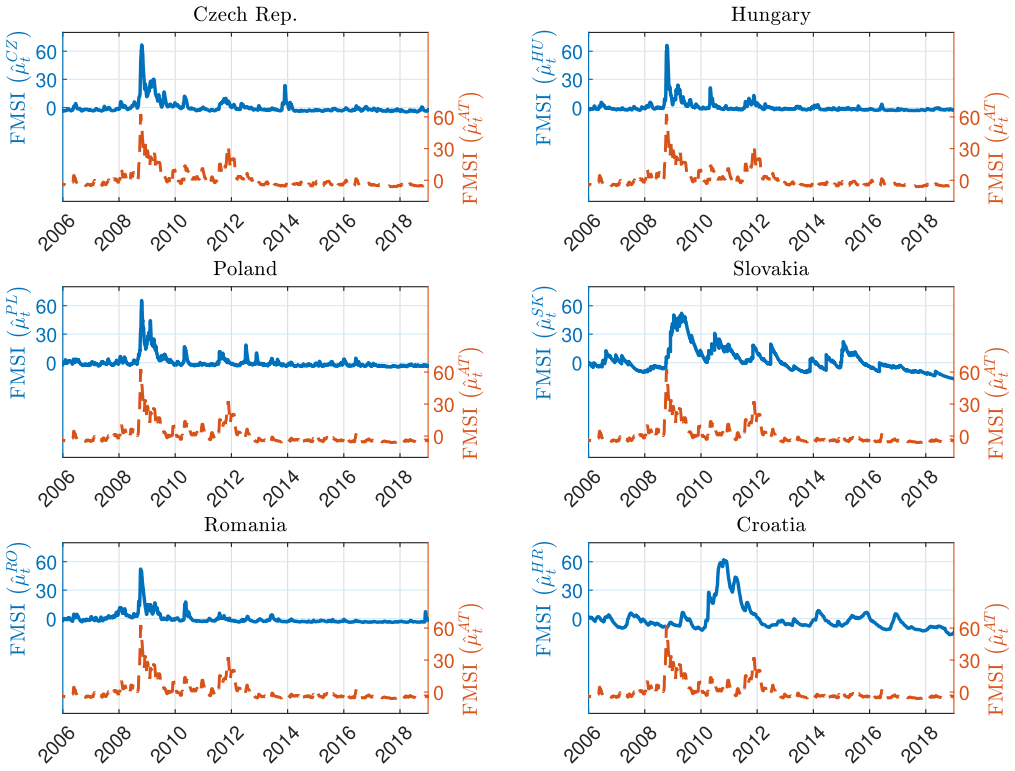

Fig. 3. Daily financial market stress indicators for the CESEE. Note: The figure shows the median of $\hat{\mu}_{t,d}^{c}$ for all CESEE country indexed by c across the draws (d) based on a Bayesian Kalman filter estimation of separate state space models, using various financial variables from each country. The sample includes daily data from January 1, 2005 through December 31, 2019. The scale on the left refers to the CESEE financial market stress indicator, and the scale on the right refers to Austria.

$$\begin{bmatrix} P(L) & 0 \\ \Psi(L) & \Gamma_t(L) \end{bmatrix} \begin{bmatrix} y_t^G \\ \hat{y}_{t,d}^C \end{bmatrix} = \begin{bmatrix} Z \\ B \end{bmatrix} \xi_t + \begin{bmatrix} Z_\eta \\ B_\eta \end{bmatrix} \boldsymbol{\eta}_t + \begin{bmatrix} e_t^G \\ e_t^C \end{bmatrix} \tag{4}$$

where the variance-covariance matrix of the joint error vector $\left[(e_t^G)', (e_t^C)'\right]'$ has a block-diagonal structure (Hamilton, 1994, p. 311), $P(L) = P_0 - \sum_{k=1}^{K} P_k L^k$, $\Psi(L) = \Psi_0 - \sum_{k=1}^{K} \Psi_k L^k$, and $\Gamma_t(L) = \Gamma_0 - \sum_{k=1}^{K} \Gamma_{k,t} L^k$ are lag-polynomials with a lag length of K and the interaction term $\Gamma_{k,t}$ is given by

$$\Gamma_{k,t} = \bar{\Gamma}_k + \Gamma_k \xi_{t-k} \quad \forall k = 1, \ldots, K \tag{5}$$

The vector of policy measures contains four elements and is given by $\xi_t = \left[\xi_{i,t}^A, \xi_{MP,t}^A, \xi_{i,t}^I, \xi_{MP,t}^I\right]' \forall i \in \{RC, PG, OC\}$ where A and I refer to the policy modes: *Announcement* and *Implementation*. We impose zero restrictions on Z such that only ECB monetary policy interventions ($\xi_{MP,t}^A$ and $\xi_{MP,t}^I$) have an impact on the global financial stress indicator (y_t^G), while policy measures undertaken by the Austrian authorities only affect the country specific stress indicators in $\hat{y}_{t,d}^C$, which implies $Z = \left[0, \zeta_{MP}^A, 0, \zeta_{MP}^I\right]$. The matrix B is left unrestricted.

We include each policy instrument $i \in \{RC, PG, OC\}$ in $\xi_{i,t}^j \; \forall j \in \{A, I\}$, step by step into the BVAR model, i.e. excluding the remaining ones, but always jointly with the measures taken by the ECB, $\xi_{MP,t}^j$. This procedure proves to be advantageous, as otherwise multicollinearity and numerical problems arise, aggravating both, the estimation and inference. For each policy instrument (i) we jointly estimate the announcement and implementation effects (j) on financial stress.

The vector $\boldsymbol{\eta}_t$ includes strictly exogenous variables (see Section 4.1) and the zero restrictions in the left-hand side matrix in Eq. (4) implies that global financial market stress affects financial markets in Austria and the CESEE, while the opposite is ruled out[12] (compare El-Shagi and Tochkov, 2022). Hence financial market stress at the global level is controlled for at the country level.

On the assumptions of the error terms. The baseline specification assumes that e_t^G and e_t^C are independently and identically distributed. This assumption might appear inadequate in light of the path of the stress indicators depicted in Figs. 2 and 3 where excess volatility patterns show up. While this especially applies to the country stress indicators, it is, however, of less relevance in the case of the global stress measure as the Vstoxx index enters the BVAR model in logarithmic terms. Statistical tests indicate that the null hypothesis of normality of $\hat{e}_t^G$ is rejected, but this is due to excess kurtosis rather than excess skewness. The autocorrelation is small (first order autocorrelation is at 0.12) and not significantly different from zero at the ten percent level. More important, though, are the properties of the country residuals $\hat{e}_t^C$ as they are at the core of the subsequent analysis. It turns out that in all cases, the Null-hypothesis of normality is not rejected and there is no evidence of autocorrelation. These results emerge from the fact that a relevant part of the excess volatility behaviour in the country stress indicators is already controlled for by the global stress measure. Hence, we stick to the simple specification of the error terms in our baseline but discuss an extension to this in the form of a stochastic volatility model in the Online Appendix.

On the exogeneity assumption of the policy instruments. Our baseline model is a VAR with a focus on ξ_t and $y_t \equiv \left[(y_t^G)', \left(\hat{y}_{t,d}^C\right)\right]'$ and a restriction that ξ_t does not depend on the lags of either ξ_t or y_t. When analysing the success of policy interventions at mitigating financial market stress, we will rely on the concept of impulse response functions. We choose the VAR in Eq. (4) for this purpose because the inference is particularly simple in this case (Jarociński and Karadi, 2020). In our case the shock to the dynamic system emerges from the vector ξ_t of policy interventions. This vector enters our model as an exogenous variable. Hence, we can simply induce a unit shock in ξ_t and examine the corresponding dynamic adjustment of $\hat{y}_{t,d}^C$ by means of the impulse response functions of the BVAR model (see Jarociński and Karadi, 2020, for further details). However, since the intervention dummy variables ξ_t enter the BVAR model contemporaneously, an endogeneity problem could be present. This would arise if financial markets could correctly anticipate the particular day of an announcement (or implementation) of a specific policy intervention. We examine the exogeneity assumption by evaluating the predictive content of the financial market stress indicators on the policy interventions. We do so by means of a logistic regression and test whether all coefficients of a country's stress indicator are jointly equal to zero. We find that the null hypothesis is not rejected in any of the cases examined. Details on the logistic regression and the particular results can be found in Section 3 in the Online Appendix. Hence none of the financial market stress indicators has a predictive content for the policy interventions, both in the case of an implementation or the mere announcement. This applies to all policy measures, those taken by Austrian authorities as well as to those taken by the ECB. We conclude that while market participants may eventually be right in their perception of an imminent policy intervention, they are not able to get its timing right on a daily basis (see also Section 4.9 in the Online Appendix).

[12] The block exogeneity structure is motivated by the small open economy characteristic of Austria and the CEESE relative to the euro area. It implies that y_t^G is neither contemporaneously related nor Granger caused by $\hat{y}_t^C$. We assess this joint hypothesis by means of the Schwartz information criterion. The results indeed favour the assumption of the block exogeneity structure in the BVAR model.

4.1. Estimation

We estimate the BVAR model using daily data ranging from the beginning of 2006 until the end of 2016. We use the log of the implied volatility index of the Eurostoxx50 (Vstoxx) as the only global variable in y_t^G to capture financial market stress at the euro area level. The vector of truly exogenous variables ($\boldsymbol{\eta}_t$) contains the constant term and several additional control variables. While the Vstoxx index is used to control for spillovers from euro area financial markets to the countries of interest, we consider additional dummy variables in the vector $\boldsymbol{\eta}_t$ to control for effects at the individual CESEE level. For this we use country specific event-dummy variables associated with announcements of non-standard monetary policy decisions by the local monetary policy authority. We also include announcements related to financial assistance programmes by the IMF and the European Commission in three of the six CESEE[13], events related to the *Vienna Initiative*, and the country ratings as carried out by rating agencies[14] (consider the Online Appendix for an overview).

We impose a flat prior density for the parameters and use seven lags in the model as suggested by the Schwarz Information criterion. Further details on the Bayesian estimation of the model can be found in the Online Appendix.

On the use of estimated variables in the BVAR model. The BVAR model contains estimated regressors: the financial market stress indicators $\hat{\mu}_{t,d}^c$ of each country c are estimated in Eq. (2) and constitute the vector $\hat{y}_{t,d}^C$ of endogenous variables in the BVAR model in Eq. (4). We control for the fact that the elements in $\hat{y}_{t,d}^C$ arise as an estimation from a different model by estimating the BVAR model for each draw d of the posterior distribution of the financial market stress indicators in $\left\{\hat{y}_{t,d}^C\right\}_{d=1}^{D}$. By using each draw d, we can implicitly merge the two seemingly separate models (Eqs. (2) and (4)) into one joint large-scale model.[15] As a consequence, the posterior distribution of the BVAR model's coefficient matrices fully takes into account the estimation uncertainty surrounding the financial market stress indicators ($\hat{\mu}_{t,d}^c$) as of Eq. (2) and the estimation uncertainty that arises from the BVAR model itself.[16]

4.2. The effects of policy interventions

Table 5 shows our baseline results for all policy instruments (Recapitalisation (RC), Public Guarantees (PG) and Ownership Change (OC) by Austrian authorities and Monetary Policy (MP) actions by the ECB) across the two policy modes (Announcement (A) and Implementation (I)). The numbers refer the cumulative impulse response functions (Lütkepohl, 2005; Aït-Sahalia et al., 2012; Pellegrino, 2018; Dominguez-Torres and Hierro, 2020) of which we only show the maximum value within a 5-day horizon including the date of the intervention[17] and among these, only those which are statistically different from zero at the ten percent level or higher.[18] Since all financial market stress indicators enter the BVAR model in standardised form, the values can be directly compared to each other and hence allow to assess the strength of the effect of interventions by Austrian authorities (RC, PG and OG) relative to those by the ECB (MP).[19]

The estimates result from separate models, each combining the dummy intervention variable for one type of intervention by Austrian authorities (RC, PG or OC) with ECB monetary policy actions. The responses can be interpreted to be conditional on monetary policy activities and additional country specific control variables. As regards the interpretation of the estimates in Table 5, for instance, the estimate of −0.09 for Austria in the case of the announcement of a recapitalisation action reduces financial stress by one tenth of its standard deviation across the 5-day horizon. The most striking result throughout all countries and types of interventions is the difference between the effectiveness of monetary policy relative to those by Austrian authorities. The effects of monetary policy measures dominate considerably.[20] It remains to be shown what role the interaction term plays in this context.

4.2.1. On the role of the interaction term

The interaction variable $\Gamma_k \boldsymbol{\xi}_{t-k}$ in Eq. (5) allows a dynamic relationship between policy interventions and country specific financial stress indicators via the $\Gamma_{k,t} \forall k \geqslant 1$ matrices and hence acts as a mediator of the effect of policy interventions. The response coefficients are thus allowed to change deterministically with policy interventions.

[13] These announcements concern Hungary, Poland and Romania.

[14] We recode the country ratings into dummy variables assuming the value +1 when the rating is improved, −1 when the rating is lowered and zero otherwise.

[15] The BVAR model is estimated $D = 8,000$ times and in each step we sample 1,000 draws which gives us a total of 8 million draws.

[16] A parsimonious alternative, for instance, would be to use the median across all draws d of each country's financial market stress indicator in the BVAR model, however, this approach would ignore the estimation uncertainty of the common component μ_t as of Eq. (2) when performing inference with the BVAR model.

[17] We provide further information of the responses for distinct horizons in the Online Appendix.

[18] We decide to display the impulse response functions in this concise way, as otherwise we would have to display 56 paths of impulse response function (7 [countries] × 4 [policy instruments] × 2 [policy modes] = 56) only for the baseline results, which will quickly degenerate the presentation of the results into great disorder.

[19] Consider also Falagiarda and Reitz (2015); Kizys et al. (2016); Jäger and Grigoriadis (2017) for the effects arising from ECB monetary policy interventions.

[20] This finding aligns with the results put forth in Havlik et al. (2021) in the context of the Covid-19 pandemic, focussing, though, on sovereign measures taken at the level of the European Union as a whole, rather than at the country level.

Table 5
Effects of policy interventions on financial market stress

$\xi^{j}_{i,t}$	j:	Announcement				Implementation			
	i:	RC	PG	OC	MP	RC	PG	OC	MP
Euro area countries									
Austria		−0.09**	−0.06**	–	−0.25**	−0.08**	−0.05**	−0.01**	−0.57**
Slovakia		−0.01**	−0.03**	–	−0.43**	−0.05*	−0.04*	–	−0.59**
non-Euro area countries									
Croatia		−0.04**	−0.01**	−0.07**	−0.06*	−0.12**	−0.09**	−0.08*	−0.12*
Czech Rep.		−0.03**	−0.03*	–	−0.04**	−0.08*	−0.06**	–	−0.01*
Hungary		−0.03**	−0.02*	–	−0.05**	–	−0.04**	–	–
Poland		–	–	–	−0.04*	–	–	–	−0.04**
Romania		−0.01**	–	–	−0.09*	−0.08**	−0.08**	–	−0.24**

Notes: The policy interventions are Recapitalisations: RC, Public Guarantees: PG, Ownership Change: OC, Monetary Policy: MP. Values represent the maximum of the median of the (cumulative) impulse response functions within a five day horizon. – indicates no significant response, * and ** refer to the 90% and 95% level of statistical significance. The estimates result from three distinct models, each combining MP with one of the other policy interventions i using both policy modes j. The step-by-step combination of each policy instrument with MP results in three different estimates for the effect of monetary policy. For ease of exposition, we present here only estimates for the model combining RC and MP (see the Online Appendix for the other two models).

To see how this works in practice, consider the simplified case where we have only one country specific stress indicator ($\hat{y}^{C}_{t,d} \rightarrow y^{C}_{t}$: a scalar, median across draws d), $K = 1$, and only announcements of one category of policy instruments are used ($\boldsymbol{\xi}_t \rightarrow \xi_t$: a scalar). In this case, the model simplifies to the following univariate equation

$$y^{C}_{t} = (\bar{\gamma}_1 + \gamma_1 \xi_{t-1}) y^{C}_{t-1} + \beta \xi_t + [\ldots] \tag{6}$$

where we used $\gamma_{1,t} = \bar{\gamma}_1 + \gamma_1 \xi_{t-1}$ as implied by Eq. (5). Eq. (6) represents an interacted AR(1) model, where the interaction term involves the intervention dummy variable ξ_{t-1}. The impulse response functions are then given by: $y^{C}_{0} = \beta, y^{C}_{1} = (\bar{\gamma}_1 + \gamma_1)\beta$ and $y^{C}_{n} = \bar{\gamma}_1^{n-1}(\bar{\gamma}_1 + \gamma_1)\beta \; \forall n > 1$. Hence the interaction term extends the responses only across the horizon $n \leqslant K$, while not beyond.

We highlight the role of the interaction term in Fig. 4 by the impulse response functions (normal and cumulative) for two cases: with interaction term and without. As can be seen in case of a recapitalisation, the interaction term increases the persistence of the responses. We provide further technical detail on that in the Online Appendix. Because the interaction term appears in all equations of the system, persistence can vary across all types of interventions. This can be seen when comparing the persistence of the response that arise from the announcement of a recapitalisation as opposed to its implementation. Moreover, we observe that the Γ_k-coefficients are in most cases statistically different from zero at the ten percent level highlighting the importance of the interaction term for adequately capturing the dynamic responses.[21]

4.2.2. The effects on euro area members

We find that both the announcement of policies and their implementation mitigated financial market stress in Austria and Slovakia. Compared to the impact of monetary policy interventions, however, the effects arising from the interventions by the Austrian authorities are moderate in size. Still, financial market stress declines in Austria as well as in Slovakia. With a view on Austria, the effects triggered by the interventions are similar for recapitalisation and public guarantees across the two policy modes, i.e. financial markets do not fully react to financial stability interventions at the date of announcement. This highlights the extent of policy credibility, but it also reflects the sometimes missing detail of an intervention at the date of its announcement. Only when the intervention is implemented the affected financial intermediary and the exact volume of funds released by the sovereign will be published, giving rise to another round of market calming. The announcement and implementation of ownership change interventions trigger quantitatively distinct effects in Austria. Interventions by Austrian authorities are also successful at reducing stress levels in neighbouring Slovakia. Recapitalisations and underwriting public guarantees reduce stress levels on average by one twentieth of its standard deviation in Slovakia; this applies for both policy modes; again ownership changes remain largely ineffective.

4.2.3. The effects on non-euro area members

Except for Poland, stress levels throughout the CESEE respond favourably to announcements of interventions by the Austrian authorities, although the calming effect is short-lived and abates quickly.[22] The implementation of Austrian interventions leaves the Polish market unaffected. The remaining CESEE in our sample, however, show a high sensitivity to interventions by Austrian authorities. This result nicely matches the distribution of foreign claims over host countries as well

[21] We restricted the use of the interaction terms to the local financial market stress indicators and thus to the matrix $\Gamma_t(L)$; thus the global variables y^{G}_{t} do not feature interaction terms in $P(L)$. We examined this extension and observed that the coefficients of the interaction terms of the $P(L)$ matrices are quantitatively small and not statistically different from zero in all cases. Moreover, the results did not change qualitatively. We therefore opted for the simpler setup.

[22] The details are provided in the Online Appendix.

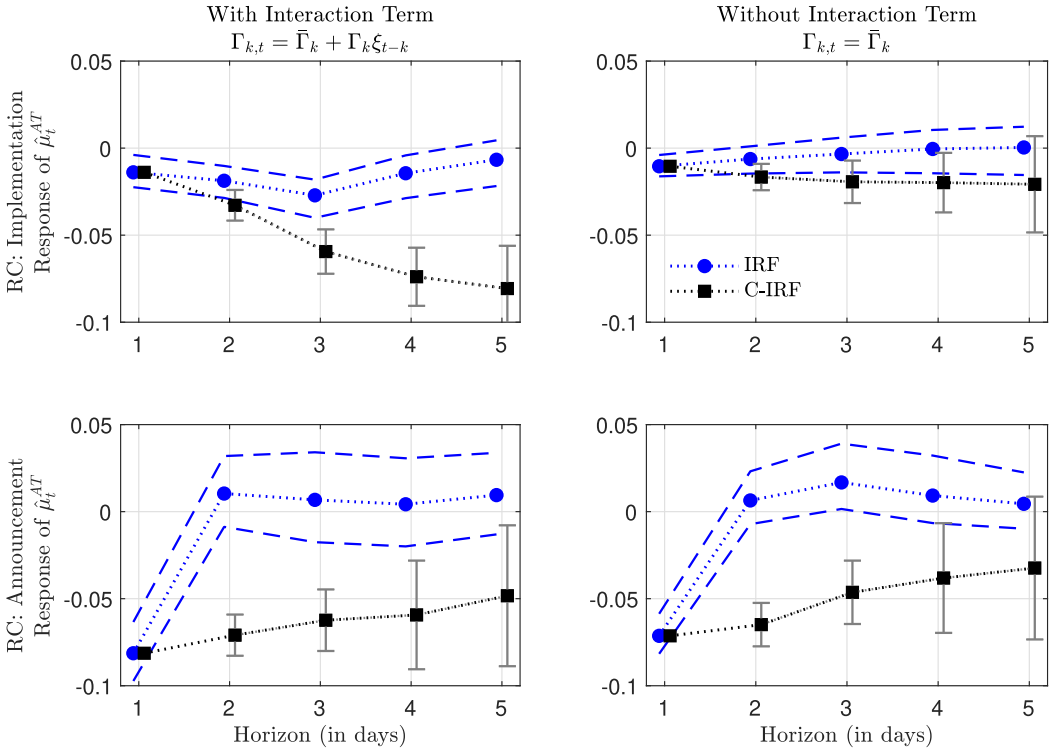

Fig. 4. On the role of the interaction term. Note: The figure compares the implications of the interaction term for the impulse response functions (of financial market stress in Austria) arising from recapitalisations for the case with interaction term and without.

as the market share of Austrian banks in the respective host countries shown in Table 2. In general, the effects of the measures taken by the Austrian authorities on local financial markets in the CESEE reflect the role of Austrian financial intermediaries in these countries. Thus, noteworthy effects arise where the market share is high. In case of an implementation of recapitalisation, the calming effect in the CESEE (excluding Poland) is as big as that in the Austrian market itself. A closer look at the results highlights that while the effect of implementations quickly abates in Austria, financial markets in Croatia, Czech Republic, and Romania show signs of reassurance over a longer horizon (see the Online Appendix). We also find a significant spillover of implemented public guarantees into CESEE. The information on underwriting guarantees in Austria apparently diffuses with different strengths into the neighbouring financial markets with Croatia being affected most. Announcements and implementations of ownership changes in the Austrian banking sector trigger noteworthy effects on financial market stress in Croatia only. This is primarily due to a troubled Austrian bank (Hypo Group Alpe Adria, HGGA) with a high exposure in Southeastern Europe, particularly Croatia.

4.2.4. The effects on sovereigns versus financial intermediaries

We further distinguish between financial market stress at the sovereign level and at the level of financial intermediaries in Table 6 to capture the feedback loop operating through the balance sheets of both sectors. For this purpose, we construct two sub-indices reflecting the stress levels of the sovereign and the financial intermediaries for each country. We then replace the indicator $\hat{y}_{t,d}^{C}$ for country specific general stress in Eq. (4) by one of the two sub-indicators and re-estimate the BVAR model. For the sake of clarity and space, we confine the presentation to implementations and skip the jointly estimated announcement effects. Table 6 depicts the effects on the sub-indices for sovereign and financial intermediary stress, respectively.

With a view on Austria, the effects triggered by the Austrian authorities' interventions differ with respect to their sign. The implementation of bank rescue measures mitigates stress for Austrian financial intermediaries, but the assumption of banking sector losses and risks by the government amplifies sovereign stress. Hence a risk-shifting effect is present.[23]

Table 6 also provides evidence for the channels along which the interventions by the Austrian authorities spill over to CESEE. The effects on sovereign stress in the host countries were limited with the exception of Croatia. In contrast to this,

[23] A look behind the scenes shows that these values lead to an increase in the spread between Austrian and German 10-year government bond yields by about eight basis points in the case of recapitalisations and public guarantees and by about five basis points in the case of an ownership change. This result conforms with the findings in Kizys et al. (2016) who document that government interventions in the banking sector deteriorate the credit risk of sovereign debt.

Table 6
Effects of policy interventions on financial market stress (*Implementation*): Distinguishing between sovereign and financial intermediary stress.

$\xi^{j}_{i,t}$	*j*:	Announcement				Implementation			
	i:	RC	PG	OC	MP	RC	PG	OC	MP
	Effects on sovereign stress								
Euro area countries									
Austria		–	–	0.14**	−0.41**	0.60**	0.67**	0.49**	−0.53**
Slovakia		–	–	–	–	–	–	–	−0.68*
non-Euro area countries									
Croatia		–	–	–	−0.16*	–	–	−0.04*	−0.11**
Czech Rep.		–	–	–	–	–	–	–	–
Hungary		–	–	–	–	−0.02**	−0.01**	–	–
Poland		–	–	–	–	–	–	–	–
Romania		–	–	–	−0.03**	–	−0.01**	–	−0.22**
	Effects on financial intermediary stress								
Euro area countries									
Austria		−0.09*	−0.04**	–	−0.29**	−0.75**	−0.71**	−0.23**	−0.69**
Slovakia		–	–	–	−0.37*	−0.15**	−0.11*	–	−0.50**
non-Euro area countries									
Croatia		–	–	−0.16*	−0.21*	−0.12**	−0.08*	−0.55**	−0.15**
Czech Rep.		–	–	–	–	−0.08*	−0.11**	−0.03**	−0.11**
Hungary		−0.04**	–	–	–	−0.05*	−0.05*	–	−0.26*
Poland		–	–	–	–	−0.03**	–	–	−0.05**
Romania		–	–	–	−0.22*	−0.09*	−0.05**	−0.06**	−0.06**

Notes: The policy interventions are Recapitalisations: RC, Public Guarantees: PG, Ownership Change: OC, Monetary Policy: MP. Values represent the maximum of the median of the (cumulative) impulse response functions within a five day horizon. – indicates no significant response, * and ** refer to the 90% and 95% level of statistical significance. The estimates result from three distinct models, each combining MP with one of the other policy interventions *i* using both policy modes *j*. The step-by-step combination of each policy instrument with MP results in three different estimates for the effect of monetary policy. For ease of exposition, we present here only estimates for the model combining RC and MP (see the Online Appendix for the other two models).

there are sizeable spillover effects on financial intermediary stress. This applies to all the CESEE, even Poland where Austrian banks have a small exposure. Moreover, the effects are highly persistent. This highlights the role and importance of foreign parent banks as providers of funding to their subsidiaries in host countries and identifies the international bank lending channel[24] as transmission channel for the spillover effects of the Austrian authorities' interventions into CESEE. This channel is qualitatively identical to its domestic counterpart: the interventions mitigate financial intermediary stress and therefore remove barriers to refinancing and reduce funding costs, which has a positive effect on banks' domestic and foreign activities. The international bank lending channel is likely to be particularly important in CESEE due to the dominance of banks in their financial system. Moreover, since other banks operating in CESEE are likely to benefit from the reduction in counterparty risk, there is hence the potential for a reinforcement of stress mitigation that goes beyond the direct effect.

While interventions by the Austrian authorities triggered opposing effects on domestic sovereign and financial intermediary stress, those arising from monetary policy measures are uniformly stress mitigating. ECB policy measures reduced sovereign stress in Austria, Slovakia, Croatia, and Romania (see Table 6). A persistent and large effect can be observed, where sovereign stress on average abates by roughly one third to three quarters of its standard deviation. This result conforms with the findings in Jäger and Grigoriadis (2017) and Falagiarda and Reitz (2015). Compared to the non-euro area members, financial intermediary stress in Austria and Slovakia benefited more from ECB interventions. This aligns with the findings in Haitsma et al. (2016).

4.3. Discussion

Our results underscore the success of policy interventions to mitigate financial market stress. Kizys et al. (2016), however, stress the role of state-dependencies in this respect. Against this background we assess the effects of policy interventions across two periods: (i) the acute crisis period during the years 2008 and 2009, and (ii) the post global financial crisis period after 2009. We carry out the same exercise as before and provide the results in Table 7, again limited to the implementation mode.

The impact of the Austrian authorities' interventions is state-dependent. Considering the effects in Austria, this applies especially for ownership change interventions. They reduced financial market stress during the post global financial crisis period, while the opposite applies during the acute crisis period. This highlights that ownership change interventions may increase market participants' concerns about the sustainability of public finances. Moreover, in most cases when governments implemented ownership change policies, these were carried out with constructive ambiguity about the govern-

[24] As explained in Auer et al. (2019), the international bank lending channel concerns the frictions related to banks' foreign subsidiaries own ability to attract funding. They therefore depend on the parent bank as a provider of liquidity. This channel has traditionally been analysed in the context of the international effects of monetary policy.

Table 7
Effects of policy interventions on financial market stress (*Implementation*): Splitting the sample into an acute-crisis and a post-crisis period

$\xi^j_{i,t}$	j:	Announcement				Implementation			
	i:	RC	PG	OC	MP	RC	PG	OC	MP
		Effects in acute crisis period (2008–2009)							
Euro area countries									
Austria		−0.12*	−0.15**	0.21**	−0.46**	−0.39**	−0.43**	0.51**	−0.69**
Slovakia		−0.04*	–	–	−1.45**	−0.10**	–	–	−1.76**
non-Euro area countries									
Croatia		–	–	–	−0.09*	−0.02**	–	–	−0.14**
Czech Rep.		–	–	–	−0.26**	–	−0.09**	–	−0.40**
Hungary		−0.03*	–	–	–	−0.11**	−0.05**	–	−0.53*
Poland		–	–	–	−0.07*	−0.03**	–	–	−0.11**
Romania		–	–	–	–	−0.09**	−0.09*	–	−0.33*
		Effects in post global financial crisis period (2010–2016)							
Euro area countries									
Austria		−0.01*	–	–	−0.09**	−0.08**	−0.01**	−0.07*	−0.15**
Slovakia		–	–	–	−0.12*	−0.02*	–	–	−0.17**
non-Euro area countries									
Croatia		−0.14**	−0.08*	−0.12*	–	−0.49**	−0.22*	−0.42**	−0.05*
Czech Rep.		–	–	–	–	–	–	–	–
Hungary		–	–	–	–	–	–	–	0.03*
Poland		–	–	–	–	–	–	–	−0.02**
Romania		–	–	–	–	−0.06**	–	–	0.05**

Notes: The policy interventions are Recapitalisations: RC, Public Guarantees: PG, Ownership Change: OC, Monetary Policy: MP. Values represent the maximum of the median of the (cumulative) impulse response functions within a five day horizon. financial market stress indicators. – indicates no significant response, * and ** refer to the 90% and 95% level of statistical significance. The estimates result from three distinct models, each combining MP with one of the other policy interventions i using both policy modes j. The step-by-step combination of each policy instrument with MP results in three different estimates for the effect of monetary policy. For ease of exposition, we present here only estimates for the model combining RC and MP (see the Online Appendix for the other two models).

ment's willingness to provide further support. In the case of Austria, constructive ambiguity not only played a role at the national policy level, but also at the level of the European Commission, as it had to approve the Austrian authorities' ownership change measures.

By contrast, recapitalisations and public guarantees were always associated with a reduction in financial market stress. Interventions of these types were especially effective during the acute crisis episode and the size of their effects almost matches the one of monetary policy interventions.[25] Hence, to the extent that the Austrian authorities' interventions mitigated financial market stress at home, they contributed to reducing stress among financial intermediaries in the CESEE alike. This highlights substantial cross-border effects of domestic financial sector rescue programmes. From the point of view of CESEE, foreign banks were a stabilising factor during the crisis (Bakker and Klingen, 2012). Indeed, no Austrian parent bank allowed any of its subsidiaries to fail in the entire region. Equally remarkably, no foreign-owned subsidiary was put up for sale (Bakker and Klingen, 2012). In most cases, parent banks provided sufficient liquidity and capital to their subsidiaries in CESEE.

4.3.1. On the dominance of monetary policy measures

Our results have highlighted that interventions by Austrian authorities spill over to the CESEE, however, those taken by the ECB clearly dominate in size (consider also Ciarlone and Colabella, 2016; Potjagailo, 2017; El-Shagi and Tochkov, 2022). This deserves a closer look. One possible explanation pertains to the fact the interventions by Austrian authorities trigger opposing effects on sovereign stress and financial intermediary stress which undermines their overall effectiveness. Another reason could be the frequency of policy measures. The higher incidence of measures taken by the ECB compared with those taken by Austrian authorities could also explain (part of) the quantitative difference in the impact of the measures. Yet another explanation relates to the fact that the transmission of ECB interventions to financial market stress at the country level ($\hat{y}^C_{t,d}$) occurs along two dimensions. To see this, consider Eq. (4) and assume y^G_t and $\hat{y}^C_{t,d}$ are scalars (y^G_t and y^C_t with median across draws d) for simplicity and so too is ξ_t which only contains monetary policy interventions. Then the contemporaneous effect of monetary policy interventions on y^G_t and y^C_t is given by the following expressions

$$\frac{\partial y^G_t}{\partial \xi_t} = \frac{\zeta}{\rho_0} \tag{7}$$

$$\frac{\partial y^C_t}{\partial \xi_t} = \underbrace{\frac{\beta}{\gamma_0}}_{\text{DE}} + \underbrace{\frac{-\psi_0}{\gamma_0}\frac{\partial y^G_t}{\partial \xi_t}}_{\text{IE}} \tag{8}$$

[25] This comparison warrants caution due to the large disparity in the number of interventions and a potential sub-sample bias. This conforms with the findings in Aït-Sahalia et al. (2012); Artuç and Demiralp (2010).

Table 8
Monetary policy effects on impact: direct and indirect effects

$\xi^j_{MP,t}$	j:	Announcement		Implementation	
		direct (DE)	indirect (IE)	direct (DE)	indirect (IE)
Austria		−0.02**	–	−0.12**	−0.05**
Slovakia		−0.08**	−0.03**	−0.07**	−0.08**
Croatia		−0.02**	–	−0.03**	0.01*
Czech Rep.		–	−0.05**	–	−0.01*
Hungary		–	–	−0.02*	−0.03**
Poland		–	–	−0.01*	−0.03**
Romania		–	−0.01**	–	−0.02*

Notes: – indicates no significant response, * and ** refer to 90% and 95% level of statistical significance.

where small Greek letters denote scalars and refer to the corresponding matrices denoted with capital Greek letters in Eq. (4). Eq. (8) implies that, the effect of monetary policy on financial market stress at the country level y^C_t is composed of two elements. First, there is a direct effect (DE) which is captured by β/γ_0. Second, there is the indirect effect (IE) which works via the global variables (y^G_t). Since we use the Vstoxx index as the sole variable in y^G_t, the indirect effect can be interpreted as capturing the confidence channel along which monetary policy affects financial market stress at the country level. The total size of the indirect effect depends on $-\psi_0/\gamma_0$.

Since we rely on Bayesian methods, the computation thereof is straightforward: For each draw i of the posterior density of the parameters of interest $(\psi^i_0, \gamma^i_0, \beta^i, \zeta^i, \rho^i_0)$, we compute $\text{DE}^i = \beta^i/\gamma^i_0$ and $\text{IE}^i = -\psi^i_0/\gamma^i_0 + \zeta^i/\rho^i_0$. We then use the median of DE^i and IE^i across all draws. The estimates shown in Table 8 refer to the impact response (consider also the Online Appendix).

The results highlight that both channels matter for both the announcements and the implementations of monetary policies policies. For non-euro area CESEE, the indirect channel tends to dominate, with the exception of Croatia. This discrepancy is already suggested by Fig. 3, which shows that the financial market stress indicator for Croatia was insulated from Western European stress until 2010, while financial markets in the remaining CESEE appear synchronised with Western European counterparts. Even after 2010, financial stress in Croatia appears to be dominated by domestic rather than foreign factors. Consequently, the indirect effect for Croatia documented in Table 8 deviates from other CESEE.[26] The dominance of the indirect effect highlights the role of the confidence channel of monetary policy and hence of the sizeable effects of ECB policies in CESEE compared to those by the Austrian authorities. But as the case of Croatia shows, this channel only works if financial stress is not home-made. Evidence for the working of the confidence channel is also provided in Falagiarda et al. (2015).

4.3.2. Further robustness checks

We provide further robustness checks in the Online Appendix which involve, (i) different measures of financial market stress (ii) stochastic volatility in the BVAR model, (iii) the use of event-windows, (iv) the role of omitted variables, and (v) the importance of controlling for ECB interventions. Across all extensions, our baseline results are confirmed qualitatively.

5. Conclusions

We examined the effects of financial sector stabilisation measures by the Austrian authorities in the wake of the global financial crisis and its aftermath. Interventions include recapitalisations, public guarantees, and ownership changes. Their effects are measured conditional on ECB monetary policy interventions, allowing us to compare their effectiveness. The assessment involves Austria and Central, Eastern and South-eastern European Economies (CESEE) in which Austrian banks have high market shares. The analysis draws on a unique new database of policy announcements and implementations. Our key results can be summarised as follows:

(1) Interventions by the Austrian authorities alleviated stress in domestic financial markets. This applies to both their mere announcement and actual implementation. This underscores the partial credibility (imperfect foresight) of the policy, as the announcement of a policy alleviates stress, but so does its actual implementation.
(2) The measures most effective in calming financial markets are recapitalisations and public guarantees, while the ability of ownership change appears limited. Moreover, there is evidence for a state-dependency of the effects: Recapitalisations and public guarantees had a particularly strong calming effect in times of acute financial market stress while the opposite applies for ownership change policies.
(3) There is a risk-shifting effect: While interventions by the Austrian authorities curtail financial intermediary stress, they concurrently raise sovereign risk. This might explain the observation that the mitigation effects arising from ECB interventions outweigh those of the Austrian authorities.

[26] An important element that distinguishes Croatia from the other CESEE countries in our study concerns the use of reserve requirements as a monetary policy instrument (Bokan et al., 2009; Glocker, 2021).

(4) Interventions by the Austrian authorities had positive spillover effects to CESEE. The size of the cross-border mitigation effect increases with the market share of Austrian banks in the host country and was stronger for financial intermediary as compared to sovereign stress.

The results need to be interpreted with caution as they focus on the immediate market response only, which may not always be indicative of their long-term implications. Nevertheless, they emphasise the ability of policy interventions (by a country with sufficient fiscal space) in breaking adverse loops in financial markets during stress periods, which is without doubt one of the most important goals of financial market stress containment.

Data availability

Data will be made available on request.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A. Supplementary material

Supplementary data associated with this article can be found, in the online version, at https://doi.org/10.1016/j.jimonfin.2022.102694.

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