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Effects of the Extraordinary Measures Implemented by Banco de México during the COVID-19 Pandemic on Financial Conditions

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Abstract: This paper analyzes the effects of the extraordinary measures implemented by the Bank of Mexico during the COVID-19 pandemic on financial conditions. For this purpose, we estimate a factor-augmented vector autoregressive (FAVAR) model for the period 2001-2021. Based on this model, we construct a financial conditions index, estimate the response of this indicator and its components from a shock to the outstanding amount of these measures, and conduct a counterfactual exercise to further analyze the effect of the aforementioned measures. The results indicate that the extraordinary measures seem to have contributed to improve financial conditions. In particular, we find that if these measures had not been implemented, the sovereign risk premium, the 10-year government bond yield, the slope of the yield curve, the long and short-term yield spreads between Mexico and USA, the exchange rate and its volatility would have been higher. In turn, the Mexican stock market index would have been lower.

Keywords: Financial Conditions; Central Bank Policies; Factor-Augmented VAR.

JEL Classification: C32; E58; G01; E44.

Resumen: Este trabajo analiza los efectos de las medidas extraordinarias implementadas por el Banco de México durante la pandemia de COVID-19 sobre las condiciones financieras. Para este propósito, estimamos un modelo de vectores autorregresivos aumentado por factores (FAVAR) para el periodo 2001-2021. Con base en este modelo, construimos un índice de condiciones financieras, estimamos la respuesta de este indicador y sus componentes ante un choque al saldo vigente de estas medidas, y realizamos un ejercicio contrafactual para analizar más a fondo el efecto de las medidas antes mencionadas. Los resultados indican que las medidas extraordinarias parecen haber contribuido a mejorar las condiciones financieras. En particular, encontramos que si no se hubieran implementado estas medidas, la prima de riesgo soberano, el rendimiento del bono del gobierno a 10 años, la pendiente de la curva de rendimientos, los diferenciales de rendimiento de largo y corto plazo entre México y EUA, el tipo de cambio y su volatilidad habrían sido mayores. A su vez, el índice accionario mexicano habría sido más bajo.

Palabras Clave: Condiciones financieras; políticas del banco central; VAR aumentado por factores.

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1 Introduction

The effects of the financial shock derived from the COVID-19 pandemic led to households, firms, and financial institutions in emerging market economies (EMEs) to face a complex and uncertain environment in which foreign exchange and fixed-income markets showed significant adjustments, lower liquidity, and a deterioration of trading conditions. In this context, central banks in these economies implemented, besides interest rate reductions, additional measures to provide liquidity to financial markets and strengthen the credit channels. For the particular case of Mexico, the central bank implemented a series of extraordinary measures amounting to up to 800 billion pesos, equivalent to 35.6 billion US dollars or 3.3% of 2019 GDP. According to their main purpose, such measures were grouped in three large categories. The first one included those measures adopted to provide liquidity and reestablish operational conditions in money markets; the second one consisted of those measures implemented to promote an orderly behavior in governmental and corporate bond markets; the third one included those measures to strengthen the credit channels. In particular, the measures oriented to provide credit to the economy were intended to create conditions that facilitated financial intermediaries to provide financing to the economy, so that in turn it could be used by micro, small, and medium-sized enterprises (MSMEs), as well as households whose sources of income were affected.¹

This paper presents an analysis of the effects of such extraordinary measures implemented by the central bank of Mexico, Banco de México, on financial conditions. For this purpose, we estimate a factor-augmented vector autoregressive (FAVAR) model, which allows us to analyze in a parsimonious way the dynamics from a large number of variables representing financial conditions, together with a set of macroeconomic variables for the Mexican economy. Based on this model, we construct a Financial Conditions Index (FCI) for Mexico as a factor that summarizes the information from a set of financial variables belonging to different categories, including external financial conditions, sovereign risk, money, debt, stocks, and foreign exchange, as well as economic activity and inflation. Then, we estimate the effects

¹A complete description of the extraordinary measures is presented in Banco de México (2020a).

on this indicator and its components from a shock to the outstanding amount of extraordinary measures implemented by Banco de México, that is, the amount actually used by financial institutions at each month. Finally, we conduct a counterfactual exercise using conditional forecasts from the FAVAR model in order to further analyze the impact of the aforementioned measures on the dynamics of financial conditions. That is, we estimate the dynamics for the FCI and its components that would have been observed if the extraordinary measures had not been implemented.

An important number of studies have examined the effectiveness of unconventional monetary policies (UMPs) in responding to financial crises and boosting economic activity in advanced economies (AEs).² In particular, there is considerable evidence that QE measures can be powerful tools to blunt the negative effects of a financial crisis on financial conditions (Lombardi et al., 2018).³ On the other hand, the empirical evidence for EMEs is more limited, which is associated with the novelty of extraordinary measures implemented by central banks in order to provide liquidity to financial markets.⁴ Some exceptions include the work of Hartley and Rebucci (2020) who suggest that the announcement of these types of policies in EMEs seem to have important effects on sovereign bond yields. Fratto et al. (2021) show that these policies were successful in significantly reducing bond yields in EMEs and thus they could be important tools for these economies during financial market stress. As

²For a more complete description of these policies see, e.g., Moessler et al. (2017) and Lombardi et al. (2018). In general terms, UMPs can be defined as any policy, other than the setting of short-term interest rates, that aims at achieving a stated monetary policy objective either by influencing economic outcomes or by moderating shocks to the financial system (Lombardi et al., 2018). These policies in turn can be introduced in the form of quantitative easing (QE) or forward guidance. While the former policies may involve direct intervention in the monetary system through credit policies or asset purchase programs, for instance, the latter ones aim to change expectations by sending signals about the future policy path, i.e., forward guidance policies use communication to affect policy outcomes (Lombardi et al., 2018).

³Bhattarai and Neely (2016) present a recent review of this literature. In particular, Gagnon et al. (2011), Krishnamurthy and Vissing-Jorgensen (2011), Hamilton and Wu (2012), D'Amico and King (2013), and Swanson and Williams (2014), among others, are some of the studies that analyze the effects of UMPs on interest rates, term spreads, asset prices, and credit costs.

⁴In contrast to some AEs, which implemented UMPs at or near the effective lower bound during the global financial crisis and the COVID-19 pandemic, most EMEs had policy rates above zero when they launched their extraordinary measures (Fratto et al., 2021). In addition, recent asset purchase programs in EMEs and QE measures in AEs may differ in their objectives. Central banks in EMEs have implemented these programs to provide liquidity and stabilize their financial markets, while central banks in AEs have resorted to asset purchases to provide additional monetary stimulus (Banco de México, 2020b).

explained by Bhattarai and Neely (2016), both the signaling and portfolio balance channels could be important conduits of these types of policies on long-term interest rates. In particular, the signaling channel operates by reducing expected future short-term interest rates and thereby by reducing the expectations component of long-term interest rates.⁵ Regarding the portfolio balance channel, some of these measures can change the relative supplies of bonds and influence the yield of those bonds and others with similar characteristics through their effect on some of the term premium components, such as the liquidity premium and the safety premium.

To analyze the effects of the extraordinary measures implemented by Banco de México on financial conditions we employ a FAVAR model, which has some advantages compared to alternative approaches such as event studies or standard vector autoregressive (VAR) models.⁶ Specifically, this framework allows us to capture the lagged effects of extraordinary measures on financial variables, as asset prices may keep reacting after the implementation of these measures (Greenwood et al., 2018). In addition, we can easily incorporate macroeconomic variables, as well as a large number of financial variables, typically included in the estimation of FCIs, into this framework while remaining parsimonious. Finally, the FAVAR model can be used to construct conditional forecasts, which take into account the lagged effects of the extraordinary measures, as well as the feedback between all the variables included in the model. These forecasts, in turn, can be used to conduct counterfactual exercises to estimate

⁵Long-term interest rates are determined by the average of current and future expected short-term interest rates, plus a term premium.

⁶The literature on the effectiveness of QE for AEs can broadly be divided into two different strands: events studies that analyze the immediate response to QE announcements using high-frequency data and VAR models or structural models that adopt a macroeconomic perspective in order to study the dynamic impacts of QE programs. Event studies including Gagnon et al. (2011), Swanson et al. (2011), Krishnamurthy and Vissing-Jorgensen (2011), and Hancock and Passmore (2011), for instance, show that a surprise announcement of a purchase of long-term bonds reduces 10-year US Treasury yields, mortgage-backed securities yields, and mortgage rates. In the same vein, Neely (2015) and Kiley (2014) show that foreign sovereign 10-year yields decline and stock prices rise following a large purchase of long-term bonds. Unconventional policy announcements also seem to reduce near-term option-implied tail risk in equity and interest rate markets (Roache and Rousset, 2013; Hattori et al. 2016), suggesting that such policies could have a stabilizing and stimulatory effect. On the other hand, some authors have analyzed the macro impact of UMP through DSGE models and VAR models. In general terms, the evidence suggests that UMP has had some significant impact on macro variables such as GDP, inflation, and long-term yields (Gambacorta et al., 2014; Bhattarai et al., 2021; Weale and Wiedelak, 2016; MacDonald and Popiel, 2020).

the dynamic effects of the extraordinary measures on financial variables.

The main contribution of this paper is to analyze the effects of the extraordinary measures implemented by the Mexican central bank during 2020–2021 on financial conditions in Mexico. To the best of our knowledge, this is the first paper that quantifies the effects of these measures through a FAVAR approach. As mentioned above, this model allows us to analyze the effects of these measures on a large number of variables in a parsimonious framework. The fact that FCIs typically include several financial variables provides motivation for using this model. The sample used in this study covers the period 2001–2021 on a monthly basis. This allows us to consider the financial shock associated to the COVID-19 pandemic. For this episode, the literature about the effects of the policies implemented by central banks on financial markets is relatively limited.⁷ In addition, we can also contribute to the literature by providing recent evidence for the case of an emerging economy as Mexico, which during the period of analysis experienced a significant development of financial markets (Sidaoui and Ramos-Francia, 2008).⁸

The main results indicate that the extraordinary measures implemented by the central bank of Mexico during 2020–2021 seem to have contributed to ease the financial turmoil and foster an orderly functioning of financial markets in the context of the effects derived from the COVID-19 pandemic. In particular, our results show that an increase in the outstanding amount of these measures is followed by a decrease in the estimated FCI, suggesting an improvement in financial conditions. In turn, results from the impulse-response functions indicate that an increase in these measures is followed by decreases in the sovereign risk premium, the 10-year government bond yield, the slope of the yield curve, the yield spreads between Mexico and the US, the exchange rate and its volatility. In addition, the stock index rises with increases in the outstanding amount of the extraordinary measures.

⁷Some exceptions include the works of Hartley and Rebucci (2020), Fratto et al. (2021), Jinjarak et al. (2021), and Cortes et al. (2022).

⁸According to Cortés Espada et al. (2009), after the adoption of an inflation-targeting regime in 2001, the Mexican macroeconomic environment has become more stable owing to a low and stable inflation level. This fact, along with important regulation developments, has allowed the economy to experience a significant development of financial markets, in particular, the primary and secondary markets for public sector debt of different maturities.

Regarding the counterfactual analysis, we find that if these measures had not been implemented, the sovereign risk premium, the 10-year government bond yield, the slope of the yield curve, and the long and short-term yield spreads between Mexico and the US would have been higher by around 56, 31, 28, 37, and 48 basis points in December 2020, respectively. At the same time, the exchange rate and its volatility would have been higher by 5 and 2.5 percentage points, respectively. In turn, the Mexican stock market index would have been lower by 9.5 percentage points. In addition, our results also seem to indicate that the first group of measures that were implemented and used by financial institutions, those oriented to promote liquidity and reestablish operational conditions in money markets, initially had a greater effect on financial markets. Subsequently, the second group of measures, particularly those measures aimed at promoting an orderly behavior in the bond markets, became relatively more important. At the end, the measures oriented to strengthen the credit channels, the last ones that were implemented, had a more important effect.

The remainder of this paper is organized as follows. Section 2 describes the FAVAR model and the data used in the estimation. The estimation results are reported and discussed in Section 3. The last section concludes and discusses areas for future research.

2 Methodology

In order to analyze the effects of the extraordinary measures implemented by Banco de México on financial conditions, we estimate a FAVAR model for the Mexican economy. This model has been used in the literature to analyze the impact of monetary policy on a large set of economic indicators.⁹ Both external and domestic variables that determine the evolution of financial conditions in Mexico are used in the estimation.

Unlike a standard VAR model, the FAVAR approach allows us to incorporate a large amount of information in the model in a parsimonious way. Based on this model, we can obtain the dynamic responses of a large number of variables to a shock in the outstanding

⁹See Bernanke et al. (2005), Boivin et al. (2010), Charnavoki and Dolado (2014), Wu and Xia (2016), and Dahlhaus et al. (2018), among others.

amount of extraordinary measures implemented by Banco de México. An important advantage of using an impulse response analysis, instead of using a Granger causality approach, is that the former allows us to examine not only the magnitude and direction of the response of each variable to different shocks but also its duration; thus, it provides further useful information about the effects of these shocks. In addition, we can construct dynamic forecasts that take into account the lagged effects of the dynamics of the amount of extraordinary measures, as well as the feedback between all the variables in the system.

2.1 FAVAR Model

The state-space representation of the FAVAR model is as follows:

$$\mathbf{X}_t = \mathbf{A}^Y \mathbf{Y}_t + \mathbf{A}^F \mathbf{F}_t + \mathbf{v}_t \quad (1)$$

$$\begin{bmatrix} \mathbf{Y}_t \\ \Delta M_t \\ \mathbf{F}_t \end{bmatrix} = \boldsymbol{\mu} + \boldsymbol{\delta} \mathbf{Z}_t + \boldsymbol{\lambda} \begin{bmatrix} \mathbf{Y}_{t-1} \\ \Delta M_{t-1} \\ \mathbf{F}_{t-1} \end{bmatrix} + \mathbf{e}_t \quad (2)$$

where \mathbf{X}_t is a matrix containing a panel of N domestic financial variables, $\mathbf{Y}_t = [\Delta \log Y_t, \Delta \log P_t]$, where Y_t represents domestic output and P_t represents domestic prices, \mathbf{F}_t is the unobserved factor which we interpret as the FCI and summarizes the information from the domestic financial variables, M_t denotes the variable of extraordinary measures implemented by the central bank of Mexico, and $\mathbf{Z}_t = \Delta \log Y_t^*$ is a measure of foreign output. In turn, \mathbf{v}_t and \mathbf{e}_t are vectors of errors whose covariance matrices are \mathbf{R} and \mathbf{Q} , respectively. The first equation is the observation equation of the model, while the second one is the transition equation. In equation (1) the unknown parameters consist of the elements of \mathbf{A}^Y , the factor loadings contained in \mathbf{A}^F , and the non-zero elements of the covariance matrix \mathbf{R} . Thus, the dynamics of \mathbf{X}_t depends on the unobserved factor and the macroeconomic variables contained in \mathbf{Y}_t . Following Hatzius et al. (2010) and Koop and Korobilis (2014), the vector \mathbf{Y}_t is introduced into the observation equation in order to purge \mathbf{F}_t from the effect of current

economic activity and prices.¹⁰ In the transition equation, the parameters to be estimated are the elements of μ , δ , λ , and Q . Given our particular interest in analyzing the effects of the extraordinary measures implemented by Banco de México on financial conditions, we include M_t in equation (2). Thus, this equation represents the joint dynamics of the macroeconomic variables, the extraordinary measures and the FCI. In addition, Z_t containing foreign output is included as an exogenous variable.¹¹ Finally, the unobserved factor F_t is unknown and needs to be estimated. From the system (1)-(2) we estimate impulse response functions and conduct counterfactual exercises.

Following the influential work of Bernanke et al. (2005), we employ a single-step Bayesian likelihood approach in order to estimate F_t and the parameters of the model simultaneously. In particular, we consider the joint estimation by likelihood-based Gibbs sampling techniques, developed by Geman and Geman (1984), Gelman and Rubin (1992), and Carter and Kohn (1994), which allow us to approximate the marginal posterior distributions of F_t and the parameters of the model by sampling from their conditional distributions.¹² An alternative approach followed by Bernanke et al. (2005), consists of a two-step principal components method that, although computationally simple, it does not exploit the structure of the transition equation in the estimation of the factor.¹³ Through the single-step Bayesian likelihood approach followed in our baseline specification, we can sample the factor conditional on the most recent draws of the model parameters, and then sample the parameters conditional on the most recent draws of the factor. By approximating marginal posteriors by empirical densities, this Bayesian approach helps to circumvent the high-dimensionality problem of the model. In addition, the Gibbs-sampling algorithm is guaranteed to trace the shape of the joint posterior, even if the posterior is irregular and complicated (Bernanke et al., 2005).¹⁴

¹⁰We also consider an alternative model where vector Y_t is excluded from equation (1). The results from this exercise are consistent with our baseline specification and are reported in Section 3 of the paper.

¹¹For robustness, we also include the oil price as an exogenous variable. The results are consistent with our baseline specification.

¹²Kim and Nelson (1999) present a review of this literature.

¹³For robustness check, however, we also estimate the model using a two-step principal components method. The results reported in section 3 were very similar.

¹⁴This approach, however, needs to be modified to account for the fact that Y_t enters the observation equation (1). Thus, it is necessary to set the first element of Λ^F to one and the upper row of Λ^Y to zero (see Bernanke et al. (2005)). This specific choice does not affect the space spanned by the estimated factor, although it restricts the

We assume a recursive structure where the variables entering equation (2) are ordered as they appear in such a equation, with F_t ordered last. Thus, F_t is contemporaneously affected by the shocks to M_t . Therefore, financial variables contained in F_t adjust rapidly to new information, as implied by the efficient markets hypothesis. In addition, the recursive structure implies that output and inflation respond with a lag to the extraordinary measures shock, and that the central bank takes into account the current stage of output and prices. These assumptions allow us to retrieve the extraordinary measures shock and construct the impulse response functions.¹⁵ In particular, the response of any variable in \mathbf{X}_t to a shock in M_t in the transition equation (2) can be computed using the estimated factor loadings $\hat{\Lambda}^F$ in equation (1).

Before the model is estimated, all variables are standardized and we take logs and first differences as necessary to achieve stationarity.¹⁶ Before starting the Gibbs sampling procedure, we obtain an initial guess for F_t through principal components from the domestic financial variables in \mathbf{X}_t and a set of J foreign financial variables.¹⁷ In particular, Prasad et al. (2019) highlight the importance of including foreign variables when estimating a FCI for small economies that are integrated into international financial markets and world trade. In fact, these variables may help to proxy potential restrictions that economic agents could face to obtain funding from abroad. Given the factor, the observation equation (1) is just N linear regressions and the normal and Inverse Gamma conditional distributions apply immediately to sample Λ^F , Λ^Y , and \mathbf{R} . Similarly, given the factor, the transition equation is simply a VAR model. The normal and the Inverse Wishart conditional distributions can be used to sample μ , δ , λ , and \mathbf{Q} . In line with Bernanke et al. (2005), and consistent with the standard VAR approach, we do not use prior distributions for the regression or VAR coefficients which

contemporaneous impact of \mathbf{Y}_t on the first element of \mathbf{X}_t . The implication of this is not restrictive in practice, as the main purpose of this paper is to analyze the effects of M_t on financial conditions. In addition, the variables in \mathbf{Y}_t can affect contemporaneously the financial variables in \mathbf{X}_t through their effect on F_t .

¹⁵One caveat is that the use of the Gibbs sampling methodology may impose significant computational costs when complex identification schemes are employed (Bernanke et al., 2005). Therefore, a recursive ordering is computationally more efficient.

¹⁶Further details are given in the next section.

¹⁷Empirical studies including Hatzius et al. (2010), Armendariz and Ramírez (2017), and Prasad et al. (2019) have used principal components analysis to estimate a FCI.

imply that the conditional posteriors collapse to OLS formula. As in Boivin et al. (2010) and Dahlhaus et al. (2018) we include one lag in the transition equation. Finally, given a draw for $\Lambda^F, \Lambda^Y, \mathbf{R}, \mu, \delta, \lambda$, and \mathbf{Q} the model can be cast into the state-space form shown above. Then, the Carter and Kohn (1994) algorithm can be used to draw F_t from its conditional distribution. Note that foreign financial variables do not enter into the observation and transition equations (1) and (2). Thus, foreign financial variables will not be affected by domestic variables. These variables are used only in a first step before starting the Gibbs sampling procedure to obtain an initial guess for F_t , together with the domestic financial variables included in \mathbf{X}_t which, up to a certain degree, also reflect financial conditions abroad. In this regard, from the system (1)-(2), F_t is constructed not only to summarize the information from the domestic financial markets but also to reflect, to some extent, financial conditions abroad. The Gibbs sampling algorithm and the Carter and Kohn algorithm are described in more detail in the Appendix A. Following Waggoner and Zha (2003) and MacDonald and Popiel (2020) the estimation is implemented with 5,000 iterations of the Gibbs sampling procedure, with the first 4,000 draws discarded as a burn-in and the remaining draws saved for inference.¹⁸

2.2 Data Description

In this subsection, we present the description of the variables included in the FAVAR model. This model is estimated at monthly frequency for the period December 2001 to September 2021 considering that macroeconomic variables are available on a monthly basis. As mentioned above, our main interest is to analyze the effects on financial conditions of the extraordinary measures implemented by the central bank of Mexico in the context of the effects derived from the COVID-19 pandemic. In particular, these measures were announced during the March and April 2020 monetary policy statements in order to foster an orderly functioning of financial markets, strengthen the provision of credit, and to supply liquidity for the sound development of the financial system. In turn, their withdrawal was announced in February 2021 and took place gradually from May to September 2021. In total, 15 mea-

¹⁸We diagnose convergence of the Gibbs sampler by inspecting the sequence of retained draws. We find that the use of 10,000 iterations or more gave essentially the same results.

asures were implemented, although only seven of them are measurable in domestic currency and two more in US dollars. The analysis presented in this paper is focused on the effects of those measures released in domestic currency. Table 1 presents a description of these measures as well as the total amount announced for each program.¹⁹ Specifically, we include into the model the end of month value for the outstanding aggregate amount of these measures M_t , that is, the amount used by financial institutions. Figure 1 illustrates the historical evolution of this series as well as the amount associated to each group of measures. Note that, the amount associated to the extraordinary measures is positive from April 2020 onwards, and zero before this period. In addition, not all the extraordinary measures were implemented at the same time. In fact, some of those measures were implemented at the middle of 2020, while others were deployed around the end of 2020.

According to their main purpose, the monetary authority grouped these measures in three large categories or groups. The first category includes those measures adopted to provide liquidity and reestablish operational conditions in money markets. In particular, the central bank of Mexico reduced the mandatory regulatory deposit at banks by 50 billion pesos, or about 15% of the current stock. With this facility, resources were released to support the active operations of commercial and development banks, thereby improving their liquidity and capacity to grant loans and to maintain or expand their credit lines. Likewise, the monetary authority opened a temporary securities swap window in order to provide liquidity to trading instruments whose operability and liquidity in the secondary market were affected as a result of uncertainty and volatility. In particular, this facility allowed for both commercial and development banks to exchange different securities for government bonds. The total amount

¹⁹A complete description of the extraordinary measures is presented in Banco de México (2020a). In addition to the three categories of measures presented in Table 1, the central bank implemented measures to promote an orderly behavior of the exchange rate market, as well as a greater availability of financing in dollars. In particular, following the instruction of the Foreign Exchange Commission, Banco de México expanded the non-deliverable FX forwards program from 20 to 30 billion US dollars. In addition, the monetary authority performed credit auctions in US dollars financed with the swap line facility with the Federal Reserve. This facility of up to 60 billion US dollars has been used to auction financing in US dollars to local credit institutions. Finally, the central bank incorporated the possibility to conduct foreign exchange hedge settled by differences in US dollars with institutions not domiciled in Mexico. As a robustness check, we also included the measures released in US dollars, particularly the non-deliverable FX forwards program expansion and the USD credit auctions financed with the swap line facility with the Federal Reserve. The results reported in Section 3 are consistent with our baseline specification.

| | Total amount announced | |
|---|------------------------|------------|
| | Billion pesos | % of GDP |
| Measures to provide liquidity and reestablish operational conditions in money markets | | |
| - Reduction of the Monetary Regulation Deposit | 50 | 0.2 |
| - Temporary securities swap window | 100 | 0.4 |
| Measures to promote an orderly behavior in governmental and corporate bond markets | | |
| - Government securities term repurchase window | 100 | 0.4 |
| - Swap of government securities | 100 | 0.4 |
| - Corporate Securities Repurchase Facility | 100 | 0.4 |
| Measures to strengthen the credit channels | | |
| - Provision of resources to channel credit to MSMEs and individuals | 250 | 1.0 |
| - Collateralized financing facility for commercial banks with corporate loans, to finance MSMEs | 100 | 0.4 |
| Total | 800 | 3.3 |

Table 1: Extraordinary Measures implemented by Banco de México

Source: Banco de México.

Notes: A complete description of the extraordinary measures is presented in Banco de México (2020a).

planned of this program was 100 billion pesos.²⁰

The second category consists of those measures implemented to promote an orderly behavior in governmental and corporate bond markets. In particular, Banco de México opened a government securities term repurchase window aiming to provide greater liquidity. This facility provided institutions holding government debt to obtain liquidity without having to dispose of their securities under highly volatile conditions in financial markets. In addition, through swap of government securities, the central bank received long-term securities (10-year and longer tenors) and delivered other securities with maturities of up to 3 years.

²⁰In addition to these two measures, the central bank also reduced the rate on the Ordinary Additional Liquidity Facility (FLAO, for its acronym in Spanish). The FLAO offers liquidity to commercial banks through collateralized credits or repos, the cost of which was reduced since April 1, 2020 from around 2.2 to 1.1 times Banco de México's target for the overnight interbank interest rate. In turn, the monetary authority provided further liquidity during trading hours to facilitate the optimal functioning of financial markets and payment systems. The purpose of this measure was to avoid distortions on the operational monetary policy target and the overnight interbank funding rate. Finally, Banco de México also extended the securities and counterparts eligible for the FLAO.

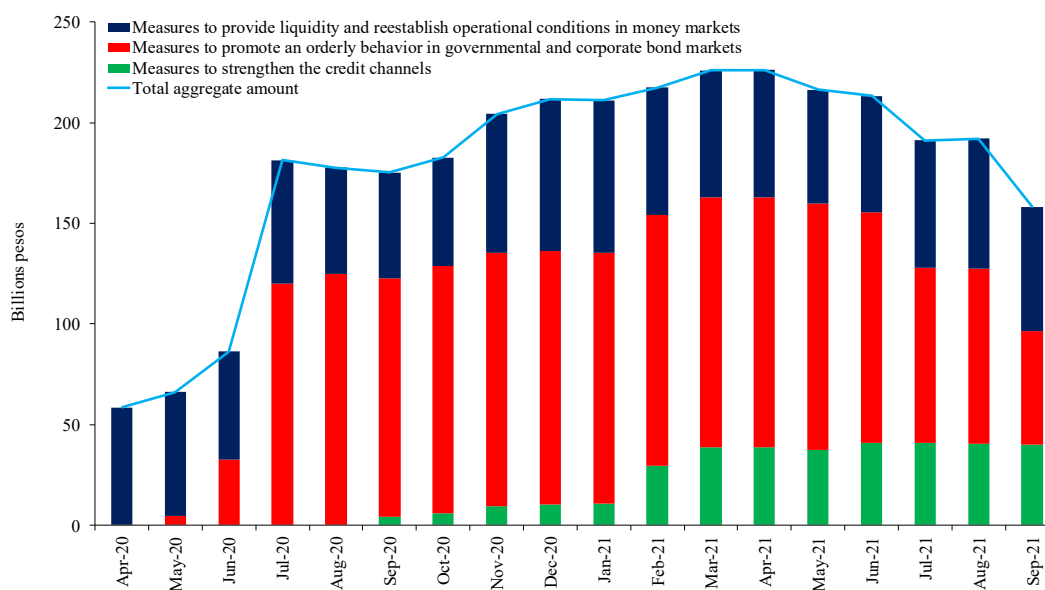


Figure 1: Outstanding Aggregate Amount of the Extraordinary Measures Implemented by Banco de México

Source: Banco de México.

Notes: A complete description of the extraordinary measures is presented in Banco de México (2020a).

Finally, the central bank established a corporate securities repo facility to provide liquidity in the secondary market of short-term corporate securities and long-term corporate debt that were affected as a result of uncertainty and volatility. Altogether, the amount announced for these three measures was 300 billion pesos.²¹ Finally, the third category includes measures to strengthen the credit channels. In particular, the central bank opened financing facilities for commercial and development banks (350 billion pesos) that allow them to channel resources to MSMEs and individuals affected by lockdown measures after the COVID-19 pandemic.

The rest of variables included in the estimation, together with their respective sources and transformations, are presented in Table 2.²² All financial variables described in this table

²¹In addition, jointly with the Ministry of Finance and Public Credit (SHCP, for its acronym in Spanish), two measures to strengthen the Government Debt Market Makers Program were also announced to foster a greater participation of the financial institutions in such program in the public debt market, thus contributing to its sound development. First, swaps of government securities held by market makers were implemented to allow a better management of their securities holdings. Second, the purchase option of government securities was changed. In particular, the exercise of this option was able to take place on the second banking day following the primary auction. Before this adjustment, the exercise time frame was of one banking day.

²²We use annual differences for the Mexican Stock Price Index and the exchange rate in order to moderate the

are included as end-of-month figures. The variables used in our analysis belong to different categories, including external financial conditions, foreign economic activity, country risk, money, debt, stocks, foreign exchange, domestic economy activity and inflation. We selected these variables following previous studies on the construction of FCIs, such as Hatzius et al. (2010), Koop and Korobilis (2014), and Prasad et al. (2019), and also studies on UMPs including Krishnamurthy and Vissing-Jorgensen (2011), and Gagnon et al. (2011), among others. In that sense, we include the VIX index, the Chicago Fed National Financial Conditions Index $NFCI_t^*$, and the US High Yield credit option adjusted spread $Spread_t^*$ as indicator variables for external financial conditions.²³ As can be seen in Table 2, these variables are not included neither in vector \mathbf{X}_t nor in vector \mathbf{Y}_t , i.e., they do not enter into the observation and transition equations (1) and (2). As mentioned above, they are used only in a first step together with the domestic financial variables included in \mathbf{X}_t to obtain an initial guess for the unknown factor before starting the Gibbs sampling procedure. In addition, we use the US Industrial Production Y_t^* as an indicator of foreign economic activity. This indicator is included as an exogenous variable in equation (2).

On the other hand, we include the bank funding interest rate i_t in vector \mathbf{X}_t as an indicator of the money market interest rate in Mexico.²⁴ Regarding the debt market variables included in such vector, the yield spread, $i_t^{10y} - i_t^{3m}$, is measured as the difference between the 10-year government bond yield i_t^{10y} and the 3-month interest rate on Mexican Treasury bills, CETES,

noise that the month-to-month volatility of these variables may bring into the model.

²³The VIX is a measure of expected financial volatility implied by the S&P 500 index options. In fact, the VIX index has been one of the proxies for investor risk aversion most used in the literature. Previous studies such as Gambacorta et al. (2014) and MacDonald and Popiel (2020) among others, have also used this indicator as a measure of global risk. For robustness, however, we also considered the risk aversion index calculated by Citigroup as an alternative indicator of risk aversion. Unlike the VIX index, which is derived from the equity market, the risk aversion index is derived from six different markets, particularly the US equity market, the emerging market debt, the interbank lending market, the corporate debt market, the foreign exchange market, and the interest rate market. The results reported in Section 3 are consistent with our baseline specification.

²⁴Unlike other money market interest rates like the interbank overnight funding rate (TIIE by its acronym in Spanish), which is available from 2006, the bank funding rate is calculated and provided by Banco de México from 1998 and thus allows us to consider a wider sample in our estimations. This rate is also an interbank interest rate that is representative in particular of the wholesale market secured with securities issued by banks. The interbank funding rate and the bank funding rate track each other so closely. Specifically, the correlation between both rates is 0.99.

i_t^{3m} .²⁵ In turn, the sovereign debt spreads, $i_t^{10y} - i_t^{*10y}$ and $i_t^{3m} - i_t^{*3m}$, are computed by using the US 10-year Treasury bond rate i_t^{*10y} and the US 3-month Treasury bill rate i_t^{*3m} , respectively. We include the 5-year credit default swap (CDS) as an indicator of country/default risk.²⁶ Because CDSs provide insurance on a bond default, we can infer the market's estimate of the likelihood of default directly from the price of this variable. The Mexican Stock Exchange Index is included to capture the Mexican stock market behavior. As indicators of the exchange rate market, we include the nominal peso-dollar exchange rate and the volatility implied in one-month options of the Mexican peso.²⁷ We use the Overall Indicator of Economic Activity (IGAE by its Spanish acronym), Y_t , as an indicator for domestic output.²⁸ Domestic inflation is measured by the monthly growth rate of the consumer price index P_t . The variables Y_t and Y_t^* are seasonally adjusted by their respective statistical offices. For the case of domestic prices, P_t , this variable is seasonally adjusted with the X13-ARIMA method. Finally, the sample period starts in 2001M12 as data on bond yields for some maturities are available from this date onwards. Hence, the beginning of our sample coincides with the adoption, on the part of Banco de México, of an inflation-targeting regime from 2001.²⁹

²⁵CETES are debt issued by the Federal Government through the Ministry of Finance and the Central Bank of Mexico. We use zero-coupon interest rates for both maturities in order to obtain comparable interest rates, as each bond pays different coupons for each maturity.

²⁶A CDS is a financial derivative that provides insurance against sovereign default. Its price is comparable to the payment of an insurance premium against such a event. An increase in its price reflects a rise in the assessment made by financial market participants that the risk of default materializes. For robustness, we also estimate the model using an alternative country-risk indicator, particularly the Mexico's EMBI plus spread. The results reported in Section 3 are consistent with our baseline specification.

²⁷In particular, we use an indicator of implied volatility, which is a measure of the degree of uncertainty that the options market attaches to future movements in the exchange rate. This variable is calculated from daily options of the Mexican peso-US dollar for one-month maturity contracts, and is obtained from Bloomberg. Thus, implied volatility incorporates not only historical information about exchange rates, but also market participants' expectations about future events that affect exchange rate volatility (Kim and Kim, 2003).

²⁸This indicator employs the methodology and the conceptual framework of the national accounts, in particular, GDP. The correlation between the Overall Indicator of Economic Activity and GDP for Mexico, both variables measured in quarterly percentage changes, is 0.99. IGAE is also subject to revisions. That is, the data actually available to the central bank at a particular month may differ from the final revised values released by the statistical office. Although it would be of interest to conduct the empirical exercise with real-time data in order to provide further information, this type of data for Mexican output is unavailable. Thus, we use revised data in our estimations.

²⁹According to Chiquiar et al. (2010), inflation in Mexico went from being a non-stationary process to being a stationary process around the end of 2000 or the beginning of 2001. In addition, Gaytán and González García (2007) find that the monetary policy transmission mechanism seems to have presented a structural change after this period. Low and stable inflation has provided certainty to financial contracts, reducing the risk premium of

| Category | Series | Definition | Transformation | Source |
|---|--------------------------|---|--------------------------|--------------------------|
| Foreign variables | | | | |
| External financial conditions | VIX | VIX Index | No transformation | Bloomberg |
| | $NFCI_t^*$ | Chicago Fed National Financial Conditions Index | No transformation | FRED |
| | $Spread_t^*$ | US High Yield credit option adjusted spread | No transformation | Bloomberg |
| Economic activity | Y_t^* | US Industrial Production Index, monthly | $\Delta \log Y_t^*$ | FRED |
| Variables contained in vector \bar{X}_t | | | | |
| Money market | i_t | Bank funding interest rate | No transformation | Banco de México |
| Debt market | $i_t^{10y} - i_t^{3m}$ | 10 year-3 month government bond yield spread | No transformation | Banco de México |
| | i_t^{10y} | 10-year government bond yield | No transformation | Banco de México |
| | $i_t^{10y} - i_t^{*10y}$ | 10 year Mexico-USA yield spread | No transformation | Banco de México and FRED |
| | $i_t^{3m} - i_t^{*3m}$ | 3 month Mexico-USA yield spread | No transformation | Banco de México and FRED |
| Country risk | CDS_t | 5-year credit default swap (CDS) | No transformation | Bloomberg |
| Stock market | IPC_t | Mexican Stock Market Index | $\Delta_{12} \log IPC_t$ | Grupo BMV |
| FX market | e_t | Exchange rate | $\Delta_{12} \log e_t$ | Banco de México |
| | σ_t | Volatility implied in one-month options of the Mexican peso | No transformation | Bloomberg |
| Variables contained in vector \bar{Y}_t | | | | |
| Economic activity | Y_t | Global Economic Activity Index, monthly | $\Delta \log Y_t$ | INEGI |
| Inflation | P_t | Consumer Price Index, monthly | $\Delta \log P_t$ | INEGI |

Table 2: Data Description

Notes: This table shows the variables included in the estimation, together with their respective sources and transformations.

3 Results

3.1 The estimated FCI

In this section we report the estimate for the unobserved factor F_t which we interpret as the FCI in Mexico. This factor summarizes the information from the financial variables included in the analysis.³⁰ The estimation was implemented with 5,000 iterations of the Gibbs sam-

interest rates, and allowing for longer term contracts.

³⁰To assess the relative importance of the domestic and financial variables in the FCI, we quantify the extent to which each of the variables is related with the FCI using a similar approach as in principal component analysis (Abdi and Williams, 2010). In particular, the relative contribution of domestic variables is calculated as the sum of the squared factor loadings for the domestic variables divided by the sum of squared factor loadings for all variables. In turn, factor loadings are defined as the correlation between each variable and the FCI. Using this approach, we find that domestic variables account for 65% of the variation in the FCI, while external variables account for 35% of such variation.

pling procedure, with the first 4,000 draws discarded as a burn-in and the remaining draws used to generate the estimate. As such, from the remaining 1,000 draws, we compute the median of \hat{F}_t at each point in time. Figure 2 shows the FCI for Mexico from December 2001 to September 2021 at monthly frequency. In particular, an increase in this variable denotes a deterioration in financial conditions, while a decrease signals an improvement in them. It is worth noting that our estimated FCI displays similar dynamics than the measures proposed by Armendariz and Ramírez (2017) and Carrillo and García (2021) for the common sample period.³¹ Notice that the FCI accurately captures periods in which financial conditions tightened significantly, such as the aftermath of the collapse of the dot-com bubble and the terrorist attacks on September 2001, the global financial crisis of 2008–2009 and, more recently, the financial shock of the COVID-19 pandemic. As can be observed, the behavior observed during the COVID-19 pandemic stands out, when the FCI reached its highest level after the global financial crisis of 2008-2009. Noted that, in a context in which the performance of global and local financial markets improved, the latter likely associated with the extraordinary measures implemented by the central bank of Mexico, the FCI decreased considerably from May 2020.

3.2 Impulse Response Functions

This section presents the impulse-response functions of the estimated FCI for the Mexican economy and a set of key financial variables that compose it to a shock to the outstanding amount of the extraordinary measures implemented by Banco de México. The size of this shock is one standard deviation and amounts to 7.5 billion pesos. The estimated FAVAR model is stable since the inverse roots of the characteristic polynomial have modulus less than one and lie inside the unit circle for each draw of the Gibbs sampling procedure. Responses are presented for a 36-month horizon with the associated 68% highest posterior density intervals (HPDIs).

³¹Banco de México (2019) also introduced a FCI for Mexico computed through a FAVAR model as in Koop and Korobilis (2014) at a monthly basis, starting in January 2005. Within the common sample, our results are also consistent with this index, attaining a correlation of 0.9. As such, the messages provided by the indices regarding financial conditions are very similar for the common sample.

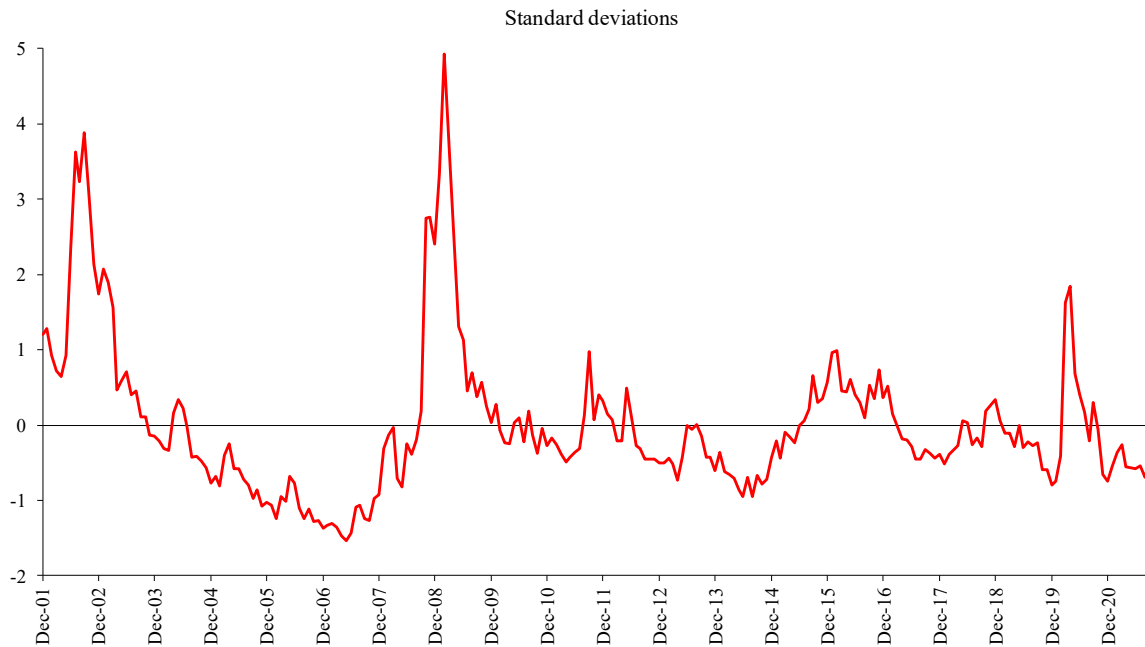


Figure 2: Financial Conditions Index in Mexico

Source: Authors' estimates using data from Banco de México, INEGI, Grupo BMV, Bloomberg and FRED.

Notes: This figure shows the median estimate for the unobserved factor F_t which we interpret as the FCI for Mexico from December 2001 to September 2021 at monthly frequency. The estimation was implemented with 5,000 iterations of the Gibbs sampling procedure, with the first 4,000 draws discarded as a burn-in and the remaining draws used to generate the estimate.

As can be seen in Figure 3, an increase in the outstanding amount of the extraordinary measures is followed by a decrease in the FCI, suggesting an improvement in financial conditions.³² In particular, we can see persistent and statistically significant effects from the second month. The maximum effect is observed three months after the shock. This finding indicates that the extraordinary measures implemented by Banco de México during 2020–2021 could have contributed to ease the financial turmoil and foster an orderly functioning of financial markets in the context of the effects derived from the COVID-19 pandemic. In fact, the implementation of these measures seem to have the expected effect on each of the financial variables depicted in Figure 4. As can be seen in this figure, an increase in these measures

³²It is worth noting that, in our model, we are not assuming that foreign financial variables used in the estimation of the FCI respond to a shock to the outstanding amount of the extraordinary measures. In this sense, the FCI is expected to respond to the aforementioned shock because of the potential effects that the extraordinary measures can have on domestic financial variables rather than on foreign ones.

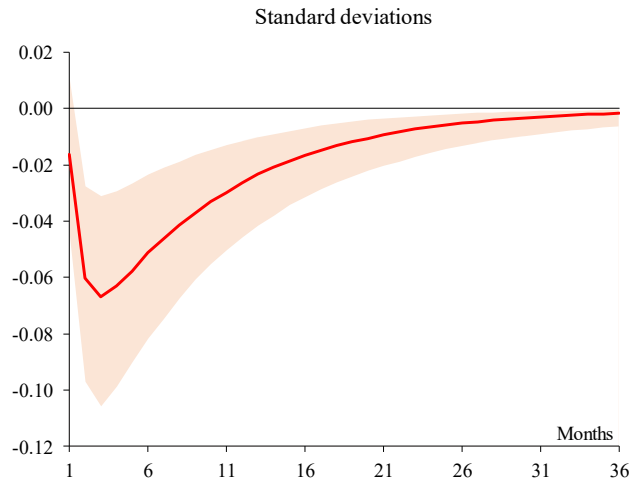


Figure 3: Response of the FCI to a Shock in the Outstanding Amount of the Extraordinary Measures

Source: Authors' estimates using data from Banco de México, INEGI, Grupo BMV, Bloomberg and FRED.

Notes: This figure shows the median impulse response for the unobserved factor F_t , which we interpret as the FCI for Mexico, to a shock in the outstanding amount of the extraordinary measures implemented by the central bank of Mexico. Responses are presented for a 36-month horizon with the associated 68% highest posterior density intervals (HPDIs). 5,000 simulations, with the first 4,000 as burn-in, were used to generate the responses.

is followed by decreases in the sovereign risk premium, the yield spreads between Mexico and the US, the 10-year government bond yield, the slope of the yield curve, the exchange rate and the volatility of the exchange rate. In addition, the stock index rises with increases in the outstanding amount of the extraordinary measures. These results are consistent with the empirical evidence for AEs presented by Krishnamurthy and Vissing-Jorgensen (2011), Gagnon et al. (2011), Bhattarai and Neely (2016), Lombardi et al. (2018), and Hartley and Rebucci (2020), among others, who highlight the effectiveness of UMP measures to influence several of these variables through QE. It is worth noting that the mere announcement of the measures alone could have had an impact on financial conditions. This effect of the measures could have been considerable, although it can not necessarily be captured using the outstanding amount of the referred measures as specified in the proposed FAVAR model.

Consistent with Krishnamurthy and Vissing-Jorgensen (2011) and Gagnon et al. (2011), the extraordinary measures are found to have a strong effect on the risk of sovereign de-

fault, which we measure from the price of the 5-year CDS. In fact, our results suggest that the implementation of these measures seem to have played an important role in decreasing the market's estimate of the likelihood of sovereign default in the Mexican economy. In particular, such measures could have reduced the risk of sovereign default by generating expectations of improved financial and macroeconomic conditions (Bhattarai and Neely, 2016). In turn, the negative responses of the 10-year government bond yield, the spreads between the domestic and US interest rates, and the slope of the yield curve, could be associated with a combination of effects of the extraordinary measures on long and short-term yields through signaling and portfolio balance channels.³³ As explained by Bhattarai and Neely (2016), the signaling channel operates by reducing expected future short-term interest rates and thereby by reducing the expectations component of long-term interest rates. Regarding the portfolio balance channel, Bhattarai and Neely (2016) emphasize that with imperfect substitutability, some of these measures can change the relative supplies of bonds and influence the yield of those bonds and others with similar characteristics through their effect on some of the term premium components, such as the liquidity premium and the safety premium. In particular, such measures might reduce the liquidity premium, which reflects the expected ease of trading in a given bond. In addition, to the extent that the extraordinary measures have been able to reduce market perceptions of extreme events, the safety premium, which reflects the value investors attach to the safety of the asset, is likely to have decreased with the implementation of such policies.

As can be seen in Figure 4, we also obtain a positive response of stock prices following a one standard deviation shock to the amount of extraordinary measures. This result could indicate that these measures may also have affected the expectations of economic activity and thereby stock prices (Bhattarai and Neely, 2016), which are the expected discounted stream of future cash flow. Finally, regarding the negative responses of the exchange rate and its volatility, our results suggest that the extraordinary measures may have helped to restore

³³ Empirical studies as Gagnon et al. (2011), Bauer and Rudebusch (2014), Christensen and Rudebusch (2012), Bauer and Neely (2014), and Hattori et al. (2016), among others, have combined term structure models with event studies to analyze the effects of UMPs on long-term interest rates through these channels. In general, both channels are found to be important.

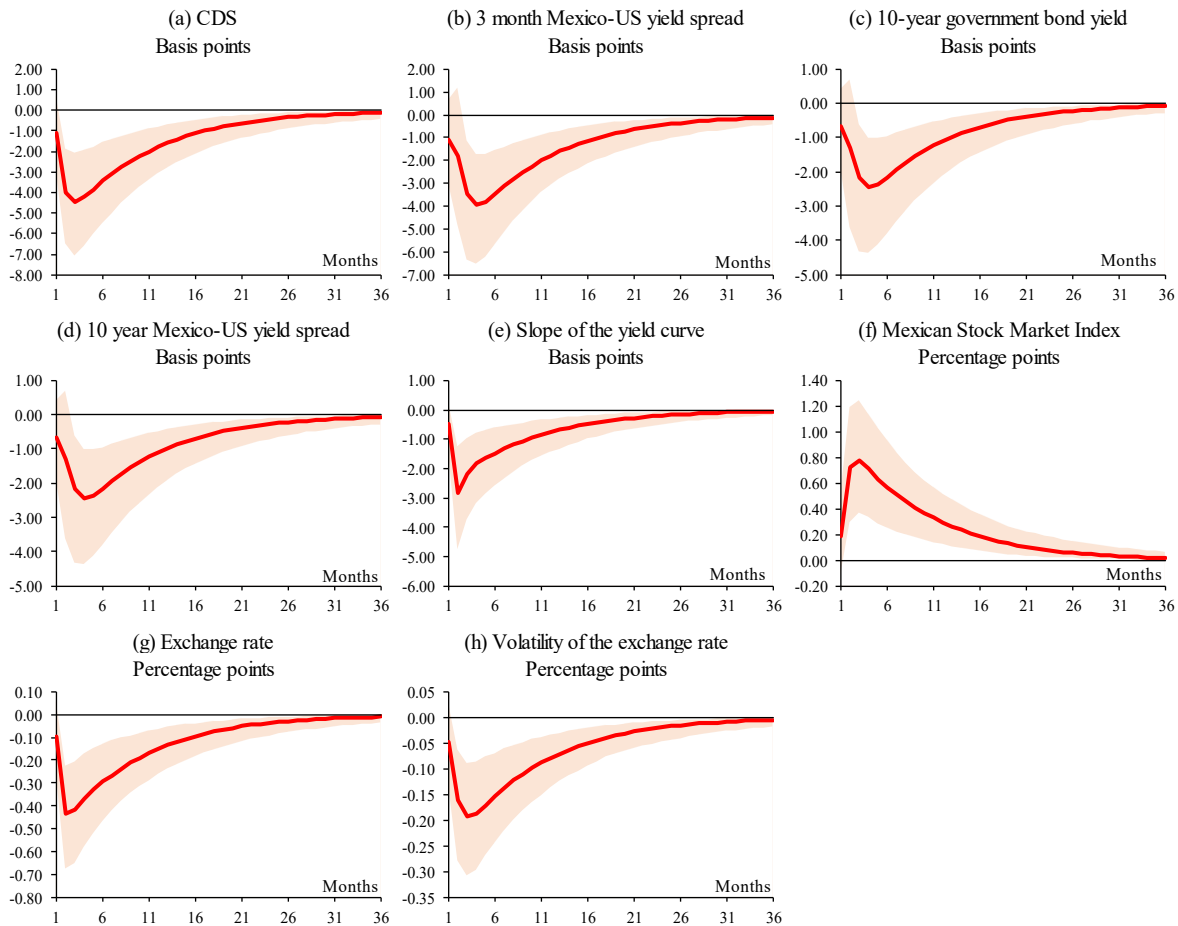


Figure 4: Impulse Response Functions

Source: Authors' estimates using data from Banco de México, INEGI, Grupo BMV, Bloomberg and FRED.

Notes: This figure shows the median impulse responses for each of the variables to a shock in the outstanding amount of the extraordinary measures implemented by the central bank of Mexico. Responses are presented for a 36-month horizon with the associated 68% highest posterior density intervals (HPDIs). 5,000 simulations, with the first 4,000 as burn-in, were used to generate the responses.

the confidence of international investors who participate in the local currency bond market. These results are somewhat consistent with Fratto et al. (2021) who find that extraordinary measures implemented during 2020 were successful in interrupting depreciation trends in EMEs.

In sum, the extraordinary measures implemented by Banco de México, in the context of the effects derived from the COVID-19 pandemic, seem to have contributed to improve financial conditions in Mexico. Therefore, in line with an extensive part of literature, who

highlight the effectiveness of these measures during periods of high financial volatility, our results also seem to support the importance of such policies as powerful tools to blunt the negative economic effects of a financial crisis. Motivated by these issues, in the next section we present a counterfactual forecasting exercise, which allows us to further quantify the effects of the extraordinary measures on the dynamics of financial conditions.

3.3 Counterfactual Exercise

In order to further assess the quantitative effects of the extraordinary measures implemented by Banco de México on financial conditions, we consider a counterfactual of what would have happened had such measures not been undertaken. In particular, using the last 1,000 draws of the Gibbs sampling procedure, we construct two in-sample forecasts. The first forecast is conditional on actual values for the outstanding amount of these measures, as well as on the other variables in the system.³⁴ We then compare it with an in-sample counterfactual scenario forecast in which the amount of the extraordinary measures remains at zero, i.e., evolving according to its pre-crisis path instead, while the other variables remain unrestricted. In line with Lenza et al. (2010), Pesaran and Smith (2014), and Dahlhaus et al. (2018), we measure the effect of the extraordinary measures as the difference between these two forecasts.³⁵ It is worth noting that the forecasts of the FAVAR model are dynamic, that is, they use the predicted values of the model variables in previous periods and, therefore, take into account the lagged effects of the extraordinary measures, as well as the feedback between all the variables included in the model.

Figures 5 and 6 report the results of this exercise. We show each original series (blue

³⁴The procedure is done for each Gibbs iteration after the burn-in period. Therefore in the end we have a set of 1,000 forecasts. This represents an estimate of the posterior density.

³⁵Note that the financial shock derived from the COVID-19 pandemic and the subsequent endogenous policy response in the form of extraordinary measures is reflected in the last observations of the sample period in the data. Thus, the accuracy of this exercise could improve in the future with further occurrences of similar events. An additional caveat on our exercise is that our method delivers interpretable results under the assumption that the coefficients of the estimated FAVAR model under both scenarios are similar. In this case, the difference in the conditional paths can be interpreted as the result of the implementation of the extraordinary measures rather than the effect of both the non-implementation of such measures and changes in the behavioral relationships. These caveats should be kept in mind when interpreting the results that follow.

line) with its counterfactual path (red line), which is constructed from May 2020 to September 2021 by adding to the observed series (estimated series in the case of the FCI) the difference between the counterfactual and baseline forecasts. We interpret such counterfactual path as the estimated path for the financial conditions had the central bank of México not implemented the extraordinary measures. The counterfactual paths are presented with their associated 68% confidence intervals (red dashed lines). As can be seen in Figure 5, the implementation of these measures seemed to have contributed to improve financial conditions as a whole. In December 2020, the estimated value for the FCI is about 0.8 standard deviations lower than its counterfactual path for which the extraordinary measures are not implemented. Note that the effects of the extraordinary measures seem to be growing during the first four months after their implementation and then remain relatively stable until the middle of 2021, date in which those extraordinary measures started to be withdrawn. Around this date, the effect of the extraordinary measures on financial conditions seems to decrease slowly. The decay in this effect may be explained because the withdrawal of such measures, announced in February 2021, was in fact both gradual and anticipated.

As can be seen in Figure 6, the effects of the financial shock derived from the COVID-19 pandemic led, in a very short period of time, to significant increases in sovereign credit risk and long-term interest rates, a depreciation and a higher volatility of the domestic currency, as well as a sharp fall in the stock market. In addition, the spreads between Mexican and US interest rates increased considerably, probably reflecting a large rise in the different risk premium that investors demand for holding domestic assets. In general, the largest impact on financial conditions took place in March and April 2020. In this context, the central bank of Mexico implemented the series of unconventional measures in order to ease the financial turmoil and foster a more orderly functioning of financial markets. The implementation of such measures seemed to have had the expected effect on each of the financial variables analyzed (see Figure 6). In particular, the observed value for the sovereign risk premium, the yield spreads between Mexico and the US, the 10-year government bond yield, the slope of the yield curve, the exchange rate and the volatility of the exchange rate, is lower than its counterfactual path for which the extraordinary measures are not implemented. The opposite

occurs for the stock index. Specifically, the simulations suggest that by December 2020, the levels of the sovereign risk premium, the 10-year government bond yield, the slope of the yield curve, and the long and short-term yield spreads between Mexico and the US are higher by around 56, 31, 28, 37, and 48 basis points, respectively, in the counterfactual scenario, in which the extraordinary measures are not implemented, compared to the observed scenario. At the same time, the exchange rate and its volatility are higher by 5 and 2.5 percentage points, respectively. In the stock market, we find that the stock price index is 9.5 percentage points lower in December 2020 in the counterfactual scenario. The estimated effects are increasing during the first four to five months after the extraordinary measures are implemented and then remain relatively stable until the middle of 2021. Around this date, the effect of the extraordinary measures on financial conditions seems to decrease slowly. Therefore, in line with an extensive part of the literature that highlights the effectiveness of these measures during periods of high financial volatility, our results also seem to support the importance of such measures as powerful tools to blunt the negative economic effects of a financial crisis.

Until now, we have analyzed the effects of the extraordinary measures as a whole. As mentioned in Section 2.2, however, the monetary authority grouped these measures in three large categories according to their main purpose. The first category included those measures adopted to provide liquidity and reestablish operational conditions in money markets; the second one consisted of those measures implemented to promote an orderly behavior in governmental and corporate bond markets; finally, the third category included those measures to strengthen the credit channels (see Table 1). As mentioned earlier, not all the extraordinary measures were implemented at the same time. In fact, some of those measures were implemented at the middle of 2020, while others were deployed around the end of 2020 (see Figure 1). In that regard, it could be also relevant to individually analyze the effects of each group of measures as well as its relative importance on the dynamics of financial conditions. In order to do this, we perform an additional counterfactual exercise where the estimated effects of each group of measures are computed as the difference between two in-sample forecasts. The first one is computed as before, i.e., conditional on actual values for the outstanding aggregate

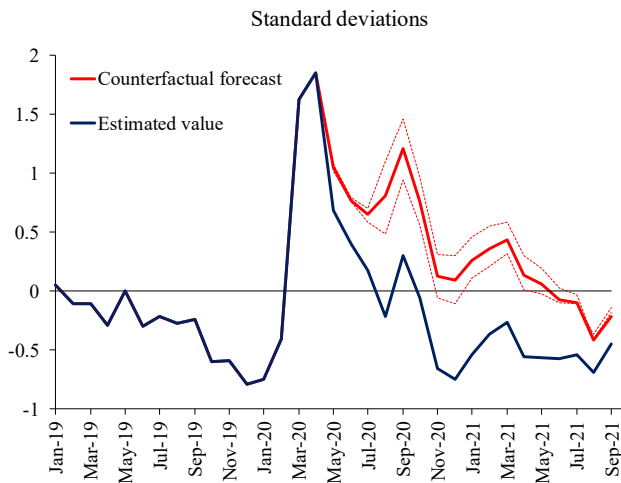


Figure 5: Estimated Value and Counterfactual Forecast for the FCI conditional on the Counterfactual Outstanding Amount of the Extraordinary Measures

Source: Authors' estimates using data from Banco de México, INEGI, Grupo BMV, Bloomberg and FRED. Notes: This figure shows the estimated path and a counterfactual path for the estimated FCI for Mexico with its 68% credible intervals. The counterfactual path is constructed by adding to the estimated series the difference between two forecasts. The first one is obtained conditional on the actual outstanding amount of the extraordinary measures (as well as on the other variables in the system). The second one is obtained with the amount of such measures remaining at zero, i.e., evolving according to its pre-crisis path instead, and the other variables remaining unrestricted. 5,000 simulations, with the first 4,000 as burn-in, were used to generate the forecasts.

amount of these measures. The second one is conditional on actual values for the outstanding aggregate amount of these measures but excluding one particular group of measures. We interpret the difference between these two forecasts as the estimated effect of each group of measures on financial conditions.

Figure 7 reports the results of this exercise. In particular, the bars represent the estimated effects of each group of measures on each financial variable, while the solid line represents the estimated effects of the aggregate amount of the extraordinary measures during their period of implementation. The results show that the first group of measures that were implemented and used by financial institutions, those oriented to promote liquidity and reestablish operational conditions in money markets, initially had a greater effect on financial markets, from May to July 2020. Subsequently, the second group of measures, particularly those measures aimed at promoting an orderly behavior in the bond markets, becomes relatively more important

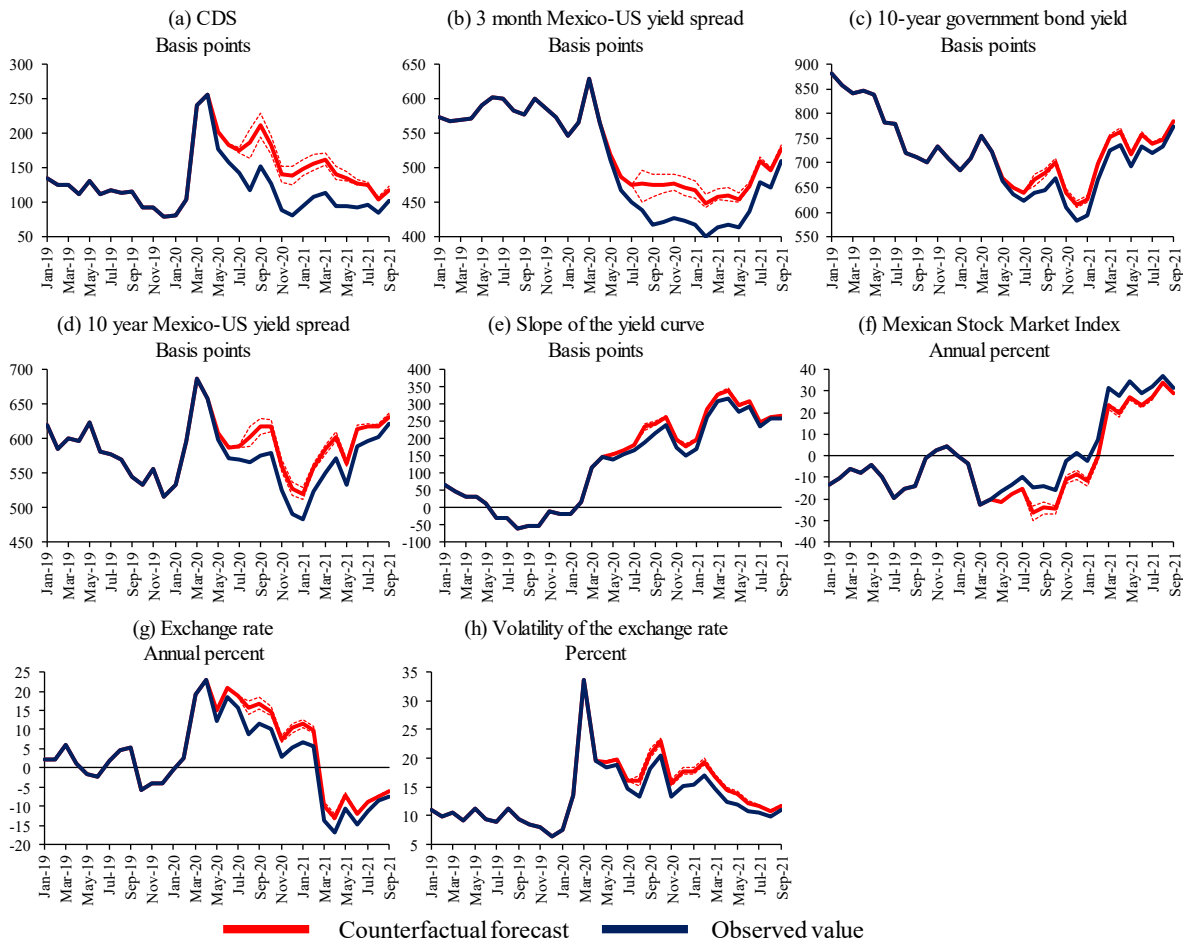


Figure 6: Observed Value and Counterfactual Forecast Conditional on the Counterfactual Outstanding Amount of the Extraordinary Measures

Source: Authors' estimates using data from Banco de México, INEGI, Grupo BMV, Bloomberg and FRED.

Notes: This figure shows the observed path and a counterfactual path for each variable with its associated 68% credible intervals. The counterfactual path is constructed by adding to the observed series the difference between two forecasts. The first one is obtained conditional on the actual outstanding amount of the extraordinary measures (as well as on the other variables in the system). The second one is obtained with the amount of such measures remaining at zero, i.e., evolving according to its pre-crisis path instead, and the other variables remaining unrestricted. 5,000 simulations, with the first 4,000 as burn-in, were used to generate the forecasts.

from August 2020 to July 2021. At the end, the measures oriented to strengthen the credit channels, the last ones that were implemented, had a more important effect, from August to September 2021. Finally, the results also show that as the extraordinary measures are withdrawn, since May 2021, the effect on financial conditions starts to decrease slowly. As mentioned above, the smooth decay in this effect may be explained because such withdrawal,

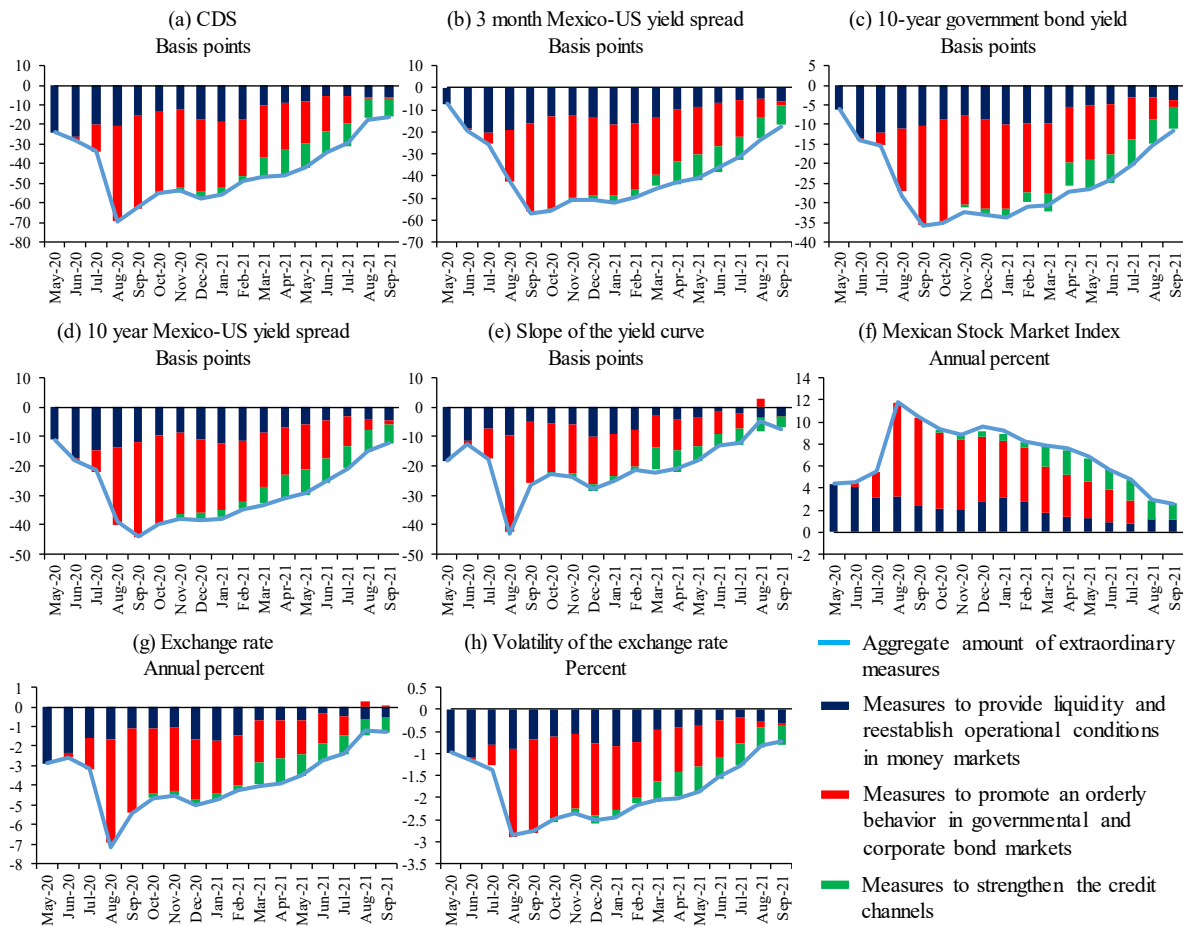


Figure 7: Estimated Effects of each Group of the Extraordinary Measures on Financial Conditions

Source: Authors' estimates using data from Banco de México, INEGI, Grupo BMV, Bloomberg and FRED.

Notes: This figure shows the estimated effects of each group of measures on each financial variable. The estimated effects of each group of measures are computed as the difference between two forecasts. The first one is obtained conditional on the actual outstanding aggregate amount of the extraordinary measures (as well as on the other variables in the system). The second one is conditional on actual values for the outstanding aggregate amount of these measures but excluding one particular group of measures, while the other variables remain unrestricted. 5,000 simulations, with the first 4,000 as burn-in, were used to generate the forecasts.

announced in February 2021, was in fact both gradual and anticipated.

3.4 Robustness Exercises

In this subsection, we present some robustness exercises including alternative specifications, additional and alternative variables, among others. In particular, we report in Appendix B the impulse response functions and counterfactual exercises corresponding to the financial variables.³⁶ As previously mentioned, in our baseline specification we introduce the vector \mathbf{Y}_t into the observation equation in order to purge the FCI, F_t , from the effect of current economic activity and prices. As a first robustness check, we estimated the model by excluding this vector from such equation. The results from this exercise, reported in Figures B.1 and B.2 of the Appendix B are very similar to our benchmark findings, as highlighted in Section 2.1 and outlined in Bernanke et al. (2005).

In addition, we also estimate the model using a two-step estimation method. In the first step, the factor F_t is estimated through principal components from all the variables described in Section 2.2. Then, in the second step, the FAVAR system is estimated by Bayesian methods, with F_t replaced by \hat{F}_t . As in the one-step Bayesian likelihood approach, the estimation is implemented with 5,000 iterations, with the first 4,000 draws discarded as a burn-in and the remaining draws saved for inference. The results from this exercise, reported in Figures B.3 and B.4 of the Appendix B, are very similar to those using the single-step Bayesian likelihood approach followed in our baseline specification.

In turn, we also estimate the model by including into M_t the outstanding amount of two additional measures implemented in US dollars by Banco de México, particularly the non-deliverable FX forwards program expansion and the USD credit auctions financed with the swap line facility with the Federal Reserve. The outstanding amount of such programs was 8.6 billion US dollars, equivalent to 174.3 billion pesos by December 2020.³⁷ In general,

³⁶Those corresponding to the FCI are available from the authors upon request.

³⁷Data are converted to pesos using the end-of-month exchange rate. The non-deliverable FX forwards program was first implemented in 2017 in order to provide liquidity to the foreign exchange market and attenuate episodes of high volatility in the exchange rate at the beginning of that year. In addition, in April 2009, Banco de México tapped into the temporary currency swap line established with the US Federal Reserve. In particular, the central bank used the funds from this mechanism to auction 4 billion US dollars in loans among Mexico's commercial and development banks, of which 3.22 billion were allocated. Thus, considering these two additional programs, the outstanding amount associated to the extraordinary measures is positive from April to June 2009 and from March 2017 onwards.

the results reported in Figures B.5 and B.6 of the Appendix B are consistent with our baseline specification. Results from the impulse-response functions, for instance, suggest that the implementation of such programs seem to have the expected effect on each of the financial variables analyzed. Regarding the counterfactual analysis, results indicate that the extraordinary measures seem to have contributed to ease the financial turmoil during the period 2020–2021 and foster an orderly functioning of financial markets.

In addition, we also estimate the model using an alternative global risk indicator, particularly the risk aversion index provided by Citigroup instead of the VIX index. This index allows us to consider financial volatility across a broader set of markets.³⁸ The results from this exercise, reported in Figures B.7 and B.8 of Appendix B, are very similar to the baseline specification.

Finally, we estimate the model using an alternative country-risk indicator instead of the CDS. In particular, we used the Mexico’s EMBI plus spread obtained from Bloomberg, which reflects the difference between the yields on sovereign bonds issued by the local government and bonds issued by governments of the industrialized world with identical currency denomination and maturity. In particular, the EMBI+ index includes US dollar and other external currency denominated Brady bonds, Eurobonds, and traded loans issued by sovereign entities. The results from this exercise, reported in Figures B.9 and B.10 of Appendix B, are consistent with our benchmark results.

4 Conclusion

In the face of the COVID-19 pandemic and the complex and uncertain environment, financial markets showed significant adjustments, lower liquidity, and a deterioration of trading conditions. In this article, we studied the effects of the extraordinary measures implemented by the central bank of Mexico on financial conditions in the context of the effects derived from the COVID-19 pandemic. The analysis is carried out by estimating impulse-response

³⁸Unlike the VIX index, which only includes information on the US equity market, the risk aversion index is derived from six different markets, particularly the US equity market, the emerging market debt, the interbank lending market, the corporate debt market, the foreign exchange market, and the interest rate market.

functions and conducting counterfactual exercises from a FAVAR model. This model allows us to construct the FCI from a set of financial variables, as well as estimating the effects on each of these variables from an increase in the extraordinary measures in a parsimonious framework. Results from the impulse-response functions suggest that an increase in the outstanding amount of these measures is followed by a decrease in the estimated FCI, suggesting an improvement in financial conditions. In fact, an increase in these measures is followed by decreases in the sovereign risk premium, the long and short-term yield spreads between Mexico and the US, the 10-year government bond yield, the slope of the yield curve, the exchange rate and its volatility. In addition, the stock index rises with increases in the outstanding amount of the extraordinary measures, suggesting that the implementation of such programs seemed to have the expected effect on each of the financial variables analyzed.

Regarding the counterfactual analysis, we find that if these measures had not been implemented, the sovereign risk premium, the 10-year government bond yield, the slope of the yield curve, and the long and short-term yield spreads between Mexico and the US would have been higher by around 56, 31, 28, 37, and 48 basis points in December 2020, respectively. At the same time, the exchange rate and its volatility would have been higher by 5 and 2.5 percentage points, respectively. In turn, the Mexican stock market index would have been lower by 9.5 percentage points. In addition, our results also seem to indicate that the first group of measures that were implemented and used by financial institutions, those oriented to promote liquidity and reestablish operational conditions in money markets, initially had a greater effect on financial markets. Subsequently, the second group of measures, particularly those measures aimed at promoting an orderly behavior in the bond markets, became relatively more important. At the end, the measures oriented to strengthen the credit channels, the last ones that were implemented, had a more important effect. Thus, these results suggest that regardless of the implementation timing, the extraordinary measures deployed by the central bank of Mexico during 2020–2021 contributed to ease the financial turmoil and foster an orderly functioning of financial markets in the context of the effects derived from the COVID-19 pandemic. It is worth mentioning that the mere announcement of the measures alone could have had an impact on financial conditions. This effect of the measures could

have been considerable, although it can not necessarily be captured using the outstanding amount of the referred measures as specified in the proposed FAVAR model.

This study has important implications from the point of view of economic policy. In particular, our findings highlight the effectiveness of the extraordinary measures in responding to a financial shock, such as that derived from the COVID-19 pandemic. In that sense, the lessons learned from the evidence for Mexico could be important for the further development of these measures in future EMEs policy frameworks. Policy makers' decisions in these economies could be adapted to consider the importance of these measures as powerful tools to blunt the negative economic effects of a financial crisis.

Further research could examine alternative methods based on the analysis of the high-frequency response of financial variables around the time of the announcement of the extraordinary measures. Another area of research would be to analyze a larger set of financial variables including, for instance, market interest rates. Finally, the impact of extraordinary measures on economic growth and other macroeconomic indicators could also be analyzed.

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A Appendix: The Gibbs Sampling Algorithm

The state-space representation of the FAVAR model is as follows

$$\mathbf{X}_t = \Lambda \beta_t + \mathbf{v}_t \quad (1)$$

or

$$\begin{pmatrix} X_{1t} \\ X_{2t} \\ \vdots \\ X_{Nt} \\ \Delta \log Y_t \\ \Delta \log P_t \\ \Delta M_t \end{pmatrix} = \begin{pmatrix} \gamma_{11} & \gamma_{12} & 0 & b_1 \\ \gamma_{21} & \gamma_{22} & 0 & b_2 \\ \vdots & \vdots & \vdots & \vdots \\ \gamma_{N1} & \gamma_{N2} & 0 & b_N \\ 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \end{pmatrix} \begin{pmatrix} \Delta \log Y_t \\ \Delta \log P_t \\ \Delta M_t \\ F_t \end{pmatrix} + \begin{pmatrix} v_{1t} \\ v_{2t} \\ \vdots \\ v_{Nt} \\ 0 \\ 0 \\ 0 \end{pmatrix} \quad (2)$$

where $\mathbf{X}_t = [\widetilde{\mathbf{X}}_t, \Delta \log Y_t, \Delta \log P_t, \Delta M_t]$. Note that $\widetilde{\mathbf{X}}_t$ is a set of N domestic financial variables representing financial conditions. In addition, $\widetilde{\mathbf{X}}_t$ is related to output growth, $\Delta \log Y_t$, inflation, $\Delta \log P_t$, and the factor, F_t , via the coefficients γ_{i1} , γ_{i2} and b_i , respectively. In turn, $\Delta \log Y_t, \Delta \log P_t$ and even ΔM_t appear in the state vector β_t (even though they are observed) as we want them to be part of the transition equation. Therefore the last rows of the coefficient matrix Λ describe the identities $\Delta \log Y_t = \Delta \log Y_t$, $\Delta \log P_t = \Delta \log P_t$ and $\Delta M_t = \Delta M_t$.

In turn, the covariance matrix R is given by

$$\text{Var}(V_t) = R = \begin{pmatrix} R_1 & 0 & 0 & \dots & 0 & 0 & 0 \\ 0 & R_2 & 0 & \dots & 0 & 0 & 0 \\ \vdots & 0 & \ddots & 0 & 0 & 0 & 0 \\ 0 & 0 & \dots & R_M & 0 & 0 & 0 \\ 0 & 0 & \dots & 0 & 0 & 0 & 0 \\ 0 & 0 & \dots & 0 & 0 & 0 & 0 \\ 0 & 0 & \dots & 0 & 0 & 0 & 0 \end{pmatrix} \quad (3)$$

The transition equation of the model is

$$\beta_t = \mu + \lambda\beta_{t-1} + e_t \quad (4)$$

or

$$\begin{pmatrix} \Delta \log Y_t \\ \Delta \log P_t \\ \Delta M_t \\ F_t \end{pmatrix} = \begin{pmatrix} \mu_1 \\ \mu_2 \\ \mu_3 \\ \mu_4 \end{pmatrix} + \begin{pmatrix} A_{11} & A_{12} & A_{13} & A_{14} \\ A_{21} & A_{22} & A_{23} & A_{24} \\ A_{31} & A_{32} & A_{33} & A_{34} \\ A_{41} & A_{42} & A_{43} & A_{44} \end{pmatrix} \begin{pmatrix} \Delta \log Y_{t-1} \\ \Delta \log P_{t-1} \\ \Delta M_{t-1} \\ F_{t-1} \end{pmatrix} + \begin{pmatrix} e_{1t} \\ e_{2t} \\ e_{3t} \\ e_{4t} \end{pmatrix} \quad (5)$$

where we have omitted the exogenous variable Z_t that contains foreign output, as indicated in Section 2.1, for notation simplicity. In turn,

$$\text{VAR}(e_t) = Q = \begin{pmatrix} Q_{11} & Q_{12} & Q_{13} & Q_{14} \\ Q_{21} & Q_{22} & Q_{23} & Q_{24} \\ Q_{31} & Q_{32} & Q_{33} & Q_{34} \\ Q_{41} & Q_{42} & Q_{43} & Q_{44} \end{pmatrix} \quad (6)$$

The Gibbs sampling algorithm consists of the following steps:

Step 1 Conditional on β_t , sample Λ and R from their posterior distributions.

1) Given an initial guess for F_t estimated by principal components, from the financial variables in X_t and a set of J foreign financial variables, and considering we do not use prior distributions for the regression or VAR coefficients, the observation equation is just N linear regressions of the form $\tilde{X}_{it} = \gamma_{i1}\Delta \log Y_t + \gamma_{i2}\Delta \log P_t + b_i F_t + v_{i,t}$ and the normal distribution applies immediately to sample the elements of Λ . In particular, for each variable in \tilde{X}_{it} the coefficients γ_{ij} and b_i have a normal conditional posterior $H(\Lambda_i \setminus \beta_t, R_{ii}) \sim N(\Lambda_i^*, V_i^*)$.

$$\Lambda_i^* = (\beta_t' \beta_t)^{-1} (\beta_t' X_{it}) \quad (7)$$

$$V_i^* = \left(\frac{1}{R_{ii}} \beta_t' \beta_t \right)^{-1} \quad (8)$$

We arbitrarily set the variance of the error terms R_{ii} in the observation equation to one in

order to start the Gibbs sampling procedure. The choice of starting values for R_{ii} has little impact on the final results given that the number of Gibbs iterations is large enough.

2) Conditional on β_t and Λ , we sample R_{ii} from the inverse Gamma distribution with scale parameter $(\tilde{X}_{it} - \beta_t \Lambda_i)' (\tilde{X}_{it} - \beta_t \Lambda_i)$ and degrees of freedom T , where T is the length of the estimation sample (hence using information from the data only; prior degrees of freedom and the prior scale matrix are set to 0).

Step 2 Conditional on β_t sample μ , λ and Q from their posterior distributions.

1) Conditional on β_t and the error covariance matrix Q , which we set to an identity matrix to start the algorithm, the posterior for the VAR coefficients $B = \{\mu, \lambda\}$ is normal and given as $H(B \setminus \beta_t, Q) \sim N(B^*, D^*)$

$$B^* = (\bar{X}_t' \bar{X}_t)^{-1} (\bar{X}_t' \beta_t) \quad (9)$$

$$D^* = \left(Q^{-1} \otimes \beta_t' \beta_t \right)^{-1} \quad (10)$$

where $\bar{X}_t = \{\beta_{t-1}, 1\}$.

2) Conditional on β_t and the VAR coefficients, Q has a inverse Wishart posterior with scale matrix $(Y_t - \bar{X}_t B)' (Y_t - \bar{X}_t B)$ and degrees of freedom T .

Step 3 Conditional on the parameters of the state space model Λ , R , μ , λ , and Q , sample the state variable β_t from its conditional posterior distribution.

Given Λ , R , μ , λ , and Q the model can be cast into state-space form and then the factor F_t is sampled from its conditional posterior distribution via the Carter and Kohn algorithm. We describe this algorithm in detail below.

The Carter and Kohn algorithm

Let $\tilde{\beta}_T = [\beta_1, \beta_2, \dots, \beta_T]$ the time series of the state variable β from time 1, 2, ..., T . Similarly, let $\tilde{Y}_T = [Y_1, Y_2, \dots, Y_T]$ the time series data. We are interested in deriving the conditional posterior distribution $H(\tilde{\beta}_T \setminus \Lambda, R, \mu, \lambda, Q, \tilde{Y}_T)$ i.e. the joint posterior for $\beta_1, \beta_2, \dots, \beta_T$.

The conditional distribution of the state variable is given by the following expression

$$H(\tilde{\beta}_T \setminus \tilde{Y}_T) = (\beta_T \setminus \tilde{Y}_T) \prod_{t=1}^{T-1} H(\beta_t \setminus \beta_{t+1}, \tilde{Y}_t) \quad (11)$$

Note we drop the conditioning arguments for simplicity. Assuming that the disturbances of the state space model e_t and v_t are normally distributed:

$$H(\beta_T \setminus \tilde{Y}_T) \sim N(\beta_{T \setminus T}, P_{T \setminus T}) \quad (12)$$

$$H(\beta_t \setminus \beta_{t+1}, \tilde{Y}_t) \sim N(\beta_{t \setminus t, \beta_{t+1}}, P_{t \setminus t, \beta_{t+1}}) \quad (13)$$

where the notation $\beta_{i \setminus j}$ denotes an estimate of β at time i given information up to time j . The two components on the right hand side of expression (11) are normal distributions. However, to draw from these distributions, we need to calculate their respective means and variances. To see this calculation we consider each component in turn.

The mean and variance of $H(\beta_T \setminus \tilde{Y}_T)$. We can compute the mean $\beta_{T \setminus T}$ and the variance $P_{T \setminus T}$ using the Kalman filter. The Kalman filter is a recursive algorithm which provides with an estimate of the state variable at each time period, given information up to that time period, i.e., it provides an estimate of $\beta_{t \setminus t}$ and its variance $P_{t \setminus t}$. To estimate the state variable, the Kalman filter requires knowledge of the parameters of the state space Λ, R, μ, λ , and Q . These are available in our Gibbs sampling framework from the previous draw of the Gibbs sampler.

The Kalman filter consists of the following equations which are evaluated recursively through time starting from an initial value $\beta_{0 \setminus 0}$ and $P_{t \setminus t}$.

$$\beta_{t \setminus t-1} = \mu + \lambda \beta_{t-1 \setminus t-1} \quad (14)$$

$$P_{t \setminus t-1} = \lambda P_{t-1 \setminus t-1} \lambda' + Q \quad (15)$$

$$\eta_{t \setminus t-1} = Y_t - \Lambda \beta_{t \setminus t-1} \quad (16)$$

$$f_{t \setminus t-1} = \Lambda P_{t \setminus t-1} \Lambda' + R \quad (17)$$

$$\beta_{t \setminus t} = \beta_{t \setminus t-1} + K \eta_{t \setminus t-1} \quad (18)$$

$$P_{t \setminus t} = P_{t \setminus t-1} + K \Lambda P_{t \setminus t-1} \quad (19)$$

where $K = P_{t \setminus t-1} \mathbf{A} f_{t \setminus t-1}^{-1}$. Consider the intuition behind each equation of the Kalman filter. The first and the second equation are referred to as the prediction equations. Equation (14) simply predicts the value of the state variable one period ahead using the transition equation of the model. Equation (15) is simply the estimated variance of the state variable given information at time $t - 1$. Equation (16) calculates the prediction error and Equation (17) calculates its variance. The final two equations of the Kalman filter are referred to as the updating equations. These equations update the initial estimates $\beta_{t \setminus t-1}$ and $P_{t \setminus t-1}$ using the information contained in the prediction error $\eta_{t \setminus t-1}$. Note that K , referred to as the Kalman gain, can be thought of as the weight attached to prediction error. Running these equations from $t = 1 \dots T$ delivers $\beta_{T \setminus T}$ and $P_{T \setminus T}$ at the end of the recursion.

The mean and variance of $H(\beta_t \setminus \beta_{t+1}, \tilde{Y}_t)$. The mean and variance of the conditional distribution $H(\beta_t \setminus \beta_{t+1}, \tilde{Y}_t)$ can also be derived using the Kalman filter updating equations. As discussed in Kim and Nelson (1999), deriving the mean $\beta_{t \setminus t, \beta_{t+1}}$ can be thought of as updating $\beta_{t \setminus t}$ (the kalman filter estimate of the state variable) for information contained in β_{t+1} which we treat as observed (for e.g. at time $T - 1$, β_T is given using a draw from $H(\beta_T \setminus \tilde{Y}_T)$ which we discussed above).

For the purpose of this derivation we can consider a state space system with the observation equation:

$$\beta_{t+1} = \mu + \lambda \beta_t + e_{t+1} \quad (20)$$

This implies that the prediction error is given by $\eta_{t+1 \setminus t}^* = \beta_{t+1} - \mu + \lambda \beta_{t \setminus t}$. The forecast error variance is given by $f_{t+1 \setminus t}^* = \lambda P_{t \setminus t} \lambda' + Q$. Note also that for this observation equation, the matrix that relates the state variable β_t to the observed data β_{t+1} is $\mathbf{A}^* = \lambda$. With these definitions in hand we can simply use the updating equations of the Kalman filter. That is

$$\beta_{t \setminus t, \beta_{t+1}} = \beta_{t \setminus t} + K^* (\beta_{t+1} - \mu + \lambda \beta_{t \setminus t}) \quad (21)$$

$$P_{t \setminus t, \beta_{t+1}} = P_{t \setminus t} + K^* \mathbf{A}^* P_{t \setminus t} \quad (22)$$

where the gain matrix is $K^* = P_{t \setminus t} \mathbf{A}^* f_{t+1 \setminus t}^{-1}$. Equations (21) and (22) are evaluated backwards

in time starting from period $t - 1$ and iterating backwards to period 1. This recursion consists of the following steps:

1) Run the Kalman filter from $t = 1 \dots T$ to obtain the mean $\beta_{T \setminus T}$ and the variance $P_{T \setminus T}$ of the distribution $H(\beta_T \setminus \tilde{Y}_T)$. Also save $\beta_{t \setminus t}$ and $P_{t \setminus t}$ for $t = 1 \dots T$. Draw β_T from the normal distribution with mean $\beta_{T \setminus T}$ and the variance $P_{T \setminus T}$. Denote this draw by $\hat{\beta}_T$.

2) At time $T - 1$, use Equation (21) to calculate $\beta_{T-1 \setminus T-1, \beta_T} = \beta_{T-1 \setminus T-1} + K^*(\hat{\beta}_T - \mu + \lambda \beta_{T-1 \setminus T-1})$ where $\beta_{T-1 \setminus T-1}$ is the Kalman filter estimate of the state variable from step 1) at time $T - 1$. Use Equation (22) to calculate $P_{t \setminus t, \beta_{t+1}}$. Draw $\hat{\beta}_{T-1}$ from the normal distribution with mean $\beta_{T-1 \setminus T-1, \beta_T}$ and variance $P_{T-1 \setminus T-1, \beta_T}$.

3) Repeat step 2 for $t = T - 2, T - 3, \dots, 1$. This backward recursion (The Carter and Kohn algorithm) delivers a draw of $\tilde{\beta}_T = [\beta_1, \beta_2, \dots, \beta_T]$ from its conditional posterior distribution.

Step 4 Repeat steps 1 to 3 S times until convergence is detected and use the last L values for inference.

B Appendix: Supplemental Results

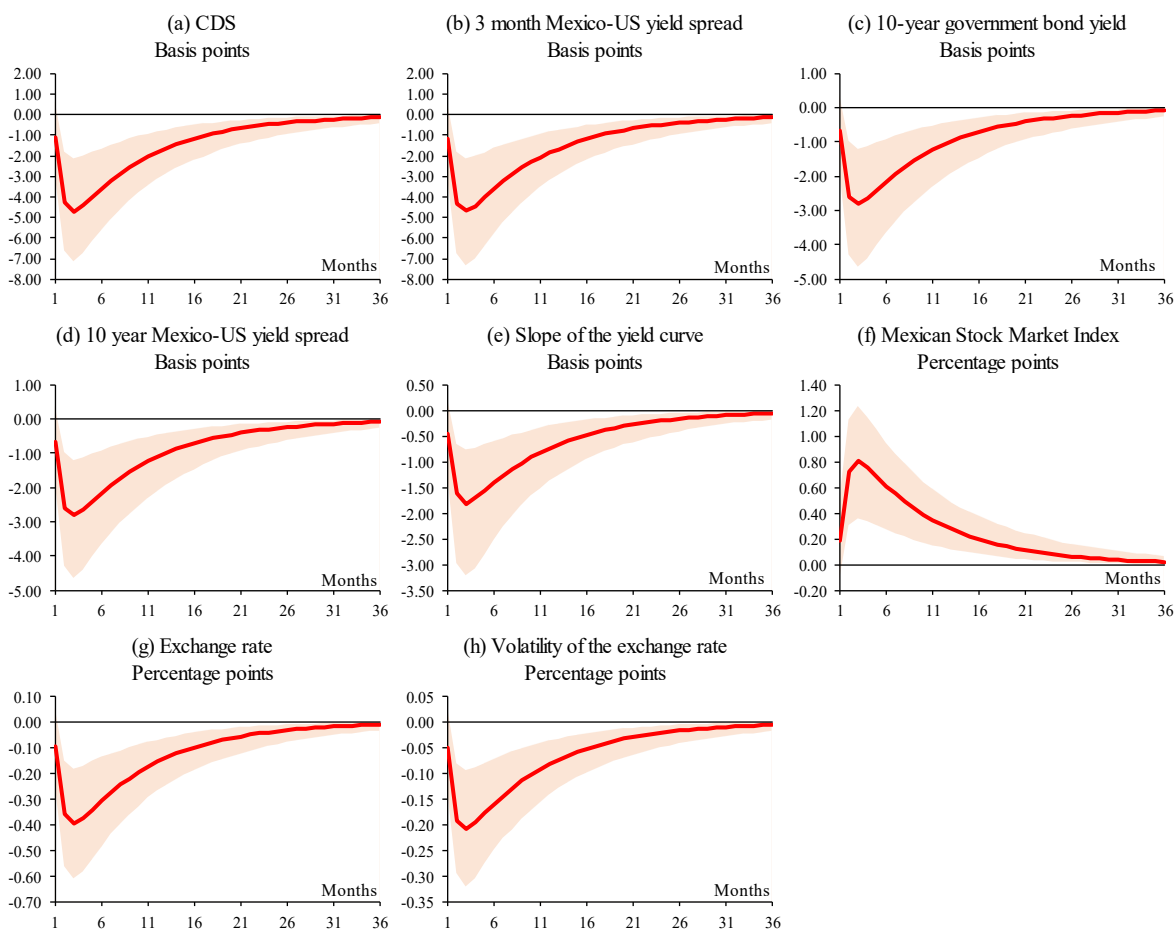


Figure B.1: Impulse Response Functions by excluding the vector \mathbf{Y}_t from the Observation Equation

Source: Authors' estimates using data from Banco de México, INEGI, Grupo BMV, Bloomberg and FRED.

Notes: This figure shows the median impulse responses for each of the variables to a shock in the outstanding amount of the extraordinary measures implemented by the central bank of Mexico. Responses are presented for a 36-month horizon with the associated 68% highest posterior density intervals (HPDIs). 5,000 simulations, with the first 4,000 as burn-in, were used to generate the responses.

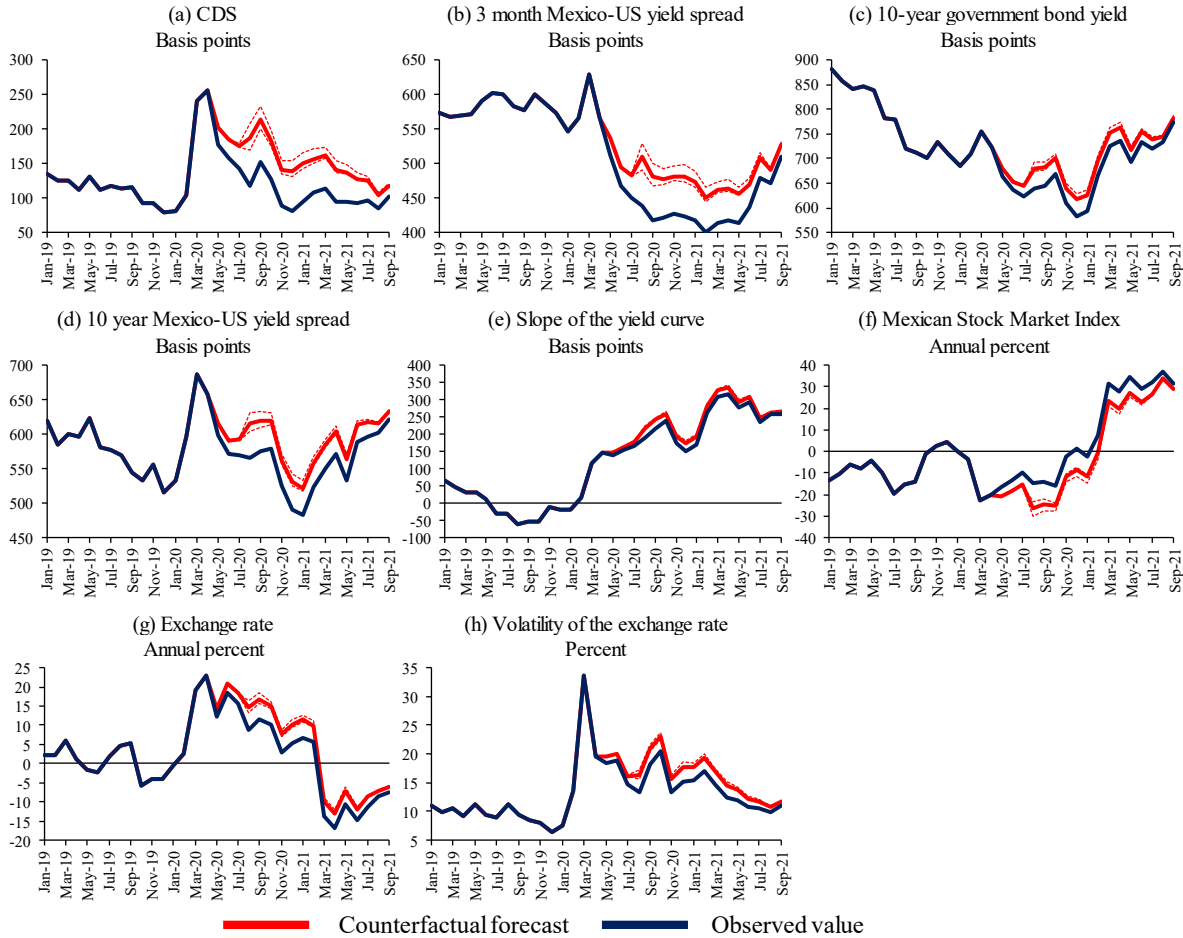


Figure B.2: Observed Value and Counterfactual Forecast by excluding the vector Y_t from the Observation Equation

Source: Authors' estimates using data from Banco de México, INEGI, Grupo BMV, Bloomberg and FRED.
 Notes: This figure shows the observed path and a counterfactual path for each variable with its associated 68% credible intervals. The counterfactual path is constructed by adding to the observed series the difference between two forecasts. The first one is obtained conditional on the actual outstanding amount of the extraordinary measures (as well as on the other variables in the system). The second one is obtained with the amount of such measures remaining at zero, i.e., evolving according to its pre-crisis path instead, and the other variables remaining unrestricted. 5,000 simulations, with the first 4,000 as burn-in, were used to generate the forecasts.

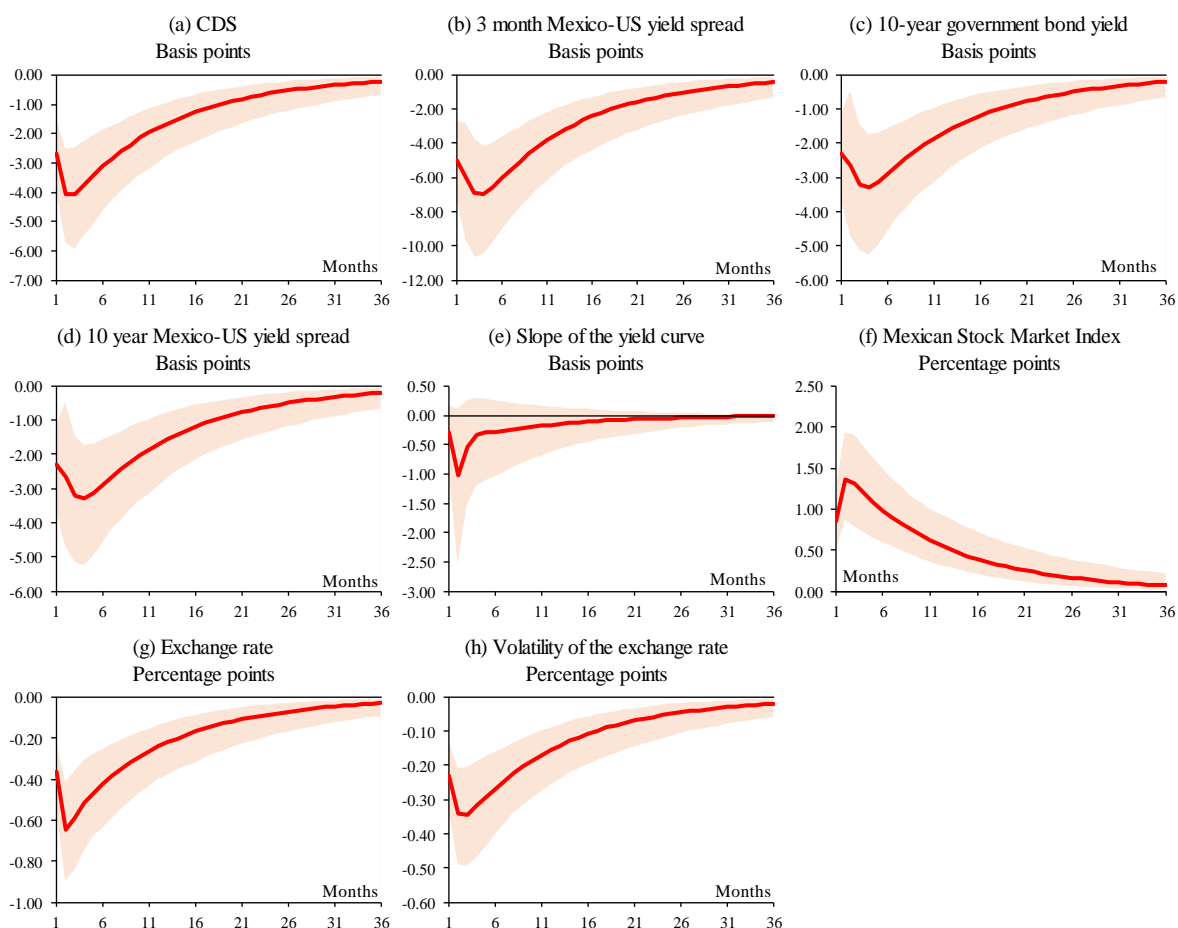


Figure B.3: Impulse Response Functions by using a Two-Step Estimation Method

Source: Authors' estimates using data from Banco de México, INEGI, Grupo BMV, Bloomberg and FRED.

Notes: This figure shows the median impulse responses for each of the variables to a shock in the outstanding amount of the extraordinary measures implemented by the central bank of Mexico. Responses are presented for a 36-month horizon with the associated 68% highest posterior density intervals (HPDIs). 5,000 simulations, with the first 4,000 as burn-in, were used to generate the responses.

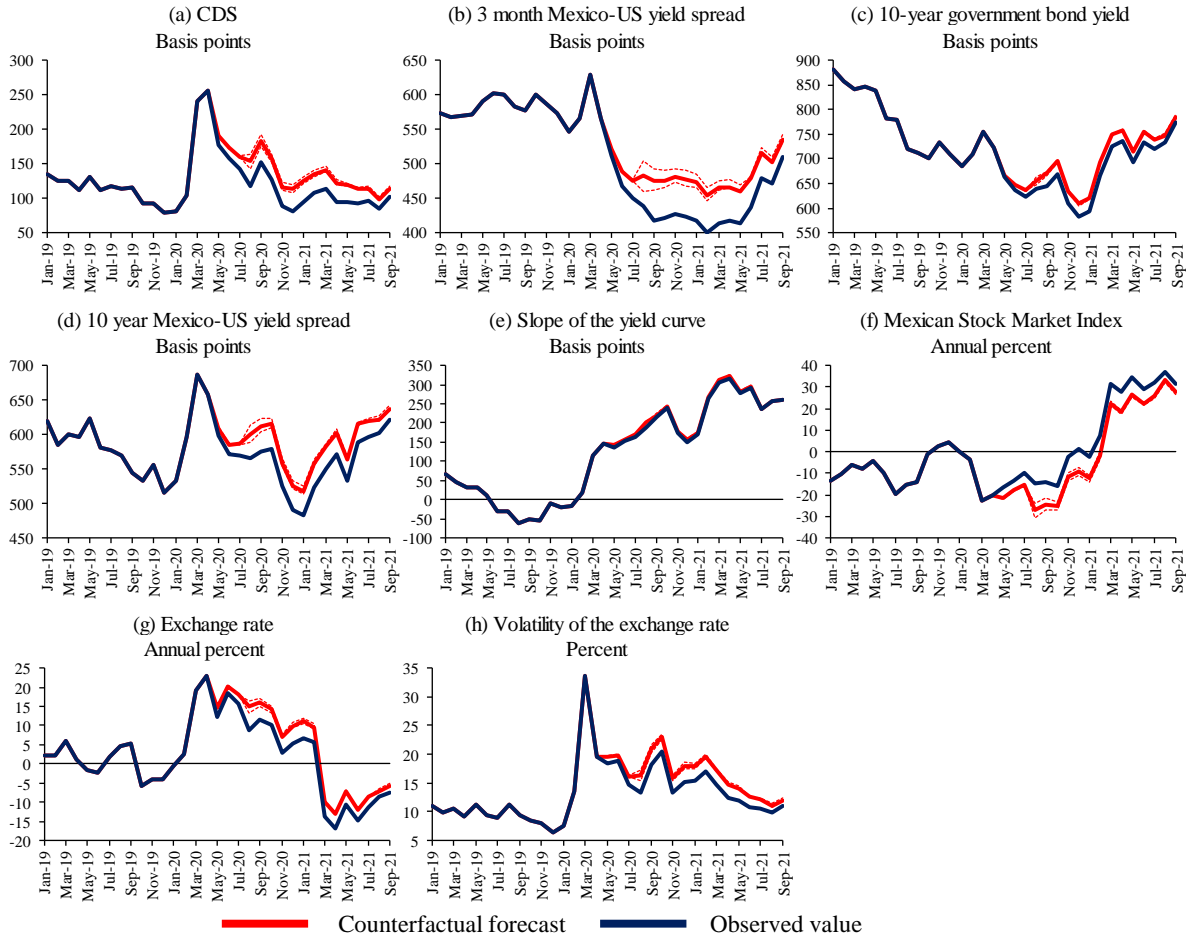


Figure B.4: Observed Value and Counterfactual Forecast by using a Two-Step Estimation Method

Source: Authors' estimates using data from Banco de México, INEGI, Grupo BMV, Bloomberg and FRED.

Notes: This figure shows the observed path and a counterfactual path for each variable with its associated 68% credible intervals. The counterfactual path is constructed by adding to the observed series the difference between two forecasts. The first one is obtained conditional on the actual outstanding amount of the extraordinary measures (as well as on the other variables in the system). The second one is obtained with the amount of such measures remaining at zero, i.e., evolving according to its pre-crisis path instead, and the other variables remaining unrestricted. 5,000 simulations, with the first 4,000 as burn-in, were used to generate the forecasts.

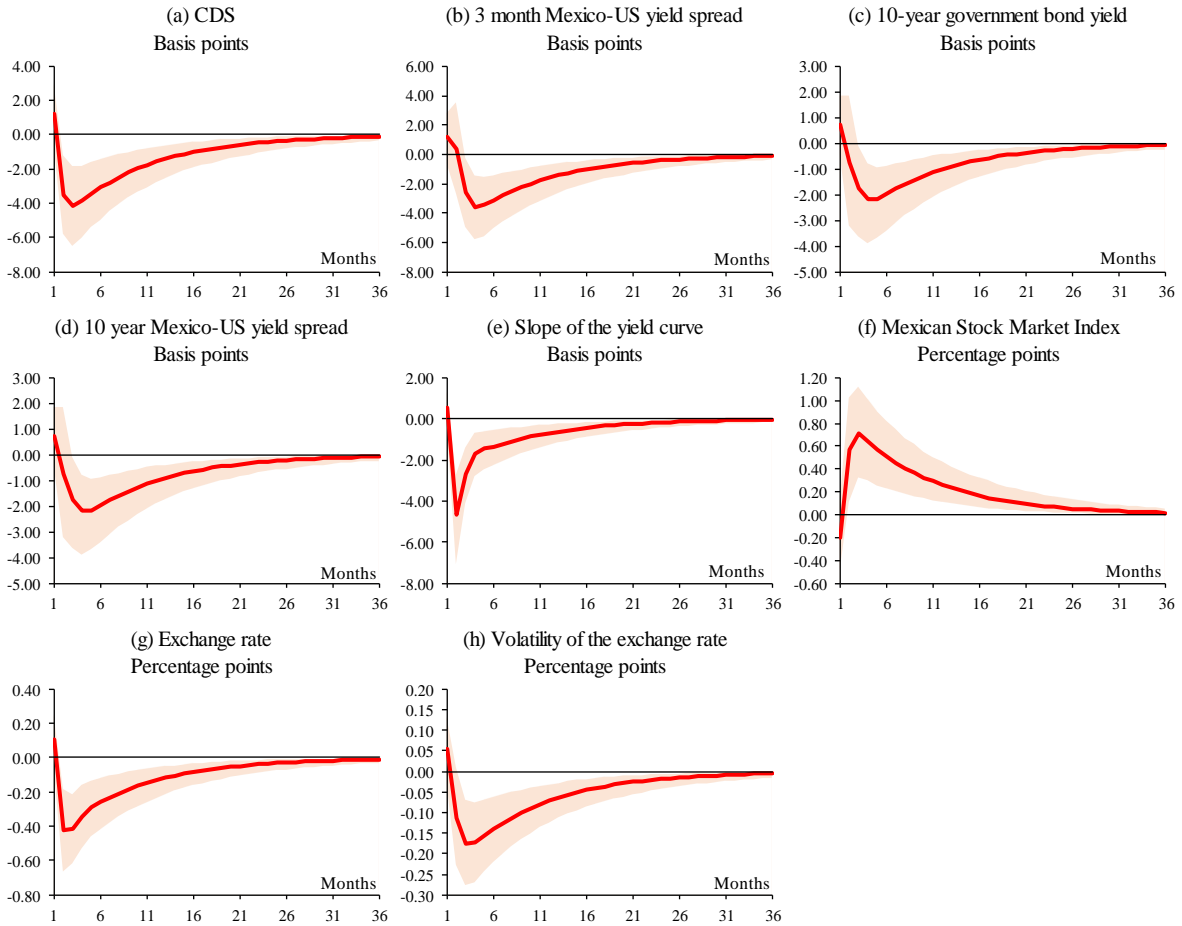


Figure B.5: Impulse Response Functions by including into M_t Two Additional Measures: The Non-Deliverable FX Forwards Program Expansion and the USD Credit Auctions Financed with the Swap Line Facility with the Federal Reserve

Source: Authors' estimates using data from Banco de México, INEGI, Grupo BMV, Bloomberg and FRED.

Notes: This figure shows the median impulse responses for each of the variables to a shock in the outstanding amount of the extraordinary measures implemented by the central bank of Mexico. Responses are presented for a 36-month horizon with the associated 68% highest posterior density intervals (HPDIs). 5,000 simulations, with the first 4,000 as burn-in, were used to generate the responses.

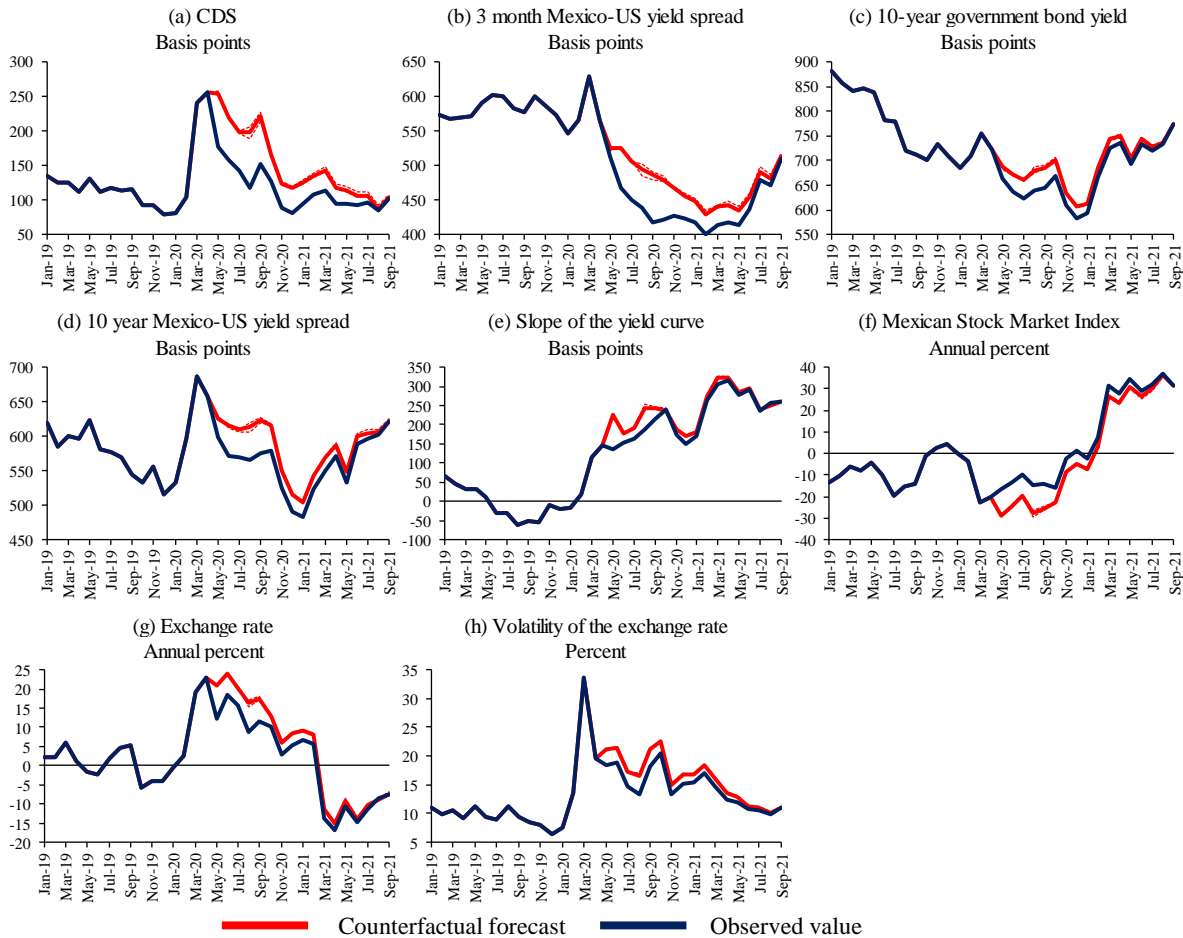


Figure B.6: Observed Value and Counterfactual Forecast by including into M_t Two Additional Measures: The Non-Deliverable FX Forwards Program Expansion and the USD Credit Auctions Financed with the Swap Line Facility with the Federal Reserve

Source: Authors' estimates using data from Banco de México, INEGI, Grupo BMV, Bloomberg and FRED.

Notes: This figure shows the observed path and a counterfactual path for each variable with its associated 68% credible intervals. The counterfactual path is constructed by adding to the observed series the difference between two forecasts. The first one is obtained conditional on the actual outstanding amount of the extraordinary measures (as well as on the other variables in the system). The second one is obtained with the amount of such measures remaining at zero, i.e., evolving according to its pre-crisis path instead, and the other variables remaining unrestricted. 5,000 simulations, with the first 4,000 as burn-in, were used to generate the forecasts.

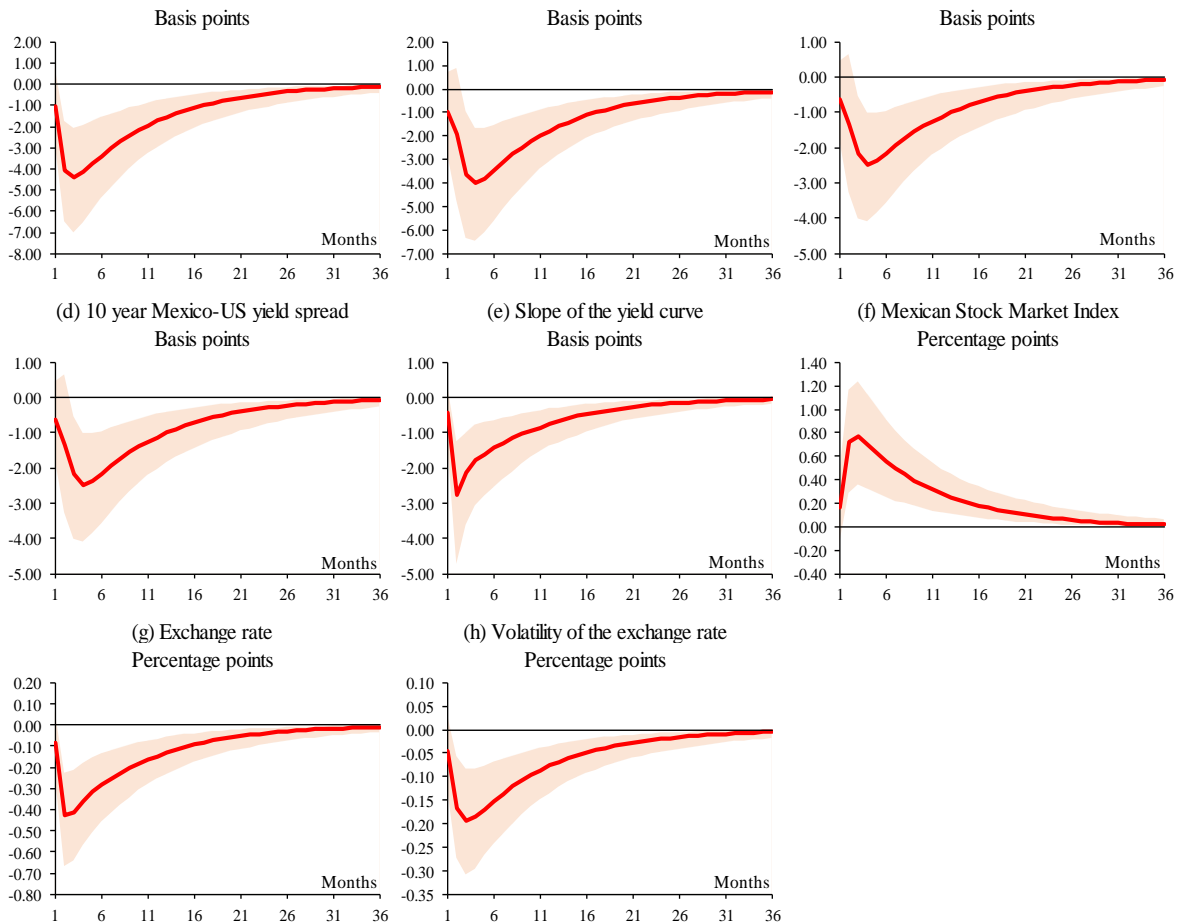


Figure B.7: Impulse Response Functions by using the Risk Aversion Index

Source: Authors' estimates using data from Banco de México, INEGI, Grupo BMV, Bloomberg and FRED.

Notes: This figure shows the median impulse responses for each of the variables to a shock in the outstanding amount of the extraordinary measures implemented by the central bank of Mexico. Responses are presented for a 36-month horizon with the associated 68% highest posterior density intervals (HPDIs). 5,000 simulations, with the first 4,000 as burn-in, were used to generate the responses.

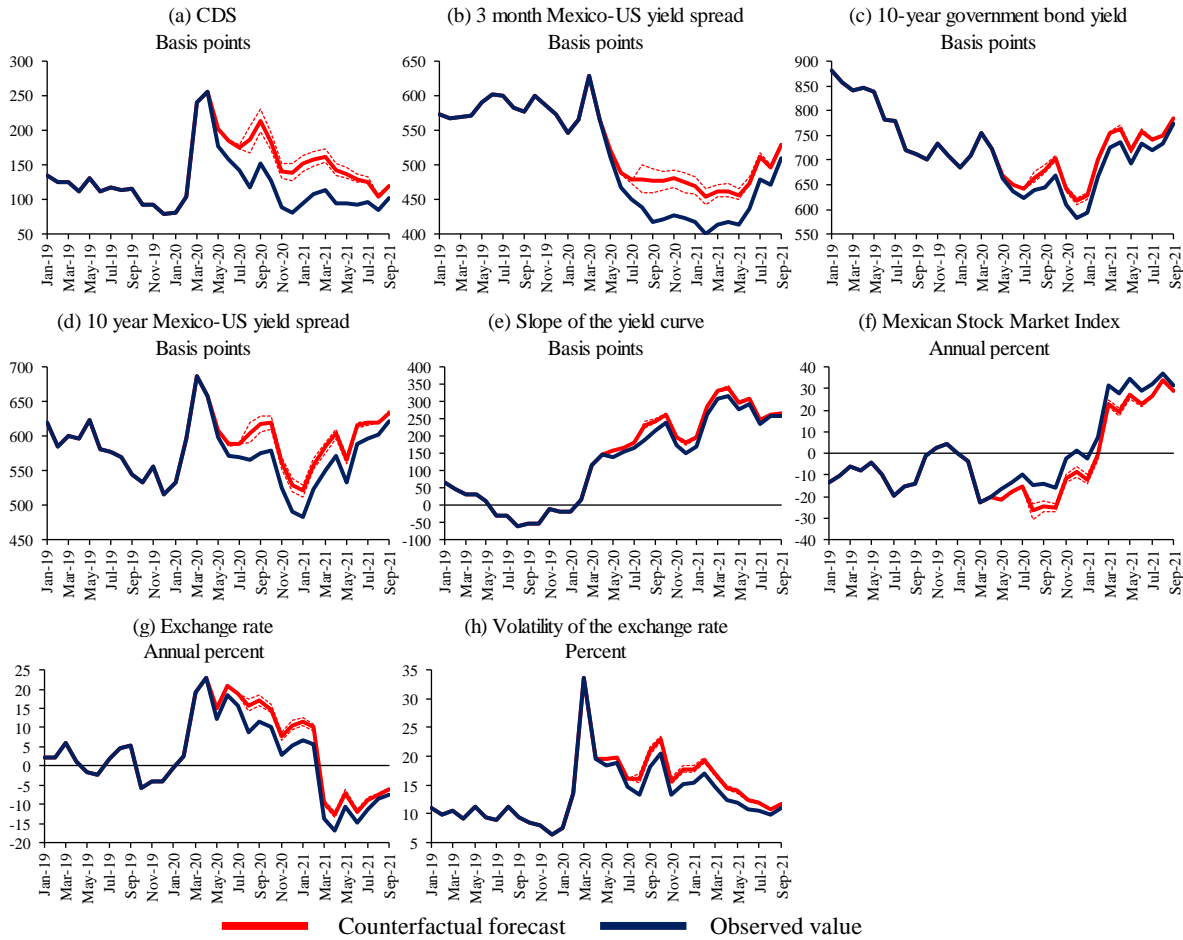


Figure B.8: Observed Value and Counterfactual Forecast by using the Risk Aversion Index

Source: Authors' estimates using data from Banco de México, INEGI, Grupo BMV, Bloomberg and FRED.

Notes: This figure shows the observed path and a counterfactual path for each variable with its associated 68% credible intervals. The counterfactual path is constructed by adding to the observed series the difference between two forecasts. The first one is obtained conditional on the actual outstanding amount of the extraordinary measures (as well as on the other variables in the system). The second one is obtained with the amount of such measures remaining at zero, i.e., evolving according to its pre-crisis path instead, and the other variables remaining unrestricted. 5,000 simulations, with the first 4,000 as burn-in, were used to generate the forecasts.

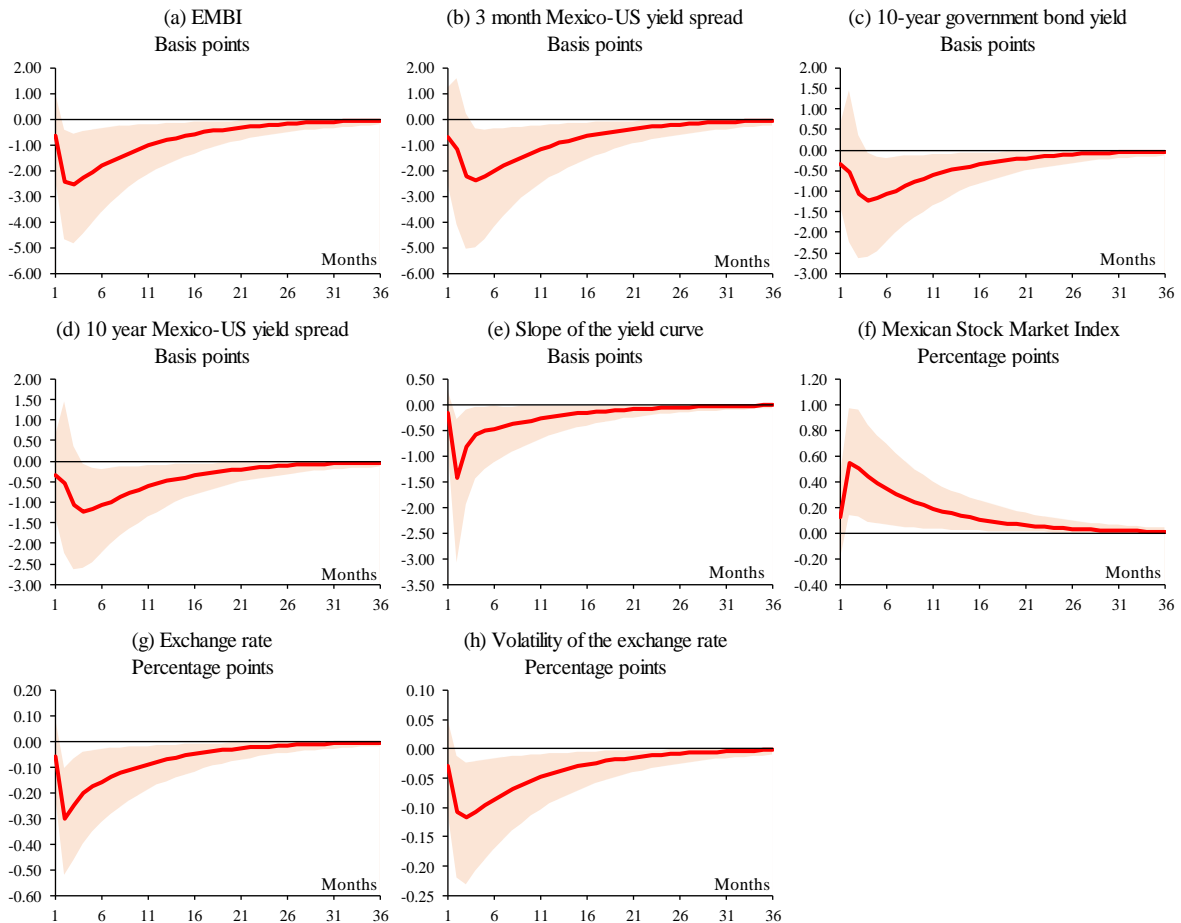


Figure B.9: Impulse Response Functions by using the Mexico's EMBI Plus Spread

Source: Authors' estimates using data from Banco de México, INEGI, Grupo BMV, Bloomberg and FRED.

Notes: This figure shows the median impulse responses for each of the variables to a shock in the outstanding amount of the extraordinary measures implemented by the central bank of Mexico. Responses are presented for a 36-month horizon with the associated 68% highest posterior density intervals (HPDIs). 5,000 simulations, with the first 4,000 as burn-in, were used to generate the responses.

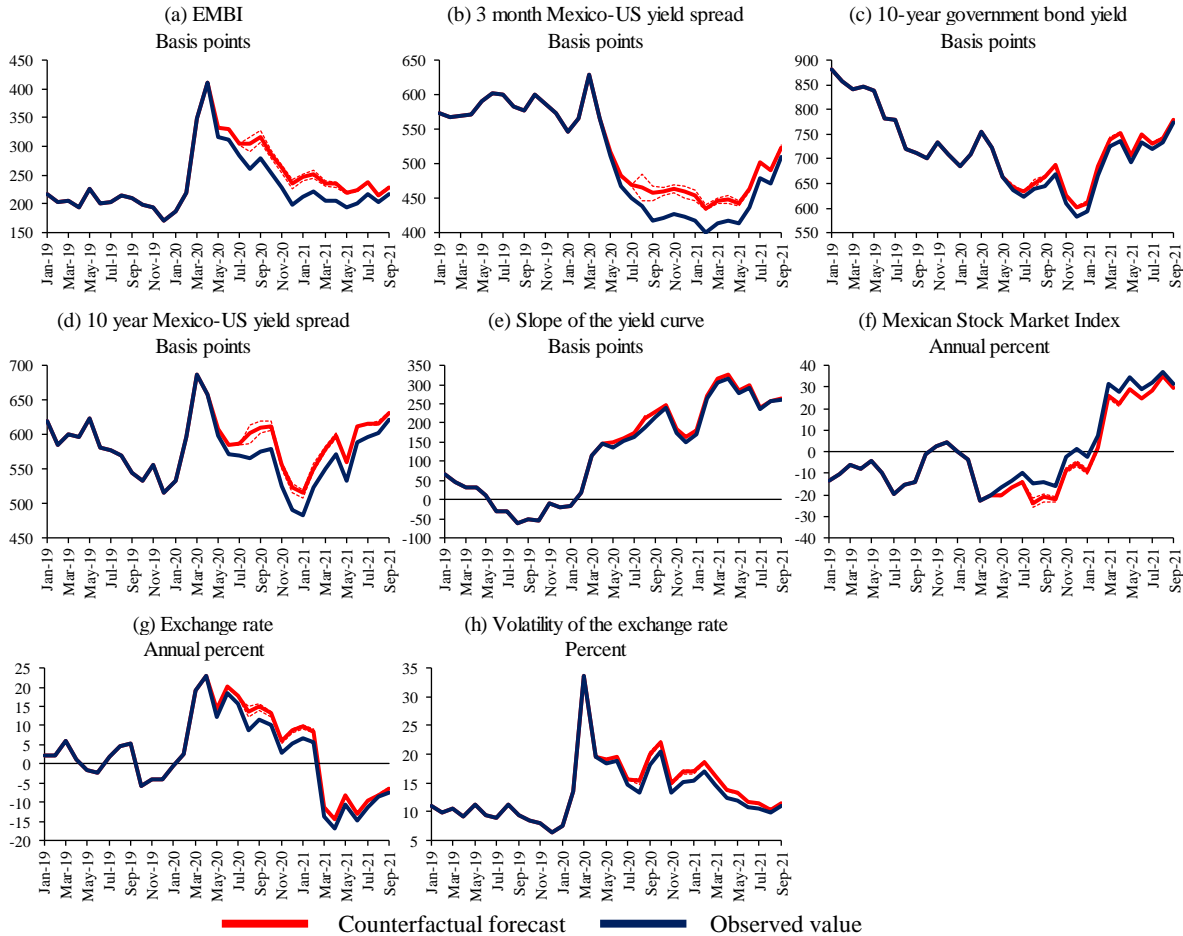


Figure B.10: Observed Value and Counterfactual Forecast by using the Mexico's EMBI Plus Spread

Source: Authors' estimates using data from Banco de México, INEGI, Grupo BMV, Bloomberg and FRED.

Notes: This figure shows the observed path and a counterfactual path for each variable with its associated 68% credible intervals. The counterfactual path is constructed by adding to the observed series the difference between two forecasts. The first one is obtained conditional on the actual outstanding amount of the extraordinary measures (as well as on the other variables in the system). The second one is obtained with the amount of such measures remaining at zero, i.e., evolving according to its pre-crisis path instead, and the other variables remaining unrestricted. 5,000 simulations, with the first 4,000 as burn-in, were used to generate the forecasts.