Exiting from an Exchange Rate Floor in a Small Open Economy: Balance Sheet Implications of the Czech National Bank's Exchange Rate Commitment*

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The aim of this paper is to model the situation of a large central bank balance sheet with assets consisting almost exclusively of foreign exchange reserves in the circumstances of a catching-up economy exhibiting an exchange rate appreciation trend. As an illustration, we present projections of the Czech National Bank's balance sheet after the discontinuation of its exchange rate commitment. Apart from the baseline projection, which suggests a switch from losses to profits in 2026, several scenarios are discussed. Some relate to the exchange rate commitment itself (such as a discussion of its fiscal consequences), while others examine more general central bank balance sheet issues (such as a long-run decline in currency in circulation).

JEL Codes: E52, E58, E47.

*We would like to thank Kamil Galuščák, Dana Hájková, Michal Hlaváček, Bernd Schlusche, Marek Šesták, Jan Vlček, Pierpaolo Benigno, and two referees at the IJCB, and seminar participants at the Slovak Economic Association Meeting 2017 and at the Czech National Bank for valuable comments. We are grateful to Adam Kučera for providing us with term premia estimates for USD and EUR bonds, Martin Motl for sharing with us the data presented in Figure 2, and Jaromír Tonner for counterfactual estimates of the macroeconomic variables without the exchange rate floor. This work was supported by Czech National Bank Research Project No. MP1/18. The opinions expressed in this paper are those of the authors and not necessarily those of the Czech National Bank. Author e-mails: michal.franta@cnb.cz; tomas.holub@cnb.cz; branislav.saxa@cnb.cz.

1. Introduction

With the conduct of unconventional monetary policy after the global financial crisis, central bank balance sheets have become a subject of renewed interest. The issues of central bank solvency and fiscal aspects of large balance sheets have received great attention from researchers, who have focused, however, mainly on unconventional monetary policies of major central banks such as the U.S. Federal Reserve (the Fed) and the European Central Bank (ECB). They have mostly concluded that the risk of central bank insolvency is "real in theory, but remote in practice" (Hall and Reis 2015) or even "truly negligible" (Cavallo et al. 2018). Nonetheless, it is important to ask if such a conclusion also holds for a central bank with assets consisting almost exclusively of foreign exchange reserves in the circumstances of a small, open, catching-up economy exhibiting an exchange rate appreciation trend.

This paper therefore focuses on the central bank balance sheet aspect of the Czech National Bank's exchange rate commitment, which was in place as an unconventional monetary policy instrument from November 7, 2013 until April 6, 2017. When the commitment was introduced, the Czech National Bank (CNB) made it clear that its balance sheet consequences were seen as being of strictly secondary importance relative to the monetary policy objectives. The central bank has also repeatedly emphasized that valuation losses on its foreign currency portfolio induced by exchange rate appreciation have no direct fiscal implications in terms of requiring a transfer from the government budget, as the central bank will be able to repay the losses out of its future profits, i.e., it remains solvent in the long run.

At the same time, the CNB's exchange rate commitment may have indirect fiscal implications in terms of reducing potential profit transfers from the central bank to the government in the future. There seems to be a relatively widespread belief in the Czech Republic outside the central bank that such indirect fiscal costs may be of first-order importance and almost immediate. As a result, the CNB's balance sheet aspect will most probably remain a topic of public debate for a protracted period of time. Indeed, after the exchange rate commitment proved effective in terms of preventing deflation and boosting the economic recovery (see Brůha and Tonner 2017) and was discontinued in a remarkably smooth manner, the main line of criticism of this publicly unpopular policy shifted to the fiscal consequences of the CNB's valuation losses. These losses originate from the devaluation of its massively larger foreign exchange reserves in a situation of an appreciating exchange rate. Given the size of the reserves and the long-term real equilibrium appreciation trend of the Czech koruna, this phenomenon is likely to persist for an extended period of time. It is necessary to be able to address this issue in a quantitative analytical framework.

Therefore, we develop and employ a simple balance sheet model for a central bank of a small open economy with assets dominated by foreign exchange reserves, and apply it to the CNB's case.[1] We show how the model can be adjusted for different remittance policies and thus employed by other central banks facing similar circumstances. Next, we estimate balance sheet projections drawing on stochastic simulations of the model. In addition to conveying a sense of the uncertainty of the results, stochastic simulations enable probabilistic assessment of various issues (such as the probability of negative equity in a given year) and examination of questions that cannot be examined in the deterministic setting (such as changes in the composition of the foreign exchange (FX) reserves portfolio).

In addition to the most probable balance sheet outlook, several scenarios are discussed. Two of them are related to the exchange rate commitment (the effect of the commitment on the balance sheet and the simulation of an earlier exit from the commitment). Furthermore, we demonstrate how some general balance sheet issues can be examined within the modeling framework—a long-run decline in currency in circulation, sales of yields on FX reserves, and the relationship between large negative equity and macroeconomic variables.

We conclude that in the baseline scenario, the CNB can be expected to stay in negative equity for about two decades, with a trough roughly 10 years from now at around 6–7 percent of GDP. This situation resembles the CNB's previous experience with negative equity from 1998 until 2013, which did not lead to any solvency issues or difficulties in pursuing appropriate policies. The financial or "policy" solvency of the CNB is thus not endangered (even though

[1] We extend an earlier approach of Cincibuch, Holub, and Hurník (2009) described in Appendix B.

the uncertainty bands are very wide according to our stochastic simulations). At the same time, these findings may at first sight suggest non-negligible indirect fiscal implications of the exchange rate commitment. However, the counterfactual simulations of no exchange rate commitment and earlier discontinuation of the commitment show that the central bank's equity would have stayed negative until at least the year 2030 anyway. Given the institutional arrangements, this means that there would probably have been no profit transfers from the CNB to the Czech government in any case until that year. From that point of view, the fiscal implications of the exchange rate commitment related to the expansion of the central bank's balance sheet seem to be relatively small (especially if one also takes into account the other indirect fiscal effects, which are clearly positive) and fairly distant in time. This conclusion is relevant not just to the CNB at present but in general to all small open economies with central bank balance sheets dominated by foreign exchange reserves that might consider using the exchange rate as an unconventional monetary policy instrument in the future.

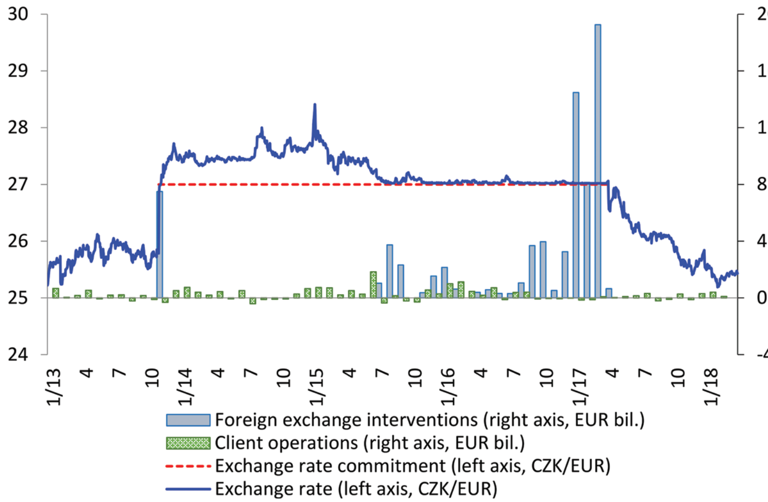
Other scenarios suggest that a long-run decline in currency in circulation can significantly affect the CNB's balance sheet. However, the main conclusion on the sustainability of central bank finances still holds. Next, sales of yields on FX reserves do not affect the size of the balance sheet too much but eliminate tail events represented by prolonged periods of extremely negative equity. Finally, based on the past Czech experience of negative equity, we found that taking into account feedback effects between the CNB's equity and macroeconomic variables implies a slightly less favorable outlook for the balance sheet.

The paper is organized as follows. In section 2 we summarize key stylized facts associated with the balance sheet implications of the CNB's exchange rate commitment. Section 3 develops the balance sheet model. Section 4 provides stochastic simulations of future CNB balance sheet developments. Section 5 uses the framework to simulate several policy scenarios, bringing a quantitative dimension to the recent public debates. Section 6 summarizes and concludes. Appendix A presents the macro models applied in the stochastic simulations, while Appendix B compares our results with those based on the Cincibuch, Holub, and Hurník (2009) model. Appendix C presents some additional results and Appendix D provides several notes on the asset-side composition. Finally, Appendix E discusses various extensions of the baseline model for different remittance policies and for the Fed's accounting treatment of losses in order to compare it with the CNB's approach.

2. Stylized Facts on the Expansion and Composition of the CNB's Balance Sheet

The CNB introduced its exchange rate commitment on November 7, 2013 in order to avoid deflation and to speed up the return of inflation to the 2 percent target (Franta et al. 2014). To establish the exchange rate commitment and build its credibility, the CNB had to purchase foreign exchange reserves worth EUR 7.5 billion (Figure 1) during the first few days of the commitment. For the next 19 months, the exchange rate was above the exchange rate "floor," so the CNB did not have to intervene in the foreign exchange market. In this period, the foreign exchange reserves were thus increasing only due to "client operations," related mainly to the drawdown of European Union (EU) funds. From mid-2015, however, the exchange rate moved close to the announced "floor," influenced by the quantitative easing of the ECB and continued favorable developments in the domestic economy. The CNB thus had to start intervening whenever needed. The most pronounced wave of interventions then took place in the first quarter of 2017. By then, it was apparent that the exchange rate commitment was coming to an end, and exporting companies were thus hedging against possible future exchange rate appreciation. At the same time, financial investors were building massive long positions in CZK. The exchange rate commitment was discontinued on April 6, 2017, once the CNB Board had concluded that the conditions had been met for sustainable achievement of the 2 percent inflation target in the future. Altogether, the FX interventions amounted to EUR 75.9 billion between November 2013 and April 2017 (another EUR 11 billion was purchased as part of client operations in the same period). Since the exit, though, there have been no foreign exchange interventions, as the exchange rate developments have been very smooth.

Figure 1. The CNB's FX Operations during the Exchange Rate Commitment



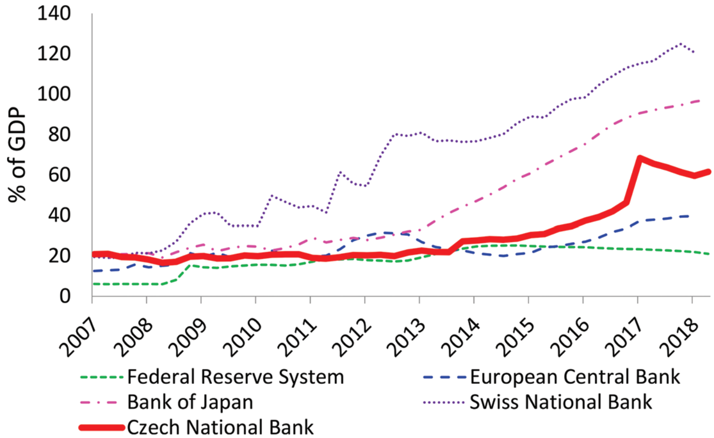
Source: CNB.

As a result, the CNB experienced a significant increase in its balance sheet size.[2] Relative to GDP, its balance sheet expansion was more significant than that of the U.S. Fed or the ECB. The most significant difference compared with these two major central banks arose in the first quarter of 2017, when the CNB's foreign exchange reserves jumped rapidly (Figure 2). Among other central banks, only the Swiss National Bank (SNB) and the Bank of Japan have seen bigger increases in their balance sheet size.[3] Since the exit from the

[2]Before 2013, the CNB's balance sheet size relative to GDP had been declining from its late-2002 peak, and later stagnating. This was partly due to a program of selling income on the CNB's FX reserves, which had been in place since 2004. In November 2012, the CNB Board decided to suspend these sales, as the central bank was getting ready for the potential use of the exchange rate as a monetary policy instrument (see Franta et al. 2014). We discuss the balance sheet consequences of the possible future resumption of this program in Section 5.4.

[3]The Swiss case is similar to the Czech one in that the balance sheet increase has been dominated by purchases of foreign exchange assets. At the same time, though, the SNB has a very different institutional setup and tradition of profit distribution than the CNB. The SNB has been a significant source of—rather

Figure 2. The Central Bank's Balance Sheet Size in International Comparison



Source: Bloomberg, CNB calculations.

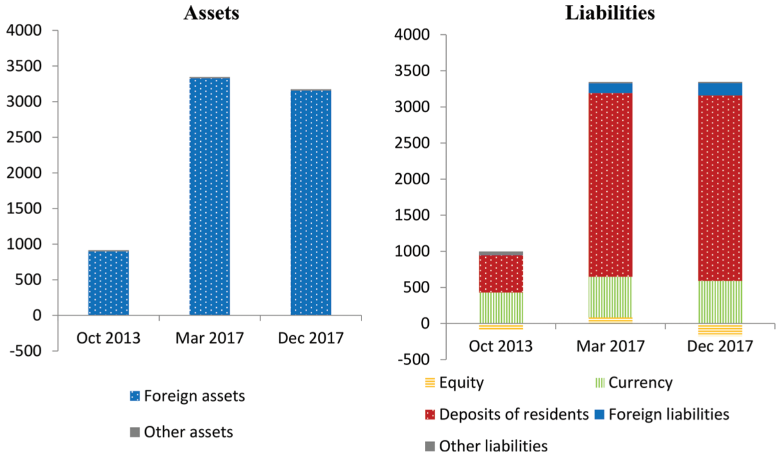
exchange rate commitment, the CNB's balance sheet has started to decline gradually in relation to GDP. This reflects the absence of any further foreign interventions, relatively swift nominal GDP growth, and a decline in the CZK value of the FX reserves due to exchange rate appreciation.

As well as changing in size, the CNB's balance sheet has changed in composition, albeit less radically. This can be seen in Figure 3, which compares the central bank's balance sheet before the exchange rate commitment (October 2013) with that immediately before the exit (March 2017) and at the end of 2017. The asset side has remained fully dominated by foreign assets, the bulk of which are composed of the CNB's foreign exchange reserves.[4] The CNB's other

stable—income not just for the Swiss federal government but also for local cantons. Its balance sheet developments have thus had important direct fiscal consequences. As a result, Amador et al. (2016) argue that the concern about future losses led to a "reverse speculative attack" and a forced exit from the SNB's exchange rate floor in early 2015. On the other hand, the CNB has paid (almost) no dividend to the government since its inception in 1993, and was thus in a better position to view its balance sheet expansion as a non-issue.

[4]The FX reserves were already a dominant part of the CNB's assets before November 2013, reflecting (i) an inflow of foreign capital under the fixed exchange rate regime that had been in place until May 1997, (ii) three waves of foreign

Figure 3. Composition of the CNB's Balance Sheet (in CZK billions)



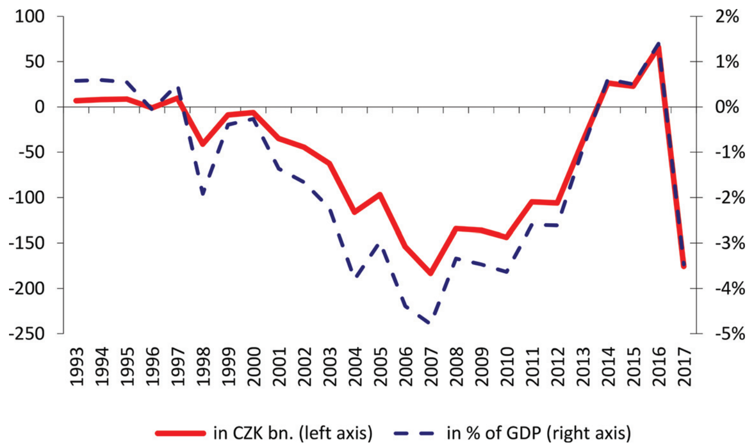
Source: CNB.

assets are negligible. On the liability side, currency issued by the CNB has continued to grow steadily, but most of the increase has been concentrated in deposits of residents. These consist mainly of commercial bank reserves placed at the CNB—which include required reserves, two-week (henceforth 2W) repo operations,[5] the O/N (overnight) deposit facility, and free reserves—as well as government deposits at the central bank. Foreign currency liabilities have increased, too, but to a much smaller extent than foreign

exchange interventions in the 1998–2002 period (see Geršl and Holub 2006), and (iii) purchases of foreign currencies from the government, related initially mainly to privatization revenues and later on to the drawdown of EU funds.

[5]The Czech banking sector exhibits a systematic liquidity surplus. 2W repo operations are thus used exclusively for absorbing liquidity, i.e., the CNB sells securities to banks with a promise to buy the securities back two weeks later. That is why the repo operations are listed on the liability side of the balance sheet and they entail a corresponding decrease in reserve balances. A stylized central bank balance sheet usually places net central bank operations on the asset side, because in the majority of cases central bank operations provide liquidity. Note, however, that the Federal Reserve balance sheet contains (reverse) repo agreements on both the asset and the liability side.

Figure 4. The CNB's Equity



Source: CNB, authors' calculations.

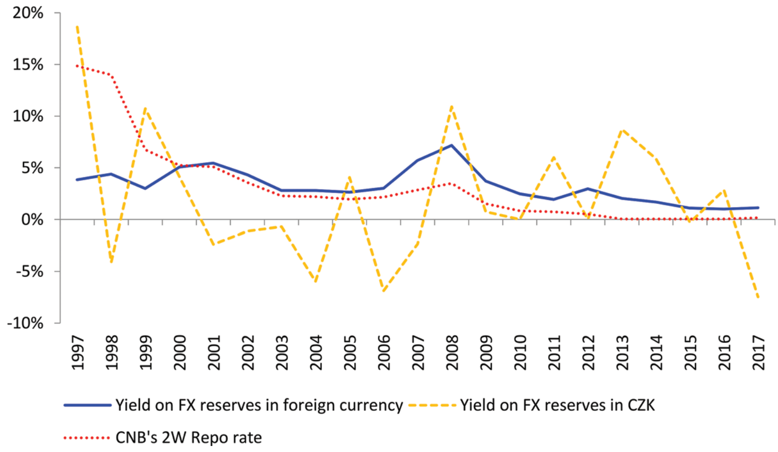
currency assets, implying significantly increased exposure of the CNB's balance sheet to exchange rate changes. Compared with the situation before the exchange rate commitment, a significantly larger share of the liability side is now interest bearing, in contrast to the interest-free currency that constitutes the base for the CNB's seigniorage (monetary income). The equity of the CNB was negative before the exchange rate commitment (at CZK –85 billion in October 2013). It turned positive during the commitment period (CZK 86 billion in March 2017), but has moved back into negative territory since then (CZK –172 billion at the end of 2017). The CNB's other liabilities have been very small.

As can be seen in Figure 4, the CNB actually had negative equity for 16 years before the exchange rate commitment was introduced, from 1998 until 2013. It peaked at almost CZK –200 billion in 2007, which at that time was equivalent to slightly less than 5 percent of annual GDP. In the late 1990s, the negative equity was related to the cost of bank bail-outs, which were partly financed by the central bank. Later on, the CNB's losses originated from valuation losses associated with an appreciating trend of the koruna against all major reserve currencies, given the dominance of foreign exchange reserves on the asset side of the CNB's balance sheet and its mark-to-market approach to exchange rate changes (see Cincibuch, Holub, and Hurník 2009; Frait and Holub 2011). The CNB followed a strategy of gradually repaying its accumulated losses out of future profits, as it did not experience any negative impact of negative equity on its policies (Benecká et al. 2012) or independence. The accumulated losses were indeed fully repaid in 2014 (i.e., much earlier than suggested in Cincibuch, Holub, and Hurník 2009) thanks to depreciation of the koruna against the euro associated with the exchange rate commitment and to even more pronounced depreciation of the koruna against the U.S. dollar. The practically zero sterilization costs during the episode of a technically zero interest rate helped improve the CNB's profitability, too. However, since the exit from the CNB's commitment, appreciation of the koruna against the euro (by almost 6 percent) and the U.S. dollar (by 17 percent) have brought the central bank back into negative equity. At the end of 2017, its size in absolute nominal terms broadly matched the pre-crisis peak of 2007. Relative to GDP, it was slightly smaller due to a higher level of domestic economic activity in nominal terms.

Given the structure of its balance sheet presented in Figure 3, the CNB's financial results are predominantly affected by two factors. First, they reflect the returns on foreign exchange reserves expressed in CZK, which consist of the yields in foreign currencies and the valuation effects stemming from changes in the value of the Czech koruna against a basket of reserve currencies. Exchange rate changes and capital gains or losses on assets in the CNB's reserves portfolio are both marked-to-market and thus immediately affect the central bank's equity.[6] Second, the interest rates paid on the deposits of residents at the CNB—mainly remunerated at the 2W repo rate—are the main item on the costs side. As can be seen in Figure 5, the

[6]Exchange rate gains and losses enter the CNB's profit and loss account and thus also its equity. The same is true for all realized capital gains or losses on assets in the FX reserves portfolio, as well as for any unrealized gains and losses in its stock indexes part. In the past (until 2018), unrealized capital gains or losses on fixed-income assets (bonds) were not shown in the profit and loss account, but instead were put into a revaluation reserve, which, however, is a part of the CNB's equity, too. For more information on the CNB's accounting procedures, see CNB (2018). In our simulations, we abstract from the distinction between realized and unrealized gains on bonds.

Figure 5. The CNB's Sterilization Costs and Yields on FX Reserves



Source: CNB.

yields on the CNB's FX reserves in foreign currencies have consistently exceeded the 2W repo rate in the last 10–15 years. However, exchange rate changes have often dominated in terms of CZK yields and thus the overall profit and loss account of the CNB.

Looking into the future, the two key questions for the CNB's ability to repay its current accumulated loss are thus (i) whether the positive differential between the foreign currency yield on the FX reserves and the 2W repo rate remains in place (especially as the CNB has started to normalize its monetary policy well ahead of the ECB) and (ii) if the nominal currency appreciation is smaller or larger than this differential on average. The answer to the former question partly depends on how the CNB's foreign exchange reserves are managed regarding the risk-return trade-off. The latter question is related to the future pace of convergence of the Czech economy to the advanced countries.

The repayment of accumulated losses will—as in the past episode—be facilitated by favorable institutional arrangements related to the CNB's profit distribution. Income losses are absorbed by corresponding variations in the equity position. Specifically, when the CNB incurs an operating loss, that loss is absorbed through a decrease in the CNB's equity position of equal size.[7] And, at the end of the subsequent fiscal year, even if the CNB makes a profit, this does not necessarily imply that it will resume its remittances (transfers) to the fiscal authority. Such an outcome, in fact, depends in the first place on the CNB's equity position. If this position is negative, remittances cannot resume until the CNB has made enough profits to make it less negative and ultimately bring it back into the non-negative domain. Even then, that is, when the equity position is no longer negative, the CNB can choose, at its discretion, to retain at least part, if not all, of its positive income realizations to further build up its stock of assets, thereby lowering the potential for future losses.

It is important to bear in mind this arrangement when drawing conclusions about the potential fiscal consequences of the various policies simulated in the subsequent part of this paper. In particular, the crucial outcome is the duration of the negative equity in various scenarios rather than the size of the negative equity in any particular year or at its peak. This is because the government gets no profit transfer no matter how large the negative equity is. At the same time, the year when the CNB's accounting equity returns above zero must be viewed as the earliest possible date of starting profit transfers, although this does not mean they would start automatically.

3. Model of the Czech National Bank's Balance Sheet

In this section we develop a model for analyzing balance sheet issues for a CNB-like central bank that employs the fair-value accounting approach.[8] The following equations assume a simplified structure of the CNB's balance sheet, with assets comprising foreign assets only and liabilities encompassing currency in circulation, deposits

[7]Note that the government has no obligation to recapitalize the central bank.

[8]As concisely defined, for example, in Bonis, Fiesthumel, and Noonan (2018), fair value "represents the market price that would be received in selling an asset in an orderly transaction between market participants at the measurement date, which is the date reported in the financial statements." The fair-value accounting approach means that the income and capital position of the central bank are affected by changes in the market value of a security.

of residents (predominantly banks and to a lesser extent the government), and equity. These are the dominant components of the CNB's balance sheet (see above in Section 2).[9]

Income in year t, Inc_t, comprises the yield on holdings of foreign assets at the end of the previous year, FX_{t-1}, which are assumed to be denominated in euros (70 percent) and U.S. dollars (30 percent). The effective yield on foreign assets expressed in the domestic currency is the weighted sum of the foreign portfolio yields and the appreciation/depreciation of the koruna with respect to the euro and the dollar:[10]

$$Inc_t = 0.7\left(yield_t^{EUR} + \Delta e_t^{EUR}\right) FX_{t-1} + 0.3\left(yield_t^{USD} + \Delta e_t^{USD}\right) FX_{t-1}. \quad (1)$$

For both euro- and U.S.-dollar-denominated assets, we assume that 90 percent of the assets will yield a return equal to the expected yield on one-year bonds,[11] while the remaining 10 percent of the assets are invested in a stock portfolio.

The next year's foreign assets increase by current-year income.[12] Moreover, we add the possibility of autonomous changes in FX holdings made by the central bank during year t, $FXInt_t$. Such transactions could include FX interventions, EU fund purchases, and sales

[9] To make the observed values of the balance sheet items numerically consistent, we distribute all other non-zero items into the three dominant categories. External liabilities are added with a minus sign to foreign assets, and all other items (remaining liabilities, loans to residents, fixed assets, and remaining assets) are added with the relevant sign to deposits of residents.

[10] The equation employed for income is an approximation. For a given foreign currency, income equals $\left(\frac{E_{t+1}}{E_t}(1 + yield_t) - 1\right) FX_{t-1}$, where E_t denotes the nominal exchange rate at the beginning of period t. Standard logarithmic approximation then implies the formula for income.

[11] At the end of 2017, the durations of the EUR and USD investment tranches were 2.7 and 5 years, respectively. The durations of the liquidity tranches were approximately 0.1 year in both the EUR and USD portfolios.

[12] The current-year income is invested in foreign currency assets. This assumption is relaxed in Section 5.4. Next, we implicitly assume that the FX portfolio is reinvested each period in order to maintain the assumed composition in terms of both currency and bonds and stocks. Several notes concerning the stock-bond ratio can be found in Appendix D.

of income on FX reserves. Including this term allows the model to be used to conduct various policy-relevant simulations.

$$FX_t = FX_{t-1} + Inc_t + FXInt_t \tag{2}$$

The expenses of the CNB, Exp_t, include interest payments on the deposits of residents. We assume that the interest rate applied is equal to the main policy rate, i.e., the two-week repo rate paid on the CNB's main monetary policy facility.[13] Operational costs, OC_t, are included and are assumed to be a constant fraction of nominal GDP, specifically the average fraction observed over the period 2006–15.

$$Exp_t = i_t^{CZ} Dep_{t-1} + OC_t \tag{3}$$

Overall liabilities evolve according to the standard law of motion extended to include the possibility of direct FX transactions by the bank, which is reflected by the liability side, and possible transfers from the central bank to government:

$$Liab_t = Liab_{t-1} + Exp_t + FXInt_t + Tr_t. \tag{4}$$

The term Tr_t represents a discretionary outlay due to the CNB's remittance policy described in Section 2. The only constraints on profit transfers imposed by law are the following:

$$\begin{array}{rl} Tr_t = 0 & \text{if } Eq_t \leq 0 \text{ or } \Pi_t \leq 0 \\ 0 \leq Tr_t \leq \Pi_t & \text{otherwise,} \end{array} \tag{5}$$

where Eq_t stands for the central bank's equity at the end of period t. In the case of positive transfers, the account that the government holds with the central bank is credited with the transferred amount and the central bank's equity is reduced correspondingly through an increase of liabilities[14]

[13]Domestic banks can deposit their excess liquidity at the CNB for a two-week period on the basis of repurchase agreements ("repos") at a rate not exceeding—but typically very close to—the two-week repo rate.

[14]In the following benchmark simulations and simulations underlying all the scenarios, profit transfers are assumed to be zero. The main reason for this is the historical experience with a long period of zero transfers covering periods with

Deposits are calculated as the residual of total liabilities and currency in circulation ($Cash_t$):

$$Dep_t = Liab_t - Cash_t, \tag{6}$$

where the growth rate of currency in circulation is approximated by nominal GDP growth g_t:[15]

$$Cash_t = (1 + g_t)\, Cash_{t-1}. \tag{7}$$

The profit or loss (net income) of the central bank is defined as the difference between income and expenses. Equity is then defined as the difference between central bank assets and liabilities; its current level reflects equity in the previous year adjusted for the profit or loss and possible profit transfer to government):

$$\Pi_t = Inc_t - Exp_t \tag{8}$$

$$\begin{aligned} Eq_t &\equiv FX_t - Liab_t \\ &= FX_{t-1} + Inc_t + FXInt_t \\ &\quad - (Liab_{t-1} + Exp_t + FXInt_t + Tr_t) \\ &= Eq_{t-1} + \Pi_t - Tr_t. \end{aligned} \tag{9}$$

The balance sheet model (1)–(9) can be easily adjusted for different remittance policies, and we discuss such extensions for the cases of the Swiss National Bank, the Riksbank, and the Bank of Korea in Appendix E. In addition, the case of the Federal Reserve is touched upon in this appendix.

Given the accounting equations (1)–(9), the projections of the balance sheet items and the income statement are based on the

both negative and positive equity. So, it is reasonable to apply the same approach to transfers in the future. Importantly, the median equity, which is of primary interest, is negative in the benchmark and the scenarios for the vast majority of periods and so is not affected by changes in positive parts of the simulated equity paths brought about by potential transfers to government. Therefore, the median is intact after imposing non-zero profit transfers for positive equity paths in the simulation. That is why our assumption of zero transfers is not crucial. Non-zero transfers are discussed in Appendix E.

[15] An alternative to the usual assumption of currency growth equal to nominal GDP growth is to model money demand explicitly, as in Veracierto (2018).

macroeconomic forecast officially published by the CNB,[16] the equilibrium values employed in the CNB's forecasting process, and the outlooks for financial variables taken from yield curves and historical averages of stock returns.

The macroeconomic outlook for the domestic monetary policy rate, nominal output, and exchange rates for the first two years of the projection is taken from the official CNB forecast. The outlook beyond two years ahead is approximated using the equilibrium values (Table 1, first row). They converge linearly to the equilibrium values expected at the end of the convergence process (Table 1, second row), which is assumed to occur after 20 years. The termination of the convergence process resembles the situation of euro-area entry, because in such a situation the foreign monetary policy interest rate becomes the domestic rate and the exchange rate with respect to the euro can be viewed as fixed. So, we can reasonably interpret the situation after 20 years in both ways.[17]

The expected yield on the one-year euro bond used to approximate the euro bond portfolio yield is based on the 3M EURIBOR (three-month euro-area interbank offered rate) outlook from the CNB's forecast adjusted for the spread between the three-month rate and the one-year rate for the first six years of simulations.[18] The expected yield on the one-year U.S. Treasury bond is based on the observed financial market yield curve and estimates of the term premia for the first 10 years of simulations.[19] After 6 and 10 years, the expected yields for both the euro and dollar bond portfolios converge to the equilibrium value, calculated as the equilibrium value of the 3M EURIBOR assumed in the CNB forecasting process

[16]The forecast published in Inflation Report I/2018.

[17]We do not, however, take into account that euro adoption would imply CNB participation in the redistribution of monetary income among euro-area central banks. This issue was analyzed in Cincibuch, Holub, and Hurník (2008).

[18]ECB (2017) provides estimates of 10-year term premia that are slightly higher than the term premium implied by the compounded 1-year EUR interest rate outlook applied in the CNB forecast and the observed yield curve. We therefore view the EUR interest rate outlook based on the CNB forecast as reasonable.

[19]The USD portfolio forward rate is calculated using the yield curve and term premia estimates from the no-arbitrage term structure model described in Adrian, Crump, and Moench (2013). The data are available at http://libertystreeteconomics.newyorkfed.org/2014/05/treasury-term-premia-1961-present.html.

Table 1. Equilibrium Values

	3M PRIBOR	3M PRIBOR – 2W Repo Spread	Inflation	Currency in Circulation Growth Rate	CZK/EUR yoy Change	CZK/USD yoy Change	3M EURIBOR	Portfolio Return	
								EUR	USD
CNB Forecast	3.00	0.24	2.00	5.00	−1.50	−1.50	3.50	—	—
End of Convergence (or Euro Zone Entry)	3.50	0.24	2.00	3.00	0.00	0.00	3.50	4.02	4.02

increased by the average difference between the three-month rate and the one-year euro bond yield.[20] The equilibrium yield is assumed starting with the twentieth year of the outlook. The expected yield on the stock portfolio is approximated by the average historical stock market yields in the respective currencies over the whole projection horizon. For both the EUR and USD market, the value is set to 6 percent per annum.[21]

To obtain stochastic projections of the CNB's income statement and balance sheet items, we follow the methodology employed in Ferris, Soo, and Schlusche (2017). As a starting point, the deterministic path defined above is taken. Then 10,000 forecast paths of the macroeconomic variables around the deterministic path are generated.[22] The forecast paths reflect the size of the shocks and their effects estimated on historical data. The core model used to generate the set of paths is a small-scale Bayesian vector autoregression (BVAR) one tailored to the Czech economy. In addition, simple satellite models are employed to generate forecast paths for stock returns and CZK/USD appreciation/depreciation. The accuracy of the underlying macro models is crucial for the accuracy of the stochastic projections of the balance sheet. Therefore, details of the models and some additional results are presented in Appendix A.

4. Benchmark Simulation

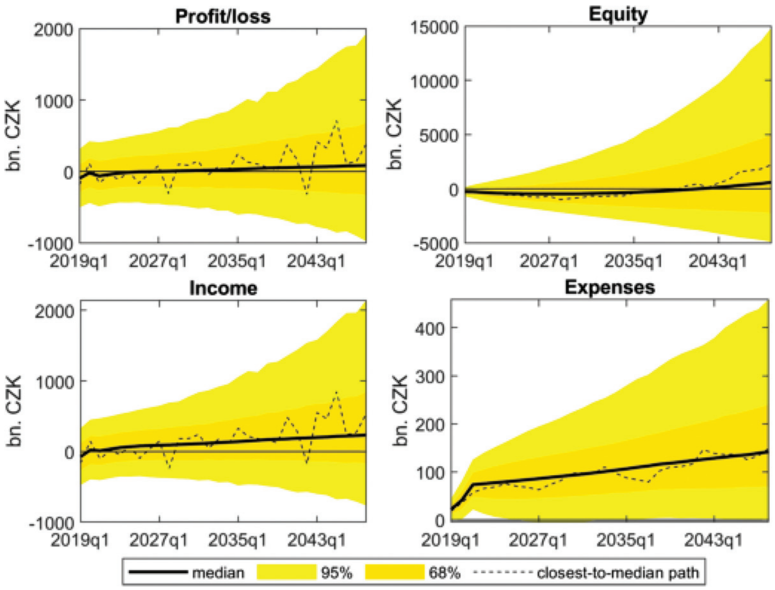
The simulation is based on the values of the balance sheet items as of December 31, 2017 and the CNB's official macroeconomic forecast published in Inflation Report I/2018, i.e., the forecast that starts with 2018 as the first forecasted year. The simulations are at yearly

[20]The average difference between the 3M EURIBOR and the one-year euro bond yield is computed over the periods 2004:Q1–2007:Q4 and 2009:Q1–2017:Q4, i.e., with the exception of 2008, when the spreads reflected a money market freeze. The spread equals 0.3 percentage point.

[21]In reality, this yield will be time varying and negatively correlated with the government bond yield. This negative correlation was in fact the main reason for adding the equities to the CNB's reserve portfolio. It is implemented in the stochastic simulations presented in Section 4 via the variance-covariance matrix of annual yields.

[22]To check whether 10,000 draws is a sufficient number, a robustness exercise with 2,500 draws only is performed, yielding very similar results.

Figure 6. CNB Balance Sheet Outlook (baseline scenario)



Note: The "closest-to-median path" is the forecast path closest to the pointwise medians of all four simulated quantities (see footnote 23).

frequency. The first simulated values relate to the first quarter of 2019, i.e., flows represent the period 2018:Q1–2018:Q4 and stock variables pertain to the first day of 2019. The projection period covers 30 years.

Figure 6 shows the baseline simulation of the CNB income statement outlook together with the evolution of equity.[23] The presented quantities are in nominal terms. The uncertainty around the median

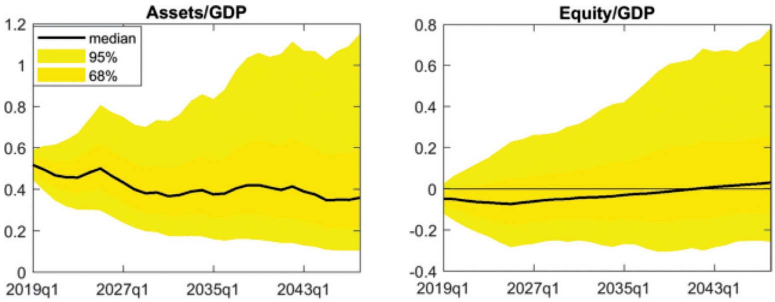
[23]Note that the median profit is not necessarily equal to the difference between the median income and the median expenses, because the forecast paths underlying the three medians can differ. For a given forecast path, the equality holds. The solution could be to take the forecast path that implies the closest-to-median profit, income, and expenses and work with that path. Such path is shown in Figure 6, which suggests that no additional information on the dynamics of the system in general is provided by using the closest-to-median paths instead of the pointwise median paths. We therefore stick to the standard approach and present pointwise medians in the paper.

projections expressed by the 68 percent and 95 percent of the distributions is substantial and grows with the length of the projection horizon. Moreover, the simulated distributions are skewed. While the macroeconomic outlooks are symmetric around the deterministic path, the implied distributions of income statement items and equity are asymmetric, because the balance sheet accounting identities are non-linear. For example, assuming constant interest rate and exchange rate outlooks, income becomes an exponential function of time with parameters determined by the two outlooks. The normally distributed interest rate and exchange rate are then transformed into a log-normally distributed income distribution, which is skewed. The sign of the skewness is determined by the particular assumed values of the macroeconomic variables constituting the deterministic path.

The wide range of uncertainty can be illustrated on past experience using deterministic simulations based on Cincibuch, Holub, and Hurník (2009) at the CNB. While this model initially—in the phase of fast convergence and exchange rate appreciation—significantly underestimated the extent of the CNB's losses and negative equity, the situation changed abruptly with the unexpected major shock generated by the global crisis. This led to much faster elimination of the CNB's negative equity compared with the simulations, followed by rapid reemergence of the losses once the central bank discontinued its exchange rate commitment in 2017 (and the dollar simultaneously started to depreciate against the euro). In general, the financial outcome and equity of a central bank with the CNB's balance sheet size and structure can be strongly countercyclical; it tends to improve in adverse situations with a depreciating currency and deteriorate in cyclical upswings with an appreciating currency. But given that the deterministic simulations draw their macroeconomic assumptions from sources that are by definition not able to forecast major future cyclical swings, the uncertainty around them is huge.

To assess the evolution of balance sheet items from the point of view of their sustainability, the ratios of total assets to nominal GDP and equity to GDP can be simulated. This is done in Figure 7, which shows (in the left panel) that the median projection of the ratio of total assets to GDP is located below 0.5 for the whole 30 years with the exception of the first year. The probability that the

Figure 7. Projections of the Ratios of Total Assets to GDP and Equity to GDP

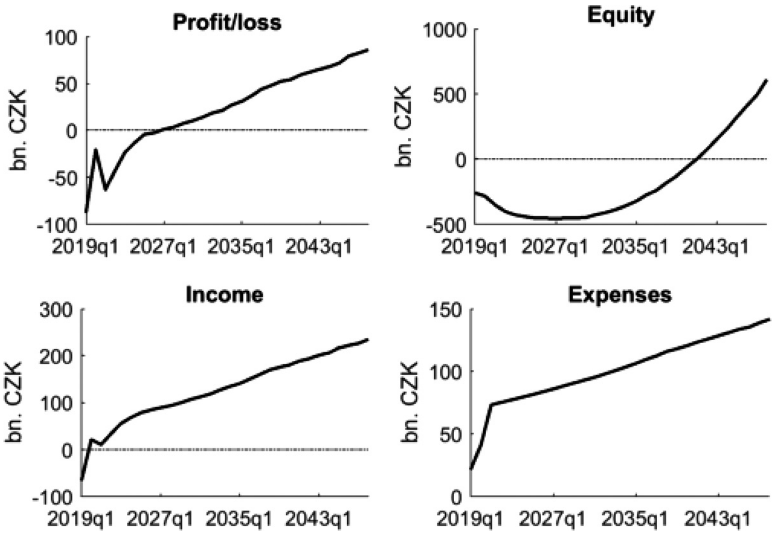


size of the balance sheet exceeds that of GDP—defined as the ratio of the simulated balance sheets with this property to all the simulated balance sheets—starts at zero and reaches 0.03 at the end of the projection horizon. Only two central banks of advanced economies currently exhibit a ratio exceeding 0.5—the Bank of Japan and the Swiss National Bank. Regarding the expected ratio of equity to GDP, Figure 7 (right panel) suggests that the median never falls below –8 percent of GDP. The probability of negative equity starts at 0.91 and 0.82 in 2018 and 2019, respectively, and decreases steadily towards 0.43 in 30 years.

To obtain a more focused picture, Figure 8 presents the medians of the benchmark stochastic projections (with all the above reservations concerning the reliability of the projections in mind). It turns out that the loss will be highest in the first year of the projection at approximately CZK 88 billion, which is equivalent to 1.6 percent of the GDP forecasted for that period. The loss will then diminish and turn into a profit after eight years in 2026. As a consequence, the equity will be negative for roughly the next two decades, the lowest point being negative equity of CZK 458 billion (i.e., 6.6 percent of GDP) in 2027:Q1. Appendix B shows that these results are qualitatively similar to the outcomes of the earlier model of Cincibuch, Holub, and Hurník (2009) but are somewhat more optimistic overall in the longer term given our more nuanced approximation of future yields on the CNB's foreign exchange reserves.

From the historical perspective, the negative equity expected during the coming 23 years is not so far from the CNB's past

Figure 8. CNB Balance Sheet Outlook (medians)



experience of negative equity lasting 16 years over the period 1998 to 2013 (see Section 2). Moreover, without the exchange rate commitment, the span of the period of negative equity starting at the end of the 1990s would have been longer (see Section 5.1 below). In terms of the size of the accumulated loss, the near future is close to the situation the CNB faced in 2007, when its negative equity approached 5 percent of GDP.

5. Policy Scenarios

Several policy scenarios are discussed in this section. The aim of the first two is to contribute to the public debate that has arisen around the central bank balance sheet recently in the Czech Republic. The debate revolves around the fiscal consequences of the exchange rate commitment, based on the idea that with a different past monetary policy the CNB would soon have been able to start paying dividends to the Czech government.[24] We provide a quantitative assessment of

[24] In reality, the CNB has never paid a dividend to the government since it was established in 1993 (with one negligible exception). The debate is thus in itself very hypothetical.

this idea, something which has so far not been delivered by its proponents. The third and fourth scenarios address the possible long-run decline in the amount of currency in circulation and the scope for active management of the central bank's balance sheet by means of resuming the program of selling yields on the FX reserves. Finally, the last scenario discusses the relationship between the CNB's large negative equity and inflation.

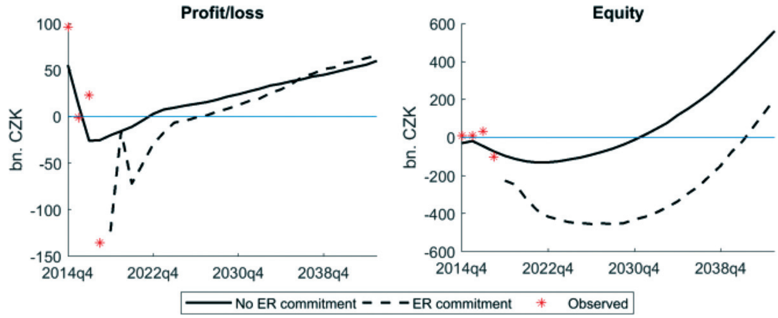
5.1 Counterfactual Scenario of No Exchange Rate Commitment

The first scenario considers the situation of no exchange rate commitment. The use of the exchange rate as an additional monetary policy tool was introduced in November 2013 and discontinued in April 2017. The scenario works with the balance sheet items as of October 31, 2013, i.e., without the central bank's purchases of euros related to the floor. The counterfactual estimates of GDP growth, the domestic interest rate, and the CZK/EUR and CZK/USD exchange rates are taken from Brůha and Tonner (2017) based on the dynamic stochastic general equilibrium (DSGE) model with the labor market block described in Tonner, Tvrz, and Vasicek (2015). The estimates of the evolution of domestic variables without the floor are available for the period 2013:Q4–2015:Q4. For the following years we assume a transition to the steady state similarly to the benchmark case. We therefore abstract from the observed shocks that apparently hit the economy in 2016 and 2017. For foreign variables (EUR and USD interest rates), the observed values are taken for the first four years of the counterfactual projection and the outlooks are based on the most recent market expectations afterwards.[25]

Figure 9 shows that without the exchange rate commitment, the CNB's equity in the first three years would have been lower than the

[25] Note that the counterfactual scenario is based on a model where endogenous variables reach steady state sooner or later and where economic agents with rational expectations consider the inflation target as fully credible. In reality, one of the motivations for the introduction of the exchange rate commitment was the risk of the deflationary spiral where expectations become unanchored on the inflation target. Such scenario would lead to much more adverse developments of the Czech economy than the counterfactual scenario considers.

Figure 9. No Exchange Rate Commitment



Note: The benchmark simulation (exchange rate (ER) commitment) is computed starting with 2017:Q4–2018:Q3 to follow the timing of the no-ER-commitment scenario. The original benchmark simulation started with 2018:Q1–2018:Q4.

observed actual numbers (see asterisks in this figure). This is due to lower GDP (and currency) growth and especially due to a stronger currency in the counterfactual scenario without the commitment, which implies a lower value of FX reserves expressed in the domestic currency and thus lower equity.[26] Subsequently, the size of the negative equity would have been less than half that in the benchmark simulation due to a lower stock of foreign exchange reserves and the resulting less-adverse valuation losses (in combination with the assumption of no deflation spiral in the counterfactual scenario and neutrality of monetary policy for long-term real economic developments). The time span of negative equity, however, would be 18 years from the beginning of the simulation. Interestingly, this is not much less than in the benchmark case with the exchange rate commitment, where negative equity is projected for 23 years (although starting in 2017/2018). In terms of the CNB's (in-)ability to pay dividends to the government, the counterfactual simulation is thus no more optimistic than the benchmark until around 2030. This shows the importance of quantifying the counterfactual scenario if

[26]Note that the CNB's FX reserves were smaller but still substantial before the exchange rate commitment was introduced (see Section 2).

one wants to discuss the fiscal consequences of the CNB's exchange rate commitment in depth.[27]

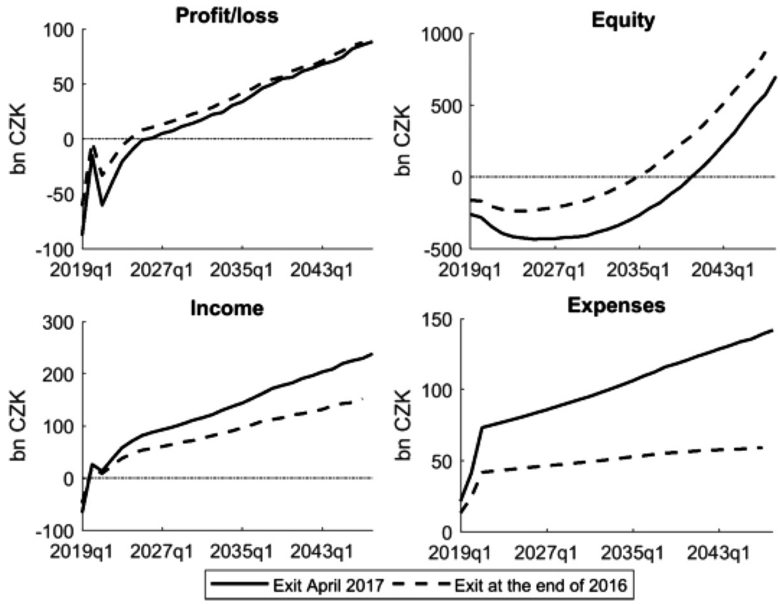
5.2 Hypothetical Termination of the Exchange Rate Commitment at the End of 2016

The second policy scenario concerns the question of how the balance sheet and its outlook would have looked if the exchange rate commitment had been terminated at the end of 2016. This situation is a subject of local public debate. The popular argument goes that an earlier exit at the end of 2016 would have led to a much smaller balance sheet and consequently to an earlier potential transfer of profits to the Ministry of Finance. The extension of the CNB's exchange rate commitment into 2017 is thus criticized for having had major (and—implicitly presumed—almost immediate) fiscal implications.

There are two major flaws to this argument. First, in September 2016 the CNB committed not to "discontinue the use of the exchange rate as a monetary policy instrument before 2017 Q2" (CNB 2016). It is extremely unrealistic to assume that the increase in the CNB's FX reserves in November and December 2016 would have been the same as the one observed in reality without this extended commitment. Most probably, exporters would have hedged before the end of 2016, and financial investors would have done the same as regards building their long CZK speculative positions. There is no significant reason to believe that the overall size of the CNB's balance sheet expansion would have been much lower; it would just have had a different timing. The only way to avoid the observed balance sheet increase would probably have been to extend the "hard" commitment in autumn 2016 and then break it. However, this would

[27]Moreover, when assessing the overall fiscal consequences of the exchange rate commitment, one cannot just look at the CNB's equity and potential future transfers of profits from the central bank to the government. In the hypothetical scenario without the commitment, the lower nominal GDP growth would lead mainly to a deterioration in the primary government budget balance as a result of lower revenues, and to an adverse denominator effect. In addition, the higher interest rate would increase the costs of debt service. Using the "no exchange rate commitment" counterfactual scenario in Brůha and Tonner (2017), the CNB's fiscal experts have estimated the debt/GDP ratio as reaching 42.7 percent at the end of 2015 in the hypothetical scenario without the commitment, compared with the observed 40 percent level.

Figure 10. Early Exit from the Exchange Rate Commitment (medians)



have been extremely harmful to the CNB's credibility. At the same time, the exchange rate developments after such a surprising exit would probably have been much less smooth than in reality; and with a more pronounced CZK appreciation, the CNB's equity might have turned more negative even with a smaller balance sheet.

Second, even if one ignores the above fundamental issues, none of the CNB's critics have taken the trouble to quantify the implications of a smaller central bank balance sheet. In Figure 10, we thus provide a simulation with the—extremely unlikely—assumption that the CNB's balance sheet expansion in 2017:Q1 would not have happened and everything else would have remained the same.

The scenario is based on the balance sheet data as of December 31, 2016, the observed data for 2017, and the macroeconomic forecast from Inflation Report I/2018. It turns out that in the event of an end-2016 exit, profits would turn positive two years earlier (i.e., in 2024) and equity five years earlier than in the baseline. Therefore, the fiscal implications of the extension of the CNB's exchange rate commitment—if there are any, given all the above disclaimers—relate to a relatively short period in the fairly distant future.

5.3 Long-Run Decline in Currency in Circulation

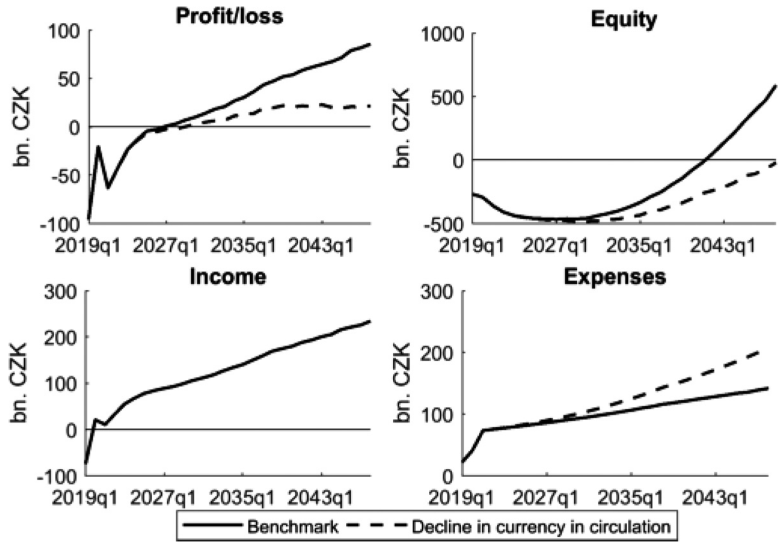
The third scenario is intended to shed some light on the CNB's finances in the event of a long-run decline in currency in circulation relative to GDP. One possible reason for such a decline would be a switch to non-cash payment systems. This issue is discussed for the Czech Republic and other OECD countries by Komárek, Polášková, and Hlaváček (2018). Even though they conclude that the popularity of cash is unlikely to drop significantly in the Czech Republic any time soon, in spite of all the advances in payment technologies, it is relevant to keep this option in mind, especially when discussing long timescales.

The situation is modeled by relaxing the assumption of currency growth being equal to nominal GDP growth. The value and volume of cash transactions in the economy are no longer approximated by nominal GDP growth, and an increasing proportion of transactions are carried out in other forms of money. In the scenario we assume that the ratio of growth of money in circulation to nominal GDP growth decreases from +1 to –2 in 30 years. The numbers are chosen to approximately mimic the trend observed in Sweden over the last two decades. Note, however, that Sweden represents an extreme case in terms of its recent decline in currency in circulation.[28]

The resulting outlook for the CNB balance sheet and a comparison with the benchmark specification can be found in Figure 11. Profit and equity are lower due to lower seigniorage (monetary income). The switch to positive profits would take place two years later than in the baseline scenario, whilst equity would approach zero at the end of the projection horizon in the scenario with declining currency in circulation. Income from FX holdings is not affected and expenses would be higher because of a large amount of interest-bearing commercial bank reserves—lower currency in circulation

[28]Williams and Wang (2017) report that Sweden and Norway are the only countries for which nominal GDP growth exceeded currency in circulation growth over the period 2006–16.

Figure 11. Declining Currency in Circulation (medians)



implies a larger amount of deposits for a given amount of liabilities. Overall, the simulated extreme decline in the cash ratio does not alter the ultimate switch to positive profit and equity and thus is not a major threat to the sustainability of the CNB's finances.

5.4 Sales of FX Income

The fourth scenario captures an example of active management of the CNB's balance sheet size in which the evolution of the asset side—and thus also the liability side—differs from simple autonomous expansion due to coupon income earnings on FX assets (expressed in the domestic currency). In particular, we focus on the option of resuming the CNB's earlier program of selling FX securities to commercial banks, with the size of the sale equal to the amount of FX income earnings realized within the period.[29] In this scenario, we assume that such sales would resume after two years, i.e., in 2020.

[29] The labeling "FX income sales" is adopted in the subsection title and in the following text for the sake of brevity.

FX income sales represent a way to keep the absolute size of the foreign exchange reserves non-increasing, leading to decline relative to GDP in the long run. A central bank with large foreign exchange reserves might prefer to limit their further growth for several reasons. For example, such action might put it in a better position for the possible use of unconventional monetary policy measures in the future. If price stability—the central bank's primary objective—is not endangered, it might also be desirable for the central bank to limit the volatility of future profits and losses stemming from holding large foreign exchange reserves, i.e., to conduct a standard profit mean-variance type of consideration over the portfolio of assets.

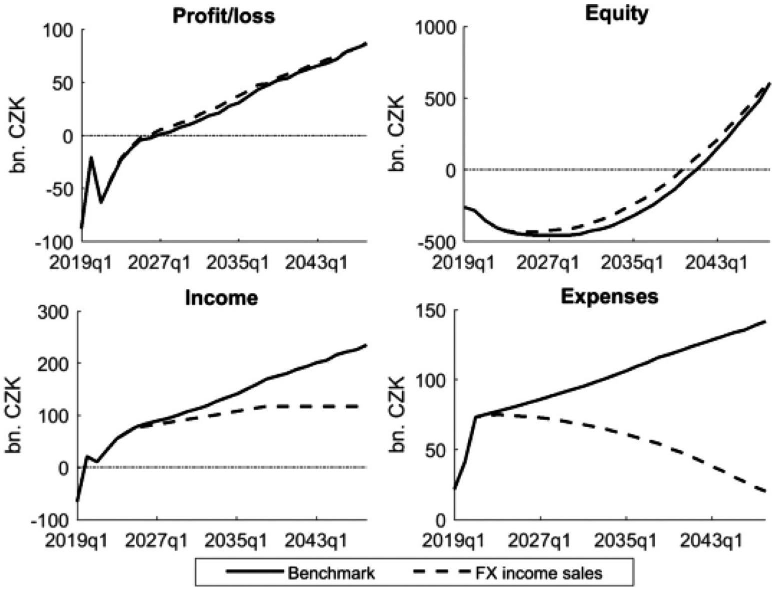
Sales of interest income earned on holdings of foreign currency assets are essentially implemented by selling to commercial banks a portion of those holdings. The size of these asset sales is thereby equal to the amount of FX reserves accumulated within the accounting period as a result of interest income earned on the stock of foreign currency securities held at the start of the period. The asset side is thus reduced by a corresponding amount. This procedure is reflected in a decrease in the reserve balances of commercial banks on the liability side of the central bank's balance sheet, which ultimately implies that reserve balances on the CNB's balance sheet are reduced by an amount equal to interest income earned on foreign currency assets.[30] By the next period, the income statement is affected by the decrease in both asset holdings and commercial bank reserves and, potentially, also by the effect of the sale on the exchange rate.

From the point of view of the modeling framework, when the securities equivalent of income earnings on foreign currency assets is sold, the intervention term $FXInt_t$ turns negative. In the scenario, an amount of securities equal to the entire interest income earned on the foreign currency portfolio in a given year is assumed to be sold to commercial banks, and the CNB's liability side decreases accordingly.

For the sake of simplicity, we assume that these sales are sufficiently small not to deflect the exchange rate path—and thus the

[30]The size of the commercial bank's balance sheet remains the same when purchasing the foreign currency securities, but the composition changes in terms of the currency denomination of its assets, with an exactly offsetting decrease in reserve balances held at the central bank.

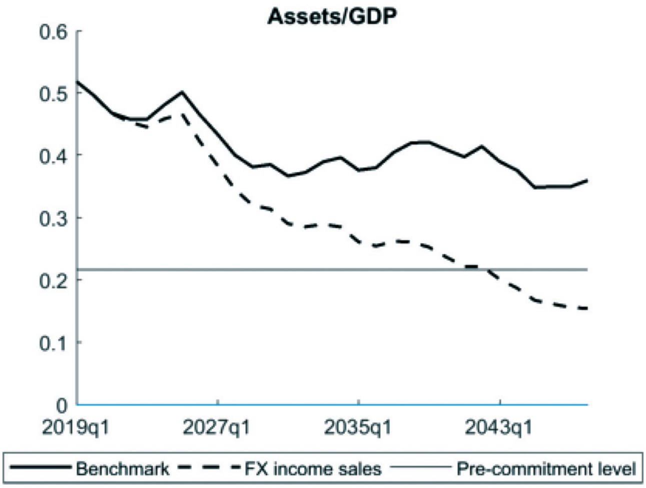
Figure 12. Sales of FX Income after Two Years (medians)



trajectory of all other macroeconomic variables—from the baseline simulation.[31] The average CZK value of the FX reserves sales during the period from April 2004 to October 2012 was approximately CZK 19 billion, or 0.5 percent of GDP, per year. The volume was set so as not to affect the CZK/EUR market significantly. In our scenario, the value of the FX sales starts at CZK 15 billion in 2020, rises to CZK 118 billion in 2040, and then remains at that level (see the evolution of income in Figure 12). In terms of GDP, the sales represent 0.3 percent in 2020, go up to 1.0 percent in 2040, and then decline to 0.9 percent at the end of the projection period, following the increase in the foreign interest rate in the first 20 years of the projection along with decreasing nominal GDP growth. Taking into account the growing openness of the Czech economy (and thus the size and depth of the CZK/EUR market), the assumption of no

[31] If the FX income sales were having a significant appreciation effect on the currency, they would worsen the CNB's losses and could also endanger the achievement of the 2 percent inflation target. The central bank would thus need to reduce their size to a level consistent with minimizing the exchange rate effect.

Figure 13. Assets/GDP Ratio for Sales of FX Income Starting after Two Years (medians)



Note: The pre-commitment level indicates the assets-to-GDP ratio at the end of 2012.

effect of FX income sales on the exchange rate in the scenario is plausible.

Figure 12 suggests that the effect of the sales is not substantial in terms of the CNB's profits and equity. The profit marginally increases in the medium term, mainly because of a decline in bank deposits at the CNB that have to be remunerated at the monetary policy rate, which slightly outweighs the lower income on the FX reserves. The equity thus turns positive marginally earlier than in the baseline simulation, but the difference is extremely small. This shows that the eventual resumption of sales of FX securities equaling FX income earnings should not be viewed as a measure to address the CNB's negative equity issue. However, it could contribute significantly to reducing the CNB's balance sheet size relative to GDP, as suggested by Figure 13, which compares the size of the balance sheet in the benchmark case and the case of FX sales. Such a reduction could be viewed as a step towards making the CNB's balance sheet better prepared for a possible new round of unconventional monetary policy measures, should it be needed in the (relatively distant) future. It turns out that over the 30 years of the projection, the size of the balance sheet relative to GDP would decline towards the levels experienced before the unconventional measures were introduced. This may be welcomed by future policymakers if they need to resort to another round of unconventional operations in the long run.

In terms of the CNB's finances, expected profits are lower in this scenario than in the benchmark simulation (almost three times lower at the end of simulation horizon), but the variance of profits decreases considerably. This implies that whenever the central bank is risk averse, or simply prefers to avoid periods with extremely negative equity due to communication and independence concerns, balance sheet size management in the form of FX income sales represents a useful tool.

5.5 The CNB's Negative Equity and Inflation

The aim of this section is to quantify the effect of the CNB's large negative equity on macroeconomic variables—especially inflation—and then to discuss the feedback effects on the balance sheet. The benchmark modeling approach does not allow for any influence of the balance sheet on macroeconomic variables. Therefore, the last scenario is a modeling scenario rather than a policy scenario.

Regarding central bank losses or negative equity, the literature often discusses the threat to the central bank's independence and therefore the credibility of its monetary policy (e.g., Stella 1997). Empirical papers investigating the relationship between the central bank's balance sheet and inflation do not provide any clear general conclusion (Klüh and Stella 2008; Benecká et al. 2012; Hampl and Havránek 2018).

Furthermore, there are several theoretical studies based on general equilibrium models that examine the possible channels through which a large central bank balance sheet can affect the conduct of monetary policy and ultimately inflation (Benigno and Nisticó 2015; Del Negro and Sims 2015; Park 2015). For example, Del Negro and Sims (2015) show that if there is no fiscal backing in the form of potential capital injections from government to the central bank, the public may start to believe that possible solvency issues of the central bank will result in higher inflation. Higher expected inflation increases the nominal interest rate, which in turn affects the value of the central bank's assets, thereby exacerbating the solvency issue even more. All in all, every theoretical study suggests that potential problems with fulfilling the goals of monetary policy can only arise when the central bank's loss is substantial and unsustainable.

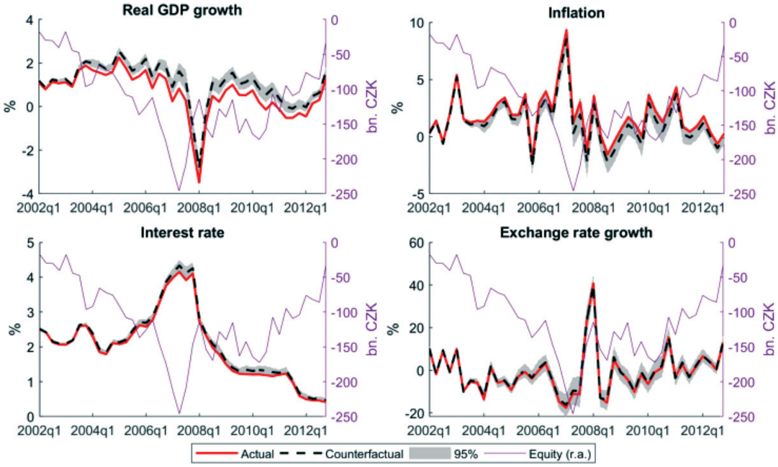
The CNB's experience with a long period of negative equity represents a great opportunity to empirically examine the impact of negative equity on inflation and other macroeconomic variables and subsequently to consider feedback effects when the balance sheet items are simulated. We start with an SVAR-based policy counterfactual imposing zero CNB equity on the observed circumstances between 2002:Q1 and 2013:Q4.[32] More specifically, we estimate a standard small open-economy BVAR model with central bank equity included in the set of endogenous variables.[33] Then we apply a triangular shock identification scheme with equity ordered last in the vector of endogenous variables and use the structural shocks to simulate the counterfactual with equity equal to zero, i.e., we impose zeros on all coefficients in the equity equation and on structural shocks to equity. In the terminology of the literature dealing with SVAR-based monetary policy counterfactuals, we zero out both the systematic and the non-systematic part of "equity policy."[34]

[32] We follow a rich tradition of SVAR-based policy counterfactuals. An example of this approach applied to the balance sheet can be found in Boeckx, Dossche, and Peersman (2017). Note that there is a serious criticism of this approach based on the Lucas critique—see, for example, the discussion in Primiceri (2005, pp. 839–41). On the other hand, to the extent that balance sheet policy is more rules based than traditional interest rate monetary policy, the critique may not be as severe.

[33] The specification of the BVAR model follows Brázdik and Franta (2017), discussed in more detail in Appendix A, with some differences. First, the CNB's equity is now included as an endogenous variable. Second, no mean adjustment is applied, as we do not want to impose long-run behavior, especially on inflation and equity. Here, we focus on the in-sample properties of the model. In Appendix A, the out-of-sample ability of the model is of interest. The period 2002:Q1–2013:Q4 is driven by the availability of quarterly data on equity on one side and the introduction of the exchange rate commitment on the other. Finally, note that the model controls for inflation target changes.

[34] Central bank equity is directly linked to assets and liabilities. So, "equity policy" can be understood as any policy related to assets or liabilities. Zeroing out equity policy means, among other things, that the central bank counteracts the standard impacts of macroeconomic variables on the balance sheet items.

Figure 14. Counterfactual Evolution of Macroeconomic Variables with Zero Equity

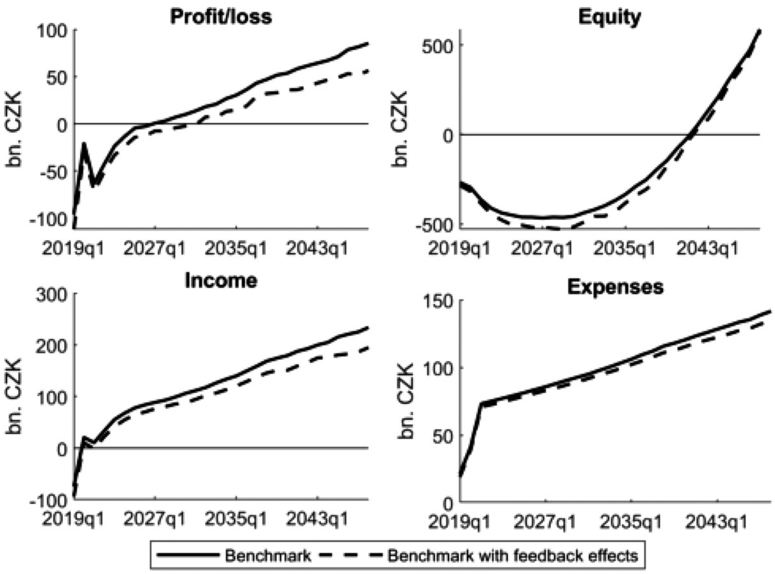


The counterfactual presented in Figure 14 suggests that zero equity during 2002–13 would have been connected with higher GDP growth, lower inflation, a higher interest rate, and a more depreciated currency on average.[35] The lower the equity, the stronger the effect.

To get a rough quantitative assessment of the feedback effect of large negative equity on the balance sheet through macroeconomic variables, we conduct the following exercise. We compute the average difference between the observed macroeconomic variables and

[35]The identification and exact quantification of the channels through which negative equity affected macroeconomic variables during the period of interest is beyond the scope of this paper. Two points, however, are worth noting. First, negative equity was related to higher inflation (although the difference is not statistically significant at the 95 percent level). This is reminiscent of the channel discussed in Del Negro and Sims (2015), which relates negative equity to higher inflation expectations and consequently observed inflation. Second, the fact that we analyze a small open economy with central bank assets consisting exclusively of FX reserves adds new channels to those discussed in the literature. For example, public expectations of FX reserves sales by the central bank in order to deal with the negative equity could explain the stronger currency in the actual exchange rate growth (again, the observation is not statistically significant).

Figure 15. The Effect of Negative Equity on Macroeconomic Variables



the counterfactual if equity is below CZK –150 billion, or approximately 3 percent of GDP. Then we add those average differences to the macroeconomic paths employed to simulate the balance sheet (for simulated equity paths below CZK –150 billion) and resimulate the balance sheet items.[36] The result is presented in Figure 15 together with the benchmark simulation. It follows that taking into account feedback effects yields a slightly less favorable picture of the CNB's finances. Profit appears a year later than in the benchmark. The switch of equity to positive numbers is not affected, but the trough is lower if feedback effects are taken into account. The main driver of the result is lower GDP growth, which is reflected in lower growth of currency in circulation and thus also in lower seigniorage revenues.

[36]We simulate 10,000 counterfactuals for potential adjustment of 10,000 simulated macroeconomic paths. Also note that the procedure only approximates the total feedback effects, because we iterate between equity and macroeconomic variables only once. However, the effect on equity is not substantial and thus the approximation seems to be sufficient.

6. Conclusions

In this paper, we use the example of the Czech National Bank balance sheet to discuss the situation faced by small open catching-up economies with central bank balance sheets dominated by foreign exchange reserves that might consider using the exchange rate as an unconventional monetary policy instrument in the future.

Looking specifically at the CNB's situation, its balance sheet has recently increased substantially as a consequence of the exchange rate commitment backed by purchases of euro. As the asset side of the balance sheet consists almost solely of foreign assets, and exchange rate changes are marked-to-market, any appreciation of the Czech currency is reflected in accounting losses and negatively affects the central bank's finances. The Czech koruna is exhibiting a real appreciation trend due to economic convergence, so some further losses are likely. Given the lively public debate related to the CNB's Financial Reports, our paper focuses on projections of the CNB's balance sheet and the uncertainty surrounding them. In addition, several policy scenarios are examined to clarify various aspects of the CNB's finances.

We demonstrate that the outlook for the CNB's balance sheet does not differ qualitatively from what has been experienced in the last two decades, and as such the fulfillment of monetary policy aims should not be endangered. In particular, the CNB exhibited negative equity for 16 years between 1998 and 2013, with the peak level corresponding to 5 percent of GDP. In our baseline projection, the equity is projected to remain negative for the next 23 years at a level not exceeding 7 percent of GDP. As the CNB has not faced any loss of independence or ability to control inflation due to the losses and negative equity it has recorded in the past, we conclude that the projected situation does not imply any problems for the central bank's operations in the future.

Apart from the most probable outlook for the CNB's balance sheet items, the simulation tool can be used for various policy-relevant exercises. In this paper, we follow five scenarios—two related to the exchange rate commitment (absence of the commitment, earlier exit from the commitment) and the other three to more general economic questions (a long-run decline in the currency-to-GDP ratio, sales of FX income by the central bank, and the role of negative equity).

The counterfactual scenarios related to the exchange rate commitment suggest that the commitment (and its duration) did not alter the outlook for central bank finances qualitatively. In particular, in both of these scenarios the CNB would currently be exhibiting negative equity and would continue to do so for an extended period of time. Given that the CNB pays no profit transfers to the government as long as it has accumulated losses in its balance sheet, no matter what size, the exchange rate commitment and the design of its exit have no immediate or medium-term adverse fiscal implications. In both counterfactual scenarios, no profit transfers are possible before the year 2030. Regarding the general economic scenarios, it turns out that a decline in the currency-to-GDP ratio, the potential restart of sales of yields on FX reserves, and feedback effects between central bank equity and macroeconomic variables do not significantly change the outlook for the CNB's equity. There are many other possible applications of the simulation tool. One important possibility is stress-testing of the CNB balance sheet along the lines of Christensen, Lopez, and Rudebusch (2015).[37]

Appendix A. Macro Models

The main macroeconomic model used to generate the forecast paths entering the balance sheet accounting identities is a small-scale vector autoregression one estimated by Bayesian techniques (BVAR).[38] The Bayesian approach is a natural choice because the forecast paths can be generated directly during the estimation of the model. Even though the balance sheet projections are of yearly frequency, the underlying macro model is estimated on quarterly data because of the very short time span that would be available for yearly data. For a detailed description of the model and its estimation, see Brázdik and Franta (2017). The main reason for the use of the mean-adjusted

[37] Christensen, Lopez, and Rudebusch (2015) focus on interest rate risk, as the U.S. Fed's balance sheet comprises U.S. mortgage-backed securities. In the CNB case, the focus would be on exchange rate risk.

[38] The model is estimated with the BEAR toolbox (Dieppe, Lagrand, and van Roye 2016).

version of the BVAR model is to guarantee sensible forecasts even at the long end of the forecasting horizon.[39]

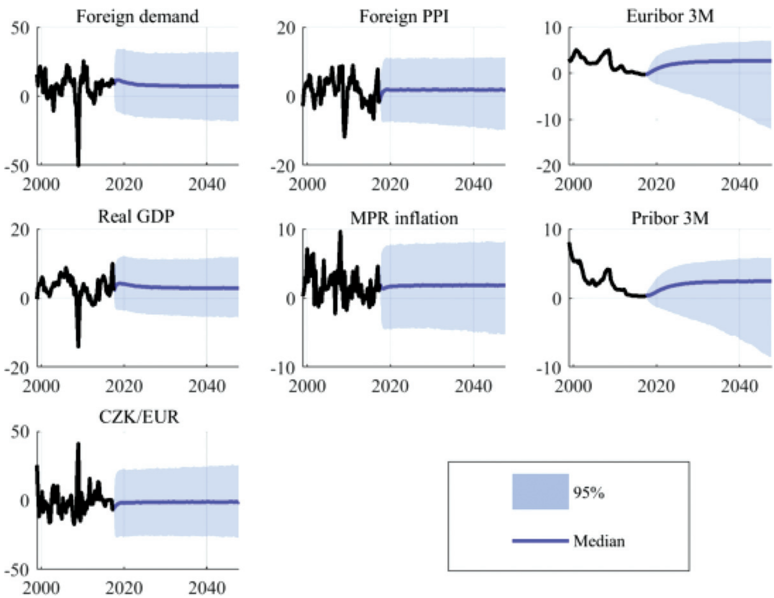
The model contains three foreign variables (foreign demand growth, foreign inflation, and the foreign interest rate) and four domestic variables (real GDP growth, monetary policy relevant inflation, the short-term interest rate, and the exchange rate change). The variables are in annualized quarter-on-quarter changes, except for the interest rates, which are in levels. In addition, the model incorporates block exogeneity of foreign variables to reflect the fact that the Czech economy is a small open economy such that domestic shocks and variables do not affect foreign variables. Furthermore, the model features mean adjustment, which allows us to incorporate information about the steady state of macroeconomic variables directly into the estimation procedure in the form of a prior on the steady state. The imposed means of the steady-state priors coincide with the equilibrium values used for the construction of the deterministic path defined in the main text.

The BVAR model is estimated on the period 1998:Q1–2017:Q3, and iterated forecasts for up to 120 quarters are generated reflecting the estimated model parameters. The forecast paths are then processed in several steps. First, the paths that are generated by unstable VARs are discarded (the ratio of the discarded paths is 0.05). We thus impose the condition that unstable forecast paths of macroeconomic variables are not a sensible description of the economic outlook.[40] Second, the median of the forecast paths for a given

[39]The reason why the main CNB forecasting model, which is a standard medium-scale New Keynesian DSGE model, is not used to generate the forecast paths of the macroeconomic variables in this paper is threefold. First, generating a high number of paths based on a complex DSGE model is computationally infeasible. Second, using a simpler VAR-type model allows us to account for the uncertainty of the model parameters in the balance sheet simulations. The uncertainty associated with the parameters of the model is presumably large for the Czech economy and should be accounted for in stochastic simulations of the balance sheet. Third, in contrast to the CNB's DSGE model, foreign variables are treated as endogenous in the BVAR model and forecast paths of the foreign interest rate can thus be generated.

[40]Note that a stable outlook for macroeconomic variables does not imply a stable outlook for the central bank balance sheet. The stability of the balance sheet also hinges on the relative steady-state values of the economic variables. Possible combinations of steady-state values that lead to indefinite loss accumulation for a converging economy are discussed in Cincibuch, Holub, and Hurník

Figure A.1. Distribution of Forecasts from the BVAR Model



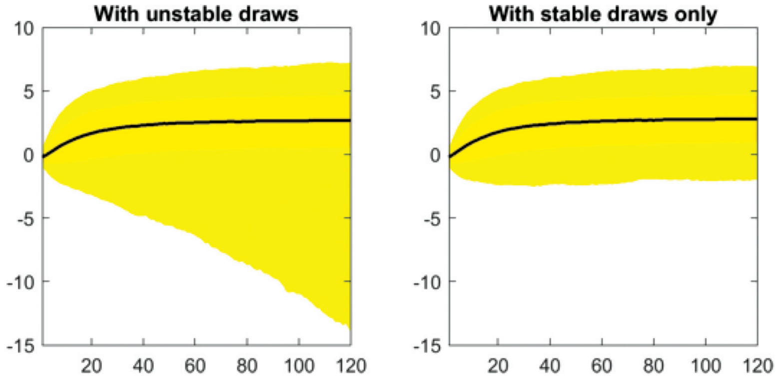
horizon and variable is subtracted from the forecast paths. The aim is to obtain paths that reflect solely the effects of possible shocks on the macroeconomic variables based on the estimated historical shocks.[41] Subtracting the median filters out the initial conditions, the transition to the steady state, and the steady state itself — those are provided by the deterministic path defined outside the model. The resulting forecast paths are then the same as if they had been simulated using just impulse response functions and estimated shocks. Finally, the forecast paths are transformed into yearly frequency by taking averages over four quarters.

Figure A.1 shows the forecast paths of the BVAR model in the form of 95 percent confidence intervals. The forecasting starts

(2009). Cincibuch, Holub, and Hurník (2009) show that the risk premium and the equilibrium real exchange rate are crucial factors for the possibility of central bank capital displaying explosive dynamics.

[41]Note that structural shocks are not identified and we work with reduced-form shocks.

Figure A.2. Distribution of Foreign Interest Rate Forecasts: The Effect of Excluding Unstable Paths



Note: 95 percent and 68 percent confidence bands are indicated by the shaded areas.

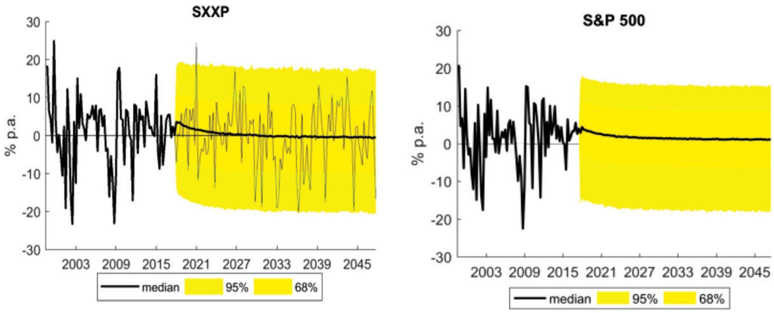
in 2017:Q4. The paths contain the paths generated by unstable VARs as visible in the forecasts of foreign and domestic interest rates (the 3M EURIBOR and the 3M PRIBOR (Prague interbank offered rate)). The effect of excluding unstable paths is depicted by Figure A.2. Note that pointwise confidence bands are presented. However, the whole paths enter the balance sheet simulation.

In addition to the BVAR model, a battery of models is used to generate forecast paths of EUR and USD stock returns and CZK/USD exchange rate appreciation/depreciation. We omit stock prices and the CZK/USD exchange rate from the BVAR model to keep the set of parameters manageable.

To obtain the forecast paths of USD and EUR stock returns, a simple bivariate vector autoregression consisting of stock returns and short-term interest rates is estimated separately for USD and EUR. The STOXX Europe 600 (SXXP) and the 3M EURIBOR are used in the model for stock returns for the euro area and the S&P 500 and the 3M USD LIBOR (London interbank offered rate) in that for the United States.[42] Based on the estimated model, the

[42]The number of lags is selected based on the Akaike information criterion (AIC) and equals two for both the EUR model and the USD model. The models are estimated on quarterly data over the period 1998:Q4–2017:Q4 and the resulting forecast paths are then averaged into yearly projections.

Figure A.3. Distribution of Stock Return Forecasts



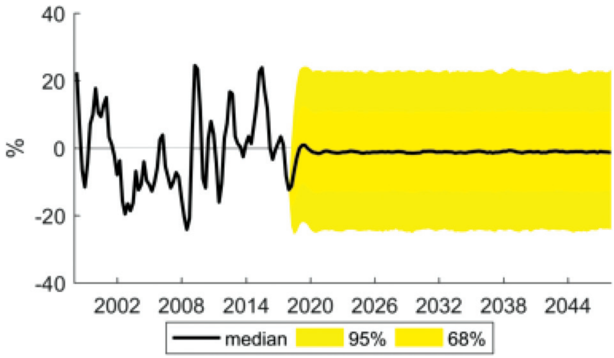
Note: The thin black line depicts a randomly drawn forecast path.

path of stock returns is computed for each forecast path of the short-term interest rate obtained from the main model. A randomly drawn historical residual estimated within the satellite model is added in each forecasting period to simulate the effect of upcoming shocks and uncertainty in the relationship between stock returns and short-term interest rates.[43] The resulting distributions of the stock return outlook are reported in Figure A.3.

The motivation for modeling stock returns based on the interest rate outlook is twofold. First, such a model setup—even though very simplistic—can capture a negative short-run relationship between interest rates and stock returns. Second, the wider confidence bands for stock returns in comparison to interest rates (see Figure A.5) hint at the higher riskiness associated with stock holdings. Stochastic simulations allow us to introduce the possibility of substantial losses on stock holdings. A randomly drawn forecast path for the SXXP stock return in Figure A.3 (the thin black line) shows that the stochastic framework allows for a situation of negative returns lasting several years, as observed, for example, during the Great Recession of 2008.

[43] Generating a forecast path of stock returns for a given path of the interest rate is basically hard-conditioning. However, we stick to the simpler procedure described in the text. Our approach ignores the estimated covariance between the residuals.

Figure A.4. Distribution of CZK/USD Exchange Rate Growth Forecasts



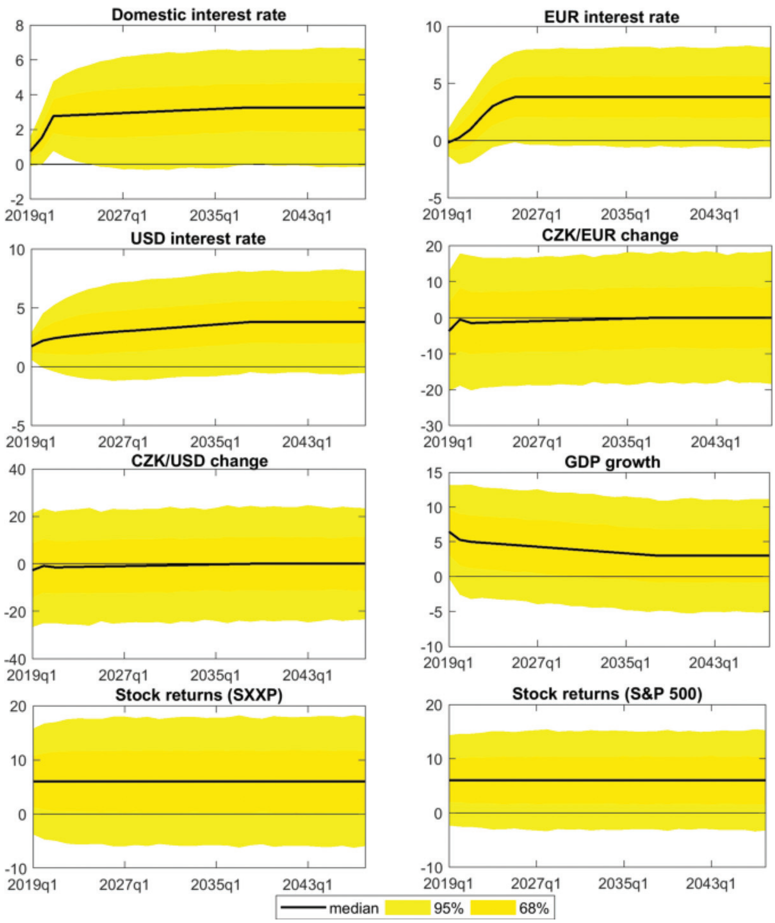
Similarly to stock returns, a bivariate VAR is used to generate forecast paths of the CZK/USD exchange rate. The CZK/USD exchange rate is not included in the core model because the model is not intended to model the world economy. On the other hand, a bivariate model consisting of the CZK/EUR and CZK/USD rates can to some extent capture the high correlation between the two, and the close relationship is thus transferred into the stochastic simulations.[44] The resulting distribution of the CZK/USD exchange rate appreciation/depreciation outlook is reported in Figure A.4.

Figure A.5 shows the projected distributions of the macroeconomic variables that serve as an input into the simulation of the balance sheet. They combine the deterministic path described in the main text and the forecast paths generated by the BVAR and satellite models. Regarding the forecast paths, some issues are worth noting.

The forecast paths for one-year foreign interest rates are taken from the model with the three-month rate. The use of the forecast paths of the three-month rate includes the assumption that the

[44]The number of lags is selected based on the AIC and equals two lags. The exchange rate enters the model in annualized quarter-on-quarter changes, consistently with the form of the CZK/EUR rate in the main BVAR model. The models are estimated on quarterly data over the period 1998:Q1–201:7Q4 and the resulting forecast paths are then averaged into yearly projections.

Figure A.5. Projected Distributions of Macroeconomic Variables



three-month and one-year rates experience similar shocks and transmission, i.e., that the difference between the two is constant. The demeaning procedure then produces the forecast path applicable to interest rates for one-year government bonds. Next, the underlying macroeconomic model includes only the EURIBOR and not the U.S. dollar interest rate. The simulated distribution of the EURIBOR is applied to the USD rate as well. The same path as for the EURIBOR is taken for the U.S. interest rate in the benchmark specification. As a robustness check, a randomly drawn forecast path of the EURIBOR is taken as the forecast path for the U.S. interest rate. The results are almost unaffected.

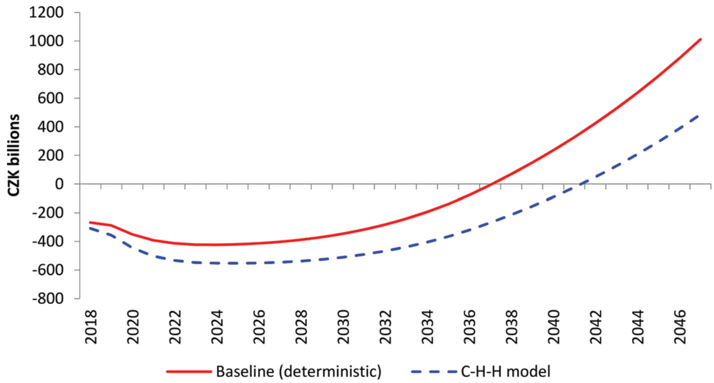
Figure A.5 also demonstrates that the effective lower bound on the nominal interest rate is ignored. Combining the forecast paths with the deterministic path defined outside the model precludes sensible treatment of the bound. The interest rates are crucial for the projections, as both income and expenses are directly linked to them. To get some idea of the effect of ignoring the bound, a robustness check is done below in Appendix C by imposing the zero bound for all parts of the interest rate forecast path that lies in negative territory. Note, however, that this adjustment ignores the impact of changes in the interest rate from negative to zero on other macroeconomic variables and as such can be considered illustrative only.

Appendix B. Comparison of the Baseline Simulation with Cincibuch, Holub, and Hurník (2009)

In this appendix, we present a comparison of our baseline simulations of the CNB's equity (in the deterministic version) with simulations based on the model from Cincibuch, Holub, and Hurník (2009) (referred to as the "C-H-H model"). This exercise serves (i) as a robustness check of our simulations; (ii) to illustrate the importance of modeling the yields on foreign exchange reserves in a more comprehensive way than the C-H-H model.

The C-H-H model setup focused strongly on central bank balance sheet issues associated with the process of economic convergence towards advanced countries. Currently, those issues remain relevant but are quantitatively less important given the more advanced stage of economic convergence in the Czech Republic and the lower speed of the catching-up process in the post-crisis period. On the other hand, the C-H-H model was very rudimentary in terms of modeling the yields on foreign exchange reserves. In fact, it assumed that all the reserves were allocated in euro-denominated assets and generated earnings equivalent to income from a one-year government bond. This was a justifiable simplification at that time, given the very conservative FX reserves management strategy followed by the CNB in the 2000s.

Figure B.1. Equity of the CNB—Baseline Simulation vs. Cincibuch, Holub, and Hurník (2009) Model



For the sake of comparability, the C-H-H model was rewritten from quarterly to annual frequency. At the same time, we used the same macroeconomic assumptions as in our baseline simulations wherever relevant. The main difference thus consists in (i) no distinction between the EUR and USD part of the FX reserves in the C-H-H model; (ii) no reflection of the investment in stock indices in that model.

As shown in Figure B.1, the two models provide a similar time profile for the equity of the CNB, including the peaks in 2023–25 followed by a gradual return to positive territory. Quantitatively, though, the C-H-H model is somewhat less optimistic than our baseline simulation, with the negative equity peaking at around 8 percent of annual GDP. This is due to more conservative modeling of the yields on FX reserves in the C-H-H model. However, the projected year of full elimination of the CNB's negative equity differs only slightly: 2038 in our deterministic setting of the baseline simulation and 2042 according to the C-H-H approach. Overall, the differences due to the different modeling approaches seem relatively small compared with the uncertainties related to the underlying macroeconomic assumptions, as highlighted in Section 4.

Appendix C. Additional Results

This appendix presents several sensitivity checks. The first check concerns the difference between the deterministic and stochastic simulations. The deterministic simulation implicitly assumes that the macroeconomic outlook underlying the balance sheet simulation is known with certainty. Importantly, the system of accounting identities is non-linear, implying skewed distributions obtained by stochastic simulations. For skewed distributions, some basic identities with medians cease to hold. For example, in the defining relationship of equity as the difference between assets and liabilities, the median of the equity distribution does not have to correspond to the difference in the medians of the distribution of assets and liabilities. The equity projection in the deterministic setting can thus differ from the median equity projection in the stochastic setting.

Figure C.1 shows the medians of CNB balance sheet and income statement items in the stochastic setting and their deterministic

Figure C.1. Deterministic and Stochastic (median) Simulations

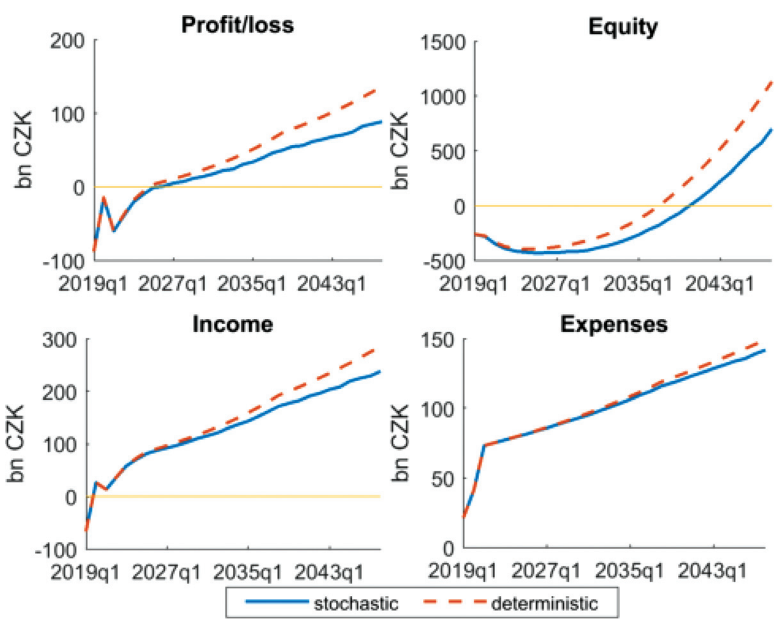
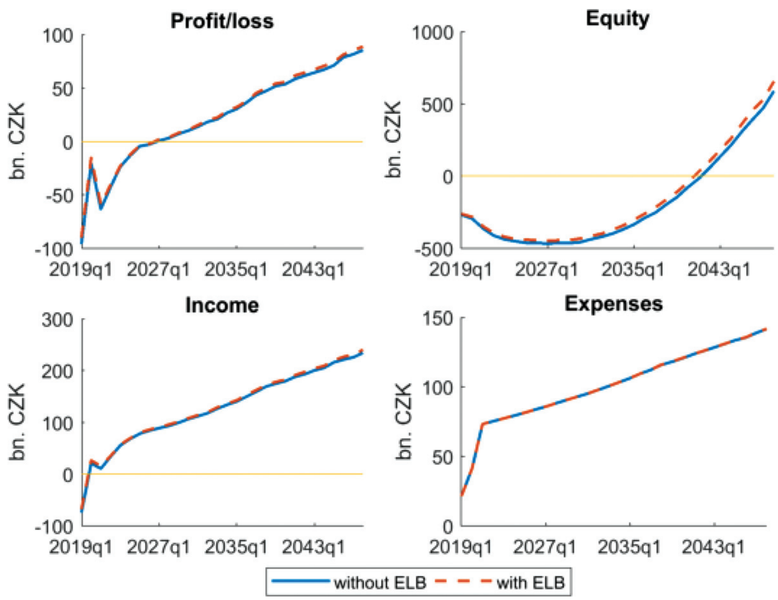


Figure C.2. Simulations without and with the ZLB



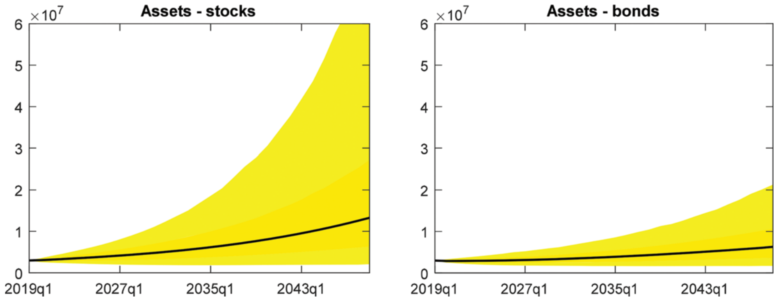
counterparts and demonstrates that relying on deterministic simulation could underestimate the duration of the negative equity period for this specific exercise.

The second check relates to the zero lower bound on the nominal interest rate (ZLB). As shown in Figure A.5, a portion of the possible realizations of future interest rate paths attain negative values. Figure C.2 demonstrates that accounting straightforwardly for the ZLB by imposing zero whenever the outlook is negative does not have a substantial effect on the projected variables. The fact that the ZLB is not accounted for in the main text is therefore not an important issue.

Appendix D. Notes on the Composition of the FX Reserves

Stochastic simulations of the balance sheet can be employed to contribute to the discussion of the composition of the asset side of the balance sheet. All the simulations presented in the main text are

Figure D.1. Stochastic Projections of the Asset Side



Note: The median (black line) and the 68 percent and 95 percent confidence intervals (shaded areas) are presented.

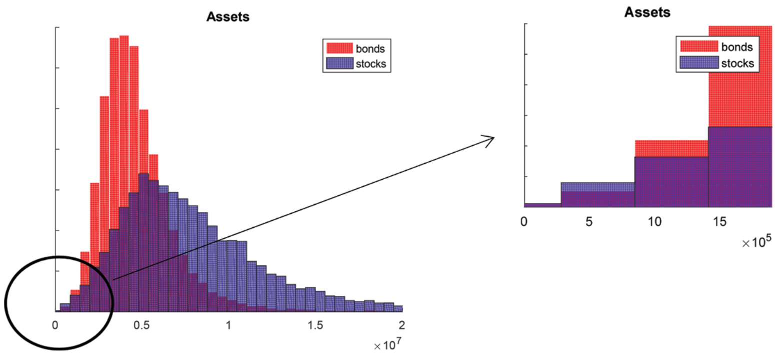
based on the assumption that foreign government bonds comprise 90 percent of assets and the rest is invested in a stock portfolio. Comparing the projections for different stock-bond ratios can help to frame the discussion underlying the asset management. Note, however, that the satellite model for stock returns employed by the simulation tool is very simple, so a more detailed quantitative analysis of the stock-bond composition is not pursued in this paper.

To shed some light on the effect of various FX reserves compositions, two extreme cases are examined—the situation where assets consist of stocks only and that where they are made up solely of foreign government bonds. Figure D.1 reports the stochastic projections of the asset side in the two cases. It turns out that the median projection is higher in the case of FX reserves fully invested in stocks. On the other hand, wider confidence bands can be observed, as holding stocks is a riskier option.

To directly compare the two cases, Figure D.2 shows the simulated distributions of FX reserves after 20 years in the cases where the CNB holds stocks only and foreign bonds only. Holding stocks only, there would be higher probability of a higher CZK value of FX reserves holdings (left panel). Furthermore, a slightly higher probability of a very low value of FX reserves is estimated in the same situation (right panel).

The difference in the probability of a very low value of FX reserves for stocks and for bonds is not substantial. This observation

Figure D.2. Distribution of the FX Reserves in 20 Years



is a consequence of an important channel that should be taken into account when considering the optimal stock-bond ratio. Assuming a negative relationship between stock returns and bond yields, lower stock returns are associated through higher foreign bond returns and the uncovered interest parity (UIP) condition with depreciation of the domestic currency and thus with higher returns on the asset side of the central bank balance sheet. The exchange rate thus moderates the central bank loss associated with a decrease in stock returns.[45]

Appendix E. Model Extensions for Various Remittance Policies

This appendix presents the extensions of models (1)–(9) for the remittance policies employed by the Swiss National Bank, the Riksbank, and the Bank of Korea. In addition, we touch upon the case of the Federal Reserve and explain its accounting treatment of losses to contrast it with the approaches employed by the CNB and other central banks.

[45] Other links affect the central bank balance sheet in the case of a fall in stock returns. For example, the open-economy IS curve suggests that an increase in the foreign interest rate leads to a fall in domestic output gap, which negatively affects seigniorage revenues and consequently leads to lower central bank profit. The estimated model, however, suggests that the link implying higher profits due to exchange rate depreciation dominates.

In contrast to the discretionary nature of profit transfers at the CNB, other central banks often systematically allocate some fixed share of their net income to capital or equity, with the rest being remitted to government or shareholders.[46] To model this type of remittances practice, an additional variable R_t is employed to represent the stock (as of the end of period t) of retained earnings accumulated over time, together with a law of motion for this variable that features the flow of within-period retained earnings $(\Pi_t - Tr_t)$ as the variable governing the change in the stock variable R_t across periods (see Equation (10) below). The implementation details differ across central banks, and we discuss several examples below.

At the Swiss National Bank, profits are transferred to the reserve account, which accumulates distributable profit and is used to fund a fixed amount of remittances T to the cantons and the Swiss Confederation. The amount T is agreed on with the Federal Department of Finance for a fixed number of years. Remittances proceed only if the size of the reserve account is positive. So, the transfers are defined as

$$\begin{array}{ll} Tr_t = T_t & \text{if } T_t < R_{t-1} + \Pi_t \\ Tr_t = max\,(0, R_{t-1} + \Pi_t) & \text{otherwise,} \end{array} \tag{5a}$$

where T_t corresponds to the payment agreed on for year t.[47]

The Riksbank remits 80 percent of net income averaged over the last five years if the number is positive, with the rest being transferred to the reserve account. In the case of large losses which cannot be absorbed by the reserve, remittances are suspended. If we define $T_t = 0.8 * \left(\frac{1}{5}\right) \sum_{i=0}^{4} \Pi_{t-i}$, then the remittance policy can be represented as follows:

[46] A survey of various remittance practices can be found in Chaboud and Leahy (2013).

[47] Two aspects are worth discussing here. First, if we do not know the agreed fixed payment to government for some future years included in the projection horizon, we can impose the last known amount or make the projections conditional on the value of the agreed payment. Second, for simplicity we assume that if the reserve account adjusted for net income cannot fund the payment to government, the central bank remits what is left of the retained earnings and net income. The same convention is held for the second example as well.

$$\begin{array}{ll} Tr_t = T_t & \text{if } 0 \leq T_t \leq R_{t-1} + \Pi_t \\ Tr_t = max\,(0, R_{t-1} + \Pi_t) & \text{if } 0 \leq T_t \text{ and } R_{t-1} + \Pi_t < T_t \\ Tr_t = 0 & \text{if } T_t < 0 \end{array} \tag{5b}$$

Finally, the Bank of Korea can transfer at most 90 percent of the profit, and any losses that exceed the balance on the reserve account are made up by the government (then the variable Tr_t is negative):

$$\begin{array}{ll} 0 \leq Tr_t \leq 0.9 * \Pi_t & \text{if } 0 \leq \Pi_t \\ Tr_t = 0 & \text{if } -R_{t-1} \leq \Pi_t < 0 \\ Tr_t = \Pi_t + R_{t-1} & \text{otherwise.} \end{array} \tag{5c}$$

The balance on the reserve account evolves for all three above-mentioned examples as follows:

$$R_t = max\,(0, R_{t-1} + \Pi_t - Tr_t)\,, \tag{10}$$

expressing the fact that profits that are not transferred to government are passed to the reserve account and losses are absorbed in the amount left on the reserve account. In the case of the Bank of Korea, the term $R_{t-1} + \Pi_t - Tr_t$ is never negative, thus implying that the max operator in (10) is unnecessary.

In our model, retained earnings can take the form of FX reserves only. If reinvested, the term R_{t-1} is added to FX_{t-1} in the equation for income (1), i.e., the interest paid for holding retained earnings is treated as income. In reality, however, the retained earnings can be invested in some other type of asset, or interest on retained earnings can be transferred to the reserve account. In such case, the asset side needs to be expanded to incorporate other types of assets and their law of motion, or the law of motion for retained earnings has to be adjusted.

The equation for equity is adjusted to reflect a new item on the balance sheet as follows:

$$\begin{aligned} Eq_t &\equiv FX_t + R_{t-1} - Liab_t \\ &= Eq_{t-1} + R_{t-1} + \Pi_t - Tr_t. \end{aligned} \tag{9'}$$

When a loss occurs and is absorbed, the equity decreases to the extent not covered by the reserve account only.

Yet another remittance approach is followed by the Federal Reserve with its surplus account. This approach does not imply smoothing of remittances, in contrast to the approaches taken by the Swiss National Bank and Riksbank.[48]

Regarding the accounting treatment of losses and its consequences for remittances, the Fed's operating losses are reflected in the creation of a "deferred asset" which, essentially, represents a pledge to cover earlier losses through future positive income realizations. More specifically, in the case in which the Fed experiences a loss on its income statement, remittances cease and such loss is recorded on the balance sheet as a negative liability, with this item labeled as a "deferred asset." The value of the deferred asset reflects the amount of future operating profits that need to be realized to pay down earlier losses before remittances to the fiscal authorities can resume. Once the deferred asset is paid down and returns to zero, the Fed is required to resume the transfer of all its positive net income realizations to the Treasury. Thus, differently from the case of the CNB described in detail in Section 2, the Fed does not enjoy any degree of discretion to retain its operating profits. Conversely, in contrast to the cases of the CNB, the Swiss National Bank, and the Riksbank, the presence of the deferred asset allows the Fed not to affect negatively its capital position in the case of an operating loss. Since the Federal Reserve balance sheet differs significantly from our model, we just mention the approach and do not discuss the model extension for this type of remittance policy and the treatment of losses.

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[48]In the case of the Fed, the positive net income is transferred to the Treasury subject to the aggregate surplus limitation set within the Federal Reserve Act. The limit on the aggregate surplus is currently \$6.825 billion, and any amounts of surplus funds that exceed or would exceed the limit are transferred.

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