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Balance of payments pressures on the nominal exchange rate: A fresh look at old ideas

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BALANCE OF PAYMENTS PRESSURES ON THE NOMINAL EXCHANGE RATE: A FRESH LOOK AT OLD IDEAS

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IES Working Paper 13/2025

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Balance of Payments Pressures on the Nominal Exchange Rate: A Fresh Look at Old Ideas

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Abstract:

This paper contributes to the existing literature on exchange rate modelling by developing a new proxy for foreign exchange market imbalances. By utilizing the monetary presentation of the Balance of Payments we create a measure of net external flows and study its impact on the exchange rate. Focusing on the case of the Czech Republic, we account for the coexistence of fixed and floating exchange rate regimes by relying on the exchange market pressure (EMP) index. A vector autoregression model provides evidence of a causal relationship from net external flows to the EMP index. We find that a positive orthogonal shock to net external flows causes the Exchange rate to appreciate already in the short term with the effect peaking three months after the initial shock.

JEL: F31, F32, F37, F41, G15

Keywords: Foreign Exchange, Exchange Rates, Capital Flows

1 Introduction

The notion that exchange rates are determined by international trade flows can be traced back at least to Adam Smith’s *Wealth of Nations*. As a critique of mercantilist beliefs that government import controls are necessary to prevent trade deficits, Smith argued that exchange rates fluctuate in response to the balance of trade. When a country imports more than it exports, its currency depreciates, making domestic goods cheaper and imports more expensive. This self-regulating mechanism discourages imports while stimulating exports, ultimately working to correct trade imbalances. These foundational ideas later contributed to the development of some of the earliest formal models of exchange rate determination.

The underlying principle is straightforward: like any other market, the foreign exchange market reaches equilibrium when demand equals supply. Under the (then reasonable) assumption that demand for foreign currency arises exclusively from importers — who require it to pay for imports — while the supply of foreign currency stems solely from exporters — who receive it in exchange for their goods — the equilibrium exchange rate naturally aligns with that of balance of payments (or the trade balance).

The reason why the relationship between the current account and the exchange rate has been neglected in more recent literature is that it performs miserably in empirical implementations. A recent study by Camacho & Lindström (2021) revisits this idea, but already its subtitle—“a correlation that got lost?”—foreshadows the same disappointing results that plagued earlier research.

The current account lost its allure as the key determinant of the exchange rate when financial — rather than current — flows overwhelmed the foreign exchange market. The liberalisation of capital flows since the 1980s and the rising interconnectedness of global financial markets necessitated alternative frameworks that placed greater emphasis on financial markets.

This shift gave rise to modern approaches to exchange rate modeling, which conceptualize exchange rates as asset prices and analyze them accordingly. As a result, contemporary models are built on various parity conditions, typically relying on the assumptions of perfect or near-perfect substitutability and full capital mobility. In practical settings, central banks rely on the uncovered interest rate parity (UIP) condition within their large structural models as an important relationship that helps guide monetary policy.

However, the pure UIP condition assumes that capital flows respond instantaneously and fully to interest rate differentials. In this framework, central bank interventions in foreign exchange markets to stabilize exchange rates are rendered ineffective, as potentially limitless capital movements would offset any intervention. Empirically, however, monetary authorities succeed in influencing exchange rates via targeted interventions (Arango-Lozano et al., 2024), (Fratzscher et al., 2019), while capital flow dynamics can be slow and constrained, revealing the limitations of a pure UIP approach. This disconnect has made it difficult to integrate the price-based no-arbitrage nature of UIP with the quantity-based nature of central bank foreign exchange interventions within DSGE models.

Recent theoretical contributions reflect some of these concerns. Basu & Gopinath (2024) critique the canonical IS-LM-BP and UIP models for overlooking real-world frictions such as shallow FX markets, dominant currency pricing, and limited policy tools. They propose an Integrated Policy Framework (IPF) that accounts for foreign exchange interventions, macroprudential measures, and capital flow management. Gabaix & Maggiori (2015) highlight the role of financial intermediaries with limited risk-bearing capacity; when global liquidity is imbalanced, these intermediaries charge a premium to hold foreign assets, thereby deviating from UIP and inducing excess exchange rate volatility. Adrian et al. (2020) build a New Keynesian model incorporating a risk premium term that makes UIP “conditional,” reflecting the impact of capital flow management measures and financial frictions. Basu et al. (2020) further demonstrate how the depth of a country’s FX market can shape the optimal policy mix, with shallow markets often necessitating additional tools like

foreign exchange interventions (FXI) or capital flow management (CFM) to stabilize the economy. Collectively, these studies reinforce the notion that real-world capital flows are not as frictionless as traditional models assume, rendering the standard UIP framework insufficient.

Despite advancements in understanding exchange rate dynamics, the field has yet to fully reconnect with its foundational ideas. The relationship between an economy’s external imbalances and its exchange rate — an idea considered discredited in theoretical literature — remains an important consideration among practitioners including central banks, international institutions, rating agencies, and commercial bank research departments. While theory has largely abandoned the current account as a predictor of exchange rate movements, it continues to be considered in practice. Many policymakers and analysts recognize its relevance, yet no comprehensive theoretical model has successfully integrated it into the theory on exchange rate determination.

Recent events underscore this point. The collapse of Russia’s ruble following the February 2022 invasion of Ukraine was consistent with modern exchange rate models that emphasize interest differentials and risk premia. However, the ruble’s subsequent spectacular surge was anticipated by few. None of the common approaches for predicting the exchange rate would have expected that the rouble would become one of the best performing currencies in 2022.

Itskhoki & Mukhin (2022) provide one of the few explanations for this phenomenon by analyzing the balance between currency supply and demand under financial constraints. Initially, the ruble depreciated due to foreign asset freezes, capital flight, panic-driven demand for foreign exchange, and disrupted exports. However, it later rebounded as imports collapsed, capital controls restricted outflows, and energy exports continued, forcing transactions in rubles. Their framework demonstrates that exchange rate movements under sanctions are not solely driven by interest rate differentials and risk premia (rendering UIP ineffective) but also by trade imbalances, capital controls, and policy interventions. Similarly, Lorenzoni & Werning (2023) challenge the assumption that sanctions necessarily lead to persistent currency depreciation, instead arguing that import restrictions can drive currency appreciation by reducing demand for foreign currency and increasing demand for domestic currency. Their analysis highlights the limitations of conventional models and underscores the importance of considering external imbalances alongside financial market constraints when assessing exchange rate dynamics.

These recent developments point to a crucial gap in existing exchange rate models. While the dominance of no-arbitrage conditions in modern exchange rate modelling does not fundamentally alter the foundational perspective that the exchange rate is determined by the interplay of supply and demand in the foreign exchange market, it no longer assigns a clear role to current account imbalances. Most modern approaches fail to fully integrate both the real-side and the financial-side determinants of exchange rate dynamics.

To bridge this gap, this paper introduces a new variable that seeks to unify the two dimensions, offering a more comprehensive measure of excess demand for currency relative to its supply. We develop a novel use for the so-called monetary presentation of the Balance of Payments, originally proposed by Bê Duc et al. (2008). The monetary presentation offers a new insight into international capital flows — irrespective whether they originate from the current or financial account. A key feature of this approach is its differentiation between economic sectors: those that autonomously optimize their transactions in foreign currency (households, firms, and the government) and those that act as mere intermediaries in payments (the banking sector). Unlike traditional models that rely on assumptions about capital mobility and asset substitutability, our approach directly measures these flows, providing a more data-driven perspective on exchange rate pressures. Additionally, since central banks routinely forecast balance of payments components, this method provides a practical tool offering insights into near-term exchange rate pressures stemming from external imbalances and capital flows. It could thus serve as a complement to the standard UIP equation, which captures the exchange rate channel of monetary policy transmission over the medium term, thereby enhancing its relevance for policy applications.

The variable identified through the monetary presentation is termed net external flows. Similar to the current account balance, a positive value indicates excess demand for domestic currency, exerting upward pressure on the exchange rate. This pressure can materialize in two ways: either through nominal appreciation or through central bank intervention via foreign exchange purchases to supply additional liquidity to the market. To capture both of these effects, we construct a version of the exchange market pressure index and study its relationship with the net external flows. A positive orthogonal shock to net external flows is expected to raise the exchange market pressure index, as it is defined such that higher values correspond to either currency appreciation or central bank purchasing excess euros from the market.

The remainder of the paper is structured as follows. Sections 2 and 3 introduce the theoretical framework that underpins our analysis: Section 2 introduces a novel variable for capturing foreign exchange market imbalance, while Section 3 proposes a reformulation of the dependent variable to accommodate both fixed and floating exchange rate regimes. Section 4 describes the data, and Section 5 presents the empirical results. Finally, Section 6 concludes.

2 Measuring Demand and Supply Imbalances

To unify the real and financial dimensions of capital movements, this paper relies on Balance of Payments (BoP) statistics, which capture both types of these flows. The current and capital accounts reflect real flows — such as trade in goods and services or cross-border payments for labor and capital — while the financial account includes financial flows like loans and bonds, which usually underpin the UIP framework. The standard presentation of the BoP is represented by equation 2.1:

$$CA + KA = FA, \quad (2.1)$$

where CA denotes current account, KA denotes capital account and FA stands for financial account. Due to the double-entry nature of BoP accounting, the current and capital accounts always balance with the financial account. This is because every transaction is recorded twice: once as the initiating driver — for example, a firm importing goods or taking out a foreign currency loan — and again as the corresponding financial flow that merely mirrors the autonomous transaction, such as the outflow of capital for the import payment or the inflow of capital when the loan is disbursed. These mirrored entries always appear with opposite signs, ensuring the BoP accounts always balance. This makes the standard presentation of the BoP challenging to identify the underlying drivers of exchange rate pressures.

To address this issue, we distinguish between flows that arise from the autonomous decisions of agents and those that merely mirror these choices. The key insight is that the actual settlement of these transactions occurs within the banking sector, which serves as a payment intermediary. In other words, decisions such whether to invest capital, export goods, or work abroad originate outside the banking system, while the corresponding payment flows are processed through it. To formalize this, we utilize the sectoral breakdown¹ of the BoP, separating the banking sector from the rest of the economy in equation 2.1. This distinction allows us to isolate the decision-driven flows from their counterpart settlement flows, providing a clearer understanding of the imbalances on the FX market. Equation 2.2 reflect this:

$$CA + KA - FA_{nonMFI} = FA_{MFI}. \quad (2.2)$$

¹A sectoral breakdown of the BoP groups the items in the financial account according to the sector of the domestic economy. These are the central bank, other monetary financial institutions (MFI), general government and other sectors.

In equation 2.2, the subscripts *MFI* and *nonMFI* represent the sectoral cut and divide financial account into transactions conducted by MFI sector (which includes commercial banks and the central bank) and other sectors (households, firms or government institutions). This approach to presenting the BoP is known as the monetary presentation, which was originally designed to analyze the monetary aggregate M3 and money creation in the economy (Bê Duc et al., 2008). However, to our knowledge, this concept has not been used to estimate exchange rate pressures stemming from the BoP.

Now, let's examine how equation 2.2 can serve as an indicator of currency pressures. The sum of the current and capital accounts forms an external balance indicator, which, as discussed earlier, was used as a significant indicator of exchange rate pressures. A positive external balance indicates an excess demand for domestic currency because claims for payments from abroad exceeds obligations to pay the rest of the world. Even if we set aside the issue of missing financial flows in this case, the current account (or the broader external balance) itself still does not provide a precise gauge of currency pressures for two reasons. First, it does not distinguish between current and future demand for foreign exchange. Second, certain transactions on the current account may have no impact on the foreign exchange market at all.

Regarding the first issue, the accrual principle in the BoP has become increasingly common for recording external sales and purchases. The accrual method recognizes income and expenses in the period they occur, regardless of whether payment has been made. For example, a firm purchasing goods on trade credit or offsetting receivables and liabilities within regular business transactions would have these recorded on the current account when the transaction happens, even though payment may be delayed for months or never materialize. These types of transactions can provide a misleading signal of increased demand or supply for foreign exchange when, in fact, no cash flow has occurred.

The second issue arises when transactions on the current account do not enter the foreign exchange market at all. A key example is reinvested earnings, which represent part of a firm's profit that is not paid as a dividend to foreign owners but reinvested domestically. Since the profit remains in the same currency and no exchange of foreign currency takes place, these earnings do not impact the foreign exchange market.

Equation 2.2 addresses both of these concerns. The accrual principle creates a mismatch between the recognition of a transaction and its payment. If the payment occurs in a different period, it doesn't affect the exchange rate directly. For instance, an import of goods on trade credit would be recorded twice: once as a debit entry on the current account and once as an increase in foreign liabilities on the financial account. However, since the payment is not yet executed, the liability falls under the non-MFI sector. By taking the difference between the current account and the non-MFI financial account on the left-hand side of equation 2.2, this entire transaction is effectively neutralized.

Additionally, the monetary presentation also handles items like reinvested earnings recorded in the current account. As noted earlier, reinvested earnings don't enter the foreign exchange market and therefore should not be part of any variable explaining currency movements. In this case, reinvested earnings are recorded as a debit on the current account and as an increase in foreign liabilities of the non-MFI sector. Again, these transactions cancel each other out on the LHS of equation 2.2, thus are excluded from any consideration of exchange rate dynamics.

Besides current transactions the LHS of equation 2.2 also contains autonomous financial transactions driven by the optimizing behavior of individual agents. Consider, for example, a situation where the central bank of a major trading partner raises interest rates in response to rising inflation expectations. According to the standard UIP model, this would trigger an immediate depreciation of the small open economy's (SOE) currency due to capital outflows. While such outflows may occur, their magnitude could be limited — particularly if capital mobility within the SOE is constrained or when the capital is scarce. In practice, the capital outflow may be less pronounced or even fully

offset by other forces. For instance, a simultaneous inflow of capital in the form of foreign direct investment (FDI) could counterbalance the outflow, particularly if the SOE’s favorable economic outlook attracts foreign investors despite higher interest rates abroad.

The correct recording of financial transactions is once again ensured by the structure of BoP compilation. For instance, the purchase of foreign bonds increases financial assets under the non-MFI category. Since this term appears with a minus sign in equation 2.2, the negative entry correctly reflects increased demand for foreign currency, indicating depreciation pressures. In other words, a negative value signals that demand for foreign currency exceeds the available supply. Moreover, the quantitative nature of this approach allows for a direct comparison between real and financial flows. Combined, these transactions form a proxy for imbalances in the FX market — a variable we refer to as net external flows (NEF).

Note that the LHS of equation 2.2 does not include autonomous financial transactions conducted by the banking sector. For instance, considering a longer horizon starting from around the year 2000, the large-scale privatization of the Czech banking sector would not be captured by this sectoral breakdown. Purchases of Czech banks by foreign investors—representing simultaneous increases in financial assets and liabilities—would fall entirely within the MFI sector. Nevertheless, these transactions led to actual cash flows, increasing the supply of foreign currency available in the domestic economy.

This issue is among several reasons why we further adjust equation 2.2 as much as possible, aiming to more accurately reflect the true nature of currency pressures. Thus, the adjusted equation 2.2 can be expressed as:

$$CA + KA - FA_{nonMFI} - x = FA_{MFI} - x, \quad (2.3)$$

where the term x represents additional adjustments within the MFI sector, such as commercial banks purchasing foreign government bonds and foreign investors acquiring shares in Czech banks, along with other ad-hoc adjustments described in further detail in subsection 4.1.

Additionally, all of these dynamics are also captured on the RHS of equation 2.2, since all payment transactions are ultimately processed through the MFI sector. From the perspective of the MFI balance sheet, the variable FA_{MFI} closely aligns with the change in net external assets (NEA) — an accounting item found on the consolidated balance sheet of the banking sector. By definition, this stock variable encompasses all transactions between MFIs and the rest of the world.²

We note two shortcomings in using the net external flows as a proxy for foreign exchange market imbalances. First, short-term (“hot”) capital flows from non-residents directly into the MFI sector represent an important determinant of exchange rate movements, yet the standard BoP breakdown does not allow us to isolate these flows.³ For example a huge part of capital inflow during the Czech exchange rate cap regime (2013-17) was short-term capital in the form of bank deposits. In that case the incurrence of liability moves from a non-MFI unit to a MFI unit and hence this transaction is netted on the RHS of equation 2.2. Nevertheless, the exchange rate is still impacted by this transaction. To the extent that MFIs act as intermediaries between residents and non-residents, the net external flows variable provides a good proxy for the relative supply and demand in the

²While MFIs record all transactions they are involved in — both domestic and cross-border — the BoP includes all external transactions for both MFI and non-MFI sectors. The common intersection between the two datasets, therefore, refers specifically to external transactions conducted by the MFI sector. In BoP terminology, this corresponds to the financial account of MFIs.

³While certain transactions, such as purchases of foreign government bonds, are explicitly categorized within the financial account and thus identifiable when attempting to isolate FX-forming transactions, hot capital inflows — particularly in the form of bank deposits — are inherently reported with their mirrored counterpart transactions (actual cash flows). Consequently, the standard BoP classification does not allow the explicit extraction of only those FX-forming components. Instead, the entire transaction is netted out on the RHS of equation 2.3, thus weakening the direct link between observed BoP transactions and actual currency pressures.

FX market. However, when MFIs themselves transact with non-residents, the FX market may be affected but the net external flows variable does not capture it.

The second issue arises from the fact that the Balance of Payments (BoP) follows a sectoral approach rather than a currency-based one. This means that transactions between residents and non-residents can be conducted in either foreign or domestic currency. However, in most cases, a currency exchange occurs regardless of the invoicing currency. Take, for example, a domestic firm that invoices all its sales in foreign currency and also imports all its goods and services in the same foreign currency. In the net external flows indicator, we are concerned only with the net result — exports minus imports — which reflects the (domestic) value added by the firm. To finance the domestic expenses associated with this value added (such as wages and cost of domestic capital or material), the firm must ultimately convert foreign currency into domestic currency in an amount equivalent to its net trade balance.

3 Accounting for FX Market Interventions

One of the main criticisms of parity-based models is their failure to account for foreign exchange interventions carried out by central banks. This limitation is particularly relevant in the case of the Czech Republic, which has implemented various forms of FX management over the years. For instance, between 2013 and 2017, the Czech National Bank adopted a currency cap regime to counter deflationary pressures and stimulate economic growth. More recently, in 2022, a managed float approach was used to support monetary policy amid heightened uncertainty. Furthermore, the central bank's policy on selling returns from reserve assets has been applied intermittently, switching on and off over time.

In this section we solve the issue by broadening the understanding of the exchange rate as an equilibrating force to include also the central bank's role on the foreign exchange market. In the mixed exchange rate regime the pressures arising from external flows may be balanced by both: the exchange rate as well as the central bank intervening on the FX market. As a result we could form a currency pressure index reflecting both mechanisms through which the system reaches an equilibrium.

The solution at hand comes in the form of the *exchange market pressure (EMP) index*. The EMP index serves as a measure of exchange rate pressures and was developed to determine and analyse a currency crisis in more detail as the usual data on realised capital flows are generally imprecisely measured, incomplete and often available only in quarterly frequency (Goldberg & Krogstrup, 2018). In crisis periods all components of the EMP index are generally seen to move up and a high index value signals a crisis period (Patnaik et al., 2017).

The EMP index seeks to capture the magnitude of exchange market inequilibrium and represents the means through which this asymmetry is equalised. The foreign exchange market inequilibrium stemming from capital flows can be offset by three channels: the exchange rate, outright capital flows through the foreign exchange reserves, policy measures in the form of an interest rate adjustment or a mixture of all.

In a fully floating exchange rate regime, an excess of demand for a currency over its supply is equalized by the exchange rate. Therefore in a fully floating exchange rate regime without changes in policy measures, the exchange rate itself would serve well for signalling currency pressures. However we must take into account that a central bank may respond to these pressures by intervening in the foreign exchange market. For that reason the EMP index includes also reserve changes or, more precisely, the amount of interventions on the market.

Moreover the value of the exchange rate as an indicator for exchange rate pressures may be further tempered by monetary policy actions such as setting the interest rate. Consider an excess demand for foreign currency. The central bank may decide, instead of intervening in the foreign exchange market, to increase the interest rate, making home assets relatively more attractive, which

in turn increases the supply of foreign currency and the exchange rate gets back to its previous level. However the literature is divided on whether interest rates serve as a capital flow driver rather than a policy measure. This view is crucial because it determines if the interest rate term should be included in the EMP index as a measure of exchange rate pressures.

Several types of EMP indices exist. Some work with the reduced version, treating the interest rate as a capital flows driver (Girton & Roper, 1977), (Weymark, 1995), (Sachs et al., 1996), (Kaminsky & Reinhart, 1999). Others incorporate the interest rate right into the EMP equation treating it as a pressure measure (Eichengreen et al., 1994), (Aizenman et al., 2012). In what follows we make use of Goldberg & Krogstrup (2018) remarks and apply them to our case.

With regards to the choice of variables, we follow most of the existing literature in excluding the interest rate treating it as a fundamental capital flow driver rather than a policy variable. Therefore we assume that interest rate changes are already included in the decision-making of economic agents and therefore reflected in capital flows. Our choice of EMP index follows (Kaminsky & Reinhart, 1999) and has the following form:

$$EMP = \left(\frac{\sigma_R}{\sigma_R + \sigma_e} \right) \left(\frac{\Delta e_t}{e_{t-1}} \right) - \left(\frac{\sigma_e}{\sigma_R + \sigma_e} \right) \left(\frac{\Delta R_t}{S_t} \right), \quad (3.1)$$

where σ_e and σ_R are standard deviations of respective series, e_t is the exchange rate, R_t are central bank's foreign currency reserves and S_t is a scaling factor for the reserve changes.

The standardisation of both components enables addition, while weights are chosen such as to level the different volatilities with which individual components enter the equation. These weights may build on different conceptual grounds. There is always an option to use equal weights as in (Girton & Roper, 1977) but this approach is oversimplified. The monetary approach as in (Weymark, 1995) is another possibility, but it requires an empirical estimation of elasticities which was criticised in some studies. The approach we are employing in the equation 3.1 above is based on so-called precision weights. Precision weights consist in weighting the elements of the index by their standard deviations. Our baseline equation above weights the relative change in the exchange rate by the share of reserves' standard deviation in the total standard deviation and vice versa. In that way we ensure that both components contribute to the EMP index equally. However as noted by (Li et al., 2006) the relative role of the components depends on the current exchange rate policy regime in place. Precision weights put more importance on the component with less variation. Say we are in a pegged exchange rate regime. The resulting EMP index puts the emphasis on exchange rate changes, which obviously contain less information on currency pressures compared to changes in reserves.

Equation 3.1 contains one more variable of interest which is a scaling factor for the reserve changes. The choice of this element determines the relative importance of the whole reserves component. Moreover as the whole ratio is used for computing the standard deviation σ_R , the choice of the scaling variable also influences the respective weights. Again the literature is split as to what theory should underline this choice. Some studies utilize the monetary base (Weymark, 1995), (Girton & Roper, 1977); others make use of a narrow monetary aggregate (Eichengreen et al., 1994). Following Goldberg & Krogstrup (2018), we decided to scale reserve changes with the level of reserves (R_{t-1}) ultimately transforming this component to relative changes in reserves. Relative reserve changes as an intervention indicator results in a higher amplitude in the periods with low level of reserves compared to periods when the level of reserves is high.

The last thing to consider is the precise definition of variables entering the index. First, let's consider the change in reserves. It is problematic to rely on the difference over time in the market value of reserves because their value does not change only as a result of interventions. Instead it is influenced by revaluation changes generated by price or exchange rate movements, the accumulated return on reserves, foreign currency transactions with the government (incl. purchasing the income

from the EU) and other factors. Therefore, instead of using the aggregate change in reserves as suggested by our equation 3.1, we utilize data on spot trades made by the central bank to avoid a potential bias.⁴ This bias would be further magnified by precision weights that put more emphasis on reserve changes exactly in the periods when the exchange rate is freely floating and reserve movement therefore reflects mostly revaluation changes.

As for the exchange rate definition, two options are frequent: nominal bilateral and nominal effective exchange rate. The problem with EMP using the bilateral exchange rate is that it does not serve as an absolute measure of exchange rate pressures, but instead indicates only relative pressures against a given currency. Imagine a situation with the USD/CZK bilateral exchange rate as an exchange rate pressure indicator. Even if there is a net money inflow caused by massive capital investment from the EU, our indicator may still suggest only modest or even depreciatory exchange rate pressures if simultaneously the euro is depreciating against the dollar.

Since capital flows are projected through the aggregate BoP, reflecting transactions in all currencies, the effective exchange rate seems like an appropriate alternative. Although Goldberg & Krogstrup (2018) argue that using the effective exchange rate prevents from converting reserves to effective exchange rate units, that is not the case for the Czech Republic as the Czech National Bank intervenes in the foreign exchange market in order to stabilise the CZK/EUR pair only. Consequently there is no need for reserve conversion and the *nominal effective exchange rate (NEER)* best reflects aggregate currency pressures in the economy.

In addition we use the bilateral exchange rate CZK/EUR as a robustness check along the lines of Goldberg & Krogstrup (2018) who emphasize the use of the exchange rate that most closely matches the main monetary base currency of a country. The main monetary base currency is defined as “the foreign currency against which a country manages its exchange rate, or if a country’s currency is floating, the main foreign currency that matters for monetary and financial conditions of a country” (Klein & Shambaugh, 2008).

4 Data

This section describes in more detail the origin of the data and its transformation for econometric purposes. The frequency of the data is discussed alongside with the appropriate scaling and seasonal adjustment. Additionally, smoothing the monthly EMP index with the Kalman filter is considered as it allows us to clear the series from noisy elements.

4.1 Net External Flows

A conventional version of the monetary presentation (and also NEF variable) as presented by the European Central Bank for the analysis of monetary aggregates is calculated by the CNB and published on its website. (Czech National Bank, 2022d) However the period publicly available starts in 2017, which is vastly insufficient for our purposes of econometric analysis. Therefore we obtained the complete dataset directly from the CNB calculated since 2004.⁵ Data on NEF are compiled on a monthly basis and they have been summed into three month intervals for a quarterly frequency.⁶

⁴From this point forward ΔR_t in equation 3.1 represents the central bank’s spot trades, while by R_t we refer to the level of reserves.

⁵The year the Czech Republic entered the European Union, data on previous years are not available.

⁶While we make use of monthly data to exploit higher frequency information and get more data points, we acknowledge the limitations inherent in these statistics. Monthly BoP figures are often based on preliminary estimates and rely on a narrower set of data sources compared to their quarterly counterparts. Nonetheless, the use of monthly data remains justified for our purpose, as it enables a more granular assessment of near-term exchange rate pressures. To mitigate potential noise, we apply the Kalman filter and seasonal adjustment techniques, while robustness checks using quarterly data consistently support our main findings.

Additionally the NEF variable in its original form was subjected to several adjustments. These include subtracting the income from the EU structural funds and the investment income from foreign exchange reserves, both of which do not enter foreign exchange market at all.⁷ The income from reserves is a publicly available information as it is a part of the BoP and can be found in the ARAD database (Czech National Bank, 2022b). For the EU structural funds we used restricted data compiled by the CNB, but a very similar statistic is calculated and published by the Ministry of Finance on their website.⁸ Additionally we have adjusted the series by several ad-hoc transactions such as the income from the sale of the state share in the company Telecom in 2005. This foreign currency income in the amount of 86,2 mld CZK was immediately purchased by the CNB into its reserves in order to prevent any exchange rate effects of capital inflows from the privatisation of state assets (Czech National Bank, 2005).

The external flows adjustments do not end here. In order to best reflect present capital flow pressures and their significance, we need to take into account financial and trade integration and globalisation of the economy. We can easily imagine that historical cross-border flow levels would not invoke currency pressures of the same magnitude today as they did 20 years ago. Moreover this approach is consistent with the literature investigating exchange market imbalances. Along the lines of Goldberg & Krogstrup (2018) we decided to scale the series with nominal GDP although the index of domestic wealth is also frequently used (Della Corte et al., 2012), (Gourinchas & Rey, 2007). We note that GDP as a scaling choice may have its flaws due to sudden and unexpected changes that say nothing about the level of economic integration. Yet we scanned the whole series and the only exception is the covid crisis in 2020 where nominal GDP plummeted down by 5.8% in year to year terms. We deal with this issue in the following paragraph.

Data on the nominal seasonally adjusted GDP are publicly available in the ARAD database which is a service tool for time series provided by the CNB (Czech National Bank, 2022c). GDP data are available at quarterly frequency with the need of interpolation to monthly frequency. Instead of linear interpolation which is based on an equal split of one quarter into three months, we decided for a more sophisticated method. The cubic spline interpolation is a robust method of disaggregating annual or quarterly data into more frequented units (Ajao, 2012). It is considered particularly useful for macroeconomic data published at lower frequencies such as the GDP, international investment position or personal income. In order to smooth the variable over time the cubic spline interpolation makes use of 3rd-degree polynomial which is generated to connect individual data points. Cubic polynomial is unique for every single unfilled space between obtainable data points and once we connect all data points by rendering the polynomial, we are able to differentiate the curve into whatever frequency we wish. This approach also allows us to deal with the previously outlined issue. As the second quarter of the year 2020 would cause a distorting drop in GDP down to 1 338 577 mil. CZK, we can simply draw the cubic polynomial from Q1 to Q3 and retrieve the value for Q2. The dataset adjusted for the covid related economy shut-down is then used for the interpolation to monthly data. Figure 4.1 displays the original drop in 2020 smoothed over by the interpolated quarterly data as well as the monthly series showing the highest degree of polynomial.

Next we are encountering the problem of data frequency. The fact that data on external flows and the exchange rate are both available monthly, tempts to use monthly data for obvious reasons. By using higher frequency data we obtain more data points as well as additional information hidden on aggregated level. However using monthly data for external flows may be problematic as it may hide some seasonality otherwise observable from quarterly data. Payout of dividends, for example,

⁷Although the recipient of the EU funds is the government, the Czech National Bank purchases the income from the EU into its reserves in exchange for newly issued korunas (the government's deposits at the central bank). This operation does not create an increased demand for domestic currency in the foreign exchange market. The same principle applies to the return the central bank earns on its foreign exchange reserves. Since both of these can be found on the LHS of the 2.2, either on the CA under primary and secondary income or the KA, leaving it there would bias our results.

⁸Available at: Ministry of Finance.

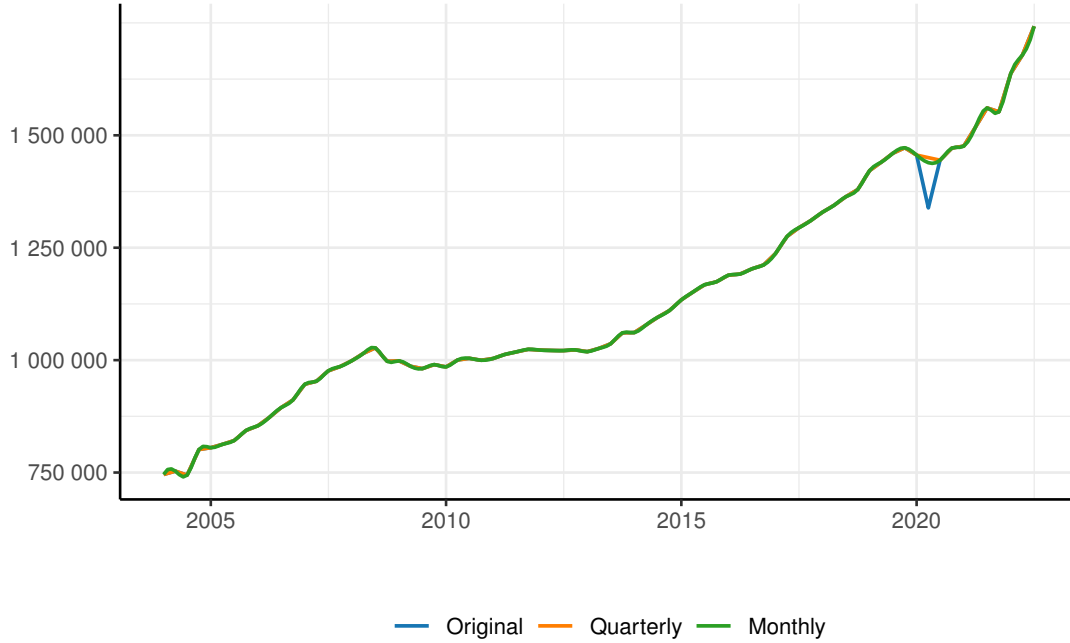


Figure 4.1: Comparison of quarterly GDP interpolated to monthly frequency

Note: i) Own elaboration based on Czech National Bank (2022c).

is typically settled in the second and third quarter of the year, but the precise months for the payout may differ tremendously. Consequently segregating quarters into months could spread out this information and conceal the seasonal pattern entirely. Seasonal adjustment in this case could be a tough task and econometric results not accurate. The second reason is the role of expectations. It is known that expectations play a significant role on the asset markets. The price of an asset reacts to the news on the day of its announcement not when the transaction is actually settled. If we go back to our example with dividends, its payout does not usually happen in the same month as when the decision is made. The shareholder's meeting is usually held after the external auditor's review and approval of financial statements and most of these General meetings happen in April or May, while the actual payout may be delayed one to several months. By looking at the quarterly data we hope to capture the real mid-term effect of net external outflows. For that reason we utilize both frequencies as a robustness check.

External flows as a share of GDP exhibit seasonality in both monthly and quarterly frequency. Before proceeding any further we seasonally adjust both time series with X-13-ARIMA-SEATS (United States government, 2022) developed and maintained by the U.S. Census Bureau. This statistical tool is implemented in R software and its method allows us to identify and decompose the series into trend, seasonal and irregular component, followed by removing the seasonal component and making the series seasonally adjusted (Sax & Eddelbuettel, 2018).

4.2 Exchange Market Pressure Index

The EMP index as expressed in equation 3.1 requires data on the nominal effective exchange rate and the central bank's spot operations in the foreign exchange market. On top of that we decided to include the bilateral exchange rate against the EUR alongside the NEER index as a robustness check.

Data on the bilateral exchange rate are straightforward. We utilize the monthly average of

the bilateral pair CZK/EUR (Czech National Bank, 2022a). The NEER index is publicly available in the ARAD database as well, however, we decided to recalculate the index according to more relevant weights.

NEER, as available from the Czech National Bank database, is computed as a product of the shares of the exchange rates of the individual trading partners raised to the power of their weights in the base period (Czech National Bank, 2022g). The weights are determined in two ways. The first variant follows the methodology of the International Monetary Fund where the entire trade turnover is utilized. The second, following the European Central Bank, comprises only four commodity groups. However both of these variants are based on the value of the goods trade rather than traded currency. To see why this trade-weighted currency index is not optimal for our purposes, consider the following: From the IMF perspective, the weights with which each country contributes to the NEER index are calculated such that 64% is attributed to Euro Area countries (identified as a single currency area), followed by Poland with 8.5%, third China with 7.5%, fourth Hungary with 3.5%, fifth the United Kingdom with 3.2% and all the way down in the sixth place are the United States with only 2.8%.⁹ But if we look at the statistic of invoiced prices from the international trade compiled by the Czech Statistical Office¹⁰ we can observe a substantial difference.

Table 4.1 contains data on 13 countries the Czech Republic trades with and their respective currencies. Weights w_{tv} are computed based on trade turnover with respective countries while w_{cv} rely on currency volumes as they appear in the invoices from realised international trades. While weights for the Euro Area countries are comparable in terms of trade value and currency traded, other countries do not exhibit concurrence. We can clearly see that the other monetary areas are divided into two distinct groups. The first group consists of countries whose weight of trade volume is bigger than the weight of that country's traded currency. These include basically all countries except the United States. On the other hand, the value of trade with the United States represents only one third of total trades realized in the U.S. dollar. It can be concluded that trade with non-EU countries is mostly conducted in U.S. dollars. Consider, for example, the import of oil and petroleum from the Russian Federation or trade with China that are carried out almost exclusively in U.S. dollars. For those reasons the original trade-weighted NEER index does not seem to be a suitable indicator of currency imbalances if it includes currencies not traded in the foreign exchange market. Hence, weights calculated based on invoiced currencies would seem as an appropriate alternative to the original trade-weighted index.

In the process of developing import and export price indices, the *Czech Statistical Office (CZSO)* collects data on invoiced prices by a questionnaire survey. The respondents report the invoiced price either in domestic or foreign currency. In reality there is no check if the trade was actually realized in the domestic currency and the CZSO's estimate is that up to 30% of prices reported in the domestic currency are actually invoiced in foreign currency. According to the pattern visible in table 4.1 that would most likely increase the weights of the EUR and USD rather than other currencies traded in the market.

Since we believe that both the EUR and USD have higher traded weights, we turn to another indicator. The CNB performs a survey of average daily turnover¹¹ in the foreign exchange market four times a year.¹² The survey involves banks and branches of foreign banks with a banking license in the Czech republic that are active in the foreign exchange market. Given that external monetary flows are nothing more than participation of MFIs in the foreign exchange market, we consider this indicator best suited for the determination of weights with which individual currencies contribute to the aggregate index. Moreover we examined the data for each year since 2004 and the sum of weights for the EUR and USD is on average higher than 0.97 indicating that the role of other

⁹Weights are calculated based on international merchandise trade turnover in 2020.

¹⁰Data obtained from the CNB's internal database.

¹¹In mil USD per day.

¹²The survey dates back to 1995 when it was conducted only two times a year (May and October).

Table 4.1: Trade volume versus currency traded weights

Country	w_{tv}	Currency	w_{cv}
Euro Area	0.640	EUR	0.629
China	0.075	CNY	0.000
Poland	0.085	PLN	0.010
United Kingdom	0.032	GBP	0.012
Hungary	0.035	HUF	0.000
Russian Federation	0.025	RUB	0.001
United States	0.028	USD	0.090
Switzerland	0.014	CHF	0.000
Korea	0.014	KRW	0.000
Romania	0.017	RON	0.001
Sweden	0.014	SEK	0.000
Japan	0.012	JPY	0.005
Denmark	0.008	DKK	0.008

Note: i) Weights as computed by traded currency do not sum to one. The difference is caused by invoices reported in the CZK. ii) Data on both the trade volume and the currency traded were obtained from the CNBs' internal database.

currencies in the foreign exchange market is lower than 3%.¹³ Given this immaterial amount we extrapolate weights for the EUR and USD to represent 100 % of the weights entering the NEER index.

The survey is conducted 4 times a year (2 times a year up to 2009) and the weight distribution between the EUR and USD during the examined period differs considerably. In April 2004 the average daily turnover of the USD represented 55% of total trade in the foreign exchange market. Over the years this share has decreased down to 17%. The entire trajectory since 2004 is displayed in figure 4.2.

It would seem appropriate to calculate the NEER index according to quarterly weights as displayed in figure 4.2. However we do not wish for the exchange rate index to exhibit excessive variability through time solely as a consequence of changing trade volumes. It would result in variation not related to currency pressures and bias our results. The IMF methodology recommends changing the weight structure every five years. Therefore we calculate the final NEER index as follows:

$$NEER_t = 100 * \prod_{i=1}^n (S_{it}^*)^{w_i^*}, \quad (4.1)$$

where $S_{it}^* = \frac{S_{it}}{S_{i0}}$ is the index calculated as a share of the exchange rate of the currency of the i -th trading partner per one CZK in period t over exchange rate of the foreign currency of the i -th trading partner in the base period and the weights w_i^* are calculated as the 5-year average and recalculated every five years to ensure consistency over time.

Data on S_{it}^* index are restricted and provided by the CNB, while the information of average daily FX turnover can be found on CNB's website (Czech National Bank, 2022f). Finally, data on the CNB's foreign exchange trading are publicly available from their website (Czech National Bank, 2022e).

¹³The exception being years 2006 and 2015 when the trading of other currencies slightly exceeded 10%.

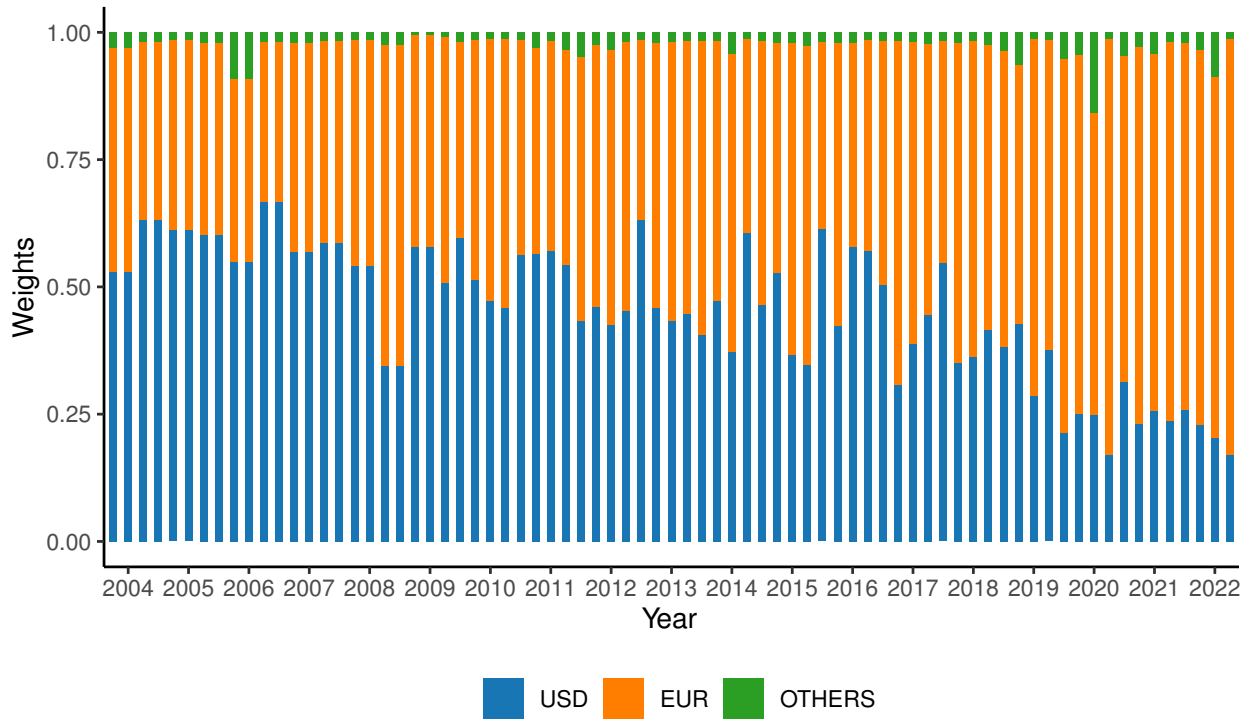


Figure 4.2: Weights calculated as a share of turnover in the foreign exchange markets

Note: i) Up to 2009 the data are extrapolated to be displayed at quarterly frequency.

ii) Own elaboration based on Czech National Bank (2022e).

Put together we create two EMP indices, one for each frequency, which are depicted in figures 4.3 and 4.4. From both graphs it is visible that a noticeable divergence between the bilateral and the effective exchange rates occurred around the year 2015, when the Czech republic was under the exchange rate cap regime and depreciation pressures were mostly caused by an outflow of capital into dollar assets.

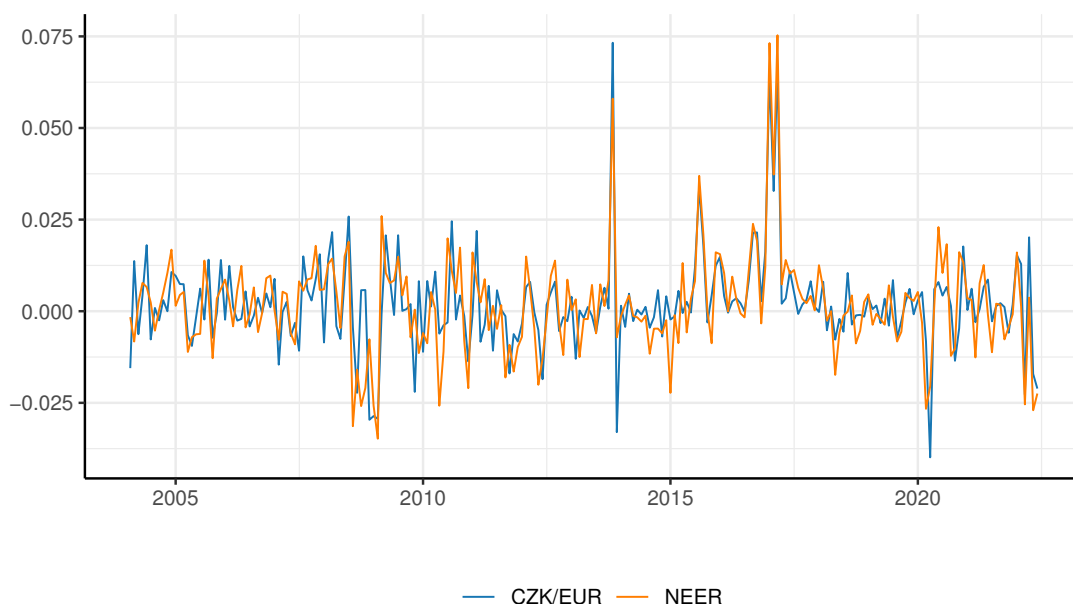


Figure 4.3: Comparison of bilateral and effective EMPs in monthly frequency

Note: i) For visualisation purposes, bilateral exchange rate was reversed - an increase indicates appreciation, which is in accordance with NEER interpretation.

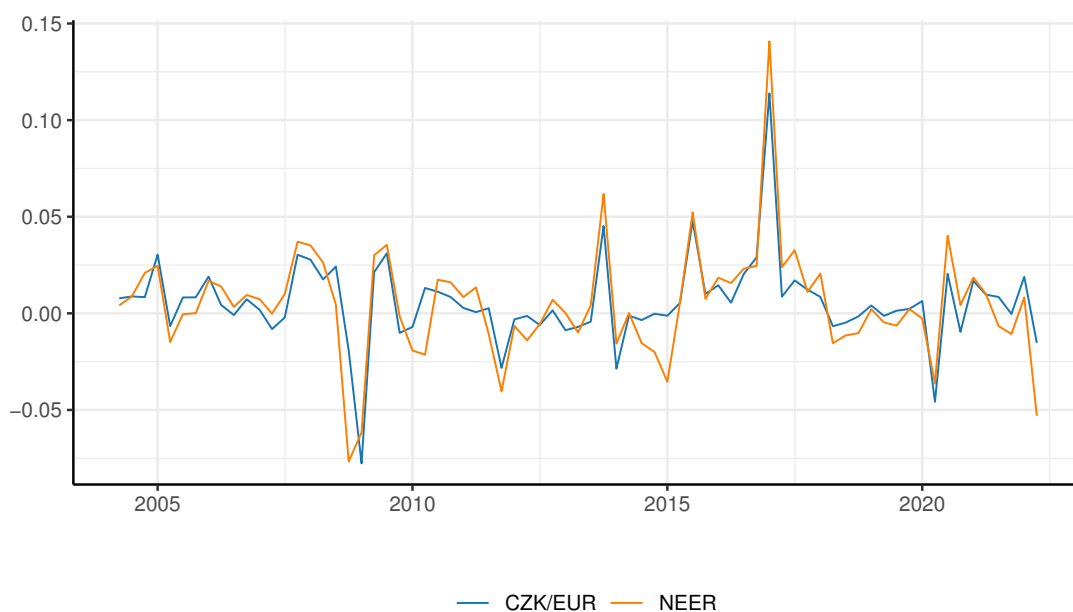


Figure 4.4: Comparison of bilateral and effective EMPs in quarterly frequency

Note: i) For visualisation purposes, bilateral exchange rate was reversed - an increase indicates appreciation, which is in accordance with NEER interpretation.

Notice the considerable difference between both frequencies. Monthly data are noisy with high month-to-month volatility, while the resulting short to mid-term effect is netted inside individual quarters. The resulting quarterly series is smoother and better captures capital flow pressures

arising from the exchange market imbalances.

This view is consistent with a different intuition underlying both series. While monthly series assumes that the exchange rate responds immediately to the situation on the market, quarterly series indicates prevailing pressures. If there is an increased demand for foreign currency for an extended period of time (say three months), exchange rate should depreciate in the mid-term.

That is given by the fact that in a very short term, the exchange rate responds to numerous news about macroeconomic variables and these reactions can be magnified by risk sentiment and market uncertainty. Over the longer horizon these sudden shocks fade away and we are left with the true value reflecting underlying market imbalances.

Given the excessive noisiness in the monthly series we filter monthly series using Kalman filter to extract the signal that the exchange rate offers. The choice of the Kalman filter to smooth the series is not random. The purpose of the Kalman filter is to separate the noise in observed data from the unobserved state representing the true intrinsic value. The unobserved state can be viewed as a signal that is jammed with noisy elements. Because we are interested in the fundamental changes of the EMP index, we need to isolate the signal from its stochastic shocks.

In our case we make use of the Local Level Model (LLM). Its usage is supported by the fact that the data is not seasonal, has no trend, and the autocorrelation structure is not apparent. The LLM in state space specification has the following form:

$$y_t = \mu_t + \epsilon_t, \quad \epsilon_t \stackrel{\text{iid}}{\sim} \mathcal{N}(0, \sigma_\epsilon^2) \quad (4.2)$$

$$\mu_{t+1} = \mu_t + \eta_t, \quad \eta_t \stackrel{\text{iid}}{\sim} \mathcal{N}(0, \sigma_\eta^2), \quad (4.3)$$

$$\mu_1 \sim \mathcal{N}(a_1, P_1).$$

Here, y_t represents the observed (noisy) EMP index at time t , while μ_t is the unobserved state capturing the true underlying exchange market pressures. The terms ϵ_t and η_t are mutually independent Gaussian white noise disturbances, representing observation noise and state innovations, respectively, with variances σ_ϵ^2 and σ_η^2 .

The Kalman filter is initialized with $\mu_1 \sim \mathcal{N}(a_1, P_1)$, where we set $a_1 = 0$ and $P_1 = \text{Var}(y_t)$, and the model is estimated using maximum likelihood methods. It holds that under correct model specification, the standardised residuals have the property $\frac{v_t}{\sqrt{f_t}} \sim \mathcal{NID}(0, 1)$. We examined the standardised residuals after maximum likelihood estimation and the results points to non-normal distribution of residuals, let alone, standard normal. The notable long tail at the right side of the distribution is connected with the sudden and substantial fluctuations in the period of the exchange rate cap regime.

We solve this issue by setting *signal-to-noise* (*s-t-n*) ratio manually, where we determine $q = \frac{\sigma_\eta^2}{\sigma_\epsilon^2} = 0.25$. This ratio is set such as to best reflect the essence of exchange rate changes while simultaneously clean the series from excessive noisiness.

We note there are more rigorous ways of how to deal with this challenge. Since the main reason for imprecise results lies within random errors, it would be useful to abandon the assumption of normality of random errors when applying the optimization problem to the Kalman filter. Another possibility would be to introduce a time-varying component into the model specification or utilization of GARCH modelling. However we note that both techniques are better suited for time series where the variance of the error term is serially autocorrelated rather than randomly distributed.

Final results can be seen in figures 4.5 and 4.6.

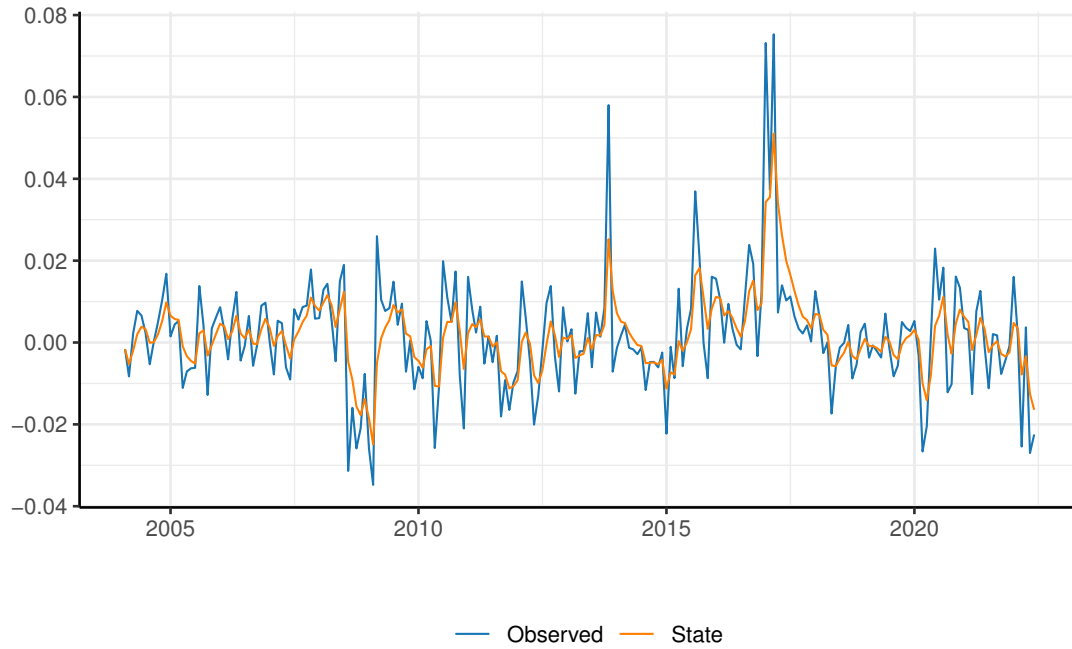


Figure 4.5: Effective EMP index with filtered state μ_t and s-t-n ratio $q = 0.25$

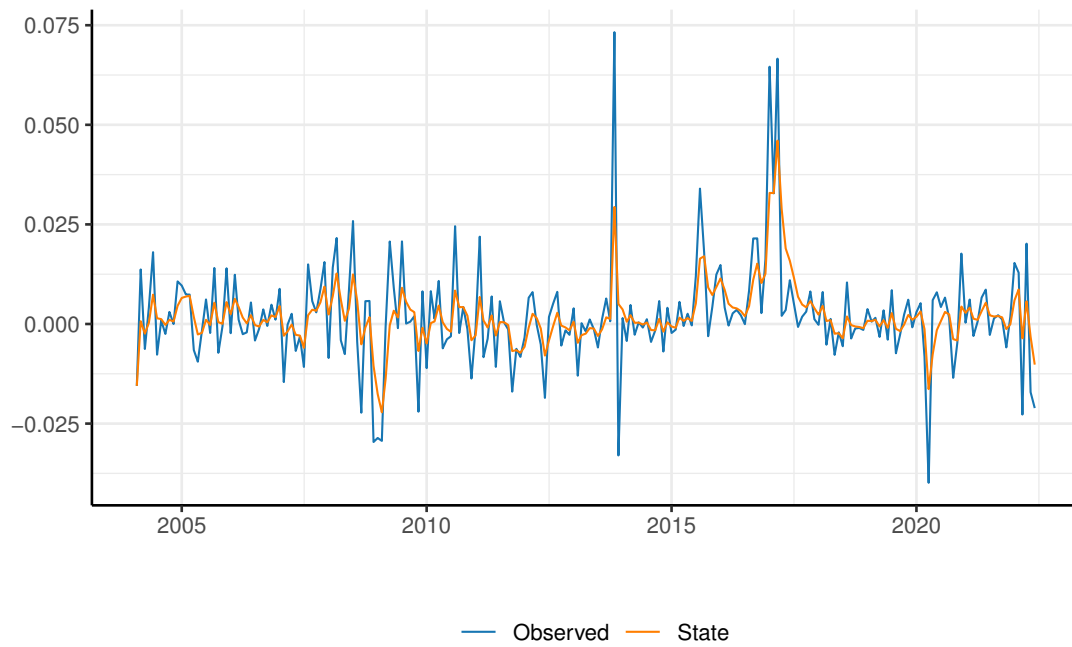


Figure 4.6: Bilateral EMP index with filtered state μ_t and s-t-n ratio $q = 0.25$

Note: Bilateral EMP was reversed for consistency and comparison with NEER EMP.

5 Results

In this section we first test all series for a unit root; this is followed by a test for Granger Causality from net external flows to the exchange market pressure index. Next, we choose the appropriate lag length for the VAR model based on information criteria.

After that we turn our attention to the estimated baseline model based on the monthly series of the effective EMP index, before examining how these estimates change when comparing the results with other series as a robustness check.

5.1 Stationarity, Granger Causality and Information Criteria

Before we proceed any further, however, we need to assess the suitability of the data for the purposes of VAR modelling. *The Augmented-Dickey-Fuller (ADF) Unit Root Test* is applied in the following form:

$$\Delta y_t = \alpha + \delta t + \theta y_{t-1} + \gamma_1 \Delta y_{t-1} + \dots + \gamma_p \Delta y_{t-p} + e_t, \quad (5.1)$$

where parameter α refers to drift, δ to trend, θ is the coefficient of interest for unit root testing and parameters γ are included to control for the possible AR(p) behaviour in Δy_t . Lag selection is based on Bayes information criteria. As t -ratios do not have t -distribution under H_0 , but follow a DF -distribution, critical values of DF -distribution are stated in table 5.1. All specifications of the model are included for prudence.

Table 5.1: Augmented Dickey-Fuller test statistics t and their critical values

Series - Monthly	None	Drift	Drift and Trend
NEF	-7.87	-7.88	-7.87
Bilateral EMP index	-4.89	-5.10	-5.09
Effective EMP index	-4.91	-5.01	-4.97
Critical value	-2.58	-3.46	-3.99
Series - Quarterly	None	Drift	Drift and Trend
NEF	-4.40	-4.39	-4.36
Bilateral EMP index	-5.15	-5.51	-5.47
Effective EMP index	-4.95	-5.04	-4.99
Critical value	-2.6	-3.51	-4.04

Note: i) Critical values are based on $\alpha = 0.01$.

Based on the test statistics in table 5.1 we can reject the null hypothesis about a unit root for all series and proceed to *Granger Causality (GC) Test*.

We start with an unrestricted VAR(p) model:

$$y_t = c + \sum_{i=1}^p \alpha_i y_{t-i} + \sum_{i=1}^p \beta_i x_{t-i} + u_t, \quad (5.2)$$

where x is said to be a Granger cause of y if present y can be predicted with greater accuracy by using past values of x rather than not using such past values, all other relevant information being identical. Under H_0 of no GC, all $\beta_i = 0$:

$$y_t = c + \sum_{i=1}^p \alpha_i y_{t-i} + u_t. \quad (5.3)$$

Number of lags is chosen according to *Information Criteria (IC)* stated in table 5.3 and discussed below. The F-test is applied where under H_0 it holds that:

$$F = \frac{(SSR_R - SSR_{UR})}{q(SSR_{UR})}(T - k) \sim F(q; T - k), \quad (5.4)$$

and k is the number of estimated parameters in UR model, q number of restrictions imposed on the R model and T is the number of observations.

Results of the GC test where NEF are assumed to cause the EMP index can be seen in table 5.2.

Table 5.2: Granger Causality test statistic F and respective p-values

Series - Monthly	F statistic	p-value
Bilateral EMP index	2.59	0.07
Effective EMP index	2.43	0.09

Series - Quarterly	F statistic	p-value
Bilateral EMP index	0.95	0.34
Effective EMP index	2.17	0.12

Based on this test only the monthly series for the bilateral and effective EMP index seem to be caused by NEF, however we note that this test includes only the lagged values of endogenous variables which runs counter to the intuition behind VAR models.

Therefore we proceed with lag selection according to information criteria shown in table 5.3.

Table 5.3: Optimal lag length selection based on information criteria

Series - Monthly	AIC	HQ	SC	FPE
Bilateral EMP	1	1	1	1
Effective EMP	2	1	1	2

Series - Quarterly	AIC	HQ	SC	FPE
Bilateral EMP	1	1	1	1
Effective EMP	1	1	1	1

The lag length selection for both the quarterly and monthly bilateral EMP index is straightforward. The difference in the lag selection by *Schwarz (SC)* and *Akaike (AIC)* criteria arise from a harsher complexity penalty term of SC. For the Effective EMP index, we choose 2 lags to better capture model's dynamics.

With appropriately chosen, transformed and tested data series we can move to the application of the VAR model identified by Cholesky decomposition. Following Bukovšak et al. (2020) we restrict the contemporaneous effect from the EMP index to NEF. That way NEF at time t affect

the EMP index at time t while the feedback effect from the EMP index to NEF may occur only with a lag (i.e. NEF at time t are influenced by the EMP index at time $t - 1$). The AB model is set such as:

$$A = \begin{bmatrix} a_{11} & 0 \\ 0 & a_{22} \end{bmatrix}, \quad B = \begin{bmatrix} 1 & 0 \\ b_{21} & 1 \end{bmatrix},$$

where matrix A maps structural shocks ϵ_t into the system and matrix B captures contemporaneous relationships between the variables. Parameters a_{11} , a_{22} and b_{21} are going to be estimated.

5.2 Estimates of Vector Autoregression Model

The monthly series of the effective EMP index is explained by NEF. Matrices A and B are estimated as follows:

$$A = \begin{bmatrix} 0.023 & 0 \\ 0 & 0.005 \end{bmatrix}, \quad B = \begin{bmatrix} 1 & 0 \\ 0.050 & 1 \end{bmatrix}.$$

The essence of VAR models identified by Cholesky allows us, as opposed to the classical VAR approach, to assess a causal contemporaneous relationship coming from NEF to the EMP index. This immediate effect is expressed by coefficient b_{12} and represents the response of the EMP index to one unit change in NEF.¹⁴ From the matrix B alone it is immediately apparent that a positive shock to NEF, meaning an inflow of capital, results in a positive change in the EMP index. Since we are using effective exchange rate, its increase represents appreciation pressures. This effect is in line with macroeconomic theory outlined in previous sections.

To assess the magnitude and the dynamic our model implies, the IRF serves as an informationally richer indicator. Figure 5.1 shows the immediate response of the EMP index to one standard deviation increase in NEF and its eventual convergence back to zero over one year horizon. First note that the effect of a NEF increase is statistically significant for all time periods, as depicted by positive confidence intervals. We can observe the typical dynamics of the IRF curve where the effect culminates in the third month followed by a gradual fade out.

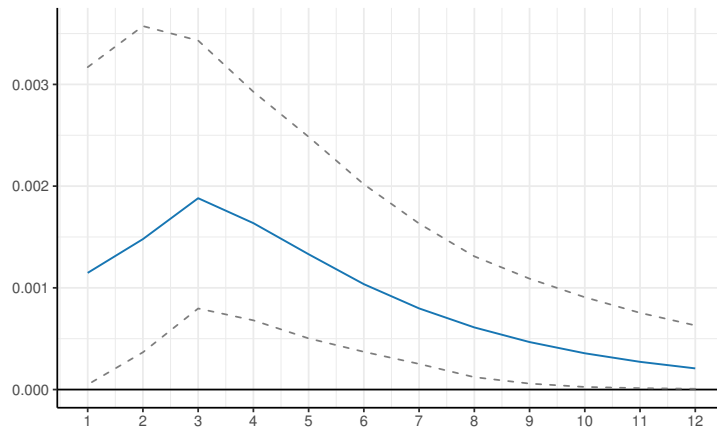


Figure 5.1: VAR Impulse Response from NEF to effective EMP index one year ahead - monthly

Note: i) 95% Confidence Intervals are computed by Bootstrap method with 100 runs.

¹⁴However, recall that NEF are expressed as a share of GDP.

The IRF suggests an appreciation pressure of 0.1% right after a positive one standard deviation NEF shock. By the third month, the pressure doubles to 0.2% in month to month terms. Note that in this case we work with the smoothed EMP series adjusted for irregular factors that cause most of the monthly volatility. What we are left with is the true underlying pressure stemming from the capital flow imbalances.

As a comparison we can use figure 5.2 showing the extent of the persistence in the EMP index that follows a positive shock of one standard EMP deviation. The positive 0.5% shock to EMP index has, needless to say, a one to one effect that eventually wears off.

A less intuitive situation is depicted in figure 5.3. A positive shock to the EMP index causes a significant response of NEF for 6 months ahead. Our model implies an increase in capital inflow right after the currency appreciates, which is in a direct contradiction with the expected rate of return theory, according to which a currency appreciation signals a lower expected rate of appreciation in the future (which reduces the expected return) and capital inflows should therefore decrease.

Two explanations are possible for the counterintuitive result.¹⁵ First, it is possible that the appreciating currency and the capital inflows both have a common driver that is missing in our modelling framework - for example, a positive investor sentiment about the strength of the domestic economy and its outlook. In that way foreign investors may be more willing to invest in the domestic assets even as the currency appreciates.

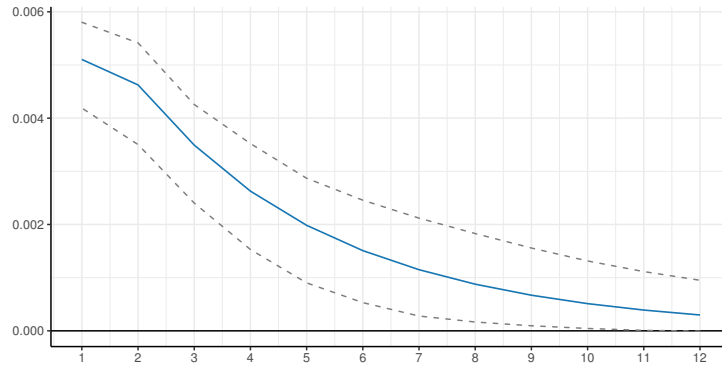


Figure 5.2: VAR Impulse Response from effective EMP index to effective EMP index one year ahead - monthly

Note: i) 95% Confidence Intervals are computed by Bootstrap method with 100 runs.

Second, the theory of the J-curve in a country's balance of trade may play a role here. The J-curve refers to an initial deficit or drop in the net exports of a country immediately after a depreciation of its currency, driven by the revaluation of its foreign currency-denominated imports. This initial decrease is followed by a gradual increase in net exports over time, driven by the additional foreign demand for cheaper domestic exports and the decline in domestic demand for the more expensive imports. The initial price effect and the subsequent volume effects create a J-shaped curve. The situation reverses in the case of a currency appreciation - the initial response is an increase in net exports, which in our framework manifests as an increase in NEF. This should be followed by a gradual decline in net exports. This phenomenon is caused by the fact that it takes time for the exchange rate to influence the supply and demand for the country's exports and imports. Similar conclusion could be drawn regarding the financial account, wherein currency appreciation immediately triggers the revaluation of financial assets purchased or disposed by residents.

Last figure 5.4 refers to the FEVD of both series. The FEVD tells us how important the

¹⁵A third explanation is that the result is driven just by the noise in the highly volatile monthly data. The estimation on quarterly data performed in subsection 5.4 does not find any statistically significant effect.

different orthogonal shocks are in explaining the dependent variable. In the case of net external flows (upper) it is evident that the variance of the forecast error is caused in most part by the series itself with the EMP index highest contribution of 6% in the last five months. Net external flows, on the other hand, contribute to the EMP index forecast error (lower) gradually from 5% in the first period to a maximum value of 16% in the last period, indicating a growing importance of NEF over time.

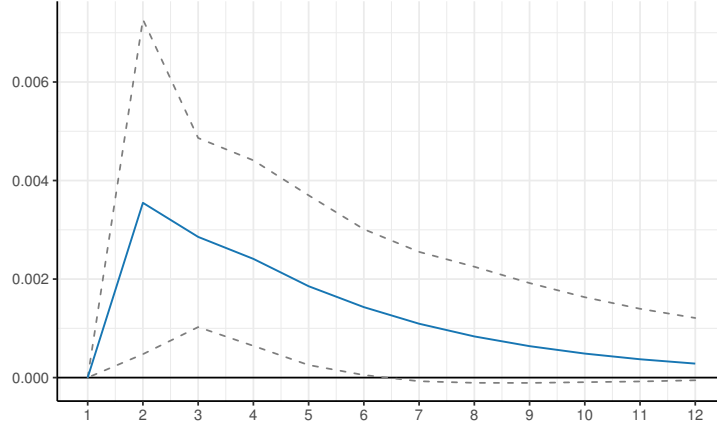


Figure 5.3: VAR Impulse Response from effective EMP index to NEF one year ahead - monthly

Note: i) 95% Confidence Intervals are computed by Bootstrap method with 100 runs.

Overall the contribution of net external flows to EMP index variability is quite reasonable given the fact that exchange rate fluctuates from month to month due to variety of factors.

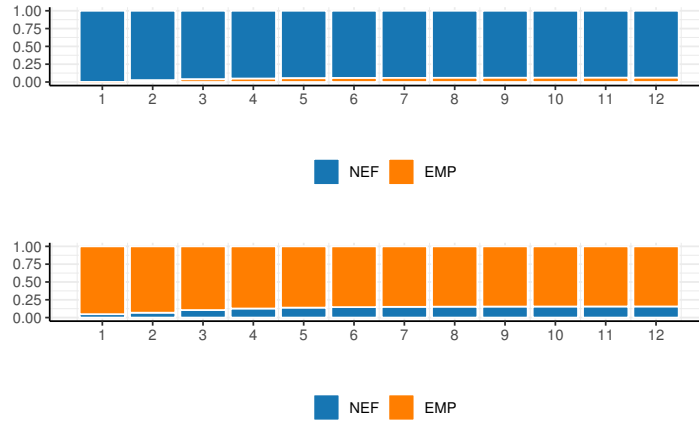


Figure 5.4: Forecast Error Variance Decomposition of NEF (upper) and effective EMP index (lower) one year ahead - monthly

5.3 Robustness Check - Monthly Series

As a robustness check first consider the bilateral exchange rate. The results are quite similar to our baseline model. Both IRFs are comparable with regard to the direction, magnitude and dynamics. Note that in the bilateral exchange rate environment both IRFs are reversed, with negative values indicating an exchange rate appreciation. The magnitude of the contemporaneous impact of NEF

to the bilateral EMP is nearly identical. With the difference that the effect does not amplify in the next two periods but instead of that slowly converges back to zero. That is understandable given the fact that NEF comprise of trade in multiple currencies and their effect on a single pair may therefore be more limited. This view is further supported by the FEVD where an orthogonal shock from NEF to the EMP index is accountable only for 6% throughout the observed period.

The important note here is that the results are consistent with our baseline model supporting the use of the NEER index as a better dependent variable in explaining currency pressures arising from market imbalances.

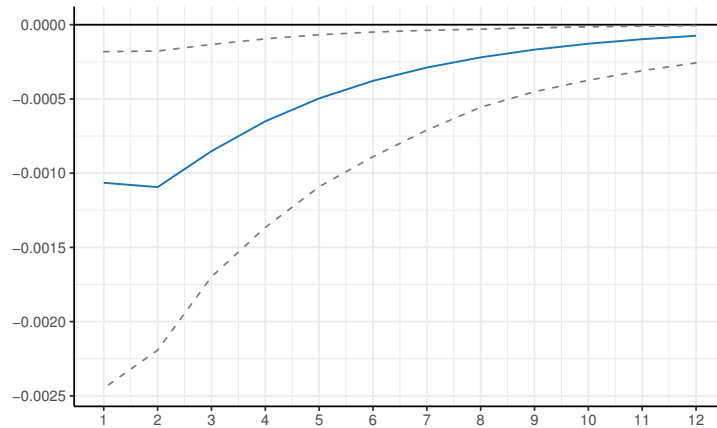


Figure 5.5: VAR Impulse Response from NEF to bilateral EMP index - monthly

Note: i) 95% Confidence Intervals are computed by Bootstrap method with 100 runs.

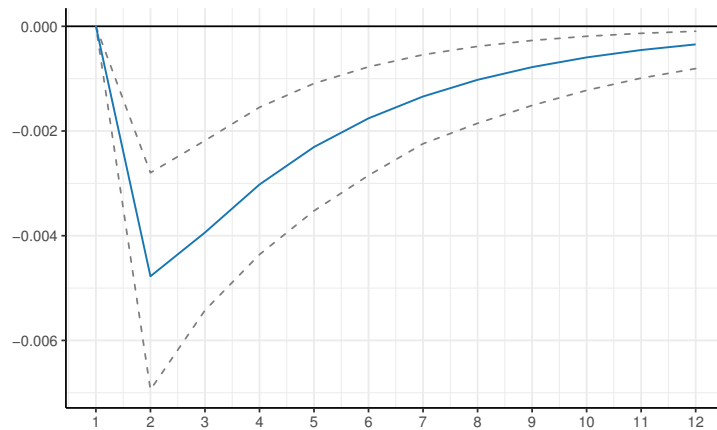


Figure 5.6: VAR Impulse Response from bilateral EMP index to NEF - monthly

Note: i) 95% Confidence Intervals are computed by Bootstrap method with 100 runs.

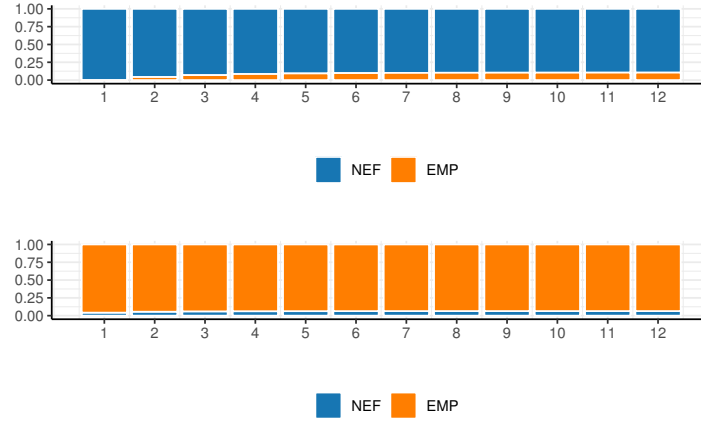


Figure 5.7: Forecast Error Variance Decomposition of NEF (upper) and bilateral EMP index (lower) - monthly

5.4 Robustness Check - Quarterly Series

The results for the quarterly series further support previous findings, although not as strongly. The response of both the effective EMP index and the bilateral EMP index to a shock from NEF is again positive with its impact diminishing back to zero over one year horizon. The effect is significant in the first quarter. This is consistent with the monthly models, where we can observe the lower bound of confidence interval to approach zero after the third month. Note that we observe the accumulated effect over three months and we did not smooth quarterly series. The resulting magnitude of the impulse response is naturally stronger.

The reverse effect from the EMP index to NEF is not statistically significant in either direction. The counterintuitive result visible in the monthly data is therefore not confirmed in the quarterly analysis.

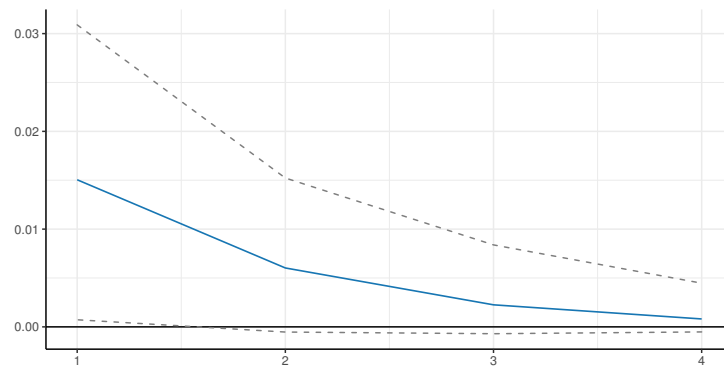


Figure 5.8: VAR Impulse Response from NEF to effective EMP index - quarterly

Note: i) 95% Confidence Intervals are computed by Bootstrap method with 100 runs.

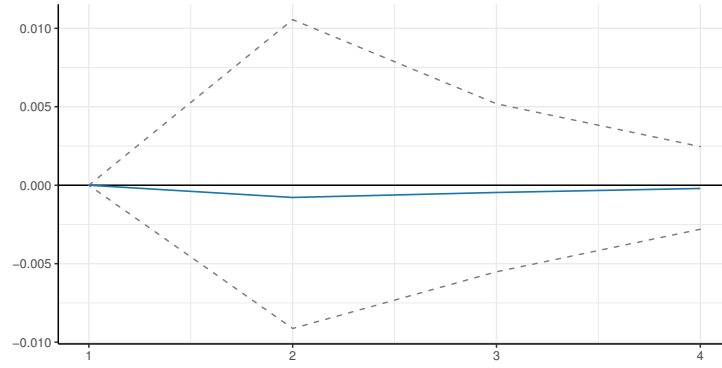


Figure 5.9: VAR Impulse Response from effective EMP index to NEF - quarterly
Note: i) 95% Confidence Intervals are computed by Bootstrap method with 100 runs.

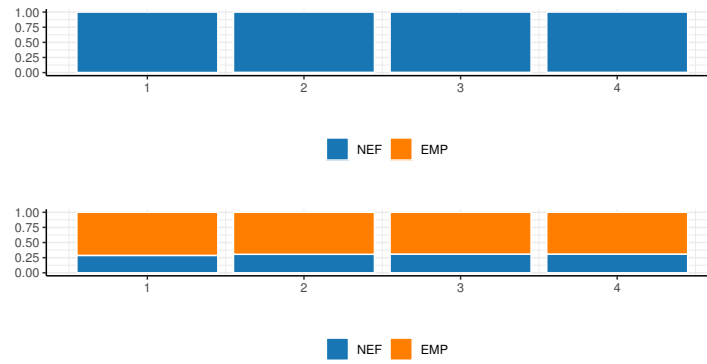


Figure 5.10: Forecast Error Variance Decomposition of NEF (upper) and effective EMP index (lower) - quarterly

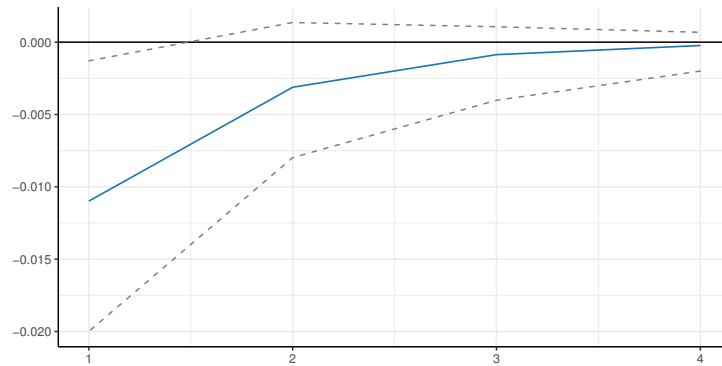


Figure 5.11: VAR Impulse Response from NEF to bilateral EMP index - quarterly
Note: i) 95% Confidence Intervals are computed by Bootstrap method with 100 runs.

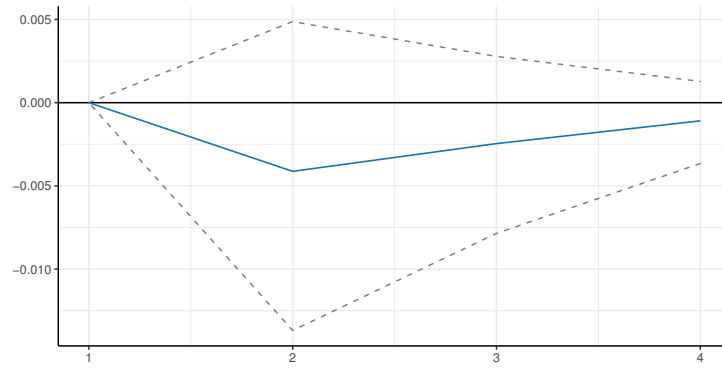


Figure 5.12: VAR Impulse Response from bilateral EMP index to NEF - quarterly
Note: i) 95% Confidence Intervals are computed by Bootstrap method with 100 runs.

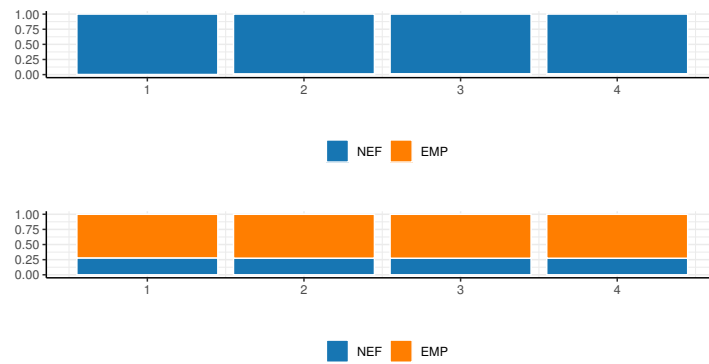


Figure 5.13: Forecast Error Variance Decomposition of NEF (upper) and bilateral EMP index (lower) - quarterly

6 Conclusion

This paper presents a fresh perspective on a long neglected theory. It shows that with several adjustments the BoP can provide a useful signal on currency pressures. We model jointly the dynamic process of net external flows and the exchange market pressure index, where VAR models are applied and the contemporaneous effect from the exchange rate to net external flows is restricted as the response of capital flows is lagged behind the exchange rate changes. Our baseline model implies that a positive shock to external flows (i.e. a capital inflow) results in an immediate exchange rate appreciation peaking three months after the initial shock. These findings are robust to the various EMP specifications as well as to the choice of the data frequency.

However, we note several areas where future research can improve on our analysis. First, rather than a macroeconomic indicator, the EMP index resembles a financial series with a typical time-varying volatility. Instead of assuming normality in random errors one should therefore consider applying more tailored techniques such as a model with time variant measures. Second, relying on the commonly used, but relatively simplistic EMP specification may be sufficient for our purposes. However, a derivation of a more sophisticated theory-based index can serve as a basis for a more universally applicable model.

References

- Adrian, M. T., Erceg, C. J., Lindé, J., Zabczyk, P., & Zhou, M. J. (2020). *A quantitative model for the integrated policy framework*. International Monetary Fund.
- Aizenman, J., Lee, J., & Sushko, V. (2012). From the great moderation to the global crisis: exchange market pressure in the 2000s. *Open Economies Review*, 23(4), 597–621.
- Ajao, I. (2012, 01). Cubic spline interpolation: A robust method of disaggregating annual data to quarterly series 1. *Journal of Physical Sciences and Environmental Safety*, 2, 1-8.
- Arango-Lozano, L., Menkhoff, L., Rodríguez-Novoa, D., & Villamizar-Villegas, M. (2024). The effectiveness of fx interventions: A meta-analysis. *Journal of Financial Stability*, 74, 100794. Retrieved from <https://www.sciencedirect.com/science/article/pii/S1572308920300930> doi: <https://doi.org/10.1016/j.jfs.2020.100794>
- Basu, M. S. S., Boz, M. E., Gopinath, M. G., Roch, M. F., & Unsal, M. F. D. (2020). *A conceptual model for the integrated policy framework*. International Monetary Fund.
- Basu, M. S. S., & Gopinath, M. G. (2024). *An integrated policy framework (ipf) diagram for international economics*. International Monetary Fund.
- Bê Duc, L., Mayerlen, F., & Sola, P. (2008). The monetary presentation of the euro area balance of payments. *ECB Occasional Paper*(96).
- Bukovšak, M., Lukinić Čardić, G., & Pavić, N. (2020). Structure of capital flows and exchange rate: the case of croatia. *Empirica*, 47(1), 113–146.
- Camacho, J., & Lindström, A. K. (2021). Exchange rate and balance of payments – a correlation that got lost? *Staff Memo - Monetary Policy Department*.
- Czech National Bank. (2005). *Annual report of czech national bank - 2005*. https://www.cnb.cz/export/sites/cnb/cs/o_cnb/.galleries/hospodareni/download/cnb_vysledky_hospodareni_2005.pdf. (Accessed: 2022-12-08)
- Czech National Bank. (2022a). *Arad database | 55931/1089*. Retrieved 2022-11-26, from https://www.cnb.cz/cnb/STAT.ARADY_PKG.PARAMETRY_SESTAVY?p_sestuid=55932&p_strid=AECA&p_lang=CS
- Czech National Bank. (2022b). *Arad database | 57102/302*. Retrieved 2022-11-25, from https://www.cnb.cz/cnb/STAT.ARADY_PKG.PARAMETRY_SESTAVY?p_sestuid=57102&p_strid=ADAA&p_lang=CS
- Czech National Bank. (2022c). *Arad database - gdp | 60793/1842*. Retrieved 2022-12-13, from https://www.cnb.cz/cnb/STAT.ARADY_PKG.PARAMETRY_SESTAVY?p_sestuid=60793&p_strid=ACCAAA&p_lang=CS
- Czech National Bank. (2022d). *Bistat database*. Retrieved 2022-11-25, from https://www.cnb.cz/analytics/saw.dll?Dashboard&PortalPath=%2Fshared%2FUNIBOP_WEB%2F_portal%2FBISTAT&Page=MONPRES&P1=dashboard&Action=Navigate&ViewState=oa7c337tvgcdte8cblit5pj2si&P16=NavRuleDefault&NavFromViewID=d%3Adashboard~p%3Atdppn6rbilu6v8m0
- Czech National Bank. (2022e). *Cnb foreign exchange trading*. Retrieved 2022-11-26, from <https://www.cnb.cz/en/financial-markets/foreign-exchange-market/cnb-foreign-exchange-trading/>
- Czech National Bank. (2022f). *Foreign exchange market turnover*. Retrieved 2022-11-26, from <https://www.cnb.cz/en/financial-markets/foreign-exchange-market/foreign-exchange-market-turnover/>
- Czech National Bank. (2022g). *Methodological sheet - nominal effective exchange rat of the koruna*. https://www.cnb.cz/docs/ARADY/MET_LIST/neer_en.pdf. (Accessed: 2022-11-30)

- Della Corte, P., Sarno, L., & Sestieri, G. (2012). The predictive information content of external imbalances for exchange rate returns: how much is it worth? *Review of Economics and Statistics*, 94(1), 100–115.
- Eichengreen, B., Rose, A. K., & Wyplosz, C. (1994). *Speculative attacks on pegged exchange rates: an empirical exploration with special reference to the european monetary system*. National Bureau of economic research Cambridge, Mass., USA.
- Fratzscher, M., Gloede, O., Menkhoff, L., Sarno, L., & Stöhr, T. (2019, January). When is foreign exchange intervention effective? evidence from 33 countries. *American Economic Journal: Macroeconomics*, 11(1), 132–56. Retrieved from <https://www.aeaweb.org/articles?id=10.1257/mac.20150317> doi: 10.1257/mac.20150317
- Gabaix, X., & Maggiori, M. (2015). International liquidity and exchange rate dynamics. *The Quarterly Journal of Economics*, 130(3), 1369–1420.
- Girton, L., & Roper, D. (1977). A monetary model of exchange market pressure applied to the postwar canadian experience. *The American economic review*, 67(4), 537–548.
- Goldberg, L. S., & Krogstrup, S. (2018). *International capital flow pressures* (Tech. Rep.). National Bureau of Economic Research.
- Gourinchas, P.-O., & Rey, H. (2007). International financial adjustment. *Journal of political economy*, 115(4), 665–703.
- Itskhoki, O., & Mukhin, D. (2022). *Sanctions and the exchange rate* (Tech. Rep.). National Bureau of Economic Research.
- Kaminsky, G. L., & Reinhart, C. M. (1999). The twin crises: the causes of banking and balance-of-payments problems. *American economic review*, 89(3), 473–500.
- Klein, M. W., & Shambaugh, J. C. (2008). The dynamics of exchange rate regimes: Fixes, floats, and flips. *Journal of international Economics*, 75(1), 70–92.
- Li, J., Rajan, R. S., & Willett, T. (2006). Measuring currency crises using exchange market pressure indices: the imprecision of precision weights. *Unpublished manuscript*.
- Lorenzoni, G., & Werning, I. (2023). A minimalist model for the ruble during the russian invasion of ukraine. *American Economic Review: Insights*, 5(3), 347–356.
- Patnaik, I., Felman, J., & Shah, A. (2017). An exchange market pressure measure for cross country analysis. *Journal of International Money and Finance*, 73, 62–77.
- Sachs, J. D., Tornell, A., & Velasco, A. (1996). *Financial crises in emerging markets: the lessons from 1995*. National bureau of economic research Cambridge, Mass., USA.
- Sax, C., & Eddelbuettel, D. (2018, December). *White paper: Seasonal adjustment by x-13arima-seats in r* (Tech. Rep. No. 10.18637/jss.v087.i11).
- United States government. (2022). *X-13arima-seats seasonal adjustment program*. <https://www.census.gov/data/software/x13as.html>. (Accessed: 2022-11-26)
- Weymark, D. N. (1995). Estimating exchange market pressure and the degree of exchange market intervention for canada. *Journal of International Economics*, 39(3-4), 273–295.

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