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Dynamics of Czech Capital Flows: A Capital Flows at Risk Approach

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Declaration of Authorship

I hereby declare that I have independently developed my master's thesis titled "Dynamics of Czech Capital Flows: A Capital Flows at Risk Approach" and I have properly cited and listed all the literature and other sources used in the attached bibliography.

In Prague on 17th of January 2025

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Bc. Adriana Wałoszková

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Abstract

This thesis applies the Capital Flow at Risk (CFaR) framework to examine how global and domestic drivers affect non-resident debt capital flows in the Czech Republic. By integrating quantile regression with a skewed t-distribution fit, the approach captures distributional asymmetries and tail risks, which are often overlooked by mean-focused models. Empirical results reveal that external push factors, such as European risk aversion and the European Central Bank's monetary policy stance, disproportionately influence the lower and upper quantiles of capital flows, indicating that sudden, volatile shifts in global markets can amplify both severe outflows and large inflows. Meanwhile, domestic pull factors, particularly GDP growth and the term spread, underscore the role of strong local fundamentals in attracting and sustaining capital inflows. Scenario analyses further demonstrate how exogenous shocks can shift both the position and shape of the distribution of future capital flows, highlighting that a quantile-based CFaR framework can serve as a critical tool for policymakers aiming to identify vulnerabilities, track evolving risks and employ appropriate policy response.

Key words

Capital Flows, Capital Flows at Risk, Quantile Regression, Push And Pull Factors, Czech Republic, Tail Risk, Surges and Stops

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Introduction

International capital flows are integral to the global economy, offering opportunities for growth and investment while posing significant risks. On one hand, capital inflows can fuel economic development and expand financial resources; on the other, sudden outflows can destabilize local economies, especially in emerging markets that depend heavily on external financing. Emerging markets are especially impacted by capital flow dynamics due to their reliance on external financing and the relative fragility of their financial systems. As a distinct asset class, emerging markets attract investors seeking high returns and diversification benefits. Capital inflows to these economies are often influenced by a combination of external push factors, such as global liquidity conditions and risk appetite, and domestic pull factors, including economic growth, asset returns and political stability. However, surges, sudden stops and retrenchments of capital flows have become recurring phenomena, with the COVID-19 pandemic serving as a recent example of such disruptions.

In light of these challenges, there has been increasing demand for tools to monitor and manage the risks associated with extreme fluctuations in capital flows. While earlier research primarily focused on the average relationships between capital flows and their drivers, newer approaches aim to address tail risks, extreme events that fall outside standard expectations. One such tool is the Capital Flow at Risk (CFaR) framework, which leverages the distributional properties of capital flows to predict and assess risks in upcoming periods. By quantifying these risks, CFaR provides a foundation for capital flow risk management, gaining recognition in major publications such as the IMF's Global Financial Stability Reports and the Bank of England's Financial Stability Papers.

The Capital Flow at Risk framework was first introduced by Gelos et al. (2019), who drew on Adrian et al. (2019) Growth at Risk methodology. Gelos and his colleagues conducted an analysis of 35 emerging markets, examining how push and pull factors influenced gross non-resident debt capital flows and exploring the impact of policy shocks on capital flow risks. Subsequent studies extended this framework. Norimasa et al. (2021) incorporated the U.S. monetary policy stance, using the shadow federal funds rate as a push driver. Eguren-Martin et al. (2021) developed the CFaR for gross non-resident capital flows to emerging markets based on data derived from financial asset prices utilized by principal component analysis. Additionally, they examined how macroprudential policies and capital flow management measures influence these distributions. Papageorgiou and Goel (2021) investigated sensitivities of local and hard currency bonds using CFaR. Later studies applied the CFaR method to individual countries, such as South Africa and India, as demonstrated by Goel and Miyajima (2021) and Muduli et al. (2022) respectively.

This thesis builds on existing literature by applying the Capital Flow at Risk framework to the case of the Czech Republic, a country that has not been included in the analysed sample of emerging markets in prior studies. Similar to the approaches used by Goel and Miyajima (2021) and Muduli et al. (2022), the focus is narrowed to capital flows of a single economy. This analysis concentrates on gross non-resident debt portfolio and other investment flows of the Balance of Payments Framework. Foreign direct investments are excluded due to their distinct characteristics. The primary objective is to understand what drives capital flow volatility in the Czech Republic and to assess whether tail risks to these flows can be quantified to guide appropriate policy measures. The thesis further investigates how the distribution of capital flows reacts to push factor shocks. By quantifying the risks associated with capital flows over future horizons, this analysis contributes to the broader understanding of how the Czech Republic can shield its economy from external financial shocks.

The rest of the thesis is organized as follows. Chapter 1 provides the theoretical background on capital flows, beginning with an analysis of the historical volatility and structural characteristics of international capital movements. It then examines the push and pull factors driving capital flows and concludes with an evaluation of the benefits and challenges associated with capital flows into emerging markets. Chapter 2 focuses solely on the volatility and patterns of capital flows into or from the Czech Republic setting background for further analysis. Chapter 3 presents the methodology for estimating Capital Flows at Risk and Chapter 4 describes the data used. Finally, Chapter 5 presents the estimated results.

1 Key Characteristics and Dynamics of Capital Flows

In the growing globalization of the financial system, emerging market economies (EMEs) have become a crucial asset class for international investors, drawn by their strong growth and higher potential returns compared to advanced economies (AEs). However, EMEs have faced significant challenges, as capital flows to these markets are often volatile, with sudden surges or reversals posing persistent risks to financial stability.

In evaluating the risks associated with capital movements, the distinction between net and gross capital flows has become increasingly important. As Obstfeld (2012) argues, net flows represent the overall change in a country's financial position with the rest of the world, while gross flows provide a more detailed perspective by separating the liabilities side of the financial account in the Balance of Payments (BoP) from the assets side.[1] A reciprocal sharp decline or significant rise in gross flows on both assets and liabilities sides of financial account can have severe repercussions, even if the net position appears stable. Furthermore, as the investment activities of residents in EMEs have expanded over time, it is no longer sufficient to analyse the behaviour of non-resident investors solely through net capital flow measures, as was done in earlier studies. This shift underscores the importance of gross flows in identifying financial vulnerabilities and understanding the dynamics of volatility (Forbes and Warnock 2012).

Within the scope of gross flows, the focus remains on non-resident debt portfolio and other investment capital flows. As highlighted by Koepke (2018), these flows are the most volatile component of capital movements. Portfolio and other investment flows, as classified in the BoP structure, can be adjusted relatively quickly in response investors' frequent portfolio adjustments reacting to economic updates or short-term financial shifts. This volatility is central to this analysis and assessing financial stability within EMEs.

Foreign direct investment (FDI) stands out from previously mentioned types of capital flows because it is less influenced by global economic cycles and more tied to the investment strategies of multinational companies. Studies like Montiel and Reinhart

[1] In the Balance of Payments, the financial account's asset side reflects domestic residents' acquisitions and disposals of foreign financial assets, whereas the liabilities side captures non-residents' acquisitions and disposals of domestic financial assets.

(1999) and Albuquerque et al. (2005) highlight that FDI are not strictly driven by traditional push and pull factors, but rather depend on long-term objectives, like market entry strategies, technology transfer, and synergies in global value chains. For these reasons, FDI was excluded from this analysis.

This chapter will focus on the structure, dynamics and key features of non-resident gross capital flows, with special attention to capital inflows to EMEs. It will begin with a brief overview of the historical volatility of capital flows, followed by an exploration of their main drivers, and conclude with a discussion of the benefits and challenges they present, as well as their impact on financial stability.

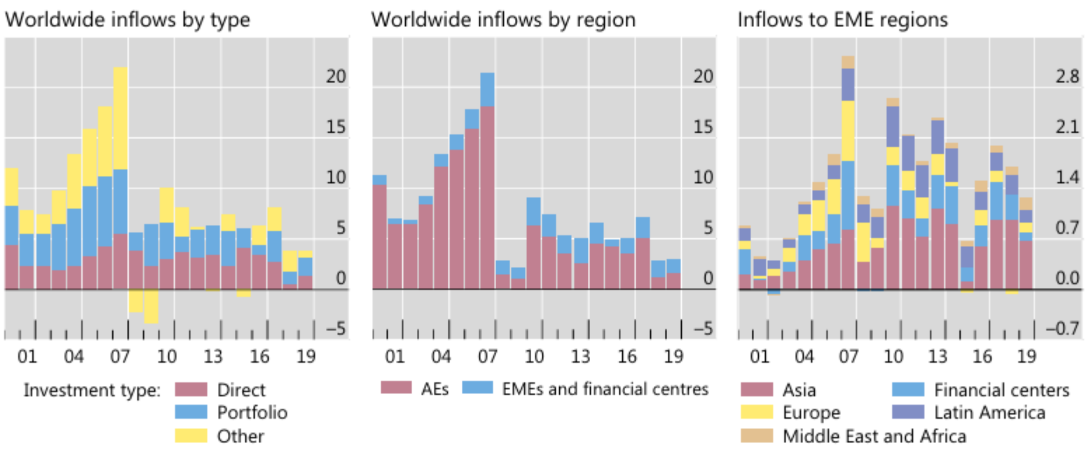
1.1 Capital Flow Episodes from GFC to COVID Crises

The collapse of the Bretton Woods system in the 1970s introduced flexible exchange rates, significantly shaping capital flows and increasing the volatility of cross-border financial transactions. At the same time, it led to several major episodes of global capital outflows that have been recorded since then.

Following Forbes and Warnock (2012), four types of events can be identified:

- capital flow surges describe sizable increases in foreign investment entering a country,
- sudden stops of capital inflows refer to rapid stops in the inflows of capital,
- retrenchments involve the gradual reduction of capital flows,
- capital flights denote the sudden and large-scale exit of financial assets from a country.

Figure 1 - Capital Flows by Type and Region as a % of World GDP



AEs = advanced economies; EMEs = emerging markets; Financial centres = Hong Kong SAR and Singapore; Emerging Asia = CN, IN, ID, MY, PK, PH, TH; Emerging Europe = CZ, HU, PL, RO, RU, TR; Latin America = AR, BR, CL, CO, MX, PE; Middle East and Africa = EG, SA, KW, QA, ZA.

Source: Committee on the Global Financial System, 2021.

Commonly, observed major capital outflow crises often are preceded by periods of sharp inflows. Historically, this observed volatility primarily affected the liability side of the BoP, but recent trends indicate similar fluctuations on the BoP asset side. This can be attributed to increased EMEs' investments abroad during financial globalization, exposing the asset side of their balance sheets to similar pressures as AEs.

In the late 20th century, ongoing financial liberalization lowered capital controls and increased integration into global markets. By 1980-1985, capital flows averaged 3.5% of global GDP. However, significant capital outflows were observed during episodes such as the Mexican Peso Crisis in 1994 and the Asian Financial Crisis in 1997(Committee on the Global Financial System, 2021).

1.1.1 Post-GFC Shifts in Capital Flow Patterns

In the period leading up to the Global Financial Crisis (GFC), capital flows to EMEs experienced significant growth. This was driven mainly by high global liquidity, favourable macroeconomic conditions in EMEs and investor risk appetite that surged aggregated capital flows to approximately 22% of the world's GDP in 2007 (Committee on the Global Financial System, 2021). The GFC marked a turning point for capital flows, bringing significant structural changes to this area, as illustrated in Figure 1. After the crisis, the volumes of global capital flows declined sharply, shrinking to about 5% of global GDP (Committee on the Global Financial System, 2021), while not returning to their pre-crisis levels since. Exceptions were EMEs in Asia (especially China) that experienced long-term robust capital inflows with increasing volumes due to their strong economic fundamentals and consistent demand for foreign capital (Boonman, 2023). According to the Committee on the Global Financial System (2021 capital flows to EMEs have shown greater resilience compared to AEs, where inflows have remained well below pre-crisis levels. Since 2010, the share of global capital inflows to EMEs has risen significantly, accounting for around 30%, compared to roughly 10% before the crisis.

The structural change after the GFC occurred also in the composition of capital flows. Capital movements to AEs and emerging markets have historically differed. Portfolio investment and other investment flows have increasingly dominated the capital inflows to advanced economies. However, recent trends indicate a substantial rise in portfolio and other investment flows to EMEs. Although FDI still remained the dominant form of capital flow into emerging markets (Committee on the Global Financial System, 2021).

The post-GFC regulatory changes, particularly tightened banking regulations and macroprudential policies, reduced international bank lending. That has led AE banks to decrease cross-border claims to strengthen capital buffers (Lane and Milesi-Ferretti, 2017). This deleveraging was particularly pronounced among euro-area banks, with cross-border claims falling significantly. On the other hand, EME banks expanded their international activities and increased their share of global lending.

Emerging markets also experienced greater regional integration, driven by their rising share of global economic activity and increased cross-border investments from other EMEs regions, particularly Asia and Latin America, as highlighted by the Committee on the Global Financial System (2021). As a result of this structural changes, non-bank financial institutions gained importance, while introducing both diversification and new systemic risks, such as passive investment strategies causing so called “herding behaviour” and potential contagion effects.

Lastly, as Lane and Milesi-Ferretti (2017) notes public sector borrowing has increased significantly. Governments and corporations in EMs have increasingly turned to local currency borrowing, reducing their reliance on foreign-denominated debt and lowering FX mismatches.

1.1.2 Post-GFC to the Pandemic

After the GFC, central banks and governments in AEs shifted their focus toward stabilizing financial systems and supporting economic recovery. Central banks cut their policy rates to nearly zero and introduced unconventional tools such as quantitative easing. Quantitative easing involved large-scale asset purchases aimed at boosting markets liquidity and encouraging lending. However, these measures had unintended effects on EMEs.

In 2013 the U.S. Federal Reserve announced it might reduce its quantitative easing program, creating uncertainty and panic in global financial markets. This episode, so-called “Taper Tantrum”, led to a sudden surge in AEs’ government bond yields, which motivated investors to reduce their positions in EMEs. The reallocation of investments triggered currency depreciation, decrease in stock prices and a sudden stop of capital flows to EMEs. Initially, all EMs experienced similar reactions, but investors began to target specific countries with weaker economic fundamentals as the situation evolved. Particularly vulnerable was Brazil, India, Indonesia, Turkey and South Africa due to their large current account deficits and domestic financial weaknesses. These economies further faced steep capital outflows and higher borrowing costs (Sahay et al., 2014).

In 2015, the unexpected devaluation of the Chinese renminbi reinforced fears of an economic slowdown in China. This sparked significant equity sales on global markets and currency depreciations in all EMEs. Capital outflows accelerated as investors sought haven in safer assets, reinforcing financial stress in EMEs that were struggling with domestic weaknesses. The impact was particularly severe for countries with commodity-oriented exports, which faced further pressures from falling global commodity prices (Chan, 2017).

As noted by the Committee on the Global Financial System, 2021, in the beginning of the COVID-19 crisis, EMEs experienced exceptional outflows driven by the fall in global investors' risk appetite. Unlike earlier crises, the pandemic was a global event affecting advanced and emerging economies at once. Nonetheless, many EMEs were better prepared than in past crises, implementing countercyclical policies to manage the volatility. Portfolio flows at that time reflected the change in U.S. dollar funding needs that moved towards a more diverse set of market participants and regions then during GFC. When EMEs started selling U.S. Treasuries to address local demand for dollar funding, handle lower commodity prices and support their currencies, it didn't have a big impact on other advanced economies, with Europe and Japan only seeing small outflows. Capital inflows began regaining their volumes in April 2020, driven by monetary easing in advanced economies. Investors preferred EMEs with strong policy frameworks and pandemic control. By late 2020, equity and local currency fund inflows increased, but a rise in U.S. yields in early 2021 caused moderate outflows, though less severe than during the 2013 Taper Tantrum.

1.2 Push-Pull Dichotomy of Capital Flow Drivers

The factors driving international capital flows, including their volume, scale and momentum, are widely examined in the literature, which identifies numerous key determinants. Among the most notorious conceptual frameworks for categorizing these drivers is the push-pull dichotomy. As defined by Calvo et al. (1993) push factors are exogenous factors that motivate foreign investors to invest in EMEs, while pull factors refer to domestic conditions within EMEs, that determine the risk-return profile of the economy. The determinants have a varying influence according to the type of flow, such as FDI, portfolio investment or other investment flows (Cerutti et al., 2015).

Koepke (2018) consolidates the findings of 34 empirical studies on capital flow determinants, while identifying push and pull factors of debt and equity capital flows within portfolio investment and other investment flows that are well-supported by existing literature and summarized in the following three subchapters.

1.2.1 Push Drivers

Among the key push factors is global risk aversion, often proxied by implied equity volatility indices such as the VIX, VXO and V2X, as well as the U.S. BBB spread. This driver has been shown to significantly influence both portfolio and other investment capital flows. The literature documents a strong negative relationship between these variables. When global risk aversion rises, investors perceive emerging markets as riskier due to their economic volatility and external vulnerabilities, prompting a shift toward safer assets like U.S. Treasury bonds. This flight to safety leads to capital outflows from EMEs, while weakening their currencies and increasing the cost of servicing their external debt. Koepke further notes that while the VIX is more closely tied to equity flows and the BBB spread is derived from U.S. bond market, there is limited evidence suggesting that changes in risk appetite disproportionately affect one type of portfolio flow over the other.

Another significant global driver of capital flows is global, which refers to the ease of obtaining financing. Global liquidity is often proxied by major AEs' monetary policy stances, specifically U.S. monetary policy rate. When U.S. interest rates rise, the return on U.S. assets becomes more attractive relative to those in EMEs. This encourages investors to shift their capital back to the U.S. leading to capital outflows from EMEs. Additionally, higher U.S. rates increase the cost of borrowing for EMEs. Debt portfolio flows exhibit a high sensitivity to global interest rates, whereas equity portfolio flows are somewhat less responsive. The evidence regarding responses of other investment flows remains mixed according to research. Although most studies confirm a negative correlation between rising global interest rates and portfolio inflows, the magnitude and timing of this effect differ depending on the sample period and market conditions. Especially, differences have been observed in capital flows response between the years prior the global financial crisis and the period afterwards as monetary policy adjustments and investor sentiment have shifted. However, a key limitation of this push factor is that the policy interest rate does not account for the forward-looking behaviour of financial markets, which reflect investors' expectations regarding future interest rate movements.

The last selected push driver is the output growth of the reference advanced economy. Theoretically, when U.S. GDP rises, it signals global growth and boosts investor confidence, encouraging risk-taking. As Koepke (2018) summarizes, a few studies have found a positive and statistically significant link between the growth of mature economies and portfolio flows to EMEs, but alternative specifications did not yield consistent conclusions. For instance, Ahmed and Zlate (2013) identified a meaningful relationship for emerging market Asia but found no comparable effect for Latin America. Furthermore, Forbes and Warnock (2012) provided additional insights, suggesting that robust global growth increases the likelihood of capital surges into EMEs while reducing the chances of unexpected retrenchments.

In addition to the determinants highlighted by Koepke, other significant push factors are commonly discussed in the literature, such as commodity prices (Davis et al., 2021) or the strength of the U.S. dollar (e.g. Avdjiev et al. 2017).

1.2.2 Pull Drivers

Pull factors, referring to domestic economic characteristics, can be divided into cyclical and structural determinants. Cyclical factors include domestic growth, interest rates, asset returns, country risk indicators, fiscal balance and current account balance. Structural factors cover financial account openness, the quality of institutions and legal systems, levels of corruption, geographic proximity and the health of banks. According to the Committee on the Global Financial System (2021), the importance of structural factors in driving gross capital flows has declined since the GFC. Instead, cyclical pull factors have become more significant in attracting capital flows to EMEs post-crisis. Recent studies also show that international investors are becoming more selective when evaluating investment opportunities (Boermans and Burger, 2020).

Koepke (2018) highlights domestic economic performance as a widely recognized driver of capital flows, although its impact varies across different components of capital flows. Both portfolio and other investment flows are found to be very sensitive to changes in domestic output growth. However, when using high-frequency proxies for domestic growth, such as fund flow data, Koepke (2014) finds a smaller impact of domestic output growth at weekly or monthly intervals. This is likely due to the quarterly reporting of reliable measures like GDP growth, whereas higher-frequency indicators ,such as purchasing manager indices and economic surprise indices, are less precise and therefore less influential in guiding investor decisions.

Domestic asset returns also play a crucial role when analysing EMEs' capital inflows with other investment flows found to be more sensitive to change in asset returns than portfolio flows. Studies by Ferrucci et al. (2004), Bruno and Shin (2013) and Herrmann and Mihaljek (2013) identify stock market returns, currency appreciation and banking sector equity performance as statistically significant determinants for other investments. For portfolio flows, local stock market returns are the most significant drivers (Chuhan et al., 1998). However, findings for domestic policy rates remain inconclusive (e.g., Ahmed and Zlate, 2013). Considering EME interest rates introduces an issue of endogenity, as an increase in EME interest rates should attract more capital into the economy, which would lead to a subsequent decrease in EME interest rates. Additionally, high volatility in proxies for EMEs' asset returns, particularly in real exchange rates, has been shown to suppress foreign inflows (e.g., Baek, 2006).

Country risk indicators, much like domestic asset returns, exhibit varying effects on portfolio and other investment flows. High external debt ratios and low sovereign credit ratings discourage other investment inflows, while strong institutional credit ratings can boost them (e.g., Ferrucci et al., 2004). For portfolio flows, elevated debt levels and weaker credit ratings deter foreign investment specifically in long-term debt instruments. Moreover, Koepke (2018) notes that reducing current account deficits can improve a country's creditworthiness, but the overall effect often reduces inflows, as the lowered financing needs more than compensate the benefits of improved fiscal health.

1.2.3 Challenges of Push-Pull Framework

As Koepke (2018) points out, the push-pull framework has several shortcomings. One key limitation is its failing to account for the complexity of interactions between various capital flows drivers, which can intensify or compensated each other, like contagion effects, when investor behaviour spreads across countries regardless of economic fundamentals.

Another limitation of the described framework is that it fails to capture the differential characteristics between AEs and EMEs, such as growth differentials or interest rate differentials. Even though the interest rate differential between AE and EME is often identified in the empirical literature as a significant driver, the differential approach has some caveats. The general view is that the characteristics of AEs and EMEs have different impacts on capital flows, as demonstrated by Ferrucci et al. (2004). Therefore, using differential variables as capital flows drivers can be misleading.

1.3 Benefits and Risks Associated with Capital Flows

It is generally recognized that inflows of foreign capital into an economy have a positive impact on economic growth, productivity and investment. Nonetheless, these flows also take along risks that economies reliant on external financing must address. Greater financial account openness can make it more challenging for policymakers to control domestic financial conditions, potentially threatening financial stability. Despite these significant challenges, the risks associated with capital flows can be effectively managed using appropriate tools and strategies. The following summarizes the findings of the Committee on the Global Financial System (2021) concerning the risks and benefits of capital flows.

1.3.1 Economic Benefits of Capital Flows

The previously mentioned increase in productivity, investment and economic growth occurs when capital flows freely between economies without restrictions, allowing funds to be directed to their most efficient uses. Access to international capital inflows provides these economies with financial resources that exceed their domestic capacity, improving the efficiency of resource allocation. The beneficial impacts of FDI inflows have been widely recognized in the literature. Cingano and Hassan (2020) show that even volatile flows, such as banking flows, can increase domestic lending, leading to higher investment, productivity and economic growth. Foreign banks further help to reduce funding shortages and improve payment systems by working with local banks and maintaining correspondent banking networks (Claessens, 2017).

From a financial stability perspective, increased financial account openness allows domestic entities to better manage their risk by diversifying their investment portfolios internationally. This access to a broader range of funding sources enhances the country's financial resilience, making it less vulnerable to internal shocks and reducing the magnification and spread of economic disturbances. Additionally, such openness offers households and businesses broader access to credit, smoothing their consumption over time and mitigating the negative effects of economic fluctuations (Ghosh et al., 2012). Moreover, incoming portfolio equity flows allow companies to obtain capital through the issuance of shares, supporting further investment and growth.

The involvement of foreign investors not only significantly deepens domestic financial markets but also enhances the quality of financial intermediation within the banking sector. The participation of foreign financial entities often drives innovation and stimulates competition, resulting in more efficient financial services (Bruno and Hauswald, 2013).

Another advantage of capital flow liberalization is its role in promoting policy discipline. International borrowing creates external pressures on governments to implement and maintain prudent fiscal and monetary policies that align with global standards. This external monitoring serves as an incentive for sound policymaking and governance, which in turn contributes to economic stability (Albuquerque et al., 2019).

1.3.2 Challenges and Risks of Capital Flows

While financial account openness offers significant benefits, it also brings risks that vary depending on the characteristics of the receiving economy. Economies with weaker fundamentals, such as underdeveloped financial markets, institutional inefficiencies or high dependence on foreign capital, are particularly vulnerable to these challenges.

Capital inflows can lead to inefficient resource allocation, particularly in economies with financial frictions where asymmetric information or moral hazard prevents efficient lending. For instance, firms with more valuable collateral may attract more funding despite being less productive, while more innovative or productive firms with fewer assets struggle to secure financing (Gopinath et al., 2017). Large inflows can also distort labour and capital allocation from productive tradeable sectors, such as manufacturing, to less productive non-tradeable sectors like services (Benigno et al., 2015). These shifts reduce aggregate productivity growth and hold back economic growth.

In weak financial systems, foreign currency borrowing can aggravate financial risks. During periods of significant inflows, firms and households often accumulate excessive foreign currency debt without fully considering the potential impact as capital inflows directly affect exchange rate dynamics. Large or persistent inflows often lead to currency appreciation, which can harm exports. Conversely, sudden stops or outflows cause depreciation, which may boost exports but simultaneously increase the burden of liabilities in foreign currency, negatively impacting overall economic output (Calderon and Kubota, 2018). Foreign currency borrowing also increases maturity and FX mismatches that heighten vulnerabilities, especially during periods of exchange rate volatility.

Large capital inflows can also drive excessive credit boom, inflating asset prices beyond sustainable levels. Tillmann (2013) demonstrates that inflows driven by external push factors, such as low global interest rates, are more likely to inflate asset bubbles, including in equity and real estate markets.

On the other hand, the sudden stops can trigger severe declines in investment, asset prices and economic activity, thereby reducing overall output, particularly when they overlap with banking or FX crises (Korinek and Mendoza, 2014). Sudden stops also carry contagion risks. When a country in a region faces a sudden stop, the likelihood of neighbouring countries experiencing similar outflows increases significantly (Forbes and Warnock, 2020). This interconnectedness, particularly through shared investors or global financial institutions, amplifies systemic risks, especially in highly leveraged banking systems (Forbes, 2013).

2 Czech Republic's Experience

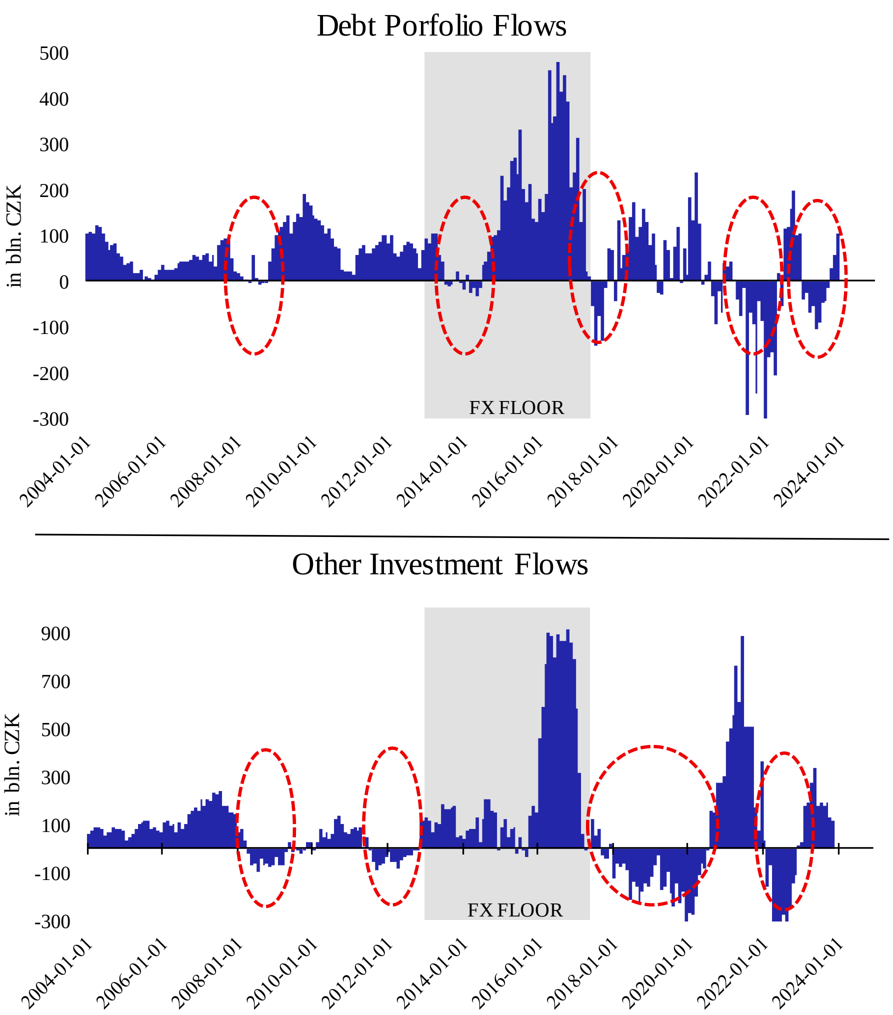
The Czech Republic occupies a distinctive position in the global financial system, often classified as an emerging market economy. However, its trajectory of economic development and extensive integration into European and global markets distinguish it from traditional EMEs. While the country shares some features common to emerging markets, such as historical transitions in governance and capital market evolution, its robust institutions and sound macroeconomic policies elevate it to a more advanced stage of development. Moreover, due to its strong integration with the broader European economy through trade, investment and shared policies the Czech Republic's capital flows are significantly shaped by economic conditions and market sentiment across Europe. Consequently, shifts in core European markets can quickly impact Czech markets, reflecting the country's ongoing dependence on the regional economic environment.

2.1 Capital Flow Dynamics in the Czech Republic

Capital inflows into the Czech Republic have closely followed the country's economic transformation, especially during its shift from a centrally planned economy. In the early stages, limited domestic savings created a strong reliance on external financing. With low confidence from foreign investors, the primary funding sources were state-negotiated loans from international institutions and direct loans via the Czech National Bank (CNB). These funds supported foreign exchange market interventions to stabilize the currency. Over time, Czech entities gradually improved their ability to secure loans from foreign creditors. This period also saw a rapid increase in the country's external imbalance, which was financed through an inflow of debt capital. The capital was attracted by the interest rate differential and the low exchange rate risk associated with the fixed exchange rate regime. To maintain the exchange rate target, the CNB had to absorb the excess foreign currency supply in the market, however, doing so, the CNB injected additional liquidity into the economy, complicating its efforts to achieve its monetary growth targets. The withdrawal of this excess liquidity led to further increase of the interest rates. However, by 1997, escalating pressure and loss of confidence in the fixed exchange rate system led the CNB to abandon it, transitioning to a managed floating exchange rate. From the late

1990s until the GFC, the Czech Republic experienced a surge in capital inflows due to structural reforms and attractive investment returns. Foreign ownership in the banking sector surged, bringing capital, advanced technologies and improved risk management. This spurred competition and reduced borrowing costs for businesses. FDI became a key entry channel for capital, complemented by the growth of domestic financial markets offering bonds and equities, providing diverse funding options for both public and private sectors (CNB, 2024).

Figure 2 – Episodes of Non-Resident Debt Capital Flows in the Czech Republic

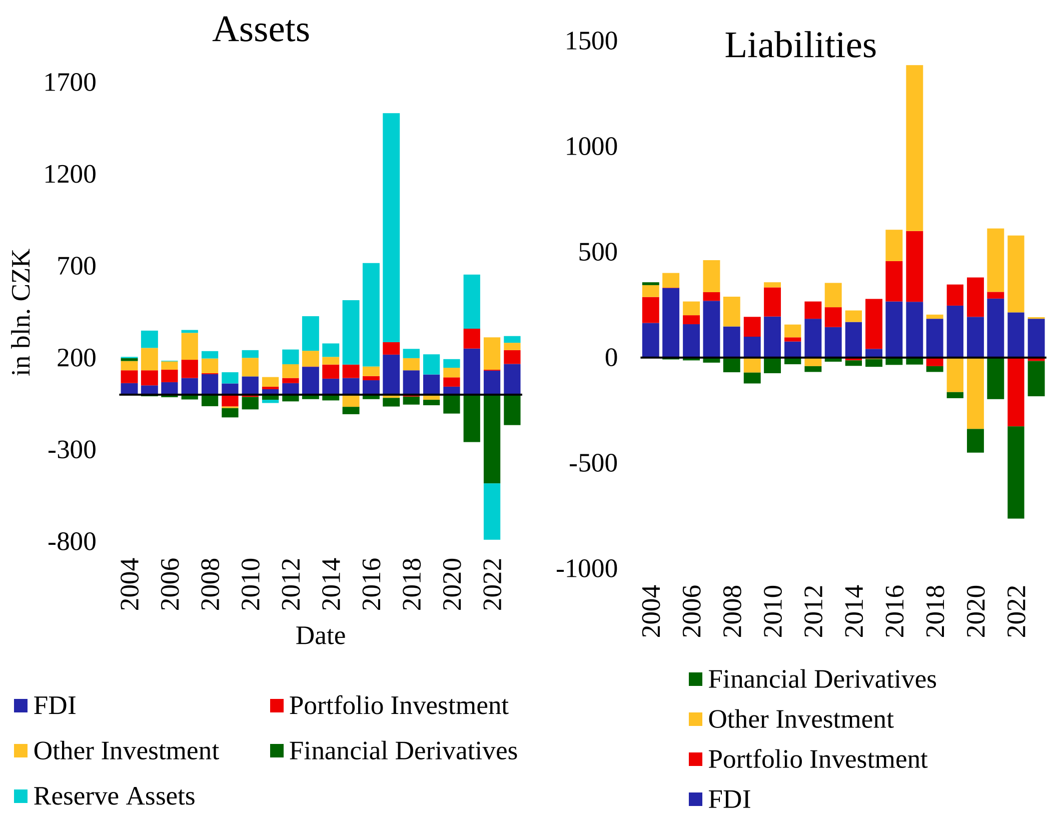


Note: Data reflects 12-month moving averages of analysed variables.

Source: Author's Visualization, ARAD Database

After the GFC, the Czech Republic's reliance on foreign financing declined, reflected in increased resident investments abroad. FDI fell by about one-third compared to pre–2008 levels (Figure 3), driven initially by the crisis and later by long-term factors such as rising wages, currency shifts and reduced investment incentives compared to other countries in the Central Europe. In the same time, Czech companies gained access to more attractive foreign financing through bond issuance attracting portfolio inflows. As the economy matured, domestic investors increased direct investments abroad, though portfolio investments declined due to crisis-related equity losses, lower yields on foreign bonds and better domestic investment conditions (CNB, 2024).

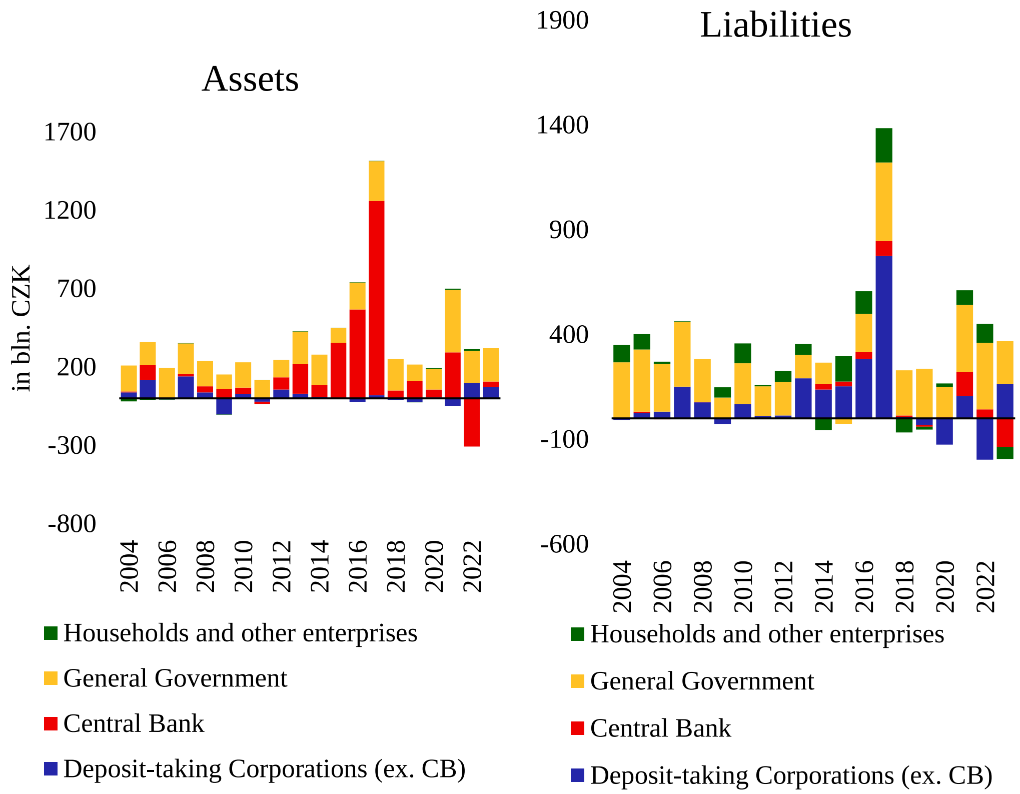
Figure 3 – Composition of BoP Financial Account by Flow Category



Source: Author's Visualization, ARAD Database

From 2013 to 2017, the Czech National Bank maintained an exchange rate floor of 27 CZK/EUR to support economic recovery and counter deflationary pressures. To address appreciation pressures from 2015 to 2017, the CNB conducted extensive foreign exchange interventions, rapidly increasing its FX reserves to record levels, as illustrated in Figure 4. During this period, the Czech Republic saw significant inflows of speculative foreign capital, as investors anticipated the eventual removal of the currency floor. These inflows were predominantly short-term, with investors aiming to profit from the expected koruna appreciation after the floor's removal (CNB, 2017). After the FX floor was removed, the volume of short-term foreign capital in the Czech Republic declined sharply, though much of it remained due to the ECB's highly accommodative monetary policy, while parallel interest rate hikes in other developed countries, particularly the U.S., likely shielded the Czech economy from further inflows tied to rising CNB rates (CNB, 2024).

Figure 4 - Composition of BoP Financial Account by Sector



Note: Financial derivatives were excluded.

Source: Author's Visualization, ARAD Database

The economic constraints following the COVID-19 pandemic led to a record current account surplus for the Czech Republic in 2020. This surplus was driven by lower energy import prices, a sharper decline in domestic demand relatively to the foreign demand and reduced outflows of corporate profits. Together, these factors contributed to significant net capital exports, with the most notable impact being a reduction in banks' short-term foreign currency debt (CNB, 2024).

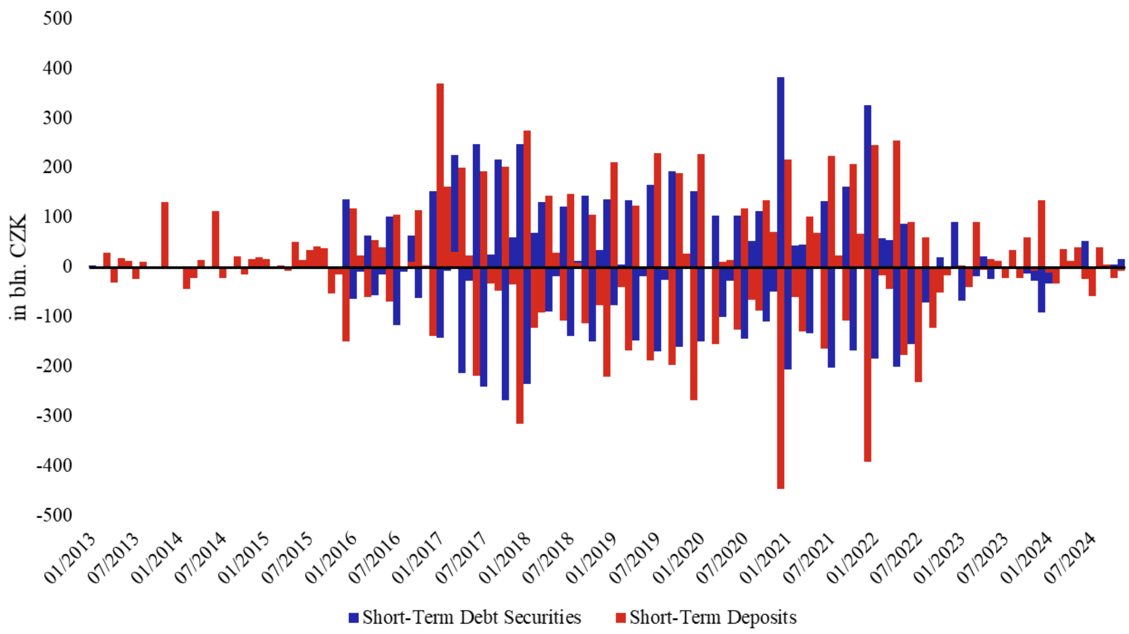
However, in 2022 the Czech Republic recorded deep deficit. Primary drivers included supply chain disruptions affecting the domestic automotive industry and a sharp rise in global energy prices. Financing these deficits required foreign capital inflows, but instead, foreign capital began leaving the country in 2023, prompted by market expectations of a more accommodative CNB monetary policy. To prevent sharp depreciation of the koruna and limit inflationary pressures, the CNB conducted significant FX interventions in 2022. However, in 2023, as the CNB ended its intervention regime and Eurozone interest rates rose, the outflow of short-term capital accelerated. Despite these pressures, a return to a current account surplus, aided by improved manufacturing conditions and lower energy import prices, mitigated the depreciation effects of capital outflows (CNB, 2024).

2.2 Impact of Banking Sector Optimizations on Capital Flows

In contrast to the original literature which analyses non-resident portfolio and other investment flows separately, here an aggregate for both portfolio and other investment will be the subject of the analysis. This is due to the significant volatility in debt flows in the Czech Republic driven by optimization transactions within the banking sector, as outlined in the Czech National Bank's 2023 Balance of Payments Report.

These transactions have been ongoing from 2014 to 2022 on quarterly basis, when mandatory contributions to the Crisis Resolution Fund were established to prevent financial sector crises. These contributions were calculated based on the size and risk profile of each bank determined by specific financial indicators. Since the implementation of these contributions, banks have engaged in so called "window dressing" practices to optimize their balance sheets during the quarterly and annual evaluation period. Short-term deposits by non-residents in Czech banks have been temporarily restructured into short-term securities issued by the banks at quarter-end. In 2023, the fund was fully replenished, so banks lost the motivation to carry out the optimisation transactions and the capital flows profile no longer reflected the usual pattern observed in previous years as visualized in Figure 5.

Figure 5 - Capital Flows in Czech Republic Distorted by Banking Optimization Transactions



Source: Author's Visualization, ARAD Database

This volatility in capital flows, which lacks any economic justification relevant to the chosen analysis, is therefore eliminated by aggregating these flows, allowing opposing movements to offset each other and smooth out their fluctuations.

3 Methodology

In this section, the methodology used is introduced, which consists of five distinct steps. The method, for the most part, follows the approach taken by Adrian et al. (2019) for the analysis of the Growth at Risk framework and the methodology used by Gelos et al. (2019) for the CFaR estimation.

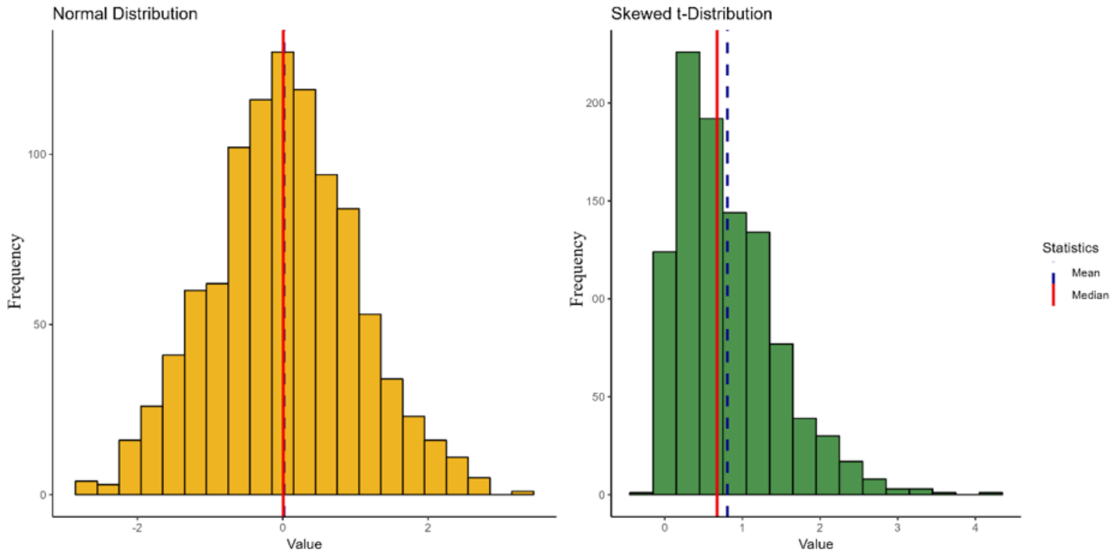
First, the quantile and quantile functions are described, then the general principles and the application of quantile regression are outlined. In addition, the inferential evaluation of coefficients estimated in the previous step is discussed thoroughly, focusing on the statistical validation of these parameters. Subsequently, the selected method for fitting the empirical quantile function to a skewed t-distribution is described. This is followed by an outline of the Capital Flows at Risk framework, which provides a structured approach for assessing the risk of future capital flows movements. Finally, the chapter illustrates impact of shock scenarios of the selected push factors independently on the estimated CFaR.

3.1 Quantile regression

The objective of regression analysis is to understand the relationship between a dependent variable and its covariates. However, in practice, it is often challenging to understand the relationship through a deterministic function as the dependent variable itself is a random variable. Therefore, to reveal how the analysed variable might respond to a covariate, several measures of central tendency are used, like mode, median or mean, while the mean is the focus of the traditional linear regression model (Hao and Naiman, 2007).

The standard linear regression estimates the conditional mean and quantifies the average response of the target variable to different values of the explanatory variables. The results are straightforward to interpret, and the method remains computationally inexpensive. However, when analysing data with asymptotic distributions or heavy tails, which violate the assumptions of linear regression, the model results may be biased. In such cases, Hao and Naiman (2007) suggest that exploring central tendency through median regression is a useful way that overcomes the limitations of the ordinary least squares method.[2] Figure 6 illustrates that for symmetric probability distributions the mean and median are consistent, but for highly asymmetric distributions the two measures can differ significantly, making the mean insufficiently representative of the entire distribution. In these instances, the median provides more accurate information about the central tendency of the distribution.

Figure 6 - Comparison of Randomly Generated Normal Distribution and Skewed t-Distribution



Source: Author-created visualization using R Studio

Nonetheless, the linear regression approach focuses only on the mean value, thereby neglecting other important properties of the conditional distribution of the dependent variable, which can provide a more nuanced understanding of the data's structure. In order to study the entire conditional distribution, it is convenient to employ quantile regression methods to estimate the response of the dependent variable at different quantiles of its probability distribution.

[2] Median regression is a special case of quantile regression, corresponding to the estimation of the 50th percentile of the dependent variable's conditional distribution.

3.1.1 Cumulative Distribution Function and Quantile Function

As Koenker (2005) shows, each real random variable X can be described by its cumulative distribution function (CDF) expressed as:

$$F(x) = P(X \leq x). \tag{3.1}$$

The CDF represented as $F(x)$ quantifies the proportion of the population such that $X \leq x$ for a range of values of a random variable. Its most distinctive properties include the behaviour at infinity given $lim_{y \to -\infty} F(x) = 0$ and $lim_{y \to +\infty} F(x) = 1$ together with its monotonic and non-decreasing profile.

Figure 7 shows that the quantile function represents the inverse of the CDF. The quantile denoted by $Q(\tau)$ is the value of this inverse CDF at level τ, while any τth quantile of random variable X can be expressed as:

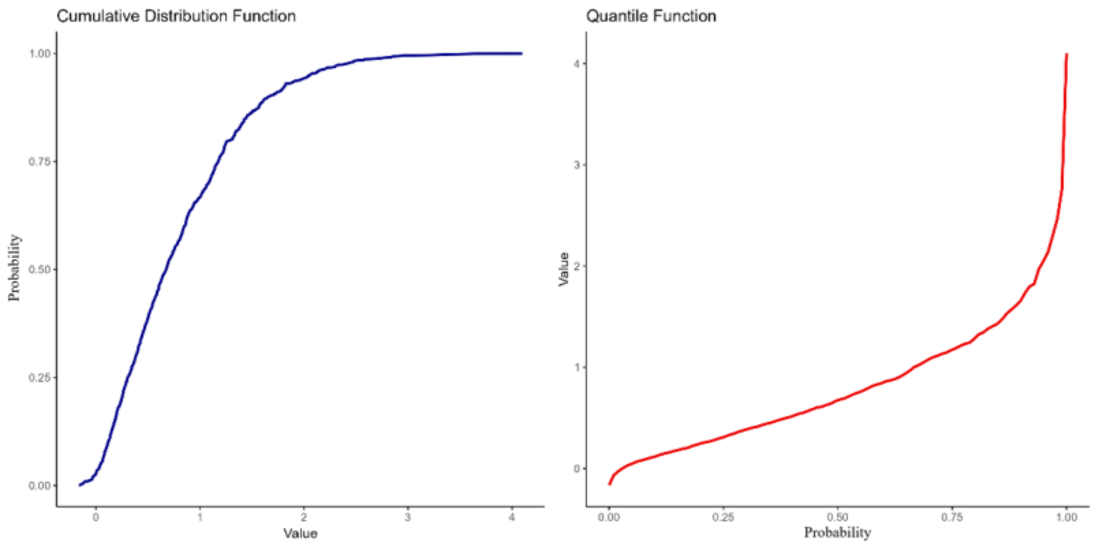
$$Q(\tau) = F^{-1}(\tau) = inf\{x: F(x) \geq \tau\}. \tag{3.2}$$

As discussed above, the quantile-based approach allows for investigations of additional properties of the distribution. Drawing on Hao and Naiman (2007), we can measure the scale[3] and skewness[4] of the probability distribution, which in this method is expressed as the ratio of the upper to lower spread from the median.

[3] It is common to use the standard deviation of a probability distribution as measure of scale. In the quantile approach a spread is used instead in the form of $QSC^{(\tau)} = Q^{(1-\tau)} - Q^{(\tau)}$, where $\tau < 0.5$.

[4] The equation for quantile-based skewness is given by: $QSK^{(\tau)} = (Q^{(1-\tau)} - Q^{(0.5)})/(Q^{0.5} - Q^{(\tau)}) - 1$, where $\tau < 0.5$. If the value of QSK is positive, this implies that the distribution is right-skewed. Conversely, a negative QSK indicates left skewness of the distribution.

Figure 7 - Cumulative Distribution Function and Quantile Function



Source: Author-created visualization using R Studio

3.1.2 Quantile Estimation as an Optimization Problem

To understand how coefficients are estimated using quantile regression, it is crucial to view a quantile as an optimization problem. This approach consists of measuring the average distance of data points in the sample from the chosen τth quantile using the absolute deviation $E|X - \hat{x}|$. The function that minimizes this deviation serves as the solution to the problem.

Koenker (2005) defines the loss function for τ within the interval [0, 1] as:

$$\rho_\tau(u) = u\big(\tau - I(u < 0)\big), \tag{3.3}$$

where $I(u < 0)$ is an indicator function that assigns different weights to positive and negative deviations. The distance between X and the estimated quantile $\hat{x}$ is measured by a weighted absolute deviation. This weight is determined by whether the observed value x lies below or above the estimated quantile $\hat{x}$. Formally, as represented by Koenker (2005):

$$E\rho_\tau(X - \hat{x}) = (\tau - 1)\int_{-\infty}^{\hat{x}} (x - \hat{x})\, dF(x) + \tau \int_{\hat{x}}^{+\infty} (x - \hat{x})\, dF(x). \tag{3.4}$$

Since the loss function is convex, a unique global minimum can be found. Differentiating with respect to $\hat{x}$ and setting the partial derivative $F(\hat{x}) - \tau = 0$ allows for solving the equation $F(\hat{x}) = \tau$ that satisfies the minimization problem. Mathematically, it can be expressed as:

$$0 = (1 - \tau) \int_{-\infty}^{\hat{x}} dF(x) + \tau \int_{\hat{x}}^{+\infty} dF(x) = F(\hat{x}) - \tau. \tag{3.5}$$

Koenker (2005) further shows the application to the empirical CDF $F_n(x)$ as follows:

$$F_n(x) = n^{-1} \sum_{i=1}^{n} I(X_i \leq x). \tag{3.6}$$

The empirical cumulative distribution function can be flat over certain intervals, which may result in multiple solutions for the equation. Consequently, this produces a vector of potential results, from which the minimum will be selected. The τth sample quantile of empirical distributions is obtain through:

$$\min_{\hat{x}} \sum_{i=1}^{n} \rho_\tau(x - \hat{x}) = \min_{\hat{x}} \left[(1 - \tau) \sum_{x \leq \hat{x}} (x - \hat{x}) + \tau \sum_{x \geq \hat{x}} (x - \hat{x}) \right]. \tag{3.7}$$

3.1.3 Parameter Estimation Using Quantile Regression

Quantile regression models the conditional quantiles as functions of predictor variables. The estimation of the parameter β is also carried out through the least absolute distance estimation. For each chosen τ, a different conditional quantile is estimated. Since there are many such curves for each τ, the final curve is derived by solving a minimization function. This involves minimizing the weighted sum of the absolute values of the residuals. A series of specific conditional quantiles can accurately describe the shape of the conditional distribution in addition to its mean (Hao and Naiman, 2007).

As demonstrated by Koenker (2005), for a sample quantile τ, the quantile function conditional on x_t is defined as:

$$\hat{Q}_{y_t}(\tau | x_t) = x_t \, \hat{\beta}_\tau. \tag{3.8}$$

Then the partial effect of each independent variable in the conditional distribution of future capital flows can be estimated as follows:

$$\hat{\beta}_\tau = \underset{\beta_\tau \epsilon R^k}{argmin} \sum_{t=1}^{T} \left[(1-\tau) \cdot I_{(y_t < x_t \beta)} |y_t - x_t \beta_\tau| + \tau \cdot I_{(y_t \geq x_t \beta)} |y_t - x_t \beta_\tau| \right], \quad (3.9)$$

where I denotes the indicator function. This procedure is robust to assumptions about the shape of the distribution as the estimator is more sensitive to the local distributional behaviour around a specified quantile rather than distant parts of the distribution, though the entire sample population is always included in the estimation of each $\hat{\beta}_\tau$. Furthermore, quantile regression is robust to heteroscedasticity and does not imply independent and identically distributed errors.

3.2 Statistical Inference for Quantile Regression

Given that the analysed data exhibited serial correlation, where observations were not independent over time, as well as heteroscedasticity in the error terms, standard methods for quantile regression inference could not be directly applied. These data characteristics led to unreliable standard errors and inferential statistics, especially in a small sample like the chosen one. To address these issues, a moving block bootstrap method as proposed by Fitzenberger (1998) and in line with Adrian et al. (2019) was applied.

3.2.1 Moving Block Bootstrap Method

The moving block bootstrap method consists of repeatedly resampling with replacement the data in blocks that preserve the time dependence between observations. For the purpose of this study, 1,000 resampled rows of data were chosen. With each bootstrapped sample the initial quantile regression model was fitted and coefficients for each explanatory variable were approximated. From this set of approximated coefficients its empirical distribution was provided and bootstrap standard errors calculated. As Fitzenberger (1998) argues the variability of such estimated coefficients yields heteroskedasticity and autocorrelation consistent standard errors.

3.2.2 Block Length Determination

There are numerous approaches for assessing the optimal block size in bootstrap techniques For this analysis, a straightforward Rule-of-Thumb method was selected for its practical implementation and its ability to balance computational efficiency while preserving essential data properties. The block size b was determined using the equation:

$$b = n^{1/3}, \tag{3.10}$$

where n represents the sample size.

3.2.3 Confidence Intervals Estimation

Following the methodology outlined by Eguren-Martin et al. (2021) the reflection method was employed to calculate confidence intervals. This approach generally provides intervals with improved coverage in the presence of biases. As described by Efron and Tibshirani (1994) confidence intervals were obtained following:

$$\left(2\hat{\beta}(\tau) - \hat{\beta}^*_{\frac{1-\gamma}{2}}(\tau), 2\hat{\beta}(\tau) - \hat{\beta}^*_{\frac{\gamma}{2}}(\tau)\right), \tag{3.11}$$

where $\hat{\beta}(\tau)$ is the coefficient estimated by the initial quantile regression model, γ corresponds to the confidence level and $\hat{\beta}^*_p$ represents the p-th quantile of the bootstrapped empirical distribution of coefficients. For the purpose of the study, confidence intervals corresponding to the 99%, 95%, and 90% confidence levels were chosen. If the spread between upper and lower confidence intervals did not contain zero, statistical significance of the coefficient was assumed.

3.3 Fitting a Skewed t-Distribution to the Empirical Distribution

In the previous step, β coefficients were estimated, which allowed the construction of the full empirical quantile function of future capital flows. However, as reported by Norimasa et al. (2021), the estimates obtained do not necessarily satisfy the monotonicity condition and the empirical probability distribution obtained may not be sufficiently smoothed and thus easily interpretable. While continuing to apply the methodology outlined by Adrian et al. (2019), in order to address these issues the empirical quantile function was fitted to a skewed t-distribution.

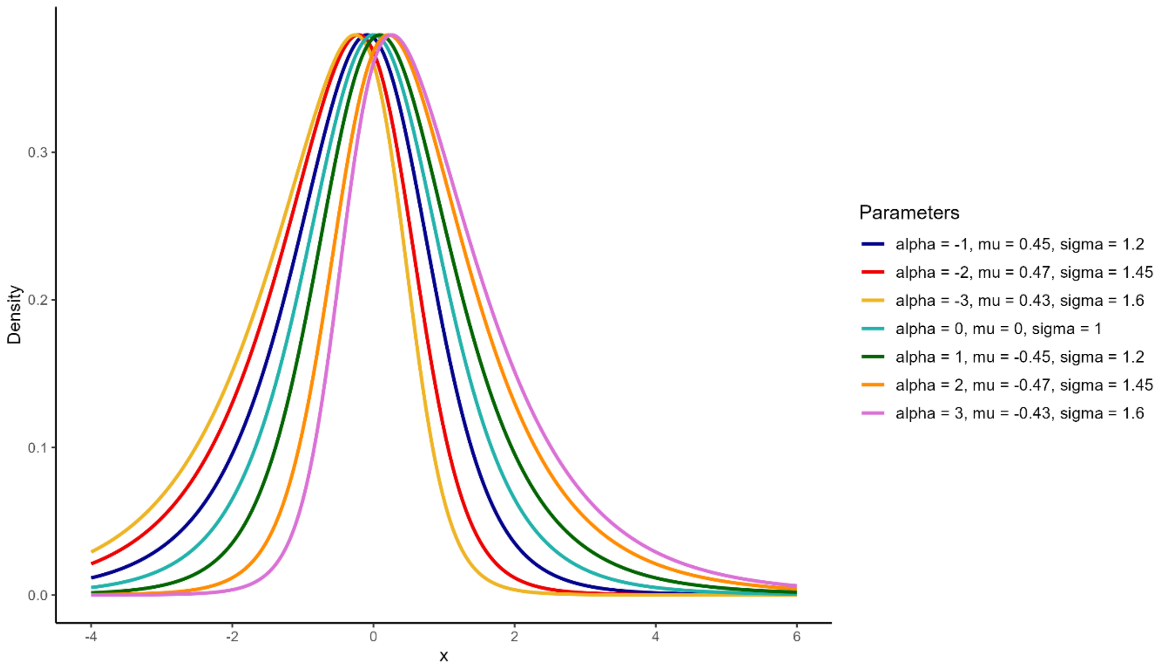
A skew t-distribution is an extended version of the classical t-distribution that makes it possible to model an asymptotically heavy-tailed distribution. The properties allow to remain generally neutral with respect to the shape of the distribution of future flows. Adrian et al. (2019) summarizes the findings formulated by Azzalini and Capitanio (2003) on the probability density of the skew t-distribution as follows:

$$f(y; \mu, \sigma, \alpha, v) = \frac{2}{\sigma} t\left(\frac{y-\mu}{\sigma}; v\right) T\left(\alpha \frac{y-\mu}{\sigma} \sqrt{\frac{v+1}{v+\frac{y-\mu}{\sigma}}}; v+1\right), \tag{3.12}$$

where the location (μ), scale (σ), shape (α) and degrees of freedom (v) represent the four parameters that characterize the distribution. Here *t* represents the PDF ,whereas *T* is the CDF of Student's t-distribution.

As shown in Figure 8, the skewed t-distribution is a flexible function, with both the normal and standard t-distributions being special cases of this distribution as Azzalini and Capitanio (2003) pointed out. The skew t-distribution converts to the standard t-distribution when the skew parameter α is equal to zero. Moreover, the skew t-distribution further reduces to normal distribution when $v \to \infty$.

Figure 8 - PDFs of Skewed t-Distribution for Various Parameters



Note: Parameter v was se to 5.

Source: Author-created visualization using R Studio

The algorithm presented by Azzalini (2023) was used to estimate the individual parameters of the smoothed quantile function. The algorithm is based on an optimization function where the chosen parameters are obtained by finding the minimum of the squared distance between the estimated and the quantile function of the skewed t-distribution. Azzalini (2023) describes this optimization problem as:

$$\{\hat{\mu}, \hat{\sigma}, \hat{\alpha}, \hat{v}\} = arg \min_{\mu,\sigma,\alpha,v} \sum_{\tau} \left(\hat{Q}(\tau|x_t) - F^{-1}(\tau; \mu, \sigma, \alpha, v)\right)^2, \qquad (3.13)$$

where $\hat{\mu}, \hat{\sigma}, \hat{\alpha}, \hat{v}$ are the estimated parameters of the skewed t-distribution quantile function and μ, σ, α, v are the parameters of the empirical quantile function resulting from the quantile regression. The resulting estimated quantile function is sensitive to selection of the fitted quantiles. In this methodology, estimation was based on quantiles selected at every decile.[5]

[5] Unlike the methodology used by Adrian et al. (2019), which incorporated the 5th, 25th, 75th, and 95th quantiles to fit the skewed t-distribution, this analysis deviates from that approach due to the smaller

3.4 Capital Flows at Risk Framework

The Capital Flows at Risk (CFaR) framework, introduced by Gelos et al. (2019), provides a forward-looking approach to monitoring and forecasting the probability of tail events in capital flows. By focusing on the risks of sudden surges or stops in the movement of international capital, the framework captures how current global and local conditions influence the likelihood of extreme outflows or inflows. Unlike traditional measures that concentrate on average outcomes, CFaR emphasizes the distributional characteristics of capital flows, offering deeper insights into potential extreme scenarios (Gelos et al., 2019).

The CFaR methodology extends beyond the scope of conventional Value at Risk (VaR) measures, which are commonly used in finance for quantifying potential losses within a given confidence interval. Similar to VaR, CFaR also targets the tail quantiles of the probability distribution, revealing the likelihood of severe inflows or outflows. This approach expands on the standard risk indicators, enabling policymakers to assess scenarios in which capital movements may deviate significantly from historical norms. The CFaR at the γ level is then defined as the γ-th quantile of the fitted distribution:

$$CFaR_{\gamma} = F^{-1}(\gamma; \mu, \sigma, \alpha, \nu). \tag{3.14}$$

The value of $CFaR_{\gamma}$ thus represents the maximum expected capital outflow from analysed country, resp. inflow to analysed country that will not be exceeded with probability $1 - \gamma$.

As Gelos et al. (2019) note, several approaches exist for the interpretation of CFaR framework. One strategy is to estimate the probability that capital flows reach a selected threshold as mentioned above. For example, the probability that capital flows become negative, indicating capital outflows, corresponds to the portion of the probability density function to the left of zero. Another application involves quantifying the magnitude of capital flows at specified quantiles, the tail 5th, 10th, 90th, and 95th percentiles, then the discussion focuses on conditional CFaR (cCFaR).

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sample size. As a result, the focus was shifted toward quantiles closer to the centre of the distribution, avoiding the 5th and 95th quantiles to ensure a more robust fit.

Conditional Value at Risk, also known as Expected Shortfall in the risk management literature, represents the expected value of the variable of interest (in this case, capital flows) given that it has already breached the VaR threshold. Applied to capital flows, cCFaR measures the expected magnitude of capital outflows beyond the CFaR level:

$$cCFaR_{\gamma} = E[y|y \leq CFaR_{\gamma}] \qquad (3.15)$$

The probability density derived from the preceding steps provides a foundation for applying the CFaR framework, enabling a comprehensive assessment of potential risks and extreme scenarios associated with capital movements.

3.5 Shock Scenarios

Further following the method outlined in Norimasa et al. (2021) the shock scenarios are constructed by consecutively adjusting each global explanatory variable by one standard deviation, while keeping all other explanatory variables constant at their mean values across the entire observed sample.

4 Data Sources and Variable Definition

This study examined gross non-resident capital flows focusing on the global and domestic factors that influenced foreign investors' motivation to invest in the Czech Republic, as outlined by Forbes and Warnock (2012). The analysis concentrated on debt flows, defined as the sum of debt portfolio investments and other investments recorded on the liability side of the BoP financial account. Foreign direct investment flows were excluded due to their unique characteristics and the different factors driving them.[6]

4.1 Target Variable

The dataset covering quarterly gross flows of debt non-resident capital to or from the Czech Republic from 2004 Q1 to 2024 Q3 was sourced from the publicly accessible database ARAD maintained by the Czech National Bank. To ensure comparability, the flows were scaled using nominal domestic GDP obtained from the Czech Statistical Office. As Koepke (2018) notes, scaling by local GDP helps adjust for differences in economic size and growth but only shows strong effects when capital inflows grow much faster or slower than GDP. Nevertheless, this method is used commonly used in the literature despite its limitations.

Figure 9 - Summary Statistics of Capital Flows as % of GDP

Mean	Median	SD	Min	Max	Count
3.45	2.08	10.29	-10.75	83.09	83

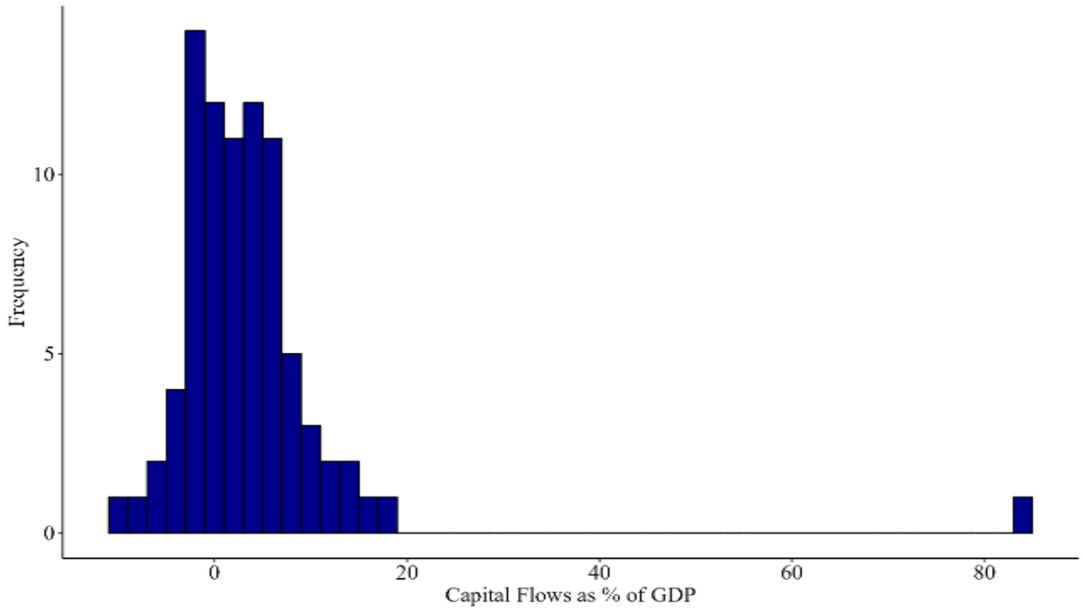
Source: Author´s calculation

Figure 9 presents summary statistics for the capital flows as a percentage of nominal GDP, showing a mean of 3.45 % and a median of 2.08 % across 83 quarterly observations. The difference between the mean and median highlights the skewness in the distribution of capital flows. The histogram in Figure 10 highlights the skewed distribution of capital

[6] A detailed explanation of the reasons for analysing non-resident capital flows in their gross form while excluding FDIs is provided in Chapter 1.

flows. Most observations are clustered near zero, with a left tail reflecting modest outflows, while heavier right tail is driven by occasional large inflows.

Figure 10 - Histogram of Selected Capital Flows

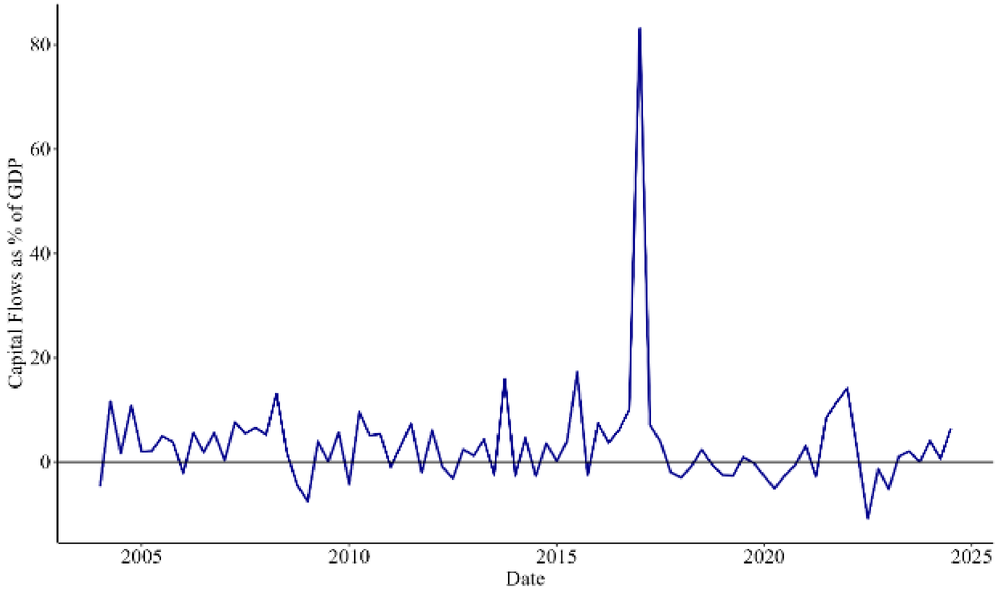


Source: Author-created visualization using R Studio, ARAD Database

Figure 11 reveals variability of selected debt capital flows of the Czech Republic marked by occasional surges or retrenchments. The minimum of –10.75 % occurred in Q3 2022, while the maximum was recorded in Q1 2017, when inflows of speculative foreign capital into the Czech Republic surged in expectation of the currency floor removal, driving inflows above 80 % of GDP.[7] This extreme value was removed from the dataset. The stationarity of the time series for the target variable was confirmed using the ADF test.

[7] More details about capital flows during the FX floor period can be found in Chapter 2.

Figure 11 - Historical Development of Non-Resident Debt Capital Flows to the Czech Republic



Source: Author-created visualization using R Studio, ARAD Database

4.2 Explanatory Variables

As Koepke (2018) points out, there is a wide range of explanatory variables that can be used to model capital inflows and outflows. As discussed in Chapter 2, the Czech Republic holds a unique position among EMEs due to its deep integration with European economies. Given that two push drivers and two pull drivers were selected that can be linked to the decision-making processes of European investors:

- V2X Index (labelled as V2X), also known as the VSTOXX Index, is derived from the option prices on the EURO STOXX 50 and captures market expectations of short and long term volatility by calculating the square root of the implied variance across options with specific expiration periods. It serves as a proxy for investors' risk aversion in Europe and is calculated as a quarterly average derived from daily data sourced from Bloomberg. The anticipated relationship suggests that an increase in risk aversion will reduce capital inflows, causing both tails of the distribution to shift further into negative territory. This shift indicates a greater likelihood of outflows and a decrease in inflows.

- ECB’s monetary policy stance (labelled as ECB_rate_QoQ_diff) is proxied by quarter-over-quarter changes in the quarterly averages of key policy rate. The deposit facility rate, set by the European Central Bank, was retrieved from the ECB database. The differences in the ECB’s rate indicate shifts in the monetary policy stance. When monetary policy tightens, reducing global liquidity, it often leads to higher borrowing costs within the Eurozone. This can attract international capital to euro-denominated assets, thereby decreasing capital inflows to the Czech Republic.

- Year-over-year real GDP growth (labelled as GDP_growth_CZ) measures the economic performance of the Czech Republic. Strong GDP growth suggests robust economic conditions and can attract foreign investors seeking stable and growing markets, thus resulting in capital inflows. Conversely, slower growth or signs of an economic downturn signal higher risk and uncertainty, which may lead global investors to reduce or withdraw their capital.

- Term spread in the Czech Republic (labelled as TERM_CZ) was calculated as a quarterly average of the daily differences between long-term (10-year) and short-term (3-month) government interest rates sourced from Bloomberg. This spread shows the steepness of the yield curve and gives an indirect view of market expectations for future economic conditions and monetary policy. A wider, positive spread usually signals stronger growth expectations and can attract more capital inflows as investors expect better long-term returns. On the other hand, a narrowing or negative spread suggests weaker growth or higher uncertainty, which can reduce investor interest and lead to outflows of non-resident capital from the Czech Republic.

A range of additional explanatory variables was also considered, such as the interest rate differential (3M PRIBOR – 3M EURIBOR) and the growth differential between the Czech Republic and the Eurozone. However, no satisfactory results were obtained.[8] Furthermore, only four indicators were ultimately selected, given the limited number of observations. Unlike other studies, this analysis did not include country-specific

[8] As mentioned in Chapter 1, differential variables within this framework can sometimes be misleading.

characteristics such as financial account openness, institutional and legal system quality, levels of corruption, geographic proximity or the health of the banking sector. These factors were excluded because they change slowly over time and are less relevant for shorter term country-level analysis.

Figure 12 - Summary Statistics of Explanatory Variables

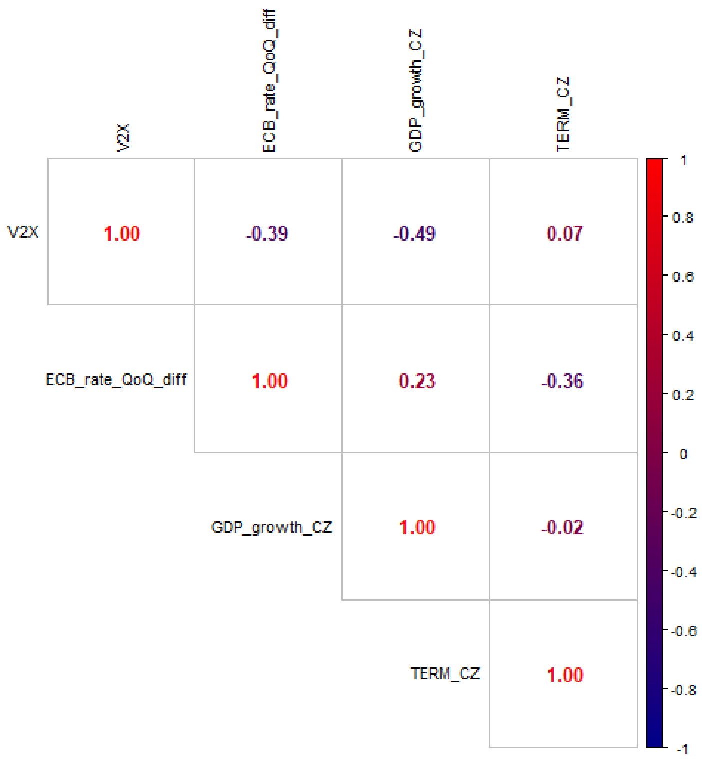
Country	Mean	Median	SD	Min	Max	Count
V2X	21.77	19.96	7.54	12.87	58.34	85
ECB_rate_QoQ_diff [p.p.]	0.02	0.00	0.33	-1.69	1.30	85
GDP_growth_CZ [%]	2.33	2.70	3.44	-10.60	9.70	83
TERM_CZ [p.p.]	1.23	1.36	0.99	-1.27	3.04	85

Source: Author´s calculation

An examination of the summary statistics for selected push and pull factors in Figure 12 reveals that the V2X index reflects moderately high market volatility expectations in Europe within the observed sample. The mean of 21.77 suggests typical levels, while occasional spikes highlight periods of increased as evidenced by a standard deviation of 7.54. Quarterly changes in the ECB policy rate show relatively steady monetary policy stance, as can be seen in Figure 14, with a median of 0. However, notable adjustments are evident, ranging from a minimum of –1.69 to a maximum of 1.30. Real GDP growth in the Czech Republic reflects moderate average growth, while standard deviation of 3.44 captures significant variability, including severe contractions at –10.60 % and strong expansions up to 9.70 %. The Czech term spread typically represents a positively sloped yield curve, with moderate variability in growth and interest rate expectations.

Figure 13 shows the correlation matrix between the covariates. A correlation cutoff of ±80% was applied, but none of the variables exceeded this threshold. Multicollinearity was also assessed using the Variance Inflation Factor (VIF), which indicated no issues with multicollinearity. Although, the V2X index has a moderate negative correlation with ECB_rate_QoQ_diff (– 39 %), suggesting that periods of higher market volatility are often associated with smaller or more accommodative changes in the ECB policy rate. Similarly, V2X is negatively correlated with GDP_growth_CZ (– 49 %), indicating that higher perceived market uncertainty typically aligns with weaker economic growth in the Czech Republic.

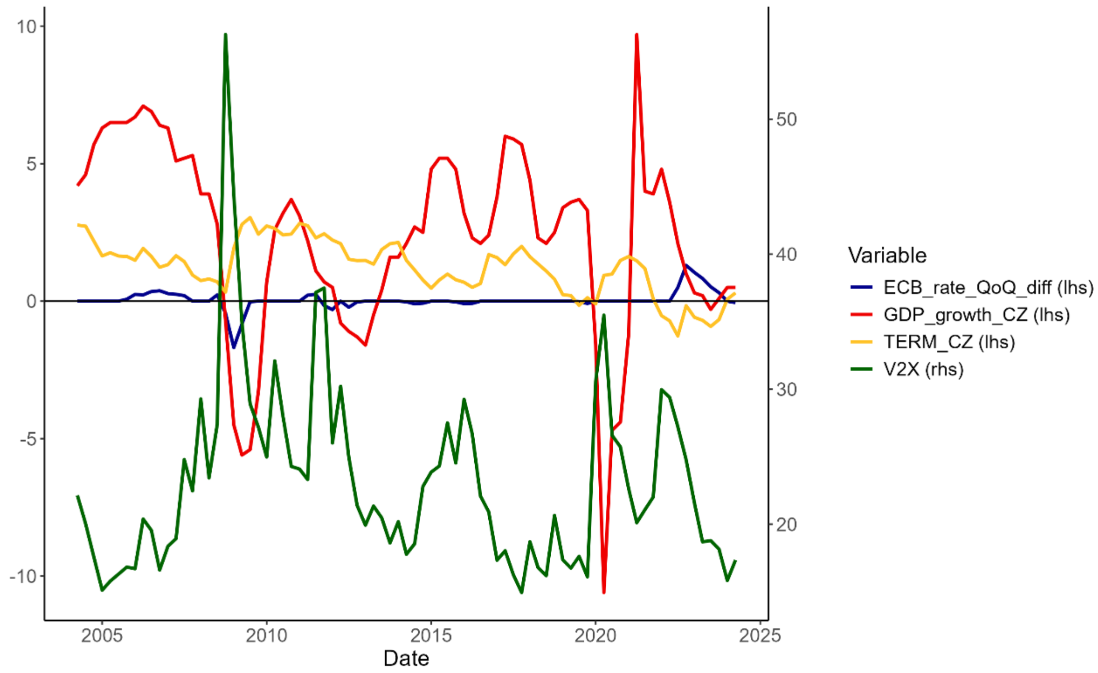
Figure 13 - Correlation Matrix of Explanatory Variables



Source: Author-created visualization using R Studio, ARAD Database

Despite the Augmented Dickey–Fuller (ADF) test indicating that the chosen explanatory variables are non-stationary (except for TERM_CZ), unlike the dependent variable, which is stationary, the methodology employed in this thesis does not strictly require their stationarity. The graphical analysis in Figure 14 indicates that these variables do not exhibit pronounced trends. This outcome may be influenced by the fact that the analysed time series spans a 20-year period, during which structural changes may have occurred, potentially violating the assumption of a constant mean. Additionally, quantile regression, unlike OLS, effectively addresses heteroscedasticity due to its different definition of the optimization function. This approach aligns with the methodology of other studies upon which this thesis is based.

Figure 14 - Time Series of Explanatory Variables



Source: Author-created visualization using R Studio, ARAD Database

4.3 Determination of Horizons

Two distinct time horizons were selected. Unlike the existing literature, which often defined short-term horizons as the average capital flows over the next two quarters and medium-term horizons as the average flows in the 5th to 8th quarters after the current observation (e.g., Gelos et al., 2019), this study took a different approach. The short-term horizon was defined as the immediate reaction of capital flows to changes in push and pull factors, focusing solely on the next quarter, as suggested by Norimasa et al. (2021). The medium-term horizon was also shorter compared to previous studies, which often examined structural characteristics of economies over longer periods. Since this analysis did not account for such characteristics, the medium-term horizon was limited to the average flows in the 1st to 3rd quarters following the current observation.

5 Results Interpretation and Scenario Analysis

This chapter begins by evaluating the quantile regression estimates for non-resident debt capital flows to and from the Czech Republic. Next, the properties of the fitted skewed t-distribution for future capital flows are visually represented using the probability density function. Following this, the chapter explores how changes in each of the selected drivers of capital flows influence the estimated probabilities of capital flows within the given horizon. Finally, several examples demonstrate the use of CFaR as a monitoring tool.

Let $\overline{Flow}_{t+1:t+h}$ denote the future capital flows to the Czech Republic in the following quarters $t + 1$ to $t + h$, where t stands for the present observation. The form of the applied quantile regression was chosen as follows:

$$Q(\tau; \overline{Flow}_{t+1:t+h}) = \beta_0^\tau + \beta_1^\tau V2X_t + \beta_2^\tau ECB\_rate\_QoQ\_diff_t + \beta_3^\tau GDP\_growth\_CZ_t + \beta_4^\tau TERM\_CZ_t + \epsilon. \quad (5.1)$$

The superscript τ denotes the quantile at which the regression was conducted. The regression estimates the quantile $Q(\tau; \overline{Flow}_{t+1:t+h})$ conditional on the set of covariates. In this thesis, the medium horizon was defined as the average capital flows spanning from 1st to 3rd quarters following the current observation (h = 3), while the short horizon represents the immediate response of capital flows to changing global and domestic conditions (h = 1). The quantile regression was performed for 10th, 20th, 30th, up to 90th quantiles.

5.1 Short Horizon

5.1.1 Quantile Regression Results

The results of the quantile regression illustrated in Figure 15 for the short horizon are statistically robust across several estimated quantiles. These findings reveal significant asymmetries in the factors influencing cross-border capital flows at different points of the distribution.

Figure 15 - Results of Quantile Regression for the Short Horizon

	Variable	10	20	30	40	50	60	70	80	90
1	Intercept	-1.7587	-2.0075	2.8344**	1.6446	-1.0344	0.2843	1.7248	7.5142**	0.9706
2	V2X	-0.1069	-0.1032	-0.1999***	-0.0824	0.0541	0.0463	0.0099	-0.1183	0.3064
3	ECB_rate_QoQ_diff	-0.628	-0.5768	-2.4752*	-1.0479	1.5529	-0.0351	0.003	-3.4056*	-5.0361
4	GDP_growth_CZ	0.0219	0.207	0.0656	0.1616	0.4339*	0.4491***	0.2664	0.2681	0.8314**
5	TERM_CZ	0.7002	1.2588**	0.8828	0.4604	1.2302*	1.0086	1.565***	0.9508	0.1487

Note: ***, ** and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

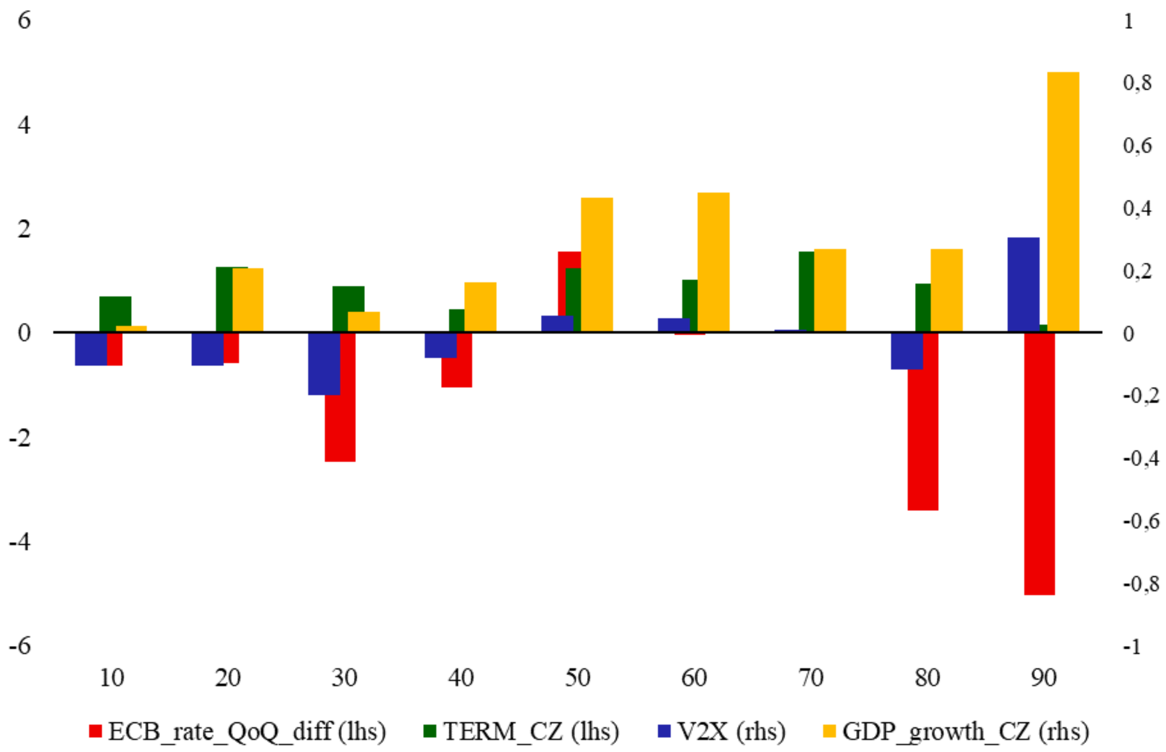
Source: Author's calculations, R Studio

The intercept is negative at low quantiles, suggesting that when all other factors are kept at their baseline levels, capital flows tend to lean toward outflows at the lower end of the distribution. At higher quantiles, however, the intercept becomes statistically significant and positive.

The estimated coefficients for European risk aversion (V2X) are largely negative across the lower quantiles, with statistical significance near the 30th quantile. This pattern aligns with economic theory, indicating that during periods of heightened volatility, weaker inflows to the Czech Republic tend to decline further. Elevated risk aversion disproportionately impacts the lower and upper tails of capital flows, as illustrated in Figure 16. At higher quantiles, where capital inflows are more sizable, the influence of market volatility diminishes. This may suggest that higher level inflows are either more resilient to temporary volatility or are influenced more by broader macroeconomic factors in such scenarios.

The monetary policy stance of the ECB shows negative and statistically significant effects at both the lower and higher quantiles, though the direction of the impact varies at some midpoints in the distribution. Specifically, ECB rate hikes relate to the reduced inflows to the Czech Republic across both outer parts of the distribution. This is in line with the expected behaviour that when euro-denominated assets become more attractive, the capital is being reallocated away from EMEs, which can intensify outflows or limit the potential for large capital inflows into the Czech Republic.

Figure 16 - Coefficient Estimates by Percentile for the Short Horizon



Note: The horizontal axis represents the percentiles, while the vertical axes indicate the magnitude of the estimated regression coefficients.

Source: Author's calculations, MS Excel

Moving to the pull factors, the coefficients for GDP growth in the Czech Republic are positive across all quantiles and become statistically significant at the median and higher quantiles, including 60th and 90th quantiles. This suggests a strong correlation between economic growth and increased capital inflows, aligning with the established view that that better macro-fundamentals attract foreign capital. The significance at these quantiles highlights that as GDP growth improves, moderate-to-high levels of capital inflows are particularly sensitive to this trend. In other words, robust growth not only mitigates the risk of capital outflows but also supports the maintenance of substantial inflows.

The immediate reaction of capital flows to the last selected variable, the term spread in the Czech Republic, is uniformly positive across all quantiles with significance concentrated around the 20th, 50th and 70th quantiles. Even in the lower tail, a positive slope can mitigate outflows, although the relationship is not statistically robust. This reflects the notion that steeper term spread, reflecting higher long-term relative to short-term yield, often signals optimism about future growth and looser monetary-policy expectations in the short run, encouraging carry-trade inflows or longer-term investments in the Czech market.

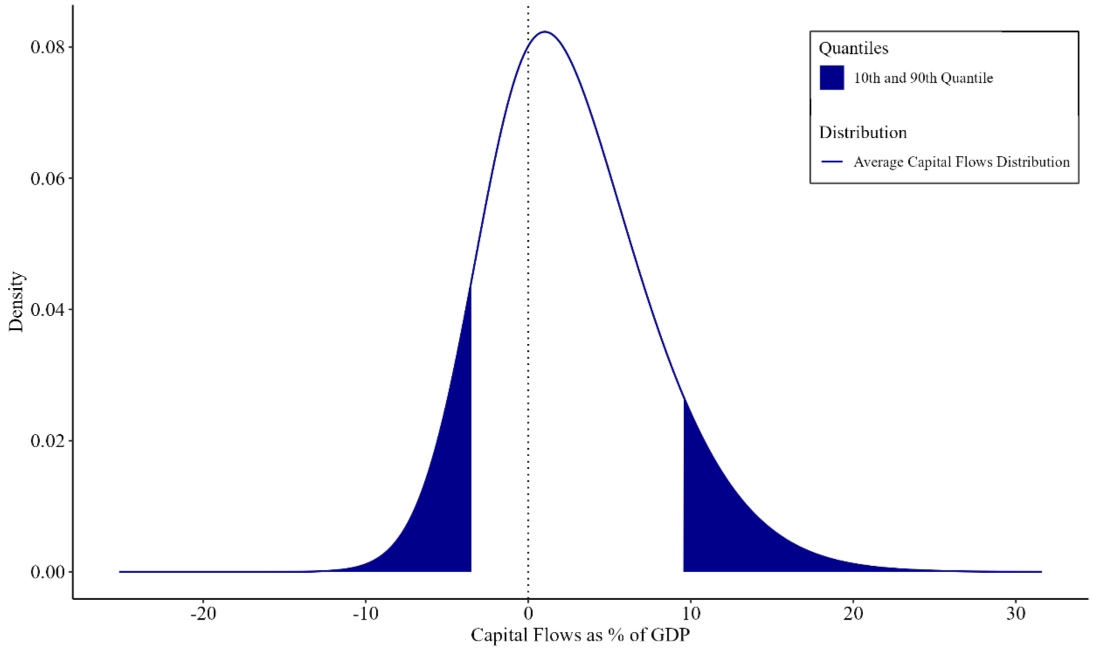
The quantile regression analysis underscores the non-linear and heterogeneous effects of selected push and pull factors. Analysed push drivers have particularly strong effects at the tails, implying that in the short horizon external shocks matter most when flows are either unusually low or unusually high. On the other hand, pull factors gain prominence toward the middle and upper range of flows, suggesting that local growth and slope of the yield curve drive capital inflows more strongly when flows are already moderate to high.

5.1.2 Fitted Probability Distribution of Capital Flows

Figure 17 presents the approximated probability distribution of average future capital flows to the Czech Republic over the next quarter, expressed as a percentage of GDP. This distribution illustrates the range and likelihood of potential inflows and outflows. The previously presented estimated coefficients were applied to historical averages of all covariates and a skewed t-distribution was fitted to the resulting empirical quantiles. The comparison between these empirical quantiles, derived from the quantile regression, and the fitted skewed t-distribution, optimized by minimizing the squared distance, is visualized in Figure 18.

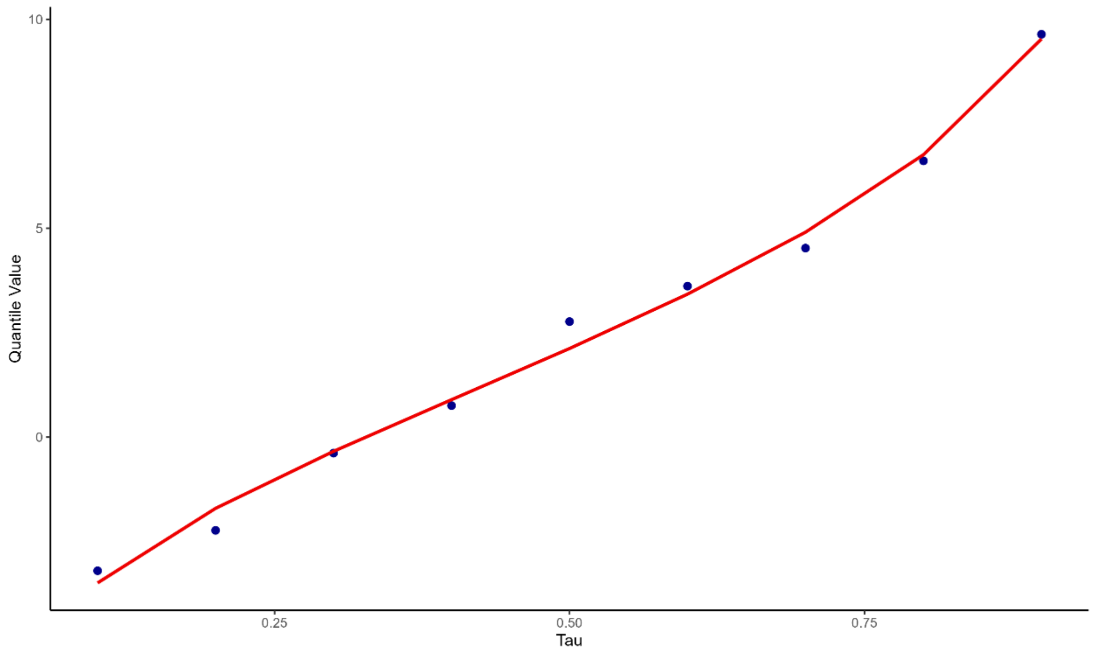
The distributional characteristics of the estimated probability distribution reveal a peak near zero, indicating that under many short-term conditions, the Czech Republic typically experiences mild inflows on average. However, the distribution exhibits pronounced tails, particularly extending to the right. The skewness parameter, $\alpha = 2.19$, confirms this right-skew, suggesting that observations above the mean are more likely to be extreme compared to those below. The degrees of freedom parameter, $\nu = 47.60$, indicates relatively thin tails, but still heavier than a normal distribution. Overall, the fitted parameters of skewed t-distribution describe a distribution widely dispersed ($\sigma = 7.32$), moderately right-skewed and featuring tails that are heavier than a normal distribution.

Figure 17 - Approximated Probability Distribution for Average Flows for the Short Horizon



Source: Author's calculations, R Studio

Figure 18- Validation of the Fitted Skewed t-Distribution for the Short Horizon



Source: Author's calculations, R Studio

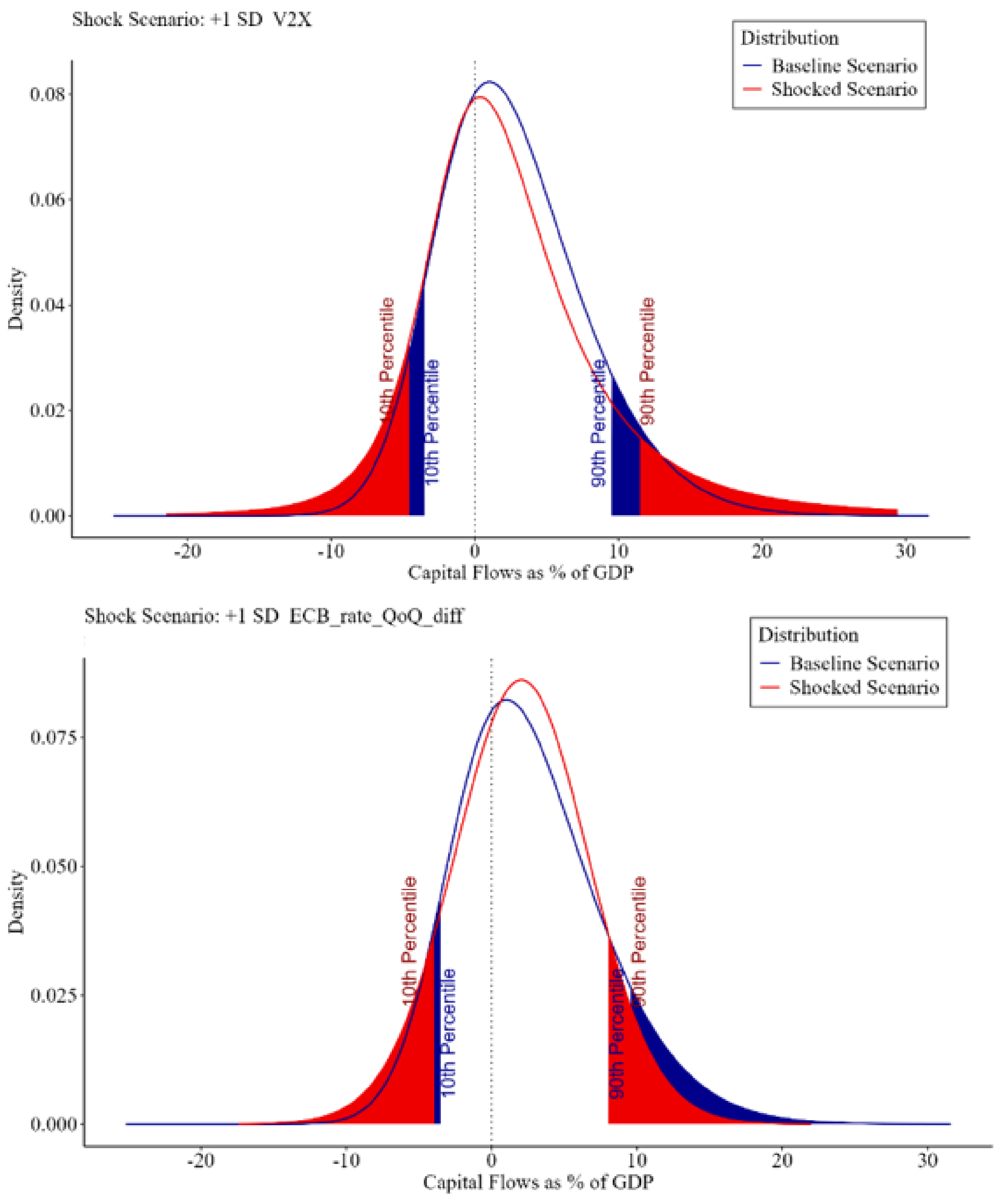
5.1.3 Exogenous Shock Scenarios

The CFaR framework facilitates scenario analysis by combining estimates from quantile regressions with a skewed t-distribution fitted to average capital flows. This approach illustrates how the short-term forecast for non-resident debt capital flows might respond to a sharp rise in global risk aversion or ECB rate hike, each represented by an increase in their respective standard deviations.

Figure 19 illustrates that a one standard-deviation increase in the V2X index shifts the capital flow distribution further into negative territory, with the 10th percentile dropping deeper into outflow territory, indicating more severe outflows at the lower end. Contrary, the 90th percentile leans toward stronger inflows, suggesting the potential for larger inflows even in a more volatile environment. This shift shows that higher market volatility, as measured by the V2X index, not only increases the risk of outflows but also raises the chance of more pronounced inflows. Overall, the distribution tilts more toward negative outcomes and has more extreme highs and lows, highlighting the greater uncertainty and extremes in capital flow behaviour.

A positive one-standard-deviation increase in the quarter-over-quarter ECB rate change, on the other hand, shifts the mode of the distribution to the right, as shown by the red shocked curve. The 10th quantile turns slightly negative, with a fatter tail, indicating a modestly increased risk of substantial outflows. However, the right tail once again exhibits a stronger reaction. The 90th percentile contracts significantly, suggesting fewer chances for large inflows. This behaviour aligns with the notion that tighter Eurozone monetary policy reduces global liquidity while at the same time enhance the appeal of euro-denominated assets. As a result, the Czech Republic faces an increased likelihood of moderate inflows, while the potential for larger inflows is diminished, accompanied by a slightly higher risk of significant outflows.

Figure 19 - Impact of Shocked Push Factors on the Short Horizon Probability Distribution



Source: Author’s calculations, R Studio

5.2 Medium Horizon

5.2.1 Quantile Regression Results

This section discusses the medium-horizon quantile regression estimates for capital flows to the Czech Republic (Figure 20) and draws comparisons with the previously evaluated short-term results. Here the broader estimation window and the inclusion of a lagged structure reflect a medium-term perspective rather than a short-term one. The results show that the medium-horizon estimates are more often statistically significant, particularly at the tail quantiles, suggesting stronger and more consistent relationships between the explanatory variables and capital flows in risky scenarios.

Figure 20 - Results of Quantile Regression for the Medium Horizon

	Variable	10	20	30	40	50	60	70	80	90
1	Intercept	−3.1324*	−1.6799	−0.9602	−1.1637	1.9355	4.463**	6.1842***	7.7798***	8.1298***
2	V2X	−0.0204	−0.035	−0.0426	0.0014	−0.0524	−0.1002**	−0.1404***	−0.1285**	−0.1211*
3	ECB_rate_QoQ_diff	2.6404	1.6393	2.9771	2.4093	0.6923	−0.9249	−1.7435	−3.8712**	−4.3059**
4	GDP_growth_CZ	−0.2036***	−0.0372	−0.0309	0.0553	0.094	0.0727	0.1048	0.2631	0.3996***
5	TERM_CZ	1.811***	1.6246***	1.8757***	1.5717***	0.9803	0.7529	0.4841	0.279	0.4265

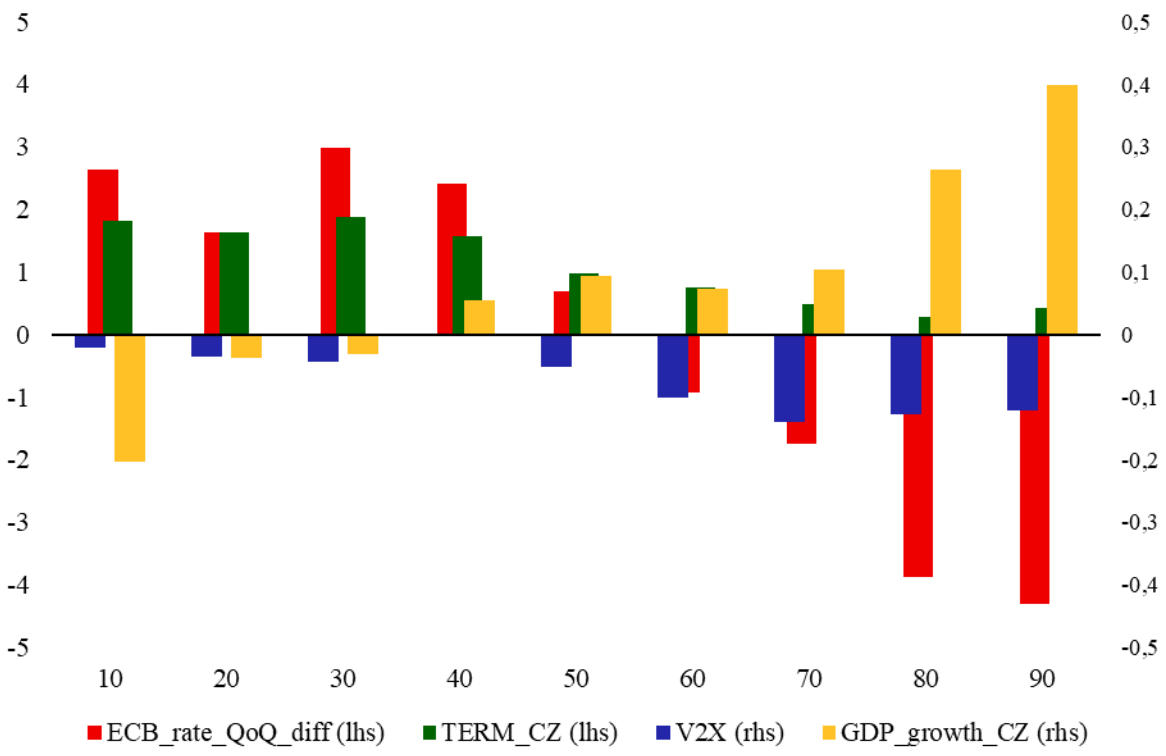
Note: ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively. Source: Author’s calculations, R Studio

Similar to the results in the short horizon, the intercept’s sign shifts from negative at the lower quantiles to positive at the higher quantiles. Over the medium term, the intercept grows larger and becomes statistically significant above the 60th percentile. This significant positive intercept in the upper quantiles indicates that, even without considering other factors, the level of capital inflows is much higher in these higher ranges.

The coefficient on risk aversion in Europe, proxied by V2X, is negative across nearly all quantiles and becomes statistically significant at many of the higher quantiles. This suggests that, in the medium term, heightened market volatility in Europe tends to reduce large capital inflows more heavily. The shift in significance from the lower quantiles, when analysing the immediate reaction, to the higher quantiles of the medium horizon indicates that initially, smaller flows may adjust quickly. But as the horizon extends, larger debt inflows to the Czech Republic become the most responsive segment, indicating investors are increasingly cautious with significant allocations when European markets show higher volatility.

Regarding the ECB's monetary policy stance the coefficient at lower quantiles is positive but lacks statistical significance. Moving to the upper quantiles the coefficient becomes increasingly negative and significant. This shift in the pattern, illustrated in Figure 21, suggests that over the medium term, tighter ECB policy may be associated with slightly higher inflows at the lower end of the distribution, but it clearly reduces inflows at the upper tail. Once flows are significant, rising ECB rates appear to deter further capital from flowing into the Czech Republic, which is consistent with the immediate response of flows in the upper tail.

Figure 21 - Coefficient Estimates by Percentile for the Medium Horizon



Note: The horizontal axis represents the percentiles, while the vertical axes indicate the magnitude of the estimated regression coefficients.

Source: Author's calculations, MS Excel

In the medium horizon domestic growth has a non-linear impact on capital flows to the Czech Republic. Unlike the short-term results, capital flows in the medium horizon react negatively on the left tail. This suggests that when flows are already low, global risk factors, such as Eurozone volatility or tight global liquidity, tend to overshadow the positive signals of domestic growth, as investors prioritize external uncertainties over local fundamentals. In such episodes of capital retrenchment, a moderate increase in domestic growth may not be sufficient to overcome prevailing risk aversion. In contrast, during the short-term horizon, investors often react quickly and uniformly to positive domestic growth signals, such as GDP releases or optimistic forecasts, resulting in a uniform positive reaction of the capital flows. Returning to the medium horizon, from 40th quantile above, the coefficients turn positive with strong statistical significance at the right tail. Thus, in more neutral to high inflow regimes, robust domestic growth acts as a strong pull factor, reinforcing the Czech Republic's attractiveness and further amplifying inflows.

Lastly, the coefficient on the Czech term spread is again positive across all quantiles, with strong statistical significance at lower quantiles, while its magnitude and significance decrease beyond the 50th quantile. This highlights the idea that a steeper yield curve has a stronger impact on encouraging inflows or limiting outflows during weaker inflow scenarios in medium term, but its influence diminishes as flows become moderate or high.

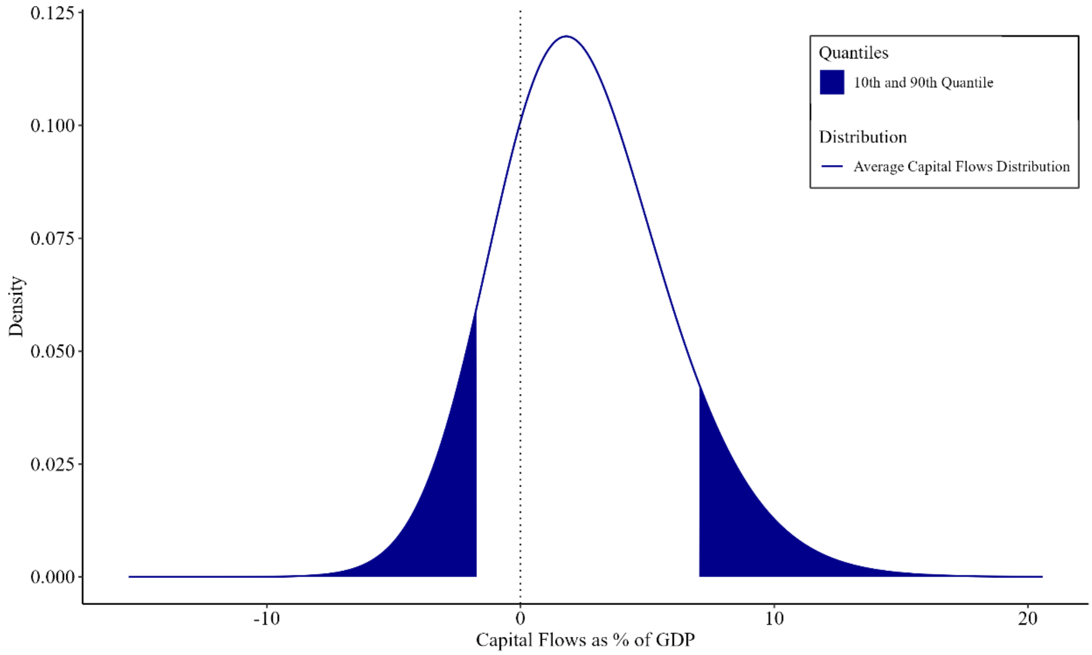
Overall, the medium horizon quantile regressions largely reinforce the key findings from the short horizon, emphasizing the significant influence of investors' risk sentiment, global liquidity, domestic growth and the yield curve slope on capital flows to or from the Czech Republic. However, differences in distributional patterns between the two horizons can be caused by the fact that while the short-horizon results capture immediate reactions to shifts in global risk and monetary policy, the medium-horizon perspective reveals how these effects develop as investors adjust their portfolios over time.

5.2.2 Fitted Probability Distribution of Capital Flows

The fitted probability distribution of average capital flows in medium horizon is in comparison to the short term horizon centred slightly more to the right, as visualized in Figure 22. The scale parameter $\sigma = 4.6$ reflects a narrower spread of the flows compared to the short-term distribution. The skewness parameter $\alpha = 1.58$ is positive, maintaining a right-skew, though less pronounced than in the previous distribution. The high degrees of freedom, v=50, result in tails closer to those of a normal distribution, although still heavier in comparison.

These findings indicate that capital flows to the Czech Republic in the following quarter are characterized by heightened volatility, with a greater likelihood of both rapid outflows and sharp inflow surges. In contrast, over the medium horizon, capital reallocation by investors tends to follow a more stable pattern, resulting in smaller average outflows and fewer instances of extreme inflow spikes.

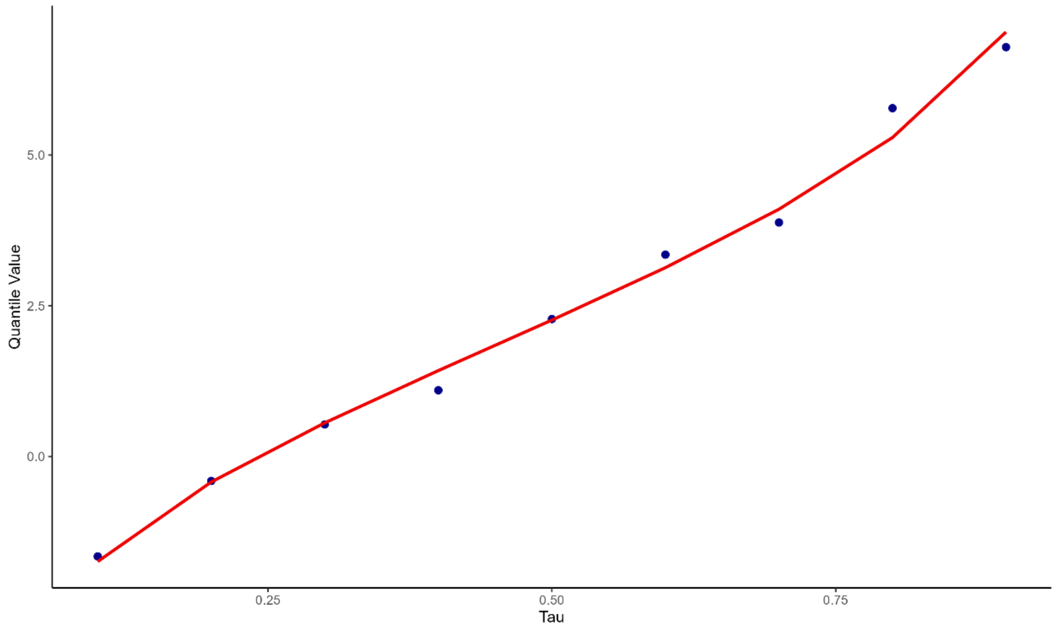
Figure 22 - Approximated Probability Distribution of Average Capital Flows in the Medium Horizon



Source: Author’s calculations, R Studio

Figure 23 illustrates the differences between the empirical quantiles obtained using the estimated coefficients from the medium-horizon quantile regression and the corresponding fitted quantiles.

Figure 23 - Validation of the Fitted Skewed t-Distribution for the Medium Horizon



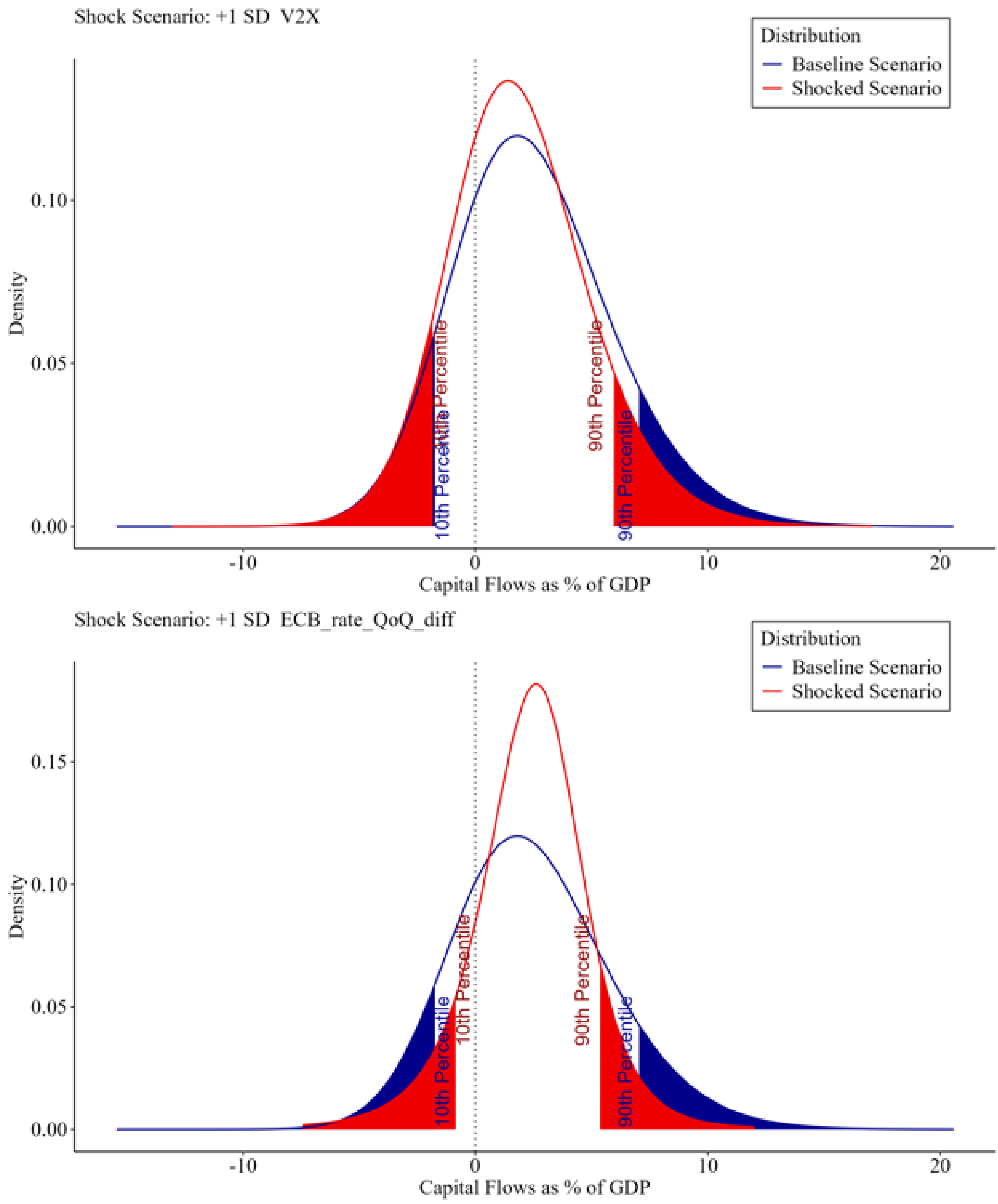
Source: Author’s calculations, R Studio

5.2.3 Exogenous Shock Scenarios

Following the same approach as in the short-term horizon, Figure 24 indicates that under the medium-horizon specification, a one standard-deviation increase in the V2X index shifts the estimated shocked distribution slightly leftward—most notably in the right tail—while leaving the 10th percentile largely unchanged. By contrast, the short-horizon scenario exhibits a more pronounced leftward shift for the same shock, reflecting greater sensitivity among short-term investors to immediate fluctuations in volatility.

In response to an external shock from tightened monetary policy in the Eurozone, the estimated distribution shows increased kurtosis and a leftward skew. Both tails move substantially closer to the centre and become thinner, resulting in a more peaked distribution. The mode shifts to the right and the overall narrowing of the distribution reduces uncertainty regarding adverse capital flow movements.

Figure 24 - Impact of Shocked Push Factors on the Medium Horizon Probability Distribution



Source: Author’s calculations, R Studio

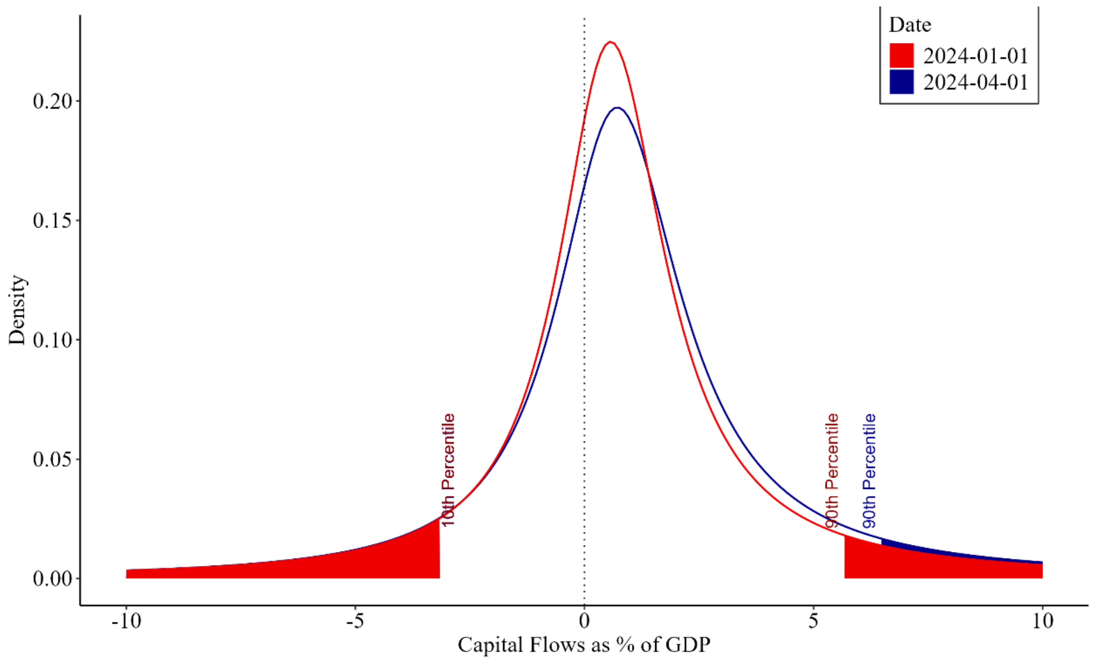
5.3 Evaluating the Framework: Short-Horizon Insights

The previous section looked at how push and pull factors affect non-resident debt capital flows. This section focuses on how well the proposed framework performs, specifically, using results from the short horizon.

5.3.1 Update of Short-Term Outlook for Non-Resident Debt Flows

Figure 25 shows how the CFaR framework can be used to track changes in the outlook for foreign debt flows to the Czech Republic quarter by quarter. The red distribution reflects the short-term outlook based on data up to 2024 Q1, projecting flows for 2024 Q2. In contrast, the blue distribution incorporates updated data as of 2024 Q2, providing a forecast for 2024 Q3.

Figure 25 – Quarterly Update of the CFaR for the Short Horizon



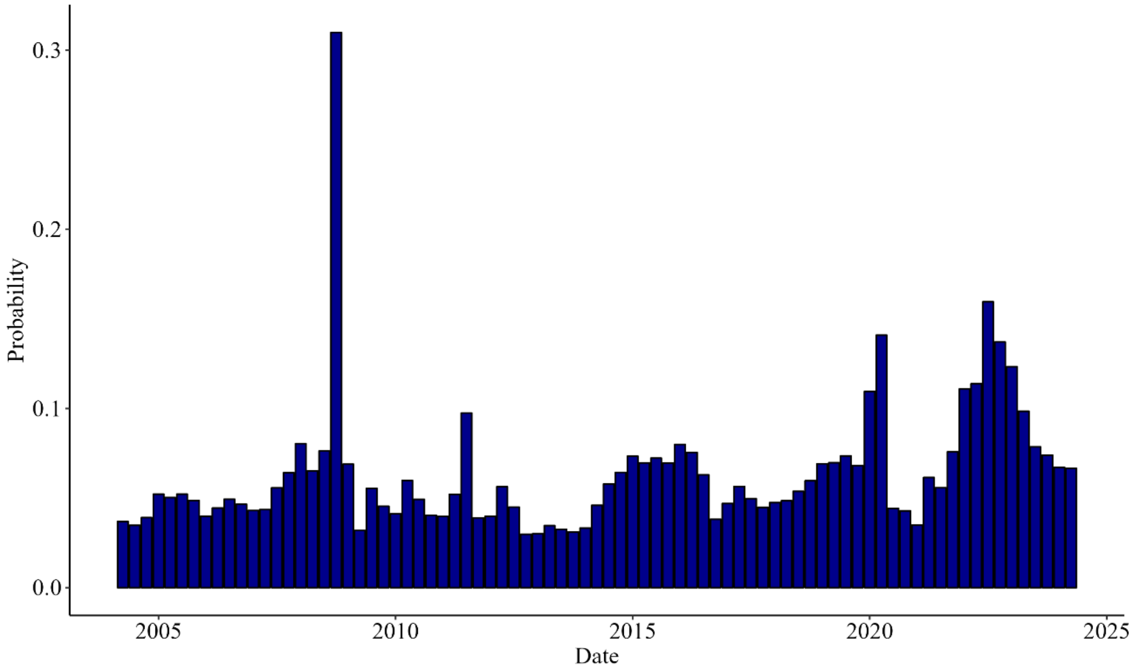
Source: Author's calculations, R Studio

The figure shows that both distributions are relatively peaked with light tails, indicating confidence in expectations for capital flows in the upcoming quarter. The shift from the red to the blue distribution reflects improved outlook for capital flows during this period. Notably, while the 10th percentile remains largely unchanged, the blue distribution's peak is slightly lower but shifted to the right, suggesting a modest increase in average inflows of non-resident debt capital to the Czech Republic. The most significant change occurs in the right tail, which has shifted further right, indicating higher probabilities of substantial inflows. This shift was primarily driven by a lower ECB monetary policy rate and a steeper yield curve in the Czech Republic, although it was partially offset by increased global risk aversion, while GDP remained stable over this period.

5.3.2 Monitoring the Probability of Capital Outflows

Another way to use this framework is to monitor the probability that capital flows will exceed a chosen threshold, whether it represents an inflow or an outflow. For illustration, a threshold of a -5% GDP capital outflow is used, representing a stress scenario for the Czech Republic.

Figure 26 - Estimated Probability of a 5% GDP Outflow in the Short Term



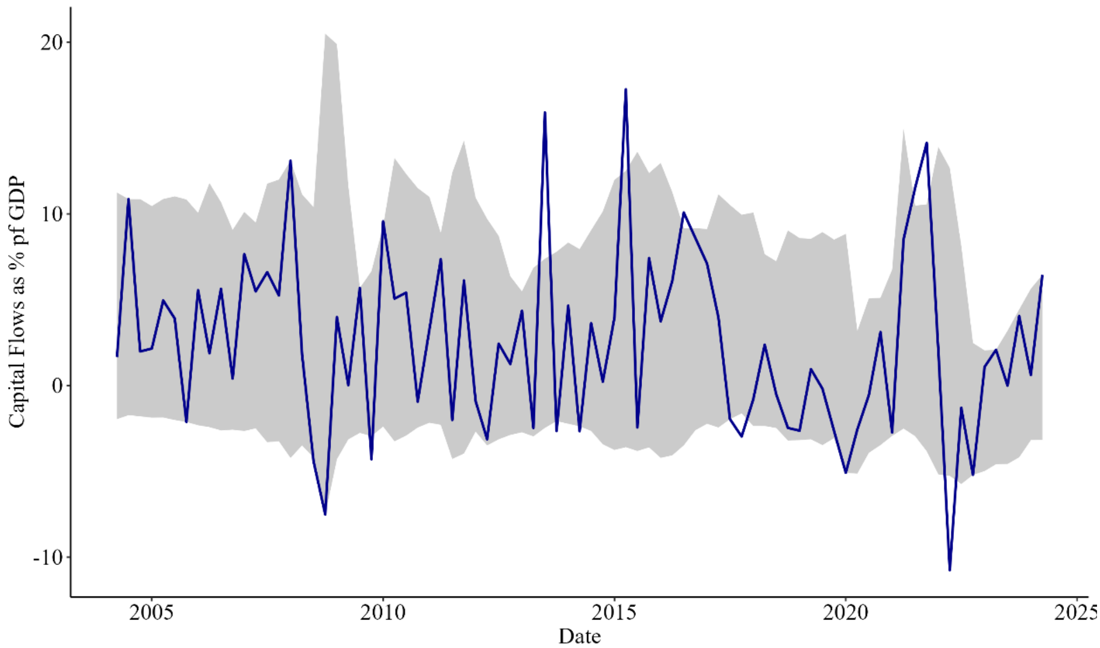
Source: Author’s calculations, R Studio

Throughout the observed period, the estimated probability of gross outflows reaching -5% of GDP in the next quarter shows sharp increases during major economic crises, as shown in Figure 26. For example, during the Global Financial Crisis, outflow risk rose above 30%, mainly due to higher global uncertainty. More recently, the chart shows spikes in outflow probability during the COVID-19 pandemic and higher levels are also seen after the start of the Ukraine conflict, when energy price shocks and increased uncertainty made investors more cautious across Europe.

5.3.3 The Performance of the Estimated Capital Flows at Risk Framework

Comparing the actual time series of capital flows, shown by the blue line, with the predicted 10th and 90th quantile bounds, represented by the grey area, provides valuable insights into the performance of the estimated CFaR in the short horizon. As shown in Figure 27, the 10th quantile effectively captures downside risks for most of the observed period. However, it deviates significantly during the aftermath of the Global Financial Crisis and the major outflow in 2022, demonstrating that the lower bound serves as a reasonable indicator of risk in most scenarios. In contrast, the 90th quantile fails to capture periods of strong inflows, such as those triggered by the currency floor policy from 2013 to 2017 and the post-COVID monetary tightening, both of which resulted in sizable inflows exceeding the model's upper quantile estimates.

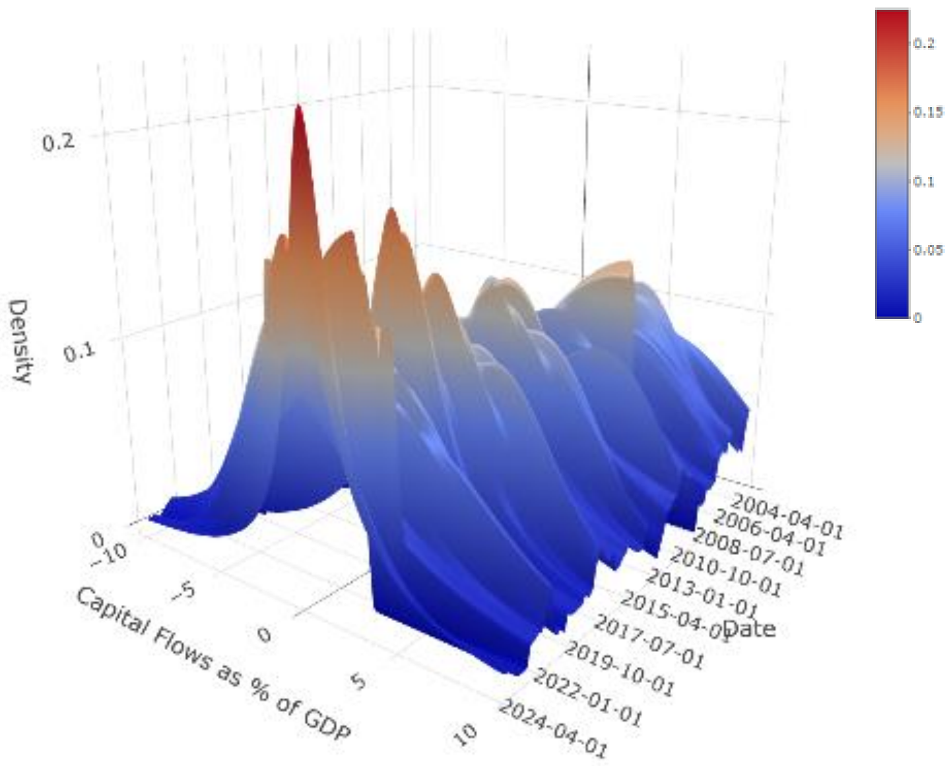
Figure 27 - Comparison of Real-Time Series with Predicted 10th and 90th Quantile Bounds for the Short Horizon



Source: Author's calculations, R Studio

Lastly, Figure 28 illustrates how the fitted probability distributions for capital flows have evolved over the past two decades, revealing notable shifts in both their shape and their central tendencies under different market conditions. At various points, the distributions have broadened and their means have shifted, reflecting changes in the likelihood of both sharp inflows and sudden outflows. Under current conditions, the most likely outcome points to relatively moderate inflows into the Czech Republic. However, during periods of pronounced capital flow volatility, the tails of the distributions expanded considerably, signalling a higher probability of extreme outcomes and an overall increase in uncertainty regarding future developments.

Figure 28 – Estimated Probability Distribution of Capital Flows Across Time



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Source: Author’s calculations, R Studio

Conclusion

The objective of this thesis was to examine the volatility of non-resident debt capital flows in the Czech Republic and analyse how global and domestic factors influence these flows, particularly during periods of stress and tail events. By employing the Capital Flows at Risk (CFaR) framework, the study modelled the entire probability distribution of future capital flows across two horizons using current domestic and global conditions. Integrating quantile regression with a skewed t-distribution fit, the analysis effectively captured distributional asymmetries and tail risks that are often overlooked by mean-focused models. The findings underscore the value of quantile-based methodologies in understanding the non-linearities in capital flows dynamics in a small open economy like the Czech Republic.

The analysis uncovered significant asymmetries in the impact of push and pull factors on non-resident debt capital flows to the Czech Republic. In the short term, external push factors such as European market volatility and shifts in ECB policy stance had a pronounced influence on the extremes of the distribution, indicating that external shocks are most impactful during periods of exceptionally low or high capital flows. In contrast, pull factors such as domestic GDP growth and the term spread became more influential in the mid-to-upper range of capital flows, suggesting that strong domestic conditions play a greater role in driving inflows when they are already at moderate to high levels.

In the medium horizon, these relationships persisted but evolved. Increased risk aversion in Europe significantly reduced inflows across the entire distribution, with smaller inflows adjusting rapidly in the short term, while larger inflows became increasingly sensitive to rising volatility over a longer horizon. Tighter ECB monetary policy showed mixed effects: lower quantiles showed minimal change or a modest increase in inflows, whereas upper quantiles experienced more pronounced and substantial decline. As inflows began to gain momentum, higher ECB rates appeared to deter additional capital from entering the Czech market. Although domestic economic growth continued to attract inflows, it proved insufficient to offset the influence of heightened external risks when flows were already low. The higher Czech term spread provided a mitigating effect against outflows at lower quantiles, though its impact diminished as inflows grew more substantial.

The fitted skewed t-distributions for both horizons confirmed that capital flows are not normally distributed and that they feature pronounced right-skewness. Scenario analyses further highlighted how an exogenous shocks can change both the position and the shape of the estimated flow distribution, underscoring the value of a quantile-based approach.

Finally, the CFaR monitoring tools, including quarterly updates of short-term forecasts and the probability of exceeding particular capital flow thresholds, demonstrated practical ways of tracking changes in risk over time. Overall, the tail-oriented CFaR framework offered valuable insights into the evolving risk profile of Czech capital flows and provided a more nuanced approach for policymakers seeking to anticipate and respond to capital flow volatility.

A key limitation of this analysis is the relatively small sample size of only 83 observations, coupled with the presence of scarce extreme capital flow movements. Larger data sample would allow for a more comprehensive set of metrics, such as policy variables, and yield a stronger foundation for the analysis. While the selected framework effectively captures variations across flow quantiles and examines distributional properties, its static approach may overlook feedback loops and the persistent effects of certain explanatory variables over time. Using more advanced methods could help provide a deeper and more detailed understanding of the capital flow dynamics.

Future research could expand the CFaR methodology in several directions. One promising possibility is to apply the CFaR framework to other types of capital flows, such as equity flows, to form a more comprehensive view of aggregate capital flow dynamics. Additionally, distinguishing flows by instrument (e.g., short-term vs. long-term, deposits vs. bonds) or by sector (bank, government, corporate) would shed light on how various segments respond to different push and pull factors. Given the limited size of the Czech dataset, a useful approach may involve conducting a panel quantile regression across similar economies, following Gelos et al. (2019) or Norimasa et al. (2021), and then applying those insights at the country level.

It would also be valuable to refine how push and pull factors are measured, for instance by using traded asset prices to capture the risk-adjusted macroeconomic outlook, as proposed by Eguren-Martin et al. (2021). This refinement, along with the exploration of multiple policy actions and their combined effects on capital flows, could deepen the understanding of global and local drivers of flow volatility.

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