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How Capital flows affect the magnitude and symmetry of Spillovers between the Triad - USA, China and Eurozone?

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1. Introduction

In today´s financial system, money moves across borders very quickly. Investors can easily shift funds from one country to another in a very short period thanks to advances in technology and the liberalization of capital markets. As a result, decisions taken in one financial center can have immediate consequences far beyond national borders.

When large institutional investors (pension funds, mutual funds, international banks…) rebalance their portfolios from one region to another, financial conditions can change simultaneously in several countries. These movements are usually described as capital flows, understood as cross-border portfolio reallocation driven by changes in risk, returns, or global financial conditions. These movements produce what the literature calls *financial spillovers*, which are the transmission of financial shocks from one economy to another through integrated markets, independently of direct changes in the affected country's domestic fundamentals.

This thesis investigates how capital flows mediate the magnitude and symmetry of financial spillovers within the Triad, consisted of the United States, the Eurozone, and China. These three economic areas collectively represent the dominant nodes of the global financial system and differ meaningfully in their institutional structure, degree of financial openness, and global influence. Examining how financial shocks travel among them, and whether this transmission is symmetric or dominated by one region, is both theoretically motivated and highly policy relevant.

The analytical focus on capital flows is grounded in the Global Financial Cycle framework developed by Hélène Rey, which argues that a common global factor, closely linked to United States monetary conditions and global risk appetite, drives synchronized movements in asset prices and gross capital flows worldwide. This framework implies that spillovers are structural features of the international financial system, that they are time-varying in nature, and that financially central economies, particularly the United States, tend to act as dominant transmitters. The empirical analysis of this thesis is designed to test whether these theoretical predictions are supported by observed capital flow dynamics within the Triad.

From this perspective, studying spillovers within the Triad is particularly relevant. These regions are deeply integrated into global financial markets and attract a substantial share of international investment. As a result, changes in financial conditions in any of these areas can influence global capital allocation and risk-taking behavior. Examining how spillovers operate among them helps to clarify the mechanisms through which financial shocks propagate in the

global system.

1.1 Financial Spillovers

Further developing the concept of spillover mentioned above, these occur when a financial event in one economy affects financial conditions elsewhere, even if there is no direct change in the affected country´s financial fundamentals. This is possible because of how they operate, through different channels, such as portfolio rebalancing, cross-border investment, or even by changing investors´ risk perception.

When investors become more risk-averse in a major financial market, they may reduce their investment in some countries and start investing in others. These portfolio reallocations can lead to changes in asset prices, borrowing costs, and financial volatility across multiple countries at the same time. Importantly, this transmission does not require a direct economic link, such as trade, but can occur purely through financial markets.

The relevance of financial spillovers has grown substantially as global capital markets have deepened and integrated. There is robust empirical evidence that periods of heightened financial stress are characterized by stronger cross-market co-movements, proving that spillovers tend to intensify precisely when financial stability is most at risk, as documented by Forbes and Rigobon (2002).

Figure 1: Global Capital Flows during the Global Financial Crisis

Source: (Fratzscher, 2012)

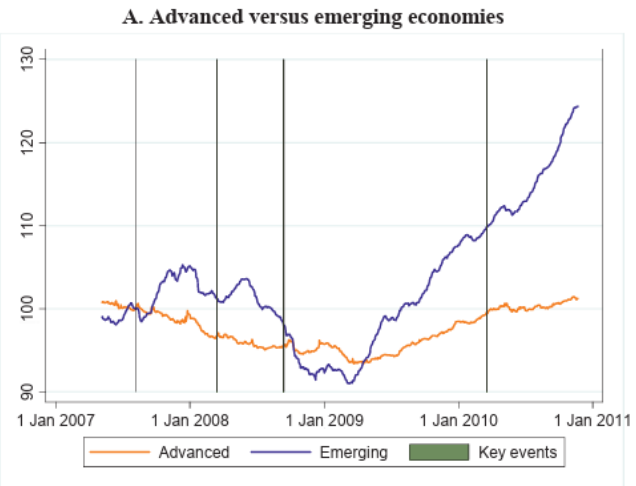


Figure 1 illustrates this relationship clearly, showing how global capital inflows collapse precisely during episodes of heightened uncertainty.

This amplification mechanism helps explain why financial crises tend to spread rapidly across borders and why global episodes of instability, such as the 2008 Great Financial Crisis or the 2020 COVID-19 shock, generate near-simultaneous deteriorations in financial conditions across a wide range of economies, as shown by Claessens, Kose and Terrones (2012).

Another relevant aspect of these financial spillovers is that they are not necessarily symmetric. Previous research has shown that shocks originating in large and financially central economies tend to have stronger international effects than shocks from smaller or less central markets. This asymmetry suggests that some countries play a more dominant role in transmitting financial conditions globally, as argued by Rey (2015).

1.2 Context of the Triad

The United States, the Eurozone, and China are commonly seen as the cornerstones of the global financial system. Collectively, they represent a significant portion of global economic output, financial market value, and cross-border capital flows. Due to their size and interconnected financial systems, changes in these regions frequently have worldwide effects.

- The **United States** holds a key position in global financial markets, being the primary provider of international liquidity and the issuer of the leading reserve currency. United States markets often serve as a reference point for investors worldwide and shifts in United States financial conditions tend to impact global risk preferences and investment choices, as documented by Rey (2015).
- The **Eurozone** represents a large and highly integrated financial area, where capital markets are closely connected across member countries. Due to its openness and financial depth, the Eurozone is particularly sensitive to changes in global financial conditions and cross-border capital flows. As a result, shocks originating outside the region can have significant effects on European financial markets.
- **China** is characterized by a financial system that remains more regulated than those of the United States and the Eurozone. Nevertheless, it has become an increasingly important participant in global finance over the last two decades. The country plays a growing role in

international investment and global portfolio decisions. Financial developments in China, specially through major regional financial hubs, can therefore totally influence international capital allocation, as noted by Claessens, Kose and Terrones (2012).

Studying these three regions together is particularly useful because they differ in terms of financial structure, market openness, and global influence. These differences allow us to analyze whether financial spillovers are symmetric across regions or whether some economies act as dominant transmitters of financial conditions. For this reason, the Triad provides an appropriate setting to study the magnitude and direction of international financial spillovers.

1.3 Research Objectives

Based on the discussion above, this project aims to analyze how financial linkages across major economies shape the transmission of shocks through international capital flows. In a highly integrated financial system, changes in investors' behavior in one region may affect financial conditions elsewhere, even in the absence of domestic shocks. Understanding this process requires focusing not only on whether spillovers exist, but also on their intensity and direction.

In this context, magnitude refers to how strong the spillover effects are. For example, it measures how much the financial conditions in China or the Eurozone change after a shock originating in the United States. This will also strike the reasons behind how small shocks in one country can cause great changes in another one.

On the other hand, symmetry refers to whether spillovers operate similarly across directions between countries, or whether shocks tend to be transmitted more strongly from certain economies than from others. Analyzing symmetry helps identify whether some regions act as dominant transmitters of financial shocks and clarifies the main transmission paths through which spillovers affect other economies. Taken into an example, how a shock in China will have a great impact in the Eurozone, but should not really happen on the contrary case.

To achieve this, the analysis is structured around three sub-objectives. The first, to establish how changes in international portfolio allocation mediate the transmission of financial shocks across the Triad, providing the capital flow foundation for the empirical analysis. Second is to measure the strength of financial spillovers among the United States, the Eurozone, and China over time, assessing how strongly a shock in one region affects capital inflows in the others. Finally, the third is to examine whether these spillovers are symmetric or whether some regions act as

dominant transmitters of financial conditions, identifying the directional structure of cross-border financial transmission within the Triad.

By focusing on both the intensity and the direction of spillovers, this analysis highlights not only whether financial links exist but also how they evolve and which regions play a central role in shaping global financial conditions.

1.4 Spillovers Changing Over Time

Since financial spillovers are not constant over time, it will be necessary to study their effects chronologically. The strength and direction of spillovers can vary depending on global financial conditions, investor behavior, and the level of uncertainty in financial markets. Periods of financial calm are usually characterized by relatively stable relationships across markets, while periods of stress often lead to stronger cross-market reactions.

One important reason for this variation is how global risk perception usually changes. When uncertainty is low, investors tend to search for higher returns and diversify their portfolios across countries. In contrast, during periods of financial stress, investors often reduce their risk exposure and rebalance their portfolios more aggressively. These shifts in behavior can intensify spillovers, as financial shocks are transmitted quicker and stronger, as explained, as explained by Forbes and Rigobon (2002).

One very important factor explaining time variation (mainly within spillovers) is the role of global financial cycles. Research suggests that global financial conditions are influenced by common factors, such as global liquidity and risk aversion. When these common factors become more dominant, financial shocks between countries tend to increase, even if domestic economic conditions remain unchanged, as further developed by Rey (2015) in section 2.4.

Empirical studies have shown that financial spillovers are particularly strong during crisis episodes. Because of this time variation, analyzing spillovers using methods that assume constant relationships may provide an incomplete picture. A framework that allows financial linkages to evolve over time is therefore better suited to capture the dynamics of international financial transmission. This insight motivates the empirical approach adopted.

1.5 Structure of the Project

Although the introduction has briefly explained the main ideas behind the cornerstones of this project, it is vital to explain how it will be assessed throughout the following chapters. Since the main idea is to prove the hypothesis of how spillovers are affected by capital flows across the Triad, the cornerstones used are the ideas emerging from the combination of taking a conceptual and literature discussion with an empirical analysis. Understanding and analyzing them both, separately and together, will feature the key answer to the main research question.

Therefore, the project will be divided into these chapters, briefly explained here:

To start the theoretical study, the **Conceptual Framework** reviews the existing literature on financial spillovers, international capital flows, and the Global Financial Cycle. The objective of this chapter is to establish the theoretical foundations that motivate empirical analysis and to explain why financial spillovers are expected to be time-varying and potentially asymmetric across countries.

Followed by the analytical research, the chapter **Data And Empirical Setting** presents the dataset used in the analysis and explains how capital flow dynamics are measured using quarterly portfolio investment inflows. It also describes the construction of the Triad dataset, the sample period, and the main characteristics and limitations of the data.

The **Methodology** chapter introduces the empirical approach adopted in the study. To capture the evolving nature of financial spillovers, the thesis employs a Time-Varying Parameter Vector Autoregression (TVP-VAR) model. The key advantage of this approach is that it allows the relationships between financial variables to change over time, rather than if spillovers remain constant. Within this framework, shocks are interpreted as unexpected changes in financial conditions in one region, and the model traces how these shocks propagate across the other regions of the Triad.

To continue and prove the hypothesis, the chapter **Empirical Results** reports the findings of the analysis. The focus is on measuring the magnitude and symmetry of spillovers between the United States, the Euro Area, and China. By examining time-varying impulse response functions, this chapter shows how strongly financial shocks are transmitted across regions and whether some economies act as dominant transmitters of financial conditions.

Finally, the Conclusions summarizes the main findings of the study and provides a clear answer to the research question. It also discusses the main limitations of the analysis and suggests possible directions for future research.

2. Conceptual Framework

This chapter establishes the theoretical foundations of the thesis and explains why capital flows are central to understanding financial spillovers among the United States, the Eurozone, and China. The key idea is that cross-border financial integration allows shocks to travel internationally not mainly through trade, but through financial channels, especially through investors' portfolio reallocations and changes in risk appetite. In this context, the relevant object is not only whether shocks spill across borders, but also how the strength and direction of transmission depend on global financial conditions.

The main theoretical framework underlying this chapter is Hélène Rey's Global Financial Cycle hypothesis. According to Rey, there is a strong global component in asset prices, credit conditions, and gross capital flows, and this global cycle is closely linked to fluctuations in global risk appetite. A central implication is that financial spillovers are expected to be time-varying and often asymmetric, with financially central economies playing a dominant role in transmitting shocks.

Building on this perspective, Miranda-Agrippino and Rey provide systematic evidence that global factors explain a substantial share of fluctuations in risky asset prices and in gross capital flows, and that these factors co-move with measures of risk appetite. Their results reinforce the view that capital flows and asset prices are jointly shaped by global forces, which helps explain why spillovers strengthen during periods of global stress.

To place these ideas in a broader macro-financial context, this chapter also draws on the work of Gourinchas on external adjustment and global imbalances. This literature emphasizes that modern international finance is characterized by large cross-border balance sheets and valuation effects, making capital flows and external financial positions key elements in the propagation of shocks across countries.

2.1 International Financial Spillovers in Literature

Financial spillovers, as previously explained, understood as the cross-border transmission of financial shocks, have been a central topic in international finance for several decades, particularly since the wave of financial crises of the 1990s. Early work in this area focused primarily on the observation that asset prices across countries tend to move together, particularly during periods of financial stress. This observation raised fundamental questions about the

mechanisms driving cross-market co-movement and about the distinction between normal financial integration and exceptional contagion.

A foundational contribution to this discussion is Forbes and Rigobon, who draw a precise conceptual distinction between these two concepts: interdependence and contagion. Interdependence refers to the normal co-movement of financial markets that arises because they are structurally linked or jointly exposed to common shocks: in this case, cross-market correlations reflect ongoing financial integration rather than any abnormal transmission. Contagion, by contrast, refers to a statistically significant increase in cross-market linkages above and beyond what would be predicted by standard interdependence, typically occurring during episodes of acute financial stress. This distinction is analytically important because it implies that spillovers are not constant: they can intensify during crises in ways that would never be fully captured by measures of average co-movement.

Miranda-Agrippino and Rey extend this framework by providing systematic empirical evidence that a single global factor explains a substantial share of the variation in both risky asset prices and gross capital flows across advanced and emerging economies. Using a large panel of financial variables, they show that this factor co-moves closely with measures of United States monetary conditions and global risk sentiment, reinforcing the view that the United States plays a structurally central role in the global transmission of financial shocks. Their findings are directly relevant to the empirical strategy of this thesis, as they motivate the use of capital flows as the primary variable through which spillovers are measured.

More broadly, the literature on international financial spillovers emphasizes two features that are particularly relevant for the present analysis. First, spillovers are time-varying: they strengthen during periods of global stress and weaken during calmer phases. Second, they are directionally asymmetric: financially central economies tend to generate stronger outward spillovers than they receive. These two features jointly motivate the use of a time-varying empirical model and justify the focus of this thesis on the magnitude and asymmetry of spillovers within the Triad.

2.2 Capital Flows as a Transmission Mechanism

A central question in the study of international financial spillovers concerns the channels

through which financial shocks are transmitted across borders. While trade linkages have historically been emphasized in international macroeconomic literature, more recent research identifies cross-border capital flows as the primary mechanism of financial transmission in a world characterized by deep financial integration. This shift reflects both theoretical advances and the empirical observation that financial crises propagate far more rapidly and broadly than trade-based transmission alone can explain.

In a financially integrated world, investors continuously reallocate their portfolios across countries in response to changes in expected returns, perceived risks, and global financial conditions. These portfolio adjustments generate capital flows that directly affect asset prices, credit spreads, and exchange rates in recipient economies. Because global investors hold diversified international portfolios, a shock in one major financial center can trigger portfolio reallocations across multiple countries simultaneously. As a result, financial conditions may change across several economies even when they have no direct bilateral financial exposure to the original source of the shock.

This transmission mechanism is formalized within the Global Financial Cycle framework. Rey argues that global financial conditions are driven by a common factor that generates synchronized movements in asset prices, credit growth, and gross capital flows across countries. This global factor is closely linked to fluctuations in global risk appetite, often proxied by the VIX, and to monetary and financial conditions in the United States. When global risk appetite declines, investors reduce their exposure to risky assets worldwide, leading to simultaneous capital flow reversals in multiple economies, as discussed by Gourinchas and Rey (2013). Conversely, periods of accommodative monetary conditions and high risk tolerance tend to be associated with large capital inflows into a wide range of markets. The empirical signature of this mechanism is a strong relationship between global capital flows and measures of global risk aversion, such as the VIX, as illustrated in Figure 2.

Figure 2: Global Capital Inflows and the VIX (Inverted)

Source: (Rey, Dilemma not Trilemma: The Global Financial Cycle and Monetary Policy Independence, 2015)

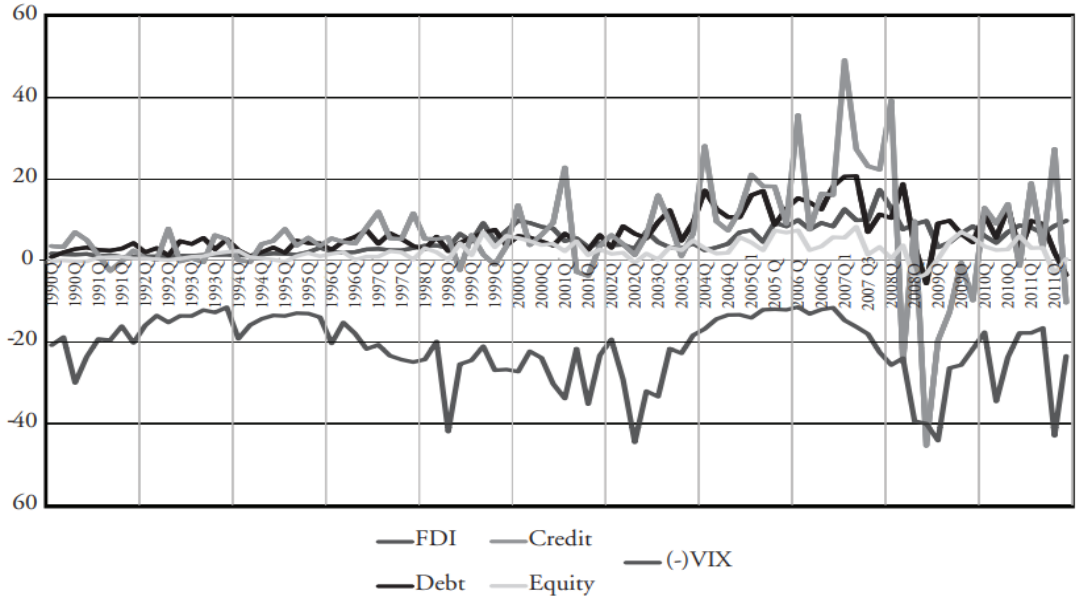


Figure 2 illustrates the relationship between the global financial factor, which is capital inflows, and the VIX, a widely used proxy for global risk aversion. Miranda-Agrippino and Rey identify a common global component driving financial conditions across countries, which closely co-moves with fluctuations in the VIX. This relationship suggests that changes in global risk appetite play a central role in shaping capital flow dynamics and in amplifying cross-border financial spillovers.

An important distinction in this literature is between gross and net capital flows. Traditional balance-of-payments analysis often focuses on net flows, which measure the difference between a country's capital inflows and outflows. However, Broner, F. shows that gross flows, which separately measure foreign purchases of domestic assets (inflows) and domestic purchases of foreign assets (outflows), are far more informative about financial integration and international transmission. Gross flows reflect active portfolio decisions and balance sheet adjustments by global investors and tend to contract simultaneously during crises, generating sharp reductions in both inflows and outflows across many countries at once.

For the purposes of this thesis, the focus on quarterly portfolio investment inflows is therefore both theoretically motivated and empirically appropriate. These flows capture the active reallocation of financial resources across the Triad and reflect the responses of global investors to changes in global financial conditions. By modelling how shocks to inflows in one

region affect inflows in the others, the empirical analysis directly engages with the capital flow transmission channel emphasized in theoretical literature.

2.3 Push and Pull Factors in International Capital Flows

A well-established strand of capital flows literature draws a conceptually important distinction between two classes of determinants: push factors and pull factors. This distinction is directly relevant to understanding the transmission mechanisms through which spillovers propagate within the Triad, and it helps clarify why some episodes of capital flow co-movement reflect global forces rather than domestic developments in recipient economies.

Push factors are external to the recipient country and originate in global or source-country conditions. The most prominent examples include the stance of monetary policy in major advanced economies, particularly the United States; the level of global risk aversion, typically proxied by the VIX; and conditions in global credit and funding markets. When push factors are dominant, capital flows to a wide range of countries move together, driven by the same external impulse. Calvo, Leiderman, and Reinhart were among the first to document this pattern systematically, showing that a large share of capital flow variation to Latin American economies in the early 1990s was explained by external conditions in the United States rather than by domestic reforms in the recipient countries. This finding has since been replicated across different time periods and regions, establishing push factors as a central driver of international capital flow cycles, as Fratzscher (2012) confirms.

Pull factors, by contrast, are internal to the recipient economy and reflect its own fundamentals: growth prospects, interest rate differentials, institutional quality, sovereign creditworthiness, and financial market depth. When pull factors dominate, capital flows are more idiosyncratic, responding to country-specific improvements or deteriorations rather than to global conditions. In practice, both push and pull factors operate simultaneously, and their relative portance varies across time and across different types of capital flows.

Table 1: Push and Pull Factors

Source: Author´s own elaboration based on Calvo and Fratzscher

Push Factors (external)	Pull Factors (internal)
US monetary policy (Fed rate)	*Domestic GDP growth*
Global risk aversion (VIX)	*Interest rate differentials*
Global liquidity conditions	*Institutional quality*
USD funding market stress	*Financial market depth*
Risk-off sentiment (flight to safety)	*Sovereign creditworthiness*

Table 1 summarizes the main push and pull factors relevant to the Triad, illustrating the distinction between global drivers and country-specific determinants of portfolio investment flows.

The distinction between push and pull factors has important implications for the analysis of spillovers. If capital flows within the Triad are predominantly driven by push factors, then a shock originating in one region, by altering global financial conditions or risk sentiment, can generate simultaneous capital flow responses in the other two regions even in the absence of any direct bilateral linkage. This is precisely the mechanism through which the Global Financial Cycle generates spillovers: a United States monetary policy tightening, for example, constitutes a push factor that simultaneously reduces capital inflows to the Eurozone and China by tightening global liquidity and raising global risk aversion. The result is a co-movement in capital flows across the Triad that reflects a common external impulse rather than a direct bilateral transmission. (Calvo, Leiderman, & Reinhart, 1993)

Fratzscher provides a comprehensive empirical assessment of push versus pull factors using a large cross-country dataset. His findings confirm that push factors, especially United States monetary conditions and global risk appetite, were the dominant drivers of capital flows during the 2008 Global Financial Crisis, while pull factors played a more important role in explaining cross-country heterogeneity during calmer periods. This result implies that the relative importance of global versus domestic drivers of capital flows is itself time-varying, consistent with the broader insight that spillovers intensify during periods of financial stress. (Fratzscher, 2012)

The push-pull framework also informs the choice of variable and empirical approach adopted in this thesis. Because push factors affect all recipient countries simultaneously, they generate correlated movements in gross inflows across the three Triad members at the same time. This synchronization would be obscured if net flows were used instead, since residents and non-residents often adjust their positions simultaneously in response to global shocks, causing inflows

and outflows to partly offset each other and compress the net signal. Gross inflows, by contrast, directly capture the external demand for domestic financial assets and therefore preserve the common variation driven by push factors. Modelling the joint dynamics of gross inflows to the United States, the Eurozone, and China in a multivariate framework exploits this synchronization precisely: episodes in which a common push shock moves all three series together are distinguishable from episodes in which an idiosyncratic development in one region generates a divergent response, which is the empirical signature of an asymmetric spillover.

2.4 The Global Financial Cycle

The Global Financial Cycle (GFC) constitutes the central theoretical reference point for the empirical analysis of this thesis. Developed primarily by Hélène Rey in a series of influential contributions, the GFC framework characterizes international financial markets as being subject to a powerful common component that simultaneously drives asset prices, credit conditions, leverage, and gross capital flows across a wide range of countries. This global factor generates synchronized fluctuations in financial conditions worldwide, even among economies with limited direct bilateral linkages.

This study provides a more structural and comprehensive account of why spillover intensification occurs. Rey argues that a global factor drives synchronized movements in asset prices, credit growth, and gross capital flows across a wide range of countries and asset classes. The key insight is that this global factor is closely linked to fluctuations in global risk appetite, proxied empirically by the VIX, and to monetary and financial conditions in the United States. When global risk appetite declines sharply, the global factor deteriorates, capital flows contract across multiple economies simultaneously, and cross-border financial transmission strengthens. This mechanism generates the kind of crisis-period amplification documented by Forbes and Rigobon, but places it within a broader structural framework that does not require direct bilateral links between the affected economies.

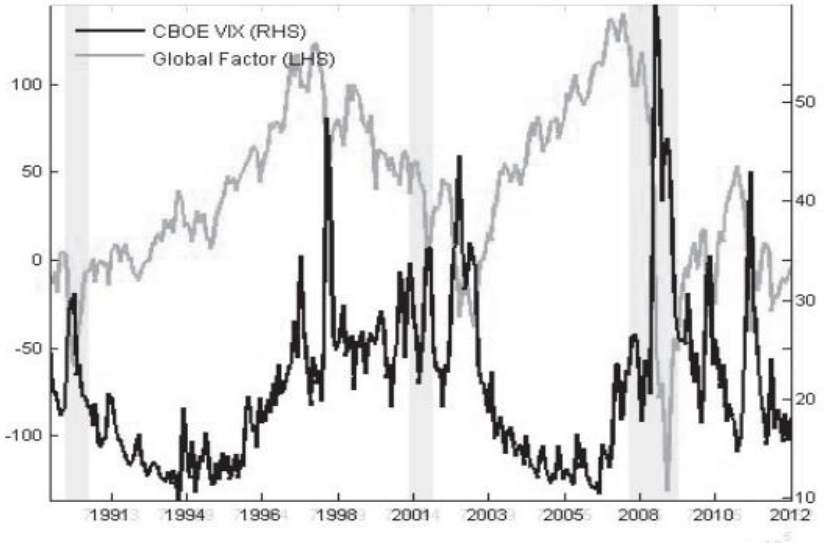
At the core of the GFC framework is the observation that fluctuations in global risk appetite are the primary driver of this common component. When global risk tolerance is high, investors expand their balance sheets, increase leverage, and allocate capital to *riskier* assets across multiple countries simultaneously. This expansion generates large gross capital inflows, rising asset prices, and credit growth in many economies at once. Conversely, when global risk appetite contracts, whether due to a financial shock, a policy shift, or an increase in geopolitical uncertainty, investors

deleverage and retrench, generating synchronized capital flow contractions, asset price declines, and tightening financial conditions across multiple economies. The global nature of this adjustment is what distinguishes the GFC from purely bilateral transmission mechanisms.

Empirically, the GFC is most clearly visible in the strong co-movement between the global financial factor and the VIX, a widely used proxy for global risk sentiment derived from option prices on United States equities. As illustrated in Figure 3, periods of low VIX, indicating compressed uncertainty and high-risk appetite, coincide with expansionary phases of the global cycle, characterized by large capital inflows and rising asset prices. Conversely, spikes in the VIX, such as those observed during the 2008 Great Financial Crisis, the 2011 European debt crisis, and the 2020 COVID-19 shock, coincide with sharp contractions in global capital flows and financial conditions, as shown by Miranda-Agrippino and Rey (2021).

Figure 3: Global financial factor and VIX

Source: Miranda-Agrippino and Rey (2012)



A critical implication of the GFC framework is the dominant role of the United States in driving global financial conditions. Because the US dollar functions as the primary international reserve currency and United States financial markets represent the largest and most liquid component of global portfolios, changes in United States monetary policy and financial conditions propagate disproportionately to the rest of the world. Tighter United States monetary policy tends to strengthen the dollar, compress global liquidity, and trigger capital outflows from other economies. Looser United States policy has the opposite effect. This asymmetric influence is at

the core of Rey's "Dilemma not trilemma" argument.

The traditional "trilemma" of international macroeconomics holds that a country can simultaneously achieve at most two of the following three objectives: monetary policy independence, a fixed exchange rate, and free capital mobility. Flexible exchange rates are conventionally assumed to restore monetary autonomy by insulating domestic financial conditions from external shocks. Rey challenges this conclusion by arguing that, in a world dominated by a powerful GFC, even economies with flexible exchange rates and open capital accounts may be unable to maintain meaningful monetary independence. Because global financial conditions, driven largely by the United States cycle, constrain domestic credit and risk-taking behavior, the effective choice facing open economies is not a trilemma but a dilemma: between capital flow management, which can preserve some monetary autonomy, and full financial openness, which implies exposure to the GFC.

Figure 4: Global Factor in Risky Asset Prices

Source: Miranda-Agrippino and Rey (2021)

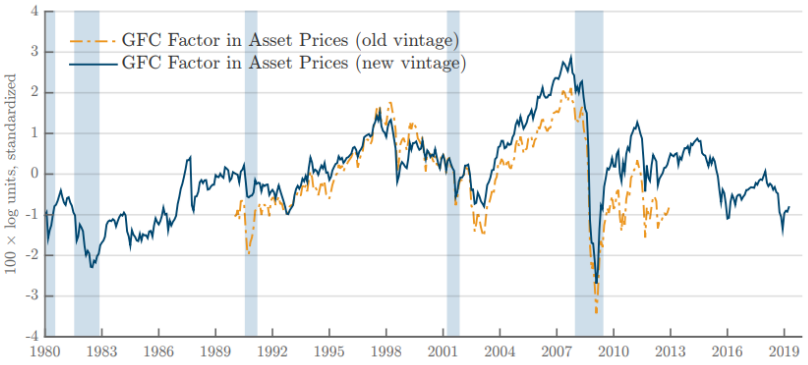


Figure 4 illustrates the share of variance in risky asset returns explained by the global factor across country groups, as reported by Miranda-Agrippino and Rey. The results confirm that the global component is the dominant source of variation in cross-border financial conditions across both advanced and emerging economies.

This theoretical perspective has direct implications for the empirical analysis of this thesis. If the GFC is a robust feature of the international financial system, spillovers within the Triad should exhibit the following characteristics: they should be stronger from the United States to the Eurozone and China than in the reverse direction; they should intensify during periods of global financial stress; and they should be mediated primarily through capital flows rather than through

trade linkages. The empirical model is designed to test these predictions explicitly, as argued by Miranda-Agrippino and Rey (2021).

2.5 Spillovers, Asymmetry and Financial Dominance

As has been explained and redacted by other investigators mentioned previously, one of the most important and policy-relevant implications of the GFC framework is that financial spillovers are structurally asymmetric across countries. Rather than financial shocks propagating equally in all directions, the literature predicts, and empirical evidence broadly confirms, that financially central economies, particularly those whose currencies are widely used internationally and whose assets constitute a large share of global portfolios, generate disproportionately large outward spillovers relative to the spillovers they receive.

This asymmetry arises from three main reinforcing mechanisms. First, the dollar's role as the dominant international reserve and invoicing currency means that dollar-denominated financial conditions have a structural hold over the balance sheets of banks, corporations, and governments in many other countries. Tightening of United States financial conditions automatically worsens the debt-servicing capacity of dollar-borrowers worldwide, irrespective of whether those borrowers have any direct exposure to the United States economy. Second, the sheer size and liquidity of United States financial markets make them the natural reference point for global portfolio allocation: changes in United States asset valuations, credit spreads, or risk-free rates propagate through the portfolios of global investors who hold this country's assets alongside assets from other regions. Third and final, United States monetary policy decisions signal changes in global liquidity conditions that directly affect the cost of capital and risk appetite in other economies through the GFC mechanism described above.

Empirical support for this asymmetry is substantial. Miranda-Agrippino and Rey document that the global financial factor is more strongly correlated with United States monetary conditions than with those of any other economy, implying that its originating shocks generate broader and stronger international transmission than equivalent shocks from other economies. Forbes and Rigobon also document evidence of asymmetric transmission during crisis episodes, with shocks from large financial centers exhibiting stronger contagion effects.

For this thesis, the question of asymmetry has both empirical and interpretive importance.

If the theoretical predictions of the GFC hold within the Triad, the model should find that shocks to United States portfolio inflows generate stronger responses in Eurozone and Chinese inflows than vice versa. The relative positioning of the Eurozone and China as recipients, and the extent to which China's capital controls attenuate its exposure to external shocks, are additional dimensions of asymmetry that the empirical analysis aims to assess.

2.6 China And Global Financial Integration

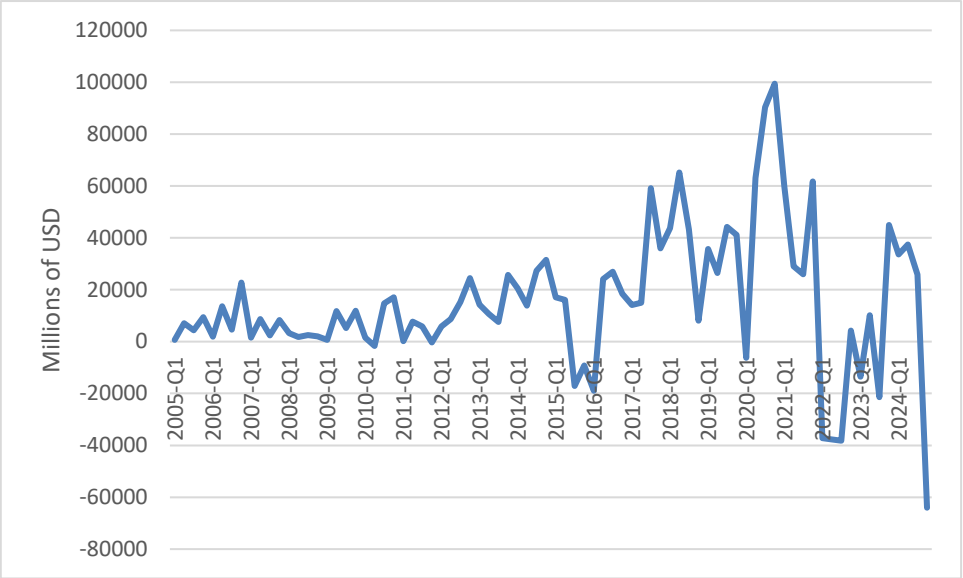
China's position within the international financial system represents one of the most analytically interesting dimensions of the Triad framework. Unlike the United States and the Eurozone, whose financial systems are highly open and closely integrated with global capital markets, China maintains a partially restricted capital account and a financial system that is subject to significant state influence. These structural differences raise specific questions about the extent to which China is integrated into the GFC and whether it can serve as a transmitter of financial shocks to other major economies.

Over the past two decades, China has progressively expanded its participation in international financial markets, both as a borrower and as an investor. The internationalization of the renminbi, the gradual liberalization of bond and equity market access for foreign investors, and China's growing role as a global creditor through initiatives such as the Belt and Road have all contributed to greater financial integration. At the same time, the capital account remains subject to regulatory constraints that continue to limit the free movement of financial resources into and out of mainland China, creating a degree of insulation from global financial cycles that does not exist in either the United States or the Eurozone.

Figure 5 illustrates the evolution of portfolio investment inflows to China over the sample period. The data reveal a clear structural shift in China's financial integration with global markets.

Figure 5: Quarterly portfolio investment inflows to China, 2005Q1-2024Q4 (millions of Dollars).

Source: IMF Balance of Payments Statistics (BPM6). Author's own elaboration.



The figure shows a clear turning point around 2022. Before that, China was consistently attracting foreign capital, reflecting its gradual financial opening. From 2022 onwards, inflows turned persistently negative, foreign investors began withdrawing. This is consistent with the growing geopolitical tensions and regulatory uncertainty that have partially reversed China's financial integration in recent years.

A particularly important institutional feature in this context is the role of Hong Kong as the primary conduit through which mainland China interfaces with international capital markets. Hong Kong operates as a fully open financial center with no capital controls, a currency board peg to the the dollar, and deep and liquid equity, debt, and derivatives markets. A significant share of cross-border portfolio investment into and out of China is intermediated through Hong Kong, making it a structural amplifier of external financial conditions for the mainland. This arrangement means that even when direct capital account restrictions are binding, global financial shocks can reach the Chinese economy through Hong Kong-based intermediation, through the external financing activities of Chinese corporations listed in Hong Kong, and through the offshore renminbi market. The practical implication is that China’s de facto financial integration with global markets may be meaningfully greater than its de jure capital account openness would suggest.

From the perspective of this thesis, including China in the Triad framework serves two

purposes. First, it allows an assessment of whether China's partial financial integration generates measurable spillovers to or from the United States and the Eurozone, even in the presence of capital controls. Second, it provides a test of whether the predictions of the GFC framework, particularly regarding asymmetric transmission and United States dominance, are held when the analysis includes an economy with a very different institutional structure. The comparison between the Eurozone, a financially open economy expected to be strongly exposed to United States spillovers, and China, a partially closed economy that may exhibit weaker integration, provides a richer and more demanding test of the GFC predictions.

2.7 Link to the Empirical Strategy

The theoretical framework developed in this chapter generates a set of empirically testable predictions that directly motivate the design of the quantitative analysis. Three predictions are particularly central.

First, financial spillovers within the Triad should be mediated primarily through capital flows rather than trade. If global investors respond to common shocks by reallocating their portfolios simultaneously across major financial areas, then quarterly portfolio investment inflows should exhibit dynamic interdependencies that reflect the transmission of financial shocks. The TVP-VAR framework, by modelling the dynamic interaction of capital flows across the three regions, is designed to capture precisely this mechanism.

Second, spillovers should be time-varying, intensifying during periods of global financial stress and weakening during calmer phases. This prediction motivates the choice of a time-varying parameter specification rather than a constant-coefficient model. The TVP-VAR allows the transmission coefficients and impulse responses to evolve over the sample period, enabling the analysis to identify whether spillovers strengthen during specific episodes such as the 2008 crisis, the 2018 global market correction, the 2020 COVID-19 shock, or the 2022-2023 tightening cycle.

Third, spillovers should be directionally asymmetric, with the United States acting as the dominant transmitter within the Triad. This prediction is tested by comparing the magnitude and persistence of impulse responses across all bilateral directions: from the United States to the Eurozone, from the United States to China, from the Eurozone to the United States and China, and from China to the other two regions. If the GFC framework is empirically relevant for the Triad,

the impulse responses should be systematically stronger in the direction from the United States to the other two regions.

By constructing a dataset of quarterly portfolio investment inflows for the United States, the Euro Area, and China over the period 2005-2024, and by estimating a Bayesian TVP-VAR model using this data, the empirical analysis directly engages with these three predictions. The results will allow us to assess whether the structural features of the GFC, specifically the time variation and asymmetry of financial spillovers, are evident in the capital flow dynamics of the Triad over the past two decades.

3. Data And Empirical Setting

3.1 Portfolio Investment Inflows as Capital Flows

The empirical analysis of this thesis focuses on cross-border capital flows as the primary mechanism through which financial spillovers are transmitted among the United States, the Eurozone, and China. To capture these flows consistently and comparably, this thesis employs quarterly portfolio investment inflows for each region as the main variable of interest.

More specifically, the variable used is portfolio investment liabilities, measured as the net incurrence of liabilities. This indicator captures the amount of foreign capital that enters a region in each quarter through portfolio investment, that is, through the purchase of financial assets such as equity and debt securities by non-resident investors. When this variable is positive, it reflects net inflows of portfolio capital into the region; when it is negative, it indicates that non-residents reduced their net holdings of domestic financial assets during that quarter.

Despite the term "net" in its name, this variable corresponds to what the literature refers to as gross inflows: it measures the foreign acquisition of domestic financial assets without netting against residents' purchases of foreign assets, the measure advocated by Gourinchas and Rey (2013) and Miranda-Agrippino and Rey (2021) as the most informative indicator of international financial transmission.

This measure is well-suited to the objectives of the thesis for three reasons. First, it directly captures the portfolio reallocation decisions of international investors, which are the primary transmission channel of the Global Financial Cycle framework developed in Chapter 2. Second, it is available at a quarterly frequency for all three regions, allowing the analysis to track the evolution of capital flow dynamics over time. Third, it provides a natural variable for the VAR framework: shocks are interpreted as unexpected changes in capital inflows to one region, and the model traces how inflows to the other regions respond over subsequent quarters.

It is important to note that these series represent aggregate inflows from the rest of the world to each region, rather than bilateral flows between the Triad members specifically. The variable therefore, captures total portfolio inflows into each economy regardless of the geographic origin of the investing counterpart. While this means the data cannot directly identify whether a given inflow originates from one of the other two Triad members, this does not undermine the analytical approach. As discussed in Chapter 2, the Global Financial Cycle operates through

common global forces that simultaneously affect portfolio flows across major financial areas. Co-movement in aggregate inflows across the Triad is therefore informative about spillover dynamics even in the absence of bilateral flow data.

The series is used in its original units, expressed in millions of dollars, without any further transformations at this stage. This keeps the analysis transparent and ensures that the impulse responses estimated in the model can be directly interpreted in terms of the magnitude of capital flow changes.

3.2 Data Description and Sources

The data used in this thesis is obtained from the International Monetary Fund (IMF), specifically from the Balance of Payments (BOP) Statistics database, compiled under the BPM6 methodology. The Balance of Payments provides internationally comparable data on cross-border transactions between residents and non-residents, covering trade flows, income flows, and financial account transactions. The BPM6 framework ensures that the series for the three regions are constructed using harmonized definitions and accounting standards, thereby making direct comparisons across economies methodologically valid.

Within the financial account, the variable selected for this study is "Portfolio investment, liabilities, net incurrence of liabilities, excluding exceptional financing", measured in millions of dollars at quarterly frequency. This variable captures the net quarterly increase in portfolio investment liabilities of each region, that is, the net amount of foreign capital invested in domestic financial assets during each quarter.

More formally, the variable is defined as follows:

Equation 1: Net Quarterly increase in portfolio investment liabilities

$$\Delta L_{i,t} = L_{i,t} - L_{i,t-1} \quad (1)$$

In Equation 1, $L_{i,t}$ is the stock of portfolio investment liabilities of region i at the end of quarter t, and $\Delta L_{i,t}$ is the net quarterly flow, that is, the net acquisition of domestic financial assets by non-resident investors during that quarter.

The expression "excluding exceptional financing" refers to the exclusion of irregular or

one-off financial operations, such as debt restructurings or emergency lending arrangements, that could distort the underlying dynamics of regular portfolio flows.

The dataset covers three reporting entities: the United States, the Euro Area, and the People's Republic of China. All series are expressed in dollars and share the same quarterly frequency, ensuring direct comparability across regions.

The sample is restricted to the period 2005Q1-2024Q4, providing eighty quarters of observations. This time span was selected for two reasons. First, it captures a broad range of global financial conditions, including the 2008 Great Financial Crisis, the European sovereign debt crisis of 2011-2012, the COVID-19 shock of 2020, and the global monetary tightening cycle of 2022-2023. Second, it provides a sample size sufficient for the reliable estimation of a time-varying parameter model, as the TVP-VAR requires enough observations to identify evolving dynamics in the transmission coefficients. This variety of episodes makes the sample well-suited to analyzing how spillover dynamics evolve across different phases of the Global Financial Cycle.

The use of quarterly frequency is consistent with the nature of capital flow data. Unlike high-frequency financial prices, portfolio investment flows are recorded within the balance of payments framework and are typically available at quarterly intervals. Quarterly data allow for the analysis of medium-term financial dynamics without being excessively influenced by short-term market noise and provide enough observations to estimate a time-varying multivariate model.

The final dataset is structured as a three-variable quarterly time series:

- $\boldsymbol{CF_US_t}$: Portfolio investment inflows to the United States
- $\boldsymbol{CF_EA_t}$: Portfolio investment inflows to the Euro Area
- $\boldsymbol{CF_CN_t}$: Portfolio investment inflows to China

Once downloaded from the IMF BOP portal, the raw dataset required a series of straightforward preparation steps before it could be used for estimation. The original file contains six metadata columns (country name, BOP accounting entry, indicator definition, unit of measurement, frequency, and scale) followed by one column per quarter. These metadata columns were removed, and the dataset was transposed so that each row corresponds to a quarterly observation and each column to one of the three regions. The resulting structure is a

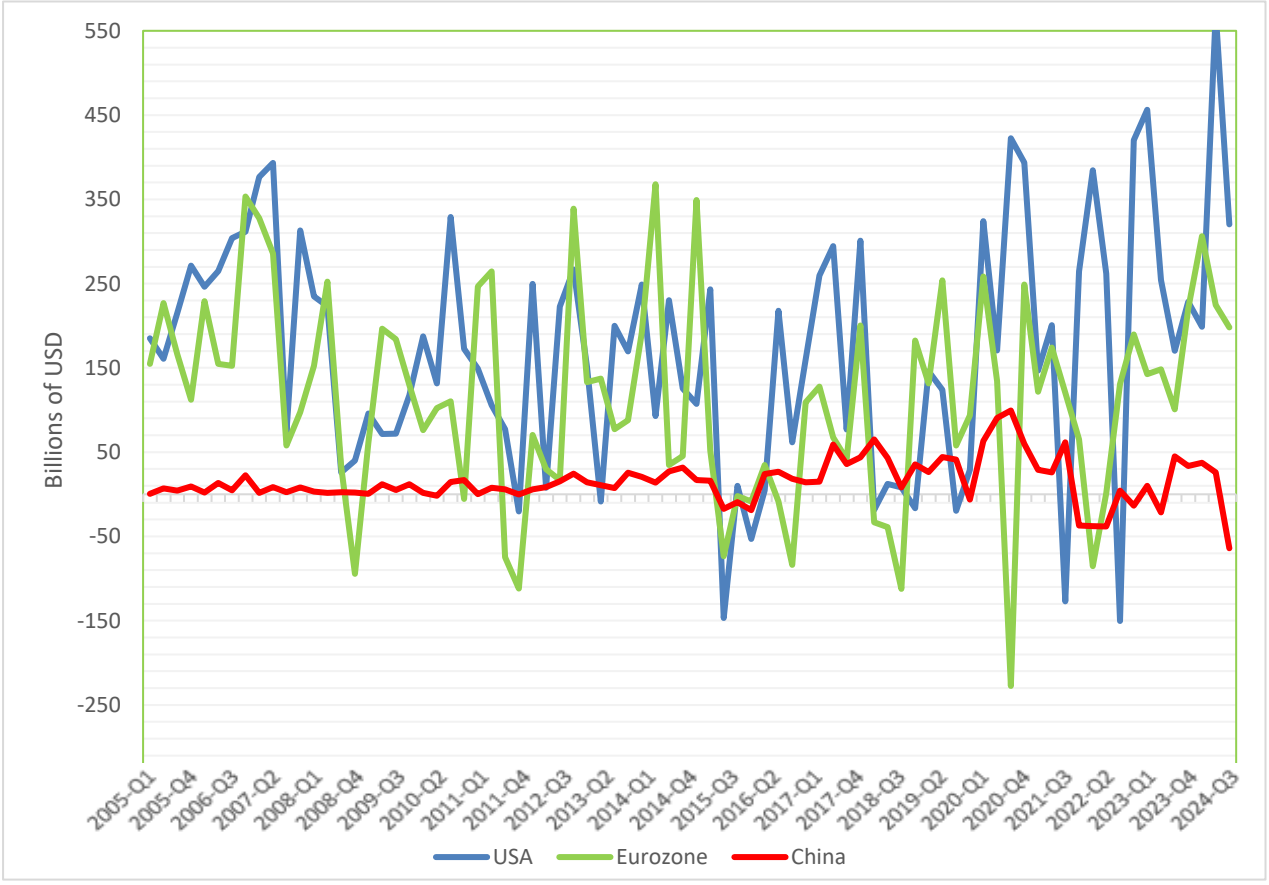
standard time-series matrix with eighty rows and three columns, directly compatible with the input format required by the TVP-VAR package.

The sample was restricted to the period 2005Q1-2024Q4. Although the downloaded series extends to 2025Q3, the three most recent quarters were excluded from the analysis for two reasons. First, these observations are preliminary and subject to revision by the IMF, which could introduce measurement error into the estimation. Second, restricting the sample to 2024Q4 ensures consistency with the BPM6 data availability for China, which is the binding constraint on the start date of the sample. The final dataset contains eighty quarterly observations for each of the three variables, with no missing values.

Figure 6 illustrates the evolution of the three series over the sample period, providing an

Figure 6: Quarterly portfolio investment inflows - United States, Euro Area, and China (2005Q1-2024Q4). Values in millions of dollars.

Source: IMF Balance of Payments Statistics (BPM6). Author's own elaboration.



Several patterns are immediately visible. United States inflows are the largest and most volatile of the three series, consistent with the dominant size of American financial markets. Euro Area inflows follow a broadly similar pattern but with lower amplitude. China stands out for the sharp deterioration from 2022 onwards, with inflows turning persistently negative, a structural shift that is directly relevant to the analysis of asymmetry developed in the empirical chapters.

3.3 Plausible Interpretations

While the dataset provides a consistent and comparable measure of quarterly portfolio capital inflows for the United States, the Euro Area, and China, several limitations should be acknowledged before proceeding to the empirical analysis.

The first concerns the aggregate nature of the flow series. The data captures total portfolio inflows into each region from the rest of the world, rather than bilateral flows between the three Triad members specifically. This means that the empirical analysis cannot directly identify whether a shock transmitted from the United States to China, for example, travels through a direct bilateral investment channel or through the broader global reallocation of investor portfolios. As argued in Chapter 2, however, this does not invalidate the approach: if the Global Financial Cycle operates through common push factors that simultaneously affect flows across major financial areas, then co-movement in aggregate inflows is precisely what should be expected under the theoretical framework. The limitation is therefore one of interpretation rather than validity.

Second, the series is expressed in nominal dollars. Exchange rate fluctuations and global valuation effects may therefore influence the measured magnitude of capital flows, particularly for the Euro Area, whose flows are converted from euros. Since all three series are denominated in the same currency and measured at the same frequency, cross-country comparability is preserved, but the absolute magnitudes should be interpreted with awareness that part of the variation may reflect currency movements rather than genuine changes in portfolio allocation.

Finally, differences in financial structure and regulatory regimes across the three regions, particularly in the case of China, may affect the comparability of the series. As discussed in Chapter 2, China's capital account remains partially restricted, which means that its portfolio investment inflows may respond to global financial conditions through different channels and with different magnitudes than those of the United States or the Euro Area. The BPM6 methodology ensures that the accounting definitions are harmonized, but it cannot fully eliminate the institutional differences that shape how each economy is integrated into global capital markets.

Despite these limitations, the dataset is well-suited to the objectives of this thesis. The combination of a standardized source, a consistent variable definition, and a sample that spans multiple phases of the Global Financial Cycle provides a solid empirical foundation for the analysis of spillover magnitude, direction, and asymmetry developed in the following chapters.

4. Methodology

4.1 Motivation for a Time-Varying Approach

A fundamental insight of the Global Financial Cycle literature is that financial spillovers are not constant over time. As discussed in Chapter 2, the strength of cross-border transmission varies systematically with global financial conditions: spillovers tend to intensify during episodes of stress and weaken during calmer phases. Estimating a standard VAR model with fixed coefficients would impose the assumption that the relationships among capital flows are stable throughout the sample period, which directly contradicts the theoretical framework motivating this thesis. A time-varying specification is therefore not merely a technical refinement but a substantive requirement for addressing the research question.

The Time-Varying Parameter Vector Autoregression (TVP-VAR) model, developed by Nakajima (2011) following the foundational work of Primiceri (2005), addresses this limitation by allowing both the VAR coefficients and the error covariance matrix to evolve gradually over time. This flexibility enables the model to capture structural changes in the transmission mechanism without needing to know in advance when or how those changes happened. The result is a framework in which impulse response functions can be computed at any point in the sample, allowing a direct comparison of spillover dynamics across different phases of the Global Financial Cycle.

For the specific context of this thesis, the TVP-VAR is particularly appropriate for three reasons. First, the sample period 2005-2024 spans episodes of markedly different global financial conditions, including the 2008 crisis, the 2015-16 market turbulence, the COVID-19 shock of 2020, and the 2022-2023 monetary tightening cycle. A constant-coefficient model would average across these episodes and fail to capture the time variation that is central to the research question. Second, the three regions of the Triad differ substantially in their institutional structure and degree of financial openness, so the transmission channels between them may themselves evolve as global integration deepens. Third, the sample of eighty quarterly observations limits the degrees of freedom available for estimation, and the Bayesian TVP-VAR addresses this by incorporating prior information through the Markov Chain Monte Carlo (MCMC) algorithm, providing more reliable estimates than a classical time-varying specification would yield on a short sample. In simple terms, the Bayesian approach helps the model make more reliable estimates when data is limited by combining the information in the sample with reasonable prior assumptions about how

parameters behave.

An alternative approach would have been to compute spillover indices following Diebold and Yilmaz, which provide summary measures of total, directional, and net connectedness using generalized forecast error variance decompositions invariant to variable ordering. However, this approach yields scalar estimates averaged over the full sample and does not capture how the direction and magnitude of spillovers evolve across different phases of the Global Financial Cycle, which is the central question of this thesis. The TVP-VAR is therefore the preferred specification, with the Diebold-Yilmaz framework representing a natural complement for future research. (Diebold & Yilmaz, 2012)

4.2. Model Specification

The TVP-VAR model follows the representation proposed by Nakajima. Let y_t denote a ($k \times 1$) vector of observed variables at time t.

In simple terms, the model asks the following question at each point in time: given what happened to capital flows in the previous two quarters, what would we expect to happen this quarter? The difference between what the model expects and what actually happens is the shock. The key feature is that the relationships between the three regions, how much a movement in United States inflows predicts a movement in European or Chinese inflows, are allowed to change gradually from one quarter to the next, rather than being fixed throughout the entire sample.

Formally, the model can be written as follows, where the key feature is that all coefficients carry the subscript t, indicating that they are allowed to change at every point in time:

Equation 2: TVP-VAR Model Representation

$$y_t = c_t + B_{1t}y_{t-1} + \cdots + B_{st}y_{t-s} + e_t\,, \quad e_t \sim N(0, \Omega_t)$$

(2)

In Equation 2, c_t is a time-varying intercept, $B_{1t}, \ldots, B_{st}$ are ($k \times k$) matrices of time-varying coefficients, and Ω_t is a time-varying covariance matrix. The covariance matrix is decomposed as $\Omega_t = A_t^{-1}\Sigma_t\Sigma_t'A_t'^{-1}$, where A_t is a lower-triangular matrix with unit diagonal elements and $\Sigma_t =$

diag(σ_{1t}, …, σ_{kt}) is a diagonal matrix of time-varying standard deviations. This recursive decomposition constitutes the identification scheme

The time-varying parameters follow independent random walk processes:

Equation 3: Random Walk Process for Time-Varying Parameters

$$\beta_{t+1} = \beta_t + u^{\beta}_t \ , \quad a_{t+1} = a_t + u_{at} \ , \quad h_{t+1} = h_t + uh_t$$

(3)

In Equation 3, β_t is the stacked vector of VAR coefficients, a_t collects the free lower-triangular elements of A_t, and $h_t = (h_{1t}, \ldots, h_{kt})$ with $h_{it} = \log \sigma_{it}^2$ denoting the log-volatilities. The random walk assumption implies that parameters can drift smoothly over time, which is well suited to capturing gradual structural changes in the transmission of financial shocks. The innovation variances Σ^{β}, Σ_a, and Σh govern the degree of time variation in each set of parameters and are estimated from the data. (Nakajima, 2011)

In this thesis, the model is applied to a vector of three variables: portfolio investment inflows to the United States (CF_US), to the Euro Area (CF_EA), and to China (CF_CN), expressed in millions of dollars at quarterly frequency. The number of lags is set to s = 2, which is the standard choice for quarterly macroeconomic data with a short sample, and which balances the need to capture short-run dynamics against the loss of degrees of freedom associated with additional lags. A time-varying intercept is included to allow for potential drift in the unconditional mean of capital flows over the sample period.

To interpret the impulse response functions as causal, it is necessary to identify structural shocks from the reduced-form residuals. This thesis employs a recursive identification scheme based on a Cholesky decomposition of the time-varying covariance matrix, as implemented in the Nakajima TVP-VAR framework. Under this scheme, the ordering of the variables in the system determines which regions can affect which other regions within the same quarter.

The ordering adopted is: *CF_US, CF_EA, CF_CN*. This ordering reflects the theoretical prior, derived from the Global Financial Cycle literature, that the United States acts as the dominant transmitter of financial shocks within the Triad. Under the recursive identification, a shock to United States capital flows is allowed to affect Eurozone and Chinese inflows within the same quarter, while a shock to Eurozone inflows can affect Chinese inflows

contemporaneously but not United States inflows, and a shock to Chinese inflows has no contemporaneous effect on either of the other two regions. This hierarchy is consistent with the theoretical predictions of Rey and Miranda-Agrippino and Rey.

It should be acknowledged that the Cholesky identification imposes assumptions about the contemporaneous structure of the system. However, the ordering adopted here, CF_US, CF_EA, CF_CN, is directly grounded in the theoretical predictions of the Global Financial Cycle literature, which consistently identifies the United States as the dominant transmitter of financial conditions within the global system.

To assess whether the main results are sensitive to this ordering assumption, a robustness check was conducted by re-estimating the model with the alternative ordering CF_EA, CF_CN, CF_US, in which the United States is placed last and therefore receives no contemporaneous effects from the other two regions by construction. The results of this exercise are discussed in Section 5.2.

Prior to estimation, the three series are divided by 100,000 to rescale them from millions to hundreds of billions of dollars. This rescaling is a standard numerical procedure applied to improve the conditioning of the covariance matrices involved in the MCMC algorithm and does not affect the structural interpretation of the results. All impulse responses reported in the empirical analysis are expressed in the original units of millions of dollars by applying the inverse transformation.

The model is estimated via a Bayesian Markov Chain Monte Carlo (MCMC) algorithm with N = 10,000 draws, following the implementation of Nakajima. The choice of 10,000 iterations ensures that the algorithm has enough steps to produce stable estimates. In simple terms, the algorithm refines its estimates progressively with each iteration. The prior distributions follow the standard specification of that framework: the innovation variances of the time-varying coefficients follow a Gamma (20, 10^{-4}) prior, while those of the stochastic volatility parameters follow Gamma (4, 10^{-4}) priors. Convergence is assessed using the Geweke statistic and the inefficiency factor, both of which are reported in the empirical results.

4.3 Impulse Response Analysis

Before presenting the results, it is important to explain what an impulse response function is. An IRF answers the following question: if an unexpected shock occurs in one region, how do

capital flows in the other regions change over the following quarters? The result is a curve that starts at the moment of the shock and shows how the effect builds up or fades away over time, when the curve reaches zero, the effect has fully dissipated and the system has returned to normal. Crucially, the TVP-VAR computes a different IRF for each quarter in the sample, meaning that the response to the same shock can differ between 2013, 2020, and 2022, reflecting the fact that the relationships between the three regions evolved over time.

The primary output of the empirical analysis is a set of time-varying impulse response functions (TVP-IRFs). As explained in the previous section, these are not observations from the dataset but simulated experiments: using the relationships learned from the 80 quarters of real data, the model calculates how capital flows in one region would respond over the following ten quarters if an unexpected shock of standard size occurred in another region. Crucially, this calculation is performed separately for each quarter in the sample, so the response can differ between 2013, 2020, and 2022, reflecting the fact that the relationships between the three regions were different in each of those periods.

The TVP-IRFs are computed for all nine shock-response combinations within the three-variable system: shocks originating in each of the three regions and responses in each of the three regions, including the source. This complete set of IRFs allows a systematic assessment of the two main empirical questions of the thesis. First, comparing the magnitude and persistence of IRFs across different time periods allows an evaluation of whether spillovers intensify during episodes of global financial stress, consistent with the time-variation prediction of the Global Financial Cycle framework. Second, comparing IRFs across bilateral directions, specifically, contrasting the responses to United States shocks with the responses to Eurozone and Chinese shocks, provides a direct test of the asymmetry prediction, allowing an assessment of whether the United States acts as the dominant transmitter of financial shocks within the Triad, consistent with the time-variation prediction of Miranda-Agrippino and Rey (2021).

The analysis focuses in particular on three specific time points corresponding to distinct phases of the Global Financial Cycle within the sample: a tranquil reference period in 2013Q1, representing stable global financial conditions prior to the major stress episodes of the sample; the COVID-19 shock of 2020Q1, representing an episode of acute global financial stress; and the 2022Q3 monetary tightening cycle, representing a sustained shift in global financial conditions driven by synchronized central bank rate hikes across advanced economies.

The estimation is conducted in MATLAB using the TVP-VAR package developed by Nakajima, available at the author's repository. The MATLAB code used in this thesis, including data preparation and impulse response computation, is available in the Appendix.

5. Empirical Results

This chapter presents the results of the TVP-VAR estimation and discusses their implications for the three empirical predictions derived from the Global Financial Cycle framework: that financial spillovers within the Triad are mediated through capital flows, that they intensify during episodes of global stress, and that they are directionally asymmetric, with the United States acting as the dominant transmitter.

5.1. Overview of Estimation Results

Before presenting the results, it is important to verify that the model has worked correctly and that the estimates it produces can be trusted. Table 3 reports the key parameters that control how much the model allows relationships to change over time, along with two standard checks that confirm the estimation has run properly. All parameters show small but positive values, indicating that the model detects that relationships between the three regions evolve gradually over time rather than remaining fixed, which is precisely what the TVP-VAR framework is designed to capture.

Specifically, sb1 and sb2 (sigma beta) measure how much the relationships between capital flows across quarters can change from one period to the next. sa1 (sigma a) measures how much the immediate effect that one region has on another within the same quarter can change over time. sh1 and sh2 (sigma h) measure how much the volatility, that is, the unpredictability, of each region's flows can change over time. All five parameters show small but positive values, indicating that the model detects gradual evolution in all these dimensions without imposing excessive instability.

The two diagnostic checks confirm the reliability of the estimation: the Geweke statistic tests whether the algorithm has converged by comparing the beginning and the end of the chain, values between 0.05 and 0.95 indicate no problems, and all five parameters fall within this range (0.171 to 0.728). The inefficiency factor measures whether consecutive samples generated by the algorithm are sufficiently independent from each other. Values below 100 are considered acceptable, and all five parameters are well below this threshold (18.53 to 37.51). Together, these diagnostics confirm that the results presented in the rest of this chapter are statistically reliable.

Table 3: Posterior estimates - TVP-VAR hyperparameters

Source: Author´s own elaboration

ESTIMATION RESULT						
Parameter	Mean	Stdev	95% U	95% L	Geweke	Inef.
sb1	*0,0056*	*0,0024*	*0,0028*	*0,0121*	*0,171*	*34,81*
sb2	*0,0056*	*0,0025*	*0,0028*	*0,0121*	*0,728*	*29,52*
sa1	*0,0056*	*0,0016*	*0,0034*	*0,0097*	*0,457*	*22,74*
sh1	*0,0057*	*0,0016*	*0,0035*	*0,0099*	*0,696*	*18,53*
sh2	*0,0057*	*0,0018*	*0,0034*	*0,0105*	*0,486*	*37,32*

Figure 7 provides a visual complement to these numerical diagnostics.

Figure 7: MCMC diagnostic plots.

Source: Author´s own elaboration using Nakajima´s model

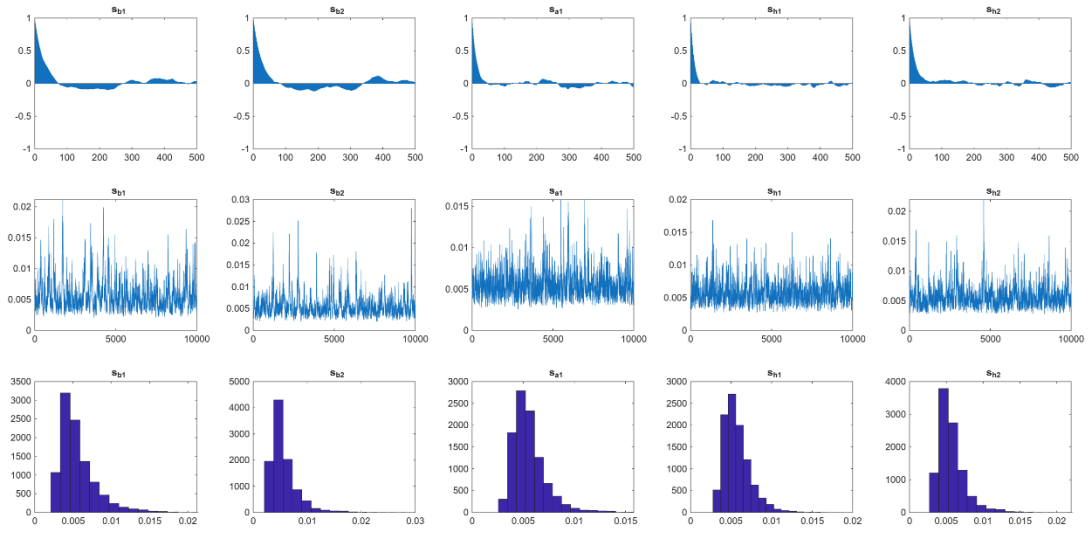


Figure 7 shows three diagnostic plots for each parameter. The first row shows the autocorrelation of the samples, when this decays rapidly to zero it means that each sample of the algorithm is essentially independent from the previous one, which is what we want: if the samples were highly correlated, we would effectively have far fewer independent samples than the 10,000 iterations suggest, making the estimates unreliable. The second row shows the sample path of the chain over the 10,000 iterations, a path that fluctuates around a stable mean without drifting upward or downward confirms that the algorithm has not got stuck in any particular region of the parameter space. The third row shows the posterior density of each

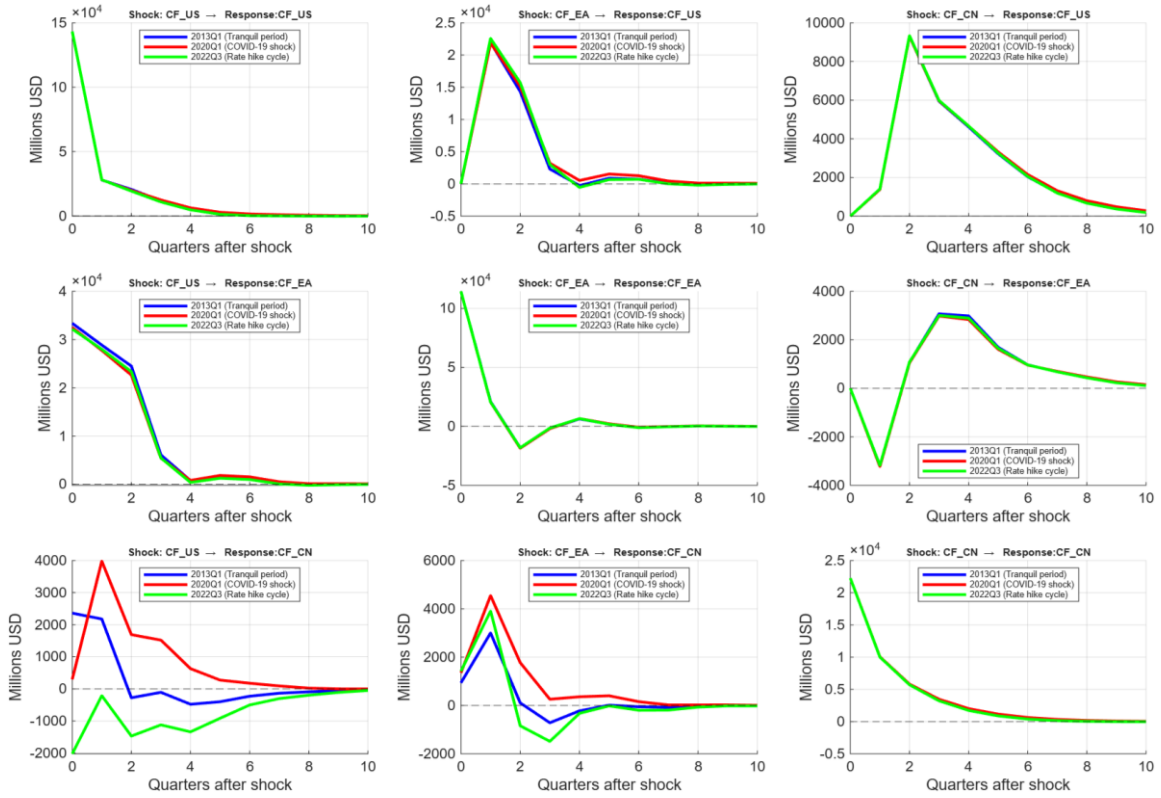
parameter, a smooth, single-peaked bell shape confirms that the model has identified a well-defined estimate rather than being uncertain between multiple possible values. All five parameters pass these three visual checks, providing additional confirmation that the estimation is reliable and the subsequent results can be trusted.

5.2. Impulse Response Analysis: Time-Variation and Asymmetry

Figure 8 presents the central empirical output of this thesis: the time-varying impulse response functions for all nine shock-response combinations within the Triad. Each panel shows how capital flows in one region respond over the following ten quarters when an unexpected shock of standard size occurs in another region. It is important to note that these curves do not show the total amount of money flowing, they show the extra movement in flows caused by the shock, above and beyond what would have happened anyway. When a curve reaches zero, the effect of the shock has fully dissipated. The shock always has the same standard size across the three time periods, so any differences between the blue line (2013Q1, tranquil period), the red line (2020Q1, COVID-19 shock), and the green line (2022Q3, rate hike cycle) reflect changes in how the system responds, not changes in the size of the shock. The three diagonal panels, United States shocks on United States inflows, Euro Area shocks on Euro Area inflows, and China shocks on China inflows, show how each region responds to its own internal shocks and serve mainly as a scale reference. A standard shock to United States inflows generates an immediate response of approximately 143,000 million US Dollars in United States inflows itself, reflecting the dominant size and volatility of American financial markets. The cross-regional panels are the focus of the analysis.

Figure 8: Time-varying impulse response functions - Portfolio investment inflows, Triad (2005Q1-2024Q4).

Source: Author´s own elaboration using Nakajima´s model



The results provide clear and direct evidence in support of the three empirical predictions of this thesis.

The first prediction, that capital flows constitute the transmission channel for financial spillovers within the Triad, is confirmed across all cross-regional panels. Shocks originating in one region generate measurable responses in the capital flows of the others over the subsequent quarters, demonstrating that portfolio investment inflows are an active channel through which financial conditions spread across the Triad, as argued by Gourinchas and Rey (2013).

The second prediction, that spillovers are time-varying and intensify during episodes of global stress, is most clearly visible in the panel showing the response of Chinese inflows to United States shocks (first column, third row). In the tranquil period of 2013Q1 (blue), a United States shock generates a moderate positive response of around 2,500 million US Dollars in Chinese inflows, which fades gradually over six quarters.

It is worth clarifying that 2020Q1 is not treated as a shock originating in the United States; the COVID-19 episode was a global shock that affected all three regions simultaneously. Rather, 2020Q1 is simply the point in time at which the model's parameters are evaluated: the relationships between the three regions as learned from the data up to that quarter. The shock simulated in each panel is always the same standard-size unexpected movement in one region's inflows, what changes across the three time periods is how the system, given its state at that moment, would respond to such a shock.

During the COVID-19 shock of 2020Q1 (red), the same shock generates a larger positive response of nearly 4,000 million US Dollars, investors were diversifying toward China as global uncertainty rose. But during the rate hike cycle of 2022Q3 (green), the same shock generates a negative response: capital flows out of China rather than in, as higher United States interest rates made American assets more attractive and drew investors away from China. This sign reversal, from positive to negative, is the most striking finding of the analysis. It shows that what matters is not just whether a shock occurs in the United States, but what type of shock it is: a stress-driven shock pushes investors toward China, while an interest-rate-driven shock pulls them away. A model with fixed coefficients would have averaged across these two episodes and missed this distinction entirely. The response of Chinese inflows to Euro Area shocks (second column, third row) also shows time-variation: the COVID period generates a larger positive response of around 4,000-5,000 million US Dollars compared to the tranquil period, suggesting that the Euro Area acted as a secondary transmitter of financial stress toward China during that episode. It should be noted that when responses are considered relative to the size of the originating shock, the Euro Area's transmission toward China during the COVID episode is proportionally comparable to, or even slightly larger than, that of the United States. However, in absolute terms, which are the economically relevant metric when assessing systemic financial risk, the United States generates larger capital flow movements in China, providing an additional reason for its position at the top of the transmission hierarchy within the Triad.

The third prediction, that spillovers are directionally asymmetric, with the United States as the dominant transmitter, is the most clearly supported result. The first column of Figure 8 shows that United States shocks generate large and persistent responses in both Euro Area inflows (around 33,000-35,000 million US Dollars on impact, stable across all three periods) and Chinese inflows (with the sign reversal described above). By contrast, the first row shows that shocks originating in the Euro Area and China generate responses in United States inflows that are close to zero on impact, a direct consequence of the Cholesky identification, and remain small

at all subsequent horizons. China's shocks generate the smallest responses of all, confirming that it acts primarily as a recipient of financial spillovers rather than as a transmitter. This hierarchical structure, the United States transmits strongly to both Europe and China, the Euro Area transmits moderately to China, and China transmits little to either, is precisely what the Global Financial Cycle framework of Miranda-Agrippino and Rey predicts, and it constitutes the central empirical finding of this thesis.

The asymmetry result is robust to alternative identification assumptions. As a robustness check, the model was re-estimated with the ordering CF_EA, CF_CN, CF_US, placing the United States last in the Cholesky decomposition. Under this alternative ordering, the transmission from the United States to the Euro Area remains large and positive (approximately 25,000 - 35,000 million dollars on impact), and the sign reversal in the United States-to-China panel is preserved across the three time periods. This confirms that the asymmetric transmission documented above is not an artefact of the identification ordering but reflects genuine differences in the transmission capacity of the three regions. The alternative ordering does present some convergence issues, the Geweke statistic for sb1 reaches 0.998, above the conventional threshold, which further supports the theoretical justification for the baseline ordering derived from the Global Financial Cycle literature. An alternative measure of spillover magnitude and asymmetry could have been provided by the connectedness indices of Diebold and Yilmaz, which are invariant to variable ordering. However, as discussed in Section 4.1, the TVP-VAR framework was preferred for its ability to capture time-variation in the direction and magnitude of transmission.

Figure 9: TVP-IRF surface plots. Portfolio Investment Inflows, Triad (2005-2024)

Source: Author´s own elaboration using Nakajima´s model

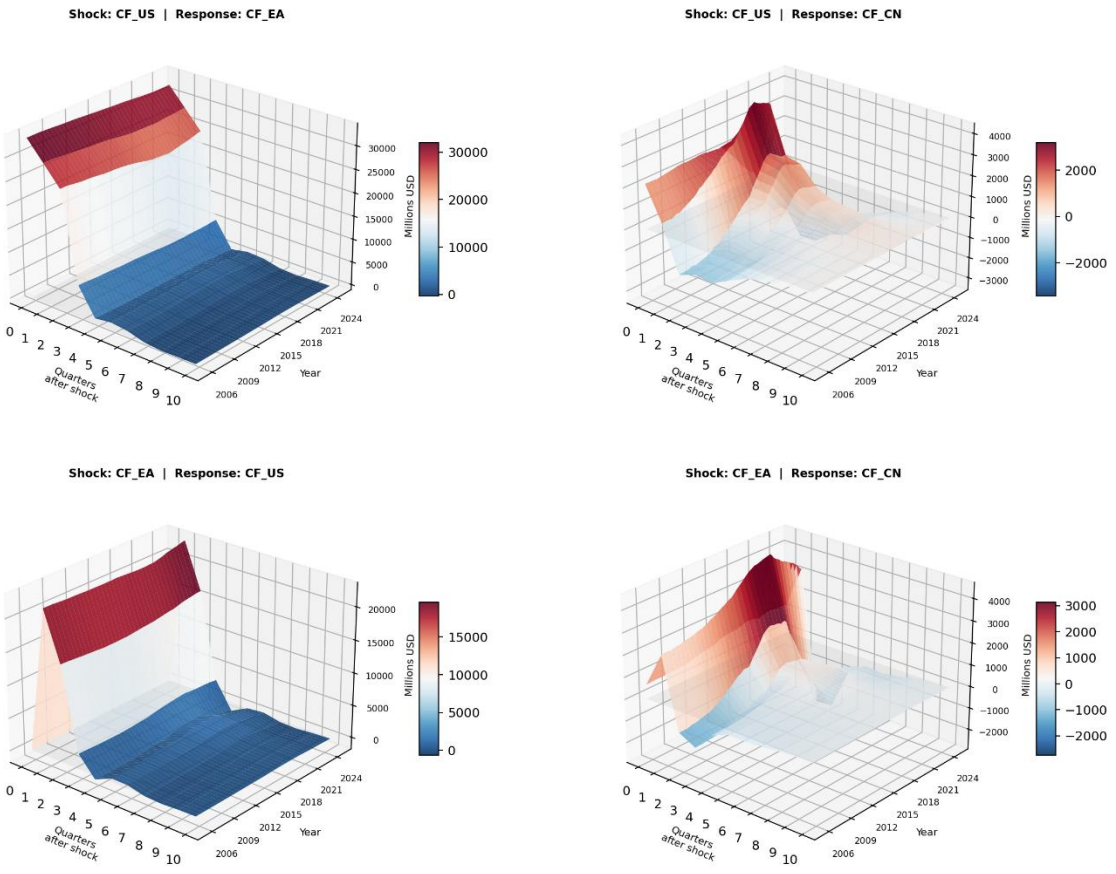


Figure 9 presents the same results in a three-dimensional format, computing the impulse responses continuously across all 80 quarters of the sample rather than at three selected points. The horizontal axis shows the response horizon in quarters after the shock, the time axis spans the full sample from 2005 to 2024, and the vertical axis measures the magnitude of the response in millions of US Dollars. Red areas indicate positive responses and blue areas indicate negative responses.

The upper-left panel (United States shocks on Euro Area inflows) shows a consistently red surface at short horizons across the entire sample, confirming that the United States-to-Europe transmission has been positive and stable throughout the twenty years covered by the

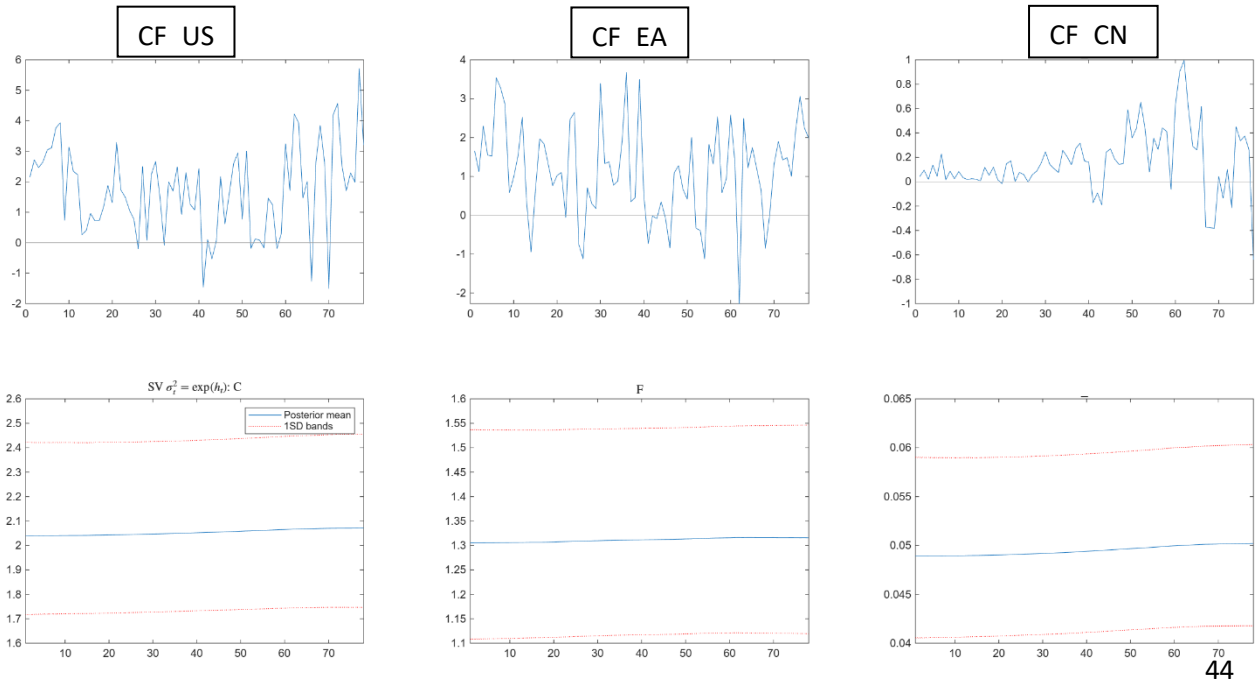
analysis. The upper-right panel (United States shocks on Chinese inflows) is the most visually striking: the surface is red in the pre-2020 years and shifts to blue in the 2022 period, providing a continuous visual representation of the sign reversal documented in Figure 8 and confirming that this is a genuine structural change in the transmission mechanism rather than a statistical artefact. The lower-left panel (Euro Area shocks on United States inflows) shows a surface with lower magnitude than the upper panels, confirming that the Euro Area transmits little to the United States, a direct visual confirmation of the asymmetry result. The lower-right panel (Euro Area shocks on Chinese inflows) is particularly informative: the surface shows a positive response that peaks during the COVID period and is smaller during tranquil and rate-hike periods, confirming that the Euro Area acts as a secondary transmitter toward China and that this transmission was amplified during the COVID episode, consistent with the findings documented in Figure 8.

5.3. Stochastic Volatility

Figure 10 shows how unpredictable capital flows have been for each of the three regions over the sample period. The upper panels show the raw data series, and the lower panels show the model´s estimate of volatility. This is how much uncertainty the model detects in each series at each point of time.

Figure 10: Estimates of stochastic volatility

Source: Author´s own elaboration using Nakajima´s model



First, United States inflows show substantially higher volatility in absolute terms than the other two regions, consistent with the dominant size of American financial markets. Second, all three series display a gradual upward trend over the sample, suggesting that capital flow dynamics have become progressively less predictable as global financial integration has deepened. The absence of sharp spikes around specific stress episodes is an expected feature of quarterly data, which smooth out within-quarter market turbulence by construction. These results provide background support for the time-varying framework adopted in this thesis and are consistent with the broader narrative of increasing financial interconnectedness developed in the preceding sections.

5.4. Discussion

The results presented in this chapter confirm the three empirical predictions of the Global Financial Cycle framework, while adding nuance that goes beyond a simple confirmation.

The most straightforward finding is the asymmetry: United States shocks consistently generate larger and more persistent responses across the system than shocks from the Euro Area or China, confirming the dominant role of the United States as a financial transmitter within the Triad. This is consistent with Rey and Miranda-Agrippino and Rey, and it implies that monetary and financial conditions in the United States propagate to the other Triad members in ways that the recipient economies cannot easily insulate themselves from.

The more nuanced finding concerns the nature of time-variation. The results do not simply show that spillovers are stronger during crises, they show that the direction of transmission can reverse depending on the type of crisis. During COVID-19, United States shocks attracted capital toward China; during the 2022 rate hike cycle, the same shocks repelled it. This distinction between stress-driven and rate-driven episodes is not captured by the existing GFC literature, which tends to treat all crisis periods as generating uniformly stronger spillovers. It represents the most original contribution of this thesis.

China's position in this hierarchy deserves particular attention. Despite its partially restricted capital account, the magnitude of the responses of Chinese inflows to external shocks, particularly during COVID-19, suggests that China's de facto financial integration with global

markets is meaningfully greater than its de jure openness would imply, consistent with the role of Hong Kong as a financial conduit discussed in Chapter 2.

These findings are broadly consistent with the methodological insights of Lenza and Primiceri, who demonstrate that standard VAR models estimated over samples including the COVID-19 period systematically underestimate uncertainty by treating that episode as a normal observation. Their central finding is that the COVID-19 shock generated a level of volatility so far outside the historical range that any model assuming constant parameters would either distort the pre-COVID estimates or fail to capture the post-COVID dynamics, exactly the problem that motivates the time-varying specification adopted in this thesis. The sign reversal documented here, from positive to negative responses of Chinese inflows to United States shocks between 2020 and 2022, is a concrete illustration of the parameter instability that Lenza and Primiceri identify as a defining feature of the post-2020 macroeconomic environment. Had this thesis used a constant-coefficient VAR, that reversal would have been averaged out and the most interesting finding of the analysis would have been lost.

In addition, it should be acknowledged that the degree of time variation detected is moderate rather than dramatic. This is an expected feature of quarterly data, which smooths out within-quarter dynamics by construction. Future research using higher-frequency data, or incorporating bilateral rather than aggregate flow data, could provide a more granular picture of how spillover dynamics evolve in real time.

A further limitation concerns the potential presence of unobserved common factors. With three aggregate inflow series, the model cannot fully distinguish between genuine bilateral transmission, where a shock in one region directly causes a response in another, and co-movement driven by a common global factor such as changes in global risk appetite or United States monetary policy conditions. A factor-augmented VAR specification, or the inclusion of the VIX as an exogenous variable, would help address this concern and represents a natural extension of this analysis.

Finally, the impulse responses reported in this thesis are computed using the posterior mean of the time-varying parameters, following the fastimp=1 specification of Nakajima. Generating posterior credible bands for the TVP-IRFs would require the fastimp=0 specification, under which the impulse responses are computed at every MCMC iteration and averaged at the end. However, this approach is computationally intensive (with 80 observations, three variables,

and 10,000 iterations, estimation time increases by an order of magnitude) and the standard implementation of the Nakajima package does not store the full distribution of impulse responses across iterations, which would require modifying the internal code of the package. The robustness of the main findings is instead assessed through the alternative identification ordering discussed in Section 5.2

6. Conclusions

This thesis set out to investigate how capital flows mediate the magnitude and symmetry of financial spillovers within the Triad, the United States, the Euro Area, and China, and whether these spillovers exhibit the time-varying and asymmetric properties predicted by the Global Financial Cycle framework of Rey (2015). To address this question, a Bayesian TVP-VAR model was estimated using quarterly portfolio investment inflows for the three regions over the period 2005Q1-2024Q4, allowing the transmission coefficients and impulse responses to evolve gradually over time rather than being fixed across the entire sample.

Three main findings emerge from the analysis. First, portfolio investment inflows constitute an active transmission channel for financial shocks within the Triad: shocks originating in one region generate dynamic responses in the others over the subsequent quarters, consistent with the capital flow transmission mechanism described in the theoretical literature. Second, spillovers are time-varying in both magnitude and sign. The responses of Chinese inflows to shocks from the United States and the Euro Area are substantially larger during the COVID-19 episode of 2020Q1 than during the tranquil reference period of 2013Q1, and the sign of the United States-to-China transmission reverses between the COVID-19 shock and the 2022 monetary tightening cycle, a result that highlights the importance of distinguishing between different types of global stress episodes. Third, and most clearly, spillovers are directionally asymmetric: United States shocks generate the largest and most persistent responses across the system, while shocks from the Euro Area and China have comparatively modest effects on United States inflows. This hierarchical structure of transmission is consistent with the dominant role of the United States in global finance and with the dilemma argument of Rey (2015), and it implies that monetary and financial conditions in the United States propagate to the other Triad members through capital flow channels in ways that the recipient economies cannot easily insulate themselves from.

Some considerations of the analysis should be acknowledged. The dataset captures aggregate portfolio inflows from the rest of the world to each region rather than bilateral flows between the Triad members specifically, which means that the empirical analysis cannot directly identify whether transmission operates through direct bilateral investment links or through the broader global reallocation of investor portfolios. Additionally, the use of quarterly data smooths out within-quarter market dynamics, which may cause the model to understate the intensity of spillovers during acute stress episodes. The moderate degree of time variation detected in the stochastic volatility is partly a consequence of this temporal aggregation rather than a reflection of

genuinely stable volatility dynamics.

Despite these, the results of this thesis provide systematic empirical evidence that financial spillovers within the Triad are real, time-varying, and asymmetric, and that understanding their dynamics requires both a theoretically grounded framework and an empirical model flexible enough to capture structural change over time.

Declaración de Uso de Herramientas de Inteligencia Artificial Generativa en Trabajos Fin de Grado
ADVERTENCIA: Desde la Universidad consideramos que ChatGPT u otras herramientas similares son herramientas muy útiles en la vida académica, aunque su uso queda siempre bajo la responsabilidad del alumno, puesto que las respuestas que proporciona pueden no ser veraces. En este sentido, NO está permitido su uso en la elaboración del Trabajo fin de Grado para generar código porque estas herramientas no son fiables en esa tarea. Aunque el código funcione, no hay garantías de que metodológicamente sea correcto, y es altamente probable que no lo sea.

Por la presente, yo, Rafael Díaz Gutiérrez-Manchón, estudiante de Grado en Administración y Dirección de Empresas, de la Universidad Pontificia Comillas al presentar mi Trabajo Fin de Grado titulado "How Capital flows affect the magnitude and symmetry of Spillovers between the Triad - USA, China and Eurozone?" declaro que he utilizado la herramienta de Inteligencia Artificial Generativa ChatGPT u otras similares de IAG de código sólo en el contexto de las actividades descritas a continuación:

1. **Brainstorming de ideas de investigación:** Utilizado para idear y esbozar posibles áreas de investigación.
2. **Crítico:** Para encontrar contra-argumentos a una tesis específica que pretendo defender.
3. **Referencias:** Usado conjuntamente con otras herramientas, como Claude, para identificar referencias preliminares que luego he contrastado y validado.
4. **Metodólogo:** Para descubrir métodos aplicables a problemas específicos de investigación.
5. **Interpretador de código y resultados:** Para realizar análisis de datos preliminares y entender resultados estadísticos.
6. **Sintetizador y divulgador de libros complicados:** Para resumir y comprender literatura compleja.
7. **Generador de problemas de ejemplo:** Para ilustrar conceptos y técnicas.
8. **Revisor:** Para recibir sugerencias sobre cómo mejorar y perfeccionar el trabajo con diferentes niveles de exigencia.

Afirmo que toda la información y contenido presentados en este trabajo son producto de mi investigación y esfuerzo individual, excepto donde se ha indicado lo contrario y se han dado los créditos correspondientes (he incluido las referencias adecuadas en el TFG y he explicitado para que se ha usado ChatGPT u otras herramientas similares). Soy consciente de las implicaciones académicas y éticas de presentar un trabajo no original y acepto las consecuencias de cualquier violación a esta declaración.
Fecha: 26/05/2026
Firma:



7. **References**

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8. **Appendix: Matlab and Python Code**

A1. Matlab Script - TVP-VAR Estimation and Impulse Response Functions

```
clear
clc

data = readmatrix('DatasetV2_clean.xlsx');
Y = data(:, 1:3);
Y = Y / 100000;

nlag = 2;
N = 10000;
imax = 10;

setvar('data', Y, ['CF_US' 'CF_EA' 'CF_CN'], nlag)
setvar('intercept', 1)
setvar('SigB', 1)
setvar('fastimp', 1)
setvar('impulse', imax)

mcmc(N)

% FIGURE 6
mimpm = xlsread('tvpvar_imp.xlsx', 'Sheet1');

k = 3; imax = 10;
t_points = [33, 61, 71];
t_labels = {'2013Q1 (Tranquil period)', '2020Q1 (COVID-19 shock)', '2022Q3 (Rate hike cycle)'};
colors = {'b', 'r', 'g'};
horizons = 0:imax;

shock_names = {'CF\_US','CF\_US','CF\_US','CF\_EA','CF\_EA','CF\_EA','CF\_CN','CF\_CN','CF\_CN'};
resp_names  = {'CF\_US','CF\_EA','CF\_CN','CF\_US','CF\_EA','CF\_CN','CF\_US','CF\_EA','CF\_CN'};

figure('Position', [100 100 1400 900]);
col_idx = 1;
for shock = 1:k
    for resp = 1:k
        subplot(k, k, (resp-1)*k + shock);
        hold on;
        for tp = 1:3
            t_val = t_points(tp);
            start_row = (t_val - 1) * (imax + 1) + 1;
            rows = start_row : start_row + imax;
            irf_vals = mimpm(rows, col_idx + 2) * 100000;
            plot(horizons, irf_vals, colors{tp}, 'LineWidth', 2);
        end
        yline(0, 'k--', 'LineWidth', 0.5);
        title(['Shock: ' shock_names{col_idx} ' \rightarrow ' resp_names{col_idx}], 'FontSize', 7);
        xlabel('Quarters after shock');
        ylabel('Millions USD');
        legend(t_labels, 'FontSize', 6, 'Location', 'best');
        grid on;
        col_idx = col_idx + 1;
    end
end
sgtitle('TVP-IRFs: Portfolio Investment Inflows — Triad (2005Q1–2024Q4)', 'FontSize', 12);
```

A2. Python Script - 3D Surface Plots

```
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt

df = pd.read_excel('tvpvar_imp.xlsx', sheet_name='Sheet1', header=None)
data = df.iloc[3:, :].copy()
data.columns = ['t','horizon','US_from_US','EA_from_US','CN_from_US',
                'US_from_EA','EA_from_EA','CN_from_EA',
                'US_from_CN','EA_from_CN','CN_from_CN']
data['t'] = data['t'].ffill()
data = data.dropna(subset=['horizon'])
data = data[data['horizon'] != 'horizon']
data['t'] = data['t'].astype(float).astype(int)
data['horizon'] = data['horizon'].astype(float).astype(int)
data = data.dropna(subset=['US_from_US'])

scale = 100000
for col in data.columns[2:]:
    data[col] = data[col].astype(float) * scale

periods = sorted(data['t'].unique())
horizons = list(range(11))

def t_to_year(t):
    return 2005 + (t - 1) / 4

T_vals = np.array(periods)
T_years = np.array([t_to_year(t) for t in T_vals])
H_vals = np.array(horizons)
H_grid, T_grid = np.meshgrid(H_vals, T_years)

# Changed bottom-right from CN->US to EA->CN
panels = [
    ('EA_from_US', 'Shock: CF_US  |  Response: CF_EA'),
    ('CN_from_US', 'Shock: CF_US  |  Response: CF_CN'),
    ('US_from_EA', 'Shock: CF_EA  |  Response: CF_US'),
    ('CN_from_EA', 'Shock: CF_EA  |  Response: CF_CN'),
]

fig = plt.figure(figsize=(16, 12))
fig.patch.set_facecolor('white')

for idx, (col, title) in enumerate(panels):
    ax = fig.add_subplot(2, 2, idx+1, projection='3d')
    Z = np.zeros((len(T_vals), len(H_vals)), dtype=float)
    for ti, t in enumerate(T_vals):
        for hi, h in enumerate(H_vals):
            row = data[(data['t'] == t) & (data['horizon'] == h)]
            if not row.empty:
                Z[ti, hi] = row[col].values[0]
    surf = ax.plot_surface(H_grid, T_grid, Z, cmap='RdBu_r', alpha=0.88,
                           linewidth=0, antialiased=True)
    ax.plot_surface(H_grid, T_grid, np.zeros_like(Z), alpha=0.08, color='gray')
    ax.set_xlabel('Quarters\nafter shock', fontsize=8, labelpad=5)
    ax.set_ylabel('Year', fontsize=8, labelpad=5)
    ax.set_zlabel('Millions USD', fontsize=8, labelpad=5)
    ax.set_title(title, fontsize=9, fontweight='bold', pad=8)
    year_ticks = [2006, 2009, 2012, 2015, 2018, 2021, 2024]
    ax.set_yticks(year_ticks)
    ax.set_yticklabels(year_ticks, fontsize=7)
    ax.set_xticks(horizons)
    ax.tick_params(axis='z', labelsize=7)
    ax.view_init(elev=25, azim=-50)
    fig.colorbar(surf, ax=ax, shrink=0.4, aspect=8, pad=0.1)

fig.suptitle('TVP-IRF Surface Plots — Portfolio Investment Inflows, Triad
(2005Q3-2024Q4)',
             fontsize=13, fontweight='bold', y=1.01)
fig.text(0.5, -0.01,

         "Source: Author's own elaboration using Nakajima (2011) TVP-VAR package.",
         ha='center', fontsize=8, color='gray')

plt.savefig('Figure_3D_IRFs.png', dpi=180, bbox_inches='tight', facecolor='white')
plt.show()

```