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ORIGINAL ARTICLE

International spillovers of unconventional monetary policy: A meta-analysis

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Abstract

The impacts of the unconventional monetary policy measures adopted by central banks after the 2007 financial crisis have been the focus of an increasing number of empirical studies. While some studies have focused on the impacts on the domestic economy, others have examined the international spillover effects of the policies adopted by the major central banks. The latter studies have, however, reported heterogeneous results. In this paper, we develop a meta-analysis of the empirical literature that examines the spillover effects of unconventional monetary policy on international capital flows. We find that, while the global average effect is not statistically different from zero, there are specific effects that vary significantly according to the development level of the destination country, the nature of the capital flow, the Central Bank that adopts the UMP, and the type and year of implementation of the UMP measure.

Keywords Unconventional monetary policy · International spillovers · Capital flows · Meta-analysis

JEL code E42 · E52 · E58 · F20 · F33

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1 Introduction

The financial crisis triggered in 2007 marked an important turning point as far as monetary policy is concerned. Despite the attempt to use conventional instruments, such as interest rates, to control and mitigate the effects of the recession, central banks were faced with a scenario where such instruments proved ineffective and insufficient to deal with deflationary pressures and weak economic growth. As such, they were forced to change their *modus operandi* and restructure their set of monetary policy instruments.

The major central banks, such as the Federal Reserve and the European Central Bank, implemented unconventional monetary policy (UMP) measures after the financial crisis to mitigate and prevent a series of economic and financial risks and disturbances. Examples of UMP measures are forward guidance (trying to shape public expectations), quantitative easing and qualitative easing (changing the size and composition of the central bank's balance sheet), and the use of negative interest rates.

As globalization advanced and economic and financial integration among countries increased, the topic of monetary policy, the way it is transmitted, and its effects have become a prominent object of study. As far as the UMP measures are concerned, the literature has found important effects not only in the domestic economy but also in external markets (e.g., Fratzscher et al. 2016; Karolyi et al. 2019; Rey 2015) – the international spillovers effects. In fact, a relevant body of literature has focused on examining the impacts of UMP measures implemented by the major central banks on the flows of capital and on the financial conditions of other economies, especially emerging economies (Bowman et al. 2015; Eichengreen and Gupta 2015; Lakdawala 2021; Tillmann 2016). However, the results obtained are quite heterogeneous regarding both the direction (positive or negative) and the magnitude of such impacts. In addition, the studies differ significantly according to the sample of countries they analyze, the type of UMP measure analyzed, the variables used, and the estimation techniques.

In this paper, we develop a meta-analysis of the literature that estimates the spillover effects on international capital flows of UMP measures implemented by the major central banks, with the aim of identifying patterns in the reported results and explaining their heterogeneity. Meta-analysis is a quantitative literature review that allows one to combine, compare, and summarize the results of different studies on a specific topic and identify patterns among them (Forza & Di Nuzzo, 1988; Cardoso, 2021). Originally used in psychology and medical sciences, it rapidly spread to other scientific disciplines, including economics. It has been particularly useful when the empirical results on a specific topic are not consensual, as it allows for the identification of the sources of disagreement and contributes to a better understanding of the phenomenon under analysis (Greenland and O'Rourke 2008).

The results of our meta-analysis show that the overall average effect of UMP measures on international capital flows is close to zero. However, there are specific effects that vary significantly according to the development level of the

destination country, the nature of the capital flow, the Central Bank that adopts the UMP, and the type and year of implementation of the UMP measure. In particular, we find that:

(i) UMP has originated lower volumes of capital flows to emerging countries than to more advanced economies;
(ii) quantitative easing has generated stronger impacts on flows than other measures of UMP;
(iii) the effects on the flows of bonds have been significantly lower than the effects on other types of flows;
(iv) the UMP measures adopted by the FED had stronger effects than those adopted by other Central Banks;
(v) the magnitude of the effects was lower in the period 2008- 2009, becoming stronger in subsequent years.

The paper is structured as follows. After the Introduction (Sect. 1), in Sect. 2 we present a description of the main UMP instruments and their transmission channels. In Sect. 3 we review the literature on the topic, and in Sect. 4 the meta-analysis is conducted. Section 5 concludes.

2 Unconventional monetary policy

According to Bernanke et al. (2004), there are four main measures of UMP: forward guidance; quantitative easing; qualitative easing; and negative interest rates.

2.1 Forward guidance

Forward guidance was first overtly implemented by the Bank of Japan in 1999 in the context of the adoption of the zero-interest rate policy. A few years later, a number of countries that aimed to keep inflation at low levels used this instrument to regularly issue quantitative statements about their future interest rate outlook (Filardo and Hofmann 2014).

According to Filardo and Hofmann (2014), forward guidance has become a key element in the conduction of monetary policy since 2008. The major central banks have since then used this instrument on a regular basis, making several predictions about the evolution of future interest rates and, in some situations, about other specific economic variables, such as the unemployment rate.

Bernanke (2013) argues that forward guidance affects not only short-term interest rates, as it influences the investors' expectations in the current period, but also the long-term interest rates. It also reduces uncertainty, which further contributes to reducing interest rates. Moreover, some studies (Eggertsson and Woodford 2003; Krugman et al. 1998; Werning 2011) suggest that when the Zero Lower Bound problem occurs, it is possible to stimulate current aggregate demand, ensuring that

interest rates will remain at zero for longer than required by economic and financial conditions.

According to Campbell et al. (2012), two types of forward guidance can be distinguished: Delphic and Odyssean. The former consists of a clear statement of a forecast of macroeconomic performance and actions to be implemented, based on the central bank's objectives, even if it does not publicly commit the central bank to follow the outlined course. This type of instrument can reduce investors' uncertainty and consequently improve macroeconomic indicators. Odyssean forward guidance commits the central bank to stick to the publicly stated course. Campbell et al. (2012) argue that, although it may seem risky to take such a position, in the presence of uncertainty economic fluctuations periodically present opportunities for the monetary policy in place to benefit from the positions taken arising from odyssean forward guidance. In this way, central banks can manage the public's expectations in the short term by improving macroeconomic indicators.

2.2 Quantitative easing

The best-known UMP instrument is quantitative easing (QE). The concept was first introduced in Japan in the 1990s, when the country was facing a housing market crisis and deflationary pressures, and subsequently gained prominence in the aftermath of the Lehman Brothers bank failure (Joyce et al. 2012).

Bernanke et al. (2004) define QE as a monetary policy that expands the size of the central bank's balance sheet by increasing its monetary base in the economy (in particular, bank reserves). This instrument is opposed to qualitative easing, since the former does not change the composition of the balance sheet. QE involves the purchase of assets by the central banks on a large scale. Joyce et al. (2010) state that by increasing the monetary base of the economy, QE also triggers an increase in nominal spending. In this way, it is possible to ensure the control of inflation in the medium term, keeping it on its intended course.

By injecting liquidity into the economy in exchange for other assets, the central bank increases private sector liquidity. Moreover, the central bank's demand for the assets held by the private sector will increase their prices, which leads to a reduction in the costs of financing and encourages consumption and investment (Joyce et al. 2010). In addition, QE can also generate positive effects in the economy via expectations, as central banks show that they are willing to do what is necessary to meet the inflation targets.

When adopted by the FED, this strategy aimed at stabilizing the financial market and economic activity in the US. However, in addition to its impact at the domestic level, QE policies affected asset prices globally and were the main driver of increased capital flows to emerging economies (Fratzscher et al. 2018).

2.3 Qualitative easing

The analysis of the FED's balance sheet during the crisis makes it possible to identify the dimensional and structural changes that occurred in this period. In the

pre-bankruptcy phase of Lehman Brothers, the three central banks - the European Central Bank, the Federal Reserve, and the Bank of England - instead of changing the size of their balance sheets, supported the financial markets by modifying their composition and structure in various ways. They sold conventional assets considered "good," such as government bonds, while buying assets considered "bad," such as bank funding. This deteriorated the composition of the central banks' balance sheet, hence this policy is called qualitative easing (Lenza et al. 2010).

According to Bagus and Schiml (2009) the adoption of qualitative easing measures by the central banks shows a clear effort to save the banking system, which at the time had a low degree of liquidity. The main objective of this measure was to transfer the "good" assets to commercial banks and to give them the ability to finance themselves again, using them as collateral.

2.4 Negative interest rates

The interest rate is a common instrument and is usually not part of unconventional monetary policy instruments. However, according to Fiedler et al. (2016), it can be important to reduce the inefficiencies of monetary policy transmission mechanisms.

In 2012, the Danish Central Bank lowered its interest rate to negative values for the first time. Later, in 2014 the European Central Bank took the same stance in an experimental way by introducing negative interest rates, followed by several central banks in other countries (Liu and Fang 2020; López-Penabad et al. 2022).

The implementation of negative interest rates means that central banks are paying interest on the excess reserves of commercial banks in an attempt to encourage them to inject liquidity back into the economy. This is expected to positively affect economic activity, by increasing the supply and demand for loans due to lower costs for both banks and borrowers.

However, negative interest rates also have disadvantages for central banks, as well as for commercial banks and depositors. As far as central banks are concerned, the greatest risk is that this instrument leads to an obstacle to further reducing interest rates to deal with a possible new shock. Regarding commercial banks, the reduction in interest rates may lead to lower results and to a reduction in the global amount of credit and reserves. As for depositors, the reduction in interest rates to a negative value discourages individuals not only from saving but also from keeping their deposits.

2.5 Non-conventional monetary policy transmission channels

The channels through which UMP affect macroeconomic variables are complex and depend on the positions of the various economic agents in the transmission process. The effects are not mutually exclusive and can be transmitted directly and indirectly to the economy (Fiedler et al. 2016; Fratzscher et al. 2016).

The first channel, called portfolio balance channel, can be activated by measures that cause an expansion or change in the composition of the central bank's balance sheet, relating it to quantitative and qualitative easing policies. This channel is based

on changes in investors' behaviour and choices as the central bank modifies the supply of certain assets. Taking as an example the measures to increase liquidity, the central bank reduces the relative supply of the assets it buys, causing an increase in prices and a reduction in its profitability. This mechanism also forces investors who hold those assets to rebalance their portfolios by replacing them. Thus, an increase in demand arises again, leading to a generalized increase in asset prices and a decrease in interest rates and yields (Fiedler et al. 2016; Fratzscher et al. 2018). This transmission channel can generate a spillover effect and capital outflows, as investors have the possibility to choose assets from external economies.

The signaling channel is a second mechanism through which central banks' interventions can influence asset prices and investors' portfolio decisions. Announcements about future events, such as interest rate changes and QE program implementations, in case they are perceived by the market as a future interest rate decline below what was expected, prevent asset prices from falling (e.g., Cecioni et al. 2011; Fratzscher et al. 2018).

At the same time, the announcements of central banks can provide new information about the state of the economy, introducing confidence in the financial system. This impacts economic agents, in particular in shaping their current expectations about the future. This third channel, dubbed the confidence channel, can affect portfolio decisions and asset prices by changing investors' risk propensity (Fratzscher et al. 2016, 2018). Therefore, the impacts of the central bank announcements can generate spillover effects similar to those mentioned in the portfolio balance channel.

Finally, the exchange rate channel results from capital flows between economies. In the scenario of a large-scale asset purchase by a major central bank, there will be an increase in demand for foreign currency if foreign investors hold part of those assets. In addition to leading to a depreciation of the exchange rate, this event may worsen the situation if, in the process of portfolio rebalancing, domestic investors purchase assets denominated in foreign currency (Fiedler et al. 2016). As in the previous channel, this mechanism also generates spillover effects via capital flows, which depend on agents' decisions.

3 Literature review

Over the last few years, a considerable increase in capital flows between advanced economies (AE) and emerging markets (EME) has been observed. According to Fratzcher (2012), this phenomenon is explained by the fact that interest rates in developed economies have remained low, in contrast to the higher rates in many EME.

Increasing capital flows have triggered a debate around the effects of UMP implemented by the major central banks on both the domestic and external economies (e.g., Fratzscher et al. 2016; Karolyi et al. 2019; Rey 2015), especially EME. The literature that emerged after the implementation of QE has sought to quantify its impacts on a range of macroeconomic phenomena, such as interest rates (Christensen and Rudebusch 2012; Gagnon et al. 2011; Krishnamurthy and Vissing-Jorgensen 2011; Pesaran and Smith 2016), risk premia in financial markets (Bauer and

Rudebusch 2014; Breedon et al. 2012), gross domestic product (GDP) and inflation (Chen et al. 2012; Kapetanios et al. 2012).

The mainstream literature on the determinants of capital flows to EME uses the traditional "push"[1] and "pull"[2] approach to identify global and country-specific determinants, respectively (e.g., Ghosh et al. 2014). This literature can be subdivided into three main branches: the first branch focuses on capital flows directed to EME, without distinguishing between the various forms of flows (Calvo et al. 1996; Eller et al. 2020; Fernandez-Arias 1996; Ghosh et al. 2014), and highlights the predominance of global factors over local factors; the second branch differentiates between different forms of capital flows, such as foreign direct investment, debt, and flows related to changes in portfolio composition (Broto et al. 2011; Contessi et al. 2013; Kim and Wu 2008); the third branch includes more recent studies that focus on a specific type of capital flows, such as stocks and bonds, and its impact on external economies (Andreou et al. 2022; Bathia et al. 2020; Dahlhaus and Vasishtha 2020; Fratzscher et al. 2016; Koepke 2018; Li et al. 2018).

Within the third branch of literature, Andreou et al. (2022) assess the impact of net capital flows to EME arising from the growth of assets held by the FED and find a statistically significant effect. Ahmed and Zlate (2014) study the effects of UMP announcements on net portfolio capital flows in 12 EME, finding that, since the financial crisis, capital flows have decreased significantly.

In addition to push and pull factors, Forbes and Warnock (2012) and Li et al. (2018) also include "contagion" as an additional set of variables that determine international capital flows. In particular, they identify three ways through which contagion effects are captured: trade linkages, financial linkages, and geographic proximity. The authors use gross financial flows, arguing that the results obtained from studies using net capital flows may be inaccurate since domestic investors' decisions embodied in capital outflows may be driven by different factors, even if gross capital inflows and outflows have a similar pattern.

Using a sample of 46 EME, Gamboa-Estrada (2020) shows that the effects of UMP depend on the type of measure adopted, the type of flow and the direct financial exposure of each country to the US economy. The results indicate that the impacts on flows are greater in the long run, highlighting the role of policy transmission channels.

Anaya et al. (2017), Chari et al. (2021), Fratzscher et al. (2012) and Kiendrebeogo (2016) find that the unconventional measures implemented by the FED had considerable impacts on flows at the portfolio composition level from the United States to EME, and to a lesser extent to AE. Kiendrebeogo (2016) also concludes that UMP measures are associated with higher levels of bond flows to EME than other flows, such as equities.

[1] Pull factors correspond to country-specific variables, such as macroeconomic fundamentals and political characteristics.

[2] Push factors are related to global conditions that capture the external economic environment for investment in emerging economies (e.g., global liquidity, global risk, etc.).

Chari et al. (2021) emphasize the importance of the transmission channels of unconventional policy and find a substantial difference between the effects of UMP during the QE period and in the subsequent retrenchment period. Their results show that during the QE period, there were no significant effects on capital flows to EMEs, in contrast to the subsequent period, in which large decreases in flows in the opposite direction were observed.

Lim and Mohapatra (2016) analyze the effect of the US QE measures on gross financial flows in EME and assess to which extent such measures generate different impacts on different classes of flows. The authors focus their analysis on gross capital movements, since these have a greater responsiveness to monetary phenomena. This makes them particularly important to understand the potential spillover effects, especially to EME. They find that flows directed to this type of economy happen via transmission mechanisms, namely the portfolio balance channel and the confidence channel. In addition, the results point to heterogeneity in the type of flows impacted by UMP, showing a greater effect on portfolio flows compared to foreign direct investment.

Finally, Fratzscher et al. (2012) and Fratzscher et al. (2018) divide the QE measures into different time periods, checking for the possible existence of different results among them. The articles classify the periods in question as QE1, QE2 and QE3, corresponding to the years 2008–2009, 2010–2011 and 2012, respectively. The results show that the QE1 measures triggered a portfolio rebalancing, with flows migrating from EME and other AE mainly to US assets and bonds. In contrast, QE2 and QE3 measures had a strong impact on flows to EME. The authors also argue that in periods when economic uncertainty is low and there is an environment of optimism among investors, QE policies generate higher levels of capital flows to non-US markets. However, whenever there are expectations of economic recession and fears of future instability, the flows change to the opposite direction.

Thus, the results of the empirical literature that estimates the effects of UMP on economic flows are somewhat divergent. The meta-analysis performed in the next sections helps to systematize the main results and explain their heterogeneity.

4 Meta-analysis

4.1 Concept and objectives

Meta-analysis is described as a quantitative literature review through which statistical procedures are used to systematize and compare the findings of several empirical studies on a specific research question (Stanley and Jarrell 1989). It is particularly useful when the findings of the empirical literature are not consensual, because it allows identifying the sources of divergence in an objective way. The analysis of the sources of heterogeneity of the studies' findings is often conducted by estimating a multivariate meta-regression, as follows Eq. (1):

$$b_j = \beta + \sum_{k=1}^{K} \alpha_k Z_{kj} + e_j, \ (j = 1, 2, \ldots, L) \quad (1)$$

where: b_j is the reported estimate of the phenomenon β of interest in study j in a literature comprised of L studies; Z_{kj} corresponds to the K meta-independent variables that measure relevant characteristics of the primary empirical studies (e.g., estimation techniques, sample period, data structure); α_k are the meta-regression coefficients; and e_j is the usual regression error (Pinheiro et al. 2023). Thus, the estimation of Eq. (1) allows examining how the studies' characteristics influence the results reported in the primary studies, thereby contributing to explaining differences among them. Typically, conducting a meta-analysis involves the following steps: formulation of the problem, collection and selection of studies to be included, data assessment, meta-analytic estimations, and results presentation (Cook et al. 1992; Forza and Di Nuzzo 1998).

4.2 Studies selection

To select the studies to be included in the meta-analysis, we started by searching in the Scopus and Web of Science databases for articles containing the terms "unconventional monetary policy spillovers", "unconventional monetary policy and capital flows" and "impacts of unconventional monetary policy on flows". Since the focus is on empirical articles that analyze the effect of UMP on capital flows with foreign countries, we applied the following inclusion criteria:

i) only empirical studies should be included – therefore, theoretical works were excluded;
ii) studies must report at least one estimate of the effect of UMP on capital flows with foreign countries – thus, we excluded papers that analyze the effects of UMP in the domestic economy;
iii) studies must also report the necessary statistics to conduct the meta-analysis – therefore, articles that do not provide the estimated coefficient of the effect of UMP on capital flows, the respective standard errors or the number of observations could not be considered in the meta-analysis;
iv) all types of works should be included, namely journal articles, book chapters or working papers.

Applying all these criteria, we obtained nine studies to be included in the meta-analysis. From these, we collected 254 estimates of the effect under analysis. Six of the nine selected studies use QE as the measure of UMP. Most of them analyze the effects on capital flows to emerging economies. While most of the observations are related to monetary policies implemented by the Federal Reserve (240), there are also others related to policies implemented by the European Central Bank (7) and by the Bank of Japan (7). In Table 1 we present some characteristics and relevant information of the selected studies.

Table 1 Summary of the main characteristics of the studies included in the meta-analysis

(1) Study	(2) Nr. of estimates	(3) Average of effect sizes	(4) Average of SE	(5) UMP measure>	(6) Destination of flows	(7) Central Bank
Andreou et al. (2022)	21	0.02537	0.03855	QE	EME	FED, ECB, BOJ
Kiendrebeogo (2016)	20	0.00171	0.04607	Other	EME and EA	FED
Lakdawala (2021)	2	−0.22955	0.11323	Other	EME	FED
Ahmed and Zlate (2014)	24	−0.01819	0.04460	Mix QE and Other	EME	FED
Chari et al. (2021)	12	−0.04271	0.02072	Mix QE and Other	EME	FED
Gamboa-Estrada (2020)	17	−0.01496	0.02277	Other	EME	FED
Lim and Mohapatra (2016).	48	0.09718	0.04353	QE	EME	FED
Fratzscher et al. (2012)	30	0.00564	0.00425	Mix QE and Other	EME and EA	FED
Fratzscher et al. (2018)	80	−0.00342	0.00551	Mix QE and Other	EME and EA	FED

QE - quantitative easing; *EME* - emerging economies; *AE* - advanced economies; *FED* – Federal Reserve; *ECB* – European Central Bank; *BOJ* – Bank of Japan

Since the studies use different scales for the relevant variables and different methods to measure the effect of UMP, it is necessary to convert the reported estimates to a common metric. To do so, we calculate the partial correlation coefficient (r) and its standard error (se), which are equal to Eq. (2) and (3):

$$r_i = t_i / \sqrt{t_i^2 + df_i} \tag{2}$$

$$se_i = \sqrt{(1 - r_i^2)/df_i} \tag{3}$$

In expressions (2) and (3), t_i denotes the t-statistic associated with the coefficient measuring the effect of UMP on flows, reported in the i-th estimate (i = 1,2,3, …, 254), and df_i denotes the respective degrees of freedom.

Thus, in our meta-analysis partial correlation coefficients are standardized measures of the effect of UMP on capital flows. They are comparable across studies, as they are unaffected by the metrics used by the primary studies for measuring the UMP and the capital flow variables (Ugur, 2014).

The estimates of r_i range between a minimum of -0.38038 and a maximum of 0.47619. Of the set of 254 estimates considered, 175 are positive and 79 are negative. The mean values of the estimates of r_i and se_i for each study are shown in Table 1, Columns (3) and (4).

4.3 Average effect and publication bias

We start by calculating the average effect of the reported estimates. In a meta-analysis, the traditional methods used to calculate the average effect size are fixed effects and random effects. The fixed effects method assumes that there is only one underlying effect and that all the differences in the reported effect sizes result from sampling error. It corresponds to a weighted average of all the reported estimates of the effect size, r_i, with weights given by the inverse of their respective variance, $1/se_i^2$. The random effects method assumes that there is heterogeneity in the studies' results, as each study has its own underlying effect. In this case, the heterogeneity observed in the reported estimates results not only from sampling variation, but also from the random variability of the true effects. The random effects estimator is also a weighted average of the reported effect sizes, with weights given by $1/(se_i^2 + \theta^2)$, where se_i^2 represents the variance of the sample error and θ^2 a measure of the variance of the true effect (Hedges and Olkin 1985; Sutton et al. 2000; Dominicis et al. 2008).

Thus, the average fixed effect is computed according to Eq. (4) and (5):

$$r_{FE} = \frac{\sum_{i=1}^{254} \frac{1}{se_i^2} r_i}{\sum_{i=1}^{254} \frac{1}{se_i^2}} \tag{4}$$

while the average random effect is equal to:

$$r_{RE} = \frac{\sum_{i=1}^{254} \frac{1}{se_i^2+\theta^2} r_i}{\sum_{i=1}^{254} \frac{1}{se_i^2+\theta^2}} \quad (5)$$

Applying expressions (4) and (5) to our meta-data sample, we obtained average effects of -0.00056 and 0.00673 for the fixed effects and the random effects estimators, respectively.

Although weighted averages are more accurate than simple averages, they cannot be considered reliable estimators of the average true effect in the presence of publication bias. Publication bias occurs when articles with statistically significant results are more likely to be published than articles with non-significant results. This leads to a bias in the empirical estimates, as the reported effects tend to have a greater magnitude than the real effect (Doucouliagos 2005; Stanley 2005; Stanley et al. 2008).

Although there are several methods to test for the presence of publication bias (Stanley 2005), we first focus on the funnel plot. Popularized by Egger et al. (1997), the funnel plot is represented by a scatter diagram, with the effect size on the horizontal axis and its precision (the inverse of the standard error) on the vertical axis. If there is no publication bias, the diagram should take the form of an inverted funnel, as the estimates will be randomly distributed around the mean in a symmetric way. However, in the presence of publication bias, studies with higher standard errors tend to report higher estimates to obtain statistically significant results, deforming the shape of the funnel (Stanley 2005). In this case, the diagram is expected to be asymmetrically distributed.

Inspection of Fig. 1 suggests that the funnel shape is not perfectly defined, with a lack of observations in the centre of the graph. However, there does not seem to be an asymmetry to either the left or the right side of the plot. In the face of these inconclusive results, we use a more rigorous technique that consists in estimating a simple regression of the partial correlation coefficient on its standard error Eq. (6) :

$$r_i = \alpha_0 + \alpha_1 se_i + \mu_i \quad (6)$$

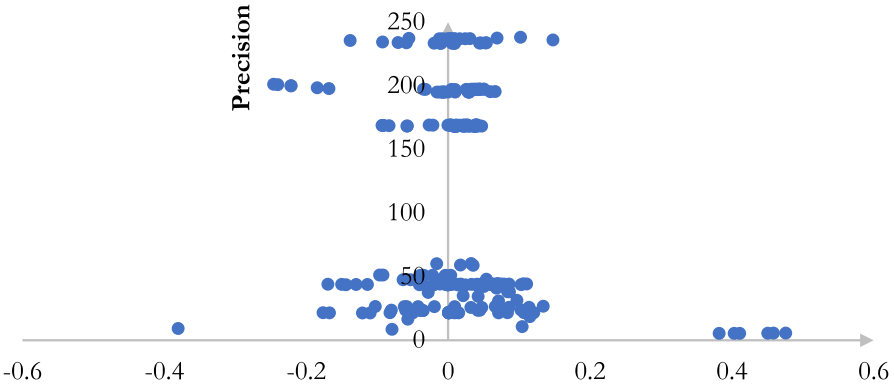

Fig. 1 Funnel plot of the effects of unconventional monetary policy on capital flows

According to Stanley (2005), in the absence of publication bias, r_i and se_i are not correlated and α_1 is not statistically different from zero, as estimates vary randomly around the mean effect, α_0, regardless of the value of the standard error. On the other hand, if there is publication bias, r_i and se_i will be correlated and α_1 will be statistically different from zero, because studies with higher standard errors will tend to report effects with higher magnitudes. Therefore, the estimation of Eq. (6) allows testing for both the presence of publication bias (through the Funnel Asymmetry Test, $\alpha_1 = 0$) and the existence of a significant average effect (through the Precision Effect Test, $\alpha_0 = 0$) – Egger et al. 1997; Stanley 2005. However, the estimation of (6) by OLS has two econometric problems: heteroscedasticity and statistical dependence. Heteroscedasticity occurs because each estimate collected from the primary studies has its own standard error and, therefore, the errors in (6) do not have the same variance. This problem can be solved by dividing Eq. (6) by the standard errors, se_i (Stanley 2005), which leads to Eq. (7):

$$t_i = \alpha_0 precision_i + \alpha_1 + V_i \tag{7}$$

where t_i represents the t-statistic associated with r_i in the primary studies, and *precision* is equal to $1/se_i$. The coefficients in Eq. (7) are now reversed, as the Funnel Asymmetry Test is now a test for the constant α_1, whereas the Precision Effect test is a test for the slope α_0.

The second problem is related to the possible existence of correlation within each study. When several observations taken from the same primary study are used, they share the same databases, specifications, and estimation procedures, and therefore they are likely to be correlated (Nelson and Kennedy 2009). In this case, OLS estimators will be biased and statistical inference will not be valid. We address this problem by using two alternative methods: OLS with clustered standard errors and hierarchical models (Nelson and Kennedy 2009). In the first case, the coefficients are estimated by OLS, but the standard errors are clustered in groups, each group corresponding to a different study. In addition to correcting

Table 2 Results of the estimation of Eq. (4)

	(1)	(2)
	OLS with clustered SE	Hierarchical models
Precision	−0.00392	−0.00392
	(0.00682)	(0.00681)
Constant	0.57653	0.57653
	(0.82105)	(0.81942)
Nr. of obs (studies)	254 (9)	254 (9)

The dependent variable is *t*. Standard errors are in parentheses. Significance level: *** for *p*-value < 0.01, ** for *p*-value < 0.05, * for *p*-value < 0.1. Coefficients estimated by OLS in (1) and maximum likelihood in (2).

the standard errors for correlation within each group, estimation using hierarchical models allows regression coefficients to vary randomly across studies, as each coefficient has a fixed part, common to all studies, and a random part, representing variation across studies.

Table 2 shows the results of the estimation of Eq. (7) using both OLS with clustered standard errors and hierarchical models. The constant is not statistically different from 0, meaning that there is no evidence of publication bias in the literature that estimates the international spillover effects on capital flows of UMP. The results also show that variable *Precision* is not significant, which implies that, on average, the effect size is close to 0.

4.4 Multivariate meta-regression

In this section, we estimate a multivariate meta-regression to examine how certain characteristics of the primary studies explain the heterogeneity in the reported results. Most of these characteristics are captured by dummy variables, which assume the value 1 if a specific attribute is present and 0 otherwise. We account for differences in the: nature of the implemented UMP measure; type of capital flow that is analyzed; destination country of the capital flow; central bank that implemented the UMP measure; period under analysis; year of publication of the study; number of citations that the study has received; number of observations; year of publication. Table 3 describes in detail the moderator variables to be included in the multivariate meta-regression.

The estimation results are reported in Table 4. Variables *MetEstim*, *Obs* and *Cit* are not statistically significant, meaning that the reported spillover effects of UMP on flows did not vary with the estimation method employed, the number of observations or the number of citations the primary studies have received.

On the contrary, dummy *FED* is significant at 5% in both regressions and has a positive coefficient, implying that the international spillover effects of the FED's UMP measures were, in general, stronger than the effects of the policies adopted by other major Central Banks. Dummy *EME* is also statistically significant, its negative coefficient suggesting that the international spillovers were less pronounced in emerging economies than in other countries. However, the effects were not statistically different across different groups of emerging economies, as the interactions of *FED* with dummies *ASIA*, *EMEA* and *LA* are not statistically significant.

Dummies *QE* and *Bonds* are also statistically significant, with a positive and negative coefficient, respectively. This means that quantitative easing produced stronger effects on international flows than other forms of UMP, and that the effects of UMP on the flow of bonds were smaller than the effects on other types of flows. Moreover, the positive coefficient of variable *Period*, together with the negative coefficient of QE1, shows that the effects of UMP on international flows were lower in the initial years, becoming increasingly stronger in the years after the 2008–2009 period.

Table 3 Moderator variables of the meta-regression

Variable	Type	Description	Mean	Standard deviation	Description
Period	Quantitative	Mean year of the time span considered in the sample subtracted by 2008.	2.16	1.25	
Cit	Quantitative	Square root of the number of citations, taken from Google Scholar on 05.06.2022.	14.21	10.45	
FED	Dummy	1 if the monetary policy measure was implemented by the FED, 0 otherwise.	0.944	0.23	
Obs	Quantitative	Square root of the number of observations.	104.03	83.53	
MetEstim	Dummy	1 if the fixed effects method was used in the estimation, 0 otherwise.	0.48	0.50	
EME	Dummy	1 if the destination country of the flows is an EME, 0 otherwise.	0.69	0.47	
ASIA	Dummy	1 if the destination country of the flows belongs to Asia, 0 otherwise.	0.02	0.14	
EMEA	Dummy	1 if the destination country of the flows belongs to the EMEA (Europe, Middle East and Africa) region, 0 otherwise.	0.01	0.11	
LA	Dummy	1 if the destination country of the flows belongs to Latin America, 0 otherwise.	0.01	0.11	
QE	Dummy	1 if the implemented UMP measure is QE, 0 otherwise.	0.59	0.49	
QE1	Dummy	1 if the period in which UMP was implemented is QE1, 0 otherwise.	0.09	0.29	
QE2	Dummy	1 if the period in which UMP was implemented is QE2, 0 otherwise.	0.09	0.29	

Table 4 Results of the estimation of the multivariate meta-regression

	(1) OLS with clustered SE	2) Hierarchical models
Precision	−0.13004**	−0.13004***
	(0.04889)	(0.04752)
Period	0.02541*	0.02541**
	(0.01191)	(0.01158)
Cit	−0.00303	−0.00160*
	(0.00164)	(0.00164)
FED	0.09247**	0.09247***
	(0.03642)	(0.03540)
Obs	−0.00001	−0.00001
	(0.00021)	(0.00021)
MetEstim	0.08683	0.08683
	(0.06534)	(0.06534)
EME	−0.01527**	−0.01527***
	(0.00556)	(0.00540)
FED*ASIA	0.04299	0.04299
	(0.12245)	(0.11901)
FED*EMEA	−0.01174	−0.01174
	(0.02407)	(0.02340)
FED*LA	0.01668	0.01668
	(0.02407)	(0.02340)
Bonds	−0.03929**	−0.03929**
	(0.01647)	(0.01601)
QE	0.01770***	0.01770***
	(0.00530)	(0.00515)
QE1	−0.05428*	−0.05428**
	(0.02695)	(0.02619)
QE2	0.00268	0.00268
	(0.02269)	(0.02205)
Constant	0.74902	0.74902
	(0.71013)	(0.69020)
No. of obs. (studies)	254 (9)	254 (9)

The dependent variable is *t*. Standard errors are in parentheses. Significance level: *** for p-value < 0.01, ** for p-value < 0.05, * for p-value < 0.1. Coefficients estimated by OLS in (1) and maximum likelihood in (2)

5 Conclusion

The financial crisis in 2007 forced central banks to adopt unconventional monetary policy measures to mitigate economic and financial risks and disturbances. This paper focused on the policies and actions adopted by the major central

banks, with an emphasis on their impacts on international capital flows between advanced and emerging market economies in the post-crisis period.

The empirical literature reports the existence of important international spillover effects arising from the adoption of unconventional monetary policy measures. However, different studies have different characteristics and methodologies, resulting in different reported effects. We developed a meta-analysis of this literature with the aim of identifying some patterns and the sources of the results' heterogeneity.

We found that the international spillover effect is, on average, close to zero. However, such an effect tends to positively influence flows in some circumstances and negatively in others. In particular, the results of the estimation of the meta-regression suggest that: (i) unconventional monetary policy has originated lower volumes of capital flows to emerging countries than to more advanced economies; (ii) quantitative easing has generated stronger impacts on flows than other measures of unconventional monetary policy; (iii) the effects on the flows of bonds have been significantly lower than the effects on other types of flows; (iv) the international spillover effects of the FED's UMP measures were in general stronger than the effects of the policies adopted by other major Central Banks; v) the magnitude of the effects was lower in the period 2008–2009, becoming stronger in the subsequent years. Moreover, we found no evidence that other characteristics of the primary studies, such as the estimation method, the number of observations or the number of citations obtained, influence the magnitude of the effect size.

The meta-analysis results highlight the need to investigate further the external effects of unconventional monetary policies and their causes and specificities to help policymakers in the affected economies design the most appropriate policies.

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Data Availability Data used in this research are available upon request.

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