Augmented Taylor rule *versus* macroprudential rule.

What DSGE models tell us?

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Abstract

We perform a meta-analysis of 18 DSGE models that all specify the policy mix between monetary policy and macroprudential policy. These models have in common to incorporate macroprudential policies, particularly in the form of rules used to limit financial fluctuations, and represent monetary policy through an augmented Taylor rule which adjust the interest rate to the inflation gap, the output gap and a financial gap. We consider the response to the financial gap in the augmented Taylor rule as our dependent variable considering that its value is representative of the policy mix between monetary policy and macroprudential policy. The higher the value of this response coefficient, the more these two policies are combined ("integrated policy mix") in order to seek, jointly, a financial stability objective. Conversely, the lowest this value is the less these two policies are combined ("separated policy mix"), each standing on its target (the stability of inflation and output for monetary policy, financial stability for macroprudential policy). In the relationship that we test our explained variable is mainly linked to the type of macroprudential instruments, to the magnitude in the Taylor rule of the response coefficients on inflation and the output gap, and to the method for obtaining parameters (by optimization or calibration). Our results suggest that the type of macroprudential instruments significantly influences the choice of the policy mix between monetary policy and macroprudential policy, and that this policy mix is less "integrated" when the monetary policy rule grants importance to inflation.

Keywords: policy-mix, monetary policy, augmented Taylor rule, macroprudential policy.

JEL codes: E3, E5, E6, G01, G28

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1. **Introduction:**

In the United States, United Kingdom, as in the European Union, the reforms undertaken in response to the financial crisis consist largely in strengthening the prudential framework for banks. The new institutional framework of regulation involves central banks more than before. In fact, the Bank of England has got a large part of the prerogatives of the Financial Services Authority in the field of banking supervision. Indeed since the Banking Act of 2009 the mandate of the Bank of England has been broadened with increased responsibility for financial stability. At the institutional level, this translates into the establishment within the Bank of England of a new financial policy committee alongside the traditional monetary policy committee. Similarly, the Federal Reserve is now in charge of monitoring systemic institutions when the European Central Bank (ECB) prepares itself to become the supervisor of major banks in the area euro. For the moment, it is especially a microprudential involvement of central banks in financial supervision.

However, several evolutions at the institutional level also reflect the development of a macroprudential policy with the objective of safeguarding the stability of the financial system as a whole. Within the European Union the European Systemic Risk Board (ESRB) has been established since January 2011, and progressively its national equivalents are put in place across each Member state. In the United States, the Dodd-Frank Act, approved in July 2010, has assigned the task of monitoring systemic risk to the Financial Stability Oversight Council (FSOC) attached to the U.S. Treasury. The identification of systemic risks and the monitoring of systemic institutions (SIFIs) are among the main tasks of the FSOC. These committees are beginning to lay the groundwork for future macroprudential policy and should choose the best instruments to prevent systemic risk.

The difficulty to which macroprudential and monetary authorities, whether or not under the same roof of the central bank, will soon be confronted is the coordination of the actions of their respective policies. To address financial instability, should monetary policy be more *'lean'* ? Augmenting the Taylor rule (1993) with a financial target to allow the interest rate to react to financial stress was one of the first ways to consider the end of the so-called 'separation principle' (Christiano et al. 2010; Curdia and Woodford, 2010; Issing, 2011). From this point of view, the financial crisis seems to have shift the strategic considerations about monetary policy and weaken the strategy of '*cleaning up afterwards'*.

The advent of macroprudential instruments, however, radically shifted the debate 'clean' versus 'lean'. Presented as the effective instrument against financial instability, macroprudential instruments tend to restore the consensus that prevailed before the crisis: the interest rate is not the best instrument to dampen financial instability, the standard Taylor rule becomes the preferred option, and with it the regime of inflation targeting. Several simulations (Bank of England, 2009; Bean et al., 2010) have indeed shown that an augmented Taylor rule alone does not constitute a possible alternative to a set of tools dedicated to macroprudential policy, because if all the efforts of restraining financial misalignments rely on the sole interest rate instrument, it would be necessary in certain situations to raise it to unlikely high levels. This illustrates one of the most basic lessons in economic policy, that derives from the Tinbergen principle (1952) which stipulates that we must have at least as many instruments as targets. In this case, it means that the interest rate cannot achieve alone three goals simultaneously: monetary stability, economic stability and financial stability.

Another justification for maintaining the standard Taylor rule is inspired by the principle of Mundell related to the assignment of instruments to targets: the instrument that is most efficient for a target must be used for that specific target. However, many studies suggest that macroprudential instruments have more effects on the financial stability that the interest rate instrument (Goodhart et al., 2010).

The supporters of the augmented Taylor rule (Cecchetti et al., 2000; Blanchard, 2000), are probably not considering it as the sole response to financial instability. In addition, the Tinbergen principle does not teach either (contrary to the strict interpretation of this principle which is commonly given but was rejected by Tinbergen himself) that each instrument is allocated to a single goal. The 'soft' interpretation of this principal is that we need as many as many instruments as targets. In this interpretation nothing prevents theoretically to affect an instrument to several objectives by prioritizing assignments (Blanchard, 2012). In other words, if the interest rate cannot do everything alone, maybe it can act as a complement to macroprudential instruments, and can provide the element of coordination between monetary policy and macroprudential policies? If one takes for granted the assumption, now widely accepted in the academic literature (Beau et al., 2011), that a macroprudential policy is essential to financial stability, a policy-mix of monetary and macroprudential policies is necessary. This revives the debate about the strategic orientation "clean" versus "lean" of monetary policy in the presence of macroprudential policy. Two polar combinations of monetary and macroprudential policies are possible. In the first option of the policy-mix the interest rate could act primarily on monetary stability, and also act timely on financial stability as a complement to macroprudential instruments. This is the *integrated approach* of the policy-mix. In this approach, monetary and financial stability are integrated into an "augmented" Taylor rule. Monetary policy is oriented "*lean*" to support macroprudential instruments. The interest rate and macroprudential instrument are then supposed complementary. In contrast to this view, *the separate approach* of the policy-mix does not consider that the interest rate can respond at any time to financial stability. Based on a strict reading of both the Tinbergen and the Mundell principles, this approach advocates to affect the monetary policy solely to monetary stability, and to fully affect macroprudential policy to financial stability.

In the remainder of this paper, we perform a meta-analysis of a recent subset of DSGE models (*Dynamic Stochastic General Equilibrium*) that meet the specifications for studying the policy mix between monetary and macroprudential policies: they incorporate macroprudential policies, particularly in the form of rules used to limit financial fluctuations, and represent monetary policy through an augmented Taylor rule taking into account the inflation gap, the output gap and a financial gap (articles excluding the augmentation of the Taylor rule do not consider the articulation of monetary and financial stability via the policy interest rate). Accordingly, we assemble 18 DSGE models which have in common to not exclude the combined action of monetary and macroprudential policies. We consider the coefficient response to the financial gap in the Taylor rule as our explained variable considering that its value is representative of the relationship between the policy mix. The 18 identified models provide us with 112 observations of the coefficient response to the financial gap in the Taylor rule. We investigate econometrically the determinants of these response coefficients.

The main questions we ask are: what it the current state of the art in this new subset of DSGE models in the specific question of the possible policy mixes between monetary and macroprudential policies? Are DSGE models which do not prohibit the combined action of monetary policy and macroprudential policy (via an augmented Taylor rule) considering complementarities between interest rate and macroprudential instruments to preserve financial stability? Does the importance given to financial stability (via the optimization of a loss function that takes into account financial instability) impact the policy-mix solution? Do the nature and diversity of macroprudential instruments influence the policy-mix solution? Is the institutional affiliation of the authors of these models affecting the obtained solution?

This article continues as follows. Section 2 presents the two types of policy mix between monetary policy and macroprudential policy adopted in the literature. Section 3 provides an overview of DSGE models incorporating both monetary policy (in the form of an augmented Taylor rule) and macroprudential policy. Section 4 presents a set of descriptive statistics and explains the methodology of our study, our variable of interest and the tested relationship. Section 5 presents and interprets the results. Section 6 concludes.

Section 2. "Separated policy mix" versus "integrated policy mix"

Two polar cases of policy mix between monetary and macroprudential policies emerged in the literature. The two approaches don't have the same theoretical foundations and defend different views of the transmission channels, the instruments and their affectation (Table 1 provides a summary). Adrian and Shin (2009), Mishkin (2011), Eichengreen et al. (2011), the Bank for International Settlements (BIS) (CGFS, 2010; 2012) are the main advocates of the *integrated approach* of the policy mix between monetary and macroprudential policies where the Taylor rule is augmented. These authors emphasize that a standard Taylor rule increases the financial risks through the "risk taking channel - RTC" inspired by Minsky (Borio and Lowe, 2002). These authors also highlight some limits to macroprudential instruments (Mishkin, 2011) and the importance of involving the interest rate in the search for financial stability. The argument for involving the interest rate instrument in financial regulation is that with an augmented Taylor rule not only banks but also the whole financial markets is impacted in function of financial imbalances. In addition, as the effectiveness of macroprudential instruments is not yet clearly established, it may be prudent to add the action of interest rates (Agénor et al., 2013). In contrast, Svensson (2012) defends the *separate approach,* focusing on the limitations of the interest rate instrument, and on the contrary the effectiveness of macroprudential instruments against financial instability. Smets (2013) sees in this approach a renewed Jackson Hole consensus. We find in this separate approach the standard argument that the reputation and credibility of the central bank may have to suffer from a double objective of monetary and financial stability (Goodhart and Schoenmaker, 1995). Moreover, in the absence of uniform rules clearly established, macroprudential policy is more exposed to problems of time inconsistency, which can also harm the credibility of central banks and, consequently, the effectiveness of their monetary policy (Ueda and Valencia, 2012).

In the United States and Europe, although macroprudential policy is not yet fully operational, central banks have diverging views on these two conceptions of the policy-mix. Even within monetary policy committees, opinions may be different. Hence Praet (2011) for the ECB, Olsen (2013) for the Bank of Norway and Stein (2013) for the Fed support an *integrated approach*. However, Ekholm (2013) for the Riksbank, Spencer (2010) for the Reserve Bank of New Zealand, and Bernanke (2010; 2012) for the Fed prefer the *separated approach*.

Table 1 - monetary and macroprudential policies: two conceptions of the *policy mix*

Paradigm	**Integrated *policy-mix* approach*:*** **Monetary *cum* macroprudential policy**	**Separated *policy mix approach:*** **Monetary policy *exclusion* macroprudential policy**
Macroeconomic foundations	• Price stability is not a sufficient condition for financial stability • Interdependence of the two policies • Joint optimization of both policies	• Risk of conflicting objectives (price stability / financial stability) • Both objectives have different time horizons • Risk of loss of credibility: confusion among the public on the final objective of monetary policy, so the risk of loss of credibility on its commitment to price stability
Transmission channels	• Similar for both policies • Risk-taking channel	• Separate for each policy
Instrument of interest rate	• Leaning against the wind	• Last line of defense against financial instability • Has little impact on financial stability (Sweden, example of real estate prices) • Too broad instrument, not accurate enough for financial stability, targeting wrongly financial instability • Jackson Hole consensus, Greenspan put, Cleaning up Afterwards
Macroprudential instrument	• Insufficient alone to ensure financial stability, particularly in times of financial crisis • Cannot do everything against financial instability • Effective *ex ante* but not *ex post* when the bubble burst • Instrument not as rapidly effective as monetary policy • Risk of capture by financial lobby inducing a risk of "too little, too late"	• First line of defense against financial instability • Few limits, effective
Both instruments	• Additional • Interdependent	• Independent • Separate policies, dichotomy
Allocation and assignment of instruments	• "Soft" Tinbergen and Mundell principles • Use all possible instruments against financial instability	• "Strict" Tinbergen and Mundell principles • Simple, more transparent than the integrated approach
Specification of the Taylor rule	• Augmented • $\alpha_s \neq 0$	• Standard • $\alpha_s = 0$ or close to 0
References	• Angeloni and Faia (2013) • Adrian and Shin (2009) • Eichengreen et al. (2011) • Mishkin (2011) • Woodford (2012)	• Svensson (2012) • Gali (2013) • Collard et al. (2013) • Ozkan and Unsal (2011) • Glocker and Towbin (2012) • Suh (2012)
Central banks	• ECB (Praet, 2011) • Bank of Norway (Olsen, 2013) • Fed (Stein, 2013)	• Riksbank (Ekholm, 2013) • Fed (Bernanke, 2010, 2012) • Reserve Bank of New Zealand (Spencer, 2010)

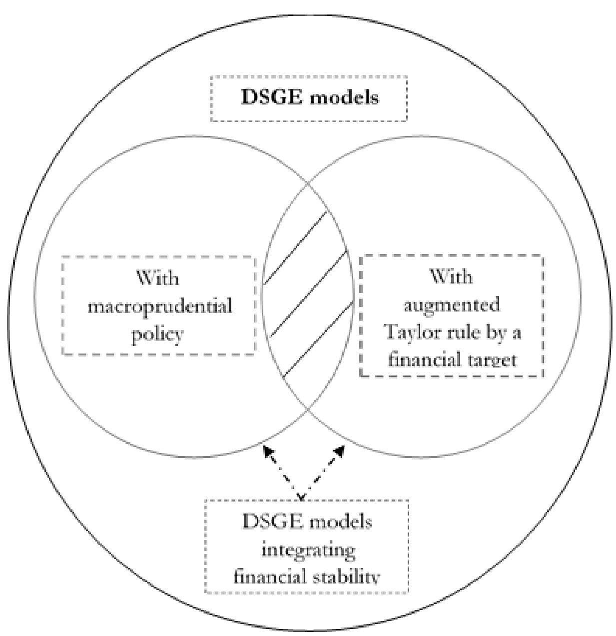
For each of these policy-mixes correspond a representation of monetary policy via the Taylor rule. In the "separate" policy mix, there is no reason to increase the Taylor rule. The macroprudential instrument is assumed to be sufficiently effective to prevent financial instability. Conversely, in the "integrated" policy mix, the Taylor rule is increased by a financial gap so that the interest rate complements the action of macroprudential policy or at least ensure that interest rate action does not go against financial stability.

In practice, the choice of this policy mix will probably be more a question of art than of science. However, the "science" on which monetary policy relayed on during the Great Moderation has recently been deeply transformed. Indeed, DSGE models, which are the main theoretical tool for modeling macroeconomics were used in central banks since the early 2000[4], integrate recently financial frictions in a relatively more satisfactory manner than before the crisis.

Section 3. A brief overview of DSGE models incorporating both augmented Taylor rule and macroprudential policy

Until the financial crisis triggered in 2007-2008, the inclusion of financial frictions in DGSE models was limited to the introduction of a financial accelerator, modeled either by an external finance premium (Bernanke et al., 1999) or by collaterals that restrict the amount of borrowing (Kiyotaki and Moore, 1997; Iacoviello, 2005). This approach did not provide any explicit role of financial intermediation and was limited to the credit demand side. It is different now. The most recent models try to include systemic risk and also the action of macroprudential policy in addition to monetary policy. Going further in the refinement, some models combine one or more macroprudential instruments with a Taylor rule augmented by a financial gap, thus allowing the articulation of the interest rate and macroprudential instruments to restore and preserve financial stability. It is this subset of models that we identified in our study (see the hatched intersection in Figure 1).

Figure 1 - Identification of the subset of DSGE models analyzed



Source: authors

[4]Following the seminal contributions of Woodford (2003), Smets and Wouters (2003) and Christiano et al. (2005).

This literature is at the intersection of two previous literatures (Beau et al., 2011): 1) the literature centered on the debate *"clean versus lean"*, dealing with the question of whether or not to increase the Taylor rule, and 2) the literature devoted to macroprudential policy.

The Taylor rule is the most common way in this literature to model monetary policy, except in the few cases where pegging issues are considered (for some emerging countries). The Taylor rule is undoubtedly the most comparable element of models of this class, providing us with a database of comparable data. The modeling of monetary policy is relatively homogeneous in this literature, in contrast with macroprudential policy modeling. Macroprudential specifications are very diverse in these models (a wide variety of instruments are used, see Appendix - Table A2). Probably, macroprudential specification will stabilize as some macroprudential instruments will be preferred in the literature and in practice. The specification of macroprudential is however often rudimentary in these models, although some retain a complex macroprudential rule. As can also be observed in the literature on macroprudential instruments, the distinction is not always easy between micro and macro-prudential instruments. It follows that macroprudential instruments used in DSGE models may be more related to micro-prudential instruments (Ellis, 2012).

Methodologically, even by retaining a precise class of models incorporating both macroprudential rules and an augmented Taylor rule, the diversity of these models is still important. Some models calibrate the response coefficients of the Taylor rule when others optimize them. And even when they are optimized, methods are diverse. Optimization can focus on the variance of inflation and output, or involve an *ad hoc* central bank loss function, or even a loss function without financial stability. Loss functions of monetary and macroprudential authorities may be joined or separated, formalizing the fact that they can operate under a single roof or not. A loss function can be micro-founded upon the utility function of the individual consumer, or of both consumer and the entrepreneur, following Rotemberg and Woodford (1998) and Woodford (2003).

However, this literature leaves open the debate over whether to increase the Taylor rule or not. All DSGE models that retain a Taylor rule do not necessarily increase it. And even when they increase the Taylor rule, the response coefficient on financial stability is frequently zero. The few reviews of this class of models with augmented Taylor rule and macroprudential policy, such as those conducted by the IMF (2012; 2013a; 2013b) does not provide a clear conclusion on the value of the response coefficient of the financial gap in the Taylor rule (α_s), and deliver ambiguous conclusions. Sometimes the IMF states that this class of DSGE models leads to a zero response coefficient α_s and the optimal policy mix is a separate one. Sometimes, the IMF (2012) argues that the optimal value of the coefficient α_s depends on the type of shock that hits the economy and its magnitude (IMF, 2013a) and that monetary policy may have to respond to financial conditions. These reviews of the IMF are made on the basis of 6 or 7 models (against 18 in our assessment). The diversity of results and the absence of robust findings may reflect differences in specifications of DSGE models from one to another, and eventually the mode of determination of the response coefficients α_s of the Taylor rule (optimization or calibration). Our study could contribute to the clarification of these questions.

Section 4. Methodology

4.1. Meta-analysis of a class of DSGE models

The method that we use is related to meta-analysis. Well known, this quantitative method can summarize the empirical literature dealing with a particular topic. It presents itself as an alternative to the narrative approach of surveys (Stanley, 2001). First used in medical research, meta-analysis has gradually developed in social sciences, including economics, especially in labor economics (Card and Krueger, 1995), international trade (Head and Disdier 2008), macroeconomics and even in monetary policy (Havranek and Rusnak, 2013). By bringing together many heterogeneous empirical studies with different characteristics (sample sizes, estimation methods, different *a priori* of researchers (Chatelain, 2010)), meta-analysis permits to extract theoretically more robust results than would a simple review.

Assuming that macroprudential policy is essential to financial stability, we bring together all DSGE models that incorporate one or more types of macroprudential instruments and does not exclude the possibility of increasing the Taylor rule. Using different search engines of academic articles (*JSTOR, Science Direct, Google scholar,* etc…) and conducting a research on cascade using bibliographies of articles, we are able to identify 18 articles with the desired characteristics.

To our knowledge this class of models did not exist before the financial crisis. There had certainly DSGE models with augmented Taylor rules, but very few with macroprudential and, to our knowledge, no combination of the two. Our database (see Table 2) begins with a working paper in 2009, that of Angeloni and Faia, and stops at the end of 2013 with the article of Ozkan and Unsal. We incorporate in our database both working papers and published articles. When an article belongs to both categories, we retain both versions only if the results differ, we retain only one of the two elsewhere.

Table 2 - List of DSGE models (in alphabetical order)

Agénor et al. (2011)
Angeloni and Faia (2009, 2013)
Bailliu et al. (2012)
Beau et al. (2011)
Benigno et al. (2011)
Bofinger et al. (2011)
Christensen and Meh (2011)
Pariès Darracq et al. (2011)
Gelain et al. (2012)
Glocker and Towbin (2012)
Kannan et al. (2012)
Lambertini et al. (2011)
Lopez and Prada (2009)
Ozkan and Unsal (2011, 2013)
Rubio and Carrasco-Gallego (2012)
Suh (2012)

In each of these 18 models, we collect variables of interest to study the interaction between monetary and macroprudential policies as formalized in these models. For monetary policy, we collect all coefficients linked to the augmented Taylor rule. Recall that the augmented Taylor rule formalizes the response of the nominal interest rate of the central bank to three gaps: an inflation gap, output gap and financial gap. Simply, this rule can be expressed as follows:

$$i = r + \pi + \alpha_\pi(\pi - \pi_c) + \alpha_y(y - y^*) + \alpha_s(f - f^*)$$

The nominal interest rate of the central bank *(i)* meets the gap between inflation *(π)* and inflation target (π_c), the difference between production *(y)* and its potential *(y*),* and the difference between a financial stability proxy *(f)* and a measure of the optimal/historical level of this financial stability proxy *(f*)*. In the absence of gap (zero gap), the policy rate is the nominal rate formed by the sum of the real interest rate and the observed inflation rate (Fisher relation). The financial stability proxy *f* takes various forms in the literature since it can be based on the *credit spread* (Toloui and Mculley, 2008; Curdi and Woodford, 2010), asset prices, credit (Christiano et al., 2010; Agénor and Pereira da Silva, 2013) or money (Issing, 2011) (there are also synthetic financial stability indicators). The response coefficients for inflation, production and financial gaps are respectively denoted α_π, α_y and α_S. These coefficients reflect the intensity of responses of the interest rate, and are extracted from the structure of the economy (inflation/production tradeoff for example) and the central bank's preferences in its loss function. We collect in each model the value of these response coefficients. The 18 models listed above provide us with a total of 112 observations on each of these response coefficients.

We also collect in each paper the available informations about macroprudential policy: more precisely, we manage to identify within each article the type of macroprudential instruments considered.

In addition, we also collect information about authors' affiliations, and the country represented in the model, which then form the variables of interest or control variables to the relationship that we test.

4.2. Explained variable

The central question of our meta-analysis is about the policy mix between monetary policy and macroprudential policy. We have previously distinguished between two polar cases of this policy mix: 1/ the "separate policy mix" in which monetary policy remains focused on monetary stability and macroeconomic stability, while macroprudential policy focus on financial stability; and 2/ an "integrated policy mix" in which monetary policy can assist macroprudential policy in its financial stability goal. Accordingly, the more the interest rate response to financial conditions the greater the probability of adopting an integrated policy mix and vice versa. The intensity of this response is directly informed by the coefficient α_S in the augmented Taylor rule. Therefore α_S constitutes the dependent variable.

4.3. Explanatory variables

Number of our explanatory variables are linked to the Taylor rule. The response coefficients on inflation, $\alpha_{\pi,}$ and the production, α_y are the first two explanatory variables. Assuming Woodford's hypothesis (2012), we can consider that there is tradeoff among central bankers between macroeconomic stability (inflation, production) and financial stability. These coefficients depend on the preferences of the central bank in its loss function. The main argument against the involvement of the central bank in preserving financial stability lies in the possibility of conflicting objectives damaging the credibility of the central bank's price stability goal (IMF, 2013a; Smets, 2013). Thus, the more the central bank is attached to inflation the less financial stability will matter. Formally, we expect a negative sign for the explanatory variable α_π. Therefore we expect to observe a negative relationship between these two independent variables (α_π, α_y) and the dependent variable (α_S).

However, this first approach should be refined. Indeed, if we can actually expect a negative coefficient for inflation, the expected sign for the output is less clear. If central banker is more "dove" than "hawk", he will tend to be more concerned with the output and may be more open to other goals than inflation. In this case, it may also be open to financial stability as an additional goal. In fine, the expected sign before the variable α_y is ambiguous.

Furthermore, we seek to assess whether the fact that the coefficients of the Taylor rule result from an optimization or conversely from simple calibration (inherited from real business cycle models) have an influence on our dependent variable. We create a dummy variable noted *opti* whose value is equal to 1 when the response coefficients are optimized, and 0 they are calibrated. If one can assume that financial instability remains partially embedded in DSGE models and often explicitly absent from the loss function of the central bank, we should rather expect a negative sign to the extent the underlying loss function remains a traditional New Keynesian inflation targeting loss function with only inflation and output as arguments. In addition, 84% of our optimized coefficients are derived from models in which the loss function does not include financial stability.

There are several ways to consider response coefficients of the Taylor rule in our estimates. Either one considers each variable in absolute terms, with a corresponding risk that observations are very different from one article to another, and are not perfectly comparable. Either they are considered in relative terms by expressing the weight of an individual coefficients (α_i) in relation with the sum of the three coefficients in the Taylor rule (response to inflation, output gap and financial stability), i.e.: $\alpha_i/(\alpha_\pi + \alpha_y + \alpha_s)$. In this second case, our explained variable will be also expressed in relative terms. On the side of the explanatory variables, the *output gap* variable is omitted as the sum of the three coefficients is equal to unity, in order to avoid a collinearity problem. Nonetheless, the relative weight of the response to inflation remains a way of expressing the more or less "hawkish" (high sensitivity to inflation) or "dovish" (lower sensitivity to inflation and high sensitivity to production and employment and by extension to financial stability) degree of the central bank in his conduct of monetary policy, following the work of Assenmacher-Wesche (2006) and Blinder (2007). Formally, the relative importance of the response coefficients in the reaction function of the central bank (expressed with the Taylor rule) derives from the relative weights applied to the variability of inflation, the production, and probably the financial conditions in the loss function. In either absolute or relative terms, we expect that the sign of the response to inflation is statistically significant and negative.

Outside this block of variables related to the Taylor rule, our next variable of interest is macroprudential policy. We pay a particular attention to the relationship between the value of the coefficient α_s, our dependent variable, and the type of macroprudential policy considered since our objective is to clarify the nature of the policy mix in these models. We try to classify the various macroprudential tools used in this class of DSGE models. This classification cannot, unfortunately, be based on the typology of Borio (2009) which distinguishes between macroprudential measures that are cross-sectional (related to the distribution of systemic risk at a given point in time, in particular, the common exposures that arise owing to balance sheet interlinkages) and that temporal (aimed to limit the formation of systemic risk over time) because cross-sectional measures are almost absent from DSGE models. However, the taxonomy of Blanchard et al. (2013) proves to be very operational because of its simplicity. The macroprudential instruments are divided into three categories according to whether they constrain: lenders, borrowers or capital flows. The Bank of

England (2011) also identifies three sets of macroprudential instruments: even if the titles are different, the first two sets are quite close to those of Blanchard et al. (2013) which are the "Balance sheet tools" (these constraining lenders) and the "Terms and conditions of transactions" (LTV and LTI fall into this group), the third set refers instead to market structures (clearing house and information requirements) is not clearly established as macroprudential. Ellis (2012) notes in his typology some kind of porosity between the macro and micro-prudential instruments and distinguishes between "true" and "false" macroprudential instruments which essentially fall into the micro-prudential category of instruments.

Among these typologies, we choose the one that allows us to better distribute macroprudential instruments: the typology of Blanchard et al. (2013). To be precise, in the typology of Blanchard et al. (2013), however, we retain only two categories of instruments because the third is rarely present in the models we have identified. We then construct a dummy variable, denoted *mpp,* which takes the value 1 when the chosen macroprudential instrument directly affects borrowers (LTV, LTI ...) and 0 when it directly affects lenders (dynamic provisions, countercyclical capital buffer...). The sign of this variable will then be interpreted by considering the influence of the first set of instruments (those that directly affect borrowers) to the second (those that directly affect lenders). A positive (negative) sign mean that macroprudential instruments affecting borrowers promote greater (weaker) intensity of the response of monetary policy to financial conditions (and promotes a more integrated (separated) policy-mix) than instruments constraining lenders. In all cases, a statistically significant coefficient means that the type of macroprudential influences the coefficient α_s and the policy mix between monetary and macroprudential policy is not indifferent to the selected macroprudential instruments. Conversely, a statistically insignificant coefficient would suggest neutrality of the macroprudential instrument type for the policy mix.

Table 3 - Types of macroprudential instruments

Study	Typology	Macroprudential instruments
Borio (2009)	"Time" Dimension	Instruments to limit the formation of systemic risk over time: countercyclical buffer, dynamic provisioning, LTV, LTI ...
	"Cross-sectional" Dimension	Instruments affecting the distribution between systemic institutions of systemic risk at a given point in time: capital requirement surcharges that are proportional to the size of the institution or the size of the maturity mismatch....
Blanchard et al. (2013)	"Lender"	Instruments limiting risk-taking by lenders: dynamic provisions, countercyclical capital buffer...
	"Borrower"	Instruments limiting the borrowing capacity: LTV, LTI ...
	"Capital Flows management"	Reduction of capital flows via reserve requirements applied to the indebtedness in a foreign currency, direct or indirect control of capital...
Bank of England (2011)	"Balance sheet tools "	Countercyclical capital buffer, leverage ratio, dynamic provisions...
	"Terms and conditions of transactions "	LTV, LTI ...
	"Market Structure"	Use of central counterparties, disclosure requirements ...
Ellis (2012)	"True"	Instruments to regulate the financial cycle (credit or asset prices) or to reduce the contribution of systemic institutions to systemic risk
	"False"	Misnamed "macroprudential" instruments while are micro in nature
Galati and	Tools based on "price"	Constraints affecting price (tax) to increase the marginal cost of

Moessner (2013)	restrictions	some operations.
	Tools based on "quantity" restrictions	Constraints affecting volumes

Source: authors

4.4. Control variables

We introduce several control variables.

First, to assess whether the lack of uniformity in the definition or proxy of financial stability affects our results, we introduce an additional variable for the type of the chosen measure of financial stability (in the augmented Taylor rule). Financial stability targets are various[5] (as much as can be the dimensions of financial stability) but they can be divided into two broad categories depending on whether they involve credit (and therefore relate to the regulation of the credit cycle) or involve assets prices (stock or real estate prices). We use another binary variable, denoted *target,* taking the value 1 when the target is related to asset prices, 0 if it is linked to credit. As with macroprudential instruments, the sign of this variable will then be interpreted by considering the influence of the first type of targets (those related to credit) to the second type (those relating to price assets).

Then, it is common in meta-analysis attempting to assess the impact of authors' affiliation on results produced by their models (Doucouliagos and Paldam, 2009). If authors are affiliated to a central bank, it may be expected that they embrace a more conservative view of the central bank. According to the idea of Kenneth Rogoff (1985), the central banker has a conservative bias, which leads to favor inflation at the expense of output and unemployment. For Schellekens (2002), Diouf and Pepin (2010), central bankers are also more "cautious" to change, and may be characterized by an "institutional conservatism". This effectively means that central bankers are probably less likely than society or the median voter to change their strategy to bring a new financial stability objective. Central bankers could possibly be in favor of the traditional consensus on a separated policy-mix. To test the effect of affiliation, we construct a dummy variable, denoted *nacb* coded 1 if at least one of the authors of the article has an affiliation outside of a central bank and 0 elsewhere (see Appendix Table A2). Descriptive statistics show that the two cases are fairly equally distributed in our sample (see Table 5).The anticipated sign is *positive* since it is expected that authors who don't belong to a central bank are less conservative and have a stronger preference for change in monetary policy strategy in the sense of a greater consideration of financial stability (combined policy mix).

Finally, the countries represented the articles of our database appear to be a potentially important explanatory variable. There are, indeed, an extensive literature[6] on the specificities of the monetary/ macroprudential policy mix in emerging economies. These countries have been using more intensively and frequently macroprudential policies than advanced economies, in part because of their exchange rates regime end the fact that they are more vulnerable to reversals of capital flows (Lim et al., 2011; Claessens and Gosh, 2012; Rey, 2013). This issue has gained relevance with unconventional monetary policy measures adopted by the central banks of industrialized countries to cope with the financial crisis, to the extent that these measures are not without implications for developing countries. As highlighted by Hahm et al. (2012), unconventional monetary policies have made the combination of monetary and macroprudential policy in emerging countries more important than it was. Similarly, Agénor and Pereira da Silva (2012) propose to combine an

[5]See Appendix Table A2.

[6]See the papers of the BIS (Moreno, 2011; Turner, 2012), IMF (Lim et al., 2011) or those of Hahm et al. (2012).

augmented Taylor rule and macroprudential policy to better manage systemic risk in the temporal dimension in emerging markets. We decide to add an explanatory variable "country" based on the IMF classification between advanced and emerging economies. It takes the form of a dummy variable taking the value 1 if the modeled country is an emerging one (including middle-income countries according to the IMF) and 0 if it is an advanced economy. Three articles in our database do not indicate a specific country but consider a "small open economy" that can be advanced or emerging countries. After a thorough reading of these papers, they treat all of emerging economies[7]. The article of Ozkan and Unsal (2013) which deals with a large open economy is also calibrated for a generic emerging economy. Based on the analysis of the BIS, the IMF and Agénor and Pereira da Silva (2012), it is expected that this variable "country" positively influence our dependent variable.

Tables 4a and 4b show all our variables of interest.

Table 4a - Variables of the basic regression

Marking	Meaning	Type of variable	Expected sign
α_s	Response coefficient on financial stability in the Taylor rule	Explained variable. Expressed in absolute terms or relative weight ($\alpha_s/(\alpha_\pi + \alpha_y + \alpha_s)$) and noted in this case weight α_s	
α_π	Response coefficient on inflation in the Taylor rule	Expressed in absolute or relative weight terms ($\alpha_\pi/ (\alpha_\pi+\alpha_y+\alpha_s)$) and noted in this case weight α_π	(-)
α_y	Response coefficient on output in the Taylor rule	Expressed in absolute terms	(+) or (-)
opti	Optimization or calibration of coefficients	Dummy equal to 1 if optimization, 0 otherwise	(-)
mpp	Type of macroprudential instruments depending on the typology of Blanchard et al. (2013)	Dummy equal to 1 if the instruments affect borrowers, 0 if they concern lenders	To interpret considering the influence of the set of instruments coded 1 relative to one coded 0 (-)

Table 4b - control variables

Notation	Meaning	Type of variable	Expected sign
target	Financial target in the Taylor rule.	Dummy equal to 1 if the target is liked to asset prices, 0 if it carries on credit	To interpret considering the influence of the set of instruments coded 1 relative to one coded 0
nacb	Affiliation or not of authors to a central bank	Dummy equal to 1 if at least one author is not affiliated to a central bank and 0 otherwise	+
country	Type of the country modeled	Distinction of the IMF between advanced and emerging economies. dummy equal to 1 if the country is an emerging economy, 0 if it is an advanced economy	+

[7]Ozkan and Unsal (2011) repeatedly show their calibrations and the dynamics of their model are for emerging markets. Glocker and Towbin (2012) mention emerging economies in their abstract and introduction. For Benigno et al. (2011), the modeled country is a small open economy. However, the four articles of Benigno listed in the bibliography of Benigno et al. (2011) are dealing with small open economies and are calibrated on emerging economies (specifically Mexico and Argentina).

4.5. Relationship tested

Regression tested takes the following form:

$\alpha_s = a\ constant + b\ \alpha_\pi + c\ \alpha_y + d\ mpp + e\ opti$

$\alpha_s = a\ constant + b\ \alpha_\pi + c\ \alpha_y + d\ mpp + e\ opti\ +\ f\ control\ variables$

or when the coefficients of the Taylor rule are expressed in relative weights:

$weight\ \alpha_s = a\ constant + b\ weight\ \alpha_\pi + c\ mpp + d\ opti$

$weight\ \alpha_s = a\ constant + b\ weight\ \alpha_\pi + c\ mpp + d\ opti + e\ control\ variables$

Where α_s is the coefficient of response to financial conditions in the Taylor rule

α_π the coefficient of response to the deviation of inflation from its target in the Taylor rule

α_y the response coefficient to the output gap in the Taylor rule

mpp indicates the type of macroprudential instruments

opti is whether coefficients are the result of an optimization or a calibration

control variables alternatively are the type of financial target in the augmented Taylor rule *(target)*, the affiliation of authors to an institution other than a Central Bank *(nacb),* the type of country represented in the DSGE model *(country)*.

We apply the simple ordinary least squares (OLS) econometric method, commonly used for qualitative studies (Wooldridge, 2006), as well as for meta-regression (Görg and Strobl, 2001; Bineau 2010). Our database is compiled from various independent articles, using different techniques (calibration or optimization), independent variables and parameters. Following Stanley and Jarrell (1989), we expect that the estimated coefficients using OLS to be unbiased. In addition, we operate a conventional "standardization" of variables by subtracting from each observation the mean, and dividing this difference by the standard deviation of all observations. The coefficients of the regression of standardized variables are then analyzed to compare the relative strength of each explanatory variables: we interpret not a marginal unit variations of each variable but variations measured on the basis of the standard deviation.

4.6. Descriptive Statistics

In one of the listed models, the response coefficient α_s (dependent variable) take negative values. We decide to remove the two correspondent observations, considering them as probable outliers. Our explained variable α_s takes values between 0 and 2.5, with a mean of 0.40. Hence we found relatively low values for the coefficient of response to the financial stability. The observation of the distribution of the coefficient also indicates a high concentration between 0 and 1 (see Appendix, Figures A1-A3). Moreover, this coefficient α_s is equal to zero in several of the tested models which, although they allow the Taylor rule to be augmented, hold a zero value after optimization. We do not exclude these null values from the database since they relate to DSGE models that allow for an augmented Taylor rule. It is interesting to note that when this variable α_s is expressed in relative weight, it can represent 60% of the sum of response coefficients, which means that some of the identified models give a high importance to the financial stability objective.

The values taken by the coefficient of inflation α_π are on average much higher. 80% of the observations relating to this coefficient have a value between 0 and 5. Finally, values and distribution of the output gap coefficient α_y are intermediate.

Table 5 - Descriptive statistics

	Data	Mean	Median	Standard deviation	Minimum	Maximum
Parameters of the Taylor rule	α_s	0,4	0,3	0,5	0	2,5
	α_π	10,5	2,4	17,7	0,5	71,4
	α_y	0,9	0,3	1,9	0	12,2
	weight α_s	0,1	0,1	0,1	0	0,6
	weight α_π	0,8	0,8	0,2	0,1	1,0
	weight α_y	0,1	0,1	0,2	0	0,9
	target	0,3	0	0,5	0	1,0
Macroprudential	mpp	0,3	0	0,4	0	1,0
Models characteristics	opti	0,6	1	0,5	0	1,0
	country	0,2	0	0,4	0	1,0
	nacb	0,4	0	0,5	0	1,0

Section 5. Results

First we present results from our baseline estimation, and then of regressions involving control variables for robustness. We first consider the results obtained with response coefficients of the Taylor rule expressed in absolute terms (models 1 for baseline estimation, 2, 3 and 4 for complete estimations), then secondly those obtained with relative weight coefficients (models 5 for baseline estimation, 6, 7 and 8 for complete estimations).The 8 tested models are exposed in Tables 6a and 6b.

Table 6a

α_s	**Model 1**	**Model 2**	**Model 3**	**Model 4**
	Coefficient (standard deviation)			
α_π	**-0.25***	**-0.12**	**-0.25***	**-0.18**
	(0.00)	(0.00)	(0.00)	(0.00)
α_y	**-0.08**	**0.01**	**-0.09**	**-0.10**
	(0.03)	(0.02)	(0.03)	(0.02)
mpp	**-0.41*****	**-0.27****	**-0.41*****	**-0.42*****
	(0.11)	(0.11)	(0.11)	(0.11)
opti	**-0.09**	**-0.12**	**-0.09**	**-0.19**
	(0.10)	(0.10)	(0.11)	(0.12)
country		**0.35*****		
		(0.12)		
nacb			**0.02**	

			(0.10)	
target				**-0.21***
				(0.11)
N	112	112	112	112
adj. R-sq	0.15	0.24	0.15	0.18
* p<0.05 ** p<0.01 *** p<0.001				

Table 6b

weight α_s	Model 5	Model 6	Model 7	Model 8
	Coefficient (standard deviation)			
weight α_π	**-0.52***	**-0.45***	**-0.55***	**-0.49***
	(0.05)	(0.04)	(0.05)	(0.05)
mpp	**-0.20**	**-0.10**	**-0.21**	**-0.22**
	(0.02)	(0.02)	(0.02)	(0.02)
opti	**-0.28***	**-0.26***	**-0.27***	**-0.34***
	(0.02)	(0.02)	(0.02)	(0.02)
country		**0.39***		
		(0.02)		
nacb			**-0.10**	
			(0.02)	
target				**-0.15**
				(0.02)
N	112	112	112	112
adj. R-sq	0.44	0.57	0.44	0.45
* p<0.05 ** p<0.01 *** p<0.001				

5.1. Results of the baseline estimation

Models 1 and 5 assess the impact of the type of macroprudential instrument, the response coefficients to inflation and the output gap in the Taylor rule and the method for obtaining parameters.

The main result that emerges from our regressions is that the type of macroprudential instrument has an impact on the macroprudential / monetary policy mix. A significant and negative coefficient is obtained for the *mpp* variable. This result suggests that macroprudential instruments constraining borrowers directly (LTV, LTI ...) reduce further the response of monetary policy to financial stability, and are less favorable to the *integrated policy mix* in comparison to instruments that constrain lenders (countercyclical buffer, dynamic provisioning ...). This result holds when we express coefficients either in absolute or relative weights terms. It confirms the assumption made in each policy mix approach about the effectiveness of macroprudential policy. The more macroprudential policy is effective and less there is a need to complete it by the interest rate instrument of monetary policy. So, constraining borrowers' instruments (LTV, LTI ...), whose effectiveness is fairly well established in the literature, less call for a Taylor rule augmented from financial stability. In contrast, models that retain macroprudential instruments constraining lenders, whose effectiveness is less well documented in the literature, seem logically necessary to consider further action of central bank trough interest rate to struggle against financial instability in addition to macroprudential policy.

The response coefficient to inflation α_π also appears to influence significantly, but to a lesser extent than the macroprudential instrument, the intensity of monetary policy response to financial stability. The coefficient for this variable is significant and negative as expected. This result suggests that in the class of DSGE models we study the inflation/financial stability tradeoff could exist. This result is confirmed when the response coefficient to inflation is expressed in relative weights (model 5), where we obtain a more significant result. The more the central bank is "hawkish", the less it will seek to mix monetary and macroprudential policies via an augmented the Taylor rule.

More disappointing, however, is the response coefficient to the output gap (α_y) which is not significant. In other words, the response to the output gap does not appear to influence the policy-mix. This relativizes the importance of the arbitrage between macroeconomic and financial stability, despite this tradeoff is very present in the literature on monetary policy.

The fact that the response coefficient to financial stability is the result of an optimization *(opti)* does not appear to be an important explanatory variable when it is expressed in absolute terms. However, it becomes significant once these coefficients are expressed in relative weights. This makes us think that in addition to the problem of comparability highlighted above, it is more in relative terms, that we should express the response coefficients.

5.2. Result of estimations with control variables

Our control variables are included one by one: the *country* variable (Models 2 and 6), the *nacb* variable (models 3 and 7), the *target* variable (models 4 and 8). The coefficients of the Taylor rule are expressed in absolute terms in models 2, 3, 4, and in relative weights in models 6, 7, 8.

Our tests confirm the significance and the positive influence of the variable *country*. This seems to confirm, in accordance with the hypothesis formulated in the literature, the interest of the *combined policy mix* for emerging countries. It also means that there is no single one best way for the policy mix, but instead a contingent policy mix depending on the specific constraints faced by countries. The inclusion of this variable *country*, however, reduces the influence of the type of macroprudential instruments *(mpp)*. Yet the effect of type of macroprudential instruments is preserved, although less strong, when the response coefficients are in absolute terms, but becomes insignificant when the coefficients are in relative weights.

Affiliation of authors to an institution other than a central bank *(nacb)* does not appear significant, and its introduction does not alter the results of our baseline estimation. Indeed, this result does not seem to confirm the Rogoff's hypothesis that central bankers have a conservative behavior compared to other institutions.

Section 6. Conclusion

We collect in this meta-analysis information from 18 DSGE models that have necessarily characteristics to analyze the policy mix between monetary policy and macroprudential policy. They allow us to observe whether the proposed combination is close to the "separate" policy mix where monetary policy don't responses to financial conditions and focuses only on inflation and output stability, or close to an "integrated" policy-mix where monetary policy is complementary to macroprudential policy in preserving financial stability. The coefficient of response to financial conditions in the Taylor rule seems to be a good representation of the relationship between monetary policy and macroprudential policy in the pursuit of financial stability: so it is our dependent variable. For key explanatory variables, we used the type of macroprudential rule, the importance given to inflation and output gap in the Taylor rule, the procedure for obtaining coefficients (optimization or calibration). Then we introduce several control variables (type of financial target in the augmented Taylor rule, country modeled in the model, the authors' affiliation to an institution other than a central bank).

After initially expressing the Taylor coefficients in absolute terms, we have re-expressed them in relative weights, which have the advantage of making these coefficients perfectly comparable from an article to another. Generally, results are improved by this transformation.

In particular, we highlight from our baseline estimation that the type of macroprudential instrument has an impact on the macroprudential/monetary policy mix. This result is important because it suggests that certain types of macroprudential instruments are more favorable than others to a strong link between monetary policy and macroprudential policy in order to struggle against financial instability. Our finding suggests that macroprudential instruments whose effectiveness are well documented in the literature (those constraining borrowers such as LTV, LTI…) are also the ones that favor least the 'integrated' policy mix. This result is robust to the way of expressing the coefficients of the Taylor rule (in absolute or relative terms) and also to the introduction of many control variables.

The importance given to inflation in the Taylor rule seems to negatively influence the response coefficient to financial stability and can therefore be interpreted as an obstacle to an 'integrated' policy mix. However, our results do not find clear evidence of an arbitrage between economic and financial stability in DSGE models that we have identified. Regarding the method for obtaining coefficients in the Taylor rule (optimization or calibration), we identify a negative influence between optimization and financial stability's coefficient, in line with what we expected, but only when coefficients are expressed in relative weights.

Among the control variables we introduce, the variable *country* has the more important influence. This suggests that the combination of monetary and macroprudential policies do not follow a universal formula and differs across countries: the economic policy response to financial instability depends on country specific constraints, including presumably the external ones, and externalities from monetary policies of advanced countries that are of importance in crisis period with unconventional monetary policies in advanced countries.

This work remains at a preliminary stage but it has the merit to contribute to this recent and crucial debate about the future regulation of financial instability, revolving around the optimal policy-mix of monetary and macroprudentiel policies. In particular our research is a contribution to the analysis of the modeling of this policy-mix in the state-of-the-art DSGE models.

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Appendices

Figure A1 - Distribution of coefficient response to financial stability *(α_s)*

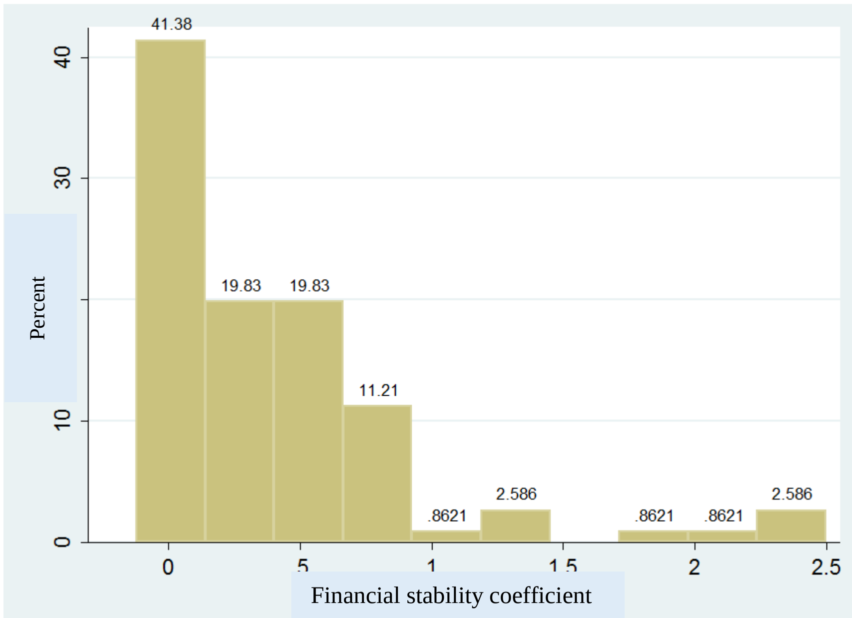

Figure A2 - Distribution of coefficient response to inflation

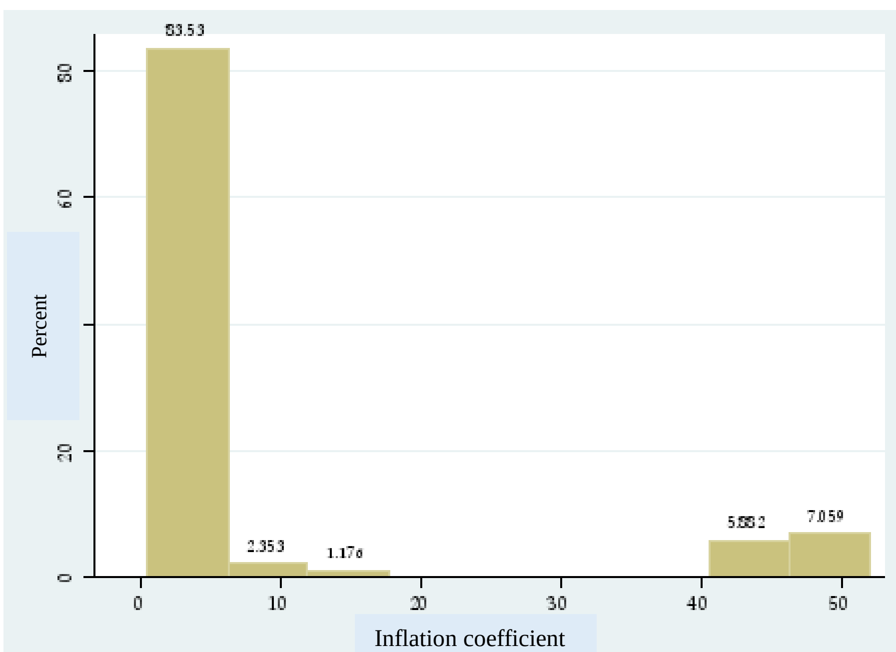

Figure A3 - Distribution of coefficient response to output gap

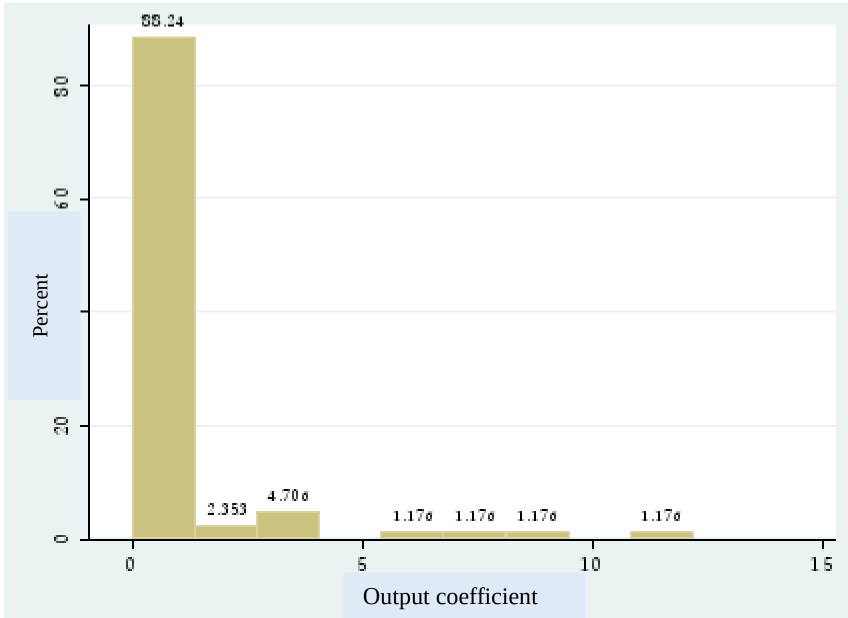

Table A1 - Matrix de correlation

	α_s	α_π	α_y	weight α_s	weight α_π	mpp	opti	country	nacb	target
α_s	1,0									
α_π	-0,2	1,0								
α_y	0,0	0,1	1,0							
weight α_s	0,9	-0,4	-0,2	1,0						
weight α_π	-0,5	0,5	-0,5	-0,6	1,0					
mpp	-0,3	-0,3	-0,2	-0,2	0,1	1,0				
opti	-0,1	0,4	0,2	-0,4	0,2	-0,2	1,0			
country	0,5	-0,3	-0,2	0,5	-0,2	-0,3	0,0	1,0		
nacb	0,1	-0,2	0,3	0,1	-0,3	-0,2	0,0	-0,2	1,0	
target	-0,1	0,2	-0,2	-0,1	0,1	-0,1	-0,4	-0,1	-0,3	1,0

Table A2 - Snapshot of the database

Article (date)	απ	αy	αs	Modeling of the financial target	Modeling of macroprudential	Country	Opti	nacb	Central bank	Other (IMF, BIS, university, …)
Rubio & Carrasco-Gallego (2012)	0,5	0,5	0,1	House prices	LTV rule	US	0	1	1	1
Ozkan & Unsal (2013)	1,4	0,0	0,1	Credit growth	credit growth	Open economy	1	1		2
Lambertini et al. (2011)	1,4	0,5	0,7	Credit growth & Housing price	LTV ratio rule	US	1	1	2	2
Agénor et al. (2011)	1,5	0,2	2,5	deviation of nominal credit growth from its steady state value	capital ratio rule	Middle incomes countries	0	1	2	1
Benigno et al. (2011)	1,5	0,0	0,0	level of borrowing to GDP	Level of borrowing to GDP	Small open economy	0	1		5
Gelain et al. (2012)	1,5	0,3	0,1	House prices & Credit growth	Ratio borrowing/expected housing stock + borrowing rule	US	0	0	3	
Suh (2012)	1,5	0,1	0,0	Deviation of credit from its steady state value	Capital requirement & LTV ratios	US	1	1	1	1
Ozkan & Unsal (2011)	1,6	0,0	0,1	Credit growth	Regulation premium based on nominal credit growth	Small open economy	1	1		2
Beau, Clerc and Mojon (2011)	1,6	0,4	0,1	Nominal growth rate of credit	LTV ratio	Euro Area & US	0 & 1	0	3	
Angeloni & Faia (2013)	1,8	0,5	0,4	Deposit ratio & Asset prices	ratio bank capital/total bank loans	US	0	1	1	2
Lopez and Prada (2009)	1,8	0,5	0,5	weighted average of equity prices and real state prices	Reserve requirement as share of deposits	Colombia	0	0	2	
Bofinger et al. (2011)	2,0	0,3	1,2	Credit spread (differences of interest rates) & Debt volume	Equity regulation (impact on loan rates)	Others	0	1		4
Angeloni & Faia (2009)	2,1	0,4	0,5	Deposit ratio & Asset prices	ratio bank capital/total bank loans	US	0	1	1	2
Christensen & Meh (2011)	2,5	0,0	0,2	Credit gap	LTV ratio	Canada	0	0	2	
Glocker and Towbin (2012)	2,9	0,2	0,9	deviation of loans from its steady state value	Reserves requirement ratio	open economy	1	0	2	
Bailliu et al. (2012)	3,0	0,1	0,6	Deviation of credit growth from its steady state value	Nominal credit growth rule	Canada	1	0	3	
Kannan et al. (2012)	14,0	3,8	0,4	growth rate of nominal credit	Nominal credit growth rule	US	0 & 1	1		3
Darracq-Parries et al. (2011)	38,0	0,5	0,2	Changes in the relative prices of houses; House prices; Households loans; real equity; Entrepreneurs loans	time-varying capital requirements	Euro Area	0 & 1	0	3	

Source: authors. We retain the average of coefficients in column 2, 3 and 4.