The regional effects of monetary policy. A survey of the empirical literature.

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Abstract

This survey provides an updated review of the empirical literature on the regional effects of monetary policy in economic activity by means of undertaking a threefold perspective. Firstly, the main methodological dimensions of this literature are examined while pinpointing those modelling or methodological traits that constitute a source of diverging estimates and thereby produce inconclusive evidence. Secondly, the estimates yielded by the literature are summarised by carrying out a cross-study analysis of the results for each monetary union. By drawing on empirical regularities that are robust across studies, the conclusiveness of the results is assessed, while those monetary unions for which conclusive evidence is still lacking are also identified. Lastly, the sources of regional heterogeneity identified by these studies are reviewed in order to shed some light on the linkage between monetary policy and territorial heterogeneity. As a result of this threefold perspective, this survey delivers overall structured conclusions and updated policy-relevant lessons. Moreover, various research gaps and emerging topics in the literature are also identified.

1. Introduction

Within the scope of study of the regional effects of monetary policy, empirical analyses of asymmetric effects of monetary policy on economic activity date back to the 1970s (Beare, 1976). The territorial effects of monetary policy on economic activity might turn out to be asymmetrical if the socio-economic structures of the territories are heterogeneous (see Rodríguez-Fuentes and Hernández-López, 1997; Rodríguez-Fuentes and Dow, 2003; Rodríguez-Fuentes, 2006), and hence there may be territories where the applied monetary policy is practically neutral and others where it has an effect of considerable magnitude (e.g. Carlino and Defina, 1998, 1999; Georgopoulos, 2009; Fraser *et al.,* 2014; Ridhwan *et al.,* 2014; Georgiadis, 2015). On the other hand, the non-synchronization of territorial business cycles also hinders the territorial application of monetary policy (see Dunn, 1999; Guiso *et al.,* 2000), to the point that it could even give rise to procyclical effects in certain territories if there were to exist territorial differentials in terms of inflation or other macroeconomic and financial variables (see De Grauwe, 2013; Micossi, 2015).[1]

The asymmetric territorial effects of monetary policy on economic activity constitute a high stakes issue, the relevance of which has led to a continuous flow of empirical research. Until the 1990s, studies almost exclusively focused on the United States (e.g. Garrison and Chang, 1979; Garrison and Kort, 1983; Carlino and DeFina, 1998, 1999), and only occasionally on Canada (Beare, 1976). Closer to the end of the century, studies focused on Europe on the occasion of the launch of the Euro (e.g. Gerlach and Smets, 1995; Dornbusch *et al.,* 1998; Tremosa-Balcells and Pons-Novell, 2001; Peersman, 2004).

Pioneering compilation endeavours of these studies were carried out by Rodríguez-Fuentes (1997) and Dow and Rodríguez-Fuentes (1997), who reviewed the contributions as part of a broader analysis of regional monetary policy. Other reviews that are also relevant are those by Dornbusch *et al.,* (1998) and Kieler and Saarenheimo

(1998), which surveyed the literature on the effects of monetary policy during the period prior to the European monetary union (EMU). These reviews would be further extended by Rodríguez-Fuentes and Dow (2003) and Rodríguez-Fuentes (2006) through the addition of the literature on the regional impacts of monetary policy that emerged on the occasion of the creation of the monetary union in Europe.

The global economic crisis of 2008 and the widespread use of monetary policy to counteract its effects have triggered renewed interest in empirical research on this issue. The profusion of studies in this period has been broader for Europe, where sufficient data regarding the validity period of the Euro has begun to be available (e.g. Boivin *et al.,* 2009; Cavallo and Ribba, 2015; Georgiadis, 2015), than for the United States (e.g. Owyang and Wall, 2009; Beckworth, 2010). Although both monetary unions have retained the main territorial objective, the studies have also extended their geographical focus to other countries, such as China (e.g. Guo and Tajul, 2017), Australia (e.g. Vespignani, 2015), Brazil (e.g. Rocha *et al.,* 2011), Indonesia (Ridhwan *et al.,* 2014), and India (Nachane *et al.,* 2001). The crisis has also led to the emergence of anti-inflationary monetary policies of quantitative expansion, whose regional effects had not previously been studied, and which have only now begun to be analysed, although only within the context of the EMU (Boeckx *et al.,* 2017; Burriel and Galesi, 2018). Moreover, not only have empirical studies broadened the geographical focus and the monetary instruments under study, but they have also introduced methodological advances by incorporating the combination of Vector Auto-regressive models (VARs) with other methodological approaches in recent years: Panel VARs (e.g. Ciccarelli *et al.,* 2013), Global VARs (e.g. Burriel and Galesi, 2018), and near-VARs (e.g. Boeckx *et al.,* 2017).

Hence, considering that the latest and most relevant review is that of Rodríguez-Fuentes (2006), that the profusion of studies since that date has been extensive, that the conclusions are partial and geographically and temporally dispersed, and that there is an extensive range of methodological features that might have a bearing on the results, it seems necessary to strive towards an analysis and ordering of the empirical results obtained by the literature.[2]

To this end, a threefold perspective is undertaken when reviewing these studies: a) an analysis of the main methodological dimensions of this literature is carried out in order to pinpoint those methodological features that might constitute a source of divergent results; b) a cross-study approach is adopted for each monetary union in order to identify geographical and qualitative cross-study patterns that can be deemed to constitute conclusive evidence, while those monetary unions for which robust evidence is still lacking are also identified; and c) the sources of territorial heterogeneity identified by the literature are also reviewed in order to shed light on the linkage between territorial heterogeneity and monetary policy.

This synthesizing effort is of prime importance. If monetary policy happened to produce heterogeneity or asymmetry in the regional[3] responses of economic activity, then policymakers should address the issue of whether to incorporate the quantification of such heterogeneity into their analysis, and they should decide whether to accompany their measures with complementary economic policy instruments capable of mitigating the territorial disparities stemming from the implemented monetary policy. This is even more necessary when, as in the case of the Euro, the monetary union is made up of sovereign countries, which, having ceded part of their sovereignty by renouncing their currency, still have the capacity to reverse the situation and remove themselves from the monetary union. A monetary framework that systematically generates regional

differences will hardly have future viability without complementary instruments (see Micossi, 2015; De Grauwe, 2011).
This paper therefore offers a structured guide on the conclusions and methodologies of the most recent studies, which might be helpful to monetary authorities when assessing the pertinence of the analysis of the territorial impacts stemming from monetary policy within their respective area of responsibility, while also facilitating the design of such analysis through the provision of updated methodological lessons. Moreover, the examination of the role played by the different sources of territorial heterogeneity should also lead to a better understanding of the territorial dynamics stemming from monetary policy.
The remainder of this paper is structured as follows. In Section 2, a methodological analysis is carried out. In Section 3, we synthesise the results obtained by the literature while the main cross-study empirical regularities are laid out for each currency union. In Section 4, the sources of regional heterogeneity in relation to the conduction of a uniform monetary policy are reviewed. Finally, Section 5 summarises our key conclusions.

2. Methodological analysis

The empirical literature assessing the macro-economic effects of monetary policy at the regional level is characterised by the use of a wide range of variables, methodologies and specifications. In the present section, the most relevant methodological dimensions are reviewed while determining the extent to which those methodological features constitute a source of diverging results. The dimensions reviewed are: (1) the econometric approach; (2) the identification of the monetary shock; (3) territorial and temporal dimension of the studies; (4) type of monetary policy assessed; (5) economic effects analysed; and (6) spillover effects.

2.1. Econometric approach

Regarding the literature prior to the 1990s, Rodríguez-Fuentes and Dow (2003)[4] lay out the methodological approaches that have been used by these studies (which they denominate as "the old literature"). A first type of study examines the monetarist explanation of the business cycles at the regional level by making use of reduced-form models (e.g. Beare, 1976; Garrison and Kort, 1983). A second type of study employs large regional macro models (e.g. Garrison and Chang, 1979) in which monetary transmission mechanisms are included. A third type of study analyses the regional lags stemming from the transmission of open-market operations from central to peripheral money markets (e.g. Scott, 1955).[5]
As for the methodologies employed by the literature from the 1990s onwards, we follow Kieler and Saarenheimo (1998) and Britton and Whitley (1997), who lay out five different econometric methodologies spanning this period:

- Large-scale macro-econometric single-country models. This approach consists of using individual macro-econometric models for each country analysed. An example of this approach is given in the study by the BIS (1995). This study uses national models of central banks. The main weakness of this approach is the fact that the results obtained might be partially biased since they may stem from the specificities of the models instead of constituting real differences.
- Large-scale macro-econometric multi-country models. This approach is based on the implementation of the same (or very similar) specification for the whole set of countries analysed, thereby reducing the differences arising from the country-specific modelling source (Britton and Whitley, 1998). The Federal

Reserve multi-country model (BIS, 1995)[6] and the QUEST II model (Roeger and Veld, 1997) are two examples of this approach.

- Small Stylised models or small-scale structural models. This approach is based on using a limited number of equations to reflect the key features of the monetary transmission mechanism (Britton and Whitley, 1997). Britton and Whitley (1997) make use of this methodology[7] and point out that its main criticism is that it is too highly aggregated to reflect cross-country differences.
- Single-equation models.[8] This approach consists of estimating a single output equation for each country, such as that given by Dornbusch *et al.* (1998). This approach suffers from the same identification problems as those previous, but it has the upside of allowing control for the intra-European exchange rate channel (Kieler and Saarenheimo, 1998).
- Auto-regressive models (VARs). This has become the most widely used approach for the analysis of the regional effects of monetary policy over the last three decades. It was Sims (1980) who proposed this methodology as an alternative for macroeconomic analysis. However, to the best of our knowledge, Carlino and Defina (1996, 1998, 1999) are the first to apply this approach within the context of the sub-national effects of monetary policy, while Gerlach and Smets (1995) and Kieler and Saarenheimo (1998) are among the first to apply such approach at the cross-country level. Over recent years, auto-regressive models have been used together with other methodologies aimed at enhancing the empirical framework of analysis. Accordingly, studies have been found using Panel VARs (Ciccarelli and Rebucci, 2002; Ciccarelli *et al.,* 2013; Anagnostou and Papadamou, 2014); Constrained mixed frequency VARs (Mandalinci, 2015); Global VARs (Geordiadis, 2015; Burriel and Galesi, 2018) and Factor augmented VARs (Boivin *et al.,* 2009; Barigozzi *et al.,* 2014).

2.2. Identification of the monetary shocks

The type of methodology applied has a decisive bearing on the identification of the monetary shock, and hence such identification forms one of the most complicated methodological challenges tackled in the literature. Within the setting of macro-models, the identification is obtained by means of the specification of a policy rule, in which the real variables and prices are regressed on the monetary policy instrument. Since this type of model is strictly constrained to the pre-EMU experience, for which evidence is highly inconclusive, it is not possible to determine the effect that this type of identification exerts on the results.

On the other hand, within the prevalent methodological approach (VAR models) the identification is obtained by means of regressing the monetary policy instrument on the contemporaneous and lagged values of the set of variables included in the reduced-form model, as well as on the lagged values of the monetary instrument itself. The residuals yielded by such regression constitute the exogenous monetary shock. Moreover, in order to obtain such shocks, it is necessary to impose a number of restrictions on the model, whereby the most widely adopted approaches are those of the Cholesky decomposition (e.g. Beckworth, 2010; Potts and Yerger, 2010; Anagnostou and Papadamou, 2014) and structural VARs (e.g. Carlino and DeFina, 1998, 1999; Fraser *et al.,* 2014; Guo and Tajul, 2017). Only recently have sign restrictions been employed, mainly in conjunction with other type of restrictions, such as short-run exclusions (e.g. Boeckx *et al.,* 2017; Burriel and Galesi, 2018). The choice of the identification scheme appears to have no effect on the pattern of the responses yielded by these studies, since

such responses broadly exhibit a hump-shaped trajectory (when a contractive shock is analysed) irrespective of the identification scheme implemented.

The analysis of alternative identification schemes within the VAR methodology has only been marginally addressed by the literature. Georgiadis (2015) carries out a robustness analysis by using three different series as alternative shocks that have been extracted from a VAR model estimated uniquely for the Euro area, from estimated dynamic stochastic general equilibrium models, and from calculating the deviations of actual policy rates from lagged financial market expectations. The shocks obtained are incorporated as exogenous variables into the baseline model. The correlation between the results yielded by the baseline (sign restrictions) and the alternative identification schemes is fairly high, which indicates the robustness of such results to the identification strategy of the monetary policy shocks.

Lastly, the identification by means of a Taylor-rule-type equation has only been employed occasionally in the literature within the context of a robustness analysis, and the results obtained remain robust to the adoption of such an identification strategy (Rodríguez-Fuentes *et al*., 2004; Rodríguez-Fuentes, 2006).

A further issue that deserves certain attention regarding the identification of the shock within the VAR methodology involves the determination of a shock of homogeneous size for all the territorial units of analysis.[9] In this regard, the methodology used has also evolved through the refinement of the VAR methodology, with the implementation, among other techniques, of near-VAR models (e.g. Peersman, 2004; Beckworth, 2010; Boeckx *et al.,* 2017).

2.3. Territorial unit and time window of analysis

Given the multiple regional scales, one key issue to be considered when assessing the regional effects of monetary policy is that of the choice of the territorial unit of analysis. The sub-national approach can be implemented by using either homogeneous economic regions or territorial units of political nature such as states and provinces. Moreover, multi-territorial units (such as multi-state regions) are also employed. This disparity in the territorial units poses the question of whether there is an "aggregation bias", that is, whether using different types and levels of territorial aggregation conditions the results, regarding both the ranking of the territorial units by magnitude of the impacts (geographical dimension) and the trajectory of their responses (qualitative dimension). In the present section, we aim to analyse whether such an aggregation bias exists in the literature. In order to perform such an analysis, two conditions must hold: (1) there must be more than one study analysing the same monetary union, that is, cross-study evidence must be available; and (2) the level of territorial aggregation is different across such studies. According to the reviewed literature, only five monetary unions met such criteria: the US, Brazil, Canada, China, and the Eurozone. The remaining countries were therefore omitted from the analysis. A further remark is in order: throughout the analysis, the term *pattern* will make reference to the geographical and qualitative dimension of the responses.

Studies focusing on the regional effects of monetary policy in the United States represent a key example in this regard given the diverse range of territorial units employed. Starting with the highest level of aggregation, Carlino and DeFina (1998) make use of the eight regions defined by the Bureau of Economic Analysis (BEA), which constitute multi-state regions. They analyse the impacts resulting from a monetary policy shock both in the BEA regions and in the individual states, and conclude that central responses broadly correlate with the regional responses. Crone

(2005) replicates the study of Carlino and Defina. For this purpose, eight alternative multi-state regions are defined. The grouping criterion is based on the similarity of states business cycles in order to increase the degree of cohesion between the constituent states of the new regions. Crone´s analysis yields the same broad patterns as those reported in the Carlino and Defina study. Owyang and Wall (2009) increase the level of disaggregation by estimating the impact of monetary policy on nineteen sub-BEA regions (whereby each sub-BEA region is comprised of two to four states). Their results reveal several of the patterns of the previous studies. Lastly, Carlino and Defina (1999) and Beckworth (2010) use the territorial units of the states in their respective studies, and obtain a number of patterns in common with those of the previous articles. However, as expected from the higher level of disaggregation, the responses do reveal within-region heterogeneity. In short, the ranking of the geographical areas in terms of magnitude of the impacts, as well as the qualitative trajectory of those impacts, are broadly maintained when using different levels of territorial aggregation.

The results yielded by the studies focusing on China (Cortes and Kong, 2007; Guo and Tajul, 2014, 2017) also reveal common broad cross-study patterns despite using different levels of territorial aggregation.

On the other hand, we find those monetary unions for which it remains impossible to identify empirical regularities when using different levels of territorial aggregation. That is the case of Brazil (Bertanha and Haddad, 2008; Rocha *et al.,* 2011). It is important to remark that the study by Rocha *et al.* (2011) does not incoporate all the spatial units of the country in the model. This might bias the results and explain why no empirical patterns are found. Bertanha and Haddad (2008) had already pointed out this idea in their analysis.

Turning to Canada, it is also difficult to identify territorial regularities. However, this difficulty seems to stem from the use of excluding economic indicators instead of the employment of different territorial units. This issue will be further explained in the section corresponding to the economic effects analysed.

In the case of the Eurozone, since it is a supra-national currency area, there are three possible regional approaches: (1) cross-country approach; (2) country-clustering or supra-national approach; and (3) regions within countries or sub-national approach. The literature has mainly focused on the cross-country approach (e.g. Gerlach and Smets, 1995; Tremosa-Balcells and Pons-Novell, 2001; Peersman, 2004; Barigozzi *et al*., 2014; Georgiadis, 2015; Boeckx *et al*., 2017; Burriel and Galesi, 2018). However, no territorial pattern has emerged from these studies. The second approach has been used by Ciccarelli *et al.* (2013) to assess the effects of monetary policy on two groups of countries: (1) countries under sovereign stress (Greece, Ireland, Italy, Portugal and Spain); and (2) the remaining countries (Austria, Belgium, Finland, France, Germany, Luxembourg and the Netherlands). Lastly, the sub-national approach has been adopted by Anagnostou and Papadamou (2014) for the regions belonging to the countries of the south of the Eurozone (that is, Italy, Greece, Spain and Portugal), while Arnold and Vrugt (2002, 2004), Anagnostou and Papadamou (2016) and De Lucio and Izquierdo (1999), Rodríguez-Fuentes *et al.,* (2004) and Rodríguez-Fuentes (2006) have implemented this approach for the assessment of the effects of monetary policy for the regions within a single country (Germany, the Netherlands, Greece and Spain, respectively).

In short, the identification of common broad regional patterns in the responses to monetary policy across studies that make use of different levels of territorial aggregation for the same monetary union confirms the robustness of these results with respect to the territorial unit of analysis (with the highly significant exception of the

Eurozone), provided that all the spatial units comprising the monetary union are included in the model and that excluding activity indicators are not used.

Turning to the time dimension, the choice of the time period of analysis has several major empirical implications. In the first place, its modification allows the researcher to assess the robustness of the analysis. Secondly, the selection of a specific time period may be driven by the need to ensure the econometric viability of the empirical framework. Thirdly, it may be geared towards setting up a coherent framework of analysis regarding the monetary policy regime. Lastly, the time period might be set up in a recursive way in order to assess the time-varying nature of the regional effects resulting from monetary policy.

The two first aims are purely technical. In the first case, the goal involves the incorporation of various time periods into the analysis in order to evaluate the robustness of the estimates (Svensson, 2012; Georgiadis, 2015). In the second case, the choice of a time period is subject to the selection of a time horizon that allows a specific econometric model to be applied, as is the case when setting a time period that allows the cointegration relationships to be dealt with in an explicit way (Georgopoulus, 2009; Vespignani, 2015).

The third possible goal pursued when selecting a specific time period is to establish an empirical framework that allows both the estimation of the model in accordance with the monetary policy regime in place and the consideration of any possible structural breaks regarding monetary management policies. Owyang and Wall (2009) divide their empirical analysis for the US into two periods: (1) full sample period (1960:Q1 to 2005:Q2) and (2) Volcker-Greenspan Chairmanship period (1983:Q1 to 2005:Q2). In this way, the effects resulting from the various monetary policy regimes can be assessed. Regarding the geographical patterns, although the results yield a number of common regularities in the regional responses, there also exist significant differences in the ordering of the regions in terms of magnitude of their impacts. As for the magnitude and persistence of the effects, these are more moderate during the Volcker-Greenspan sub-period. Turning to the Eurozone, Barigozzi *et al.* (2014) and Boivin *et al.* (2009) divide their analysis in order to take into account the monetary regime shift resulting from the implementation of the Eurozone. Barigozzi *et al.* (2014) divide their analysis into two subsamples, namely a pre-euro sample spanning from 1983 to 1998, and a euro sample spanning from 1999 to 2007. In the same vein, Boivin *et al.* (2009) estimate their model for two periods: (1) full sample period (1988-2007), and (2) euro-sample (1999-2007). Both studies find differences between the two subsamples. In particular, during the Euro period, Barigozzi *et al.* obtain a reduction of country heterogeneity in the responses of output (although differences still remain) and, in the study by Boivin *et al.* (2009), the impacts are lower in said period.

Finally, the model can be recursively estimated. That is, the model is estimated several times, each time adding a specific unit of time (such as quarters or years) to the first time period, analysing thereby the evolvement of the regional impacts of monetary policy over different economic stages. Burriel and Galesi (2018) and Ciccarelli *et al.* (2013) make use of this estimation estrategy. Both studies obtain time-varying heterogeneity in the magnitude of the regional effects stemming from monetary policy. However, the ranking of the countries in terms of their responsiveness to monetary policy does not seem to change considerably, at least when comparing the results of the full sample with the benchmark estimation (in the case of Burriel and Galesi) or with the crisis period (in the case of Ciccarelli *et al*.). In relation to the magnitude of the responses, both studies yield the same dynamics: during the pre-crisis period, the effects of monetary policy on output remain very limited (and are even insignificant in the

analysis by Burriel and Galesi); when the period is extended to include the years when the crisis reached its highest incidence (peak-crisis period: 2002Q4-2009Q4 in Ciccarelli et al.; 2001-2012 in Burriel and Galesi), the effects yielded are considerably greater; and, finally, when the last years of the crisis are incorporated (in Burriel and Galesi until September 2015, in Ciccarelli *et al.* until the third quarter of 2011) the effects are smaller than in the peak-crisis period and greater than in the pre-crisis period. These findings therefore suggest that the choice of the time period does indeed exert an important influence on the results, and is similar to that which happens at the aggregate level (e.g. Boivin and Giannoni, 2006; Bacchiocchi *et al.,* 2017). Its incidence might therefore manifest itself by giving rise to an alteration of the territorial pattern of the responses and to a change in their magnitude and persistence (Owyang and Wall, 2009), or it may simply entail one or a number of such effects (Ciccarelli *et al.,* 2013; Burriel and Galesi, 2018). However, regarding the qualitative character of the responses (in terms of their sign), the incidence is virtually zero.

2.4. Type of monetary policy assessed

Regarding the type of monetary policy evaluated, the literature has mainly focused on assessing the so-called conventional or standard monetary policy based on steering the interest rate. Most of these studies analyse a tightening of the monetary indicator, which is a contractionary monetary intervention. Nonetheless, in those studies estimating linear VARs, the tightening and easing of the monetary indicator are treated symmetrically (e.g. Carlino and Defina, 1998).

On the other hand, studies evaluating unconventional or non-standard monetary policy from a spatial perspective remain very scarce and, to the best of our knowledge, have only focused on the set of non-standard measures implemented by the European Central Bank (ECB) in the Eurozone during the aftermath of the economic crisis of 2007 (Boeckx *et al.,* 2017; Burriel and Galesi, 2018).[10] In this case, as in those studies that resort to monetary aggregates (Weber, 2006; Guo and Tajul, 2014), the monetary policy intervention analysed is expansionary.

The type of policy examined has a direct impact on the policy variable selected to perform the empirical analysis. The interest rate is thereby the predominant variable for the representation of the monetary policy stance, namely, the Euro OverNight Index Average (EONIA) and the Main Refinancing Operations Rate (MRO) are the two most frequently employed variables in the studies that evaluate the monetary policy implemented in the Eurozone. The policy variable most commonly used for the United States is the Federal Funds Rate (FFR).

One specific problem that arose on the occasion of the creation of the euro was precisely the choice of the variable to be employed in the measurement of the monetary policy stance in those studies incorporating pre-euro samples in their analysis. Most of these studies opted for the domestic interest rate (e.g. Ehrmann, 2000). Alternatively, Tremosa-Balcells y Pons-Novell (2001) opted for a synthetic interest rate common to the whole set of countries examined. This synthetic indicator consisted of a weighted average of individual country interest rates.[11] Mojon and Peersman (2001) selected a third option based on the anchor role of Germany with regard to the Exchange Rate Mechanism (ERM); the authors split the set of countries considered into two groups (besides Germany) whose selection depended on the degree of monetary integration of each country with Germany. The monetary shock was thus identified with a shock to the German interest rate for the group of countries comprised of Austria, Belgium, and the Netherlands, while for Finland, France, Greece, Ireland, Italy, and Spain, the monetary

shock was identified as a deviation of the domestic interest rate from the German interest rate.

For their part, monetary aggregates have been used with caution since they are exposed to other disturbances unrelated to the monetary policy stance, such as temporary external capital flows (Gerlach and Smets, 1995). The identification of the shock when using monetary aggregates is therefore more complicated compared to the conventional interest rate policy indicator. Certain studies exist, however, that employ monetary aggregates to represent the monetary stance, such as those performed by Weber (2006) and by Nachane *et al.* (2001).

Boeckx *et al.* (2017) and Burriel and Galesi (2018) examine the cross-country effects resulting from the implementation of non-standard measures by the European Central Bank (ECB) by means of employing ECB balance sheet as the policy indicator. In both studies ECB balance sheet is proxied by the variable of ECB total assets.

Certain studies make use of alternative policy variables to check the sensitivity of the results to alternative indicators of monetary policy. Carlino and Defina (1998) carry out such an analysis by means of comparing the effects resulting from employing the non-borrowed reserves and the level of the Boschen-Mills index as policy indicators with the results obtained with the original policy indicator (i.e., the Federal Funds Rate). The geographical patterns arising from the sensitivity analysis are the same as that identified when using the Federal Funds Rate, which undoubtedly underlines the robustness of the results to the choice of the monetary policy variable. The time profile of the responses is also broadly similar, although the maximum cumulative impact is reached later. Guo and Tajul (2014) use three alternative policy indicators: M1, M2 and the one-year bank lending rate in China. The response pattern that emerges from the three specifications is broadly the same. Turning to the cross-study robustness of inference when using different policy indicators, the case of Australia is of particular note. Namely, the three studies analysing this monetary union (Weber, 2006; Fraser *et al*., 2014; Vespignani, 2015) obtain the same main territorial regularity despite using different policy indicators (money stock versus two different rates of interest).

One last issue regarding the type of monetary policy evaluated involves its duration. In recent years, the most extended approach has consisted of examining a monetary policy rule that allows the variable representing the monetary stance to evolve according to such a rule after a one-time change. Conversely, there are studies that analyse an unexpected change maintained for a certain period of time in the level of the policy variable (e.g. BIS, 1995) after which the monetary variables go back to their initial levels.

A final issue that could be relevant whithin the context of the type of monetary policy assessed is to analyse whether the operating procedure through which such policy is implemented gives rise to different regional effects. Even if the array of instruments used by central banks are currently quite similar (Deutsche Bundesbank, 2014), operating procedures may differ in several dimensions, such as maturities or frequency of policy adjustment. This type of analysis can be done either by designing an identification scheme capable of representing particular monetary measures with specific operating features, or by comparing the results obtained when examining two or more periods in which monetary policy has been carried out by means of different operating procedures. While the first approach is rather difficult to implement given the complexity of isolating the results stemming from a specific monetary measure from the rest of measures undertaken during the same period of time, the second approach is only feasible if a change in the operating procedure is clearly detected between two or several periods, such as the one identified for China in 2002 (see Girardin *et al*., 2017).

However, this type of analysis has not yet been addressed by the literature.

2.5. Economic effects analysed

As for the economic effects that have been analysed by the literature, it is of note that the variables representing regional economic activity vary with the geographic location of the studies. Studies focusing on the US usually employ the variable of personal income. On the cases of Canada, Sweden and Brazil (namely, for the study carried out by Bertanha *et al*., 2008) the variable used is that of employment. Studies focusing on Australia make use of either the Gross Domestic Product (GDP) or of the State Final Demand (SFD) variables. On the case of China, the studies considered in this survey make use of the GDP. Regarding Europe, the GDP is also the most extensively employed variable. Mandalinci (2015) alternatively makes use of the Gross Value Added for the United Kingdom. The recent incorporation of factor models into the empirical framework has allowed the array of economic variables under analysis, such as consumption and investment, to be extended (e.g. Barigozzi *et al*., 2014).

Moreover, those studies that make use of territorial divisions for which there is no data available or for which the data is not published with the desired frequency, usually resort to either more restrictive measures of economic activity (such as the Industrial Production Index in Europe), or to other alternatively constructed proxy variables. This latter option has been adopted by Vespignani (2015) for the case of Australia, and by Beckworth (2010) for the case of the United States. In the first study, since the Australian Bureau of Statistics does not deliver a Gross State Product (GSP) indicator on a quarterly basis, the author resorts to a proxy indicator constructed by adding the State Final Demand and the state/territory exports minus the state/territory imports. Such indicator, denominated Real Gross State Product (GSP*), is also deflated. Similarly, Beckworth (2010) opts for an alternative summary indicator of the real economic conditions for each state: he resorts to the monthly coincident indicator calculated by the Philadelphia Federal Reserve bank.

A number of researchers go a step further by employing alternative measures of economic activity in their studies in order to assess the sensitivity of the results to the choice of the economic variable. Carlino and Defina (1998) re-estimate their model by incorporating regional employment as the economic variable instead of the variable of regional personal income. The patterns emerging from both alternative specifications are generally the same. Likewise, Weber (2006) performs an analysis for the Australian states by employing two alternative measures of economic activity: the State Final Demand (SFD) and the Gross State Product (GSP). The empirical patterns arising from these two specifications are broadly the same with the only difference in the timing of the responses: the effects take place faster in the case of SFD. Vespignani (2015) carries out a similar analysis for Australia by incorporating exports into the analysis. The results show that exports is the most responsive variable, while it takes longer for the domestic demand to react.

On the other hand, it is important to note that making use of excluding economic indicators at the regional level, such as the non-agricultural employment used by Potts and Yerger (2010) versus the use of employment by Georgopoulus (2009) for Canadian regions and provinces seems to entail diverging results, thereby producing inconclusive evidence. The excluding nature of a variable has therefore to be carefully considered when selecting an indicator of economic activity, at least in certain types of monetary unions with a relatively bi-regional economic structure such as Canada.[12]

2.6. Spillover effects

In the literature of the regional effects of monetary policy, the spillover effects stemming from the implementation of such a policy are addressed from two different perspectives: (1) the within spillover approach, which refers to the spillover effects between the regions within a monetary union; and (2) the cross-border spillover approach, which focuses on the spillover effects among regions belonging to different monetary unions.

Regarding the first approach, most of the literature fails to explicitly address this issue. This is probably due to the extensive use of VAR methodology, since it is considered to implicitly incorporate spillover effects by means of allowing for feedback effects among the aggregated and individual territorial units introduced in the model. An alternative option to the capture of the dynamics of the whole of the economy of a monetary union is to make use of region-specific weighted averages of trade partners's real GDP, such as the study by Burriel and Galesi (2018). Namely, since their focus is cross-country, the authors make use of the country-specific weighted averages of trade partners' real GDP.

The identification of the spillover effects is partially different in the case of those studies that employ a near-vector auto-regression (near-VAR) model. Indeed, since the near-VAR approach is adopted in this literature with the aim of identifying shocks of the same size for the whole set of regions of the analysis, then these models only allow for the one-way causality feedback effects of the block of union-wide variables to the block of individual countries. Peersman (2004) overcomes this partial constraint by introducing, in the individual blocks, the aggregates of output and prices excluding domestic output and prices.

Beckworth (2010) also adopts a near-VAR approach but opts for a different strategy regarding the incorporation of the spillover effects in the model. The author assumes that the state-economy variables are mutually independent (this study is applied to the US) while allowing for feedback effects among the bordering economies. In order to incorporate this bordering feedback in the model, a composite measure is constructed by calculating the weighted average of the real state economies adjacent to the state whose equation is being estimated.

Burriel and Galesi (2018) and Guo and Tajul (2014, 2017) examine how the results change when the spillover effects are incorporated into the analysis. Burriel and Galesi (2018) obtain greater impacts when such effects are included in their model, and hence they make the point that their exclusion leads to an underestimation of the impacts. Guo and Tajul (2014, 2017) carry out a similar analysis for China, and obtain the same type of dynamics, although only for the short term.

Turning to the cross-border approach, these types of spillover effects in the regional context have been analysed for Canada and Australia. Both countries are representative of the prototype of a small and open monetary union. Potts and Yerger (2010) gauge the effects of a tightening of US and Canadian monetary policy upon Canadian regional non-agricultural employment. In both cases, a contractionary shock entails a decline in regional employment. More specifically, the Canadian regional effects resulting from the US monetary policy shock are broadly similar in qualitative and territorial terms to the effects stemming from a Canadian monetary shock. In quantitative terms, the results are also broadly similar, although the impacts are slightly smaller in the case of the Canadian monetary shock (with the exception of the West). Furthermore, the time profile of the responses is similar for the two policies. The authors point out that the higher responsiveness displayed by Quebec and Ontario is reflects the higher degree of

integration of these two regions with the US economy that has resulted from cross-border manufacturing activity.
On the other hand, Weber (2006) came to very different conclusions for the case of Australia. This analysis reports that an increase in the US interest rate (which is employed as a proxy for the world interest rate) entails an economic expansion in all the Australian states, whereby Western Australia is the state whose GSP exhibits a greater increase. The explanation provided in the study is based on the Mundell-Fleming model. By means of this model, it is deduced that the exchange rate experiences a depreciation which leads to an increase in exports that exceeds the decrease in investment following a rise in domestic interest rates. This explanation suitably matches the fact that Western Australia has the largest export share in GSP.

3. Main empirical regularities drawn from the studies

The qualitative and temporal patterns of the regional responses are analogous to those identified by the literature at the aggregate level: regional economic activity experiences a hump-shaped response following a contractionary monetary policy shock. Conversely, for those studies that explicitly analyse an easing of the monetary stance, the regional economic response is positive (e.g. Weber, 2006; Guo and Tajul, 2014).
Regarding the territorial heterogeneity of the responses, it is of note that for some of the monetary unions analysed, major geographical regularities emerge from the estimated results, that is, the cross-study evidence is considerably robust in a number of cases. There are, however, several countries (such as Sweden, India and Indonesia) for which it is impossible to infer the cross-study robustness of the results since there is only one study per country.

3.1. Large fairly closed monetary unions

In the United States, regional heterogeneity is empirically supported by all the studies. Regarding the results, the following territorial regularities stand out: the area around the Great Lakes (including the Great Lakes itself) is found to be one of the territories most adversely hit (Carlino and DeFina, 1998, 1999; Crone, 2007). On the other hand, the Rocky Mountains (Carlino and DeFina, 1998, 1999; Owyang and Wall, 2009 (Volcker-Greenspan sample)), the East Southwest (Owyang and Wall, 2009) and Southwest (Carlino and Defina, 1998), alternatively known as the Energy Belt (Crone 2007), are among the least adversely affected regions. Turning to the state level, the analyses carried out by Carlino and DeFina (1999) and Beckworth (2010) show several broad patterns in common with the previous studies. Indeed, the states showing a greater response are mostly those around or comprising the Great Lakes region and the Rustbelt, while those falling into the Rocky Mountains and the Southwest regions (or the Energy Belt) are generally found to be among the least responsive. In short, monetary policy in the US entails heterogeneous effects both at the regional and state level.
Conversely, it has been impossible to detect any empirical regularity in the Eurozone given the ambiguity in the results of this strand of the literature, not only concerning the studies focusing in a pre-EMU sample but also the studies covering the EMU period. The studies not only differ in terms of the country responsiveness ranking but also even with regard to the existence of heterogeneous effects, since some of these studies conclude that such heterogeneous effects are not statistically significant. Table 1 displays the countries ranked by the size of their responses for each study reviewed.[13]

Table 1. Size ranking of the impacts of monetary policy on output in European

Countries

Authors	Impact[1]	Country[3] ranking	Comments[2]
Georgiadis (2015)	Max	SVK>FI>SVN>IR>GRE>GER>IT>SPA> NL>FR>AU>BE>POR	Benchmark model
Cavallo and Ribba (2015)	Max	GER>BE>ITA>SPA> FR > GRE>IR>POR	Full sample and euro-sample
Barigozzi *et al*. (2014)	Max	POR>NL>FI>IT≅GER>FR≅GRE>BE≅ SPA>IR POR>SPA≅FI>FR≅BE>NL≅GER≅IT>IR (GRE displays a positive response)	Euro-sample Pre-euro sample
Ciccarelli *et al*. (2013)	Cum	Countries under sovereign stress> The rest of countries	Crisis period. -25 basis points monetary shock
Boivin *et al*. (2009)	Max	Highly homogeneous responses for GER, FR, SPA and IT	Benchmark model: full sample
Rafiq and Mallick (2008)	Max	GER>FR>IT	Benchmark model
Peersman (2004)	Max Cum	GER>FR>SPA>IT>BE>AU>NL GER>BE>SPA>FR>IT>AU>NL	Model 1: estimated impact of a common monetary policy shock (baseline especification)
Ciccarelli and Rebucci (2002)	Cum	GER>FR>IT>SPA IT>GER>FR>SPA	Cumulative impact 12-month/mean Cumulative impact 24-month/mean No time-varying specification
Clements *et al*. (2001)	Max	FR>FI>BE>SPA>IR>IT≅NL>AU>GER> POR	Max effect over 20 periods (Common policy shock)
Van Els et al. (2001)	Max	POR>GRE>SPA>IT>AU>IR>FI>GER>FR >NL≅LU>BE	Benchmark model
Mihov (2001)	Cum	GER>AU≅IT>NL≅FR	
Mojon and Peersman (2001)	Max	NL>FI>IR≅BE>AU>GER≅FR>SPA>IT> POR	Benchmark model
Tremosa-Balcells *et al.* (2001)	Max	GRE>BE>SPA>FR>IT>POR>NL>FI> UK>AU>DEN>IR>GER>SW	Benchmark model
Ehrmann (2000)	Cum	GER>SW≅FI≅IT>FR>UK≅NL>IR> DEN>SPA>AU≅BE	Cumulative impact 12-quarter
Dornbusch *et al*. (1998)	Max	IT>SW>GER>UK>FR>SPA SW>IT>FR≅SPA>GER>UK	Impact effect Effect after two years
Ramaswamy *et al.* (1998)	Max	BEL≅FI>GER≅UK≅AU≅NL>SW≅POR≅ IT>DEN≅FR≅SPA	Benchmark model
Britton and Whitley (1997)	Max	FR≅GER>UK GER>FR≅UK	Each country estimated separately Joint estimation
BIS (1995)	Max	UK>IT>GER>FR>BE>NL>AU>SPA UK>GER≅FR>IT	Central Bank models Fed Multi-country model
Gerlach and Smets (1995)	Max	UK>IT>GER>FR GER>UK>IT≅FR	1SD Shock to the interest rate 100 basis points eight quarter sustained increase of the interest rate

Notes:

1) Type of impact obtained: Max=maximum impact of a monetary shock on output; Cum= cumulative impact of a monetary policy shock on output**.**

2) Main features of the analyses.

3) Acronyms: GER=Germany; BE=Belgium; DEN=Denmark; GRE=Greece; SPA= Spain; FR=France; IR=Ireland; IT=Italy; NL=The Netherlands; AU=Austria; POR=Portugal; FI=Finland; SVK= Slovakia; SVN= Slovenia; SW=Sweden; UK= United Kingdom.

In contrast, in the case of non-standard measures implemented by the ECB, it is possible to extract common patterns from the studies that have hitherto analysed their effects at the cross-country level: Boeckx *et al.* (2017) and Burriel and Galesi (2018).[14] Both studies point out a major heterogeneity in the impacts. In particular, the two studies find that the effects on GDP are of considerable size in the case of Estonia and relatively large in Germany, Finland, Austria, Ireland and Luxembourg. They also agree that such effects are milder in France, Italy and Belgium, and negligible or insignificant for Spain, Portugal and Cyprus. In the case of Greece, while Burriel and Galesi obtain a negligible response, Boeckx *et al.* find a negative impact.

3.2. Small open monetary unions

The studies focusing on Australia report a common finding: the state experiencing the greatest impact resulting from monetary policy is Western Australia (Weber, 2006; Fraser *et al.,* 2014; Vespignani, 2015).[15] With regard to the remaining states, even though these papers report heterogeneous impacts, their state responsiveness ranking differs.

Turning to Canada, Georgopoulus (2009) and Potts and Yerger (2010) also report heterogeneous effects on regional activity. However, the identification of common patterns is more complicated due to two reasons: (1) they use different types of impacts (cumulative versus non-cumulative impacts); and (2) they use different economic indicators: employment versus non-agricultural employment. In the study by Georgopoulus (2009) the most adversely affected territorial units are Newfoundland and Prince Edward Island, both mainly primary-based provinces. Conversely, in the study by Potts and Yerger (2010) the regions of Ontario and Quebec, mainly manufacturing-based economies, display the greatest impact.

Other small open monetary unions for which the empirical evidence reports heterogeneity in the regional effects resulting from monetary policy include the UK (Mandalinci, 2015), Sweden (Svensson, 2012), Greece (Anagnostou and Papadamou, 2016), the Netherlands (Arnold, 2002), Germany (Arnold, 2004), and Spain (De Lucio and Izquierdo, 1999; Rodríguez-Fuentes, 2006; Rodríguez-Fuentes *et al;* 2004).

3.3. Monetary unions in emerging and developing economies

With regard to China, despite the analyses reviewed in this paper making use of different territorial units, namely regions and provinces, the same territorial regularities emerge from the responses reported. Thus, the area displaying the largest impact is the Eastern Region (Guo and Tajul, 2014) or alternatively, most of the coastal provinces conforming such region (Cortes and Kong, 2007; Guo and Tajul, 2017).

Heterogeneous territorial impacts are also reported for Brazil (Bertanha and Haddad, 2008; Rocha *et al*., 2011), India (Nachane *et al*., 2001), Indonesia (Ridhwan *et al.,* 2014), and Turkey (Duran and Erdem, 2014).

4. The sources of heterogeneous regional effects

The studies on the regional effects of monetary policy examine two major sources of regional heterogeneity: (1) differences in the regional operability of the monetary policy

transmission channels; and (2) differences in regional business cycles (asynchronous cycles) and differing shock absorbers.

4.1. Differences on the regional operability of the monetary policy transmission channels

The literature has mainly discussed three monetary transmission channels: the interest rate channel, the exchange rate channel and the credit channel. The regional operability of these channels depends on the regional endowment of a series of specific structural features[16] and on the regional economic conjuncture.

4.1.1. Interest rate channel

This channel operates through the impact of monetary policy both on liquidity conditions and on the real interest rate. The increase in the real cost of capital affects those components of aggregate demand that are sensitive to interest rates, that is, consumption and investment. The interest rate channel is shaped by different elements. Following Suardi (2012) we distinguish: (1) the interest rate pass-through; (2) the interest sensitivity of production due to both demand and supply factors; (3) price and wage rigidity; (4) the income effect; and (5) the wealth effect. Two other effects identified by the literature are (Van Els *et al*., 2001)[17] the direct substitution effect and the cost of capital channel (the latter can be considered a generalisation of the effect of the sensitivity of production).

The literature on the regional effects of monetary policy has mainly focused on the assessment of the interest sensitivity of production by making use of a proxy of either the industry mix or the regional percentage of representative sectors (mainly the manufacturing sector). The remaining elements have been only sporadically analysed.

This channel has been found to be regionally operating through the interest sensitivity of production for the United States by Carlino and Defina (1998; 1999) and by Owyang and Wall (2009); for Brazil by Rocha *et al.* (2011); for Indonesia by Ridhwan *et al.* (2014); for Sweden by Svensson (2012); and for Australia by Vespigniani (2015).[18] In the case of Canada, Georgopoulus (2009) finds that those provinces experiencing a greater impact are primary-based, followed by the manufacturing-based. These two industries are found to be interest sensitive to monetary policy by the author in the same article. Mandalinci (2015) obtains some evidence of the regional operability of the interest rate channel for the UK, while Nachane *et al.* (2001) report a greater concentration of manufacturing in those states most sensitive to monetary policy in the case of India. In the case of China, Cortes and Kong (2007) find a significant coefficient for the primary sector GDP while the results of Guo and Tajul (2017) suggest that the interest rate channel is rather weak in China on a regional basis.

For the euro area, Georgiadis (2015) obtains evidence in favour of the operability of the interest rate channel through the sensitivity of production during the post-EMU stage. Furthermore, several studies have analysed the interest rate channel at a cross-country level during the pre-EMU stage (e.g. Van Els *et al.*, 2001; Angeloni *et al.,* 2002; Clements *et al.*, 2001). Namely, Angeloni *et al.* (2002) point out the dominance of the classic interest rate channel for Finland, Spain and Luxembourg during the pre-EMU period, whereas Clements *et al.* (2001) report that, for the same period, the interest rate channel was the dominant factor at a cross-country level. Regarding the sub-national dimension, Anagnostou and Papadamou (2016), Arnold (2002, 2004), and De Lucio and Izquierdo (1999) confirm the interplay between the industrial composition and the regional responsiveness to monetary policy for Greece, the Netherlands, Germany, and Spain, respectively.

4.1.2. Exchange rate channel

This channel operates when monetary policy affects net exports through import and export prices. The final impact of this mechanism on economic activity is ambiguous as it depends on the export/import position of the region and on the regime of the prevailing exchange rate. Vespigniani (2015) verifies the significance of trade openness at the state level for Australia. Weber (2006) also argues in favour of an operable exchange rate channel in Australia since the areas found to be the most responsive in the analysis are those with an important export-based economy (primary sector). The operability of the exchange rate channel at the regional level is also reported for Sweden (Svensson, 2012) and Turkey (Duran and Erdem, 2014). Conversely, Ridhwan *et al.* (2014) obtain no regional evidence pointing towards the existence of such a channel for Indonesia.

Georgopoulus (2009) finds that the Canadian provinces most adversely affected by a monetary contraction have a high share of exports (in the form of primary goods). Moreover, the author provides a potential explanation for the lower sensitivity of Ontario and Quebec that can be framed within the context of the exchange rate channel. The author suggests that despite the strong manufacturing base of these provinces, their lower responsiveness may be due to the fact that their manufacturing inputs come from the US. The decrease of input prices that stem from the monetary contraction mitigates (or even completely counteracts) the negative effects. Svensson (2012) finds a puzzling positive effect for some regions in Sweden following a monetary contraction and suggests a similar potential explanation to that provided by Georgopoulus (2009). All these findings provide support to the regional operability of the exchange rate channel in Canada.

The analysis of the regional exchange rate channel has received almost no attention in the case of large monetary unions. In the Eurozone, the exchange rate channel has been analysed occasionally only during the pre-EMU period. Barran *et al.* (1996) find no evidence in favour of its operability except for Spain. The findings of Clements *et al.* (2001) point out to the weak operability of this channel for Finland, Ireland and the Netherlands, while Caporale and Soliman (2009) report an operable exchange rate channel for Germany and the Netherlands.

4.1.3. Credit channel

This channel is based on the role of credit market imperfections, especially those of asymmetric information, which take the form of adverse selection and moral hazard problems. These imperfections result in an external finance premium, that is, a spread in cost across internal and external funding. This spread affects the transmission of monetary policy in a different way through factors affecting both supply (narrow credit channel) and demand (broad credit channel).[19]

The narrow credit channel operates when monetary policy influences the external finance premium through the alteration of the banks's ability and willingness to provide loans. Following Suardi (2012), it is necessary that two conditions hold for this channel to be operable: in the first place, a policy tightening, by draining reserves and deposits from the banking system, should entail a reduction in the banks's ability to supply loans. Secondly, at least for a small proportion of the borrowers, there must not be perfect substitutability between bank credit and other debt instruments. If these conditions hold, then the reduction in the supply of credit will decrease aggregate consumption and investment.

Cross-country or sub-national differences arise when dependence on bank credit and its availability are territorially heterogeneous. As a proxy variable of the narrow credit

channel, the literature has used, to a greater extent, the size of banks. This choice is based on the assumption that small banks face greater difficulty in finding alternative sources of financing when a monetary contraction takes place, which hampers their ability to lend. Alternatively, Owyang and Wall (2009), in their analysis, use a measure of the concentration of the banking sector since, according to them, a highly concentrated banking sector can lead to a non-competitive market of funds that would generate a negative impact on economic activity following monetary tightening. More recently, Ciccarelli *et al.* (2013) have made use of a more elaborate proxy for the bank lending channel, namely the net percentage of banks that have changed lending standards as a result of factors associated with bank balance sheet capacity and competition.

The narrow credit channel has been regionally analysed for the United States by Carlino and Defina (1998; 1999) and Owyang and Wall (2009). The first two studies find no evidence of a narrow credit channel, while the results of Owyang and Wall (2009) suggest the regional operability of this channel.

In the Eurozone, during the post-EMU period, Ciccarelli *et al.* (2013) report the operability of this channel during 2008 and 2009 for countries under sovereign stress, while for the remaining countries it is only significant in the fourth quarter of 2008 (quarter after the fall of Lehman brothers and the introduction of the ECB's fixed rate full allotment policy).

Ridhwan *et al.* (2014) and Duran and Erdem (2014) also report the regional incidence of a narrow credit channel for Indonesia and Turkey, respectively.

On the other hand, the balance sheet channel operates due to the financial difficulties that arise in the balance sheets of companies and households following a monetary tightening (Suardi, 2012). More precisely, such a tightening in the monetary stance entails a reduction of borrowers' net worth. Consequently, borrowers face a larger external finance premium since adverse selection and moral hazard problems are worsened. If this leads to a decrease of credit, then consumption and investment should be reduced. The literature generally proxies this channel by means of a variable that represents firm size, since smaller firms are thought to face a greater external finance premium following a monetary contraction than larger firms. Ciccarelli *et al.* (2013) also resort to a more elaborate proxy for this channel (they refer to it as the (non financial) borrower´s balance sheet channel), namely the net percentage of banks that have changed lending standards as a result of factors associated with firm (household) balance-sheet strength.

At the sub-national level, evidence in favour of the broad credit channel is weaker. For the United States, Carlino and Defina (1998) only find weak support of its operability, while Carlino and Defina (1999) conclude that this channel is not significant at the state level. Owyang and Wall (2009) find mixed evidence since their analysis indicates that regions with smaller firms tend to be less responsive to monetary policy when considering the full sample.

In the post-EMU period, Ciccarelli *et al.* (2013) report an operable borrower´s balance sheet channel for the countries of the Eurozone under sovereign stress during the period following the bankruptcy of Lehman Brothers.

Ridhwan *et al.* (2014) reports the existence of a broad credit channel regionally operating in Indonesia, while Svensson (2012) finds no support for this channel in Sweden. Mandalinci (2015) finds some evidence of a broad credit channel regionally operating in the UK.

In their analyses, certain authors have made use of proxy variables that do not strictly correspond to a single credit sub-channel of the two aforementioned sub-channels.

Accordingly, Cortes and Kong (2007) find that the share of bank loans[20] going to industrial firms is the most important determinant of the provincial responses following a monetary shock, which supports the regional operability of a bank credit channel in China. Furthermore, Guo and Tajul (2017) report a positive relationship between the percentage of small firms and the magnitude of the provincial response[21] in China. However, their analysis also reports conflicting results regarding the percentage of small and large banks. For India, Nachane *et al.* (2001) report that those states intensively banked display greater responsiveness to monetary policy. Lastly, Rocha *et al.* (2011) find that those states with a higher volume of credit experience responses of greater size following a monetary policy contraction, which provides evidence of a credit channel operating at the sub-national level in Brazil.

4.1.4. Other channels/effects

Certain studies analyse other specific factors that are likely to induce differential regional effects on economic activity, such as: (1) indebtedness effects; (2) socio-demographic and economic size effects; and (3) effects owing to the capitalisation of the banking sector.

4.1.4.1.Indebtedness effects

By means of regression analysis, Vespigniani (2015) finds empirical evidence that supports the role of mortgage and government indebtedness as sources of state heterogeneity in the impacts that stem from monetary policy in Australia. Likewise, Mandalinci (2015) also obtains evidence in favour of mortgage indebtedness playing such a role at the regional level for the UK.

4.1.4.2.Socio-demographic and economic size effects

Ridhwan *et al.* (2014) assess the regional economic size as a source of differential responses in Indonesia and obtain no favourable evidence to indicate the role of this factor. Conversely, Duran and Erdem (2014) report the regional significance of this type of factor for Turkey. More specifically, they find that provinces with larger populations (and hence larger market size) are the most responsive to monetary policy. Rocha *et al.* (2011) analyse a set of diverse socio-demographic variables as sources of regional heterogeneity in Brazil. The results of the analysis point out that the most populated states (contrary to the evidence obtained for Turkey), with a greater diversity index and greater stock of human capital, are the least adversely affected by a tightening of the monetary policy. In the case of the Eurozone, Burriel and Galesi (2018) find that countries with a lower level of economic development have benefited the most from the unconventional measures implemented by the ECB, although it is important to note that this is not a direct outcome of this type of monetary policy but of its spillover effects.

4.1.4.3.Soundness of the banking sector

Boeckx *et al.* (2017) and Burriel and Galesi (2018) find that the non-standard monetary measures implemented by the ECB are more beneficial for those countries whose banking sector is more resilient. More precisely, Boeckx *et al.* (2017) obtain a positive strong correlation between the peak impact on country-specific output and bank capital. This correlation suggests that the capitalisation of the banking sector plays a relevant role in the transmission of non-standard monetary policy.[22] On the other hand, Burriel and Galesi (2018) make use of regressions and employ the share of capital in total assets held by banks as a proxy of the soundness of the banking sector.

In summarising the evidence on the sources of differential regional effects that stem from the conduction of monetary policy, it can be concluded that the interest and

exchange rate channels are those that have a greater relative importance. More specifically, the most consistent result for the US is that regions with a larger share of the manufacturing industry show a greater responsiveness to monetary policy. In Canada and Australia, this specific pattern seems to be diluted by the interplay of the interest rate channel with the exchange rate channel, since the latter seems to be prevailing in certain regions, especially in Australia. The bi-regional nature of the economic structure of these two monetary unions (Weber, 2006), whereby the primary sector is located in different geographic centres from the manufacturing industry and the services sector, together with the fact that their international trade patterns seem to be mostly based on the comparative advantage in the primary sector[23] of these two economies, explain why the defining structural feature of their most responsive territorial units is contrary to that identified for the US. With regard to the Eurozone, the available empirical evidence covering the pre-EMU period points to the interest rate channel as a prevalent monetary transmission channel. During the post-EMU phase, in addition to confirming the operability of the interest rate channel, the empirical evidence lends support to an operable credit channel that appears to have gained importance from the onset of the financial crisis. Furthermore, it appears that the soundness of the banking sector has hitherto been the key factor identified with regard to the effectiveness of the non-standard measures implemented by the ECB in the aftermath of such a crisis. However, concerning the credit channel, far more empirical evidence exists of its regional operability in Asian and emerging economies.

4.2. Differences of the position in the business cycle (asynchronous cycles) and of the shock absorbers

In addition to the explanations of the heterogeneous regional effects based on the transmission channels, certain bibliography, albeit rather scarce, suggests that the business cycle phase under which the regional economy is operating may constitute a source of heterogeneous impacts. Therefore, an alternative explanation of the territorial impacts of monetary policy can be found in the asynchrony of regional business cycles. Along these lines, Hanson *et al.* (2006) analyse the incidence that the relative position of the real economic activity of the state with respect to the national average has on the impacts of monetary policy on the state. The results indicate that those states of the United States that are depressed (relative to the national average, i.e., relatively low-growth states) display greater responsiveness following a monetary contraction, while the reverse trend holds when an expansionary monetary policy is conducted.

These types of dynamics are further explored by Rodríguez-Fuentes (1997, 1998, 2006). The author points out that the effects of monetary policy may also depend on the reactions of economic agents through a behavioural effect,[24] which may arise as a consequence of regional differences in the banking structure and development and in the preference for liquidity. Thus, if there are cyclical changes in the liquidity preference of agents (which may be influenced by monetary policy) in the context of a developed banking system, then the availability of regional credit may adopt a more acute[25] cyclical pattern in peripheral or less developed regions. Rodríguez-Fuentes (1998, 2006) and Rodríguez-Fuentes and Dow (2003) provide evidence of such dynamics in Spain.

Within the framework of the theory of optimal currency areas (OCA), a number of studies have evaluated the role played by the so-called "shock absorbers" as mitigating factors in cyclical position differences and as generators of asymmetries within the context of monetary policy. The main "shock absorbers" are: (1) wage flexibility; (2) factor mobility; (3) fiscal transfers and (4) diversification of the economy.

The role of shock absorbers in the United States has been studied by Beckworth (2010) and for the southern part of the Eurozone by Anagnostou and Papadamou (2014). In both studies, indicators are also used to measure the correlation between regional and national business cycles. While for the US this correlation measure turns out to be statistically significant, this is not the case for the southern regions of the Eurozone. Both studies use VAR models[26] and conclude that the lower the wage flexibility and the labour mobility,[27] the greater the impact on the regional activity following a contractionary monetary shock. However, these studies also feature major differences. Regarding the economic diversity measures, Beckworth finds that only the diversification of the industrial portfolio and the extractive industry are significant (the greater the two indicators, the larger the regional impacts stemming from a contractionary monetary policy), while Agnastou and Papadamou conclude that the share of non-market services and the share of manufacturing industry are significant (the greater the share of both sectors, the lower the regional response to a contractionary monetary shock).

4.3. Limits on the scope of the analysis of the sources of regional heterogeneity

The main limitation of the studies previously reviewed is that of the relatively reduced explanatory power of the monetary transmission channels, shock absorbers, and business cycles regarding regional heterogeneity in the responses. In general terms, the models employed explain at most approximately sixty-five percent (with a few exceptions in the case of the monetary transmission channels) of the cross-regional variation in the responses (taking the adjusted R^2 as a reference). It is of particular note that the proportion of variation explained by the shock absorbers and the business cycle is slightly higher than the variation explained by the monetary transmission channels for the US. It should also be borne in mind that shock absorbers explain a decreasing proportion in the time horizon of analysis in the southern regions of the Eurozone, whereas in the US this proportion is increasing. Lastly, it is worth mentioning that the wider the array of variables incorporated in the model, the greater the explanatory power of the model, as shown by Vespignani (2015). In this paper, the incorporation of a wider set of explanatory variables leads to an adjusted R^2 equal to eighty-one percent.
Summing up, it is possible to conclude that even if the models employed to examine the sources of regional heterogeneity explain an acceptable proportion of the cross-region variation in the impacts resulting from the conduct of monetary policy, there exist other sources or factors inducing differential policy responses that have yet to be incorporated in the models. There is hence further room for improvement in such analysis.[28]

5. Conclusions

In this paper, we have surveyed the empirical evidence on the regional effects of monetary policy in economic activity, and paid particular attention to the most recent contributions. We have hence proceeded to structure the empirical evidence with the ultimate goal of delivering solid lessons on which to base policy-making and further research. To this end, a threefold perspective has been undertaken when structuring and systematising the empirical results.
The overall main conclusion drawn from this survey is that monetary policy does have heterogeneous territorial incidence on economic activity. This conclusion is found to hold irrespective of the methodology and of the territorial unit of analysis.
With regard to the methodological perspective, territorial heterogeneity is robust with most of the methodological and modelling dimensions reviewed. However, several methodological and modelling features have been found to generate diverging results.

Namely, the time period of analysis does have a significant bearing on the results. Other potential sources of diverging estimates are the use of economic indicators of excluding nature and the lack of incorporation of all the spatial units of a monetary union in the model.

Concerning the perspective of the systematisation of the results yielded by the literature, it is worthy of note that significant cross-study regularities have emerged for the cases of the United States, Australia and China. These identified regularities are deemed to constitute conclusive evidence. Conversely, for the Eurozone and the European Union, the evidence is rather mixed since the results differ considerably across studies. Thus, for this latter case, the overall evidence fails to yield a consistent ranking in terms of the countries responsiveness to monetary policy, thereby making it impossible to deliver a conclusive picture regarding cross-country heterogeneity in the effects of monetary policy for the Eurozone. Nonetheless, the results obtained by the recent and still scarce literature focusing on the cross-country effects of non-standard measures implemented by the ECB do display common patterns.

From the perspective of the sources of regional heterogeneity, the following series of regularities in relation to the channels of monetary policy transmission have been identified: (1) the interest rate channel, either weakly or strongly, is regionally operating in all the economies. (2) The exchange rate channel seems regionally relevant in small and open economies, such as Australia, Canada, and Sweden. Its relevance is such that it might even alters the defining structural feature of the most responsive regions: in the US, the most sensitive regions are those with a higher share of manufacturing industry, while in the case of Australia, primary-based states are those experiencing greater impacts. In Sweden and Canada, the results suggest that the regional operability of this channel entails qualitatively divergent responses in a number of territorial units due to the importing structure of their economies, and (3) the credit channel is regionally operating to a greater extent in Asian and emerging economies.

It should be highlighted that the evidence on monetary policy transmission channels operating at the regional level has yet to be exhaustively addressed by the literature.

With regard to the influence of the cyclical position and the shock absorbers, the empirical evidence is too scarce as to draw definitive conclusions.

Summing up, the available empirical literature agrees, although not unanimously for the case of the Eurozone, on the existence of regional heterogeneity in the impacts resulting from the implementation of monetary policy. Such territorial incidence is found to be greater in those regions where consumption and investment (highly dependent on the interest rate) carry more weight in the aggregate demand. However, in small and open economies, the exchange rate channel may turn out to be regionally prevailing, although in this case it remains impossible to infer a priori the regional qualitative pattern of the response since the final magnitude of the impact depends on the type of trade maintained by each territory.

Finally, the most relevant research gaps and emerging topics identified in this survey include the following: in the first place, there is a need to attain a deeper insight into the effects resulting from opposing shocks (that is, contractionary versus expansionary shocks). Moreover, it is necessary to further analyse the Eurozone from a disaggregated territorial perspective in order to obtain evidence of a more consistent and conclusive nature that can actually inform policy-making. In addition, in order to enhance our understanding of the interaction between monetary policy and regional heterogeneity, it is necessary to further explore those monetary policy transmission channels operating at the regional level and to extend analysis on the role of asynchronous business cycles and shock absorbers as sources of regional heterogeneity. Furthermore, the almost

unexplored regional effects stemming from the implementation of the so-called non-standard measures undertaken during the aftermath of the recent economic and financial crisis also need to be thoroughly assessed. Finally, given the current background of increasingly globalised economies and financial markets, it would be advisable to carry out further research into the cross-border regional spillover effects resulting from monetary policy.

Notes

1. See Rodríguez-Fuentes (1997, 2006) for an analysis of the theoretical framework underlying the territorial effects of monetary policy. For a further insight into both the theoretical and empirical perspectives of the debate specific to the territorial implications of a single monetary policy in Europe, see, among others, Walters (1990), Dunn (1999) and Issing (2001).
2. This survey is limited to the effects on the fundamental regional macroeconomic variables. Asymmetric territorial incidence by economic sectors, such as the housing sector (Yang et al., 2013), is not considered because its inclusion falls beyond the scope of the present review.
3. Henceforth, the term "regional" will refer to the territorial units comprising a monetary union. When the study under revision refers to a supra-national monetary union such as the Eurozone, the regional effects will refer to: (1) supra-national effects when the study pools together several countries to carry out the territorial assessment; (2) cross-country effects when the study assesses the impacts on the constituent countries of the supra-national monetary union; and (3) sub-national effects when the study assesses the impacts at the sub-national level.
4. Rodríguez-Fuentes (1997) and Rodríguez-Fuentes (2006) provide further accounts of such literature.
5. This type of study does not fall into the category of papers that are being reviewed in the present survey since it does not strictly analyse the effects of monetary policy on territorial economic activity.
6. In the study by the Bank of International Settlements (BIS, 1995), both types of models (single country and multi-country) are employed.
7. The authors use the exchange rate overshooting model of Dornbusch, which constitutes an extension of the Mundell-Fleming framework.
8. This approach is mentioned only by Kieler and Saarenheimo (1998).
9. See Peersman (2004) for an extended explanation of this issue.
10. Taking as reference the benchmark estimation period.
11. Namely, data was obtained from the European Commission data set.
12. In order to be consistent with the conclusions obtained by the authors, it is important to remember that references to the regional economic structure refer to the existing regional economic structure in the time period examined by the article.
13. This table only provides information on the ordering of the countries in terms of magnitude but not on the statistical significance of such asymmetries.
14. In order to carry out this cross-study check, we employ the benchmark estimation.
15. The only exception is found in the study of Weber when the author uses the activity variable of SFD and a linear trend. That is, WA is not found to be the state displaying the greatest impact in only one out of the four cases analysed by Weber.
16. This broadly coincides with the structural effect explained by Rodríguez-Fuentes (1997, 2006) and which is analysed by Rodríguez-Fuentes and Hernández-López (1997) in the regional context of Spain through a cluster analysis.

17. Van Els *et al.* (2001) use the terminology of channels rather than effects when carrying out the analysis.
18. Vespigniani (2015) does not explicitly identify the manufacturing proportions variables as a proxy for the interest rate channel.
19. These channels are also referred to as the bank lending channel and balance sheet channel, respectively. See Bernanke and Gertler (1995) for a further explanation of these channels.
20. As Angeloni *et al.* (2002) point out, the analysis of the loan supply variable can be misleading since the granting of loans may be sensitive due to changes in the demand for loans rather than in the supply of loans.
21. The authors identify the firm-size effects with a bank lending channel, contrary to the widespread use in the literature of firm-size effects as a proxy for the broad credit channel.
22. This analysis is motivated by the fact that the effects of an expansionary shock to the ECB balance sheet on output are larger in those countries that have been less affected by the financial crisis of 2008.
23. Nimark (2007) points out that, while for most of the developed countries, profits from international trade come from their specialisation, in the case of Australia the prevalence of exports of primary goods reflects that international trade seems to be based on the classic comparative advantage.
24. See Rodríguez-Fuentes 1997, 1998 and 2006 for an extensive explanation of the behavioural effect.
25. Originally, the author employs the term *unstable pattern* to refer to greater rises and drops during expansions and recessions, respectively (Rodríguez-Fuentes, 1998).
26. More precisely, Beckworth employs a near-VAR model whereas Anagnostou and Papadamou use a Bayesian Panel VAR.
27. Georgiadis (2015) also finds that European economies that feature greater rigidities in the labour market experience greater impacts, although the estimates are considerably less robust.
28. See the Appendix for a detailed compilation of the models.

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Annex

Table 2. The channels of monetary transmission: characteristics of the studies that analyse them through regression analysis.

Type of effects[1]	Channel[2]	Proxy[3]	Country/ Period	Author	Statistical significance[4]
Industry mix effects	Interest rate channel	Share of a state's GSP accounted for by manufacturing	US 1958Q1-1992Q4	Carlino and Defina (1998; 1999)	Yes
	Interest rate channel	Sub-region's share of total non-farm employment in the manufacturing sector	US 1960Q1-2005Q2 D.T.T/T.P.I. Volcker-Greenspan period: D.T.T/T.P.I.	Owyang and Wall (2009)	Yes No
	No channel specified	Share of GDP accounted by the primary sector	China 1980-2004	Cortes and Kong (2007)	Yes
	Interest rate channel	Percent of (1) industrial establishments + (2) establishments of the industry of transformation + (3) extractive industry establishments	Brazil 1995: January-2010:November	Rocha *et al.* (2011)	Yes
	Interest rate channel	Share of employment in the goods + share of employment in the service sector + two subjective rankings of interest sensitivity	Sweden 1993Q1-2007Q4	Svensson (2012)	Yes
	Interest rate channel	Share of manufacturing to GRP	Indonesia 1990Q1-2007Q4	Ridhwan *et al.* (2014)	Yes
	Interest rate channel	Percentage share of manufacturing sector's GDP in total GDP	Turkey 1975-2000	Duran and Erdem (2014)	Yes (sign contrary to expected)
	No channel specified	GVA of manufacturing industry as a percentage of GSP	Australia 1990:September-2010:December	Vespigniani (2015)	Yes
	Interest rate channel	Share of (1) durables manufacturing in total value added+ (2) construction in total value added + (3) services in total value added	Eurozone 1999Q1-2009Q4	Georgiadis (2015)	Yes
	Interest rate channel	Percent secondary industry	China 1978-2011	Guo and Tajul (2017)	Only statistically significant in equation 1
Effects of firm size	Broad credit channel	Share of a state's small firms (percent of firms with fewer than 250 employees)	US 1958Q1-1992Q4	Carlino and Defina (1998)	Yes (one tailed-test) No (two tailed-test)
	Broad	Share of a state's small	US	Carlino and	No

	credit channel	firms (percent of firms with fewer than 250 employees)	1958Q1-1992Q4	Defina (1999)	

Table 2 (continued)

Type of effects[1]	Channel[2]	Proxy[3]	Country/ Period	Author	Statistical significance[4]
Effects of firm size (continued)	Broad credit channel	Share of total employment in firms with fewer than 100 employees	US 1960Q1-2005Q2 D.T.T/T.P.I. Volcker-Greenspan period: D.T.T/T.P.I.	Owyang and Wall (2009)	No/Yes (sign contrary to expected) No/No
	Broad credit channel	Percent of industrial establishments with 500 or more employees + Percent of local units with 250 or more employees	Brazil 1995: January-2010:November	Rocha *et al.* (2011)	Yes
	Broad credit channel	Share of small firms	Sweden 1993Q1-2007Q4	Svensson (2012)	No
	Broad credit channel	Percentage of firms that have more than 10 employees	Turkey 1975-2000	Duran and Erdem (2014)	No
	Broad credit channel	Percentage share of a region's firms with fewer than 19 employees	Indonesia 1990Q1-2007Q4	Ridhwan *et al.* (2014)	Yes
	Bank lending channel	Percent small sized enterprise (20≤number of employees<300; 3 million CHY≤ operating income< 2000 million CHY)	China 1978-2011	Guo and Tajul (2017)	Yes (equations 1 and 3)
Effects of bank size	Narrow credit channel	2 alternative measures: 1. Percent of a state's total loans made by the state's banks that are at or below the 90th percentile in assets nationally in 1982 2. Percent of a state's total loans made by the state's banks that are at or below the 90th percentile in assets nationally in 1982 and not part of a bank holding company	US 1958Q1-1992Q4	Carlino and Defina (1998)	Yes (sign contrary to expected)
	Narrow credit channel	2 alternative measures: 1. Percent of a state's total loans made by the state's banks that are at or below the 90th percentile in assets nationally 2. Percent of a state's total loans made by the state's banks that are at or below the 90th percentile in assets	US 1958Q1-1992Q4	Carlino and Defina (1999)	Yes (sign contrary to expected in the second variable)

		nationally and not part of a bank holding company			

Table 2 (continued)

Type of effects [1]	Channel[2]	Proxy [3]	Country/ Period	Author	Statistical significance [4]
Effects of bank size (continued)	Bank credit channel	Share of bank loans going to industrial firms	China 1980-2004	Cortes and Kong (2007)	Yes
	Narrow credit channel	Average deposit share of the largest three banks	US 1960Q1-2005Q2 D.T.T/T.P.I.[5] Volcker-Greenspan period: D.T.T/T.P.I.	Owyang and Wall (2009)	Yes Yes
	Credit channel	Average deposits by agencies + percent of financial institutions with 0 to 4 employees	Brazil 1995: January-2010:November	Rocha *et al.* (2011)	Yes
	Narrow credit channel	Average number of employees per bank and financial intermediary firms	Turkey 1975-2000	Duran and Erdem (2014)	Yes
	Narrow credit channel	Percentage of a region's total loans made by the province's rural banks	Indonesia 1990Q1-2007Q4	Ridhwan *et al.* (2014)	Yes
	Bank lending channel	Percent small banks + percent of large banks	China 1978-2011	Guo and Tajul (2017)	Yes (sign contrary to expected)
Effects of the degree of openness	Exchange rate channel	Share of exports to GRP	Indonesia 1990Q1-2007Q4	Ridhwan *et al.* (2014)	No
	Exchange rate channel	Export intensity	Sweden 1993Q1-2007Q4	Svensson (2012)	Yes
	Exchange rate channel	Share of total exports and imports within GDP of the province	Turkey 1975-2000	Duran and Erdem (2014)	Yes
	Exchange rate channel	State/territory exports plus imports as percentage of GSP + one period lag IRF of real gross rate of state/territory exports to monetary shocks	Australia 1990: Septiembre-2010: Diciembre	Vespigniani (2015)	Yes

Notes:

1) The type of effects makes reference to the categorization provided by Rodríguez-Fuentes (1997, 2006) and Rodríguez-Fuentes and Dow (2003) regarding the variables explaining the structural effects.

2) The channel makes reference to the type of channel whose regional operability is being tested.

3) The term proxy indicates the variable that is used by the studies to proxy for the channel or effects examined.

4) The statistical significance indicates whether the effects/channel analysed are statistically significant.

5) Acronyms: GSP= Gross State Product; GDP=Gross Domestic Product; GRP= Gross Regional Product; GVA= Gross Valued Added; IRF= Impulse response function; CHY= Chine Yuan; D.T.T.= depth of the total trough; T.P.I.= total personal income cost.

Table 3. Explanatory power of the models used to analyse monetary transmission channels.

Study	Model	R^2/ Adjusted R^2 (in percent)	Dependent variable
Carlino and Defina (1998)	Equation 1: - Intercept - Percent manufacturing - Percent small firms - Percent small bank loans (all banks)	Adjusted R^2: 15.86	8-Quarter personal income cumulative response
	Equation 2: - Intercept - Percent manufacturing - Percent small firms - Percent small bank loans (no banks members of a holding company)	Adjusted R^2: 17.29	8-Quarter personal income cumulative response
	Equation 3: - Intercept - Percent manufacturing - Percent small firms - Percent small bank loans (all banks) - Dummy variables (identifying the region in which a state is located)	Adjusted R^2: 38.21	8-Quarter personal income cumulative response
	Equation 4: - Intercept - Percent manufacturing - Percent small firms - Percent small bank loans (no banks members of a holding company)	Adjusted R^2: 41.15	8-Quarter personal income cumulative response
Carlino and Defina (1999)	Model 1: - Intercept - Percent manufacturing - Percent extractive - Percent small firms - Percent small bank loans	Adjusted R^2: 45.91	8-Quarter personal income cumulative response
	Model 2: - Intercept - Percent manufacturing - Percent extractive - Percent small firms - Percent small bank loans (no banks members of a holding company)	Adjusted R^2: 42.43	8-Quarter personal income cumulative response
	Model 3: - Intercept - Percent manufacturing - Percent extractive - Percent small firms - Percent small bank loans (all banks) - Dummy variables (identifying the region in which a state is located)	Adjusted R^2: 47.34	8-Quarter personal income cumulative response
	Model 4: - Intercept - Percent manufacturing - Percent extractive - Percent small firms	Adjusted R^2: 49.25	8-Quarter personal income cumulative response

	- Percent small bank loans (no banks members of a holding company)		

Table 3 (continued)

Study	Model	R^2/ Adjusted R^2 (in percent)	Dependent variable
Cortes and Kong (2007)	Benchmark model: - Constant - Percent of state-owned firms - Percent of loans to industrial firms - Primary sector GDP share - Coastal province dummy variable	Adjusted R^2: 49	6-Year cumulative real GDP response
Owyang and Wall (2009)	Full sample model - Constant - Manufacturing share - Small firms's share - Share of 3 largest banks Volcker-Greenspan model - Constant - Manufacturing share - Small firms's share - Share of 3 largest banks	R^2: 50.3 R^2: 64.1 R^2: 51.9 R^2: 32.3	Personal income loss at trough Total personal income loss Personal income loss at trough Total personal income loss
Beckworth (2010)	Model 1: - Constant - Relative manufacturing wage - Relative inflation rate - Unemployment persistence - Fiscal transfers - Relative share: extractive industries - Relative share: manufacturing - Industry portfolio volatility Model 2: - Constant - Relative manufacturing wage - Relative inflation rate - Unemployment persistence - Fiscal transfers - Relative share: extractive industries - Relative share: manufacturing - Industry portfolio volatility - Coincident indicator correlation Model 3: - Constant - Relative manufacturing wage - Unemployment persistence - Industry portfolio volatility - Coincident indicator correlation	R^2: 44.6 Adjusted R^2: 34.9 R^2: 54.75 Adjusted R^2: 46.8 R^2: 59.25 Adjusted R^2: 52.1 R^2: 47.3 Adjusted R^2: 36.5 R^2: 65.01 Adjusted R^2: 57.8 R^2: 71.22 Adjusted R^2: 65.3 R^2: 42.43 Adjusted R^2: 37.1 R^2: 62.51 Adjusted R^2: 59 R^2: 67.89 Adjusted R^2: 64.9	12-Month coincident indicator response 24-Month coincident indicator response 36-Month coincident indicator response 12-Month coincident indicator response 24-Month coincident indicator response 36-Month coincident indicator response 12-Month coincident indicator response 24-Month coincident indicator response 36-Month coincident indicator response
Rocha *et al.* (2011)	Model 1: - Constant - Percent of industrial establishments - Percent of industrial establishments with 500 or more employees - Percent of public employment Model 2: - Constant	Adjusted R^2: 64.5 Adjusted R^2: 72	Maximum state industrial production response Maximum state industrial production

	- Average deposits by agencies - Percent of public employment		response

Table 3 (continued)

Study	Model	R^2/ Adjusted R^2 (in percent)	Dependent variable
Rocha *et al.* (2011) (continued)	Model 3: - Constant - Percent of extractive industry establishments - Degree of openness	Adjusted R^2: 50	Maximum state industrial production response
	Model 4: - Constant - Percent of financial institutions with 0 to 4 employees - Diversity index	Adjusted R^2: 37.6	Maximum state industrial production response
	Model 5: - Constant - Percent of establishments of the industry of the transformation - Percent of local units with 250 or more employees	Adjusted R^2: 44,8	Maximum state industrial production response
	Model 6: - Constant - Diversity index	Adjusted R^2: 6.7	Maximum state industrial production response
	Model 7: - Constant - Human capital	Adjusted R^2: 0.7	Maximum state industrial production response
Ridhwan *et al.* (2014)	Benchmark model: - Constant - Share of manufacturing to GRP - Share of a region´s small firms - Small banks loans´s share - Inflation rate - Size of GRP - Exports (% of GRP)	Adjusted R^2: 53.3 Adjusted R^2: 40.8 Adjusted R^2: 54.6 Adjusted R^2: 16.8	Maximum cumulative real GDP response 4-Quarter cumulative real GDP response 20-Quarter real GDP cumulative effects Time elapsed at maximum real GDP cumulative response
Anagnostou and Papadamou (2014)	Model 1: - Constant - Relative manufacturing wage - Relative sectoral share of manufacturing - Relative sectoral share of non-market services - Unemployment persistence	R^2: 42.43 Adjusted R^2: 38.09 R^2: 35.38 Adjusted R^2: 30.5 R^2: 16.78 Adjusted R^2: 10.5	12-Month GDP response 24-Month GDP response 36-Month GDP response
	Model 2: - Constant - Relative manufacturing wage - Relative sectoral share of manufacturing - Relative sectoral share of non-market services - Unemployment persistence - Business cycle coincident indicator	R^2: 42.54 Adjusted R^2: 37.02 R^2: 35.98 Adjusted R^2: 29.83 R^2: 16.99 Adjusted R^2: 9.01	12-Month GDP response 24-Month GDP response 36-Month GDP response
Georgiadis (2015)	Model 1: - Labor market rigidities	R^2: 32	Real GDP response at trough
	Model 2: - Real wage rigidities	R^2: 35	Real GDP response at trough

	- Unemployment rigidities		

Table 3 (continued)

Study	Model	R^2/ Adjusted R^2 (in percent)	Dependent variable
Georgiadis (2015) (continued)	Model 3: - Industry mix	R^2: 51	Real GDP response at trough
	Model 4: - Labor market rigidities - Industry mix	R^2: 55	Real GDP response at trough
	Model 5: - Real wage rigidities - Unemployment rigidities - Industry mix	R^2: 56	Real GDP response at trough
	Model 6: - Real wage rigidities - Industry mix	R^2: 55	Real GDP response at trough
	Model 7: - Unemployment rigidities - Industry mix	R^2: 52	Real GDP response at trough
Vespigniani (2015)	Model 2 with Constant: - One period lag IRF of real gross rate of state/territory exports to monetary shocks - Mortgage repayment as a percentage of disposable income - State/territory exports plus imports as a percentage of GSP - State/territory debt as a percentage of GSP - GVA manufacturing industry as a percentage of GSP	R^2: 84 Adjusted R^2: 81.7	State final demand response
Guo and Tajul (2017)	Equation 1: - Intercept - Percent secondary industry - Percent small bank - Percent small sized enterprise	Adjusted R^2: 31.24	6-year cumulative real GDP response
	Equation 2: - Intercept - Percent secondary industry - Percent large bank - Percent state-owned enterprise	Adjusted R^2: 41.63	6-year cumulative real GDP response
	Equation 3: - Intercept - Percent secondary industry - Percent small bank - Percent small sized enterprise - Dummy east region	Adjusted R^2: 40.98	6-year cumulative real GDP response
	Equation 4: - Intercept - Percent secondary industry - Percent large bank - Percent state-owned enterprise - Dummy East region	Adjusted R^2: 46.33	6-year cumulative real GDP response
Burriel and Galesi (2018)	Model with spillover effect (total effect) - Real GDP per capita - Bank´s capital ratio - Unemployment rate	R^2: 71	Median peak response of output growth

	- Ease of doing business - Constant		