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Okun in the Euro

New Evidence from Structural Okun Law's Estimates for the Euro Area, 1979-2019

Nauro F. Campos, Corrado Macchiarelli, Fotios Mitropoulos

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ABSTRACT: This paper provides new estimates of Okun's unemployment-output relationship in euro area countries between 1979 and 2019. We find our structural estimates are stable but substantially lower than the reduced-form estimates that tend to characterise the literature and that the responsiveness of output to unemployment is driven by idiosyncratic factors in both euro core and periphery countries. The results are robust to conditioning on wage bargaining institutional set-ups and, yet, in the euro periphery, we find product market regulation as playing a major role in explaining the significance of Okun's law estimates across countries.

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Prepared by Nauro F. Campos, Corrado Macchiarelli, Fotios Mitropoulos[1]

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Glossary

AD = Aggregate Demand

CBC = Collective Bargaining Coverage

EPL = Employment Protection Legislation

GDP = Gross Domestic Product

GFC = Great Financial Crisis

MR = Money Rule

OL = Okun's Law

PMR = Product Market Regulation

PS = Price Setting Equation

SP VAR = Structural Panel Vector Autoregression

TU = Trade Union Density

VAR = Vector Autoregression

Executive Summary

How sensitive is output growth to changes in unemployment in the euro area, and how has this changed over time? This study examines these dynamics and provides new evidence showing that the relationship between output and unemployment (the so-called Okun's Law) in the euro area has not weakened much, on average, since the Great Financial Crisis. This is done in this paper in a novel way by trying to circumvent the conventional limitations often encountered when estimating Okun's Law.

This paper provides important new insights about the validity of the output-unemployment relationship, stressing the role of idiosyncratic shocks in a structural multivariate framework which considers different core and peripheral country groupings and worker categories, such as young and female workers. In a nutshell, we find that the variations observed in the responsiveness of output to unemployment growth are significantly influenced by country-specific shocks experienced by different groups of countries in the euro area, and workers' categories within them. In particular, we identify four key factors: first, whether the sample includes years after 2008 (post-Great Financial Crisis); second, whether total, young or female unemployment is considered; third, whether institutional factors such as labor legislation, product market regulations, central bargaining, and trade union density are fully accounted for; and fourth, whether a country is part of the euro area core or the euro area periphery.

For countries situated in the euro area periphery, the results suggest that the relationship between output and unemployment is influenced by the levels of product market regulation, particularly for female workers. Strong labor market adjustments brought about by the Global Financial Crisis (GFC) also had a major role in the observed importance of Okun's Law. The analysis for core countries does, however, indicate that institutional characteristics significantly affect how the labor market responds to a GDP growth shock mostly up until GFC. In this regard, regarding the stability of the Okun's Law since 2008, our findings suggest that the Law's traditional dynamics may not hold as strongly as previously believed in core countries during GFC. Instead, the Okun's Law holds strongly for young and female workers in peripheral countries, overall suggesting that the Okun's Law overall stability necessitate further attention towards considering different country groupings, underlying labor market institutional set-ups and worker groups.

Introduction

Arthur Okun (1962) has put forward a seminal understanding of the relationship between changes in the unemployment rate and changes in a country's gross domestic product (GDP). Seminal because it has become to this day a fundamental tool for policymakers and macroeconomic forecasters alike, particularly given the importance of labour market in understanding employment and wage dynamics in the context of advanced economies central banks' goals of returning inflation to target. What is now known as Okun's Law is that a 2-percentage decline in inflation-adjusted GDP growth relative to the trend is associated with roughly a 1 percentage point increase in the unemployment rate.

The vast majority of the empirical literature provide at least some level of support for the Okun's Law. Research often finds that changes in the unemployment rate and GDP growth generally exhibit an inverse relationship, supporting the basic premise of the Okun's Law but highlighting at the same time some important nuances that affect the law's straight application. For instance, the degree of sensitivity between unemployment and GDP growth can vary across countries and over time with the change in GDP growth associated with a 1% change in unemployment not universally consistent. Factors such as labour market institutions, industrial transformation, and labour market flexibility all can have an influence on the magnitude of the Okun's coefficient (e.g., Ball et al., 2019).

The validity of Okun's Law has also been examined within the context of structural change, economic crises, and labour market reforms. Technological advancements, globalization, shifts in the nature of work, the rise of technology and changes in labour force participation have raised questions about the stability of the relationship between unemployment and GDP growth over time. In addition, the impact of policy interventions, such as fiscal, e.g., through active labour market policies, and monetary policy also play an important role (Gordon 1984).

Economies differ in terms of their structure, institutional frameworks, and responses to shocks, suggesting that a "one-size-fits-all" law may not be always appropriate. As a result, the empirical evidence on Okun's Law often underscores the importance of considering country-specific factors when assessing this relationship empirically. For instance, one could ascertain that the empirical evidence surrounding the validity of Okun's Law might well reflect a mixed picture when considering the response of unemployment of young and female workers, whose rate of transitions in and out of work is typically recognized to be higher than the average.

While many studies support the basic notion of an inverse relationship between changes in unemployment and GDP growth, the sensitivity of the Okun coefficient, and the impact of structural changes and policy interventions highlight the complexity of this relationship. The academic literature underscores the need to carefully consider country-specific factors when applying Okun's Law as a policy tool. This also obtains in the context of considering the relevance of structural breaks in the economy, such as the Great Financial Crisis (GFC). The GFC led to acute output disruptions and increases in unemployment in almost all advanced economies, including euro area countries. However, there were notable variations in the volume and duration of these unemployment fluctuations, which were further amplified by events such idiosyncratic fiscal responses and regulatory and institutional differences within the currency union.

Since the outbreak of GFC, the analysis of the responsiveness of unemployment to output regained interest, mainly due to policies beyond active labour market strategies and short-term demand stimuli that were adopted, including structural reforms.

By studying the unemployment-output relationship from 1979 to 2019 for euro area countries, this paper makes four main contributions to the literature. Firstly, it provides *structural* estimates of the Okun's Law and embed the Okun relationship within a simple structural closed-economy model (Blanchard, 1989) with theory-driven

restrictions where unemployment rate is considered together with output growth, (wage) inflation and nominal money growth. Secondly, we study whether our structural Okun estimates change dynamically over time and/or across countries in a Structural Panel VAR (SP-VAR) using the framework suggested by Pedroni (2013).[2] Here, we assess the validity of the Okun's Law for a set of euro area countries between 1979 and 2019 using annual data, by looking at the contribution of the Great Financial Crisis (GFC). Third, we study the roles of common and idiosyncratic shocks in driving the behaviour of our Okun's Law estimates and investigate the extent to which labour market regulation, product market regulations and union density play a role in this context. Fourth, we study whether the estimates effects of Okun's Law vary across specific demographic groups such as youth and female workers (see also Banerji, Lin, and Saksonovs, 2015). Unlike standard heterogenous panel models, the SP-VAR approach allows us to obtain a structural identification of the shocks through coefficient restrictions achieved with the help of economic theory. Thus, we can identify the Okun relationship within a structural (reduced form) model where the unemployment rate is considered within output growth, wage inflation, price inflation, and nominal money growth. In our view, this method helps track the dynamic response of unemployment and explain dynamic responses to shocks' not only in the context of the Economic and Monetary Union – where common factor might be at play – but also across core-periphery country groupings. Within this procedure, we can estimate the responses of unemployment to output growth for (i) different types of unemployment rates (total, youth, and female), as well as (ii) account for standard labour market institutional features influencing the SP-VAR idiosyncratic responses (EPL, PMR, central bargaining, and wage bargaining institutional set-ups), thus accounting for a much greater degree of heterogeneity overall.

Our main findings are as follows. The structural estimates we obtain are substantially lower than most of the reduced-form figures found in the literature: our Okun structural estimate is -0.12 while we estimate that the same figure from a reduced-form single-equation setting is around [-0.3, -0.6] for advanced economies (see Ball *et al.*, 2019). Female workers response to output shocks in the context of the Okun's law is not statistically significantly different from that of median unemployment, in line with previous findings (Hutengs and Stadtmann, 2013; Banerji et al., 2014; Banerji, Lin, and Saksonovs, 2015). At the same time, youth unemployment response to output growth is on average more pronounced than that of median unemployment and statistically significantly different so (see also Dixon, Lim, and van Ours, 2017; An, Bluedorn, and Ciminelli, 2021). We also find that the responsiveness of output to unemployment is mainly driven by idiosyncratic factors in both core and periphery country groupings and this has *not* significantly changed regardless of whether the Great Financial Crisis years are excluded from the sample or not. Besides showing that structural estimates are stable on average and that the results are generally robust to conditioning the sample on institutional factors, such as employment protection legislation (EPL) and wage bargaining institutional set-ups, unpacking those results show that unemployment to output growth responses are heterogenous both within and across country groupings. Interestingly, the results for the periphery are mainly explained by the strictness of product market regulation (PMR) when the sample includes the years after 2008. Results for the core countries are also sensitive to conditioning on several institutional indicators considered over the full sample, compared to a sample which excludes the years post-2008. In our view, the approach adopted in the paper is not only novel when it comes to application to the Okun's Law, but also represents a much more informative way of reading the results than in traditional univariate or multivariate analyses.

The paper is organised as follows. The next section briefly presents and takes stock of the vast body of empirical evidence on Okun's law. We note that most of it favours reduced form strategies (while here we present structural estimates couched on the model in Blanchard, 1989). Section 3 presents the data we used,

[2] Our method is different from a Factor-augment VAR because we take cross-sectional averages, and we treat those as common factors.

and Section 4 discusses our estimation methodology. Section 5 presents and discusses our econometric results. Section 6 concludes.

Literature Review

A large literature has been devoted to understanding the relationship between unemployment and growth (e.g., Ball et al. 2015, 2019), most of it departing from the Okun's Law framework (Okun, 1962). Yet regarding the strength and robustness of such linear relationship during crisis episodes the evidence remains mixed. Some studies conclude that unemployment becomes significantly more sensitive to output shocks following a severe shock, while others find that the relationship is stable irrespectively. Indeed, many findings seem to depend on factors such as sample periods and the econometric methodologies adopted (for a survey, see Gordon, 1984; Kaufman, 1988; Prachowny, 1993).

For instance, Kaufman (1988) estimated the cyclical responses of unemployment rate to output shocks among six industrial countries by testing the Okun's law before and after the 1970s oil shocks. He concluded that the output elasticity of employment significantly increased after the oil crisis. Lee (2000) evaluated the robustness of Okun's law for 16 OECD countries on post-war data, concluding that there are marked differences depending on whether unemployment and output were considered in deviations from their trend (hence, the output/unemployment gap) or in first differences, with stronger evidence for the law's validity in the US compared to continental Europe. Other important comparative work, such as Moosa (1997), Freeman (2001) and Furceri et al (2020), further support the conclusion that unemployment tends to be much more reactive to output shocks in the US rather than in Europe.

Knotek (2007) estimated a negative relationship in the unemployment rate and real output growth for USA in a rolling regression framework. He documents that the estimates underlying Okun's law varied over time and over the business cycle. A similar conclusion is reached by Aguiar-Conraria et al. (2020). Perman and Tavera (2007) tested the convergence of Okun's law coefficients using data from 17 European countries over the period 1970Q1-2002Q2 (see also Evans, 1996), showing that the hypothesis of convergence of the Okun's law coefficient is rejected for most country groupings. Similarly, Owyang and Sekhposyan (2012) support the view that the stability of Okun's Law depends on the business cycle and those deviations were observed in the US during the mid-1990s, early-2000s and 2007-08 recessions (see also Ball et al. 2019).

Some literature also focuses on the stability of employment-growth by looking at the role of different labour market institutions. Cazes et al. (2013), for instance, investigates whether unemployment responds differently to the global financial crisis across OECD countries. They point out that Okun's law coefficient increased rapidly in economies such as the US, Canada and Spain after the crisis. On the other hand, in countries where unemployment remained low, the Okun estimates decreased suggesting that the reaction of unemployment to GDP weakened. Interestingly, these findings were found to be related to changes in the strictness of employment protection legislation and labour market reforms. Similar results were found by Oberst and Oelgemoller (2013). By the same token, Guisinger et al. (2015) and Prieto et al. (2018) examine individual US states and find that the heterogeneity in the Okun estimates is better explained by labour market and demographic differences, as well as industrial and labour regulation.

However, the debate has not yet settled on whether Okun's Law estimates are stable over time and across countries. Ball *et al.* (2015, 2019) and Daly et al. (2014) suggest that the Okun's Law was surprisingly stable during the last financial crisis and in a recent paper, Mutascu and Sokic (2021) notes that Okun's Law tends to vary across time and frequency and in the short term is more idiosyncratic. Similarly, Kruger and Neugart (2022) found an on-off pattern with a re-emergence of the Okun's Law during the Great Recession.

Given the importance of raising the labour force participation of demographic groups such as young and female workers, it is somewhat surprising how small the attendant empirical literature is. Hutengs and Stadtmann (2013), Banerji et al. (2014), and Banerji, Lin, and Saksonovs (2015) examined the sensitivity of youth unemployment for samples of advanced European countries and conclude that it is be about twice as large as that of adult workers. To a similar token, Dixon, Lim, and van Ours (2017) estimated Okun coefficients for OECD economies by age and gender. Although they find that young workers respond more intensely to unemployment than older male workers, women do not. Similarly, An, Bluedorn, and Ciminelli (2021) re-estimate Okun's law for advanced and developing economies and find that while youth's unemployment is twice as sensitive as that of adults', while women's unemployment is significantly less sensitive to demand than that of men in advanced economies.

Data and sample

In the paper, we employ annual data from 1979 to 2019, as follows: *endogenous variables* include GDP, CPI, wages and nominal money (M3) from the IMF World Economic Outlook, unemployment data from the Eurostat. These variables are log-transformed for stationarity, i.e., output growth, unemployment rate growth, *CPI*-inflation, wage inflation, and nominal money growth. In the analysis, we consider total unemployment, female unemployment, and youth unemployment (i.e., in the working age 15-29, according to the Eurostat). *Exogenous variables* are institutional variables from the Organization for Economic Cooperation and Development (OECD), such as labour and product market regulation, measures of central bargaining set-ups and union density. The choice of the sample is justified by avoiding having to deal with shocks the euro area experienced post-2019, including the Covid-19 pandemic and the Russia-Ukraine conflict. These subsequent shocks could potentially blur the picture and make identification of unemployment-to-output response harder.[3] We performed the same exercise since the introduction of the euro, i.e., 2000-2019, and the results remain generally robust to considering a shorter sample.[4]

In the results' section, we also explore the heterogeneous composite impulse responses of unemployment to output growth by excluding the crisis years, i.e., considering the sample 1979-2008, consistent indeed with the idea that unemployment rate often presents a structural break around 2008. We cut the sample to pre-2008 as using a subsample concentrating on the crisis years alone would otherwise pose challenges in terms of accurate estimation due to the shorter time frame available.

Estimation

Okun's Law has been at the center of macroeconomic research for many decades because it elegantly brings in supply-side considerations to the standard Keynesian perspective. There are basically two versions of Okun's Law: the one measuring output and unemployment as gaps, or in trend-deviation; the second considering their first difference. The first version is defined as:

(1) $$(U - U^*) = \beta(y - y^*) + \varepsilon_t$$

[3] Extending the sample up to the pandemic years, and beyond, has been documented to represent an outlier with respect to the historical Okun's Law relationship as the pandemic represented a significant output drop, itself associated with rather muted unemployment response (see Ando et al., 2022). As highlighted by the literature, the use of job-replacement schemes (e.g., as part of the European Commission SURE program) might have also distorted some of the "standard" labor market functioning.

[4] These results are available upon request from the authors.

where the term on the left-hand side is the difference between the actual rate of unemployment (*U*) and natural rate of unemployment (U^*), i.e., cyclical unemployment. The coefficient β is the Okun's coefficient to be estimated, y is real GDP, y^* is potential GDP, and ε_t is a standard disturbance.

The second version of the Okun's Law calculates the relationship in the delta of the unemployment rate (Δu) and output (Δy), as:

(2) $$\Delta u_t = a + \beta \Delta y_t + e_t$$

To empirically estimate the dynamic impact on unemployment of changes in output over the short and medium term and the role of common vs idiosyncratic factors, we follow Pedroni (2013). This method consists of estimating impulse response functions (IRFs) from a Structural Panel VAR (SP-VAR) model to test the dynamics between different responses to idiosyncratic and common shocks, using a recursive identification method. This allows using the structural identification outlined before in a multivariate framework, controlling, at the same time, for country fixed- effects and full heterogeneity over the cross section. In this sense, estimation of the loading matrices for the decomposition into idiosyncratic versus common shocks represents an extension to standard heterogenous panel approaches (see Pedroni, 2013).

Formally, let usconsider an unbalanced panel composed of $i = 1, \dots, N$ individual member states for $N = 11$ euro area country, each of which consists of an $M \times 1$ vector of observed endogenous variables, $X_{1,it} \dots X_{m,it}$, with $m = 1, \dots, M$. We employ traditional interpretation of macroeconomic fluctuations in the aggregate demand and aggregate supply dynamics, where the endogenous variables of interest are a) the log of output$y$, b) the unemployment rate u, c) the logarithms of the price level p, d) the logarithm of wage level w, and e) the logarithm of nominal money m (Blanchard 1989).

The data are observed over specific time $t = [1, \dots, T_i]$. To control for fixed effects and to simplify the notation, we demean the data, where $X^*_{i,t} = X_{i,t} - X_i$, with $\bar{X}_i = T_i^{-1} \sum_{t=1}^{Ti} X_{it}, \forall_i$

To allow for heterogeneous dynamics, we first estimate and identify reduced-form structural VARs (SVARs) for each country i:

(3) $$\begin{aligned} A_1 X^*_{1,t} &= A_i(L) X^*_{1,t-1} + BZ_{1,t} + Ce_{1,t} \\ &\vdots \\ A_M X^*_{M,t} &= \mathrm{A_i}(L) X^*_{M,t-1} + BZ_{M,t} + Ce_{M,t} \end{aligned}$$

where $\mathrm{A_i}(L)$ is a polynomial of lagged coefficients $A_i(L) \equiv \sum_{j=0}^{Ji} A_j^i L^j$ with country -specific lag-lengths J_i. The matrix A_j^i is a matrix of coefficients, $e_{i,t}$ is a vector of stacked residuals, and A_i is a matrix of contemporaneous coefficients.

The structural identification of each individual SVAR is built on a system of equations including an aggregate demand equation (AD), the Okun's Law (OL), a price setting equation (PS), a wage settings equation (WS), and a simple money rule (MR) (Blanchard, 1989). These are specified as:

(AD) $$y = ce_u + e_d,$$

(OL) $$u = a_{21} y + e_u,$$

(PS) $$p = a_{34} w + a_{31} y + c_{32} e_u + e_p$$

(WS) $$w = a_{43} p + a_{42} u + c_{42} e_u + e_w$$

(MR) $$m = a_{51} y + a_{52} u + a_{53} p + a_{54} w + e_m$$

where e_d , e_u, e_p, e_w and e_m are considered autonomous shocks to aggregate demand, shocks to labour supply and technology, or supply shocks, shocks to price and wage setting, and shocks to nominal money,

respectively. The shocks have no cross correlation. We transform the variables depending on their statistical properties; hence, we estimate a 5-variables $I(0)$ SVAR (Structural Vector Autoregression) including output growth, unemployment rate growth, *CPI*-inflation, wage inflation, and nominal money growth.

For our purposes, the coefficient a_{21} is the response of unemployment to output growth (Okun's Law).

Together with reduced form SVARs for each country, we estimate an auxiliary VAR to recover *common* dynamics, which are captured by averages, across countries, for each period ($\bar{X}^* \equiv M^{-1}\sum_{i=1}^{M} X_{i,t}^*$). Disregarding the predetermined factors to simplify the notation, we obtain:

$$\bar{A}\bar{X}_t^* = \bar{A}(L)\bar{X}_{t-1}^* + \bar{C}\bar{e}_t$$

Following usual practice, after transforming the reduced form residuals in their structural equivalent ($x_{i,t} = A^{-1}Ce_{i,t}$ and $\bar{x}_{i,t} = \bar{A}^{-1}\bar{C}\bar{e}_{i,t}$). Such reduced form summarizes the sample information about the joint process of the endogenous variables.

To go from the reduced form to the structural model, one needs a set of identifying restrictions on A and C. Given the restrictions derived from equations (AD), (OL), (PS), (WS) and (MR) one can recover the structural equations, as well as their structural innovations.

We run nM linear regressions to decompose the shocks into two terms:

$$\begin{aligned} x_{1,t} &= \Lambda_1 \bar{x}_t + \tilde{x}_{1,t} \\ &\vdots \\ x_{M,t} &= \Lambda_N \bar{x}_t + \tilde{x}_{M,t} \end{aligned} \tag{4}$$

where $x_{i,t}$ are the so-called *composite* shocks, $\bar{x}_{i,t}$ are *common* shocks, $\tilde{x}_{i,t}$ are *idiosyncratic* shocks and Λ_i are *n*-by-*n* diagonal matrices with country specific loadings OLS regressions coefficients. The $\tilde{x}_{i,t}$vectors are truly idiosyncratic, since they are by construction orthogonal to the shocks derived from the average dynamics shared by all members in the panel.

We finally use the method described in Lütkepohl (2007) to recover the matrices of composite responses to structural shocks $[R_i(L)]$ for each country, which are shown below in the vector moving average representations of M structural VARs (see Goes, 2016):

$$\begin{aligned} X_{1,t}^* &= R_1(L)x_{1,t} \\ &\vdots \\ X_{M,t}^* &= R_1(L)x_{M,t} \end{aligned}$$

and then use the loading matrices estimated in (7) to decompose the composite responses into country-specific responses to common shocks and responses to idiosyncratic shocks:

$$\begin{aligned} R_1(L) &= \Lambda_1 R_1(L) + (I - \Lambda_1\Lambda_1')R_1(L) \\ &\vdots \\ R_M(L) &= \Lambda_M R_M(L) + (I - \Lambda_M\Lambda_M')R_M(L) \end{aligned}$$

Equivalently, $R_i(L) = \bar{R}_i(L) + \tilde{R}_i(L)$, where $\bar{R}_i(L) \equiv \Lambda_i R_i(L)$ and $\tilde{R}_i(L) \equiv (I - \Lambda_i\Lambda_i')R_i(L)$.

We finally use the cross-sectional distribution of $R_i(L)$, $\bar{R}_i(L)$ and $\tilde{R}_i(L)$ to describe the properties of the collection of impulse response functions, such as their medians, averages and interquartile ranges.

While country fixed effects are considered in the SP-VAR, there might be still country specific time-varying effects that could lead to endogeneity bias. In fact, one might argue, the heterogeneous composite impulse responses across these different definitions of unemployment to output growth are simply capturing different labor market types instead of dynamics justified by the structural Okun's relationship. For instance, is the validity of the Okun's Law stronger in countries that have more flexible labor markets? As idiosyncratic (and

common) factors may be affected by structural reforms, the latter can be useful tool to explain our shocks' decomposition. To address this concern, we condition the SP-VAR on several exogenous variables, one at a time: product market regulation (PMR), employment product legislation (EPL), trade of union intensity (TU), and collective bargaining coverage (CBC).

Results

Figure 1 provides a first descriptive account of the Okun's Law relationship and some stylized facts. It shows there is a statistically negative correlation between unemployment growth and output growth.

[Figure 1 about here]

Table 1 presents the results for a group of 11-euro are countries, over the period 1979-2019. For sake of exposition, we first present the results from a reduced-form OLS regression in first differences and contrast it to a 5-equation SVAR estimated for each country.[5] The average value of the coefficient is -0.3 with the univariate framework and -0.1 with the 5-equation SVAR. One should note that the SVAR results display sometimes higher standard errors but a much higher goodness of fit overall, with the R2 being on average substantially higher than that reported with the univariate approach. These univariate results are broadly in line with those from recent contributions, such as, e.g., Ball *et al.* (2019), whose estimates cover about the same time period.[6]

A key question has to do with the stability of Okun's Law over time (see, e.g., Lee 2000, Knotek *et al.* 2007). Previous findings suggest that there has not been substantial change in Okun's coefficient after the Great Recession (Daly 2014; Ball et al., 2017). We further investigate this issue using our Structural Panel VAR estimates, as explained in Section 4. In our view represents a much more informative way than traditional Panel VAR analyses as identifying idiosyncratic dynamics provides for much more robust inference than simply relying on average estimates. At the same time, as shown by Pesaran & Smith (1995), if individual dynamics are heterogeneous, aggregating or pooling coefficient estimates can bias the results, making individual regressions preferable.

[Table 1 about here]

Despite country-specific heterogeneity, the estimated Structural Panel-VAR is stable. This means that, for a standard shock, each variable's impulse response function (IRFs) is expected to converge back to its mean or deterministic trend over the long run.

Before we turn to the interpretation of IRFs, in Table 2 we look at the median IRFs half-lives (the number of years it takes to go to 0.0). Let f denote the sampling frequency of the data ($f = 1$ for years). Let $\varphi(f)$ denote the median response of unemployment to a unit growth shock i periods ago. First, we find the largest i in the range $(1,\ldots,11)$ for which $\varphi(f) = 0.0$; we denote that i by h. Secondly, we verify $\varphi(j) < 0.1$ for all $j > h$ for at least another 5 years. This condition effectively rules out unstable or explosive oscillatory patterns. If h satisfies this second condition, we say that h is the half-life. The findings show that the main effect of exogenous parameters is visible primarily on idiosyncratic shocks in the periphery and common shocks in the core.

From Table 2, when conditioning SP-VAR on various institutional variables the typical Okun's response of unemployment to output growth tend to fade more quickly, as regulation seem to hinder the labor market

[5] In the estimation, we use GNP as in Blanchard (1989) opposed to GDP.

[6] Results by country should be taken with care, however, due to the relatively small sample post-crisis, which is evident also from a visual inspection of the data in Figure 1.

adjustment in the medium run. In other words, when conditioning on institutional factors, the half-life of idiosyncratic response (median) is almost halved in most cases.

We do not find a specific pattern across peripheral or core countries although idiosyncratic shocks tend to be stronger among the former group. Moderate levels of product market regulations, trade union density and centralized wage bargaining, seem to affect common responses of unemployment to output in core countries by a similar degree, differently from peripheral countries. This suggests not only that the group of countries considered as 'core' could be considered more homogenous, but also that countries that have more flexible labor markets might present common features which make them more sensitive to frictions and limits to lay-offs and/or hiring in the light of business cycle fluctuations.

We now turn to cumulative IRFs across total unemployment, female and youth unemployment in response to an output growth shock in Figure 2. We believe that one aspect of the Okun relationship that is yet to receive more careful consideration is the extent to which the response of unemployment to output shocks varies across demographic groups. This is particularly so when we turn our attention to young and female workers. In our view, there are straightforward and intuitive reasons for potential differences in unemployment responses of these two groups *vis-a-vis* that of the median unemployment as both young workers and women face different opportunity costs for participating vs not participating into the labor force. Younger workers can fall back into education or further training considering unexpected tightening in the labor market. This is in line with the empirical evidence (i.e., Monastiriotis et al., 2019) suggesting that young workers typically present a faster pace of transition in and out of work, i.e., because of job changes at the beginning of the working career and gap years. Female workers have been observed to temporarily revert to household and care work facing similar labor market conditions but also following maternity leave patterns and childcare responsibilities (see also Monastiriotis et al., 2019; Macchiarelli and Ward-Warmedinger, 2014). Based on the impulse response functions, we calculate the median and the top/bottom quartiles (5%). The composite chart in Figure 2 for the pool of 11-euro area countries shows a negative relationship between output and unemployment: the average heterogeneous composite impulse responses (Fig 2, bottom panel) across different definitions of unemployment to output growth are negative and averaging around -0.4 when countries fixed effects are considered.

The IRFs are then decomposed into country-specific responses to common shocks and idiosyncratic shocks. This step, while confirming previous findings, also suggests the response is mostly driven by the impact of idiosyncratic responses in the sample, which tend to be on average stronger. The findings are on average not susceptible to whether we exclude the years since the Global Financial Crisis (some more discussion in Subsection 6.1).

In Figure 3, we then present the results by country groupings and divide the sample in *core countries* (Austria, Belgium, Finland, France, Germany, Netherland) and *periphery countries* (Greece, Ireland, Italy, Portugal, Spain).[7] When we look at different groups of countries, we find that, for the whole sample, the unemployment response to output tends to be quite varied. The effect of common and idiosyncratic shocks is significant both in the core (Figure 3) and in peripheral countries (Figure 4).

[Figure 3 and 4 about here]

[7] As pointed out by Belke et al. (2016), there is not broadly accepted and exact definition as to which countries belong to the core or to the periphery. For instance, some studies place Italy in the periphery group (e.g., Hughes-Hallet and Richter, 2008; Caporale et al., 2015), but recent evidence suggests otherwise, showing it has strong business cycle synchronization with the core (Belke et al., 2016; Campos and Macchiarelli, 2016). As far as the unemployment rate is concerned, we place Italy in the periphery, in line with the idea that the labour market dynamics may be affected by welfare systems themselves (see also Monastiriotis et al., 2019).

An increase in GDP growth reduces unemployment much more in the periphery than in the core; this effect is quite persistent particularly among young workers with these results being mainly driven by the crisis years in the periphery. In other words, youth unemployment response to an output growth shock is stronger and tends to be more persistent in periphery countries. Furthermore, when we stop the sample by excluding the post 2008 crisis years, the response of youth unemployment is not as pronounced as in the full sample for the periphery, suggesting that the strong youth unemployment response to output growth is largely driven by the crisis. When we restrict the sample to pre-crisis the Okun's Law coefficient is 0.5 stronger than the baseline for the median young worker, compared to 2.1 for the full sample. For core countries, the median idiosyncratic and composite response does not appear to be largely statistically different if we stop the sample to the pre-crisis year, although there is heterogeneity in the response of young and female workers.

In Figure 3 and 4, female unemployment seems to respond to a GDP growth shock similarly to total unemployment and not in a statistically significant way with respect to the median unemployment response to output. Youth unemployment response to output growth is on average more pronounced and outside of the conventional significance bands for the median total unemployment, suggesting a statistically significant difference between those two responses.

The heterogeneous composite impulse responses across unemployment to output growth, conditional on product market regulation-PMR, employment protection legislation-EPL, trade union density-TU, and collective bargaining coverage-CBC, are reported in Figure 5-16, both for the all 11-euro area countries, and for the core-periphery split. In the periphery, and in some countries in particular, the share of contracts covered by some form of collective bargaining is among the highest among Western countries: around 85%. This happens even though union membership is on the low side. The potential reason is that collective contracts typically apply to non-unionized workers as well as unionized ones, and they are also enforced outside the sector where they are negotiated. There are important differences among core countries; in Germany, for instance collective bargaining takes place at regional/lander level.

[Figure 5 to 16 about here]

We now summarize the information from Figure 5 onwards in Table 3 and 4. Table 3 denotes the cumulated response at the 12th period horizon in deviations from the baseline. The baseline is represented by the full sample for all the 11 countries, without conditioning on any exogenous variables. That is, we consider the endpoint of the cumulative IRFs from Figure 5 onwards in deviation from the IRFs in Figure 2.

Table 4 instead denotes the cumulated response at the 12th period horizon in deviation from each sample of, e.g., core, periphery, pre-crisis, full sample. This means that by a direct comparison of each sample we can isolate fewer factors at a time. For instance, the first line in Table 4 compares the pre-crisis sample for all countries, with the full sample for all countries, thus measuring the effect of the Okun's Law coefficient obtained by cutting the sample to pre-crisis (the results are identical to Table 3, third row). Equally, the third row in Table 4 measures the Okun's Law response of periphery countries when the sample is cut to pre-crisis, vs the baseline of the full sample for the periphery itself. In this example, specifically, the third row in Table 4 measures indeed the effect on the Okun's Law coefficient of cutting the sample to pre-crisis (conditional on a country being part of the euro area periphery). By this metrics, the Okun's coefficient so obtained plus the Okun's coefficient for the periphery sample (Table 4, fifth row) measure the joint effect of the Okun's Law coefficient for a periphery euro area country *and* cutting the sample to the pre-crisis years.

From Table 3 (line five):

$$Periphery\ (pre-crisis) - All\ (Full\ sample)$$

equals the sum of Table 4 (line three):

$$Periphery\ (pre-crisis) - Periphery\ (Full\ sample)$$

and Table 3 (line five):

$$Periphery\ (full\ sample) - All\ (Full\ sample)$$

To make another example, from Table 3 (line thirteen), the joint effect on the Okun's coefficient of being in the euro area core *and* conditioning on Employment Protection Legislation:

$$Core\ (full\ sample|EPL) - All\ (Full\ sample)$$

equals the sum of Table 4 (line five):

$$Core\ (full\ sample|EPL) - Core\ (Full\ sample)$$

and Table 3 (line one):

$$Core\ (full\ sample) - All\ (Full\ sample)$$

This suggests overall that the figures in Table 3 represent the effect of different groupings jointly, by comparing the Okun's Law coefficient to the full sample for all countries. Table 4 is useful to disentangle whether the results are driven by conditioning on one subgrouping, subsamples or a specific exogenous variable at a time.

The first result we obtain from the results in Table 3 is that conditioning on different subgroups, samples or information sets has mainly an effect on idiosyncratic rather than common responses of the Okun's Law coefficients. By interpreting these results with the help of a heatmap – where a positive difference from the baseline implies a higher Okun's Law coefficient, i.e., the Okun's Law is weakened (shades of red), and a negative difference from the baseline implies a lower Okun's Law coefficient, i.e., the Okun's Law is strengthened (shades of green) – we can see that the sample until pre-crisis and the likelihood of being in the euro area core both weaken the Okun's Law coefficient for idiosyncratic IRFs in the panel SVAR. This effect is particularly evident for younger workers, where idiosyncratic Okun's' Law responses is on average 0.4 p.p. weaker than in the full sample.

By looking at rows three to five in Table 3, one can notice that the results are mainly driven by the crisis years; instead, stopping the sample in 2008, yields a better Okun's Law coefficient for young and female workers. For the average worker, the Okun's Law appears somewhat weaker, on the contrary. This overall confirms the common finding of higher transitions in and out of work of young and female workers (Macchiarelli et al., 2019): young workers often experience frequent job changes at the start of their career; for female workers, transitions are often influenced by factors like maternity leave, childcare responsibilities, and the desire for work-life balance.

When we introduce exogenous factors, such as reforms in employment or product market, the labor market response to an output growth shock tends to vary.

Reforms in product market regulation (PMR) and employment protection legislation (EPL) increase the average response of unemployment (they weaken the Okun's Law) for core countries, especially for the pre-crisis period and, to some extent, female workers. On the contrary, when conditioning on PMR, the average response of unemployment is stronger for the median young and female worker, and these results remain valid when stopping the sample to pre-crisis and particularly so for the euro area periphery.

When we introduce other exogenous factors such as centralized bargaining and trade union density, the average idiosyncratic response is lower than without these exogenous factors (the Okun's coefficient strengthens), but the results seem to be driven more by core countries than periphery when we stop the sample in 2008. For the full sample, instead, centralized bargaining and trade union density strengthen the Okun's Law coefficient for periphery countries across the board.

One plausible critique is the possibility of significant structural changes occurring after 2008 in our sample. With this in mind, we conducted a robustness analysis that involved comparing a sample containing years preceding the Global Financial Crisis (GFC) with the full sample that included the GFC years, to directly impute the significance of the period post-financial crisis.

We thus explore the heterogeneous composite impulse responses of unemployment to output growth by excluding the crisis years, i.e., considering the sample 1979-2008 and consistent indeed with the idea that unemployment rate often presents a structural break around 2008.

The results are also generally robust to different sample specifications when excluding GFC. When conditioning the SP-VAR on institutional indicators, the results for the periphery are mainly influenced by PMR pre-crisis. The group of periphery countries is sensitive to conditioning the set on PMR and particularly so for female workers. EPL, central bargaining and trade union density, all strengthen the Okun's coefficient for core countries pre-crisis. In all cases, the median unemployment response of young workers is stronger, in line with the usual finding of higher labor market flexibility.

Complementing these findings with those in Figure 7, one can also notice that by excluding the crisis years and conditioning the SP-VAR on PMR for the periphery, the IRFs are no longer significant cross-sectionally (common, idiosyncratic and composite IRFs are not statistically different from zero), suggesting that PMR does carry important explanatory power when it comes to interpreting the stability of the Okun's Law coefficient since the crisis. In other words, these findings confirm that the presence and characteristics of institutional factors can significantly impact the explanatory power of Okun's Law when it comes to understanding the relationship between unemployment and output growth.

Conclusions

The study investigates the dynamics of Okun's Law within the context of euro area countries, shedding light on the responsiveness of output to unemployment growth. By relaxing the customary limitations of estimating Okun's Law in a reduced-form univariate framework and favoring instead structural estimates, we find that the relationship between output and unemployment has not notably weakened in the euro area countries on average but these results underscore a lot of heterogeneity.

An interesting finding that emerges from our analysis is the role played by idiosyncratic shocks, particularly when considering the diverse core and periphery country groupings and different workers' categories, such as young and female workers. These idiosyncratic shocks appear to be the driving force behind the validity of Okun's Law. The variations observed in the responsiveness of output growth to unemployment growth are significantly influenced by country-specific shocks experienced by different groups of countries in the euro area, and workers' categories within them.

Taking a closer look at the heterogeneity of effects across countries, the study finds a complex interplay of factors that contribute to the observed outcomes. Specifically, we identify four main factors: whether the sample includes the years after 2008 (post GFC); the dynamic response of unemployment to an output shock for different demographic groups such as total, young, female workers; institutional factors such as employment protection legislation, product market regulation, central bargaining and trade union density; and whether a country belongs to the core or euro area periphery. These factors seem to exert varying degrees of influence of the unemployment growth response to an output growth shock depending on whether a country falls within the intersection of these categories.

Generally, female unemployment seems to respond to output growth in a similar way as median unemployment, suggesting that female workers response to output shocks in the context of the Okun’s law is not statistically significantly different from that of median unemployment. At the same time, youth unemployment response to output growth is on average more pronounced than that of median unemployment and statistically significantly different so.

For countries situated in the periphery, our results suggest that the relationship between output and unemployment is heavily influenced by the levels of product market regulation, particularly for female workers.

During the period encompassing the global financial crisis, the strong labor market adjustments in periphery countries, brought about by the recession, significantly contributed to the observed significance of Okun's Law through a stronger labor market response. In other words, the recessionary economic conditions experienced in the euro area periphery during the crisis highlight the importance of Okun's Law. However, when including the crisis years for core countries, the study suggests that institutional factors would not have any significant effects in the labor market adjustments to a GDP growth shock. This implies that the conventional dynamics of Okun's Law might not hold as strongly as previously thought since the GFC in core countries; the Okun’s Law holds more strongly instead for periphery’s young and female workers during the crisis years.

Annex I. List of Tables and Figures

Table 1 Okun law estimates (univariate vs multivariate) for 11 Euro Area countries, 1979 – 2019

	OLS			SVAR		
	Coeff.	St.error	R2	Coeff.	St.error	R2
AT	-0.169	0.049	0.235	-0.071	0.079	0.195
BE	-0.262	0.085	0.199	-0.244	0.096	0.384
FI	-0.349	0.055	0.511	-0.224	0.088	0.537
FR	-0.233	0.062	0.271	-0.219	0.079	0.329
DE	-0.221	0.059	0.270	-0.064	0.063	0.538
IE	-0.229	0.046	0.402	-0.084	0.062	0.379
IT	-0.135	0.065	0.101	-0.084	0.072	0.334
NL	-0.309	0.061	0.400	-0.179	0.069	0.658
PT	-0.338	0.060	0.455	0.033	0.274	0.528
ES	-0.840	0.105	0.625	-0.176	0.300	0.470
GR	-0.367	0.061	0.491	-0.067	0.091	0.635
Average	**-0.314**	**0.065**	**0.360**	**-0.125**	**0.116**	**0.453**

Table 2 Half-lives of the median heterogeneous composite impulse responses across sample of unemployment to output growth (SP-VAR for 11-euro area countries)

	Core	Core (PMR)	Core (EPL)	Core (TU)	Core (CBC)
Common	6	3	3	3	3
Idiosync.	5	3	6	3	3
	Periphery	Periphery (PMR)	Periphery (EPL)	Periphery (TU)	Periphery (CBC)
Common	5	4	5	4	3
Idiosync.	7	4	4	4	4

Table 3 Joint cumulative effect on the Okun's Law coefficients of different sample selections, institutional and regulatory measures (p.p. difference from the full sample for all 11 countries)

		COMMON (Median response)			IDIONSYNCRATIC (Median response)		
		All	Youth	Female	All	Youth	Female
	Cor. (full sample)	0.042	0.158	0.048	0.354	0.296	0.330
	Per. (full sample)	-0.262	-0.429	-0.180	-0.676	-2.063	-1.057
	All (pre-crisis)	0.060	-0.030	-0.123	0.240	-0.036	-0.102
	Core (pre-crisis)	0.088	-0.057	0.048	0.210	-0.552	-0.186
	Per. (pre-crisis)	0.212	0.056	0.075	0.147	-0.520	-0.150
PMR	All (full sample)	0.029	-0.029	-0.047	0.106	-0.381	-0.196
	Cor. (full sample)	0.140	0.171	0.054	0.414	0.233	0.250
	Per. (full sample)	-0.139	-0.330	-0.122	0.243	-1.039	-0.370
	All (pre-crisis)	0.267	0.159	0.222	0.084	-0.600	-0.238
	Core (pre-crisis)	0.205	0.280	0.036	0.322	-0.400	0.084
	Per. (pre-crisis)	0.152	0.315	0.218	0.259	-0.558	-0.407
EPL	All (full sample)	0.000	0.043	-0.039	0.219	-0.068	-0.019
	Cor. (full sample)	0.163	0.150	0.032	0.517	0.387	0.244
	Per. (full sample)	-0.447	-0.137	-0.121	-0.141	-1.123	-0.551
	All (pre-crisis)	0.006	-0.198	-0.094	0.221	-0.080	-0.020
	Core (pre-crisis)	0.113	-0.173	0.053	0.169	-0.611	-0.200
	Per. (pre-crisis)	0.052	0.015	0.076	0.371	0.137	-0.267
Central bargaining	All (full sample)	-0.013	0.032	-0.041	-0.010	-0.039	-0.012
	Cor. (full sample)	0.035	0.149	0.028	0.345	0.409	0.229
	Per. (full sample)	-0.269	-0.191	-0.140	-0.677	-1.083	-0.659
	All (pre-crisis)	0.052	-0.165	-0.098	0.228	-0.085	-0.301
	Core (pre-crisis)	0.075	-0.125	0.053	0.194	-0.594	-0.232
	Per. (pre-crisis)	0.214	0.043	0.086	0.160	-0.032	-0.338
Trade Union density	All (full sample)	-0.009	0.034	-0.042	-0.008	-0.052	-0.008
	Cor. (full sample)	0.041	0.151	0.032	0.350	0.402	0.241
	Per. (full sample)	-0.266	-0.162	-0.131	-0.697	-1.274	-0.598
	All (pre-crisis)	0.058	-0.209	-0.099	0.239	-0.137	0.016
	Core (pre-crisis)	0.079	-0.150	0.074	0.206	-0.637	-0.255
	Per. (pre-crisis)	0.220	0.064	0.059	0.163	-0.067	-0.306

Note: The value in the table denotes the cumulated response at the 12th period horizon in deviation from the baseline.

Table 4 Cumulative effect on the Okun's Law coefficient of different sample selections, institutional and regulatory measures (p.p. difference from individual subsamples)

		COMMON (Median response)			IDIONSYNCRATIC (Median response)		
		All	Youth	Female	All	Youth	Female
	All (pre-crisis)	0.060	-0.030	-0.123	0.240	-0.036	-0.102
	Core (pre-crisis)	0.045	-0.215	0.000	-0.144	-0.847	-0.517
	Periphery (pre-crisis)	0.474	0.485	0.255	0.823	1.542	0.907
PMR	All (full sample)	0.029	-0.029	-0.047	0.106	-0.381	-0.196
	Core (full sample)	0.098	0.013	0.006	0.061	-0.062	-0.080
	Periphery (full sample)	0.124	0.099	0.057	0.918	1.024	0.688
	All (pre-crisis)	0.207	0.189	0.346	-0.156	-0.565	-0.136
	Core (pre-crisis)	0.117	0.337	-0.012	0.112	0.151	0.270
	Periphery (pre-crisis)	-0.059	0.259	0.143	0.111	-0.038	-0.257
EPL	All (full sample)	0.000	0.043	-0.039	0.219	-0.068	-0.019
	Core (full sample)	0.121	-0.008	-0.016	0.164	0.091	-0.086
	Periphery (full sample)	-0.184	0.291	0.058	0.535	0.940	0.506
	All (pre-crisis)	-0.054	-0.168	0.029	-0.019	-0.044	0.082
	Core (pre-crisis)	0.025	-0.117	0.006	-0.041	-0.060	-0.014
	Periphery (pre-crisis)	-0.159	-0.041	0.001	0.224	0.657	-0.117
Central bargaining	All (full sample)	-0.013	0.032	-0.041	-0.010	-0.039	-0.012
	Core (full sample)	-0.007	-0.009	-0.020	-0.009	0.113	-0.101
	Periphery (full sample)	-0.007	0.238	0.039	-0.001	0.980	0.398
	All (pre-crisis)	-0.008	-0.135	0.025	-0.012	-0.049	-0.199
	Core (pre-crisis)	-0.013	-0.069	0.005	-0.016	-0.042	-0.046
	Periphery (pre-crisis)	0.002	-0.013	0.011	0.013	0.488	-0.187
Trade Union density	All (full sample)	-0.009	0.034	-0.042	-0.008	-0.052	-0.008
	Core (full sample)	-0.001	-0.008	-0.016	-0.004	0.106	-0.089
	Periphery (full sample)	-0.003	0.267	0.049	-0.021	0.789	0.459
	All (pre-crisis)	-0.002	-0.179	0.024	-0.001	-0.101	0.118
	Core (pre-crisis)	-0.009	-0.093	0.026	-0.004	-0.085	-0.069
	Periphery (pre-crisis)	0.008	0.008	-0.016	0.016	0.453	-0.155

Note: The value in the table denotes the cumulated response at the 12th period horizon in deviation from the baseline.

Figure 1 Correlation between output and unemployment growth across 11-euro area countries

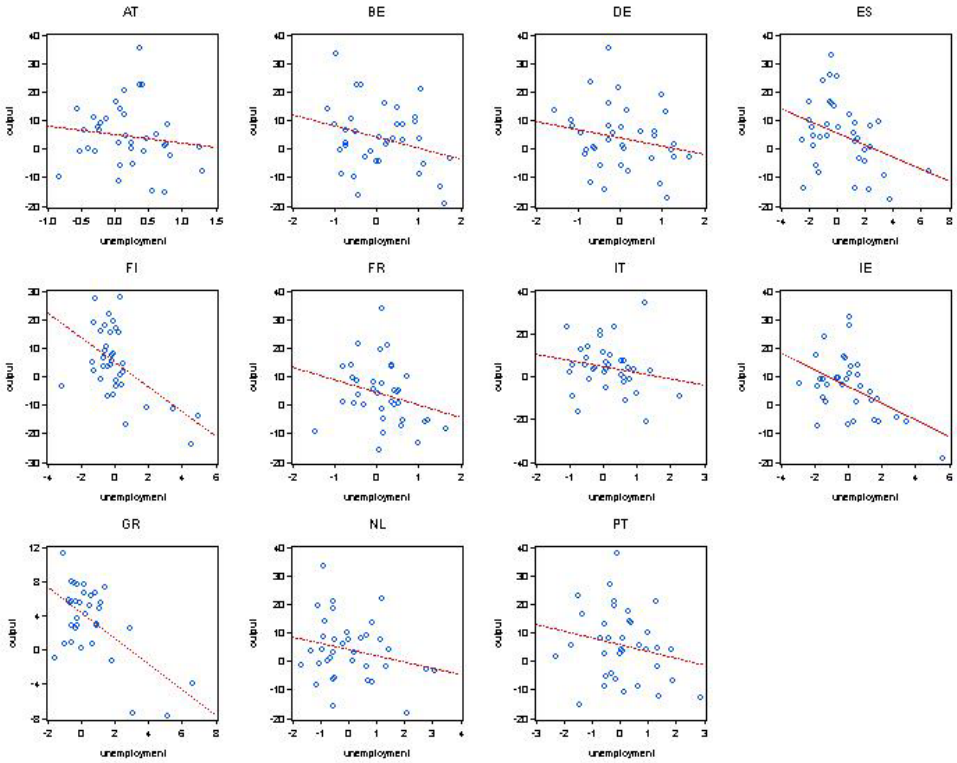


Figure 2 Heterogeneous composite impulse responses of total, youth, and female unemployment to output growth (SP-VAR for **11-euro countries**)

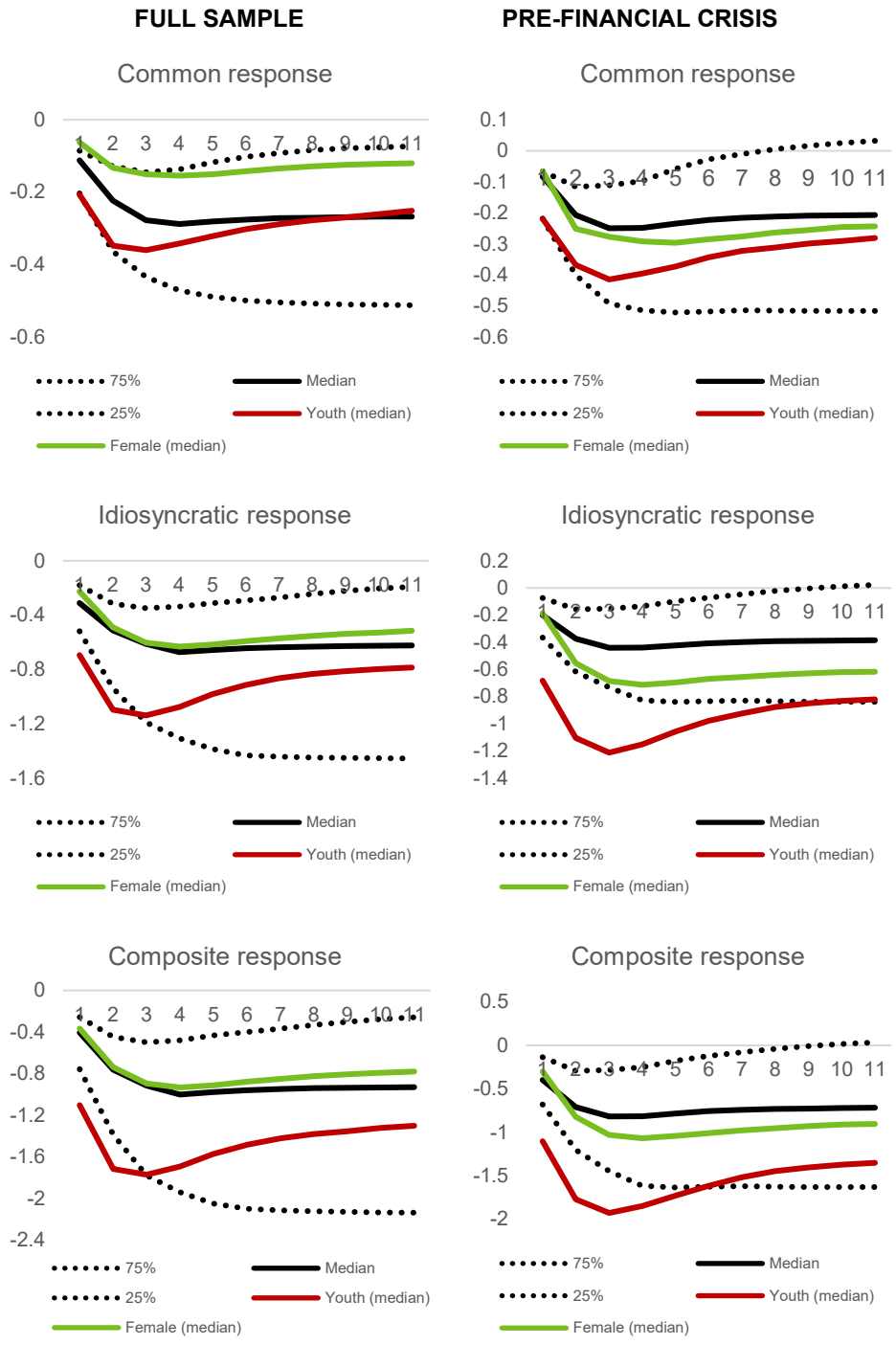


Figure 3 Heterogeneous composite impulse responses of unemployment to output (SP-VAR for **core countries**)

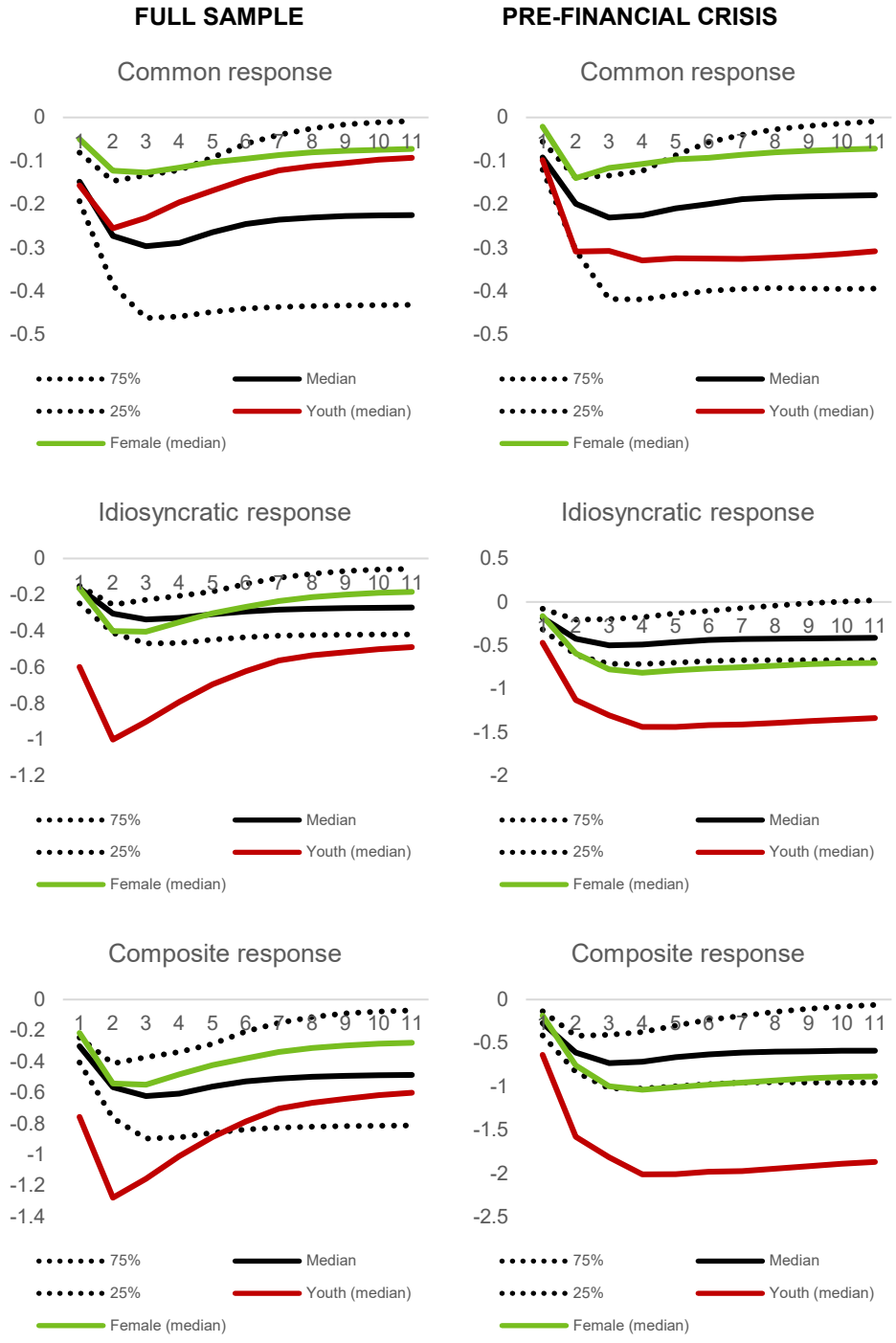


Figure 4 Heterogeneous composite impulse responses of unemployment to output (SP-VAR for **peripheral** countries)

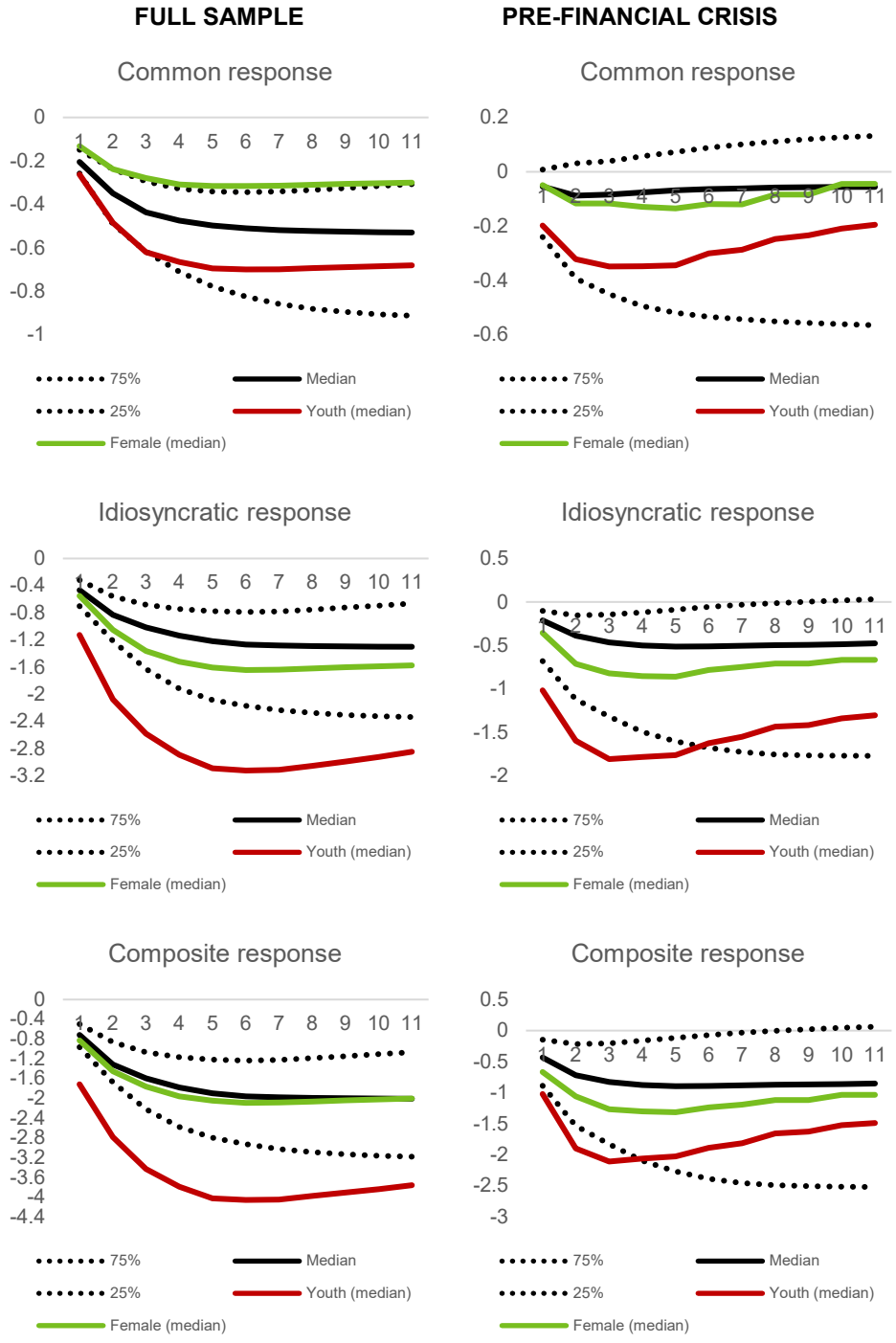


Figure 5 Heterogeneous composite impulse responses of unemployment to output (SP-VAR for **11-euro countries**), conditional on **PMR**

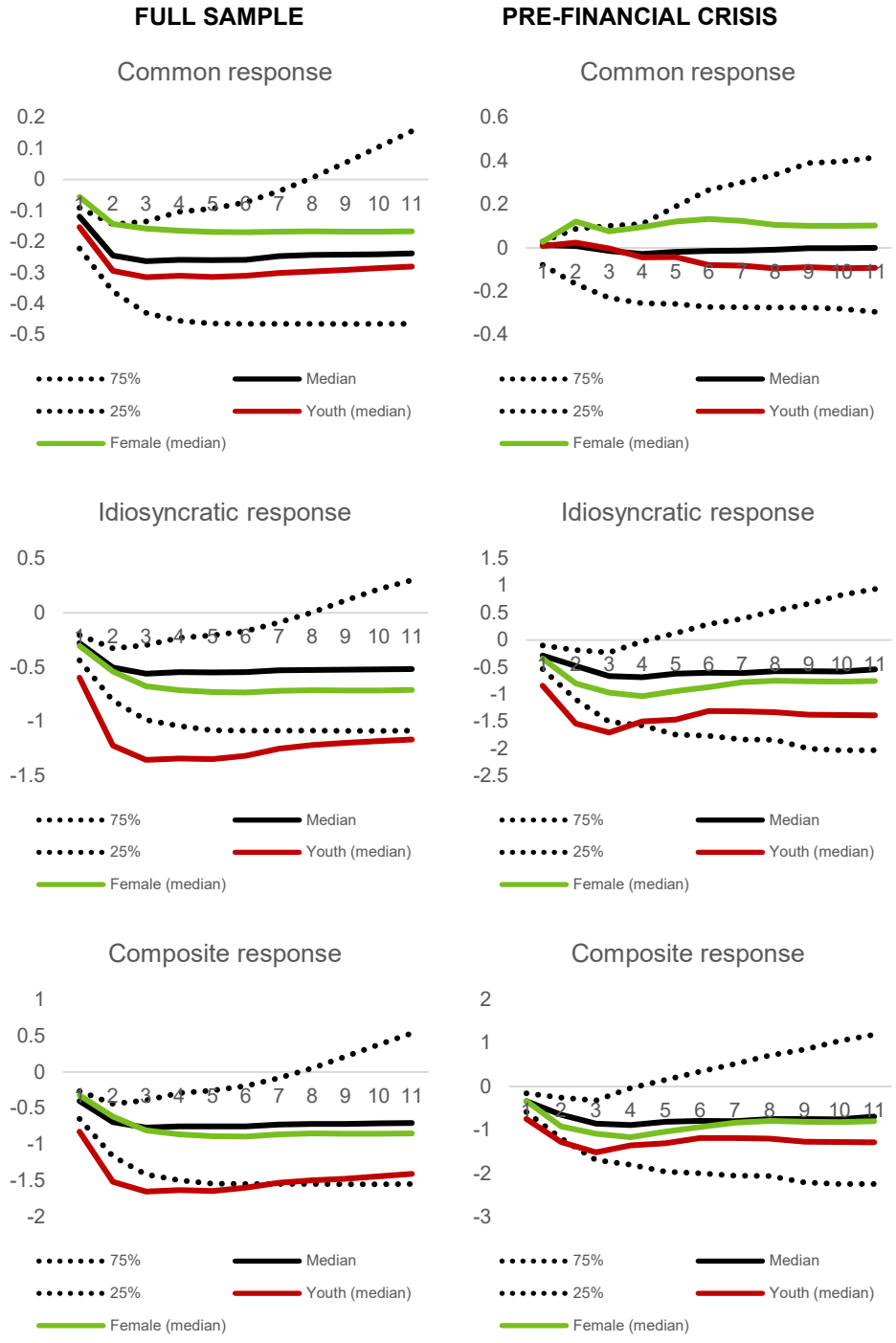


Figure 6 Heterogeneous composite impulse responses of unemployment to output (SP-VAR for **core countries**), conditional on **PMR**

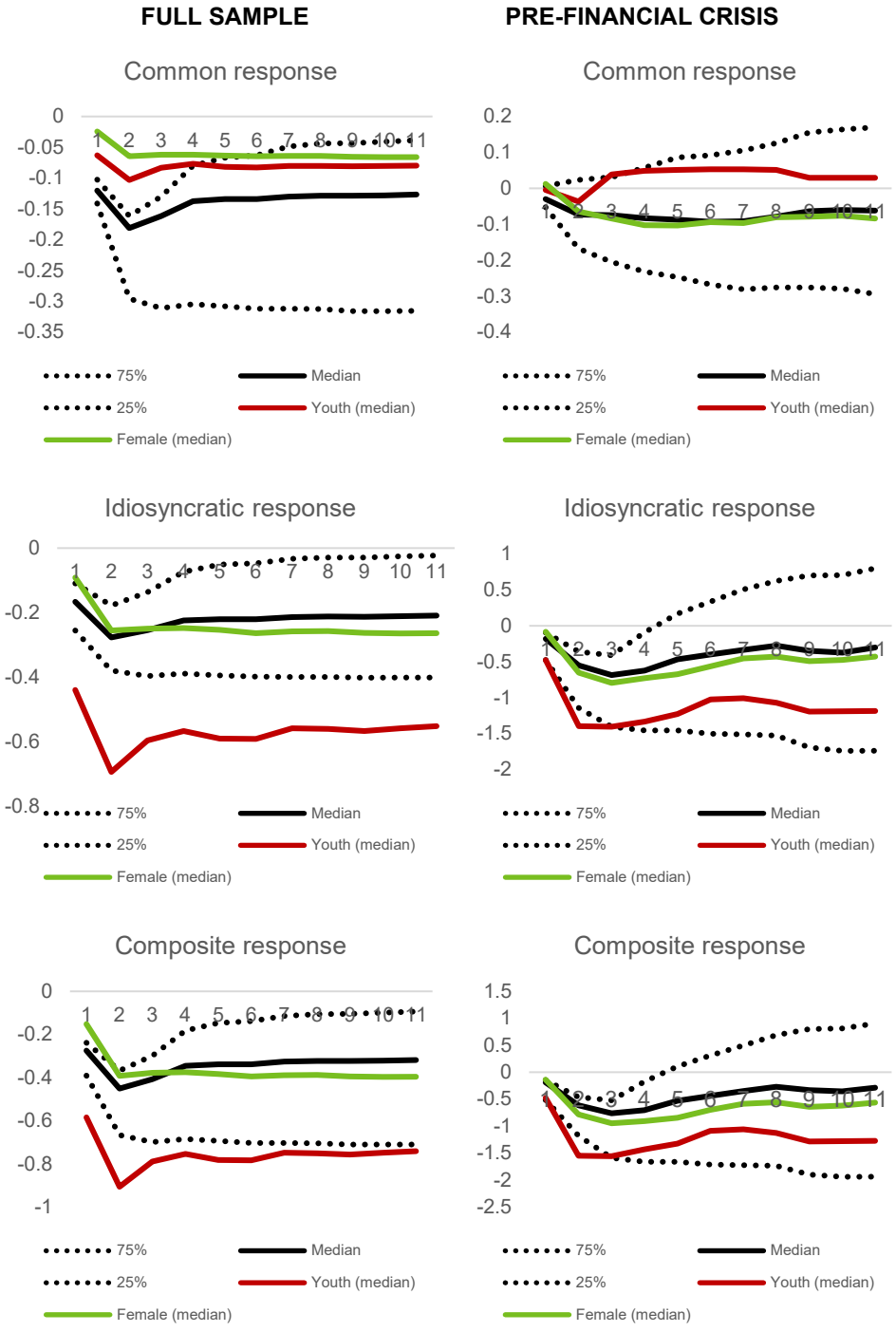


Figure 7 Heterogeneous composite impulse responses of unemployment to output (SP-VAR for **peripheral countries**), conditional on **PMR**

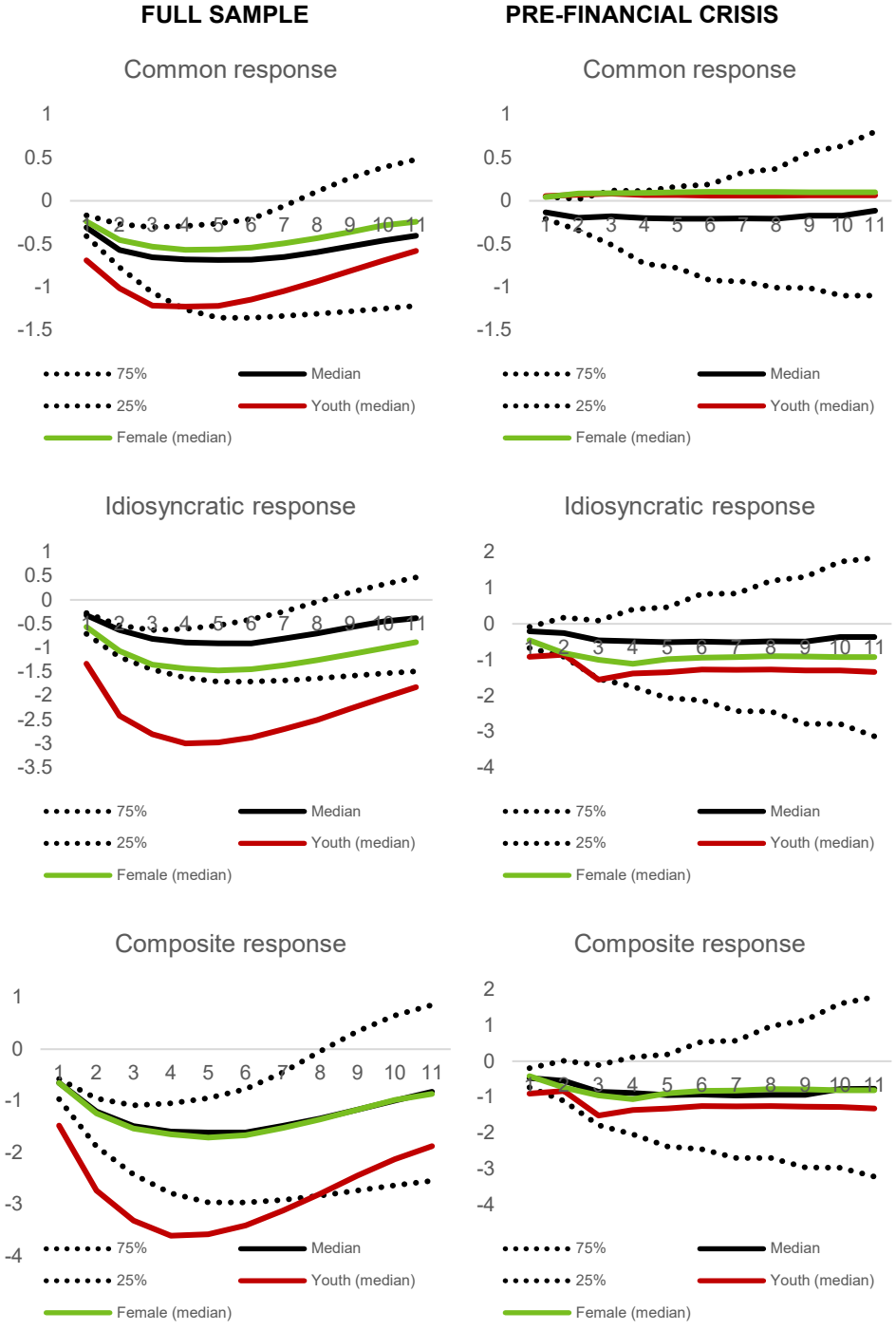


Figure 8 Heterogeneous composite impulse responses of unemployment to output (SP-VAR for **11-euro countries**), conditional on **EPL**

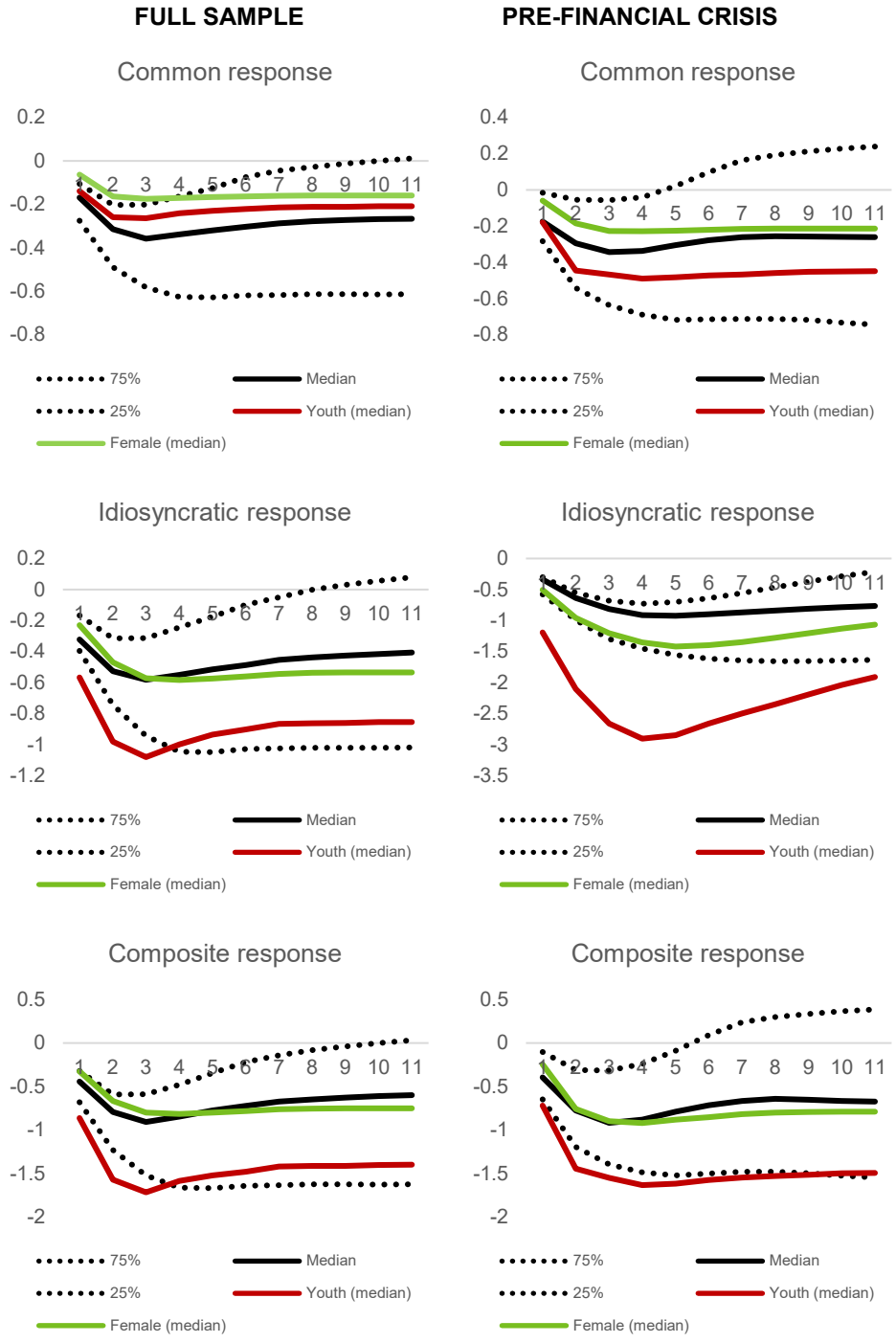


Figure 9 Heterogeneous composite impulse responses of unemployment to output (SP-VAR for **core countries**), conditional on **EPL**

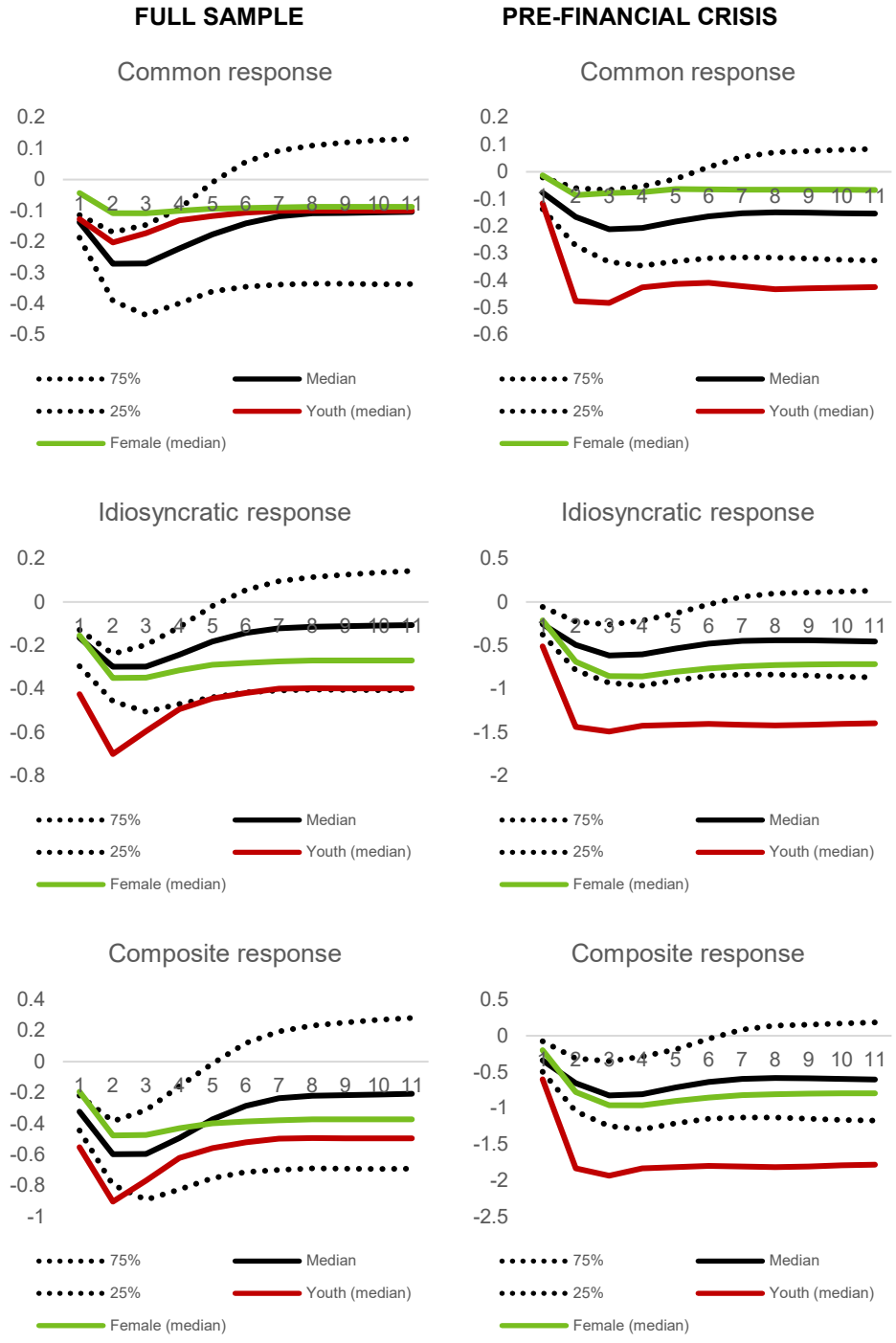


Figure 10 Heterogeneous composite impulse responses of unemployment to output (SP-VAR for **peripheral countries**), conditional on **EPL**

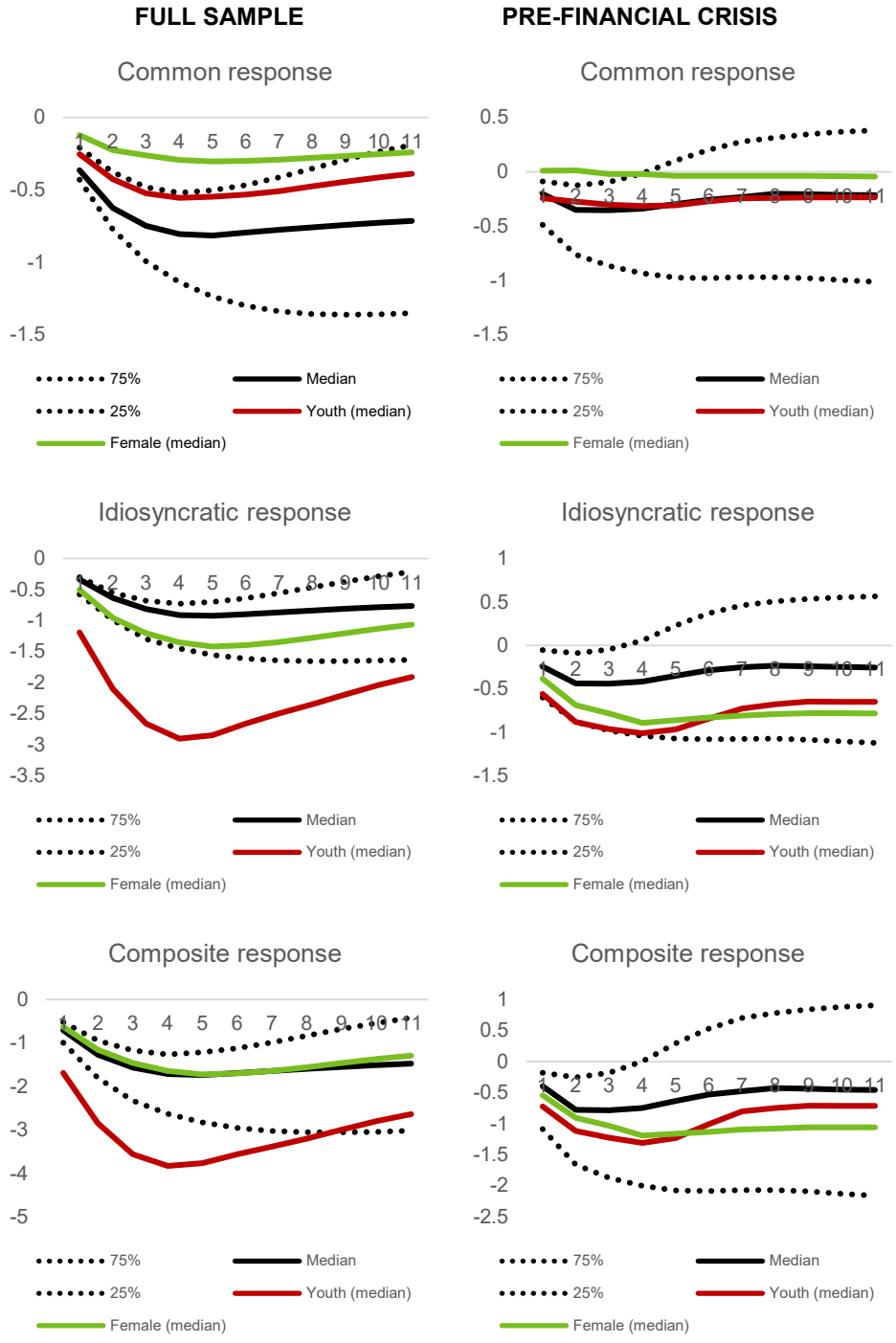


Figure 11 Heterogeneous composite impulse responses of unemployment to output (SP-VAR for **11-euro countries**), conditional on **CBC**

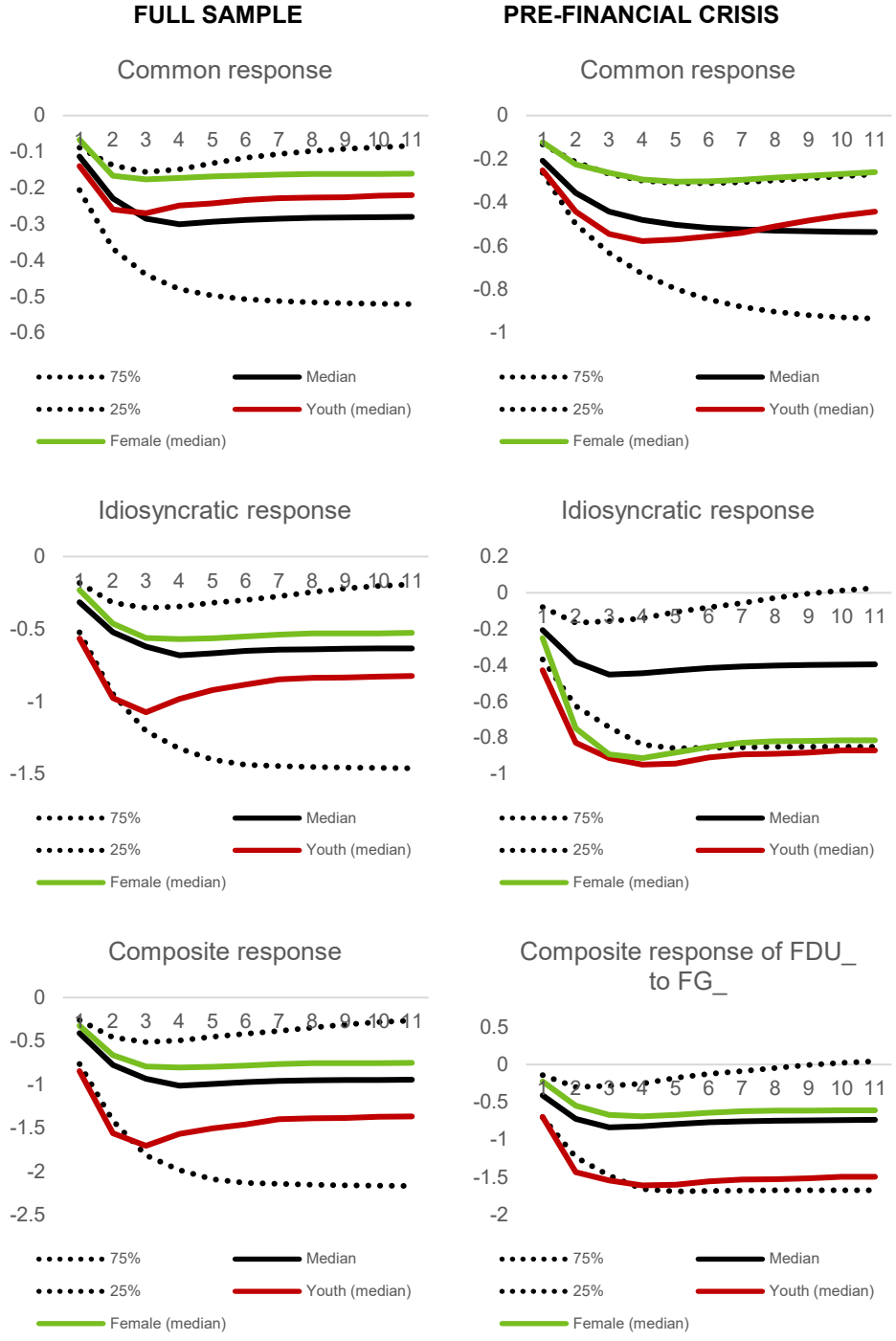


Figure 12 Heterogeneous composite impulse responses of unemployment to output (SP-VAR for **core countries**), conditional on **CBC**

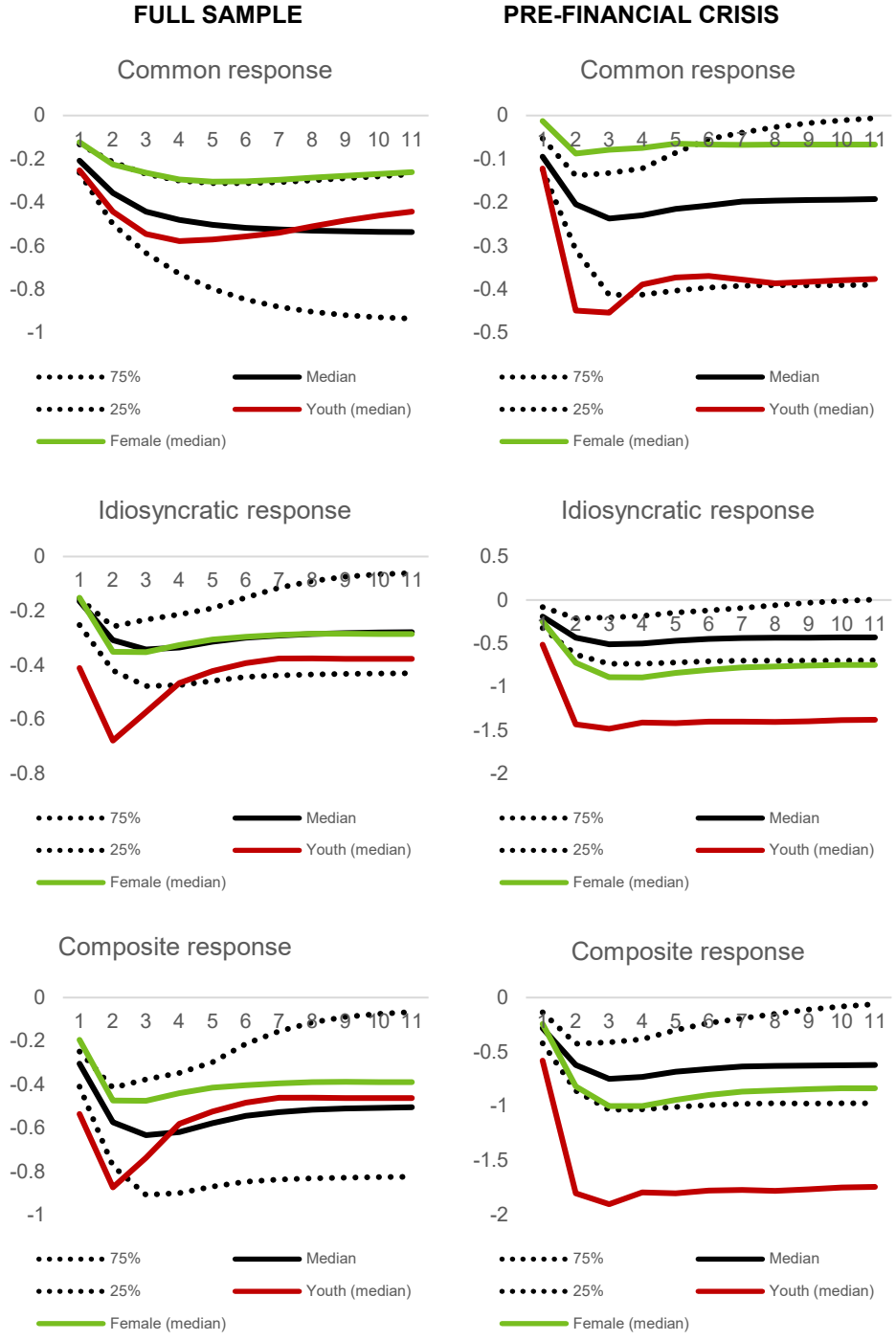


Figure 13 Heterogeneous composite impulse responses of unemployment to output (SP-VAR for **peripheral countries**), conditional on **CBC**

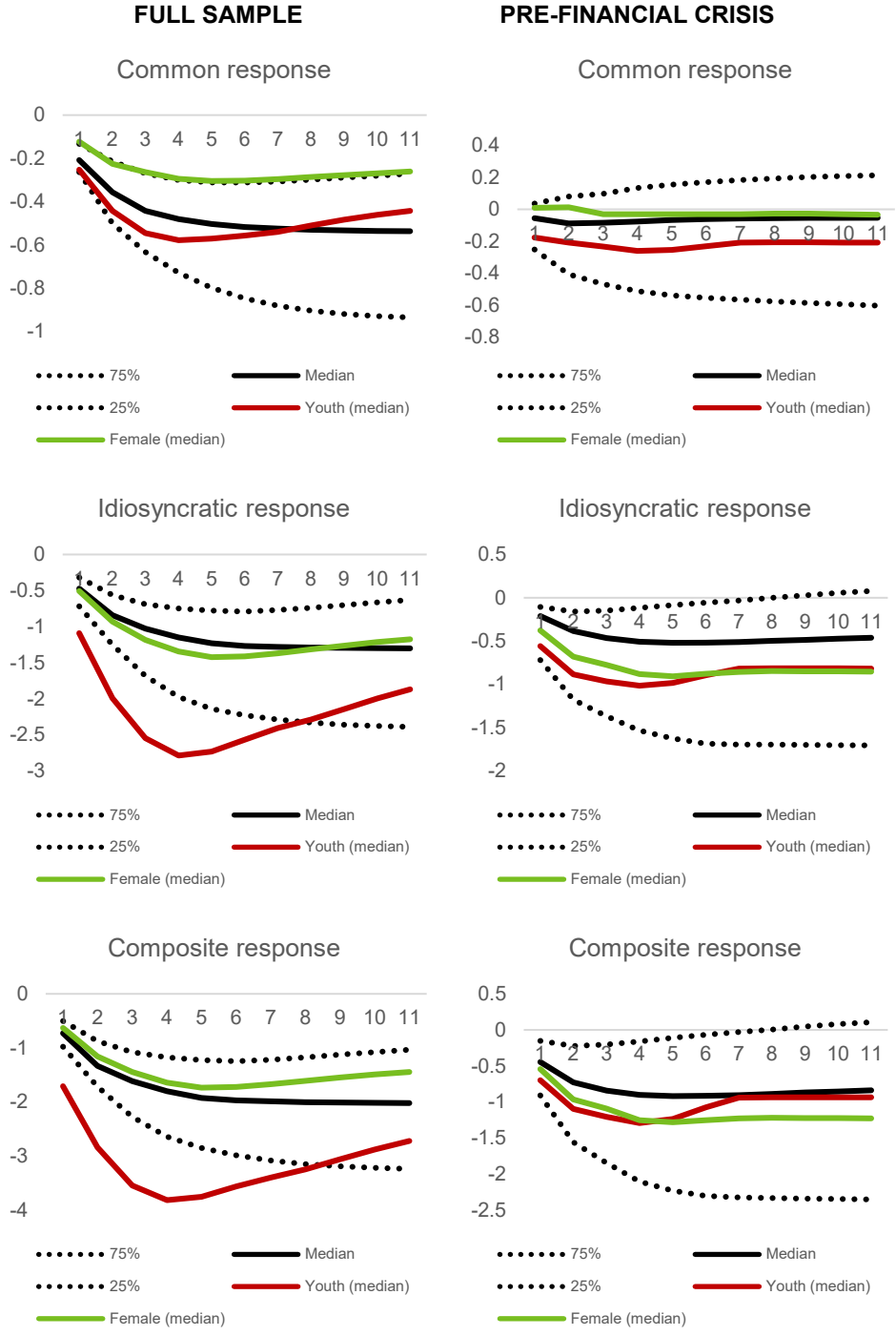


Figure 14 Heterogeneous composite impulse responses of unemployment to output (SP-VAR for **11-euro countries**), conditional on **TU**

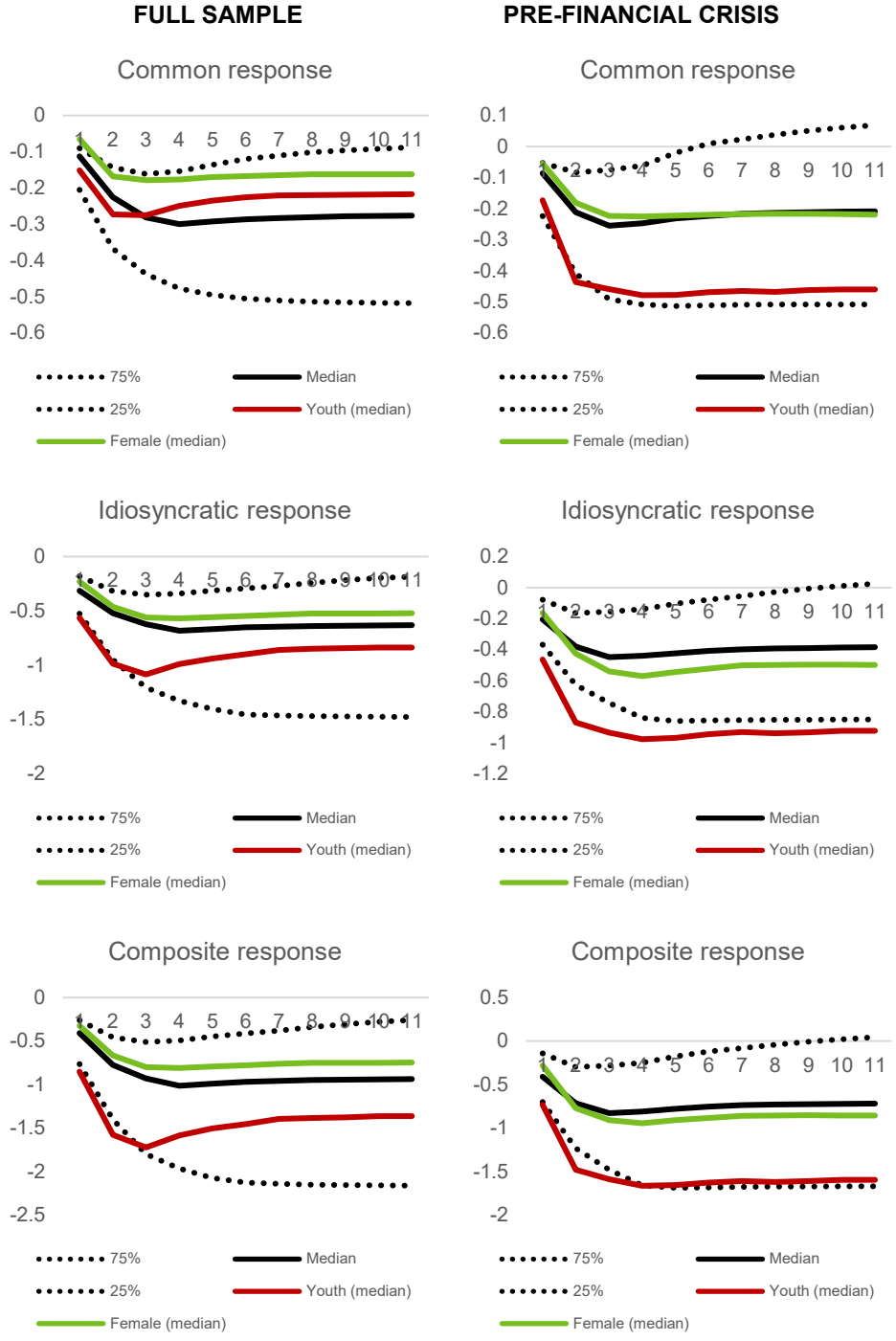


Figure 15 Heterogeneous composite impulse responses of unemployment to output (SP-VAR for **core countries**), conditional on **TU**

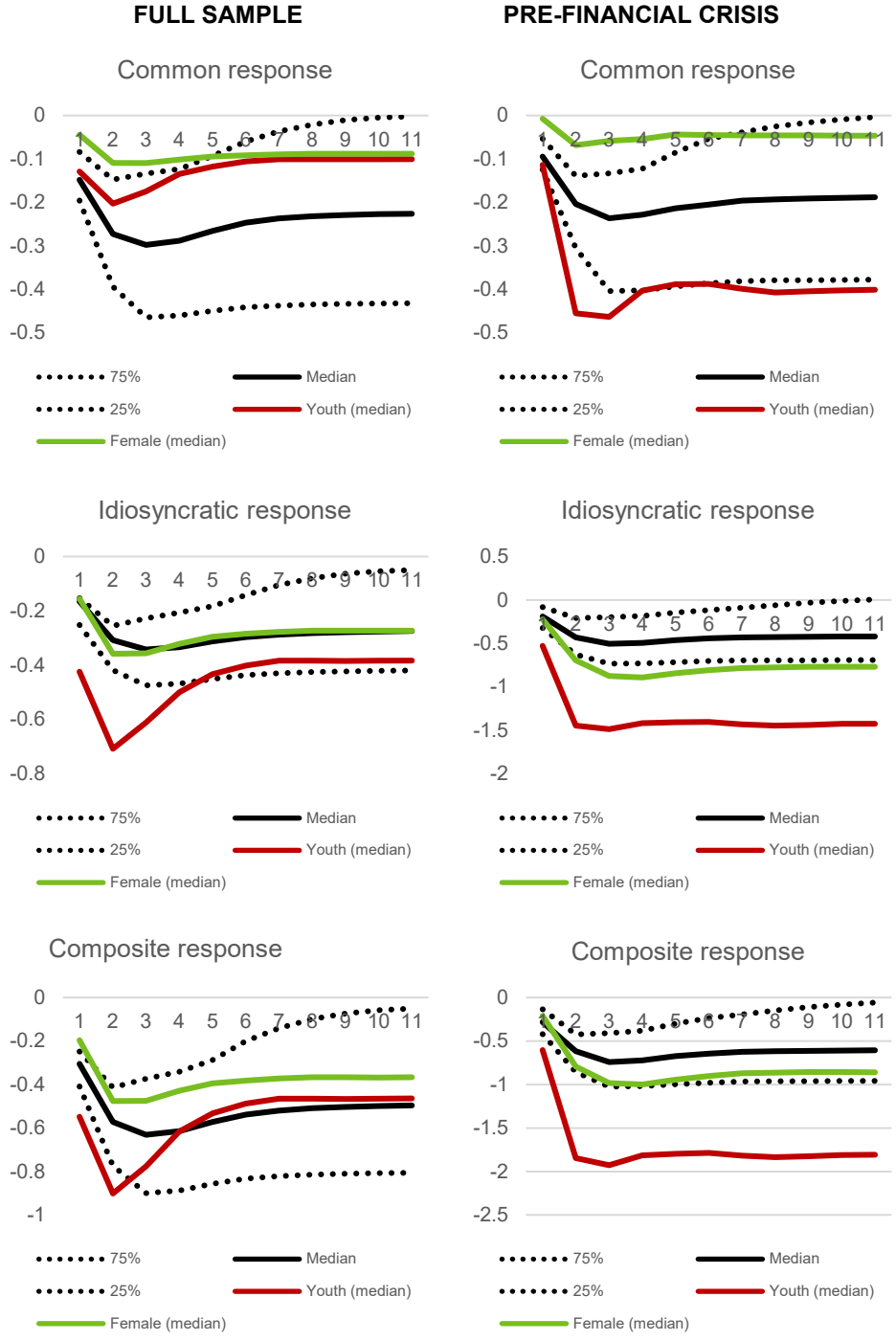
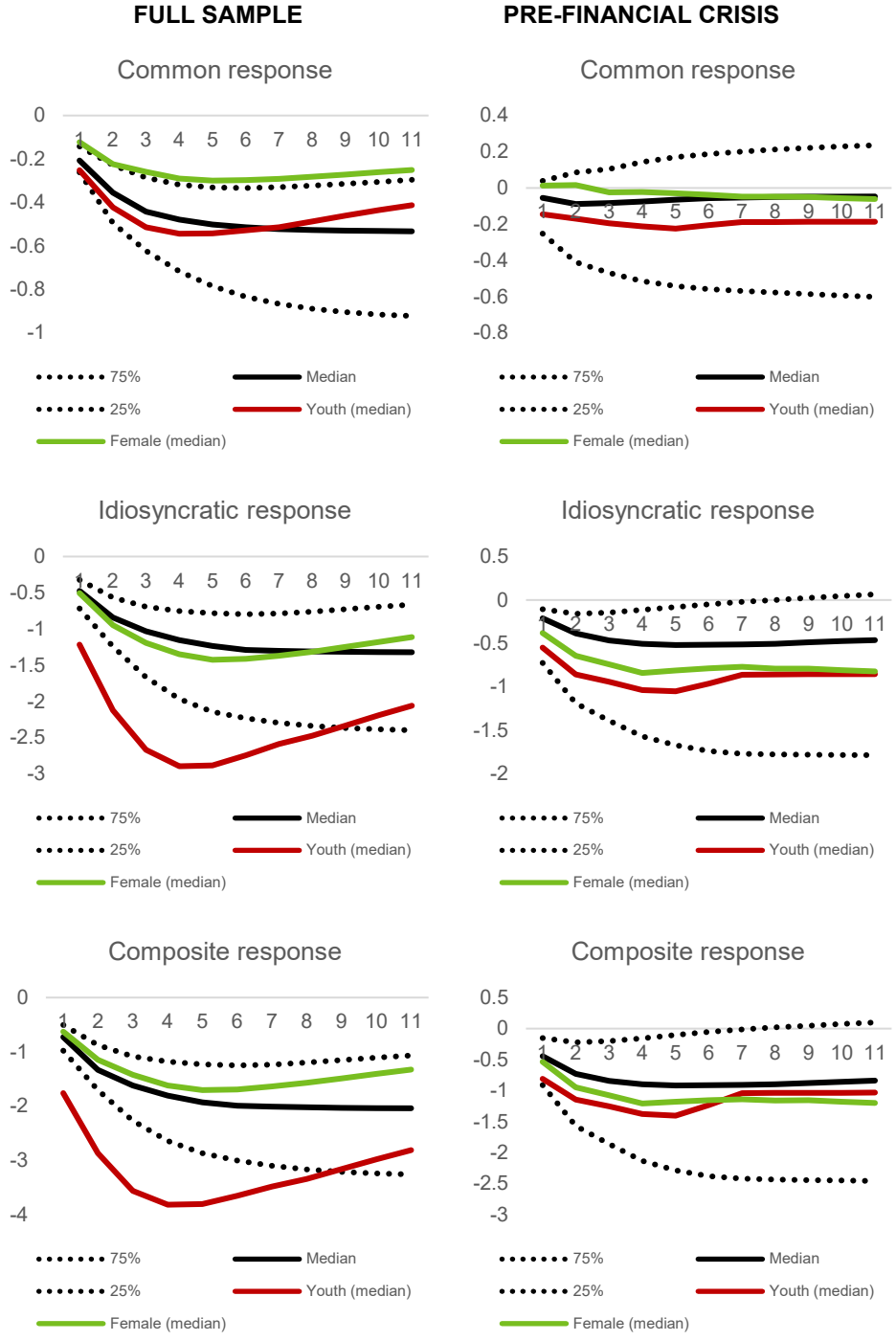


Figure 16 Heterogeneous composite impulse responses of unemployment to output (SP-VAR for **peripheral countries**), conditional on TU



References

Aguiar-Conraria, L., M. Martins, and M. Soares (2020). Okun's law across time and frequencies. *Journal of Economic Dynamics and Control* 116: 103897.

An, Z., J. Bluedorn, and G. Ciminelli (2021). Okun's law, development, and demographics: Differences in the cyclical sensitivities of unemployment across economy and worker groups, IMF Working Paper No. 21/270.

Ando, S., Balakrishnan, R., Gruss, B., Hallaert, J., Jirasavetakul, L. F., Kirabaeva, K., Klein, N., Lariau, A., Liu, L. Q., Malacrino, D., Qu, H., & Solovyeva, A. (2022). European Labor Markets and the COVID-19 Pandemic: Fallout and the Path Ahead, International Monetary Fund, Departmental Papers, 2022(004), A001.

Ball, L., J. T. Jalles, and P. Loungani, (2015). Do forecasters believe in Okun's Law? An assessment of unemployment and output forecasts. *International Journal of Forecasting*, 31(1), 176-184.

Ball, L., D. Leigh, and P. Loungani, (2017). Okun's law: Fit at 50? *Journal of Money, Credit and Banking*, 49(7), 1413-1441.

Ball, L., Furceri, D., Leigh, D., & Loungani, P. (2019). Does one law fit all? Cross-country evidence on Okun's law. *Open Economies Review*, 30(5), 841-874.

Banerji, A., Lin, H. and Saksonovs, S. (2015). Youth Unemployment in Advanced Europe: Okun's Law and Beyond, *IMF Working Papers* 2015/005, International Monetary Fund.

Banerji, A., S. Saksonovs, H.H. Lin, and R. Blavy (2014). Youth unemployment in advanced economies in Europe: searching for solutions. IMF Staff Discussion Note No. 14/11.

Blanchard, O. J. (1989). A Traditional Interpretation of Macroeconomic Fluctuations, *American Economic Review*, Vol. 79, No. 5, pp. 1146-1164

Blanchard, O. (2018). Should we reject the natural rate hypothesis? *Journal of Economic Perspectives* 32, no. 1: 97-120.

Blanchard, O. and D. Quah (1989). The Dynamic Effects of Aggregate Demand and Supply Disturbances, *American Economic Review* 79 (4): 655-673.

Campos, N. and C. Macchiarelli (2016), Core and Periphery in the European Monetary Union: Bayoumi and Eichengreen 25 years later. *Economics Letters*, 147: 127-130.

Cazes, S., Verick, S., & Al Hussami, F. (2013). Why did unemployment respond so differently to the global financial crisis across countries? Insights from Okun's Law. *IZA Journal of Labor Policy*, 2(1), 1-18.

Daly, M., B. Hobijn, A. Sahin, and R.G. Valletta (2012). A Search and Matching Approach to Labor Markets: Did the Natural rate of Unemployment Rise? *Journal of Economic Perspectives* 26 (3): 3-26.

Dixon, R., G.C. Lim, and J. C. van Ours (2017). "Revisiting the Okun relationship". *Applied Economics* 49 (28), pp. 2749–2765.

Freeman, D. (2001). "Panel tests of Okun's law for ten industrial countries," *Economic Inquiry*, 39(4), 511-523.

Furceri, D., Jalles, J. T., & Loungani, P. (2020). On the determinants of the Okun's Law: New evidence from time-varying estimates. *Comparative Economic Studies*, 62(4), 661-700.

Goes, C. (2016). Testing Piketty's Hypothesis on the drivers of income inequality: Evidence from Panel VARs with Heterogeneous dynamics, IMF working paper 16/160

Gordon, R (1984). Unemployment and potential output in the 1980s. *Brookings Papers on Economic Activity* 1984(2):537–569

Hutengs, O. and G. Stadtmann (2013). "Age effects in Okun's law within the Eurozone". *Applied Economics Letters* 20 (9), pp. 821–825.

Kaufman, R. (1988). An international comparison of Okun's laws. *Journal of Comparative Economics*, 12(2), 182-203.

Knotek, E.S (2007). How useful is Okun's Law? *Federal Reserve Bank of St. Louis Review*, p.73-103

Krüger, J. and Neugart, M. (2021) Dissecting Okun's law beyond time and frequency, *Applied Economics Letters,* 28(20), 1744-1749, DOI: 10.1080/13504851.2020.1853664

Lee, J (2000), The robustness of Okun's law: Evidence from OECD countries, *Journal of Macroeconomics*, Vol. 22, p. 331-356

Monastiriotis V., C. Macchiarelli, and N. Lampropoulou (2019), "Transition dynamics in European labour markets during crisis and recovery" *Comparative Economic Studies*, 61(2), 213–234.

Mutascu, M., Alexandre Sokic, A. (2021). Okun's law in the US: New insights in time and frequency, *The Quarterly Review of Economics and Finance*, 82, 207-222.

Moosa, I. (1997). A cross-country comparison of Okun's coefficients, *Journal of Comparative Economics*, Vol. 24 n 3, p 335-356

Oberst, C.A. and Oelgemoller, J. (2013): Economic growth and regional labor market development in German regions: Okun's law in a spatial context, FCN working paper, N 5, p 1-41.

Okun, A. M. (1962). "Potential GNP: Its Measurement and Significance", Proceedings of the Business and Economic Statistics Section of the American Statistical Association, pp. 98–104.

Owyang, M.T. and Sekhposyan, T. (2012): Okun's law over the business cycle: was the Great Recession all that different? *Federal Reserve Bank of St. Louis Review*, Vol. 94 n. 5., p 399-418

Pedroni, P (2013). "Structural Panel VARs'' *Econometrics* 1, p. 180-206

Perman R., Tavera C. (2007), Testing for convergence of the Okun's Law coefficient in Europe, *Empirica* 34, p.45-61

Prachowny M. (1993). Okun's law: Theoretical foundations and revised estimates. *Review of Economics and Statistics*, 75, 331-336

Prieto, N., P. Loungani, and S. Mishra (2018). What Lies beneath? A Sub-National Look at Okun's Law in the United States. *Open Economies Review* 29, no. 4 835-852.

Ward-Warmedinger, M., C. Macchiarelli (2014), Transitions in labour market status in EU labour markets. *IZA Journal of European Labor Studies*, 17 (3).

PUBLICATIONS