Financial Crises and Unemployment in Developed and Developing Countries

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ABSTRACT

In this paper, Okun's Law is extended beyond the effect of GDP changes on unemployment to also consider the impact of financial crises. Furthermore, the following key aspects are considered: (i) persistence of unemployment rate dynamics; (ii) lagged effect of GDP on unemployment; (iii) existence of cross-country institutional and structural differences; (iv) possible different values of Okun's coefficients under recession with respect to periods of increases in GDP. The above extensions lead to an operational model that belongs to the family of linear Mixed-Effects Models. In particular, we estimate this model for a large set of countries over the period 1980-2010, primarily by distinguishing high-income from non-high-income countries. The results demonstrate evidence of an additional effect of certain types of financial crises on the unemployment rate in the case of high-income countries.

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I. INTRODUCTION

To better investigate the complex relationship between GDP dynamics and unemployment rate changes in both normal times and times of financial crisis, we first propose an extended version of Okun's Law considering the possible additional impact of financial crises and some other key factors (the persistence of unemployment rate dynamics, the lagged effect of GDP on unemployment, the existence of cross-country institutional and structural differences, and possible different values of Okun's coefficients under recession with respect to periods of increases in GDP). We obtained Okun’s coefficients for a large set of countries with different levels of development, including model dummy variables for three different types of financial crises (systemic banking crises, currency crises, and sovereign debt crises), to detect the possible additional impact on the unemployment rate (additional with respect to the direct impact of GDP changes considered in the simple Okun’s model). The above extensions lead to an operational model that belongs to the family of linear Mixed-Effects Models (see McCulloch *et al.*, 2008). We estimated this model for a large set of countries globally over the period 1980-2010, mainly by distinguishing high-income from non-high-income countries. The model is estimated by an Expectation-Maximization algorithm (Dempster *et al*., 1977). To better highlight the estimation results, simulations under different scenarios are also presented.

The results indeed demonstrate evidence of an additional effect of certain types of financial crises on the unemployment rate in the case of high-income countries. We interpret this additional effect as the consequence of the increase in the degree of “systemic uncertainty”, much more significant in high-income countries in the event of a financial crisis. It should be noted that the link between GDP and unemployment has been thoroughly studied in “Okun’s Law” literature, and, similarly, the effect of uncertainty on economic decisions and on macroeconomic performance has also been extensively studied; however, the two strands of literature have not been jointly considered. We think that the channels hypothesized in our theoretical framework, especially the role played by systemic uncertainty, are useful for understanding the overall labor market impact of financial crises, particularly in high-income countries.

The structure of the paper is as follows. The next section provides a review of the literature, both on Okun’s Law and on the role of uncertainty. The proposed theoretical framework and the operational model are presented in Section 3; they are used in our empirical estimations that are presented and discussed in Section 4. Section 5 concludes, providing some policy directions.

II. LITERATURE REVIEW

Two key strands of existing economics literature are relevant for this study: the first one refers to the so-called Okun's Law and the second one regards the role played on economic (and labor market) performance by the degree of uncertainty (and its changes). To our knowledge, studies combining the two strands have never been conducted previously.

II.1. Literature on Okun's Law

The economic literature has devoted particular attention to relationships between employment/unemployment changes and GDP dynamics, especially from a cyclical point of view. Considering the aims of this paper, we present only a brief review regarding the last three decades.

Okun (1970) defined a coefficient corresponding to the rate of change of real output associated with a given change of the unemployment rate, focusing on the estimation of “potential” GDP. In that seminal paper, unemployment was seen as the exogenous variable and real GDP growth as the dependent variable. In much empirical research estimating the Okun coefficient, causality is mostly assumed to be in the opposite direction, i.e., changes in output explain variations in unemployment. Prachowny (1993) considered the theoretical foundation of Okun's Law and derived empirical evidence for the U.S., supporting the view that the Okun equation is a useful proxy in macroeconomics. Erber (1994) estimated the Okun equation for a number of OECD countries, finding a significant negative correlation between unemployment and growth. Padalino and Vivarelli (1997) found that the Okun equation is valid for the G-7 countries and that the growth-employment link in manufacturing is stronger than that for the total economy. Blinder (1997) counted the relationship between unemployment and growth among the principles of macroeconomics in which "we should all believe", but he also argued that a simple equation between the percentage change of output and the absolute change in unemployment rates is "atheoretical, if not indeed antitheoretical". Baker and Schmitt (1999) estimated the Okun coefficient for a panel of OECD countries and found that employment intensity of growth was higher in the 1990s than in previous periods. Lee (2000) estimated the Okun equation for all OECD countries and stressed that the relationship is not stable over time and is different across countries, but concluded that the impact of growth on employment is still valid. Solow (2000) argued that a good deal of European unemployment is due to a lack of demand; he utilized the Okun equation to quantify the output gap for Germany. In short, notwithstanding the various empirical results, many studies suggest that the link between unemployment and growth is still a useful macroeconomic "rule of thumb"[1].

Many other studies have investigated different aspects related to Okun's Law,[2] and some very recent empirical literature refers to Okun's Law. For example, the IMF (2010) examined the role of institutions and policies in explaining changes in Okun's Law across countries and over time; Beaton (2010) investigated the stability of Okun's Law for Canada and the United States employing a time varying parameter approach. He found structural instability, with the unemployment rate increasingly sensitive recently to movements in output growth in both countries; moreover, an asymmetric behavior in Okun's Law has been detected over the business cycle (in particular, the unemployment rate typically increases by more during recessions than it falls during expansions)[3]. The IMF (2010) related Okun's coefficient – i.e., the elasticity of the unemployment rate with respect to output – to some key labor market reforms: employment protection legislation, unemployment benefits, temporary employment contracts, and wage flexibility (with a more decentralized wage system). Moreover, the response during recoveries may differ from that during recessions because of the following: (i) presence of financial crises and stress, (ii) sectoral shocks, (iii) uncertainty, (iv) specific policies. From a methodological standpoint, the IMF (2010) proposed a dynamic version of Okun's Law in which the change in unemployment depends on the lagged values of the change in output, of the change in unemployment itself and some control variables (including a dummy to indicate a state of recession).[4] Recently, Gordon (2010) argued that the tendency of aggregate hours to grow slowly and productivity to grow rapidly in an output recovery has exhibited a significant change in magnitude (over successive business cycles) from those predicted by Okun's Law.

II.2. Literature on the Role of (Changes in) Uncertainty

According to various studies, uncertainty is a persistent factor characterizing the functioning of economic systems and conditioning the behavior of economic agents; consequently, it is reasonable to argue that a financial crisis produces a certain increase - at least temporarily - in the degree of (systemic) uncertainty.

Many studies have investigated, especially from a theoretical point of view, the role of uncertainty (and its changes) in affecting the functioning of economic systems, also through the conditioning of firms' behavior. Here, we only consider a small part of the literature, particularly the seminal works and some of the more recent research.

As for ground-breaking research, we recall Knight's (1921) distinction between risk and uncertainty and Keynes's (1936) considerations on the "weight of argument", especially with reference to the preference for liquidity. In more recent literature, many authors have considered the role of uncertainty, especially from a post-Keynesian perspective.[5] Vercelli (2002) distinguished soft uncertainty from strong (or hard) uncertainty and explored the interaction between rationality and learning. Sordi and Vercelli (2010) discussed the process of formation and revision of expectations in light of Keynes's epistemological view of the behavior of "bounded" rational agents under conditions of strong uncertainty. In particular, the authors argued that a lower "weight of argument" (i.e., a high degree of uncertainty) may be interpreted as an index of potential learning, and thus, the higher the potential learning there is, the higher the degree of intertemporal flexibility sought by a rational agent. Some research[6] previously investigated the relationship between uncertainty and flexibility and, in particular, demonstrated how an increase in the degree of uncertainty suggests the adoption of more flexible strategies, i.e., solutions permitting a higher set of options.

Bernanke (1983), Pindyck (1991) and Dixit and Pindyck (1993) analyzed the effect of uncertainty on investment decisions by considering the role played by irreversibility. For example, if an investment has some characteristic of "irreversibility", because of the existence of "sunk costs", an increase in the degree of uncertainty will probably suggest delaying the realization of that investment, waiting for a reduction of uncertainty and an increase in the value of the Keynes' "weight of argument". In any case, investment decisions may be affected both by the deterioration in entrepreneurs' expectations and by credit constraints (depending on bankers' expectations). In contrast, consumption decisions are mainly influenced by the risk of unemployment (the likely effects on labor demand will be briefly analyzed below). Bloom (2009) also highlighted the effects of a high uncertainty (i) on reducing the firms' investment due to more uncertain expectation on future profits and (ii) on partly postponing the expenditure of (durable) goods and services.

Some recent research has been devoted to empirically measuring uncertainty. One of the most used proxies for uncertainty is the "VIX" index (so-called "fear index") based on the volatility of the stock exchange index (see, for example, Bekaert *et al.*, 2013; Basu and

Bundick, 2012). In addition to this index, Jurado *et al*. (2013) proposed the "Forecast Error Common Factor" based on the volatility of a large set of macroeconomic indexes, while Baker *et al*. (2013) created the "Economic Policy Uncertainty" index based on the perceived uncertainty about economic policies by households and firms[7].

An indirect approach is based on the assumption that during specific economic episodes, such as after financial crises, uncertainty increases and this produces relevant effects on the economic system, although uncertainty is not explicitly measured.

For example, Mulligan (2010) found that because of uncertainties ensuing from financial crises, labor demand could be reduced and remain below pre-recession levels (unemployment rates and GDP growth have been predicted within neo-classical growth models). Hall (2010) argued that current macroeconomic models predict declines in real GDP and employment correctly, as witnessed in the current crisis, but are unable to demonstrate the failure of economies to recover after subsiding from the financial crisis.

In other research, uncertainty is related to some specific aspects of labor markets (e.g., Sawyer and Shapiro, 2002). Signorelli (1997) analyzed the impact of changes in the degree of uncertainty on (desired and actual) labor demand. He considered the firms' hiring decisions as a sort of investment (in "human capital") with a certain degree of irreversibility[8] due to sunk costs (e.g., selection and training costs) and institutional factors (firing costs). An increase in the degree of uncertainty, as shown in some of the abovementioned literature, negatively affects the investment with a certain degree of irreversibility and, consequently, (desired and actual) labor demand can also be affected by changes in the degree of uncertainty.

As to the recent literature following the global financial crisis, we can find studies on the role of uncertainty concerning both developed and developing countries.[9] For example, Hurd and Rohwedder (2010) considered household expectations and uncertainty of US households in the aftermath of the crisis. On the other hand, Huynh *et al*. (2010) discussed why labor market recovery in Asia lagged behind the output growth after the current crisis.

In very recent research, Bloom (2014) analyzed how changes in the level of uncertainty partly explain the weak GDP growth of an economic system, while Caggiano *et al*. (2014) used the VIX index for the US case and found a significant impact of an uncertainty shock on the unemployment rate.

In conclusion, according to the existing literature, we can state that the presence of a financial crisis is likely to increase the degree of uncertainty of an economic system, with probable additional real consequences on investment, labor demand and unemployment. A key research question of this paper is consequently to investigate the “uncertainty effect” of financial crises on the unemployment rate, beyond the impact already explained by Okun’s Law, i.e., by the relationship between GDP dynamics and unemployment rate change.

III. EXTENDED OKUN'S MODEL

In this section, we define the theoretical framework from which we derive the operational model employed for the econometric estimation.

III.1. Theoretical Framework

Starting from Okun's Law, we initially estimate Okun’s coefficients for different groups of countries distinguished by level of development. In a second step, we emphasize the need to include the possible supplementary impact (additional to that caused by the fall in production predicted by the simple Okun’s equation) of financial crises on the labor market. We argue that, if detected, this further effect is possibly due to an increase in “systemic uncertainty” deriving (immediately or with short lags) from a financial crisis. In our view, financial crises can have a greater impact on the labor market with respect to simple economic recessions because of their greater effect in increasing uncertainty and, through this additional channel, in further reducing labor demand[10]. For example, a firm facing a higher degree of uncertainty (causing less reliable expectations on future budgets and profits) is likely to reduce investment in "employment" (e.g., decreasing or delaying hiring), especially if characterized by high sunk costs and high degree of irreversibility due to firing costs. By sunk costs, we mean search, selection, and training costs.

In the proposed theoretical framework, changes in unemployment are first explained by changes in GDP (consistent with Okun's Law) but, in addition, we try to capture – in our "extended Okun's model" – the possible supplementary factor of "financial crises". Then, we include in the model dummy variables for the different types of crises (Banking, Currency, and Debt) to measure the additional impact on the unemployment rate.

To obtain reliable econometric results, we also control for many relevant factors and variables. In particular, we consider a model in which: (i) the "persistence" in the dynamics of the unemployment rate is captured by including autocorrelated error terms; (ii) the lagged effect of GDP dynamics on labor market indicators (e.g., due to labor "institutions" and labor hoarding strategies) is captured by the lagged values of GDP changes (we also allow for possible different values of Okun's coefficients under recession conditions); (iii) the existence of cross-country "institutional and structural" differences is controlled by the adoption of country-specific parameters.

In short, we argue that our model is able to detect such additional effects of financial crises with respect to the "standard" effect passing through (current and past) GDP changes and not simply determined by the inertia in unemployment variations and differences in the national institutional frameworks.

III.2. Proposed Okun's model for empirical estimation

Let N denote the number of countries, and let T denote the number of periods of observation. Also let u_{it} denote the (percentage) unemployment rate for county i in period t, with $i = 1, \ldots, N$ and $t = 1, \ldots, T$, and let y_{it} denotes the GDP. A basic formulation of Okun's Law is based on the following assumption for each country i:

$$\Delta u_{it} = \alpha_i + \Delta y_{it} \beta_i + \varepsilon_{it}, \quad t = 2, \ldots, T, \tag{1}$$

where Δu_{it} is the increase in the percentage unemployment rate for country i in year t and Δy_{it} is the corresponding percentage increase in the GDP. Moreover, α_i is a country-specific intercept and β_i is a country-specific parameter measuring the impact of the GDP variation on the unemployment rate (i.e., the so-called Okun coefficient); this parameter is obviously expected to be negative. The error terms ε_{it}, $i = 1, \ldots, N$, $t = 1, \ldots, T$, are assumed to be independent and to have a Normal distribution with mean 0 and variance σ^2, in symbols $\varepsilon_{it} \sim N(0, \sigma^2)$.

The above formulation is naturally extended to include a more sophisticated structure of dependence on the GDP changes. In particular, an interesting formulation, similar to that in Beaton (2010) and IMF (2010), is the following:

$$\Delta u_{it} = \alpha_i + \sum_{l=0}^{L_1} \Delta y_{i,t-l} \beta_{il} + \sum_{l=0}^{L_1} r_{i,t-l} \Delta y_{i,t-l} \gamma_{il} + \varepsilon_{it}, \quad t = \bar{L}, \ldots, T, \tag{2}$$

where L_1 is the number of lags for the percentage increase in GDP, r_{it} is a dummy variable equal to 1 if there is a recession ($\Delta y_{it} < 0$), and $\bar{L} = max(2, L_1 + 1)$. In this way, Okun's parameters β_{il} are lag specific, whereas γ_{il} measures the differential effect of the GDP change when the latter is negative rather than positive. It may also be reasonable to include, in the above formulation, the lagged response variable among the regressors.

In this paper, we propose an extension of Okun’s model, which, in addition to the above generalization, allows us: (i) to estimate the impact of the financial crisis on the change in the unemployment rate; (ii) to get different results for different groups of countries (e.g., differentiated by their level of development). Let $d_{it}^{(c)}$ be a dummy equal to 1 when a crisis of type c is observed for country i in period t; three different types of crises – as specified in the next section – are considered (systemic banking crisis, currency crisis, and sovereign debt crisis), so that $c=1,\dots,C$, with C=3. The proposed model is based on the following assumption:

$$\Delta u_{it}=\alpha_i+\sum_{l=0}^{L_1}\Delta y_{i,t-l}\beta_{il}+\sum_{l=0}^{L_1} r_{i,t-l}\Delta y_{i,t-l}\gamma_{il}+\sum_{g=1}^{G}\sum_{l=0}^{L_2} d_{i,t-l}^{(c)} z_{gi}\delta_{gl}^{(c)}+\varepsilon_{it}, \quad (3)$$

$$t=\bar{L},\dots,T,$$

where now $\bar{L}=max(2,L_1+1,L_2)$ and z_{gi} is an indicator variable equal to 1 if country i is in group g and to 0 otherwise, with G indicating the number of groups of countries. The parameters of most interest for our analysis are those measuring the effects of financial crises. In particular, each parameter $\delta_l^{(c)}$ measures the effect of crisis of type c at lag l for countries in group g .

A further extension, which we implement to make the model more flexible, is that the error terms ε_{it} are assumed to be autocorrelated (AR(1)), with correlation coefficient ρ and stationary variance σ^2. More explicitly, we assume that

$$\varepsilon_{it}\sim N(0,\sigma^2), \text{ if } t=\bar{L},$$

$$\varepsilon_{it}\sim N(\varepsilon_{i,t-1}\rho,\sigma^2(1-\rho^2)), \text{ if } t=\bar{L}+1,\dots,T,$$

where $\sigma^2(1-\rho^2)$ is the conditional variance of ε_{it} given $\varepsilon_{i,t-1}$. This formulation takes into account that residual factors (with respect to those related to the GDP dynamics and financial crises) that affect the trend of unemployment rate may have a certain degree of persistence.

It has to be clear that equations (1) and (2), defining the basic (or simple) and generalized versions of the Okun's model, are particular cases of equation (3), defining our proposed “extended Okun model”. In particular, the basic Okun’s Law in (1) is a special case of our model when $L_1=0$, $L_2=-1$ (so that, by convention, the sum involving the dummy variables $d_{it}^{(c)}$ is removed) and the autocorrelation parameter ρ is equal to 0.

It is important to note that the proposed model is based on country-specific intercepts (α_i) and regression coefficients for the GDP effect (β_{il}, γ_{il}), but on common coefficients for the crisis effects ($\delta_l^{(c)}$). The motivation behind this restriction is that financial crises are rather uncommon events, especially for high-income countries. Then, with the available dataset (see Section 4 for details and in particular, Tables 1 and 2) and contrary to the GDP effect, it would not be possible to obtain reliable estimates for these effects if considered as country specific.

Moreover, to obtain stable estimates of the country-specific parameters we follow a random-effects approach, which is based on the assumption that these parameters have a specific distribution. In particular, we consider the column vector $\boldsymbol{\theta}_i=(\alpha_i,\beta_{i0},\ldots,\beta_{iL_1},\gamma_{i0},\ldots,\gamma_{iL_1})'$ containing all the parameters specific of country i, and we assume that, for $i=1,\ldots,N$, $\boldsymbol{\theta}_i$ are independent and have a multivariate normal distribution with mean $\boldsymbol{\mu}$ and variance-covariance matrix $\boldsymbol{\Sigma}_{\boldsymbol{\theta}}$, in symbols $\boldsymbol{\theta}_i \sim N(\boldsymbol{\mu},\boldsymbol{\Sigma}_{\boldsymbol{\theta}})$. However, for the motivations given above, the parameters of the crises are treated as fixed-parameters and are collected in the vector $\boldsymbol{\delta}=(\delta_1^{(1)},\delta_1^{(2)},\ldots,\delta_{L_2}^{(C)})'$.[11]

A *linear mixed effect model* (McCulloch *et al*., 2008) follows from the above assumptions, which has reduced form

$$\boldsymbol{\Delta u}_i=\boldsymbol{X}_i\boldsymbol{\delta}+\boldsymbol{Z}_i\boldsymbol{\theta}_i+\boldsymbol{\varepsilon}_i\ , \qquad (4)$$

where $\boldsymbol{\Delta u}_i$ is a vector with elements Δu_{it} for $t=L,\ldots,T$ and $\boldsymbol{X}_i$ and $\boldsymbol{Z}_i$ are suitable design matrices formulated according to (3), with $\boldsymbol{X}_i$ defined on the basis of the dummy variables $d_{it}^{(c)}$ and $\boldsymbol{Z}_i$ on the basis of GDP dynamics measured by the percentage annual increases Δy_{it}. Moreover, $\boldsymbol{\varepsilon}_i$ is a random vector with distribution $N(\boldsymbol{0},\boldsymbol{\Sigma}_{\boldsymbol{\varepsilon}})$, where $\boldsymbol{\Sigma}_{\boldsymbol{\varepsilon}}$ is the variance-covariance matrix of an AR(1) process with parameters ρ and σ^2. This matrix has all elements in the main diagonal equal to σ^2, whereas the element in the i-th row and

j-th column is equal to $\sigma^2\rho^{|i-j|}$. Note that when for country i, the data are not available for all time periods $t=L,\ldots,T$, then $\boldsymbol{\Delta u}_i$ is made of elements Δu_{it} for only those certain values of t. This happens when both u_{it} and $u_{i,t-1}$ are defined, together with $y_{i,t-L_1},\ldots,y_{it}$ and $d_{i,t-L_2}^{(1)},d_{i,t-L_2}^{(2)},\ldots,d_t^{(C)}$. The design matrices $\boldsymbol{X}_i$ and $\boldsymbol{Z}_i$ and the random vector $\boldsymbol{\varepsilon}_i$ are defined accordingly; in particular, we now have that $\boldsymbol{\varepsilon}_i \sim N(\boldsymbol{0},\boldsymbol{A}_i\boldsymbol{\Sigma}_{\boldsymbol{\varepsilon}}\boldsymbol{A}_i')$, where $\boldsymbol{A}_i$ is a matrix obtained by removing, from an identity matrix of dimension $T-L$, the rows corresponding to each time period t for which the required information is missing.

It is worth noting that the random-effects approach formulated above is based on a reduced number of fixed parameters to estimate, that is, the parameters in $\boldsymbol{\delta}$ and $\boldsymbol{\mu}$, those in $\boldsymbol{\Sigma}_{\boldsymbol{\theta}}$, further to ρ and σ^2. For instance, with $L_1=1$ and $L_1=0$, we have 5 parameters in $\boldsymbol{\mu}$, 4 parameters in $\boldsymbol{\delta}$, 15 parameters in $\boldsymbol{\Sigma}_{\boldsymbol{\theta}}$. Overall, we then have 26 fixed-parameters to estimate. Nevertheless, as described in Appendix 1, it is possible to predict $\boldsymbol{\theta}_i$ for each country i, and then a much larger number of parameters, by using its specific conditional expected value given $\boldsymbol{\Delta u}_i$. We have to stress that because of a reduced amount of information, even a random-effects approach would not be viable to deal with country-specific coefficients for the crisis effects.

III.3. Estimation of the proposed Okun's model and selection of number of lags

Under the assumption that the GDP dynamics and the dynamics of financial crises are exogenous, expression (4) implies that the conditional distribution of $\boldsymbol{\Delta u}_i$ given $\boldsymbol{X}_i$, $\boldsymbol{Z}_i$, and $\boldsymbol{\theta}_i$ is $N(\boldsymbol{X}_i\boldsymbol{\delta}+\boldsymbol{Z}_i\boldsymbol{\theta}_i,\boldsymbol{A}_i\boldsymbol{\Sigma}_{\boldsymbol{\varepsilon}}\boldsymbol{A}_i')$. Then, marginalizing with respect to $\boldsymbol{\theta}_i$, we obtain the following distribution:

$$\boldsymbol{\Delta u}_i \sim N(\boldsymbol{X}_i\boldsymbol{\delta}+\boldsymbol{Z}_i\boldsymbol{\mu},\boldsymbol{Z}_i\boldsymbol{\Sigma}_{\boldsymbol{\theta}}\boldsymbol{Z}_i'+\boldsymbol{A}_i\boldsymbol{\Sigma}_{\boldsymbol{\varepsilon}}\boldsymbol{A}_i'),\quad i=1,\ldots,N. \qquad (5)$$

On the basis of this result, we can estimate the model by maximizing its likelihood

$$L(\boldsymbol{\beta},\boldsymbol{\mu},\boldsymbol{\Sigma}_{\boldsymbol{\theta}},\rho,\sigma^2)=\prod_i f(\boldsymbol{\Delta u}_i;\boldsymbol{X}_i\boldsymbol{\delta}+\boldsymbol{Z}_i\boldsymbol{\mu},\boldsymbol{Z}_i\boldsymbol{\Sigma}_{\boldsymbol{\theta}}\boldsymbol{Z}_i'+\boldsymbol{A}_i\boldsymbol{\Sigma}_{\boldsymbol{\varepsilon}}\boldsymbol{A}_i'), \tag{6}$$

where $f(\cdot;\cdot)$ denotes the density function of the multivariate normal distribution, which in the present case has parameters defined in (5). As usual, instead of directly maximizing the likelihood, we maximize the log-likelihood, that is the logarithm of (6), which is equal to:

$$l(\boldsymbol{\beta},\boldsymbol{\mu},\boldsymbol{\Sigma}_{\boldsymbol{\theta}},\rho,\sigma^2)=\sum_i \log f(\boldsymbol{\Delta u}_i;\boldsymbol{X}_i\boldsymbol{\delta}+\boldsymbol{Z}_i\boldsymbol{\mu},\boldsymbol{Z}_i\boldsymbol{\Sigma}_{\boldsymbol{\theta}}\boldsymbol{Z}_i'+\boldsymbol{A}_i\boldsymbol{\Sigma}_{\boldsymbol{\varepsilon}}\boldsymbol{A}_i'). \tag{7}$$

Maximization of $l(\boldsymbol{\beta},\boldsymbol{\mu},\boldsymbol{\Sigma}_{\boldsymbol{\theta}},\rho,\sigma^2)$ is performed by the Expectation-Maximization (EM) algorithm: see Dempster *et al.* (1977); see also Laird and Ware (1982) and Lindstrom and Bates (1988). A Matlab implementation of this algorithm, suitably tailored to the analysis of the data utilized in this in paper, is available from the authors upon request and is briefly illustrated in Appendix 1. However, standard errors, which may be used to test specific hypotheses on the parameters, are computed by a parametric bootstrap method (Efron and Tibshirani, 1994; Davison and Hinkley, 1997) based, in our application, on 200 replications.

As it is clear from assumption (3), the model formulation depends on the maximum number of lags in each component, that is L_1 and L_2. For selecting these quantities, we adopt the Akaike Information Criterion (AIC), which is very well known in the statistical literature; see Akaike (1973).[12] According to this criterion, the model to be selected among the available models is the one attaining the minimum of the following index:

$$AIC=-2l(\hat{\boldsymbol{\beta}},\hat{\boldsymbol{\mu}},\hat{\boldsymbol{\Sigma}}_{\boldsymbol{\theta}},\hat{\rho},\hat{\sigma}^2)+2g, \tag{8}$$

where $l(\hat{\boldsymbol{\beta}},\hat{\boldsymbol{\mu}},\hat{\boldsymbol{\Sigma}}_{\boldsymbol{\theta}},\hat{\rho},\hat{\sigma}^2)$ is the maximum of the model log-likelihood (we have the maximum likelihood estimates $\hat{\boldsymbol{\beta}}$, $\hat{\boldsymbol{\mu}}$, $\hat{\boldsymbol{\Sigma}}_{\boldsymbol{\theta}}$, $\hat{\rho}$, and $\hat{\sigma}^2$ as argument) and g is the number of non-redundant parameters. The idea behind AIC is that the selected model reaches the best good compromise between fit to the data (measured by the log-likelihood) and model complexity (measured by the number of parameters).

IV. DATA AND EMPIRICAL RESULTS

IV.1 Data

The available data concern a large set of countries (see the list in Tables in Appendix 2) over the period 1980-2010. Unemployment rate data were taken from "Key Indicators of Labor market" (KILM, 7th Edition) and GDP data from World Bank Development Indicators (WDI, historical database).

As to the definition of a financial crisis, it is obvious that national financial crises are very different from international financial crises.[13] However, to econometrically estimate the labor market impact of GDP changes – with the addition of specific dummies for financial crises – in our study, we use the definition of "financial crisis" adopted by Honohan and Laeven (2005). These authors consider a financial crisis the occurrence of either a systemic banking crisis (when a country's corporate and financial sector experiences a large number of defaults and financial institutions and corporations face great difficulties repaying contracts on time) or a non-systemic banking crisis (i.e., crisis limited to a small number of banks); they also consider two additional types of crises: currency crisis and debt crisis. All data about financial crises are taken from Laeven and Valencia (2008, 2012).

The total number of countries is 209: see Table 1, in which the countries are subdivided into 5 income groups. However, to obtain more reliable estimates (the amount of information, especially for low income countries, is very low), we subsequently decided to reduce the number of groups from five to two groups: High-income countries (joining together groups 4 and 5 in Table 1) and Non-high income countries (joining together groups 1, 2, and 3), with 66 and 143 countries, respectively. In Table 1 we also show the number of observed financial crisis events and the number of countries that for each type of crisis, experienced at least one crisis in the period of observation. Due to the limited number of observations, we had to exclude non-systemic banking crises.

We note that a reduced number of crisis events were observed; this is evident for currency and debt crises. This enforces our choice of adopting a model with crisis effects common to all countries or at the most distinguishing between two groups of countries, whereas the other parameters, for which we have more support from the data, are assumed to be country specific.

On the dataset obtained as above, we fitted the proposed model for increasing values of L_1 and L_2, computing in each case the index *AIC* defined in (8). The range of values for L_1 and L_2 goes from -1 (GDP and financial crises are not used to predict the unemployment dynamics) to 2. We do not use larger values of L_1 and L_2 to avoid to drop too many observations. The results of this preliminary analysis are reported in Table 2.

The model that according to AIC, seems to be adequate is that with $L_1 = 2$ (two lags of the GDP increase) and $L_2 = 1$ (one lag for the financial crisis dummies).

IV.2 Estimation of the proposed extended Okun model

To choose a suitable model and compare different models, corresponding to different values of the maximum number of lags L_1 and L_2, we processed the dataset so that the same set of observations is available in all cases. In fact, we recall that employing different values of the maximum number of lags affects the number of observations that may be exploited for model estimation. The resulting dataset includes the observation for country i in period t if: (i) both u_{it} and $u_{i,t-1}$ are available (so that Δu_{it} may be computed); (ii) $y_{i,t-3}, \ldots, y_{it}$ are available (so that we can use a value of L_1 equal to until 2); (iii) the dummy variables $d_{it}^{(c)}$ and $d_{i,t-1}^{(c)}$ are known (so that we can use a value of L_2 equal to until 1). The maximum values of L_1 (fixed at 2) and L_2 (fixed at 1) just mentioned are chosen on the basis of the evidence coming from the data.

The estimates of averages of Okun’s parameters (denoted above by μ) are reported in Table 3 under the basic formulation (with $L_2 = -1$) and the proposed formulation that includes the financial crisis information (with $L_2 = 1$). Moreover, $L_2 = 1$ (common) means that the estimates are obtained considering the observations of the two groups of countries together. The Table 3 also reports the corresponding standard errors and the estimates (and standard errors) of the autocorrelation parameters ρ and stationary variance σ^2 .

We note that Okun's estimates have the expected sign for lag 0 and lag 1 and that the inclusion of the financial crisis dummies slightly affects these estimates. Moreover, the estimate of the autocorrelation coefficient ρ is close to 0 in all cases, even if we have to reject the hypothesis that it is exactly equal to 0. This leads to the conclusion that the effect of further factors affecting the unemployment rate dynamics (with respect to GDP and financial crises) has a moderate persistence.

From Table 3, we can see that Okun coefficients are highly significant and with the expected negative sign: an increase in GDP of 1% leads to a 0.15% decrease in unemployment in the same year (first row of Table 3); however, if there is a recession, a decrease in GDP causes a 0.235% increase in unemployment (the sum of coefficients Okun contemporary and differential Okun contemporary). At lag 1, the coefficient is still negative and significant, while the recession coefficient changes its sign. At lag 2, the coefficient becomes positive: this may because normal business cycles generally last for one or two years.

Table 4 presents the averages of the random effects coefficients for the two main groups of countries: high-income and non-high income. It is interesting to see that the size of the coefficients differs between the two groups. For instance, the previous outcome – that an increase in GDP by 1% leads to a 0.15% decrease in unemployment in the same year – that was obtained for all countries in the sample corresponds to a greater decrease (0.18%) in the case of high-income countries and to a smaller decrease (0.13%) for the non-high income group.

If we skip for the moment the discussion concerning the remaining two lines of Table 3 (Okun coefficients in regressions with crisis effects estimated separately for the two income groups or jointly for the two groups), which are more significant for the following estimations including crisis dummies, let us focus on the "simple" Okun coefficients (i.e., the first row of Table 3) for the different groups of countries.

IV.3 Okun coefficients of the simple model by income groups

Table 5 presents the coefficients of the "simple" Okun model, i.e., without considering the impact of financial crises, as well as the coefficients of the "recession" dummy, for the five income groups. The consideration of all five income groups is feasible because the number of parameters to be estimated is smaller in this "simple" Okun model.

We can see that the greatest coefficient at time 0 can be found for the high-income OECD countries and the smallest one for the lower-middle income countries, while the coefficients for the countries of the remaining income groups are in the middle. The ranking is approximately the same also for coefficients at lag 1.

An initial conclusion is that the sensitivity of the unemployment rate to GDP variations is high in the same year and also in the following year, with the highest coefficients found in high-income countries. The recession situation increases the response of the unemployment rate, with a significant effect – for all countries – in the same year of the recession.

IV.4 Estimation results of the proposed extended model by type of crises and income level

Let us now return to the complete model, including the crisis dummies (the model corresponding to equation (3)). The estimates of the parameters measuring the financial crisis effect under the model with $L_2 = 1$ are reported in Table 6.

Quite different results emerged for the two groups of high-income and non-high income countries. In particular, systemic banking crises and currency crises have a significant additional impact – with one year lag - on the unemployment rate in the case of high-income countries[14], while a currency crisis in the case of non-high income countries determines a significant reduction – with one year lag - of the unemployment rate.

In other words, in the case of high-income countries, a financial crisis (banking or currency) produces an additional increasing effect – with a one-year lag - on unemployment with respect to the effect already captured by Okun's coefficient. We argue that a possible explanation is that a financial crisis produces a significant increase in the degree of uncertainty in the economic system, affecting the expectations and the behavior of private firms (including their decisions on labor demand and on hiring). More specifically, a financial crisis in high-income countries can significantly increase the degree of systemic uncertainty, with consequently more uncertain expectations about sales and profits, and the adoption by the firms of more cautious hiring decisions with respect to what is justified by the current or recent changes in sales and production (only the latter dynamics are captured - at an aggregate level - by GDP changes). This interpretation is corroborated by the fact that in high-income countries, hiring is to a large extent executed in formal labor contracts; they are a sort of "investment" in a "quasi-fixed factor" (Oi, 1962) with evident and implicit sunk costs for the firm (like selection and training expenditures, especially in case of early firing or dismissal of workers), especially the potential cost of firing (e.g., because of restrictions caused by employment protection legislation).

In contrast to high-income countries, a systemic banking crisis in non-high income countries does not have a significant additional (with respect to simple Okun's coefficients) effect on unemployment rate dynamics most likely because its impact on increasing the systemic uncertainty is less evident. Consider that even in "normal times", several developing countries (and in general non-high income countries) are generally characterized by a much higher systemic uncertainty than more developed countries. Moreover, in the case of non-high income countries, the significance of estimated coefficients is found for currency crises (at lag 1), but the sign of the coefficient is negative, i.e., the currency crisis reduces the unemployment rate. A possible explanation is that a significant devaluation (more than 30% in a year's time, corresponding to our definition of a currency crisis) may lead – at least in the short- and medium-term – to beneficial effects related both to current and expected evolution of exports, with a consequent additional (with respect to what is explained by GDP dynamics) positive effect on labor demand and a reduction in unemployment. In other words, this "currency devaluation effect" may overcome the small effect due to the increased uncertainty (small because uncertainty is permanently higher in these countries). On the contrary, it seems that in the case of high-income countries, a currency crisis causes a significant increase in uncertainty and a worsening in the macroeconomic expectations with an additional increase – with a one-year lag - in the unemployment rate.

IV.5 Simulations of the impact of GDP changes on the unemployment rate, with and without financial crisis

To better interpret the parameter estimates in Table 6, we computed the expected increase in the percentage unemployment rate – under different scenarios – corresponding to different values of the GDP percentage increase. The simulation results are reported in Table 7.

For example, a 3% fall in GDP typically leads to a 1.03 percentage point increase in the unemployment rate (this is the "standard" effect of a recession without financial crises); on the contrary, in the presence of financial crises, there is an additional effect, causing a greater increase in unemployment in high-income countries: 1.59 in the case of a systemic banking crisis (with an additional impact of 0.56) and 2.12 in the case of a currency crisis (with an additional impact of 1.09); the impact in the case of a combination of the two crises is 2.68

percentage points, i.e., a 1.65 additional impact on unemployment relative to the "no crises" scenario.[15].

The story is different in the case of non-high income countries with a currency crisis; for all the simulated changes in GDP (from -5 to +5 percent), the resulting unemployment rates are lower with respect to the baseline scenario of the absence of a financial crisis. For example, in the case of a GDP decline of 3%, the simulation with a currency crisis shows an impact on the unemployment rate of 0.65, i.e., lower than the 1.03 in the scenario without a financial crisis. This less negative impact is due to the previously discussed "currency devaluation effect".

V. CONCLUSIONS

In this paper, we have first obtained an empirical confirmation – for a large sample of countries classified in five groups according to per-capita GDP level - of the existence of a relationship between GDP dynamics and unemployment rate changes, also in the case where we adopt a more realistic extended version of the Okun's Law model. Our proposed extended version includes, first of all, an estimation of the impact of financial crises, with different time lags. We have also controlled for many factors, such as the lagged impact of GDP changes, the inertia of the dependent variable (i.e., the unemployment rate), possible different values of Okun's coefficients under recession (with respect to periods of increases in GDP), and country-specific factors (that should capture institutional and structural national differences), etc.

The key econometric result is that some types of financial crises have a significant additional effect on the unemployment rate, in addition to that already explained by the simple Okun's Law model. A further notable empirical result is that we find different outcomes in high-income countries with respect to non-high income economies. In particular, for high-income countries, we find that in the case of systemic banking crises and currency crises, the unemployment rate suffers an increase beyond what can be explained by GDP changes alone.

Referring to the existing literature, we argue that this additional impact can be explained by the fact that, in high-income countries, the presence of a financial crisis determines an increase in “systemic uncertainty” that further dampens employment and increases unemployment (as explained in Sections 2 and 3). For non-high income countries, we find a statistically significant result only in the case of currency crises, but the sign is opposite that found for high-income countries. We argue that in economies with a permanently high systemic uncertainty in normal times – such as developing countries and non-high income countries in general – a financial crisis does not have a very relevant impact in further increasing the uncertainty level (this is in contrast to high-income countries normally characterized by a lower systemic uncertainty). In addition, in non-high income countries, we also find – after controlling for GDP dynamics within our “extended Okun’s Law model” - that a currency crisis is likely to reduce the unemployment rate, most likely due to a “devaluation effect” that overcomes the small effect on uncertainty mentioned above.

Regarding policy implications, a first conclusion is that policy makers should be well aware of all the consequences of financial crises, not only for their direct effects on labor markets (passing through GDP changes) but also for possible additional effects. For high-income countries, we argue that during a financial crisis, “systemic uncertainty” significantly increases with a relevant additional effect on labor demand. Therefore, the macroeconomic and social costs of financial crises - especially in terms of labor market performance - go well beyond their impact on GDP decline.

The negative impact of financial crises on GDP, and on unemployment in particular, could be partially offset by adequate macroeconomic policies. A prompt, announced, and possibly internationally coordinated expansionary policy not only could positively impact GDP but could also affect expectations and thus reduce systemic uncertainty.[16] As to the preventive arm, to avoid the occurrence of financial crises, there is a need for a well-designed "regulatory system and governance" at both the national and international levels. Despite the 2007-08 financial crisis having been the worst since 1929, with remarkable and persistent impacts on the unemployment rates of several developed economies, it should be noted that reforms of "regulatory system and governance" have been – until now – very scarce and that the macroeconomic policies that have followed, at least the "austerity approach" in Europe, have so far aggravated, instead of alleviated, the labor market impact of the financial crisis.

NOTES

[1] There also exists significant literature with a critical position: for example, Flaig and Rottmann (2000) criticised the Okun coefficient literature because it neglects the influence of relative prices; indeed, they argue that the employment intensity of growth is clearly related to real labor costs; consequently, estimating a simple Okun equation is not appropriate, due to incorrect specification.

[2] For example, Thirlwall (1969); You (1979); Gordon (1984); Weber (1995); Attfield and Silverstone (1998); Kaufman (1988); Watts and Mitchell (1991); Freeman (2000); Sögner and Stiassny (2002); Apergis and Rezitis (2003); Perman and Tavera (2007); Knotek (2007); Huang and Lin (2008).

[3] The existence of possible asymmetries over the cycle was investigated also in less recent literature (e.g. Neftci, 1984; Rothman, 1991; Brunner, 1997).

[4] An employment version of Okun's law was also estimated.

[5] See, for example, Dow and Hillard (1995, 2002), Rosser (2001), Terzi (2010).

[6] See, for example, Jones and Ostroy (1984), Kreps (1979), Marshak and Nelson (1962).

[7] Colombo (2013) analyzed in this way the economic policy uncertainty in the U.S. and also compared to the situation in the Eurozone, while Nodari (2014) investigated the uncertainty on financial regulation policy and the related credit spread in the U.S.

[8] It is, however, important to distinguish between "hysteresis" models developed in New Keynesian Economics and the long run effects of uncertainty, more frequently used in the Keynesian and Post-Keynesian traditions (see Davidson, 1993).

[9] On the specific role played by uncertainty in developing countries, see Serven (1999) and Fawaz *et al*. (2012).

[10] Two additional aspects - affecting GDP growth - are not investigated in the paper. The first one refers to the fact that a further reduction in labor demand will reduce available income and consumption with further negative effects on GDP dynamics. The second one refers to

the possible reduction of the propensity to consume due to the increase in savings in a condition of higher uncertainty.

[11] Note that if we assumed that even the parameters for the financial crisis were country specific and random, it would have been possible to test only the hypothesis that these parameters have zero mean by standard tools. Employing fixed effects common to all countries instead, we can test the hypothesis that a specific crisis has no effect for all countries, even if we acknowledge that the approach may be more restrictive.

[12] For this aim, we could also rely on the Bayesian Information Criterion (BIC) of Schwarz (1978), but AIC guarantees selection of a model with a better fit, even if less parsimonious.

[13] For example, according to Bordo (2006) and Reinhart and Rogoff (2008a, 2008b, 2009), there were eight episodes of major international financial crises since 1870.

[14] The extremely low number of observations for the sovereign debt crisis in the case of high-income countries does not permit us to obtain reliable results.

[15] Please also note that – in case of financial crises in high-income countries – a hypothetical positive GDP growth (till 5%) would not be sufficient to reduce the unemployment rate in the same year.

[16] There are many recognitions of this link. For example, ECB's President Draghi, with reference to the current situation in the Eurozone, recently stated that "it seems likely that uncertainty over the strength of the recovery is weighing on business investment and slowing the rate at which workers are being rehired" (European Central Bank, 2014).

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Appendix 1: EM algorithm for maximum likelihood estimation

The log-likelihood $l(\boldsymbol{\beta},\boldsymbol{\mu},\boldsymbol{\Sigma}_{\boldsymbol{\theta}},\rho,\sigma^2)$, whose expression is given in (7), is maximized by the EM algorithm (Dempster *et al.*, 1977), which is a well-known iterative algorithm in the statistical literature. This algorithm exploits the *complete log-likelihood*, which in our case corresponds to the log-likelihood that we could compute if we knew the random vectors $\boldsymbol{\eta}_i=\boldsymbol{\theta}_i-\boldsymbol{\mu}$, $i=1,\ldots,N$. These represent the *missing values* of the problem.

The complete log-likelihood may be expressed as the sum of two components, that is $l'(\boldsymbol{\beta},\boldsymbol{\mu},\boldsymbol{\Sigma}_{\boldsymbol{\theta}},\rho,\sigma^2)=l_1'(\boldsymbol{\beta},\boldsymbol{\mu},\boldsymbol{\Sigma}_{\boldsymbol{\theta}},\rho,\sigma^2)+l_2'(\boldsymbol{\beta},\boldsymbol{\mu},\boldsymbol{\Sigma}_{\boldsymbol{\theta}},\rho,\sigma^2)$, where

$$l_1'(\boldsymbol{\beta},\boldsymbol{\mu},\boldsymbol{\Sigma}_{\boldsymbol{\theta}},\rho,\sigma^2)=-\frac{1}{2}\sum_i \log|2\pi\boldsymbol{\Sigma}_{\boldsymbol{\theta}}|+\boldsymbol{\eta}_i'\boldsymbol{\Omega}_i^{-1}\boldsymbol{\eta}_i$$

refers to the marginal distribution of each $\boldsymbol{\eta}_i$ and $l_2'(\boldsymbol{\beta},\boldsymbol{\mu},\boldsymbol{\Sigma}_{\boldsymbol{\theta}},\rho,\sigma^2)$ has a similar expression based on the conditional distribution of each vector $\boldsymbol{\Delta u}_i$ given $\boldsymbol{\eta}_i$.

Starting from suitable initial values for the parameters, indicated by $\boldsymbol{\beta}^{(0)}$, $\boldsymbol{\mu}^{(0)}$, $\boldsymbol{\Sigma}_{\boldsymbol{\theta}}^{(0)}$, $\rho^{(0)}$, and $\sigma^{2(0)}$, at the h-th iteration the EM algorithm updates the current parameter estimates by performing the following two steps (E-step and M-step):

E-step: on the basis of the parameter values obtained at end of the previous iteration, $\boldsymbol{\beta}^{(h-1)}$, $\boldsymbol{\mu}^{(h-1)}$, $\boldsymbol{\Sigma}_{\boldsymbol{\theta}}^{(h-1)}$, $\rho^{(h-1)}$, and $\sigma^{2(h-1)}$, compute the expected value of the complete log-likelihood $l'(\boldsymbol{\beta},\boldsymbol{\mu},\boldsymbol{\Sigma}_{\boldsymbol{\theta}},\rho,\sigma^2)$ with respect to the distribution of each random vector $\boldsymbol{\eta}_i$ given y_i. It can be easily shown that $\boldsymbol{\eta}_i|\boldsymbol{y}_i\sim N(\boldsymbol{\nu}_i,\boldsymbol{\Omega}_i)$, where $\boldsymbol{\nu}_i$ and $\boldsymbol{\Omega}_i$ are obtained by standard rules about the multivariate normal distribution; in particular, we have

$$\boldsymbol{\nu}_i=\boldsymbol{\Sigma}_{\boldsymbol{\theta}}(\boldsymbol{Z}_i\boldsymbol{\Sigma}_{\boldsymbol{\theta}}\boldsymbol{Z}_i'+\boldsymbol{A}_i\boldsymbol{\Sigma}_{\boldsymbol{\varepsilon}}\boldsymbol{A}_i')^{-1}(\boldsymbol{y}_i-\boldsymbol{X}_i\boldsymbol{\beta}-\boldsymbol{Z}_i\boldsymbol{\mu}),\quad i=1,\ldots,N. \qquad (10)$$

M-step: update the parameter values by maximizing the expected value of the complete log-likelihood computed at the E-step. Note that explicit expressions exist to update each block of parameters.

The algorithm described above is stopped at convergence, that is, when the difference between two consecutive log-likelihood is negligible. More precisely, we consider convergence to be reached when

$$l(\boldsymbol{\beta}^{(h)}, \boldsymbol{\mu}^{(h)}, \boldsymbol{\Sigma}_{\boldsymbol{\theta}}^{(h)}, \rho^{(h)}, \sigma^{2(h)}) - l(\boldsymbol{\beta}^{(h-1)}, \boldsymbol{\mu}^{(h-1)}, \boldsymbol{\Sigma}_{\boldsymbol{\theta}}^{(h-1)}, \rho^{(h-1)}, \sigma^{2(h-1)}) < \tau ,$$

where $\tau > 0$ is a small tolerance level. In our application we chose $\tau = 10^{-5}$. As maximum likelihood parameter estimates, denoted by $\hat{\boldsymbol{\beta}}$, $\hat{\boldsymbol{\mu}}$, $\hat{\boldsymbol{\Sigma}}_{\boldsymbol{\theta}}$, $\hat{\rho}$, and $\hat{\sigma}^2$, we take the solution at convergence. Note that, as a byproduct of the algorithm, we have the prediction of each random vector $\boldsymbol{\theta}_i$, which is simply obtained as $\tilde{\boldsymbol{\theta}}_i = \hat{\boldsymbol{\mu}} + \mathbf{v}_i$, $i = 1, \ldots, N$, where $\mathbf{v}_i$ refers to the conditional expected value computed at the last E-step; see expression (10).

Appendix 2: List of countries according to level of development and number of financial crises in the period 1980-2010 (according to our database)

countries	groups (from 1 to 5) according to development level	number of systemic banking crises	number of currency crises	number of sovereign debt crises
Algeria	3	5	2	0
Argentina	3	10	3	2
Armenia	2	1	1	0
Australia	5	0	0	0
Austria	5	3	0	0
Azerbaijan	2	1	0	0
Bangladesh	1	1	0	0
Barbados	4	0	0	0
Belgium	5	3	3	0
Belize	2	0	0	0
Bhutan	2	0	0	0
Bolivia	2	2	1	1
Bosnia and Herzegovina	3	5	0	0
Botswana	3	0	1	0
Brazil	3	9	4	1
Bulgaria	3	2	1	1
Cambodia	1	0	1	0
Canada	5	0	0	0
Chile	3	5	1	1
China	2	1	0	0
Colombia	3	4	1	0
Costa Rica	3	7	2	1
Croatia	4	2	0	0
Czech Republic	5	5	0	0

Denmark	5	3	0	0
Dominican Republic	3	2	3	2
Ecuador	2	10	2	3
Egypt	2	1	1	1
El Salvador	2	2	1	0
Estonia	4	3	1	0
Ethiopia	1	0	1	0
Fiji	3	0	1	0
Finland	5	5	1	0
France	5	3	0	0
Georgia	2	5	2	0
Germany	5	3	0	0
Ghana	1	2	4	0
Greece	5	3	1	0
Guatemala	2	0	1	0
Guyana	2	1	1	1
Honduras	2	0	1	1
Hong Kong	4	0	0	0
Hungary	5	8	0	0
Iceland	5	3	3	0
India	2	1	0	0
Indonesia	2	5	1	1
Iran	2	0	3	1
Ireland	5	3	0	0
Israel	4	0	2	0
Italy	5	3	1	0
Jamaica	3	3	2	1
Japan	5	5	0	0
Jordan	2	3	1	1

Kazakhstan	3	3	1	0
Korea Republic	5	2	1	0
Kuwait	4	4	0	0
Kyrgyz Republic	1	5	1	0
Latvia	3	5	1	0
Lithuania	3	2	1	0
Luxembourg	5	3	0	0
Macedonia	3	3	0	0
Madagascar	1	1	3	1
Malaysia	3	3	1	0
Mauritius	3	0	0	0
Mexico	3	8	2	1
Moldova	2	0	1	1
Mongolia	2	3	2	0
Morocco	2	5	1	1
Netherlands	5	3	0	0
New Zealand	5	0	1	0
Nicaragua	2	6	2	1
Norway	5	3	0	0
Pakistan	2	0	0	0
Panama	3	2	0	1
Paraguay	2	1	3	1
Peru	3	1	2	0
Philippines	2	9	2	1
Poland	3	3	0	1
Portugal	5	3	1	0
Romania	3	3	1	1
Russia	3	4	1	1
Serbia	3	0	1	0

Singapore	4	0	0	0
Slovak Republic	5	5	0	0
Slovenia	4	4	0	0
South Africa	3	0	1	1
Spain	5	5	1	0
Sri Lanka	2	3	0	0
Suriname	3	0	3	0
Sweden	5	8	1	0
Switzerland	5	3	0	0
Syrian Arab Republic	2	0	1	0
Thailand	2	5	1	0
Trinidad and Tobago	4	0	1	1
Tunisia	2	1	0	0
Turkey	3	5	4	0
Ukraine	2	5	2	1
United Kingdom	5	4	0	0
United States	5	5	0	0
Uruguay	3	9	2	2
Venezuela	3	5	5	1
Vietnam	1	1	2	1
Yemen Republic	1	1	2	0
Zambia	1	4	4	1

Table 1. *Number of observed crises for each typology together with the number of countries, of the five income groups, experimenting at least one financial crisis in the considered period.*

group description	n. of countries	n. of systemic banking crises	n. of currency crises	n. of sovereign debt crises	n. of countries with at least one banking crisis	n. of countries with at least one currency crisis	n. of countries with at least one debt crisis
1-Low income	43	102	66	12	30	36	12
2-Lower-middle income	54	107	51	22	30	33	19
3-Upper-middle income	46	113	55	23	26	30	19
4-High-income (non-OECD)	39	14	7	1	5	5	1
5-High-income (OECD)	27	94	14	0	24	10	0
Overall	209	430	193	58	115	114	51

Table 2. *Results from a preliminary fitting of the proposed model on the unemployment rate data without including financial crisis dummies; for each considered value of* L_1 *(with* $L_2 = L_1$*), "max.log-lik." refers to the maximum value of the log-likelihood, "n. pars." to the number of parameters, whereas "AIC" refers to the values of the corresponding index used for model selection; in boldface are the data referred to the model with minimum AIC.*

L1	**L2**	**max log-lik.**	**n. pars**	**AIC**
-1	-1	-3382.7	4	6773.4
-1	0	-3347.1	10	6714.3
-1	1	-3335.6	16	6703.2
-1	2	-3322.8	22	6689.6
0	-1	-3178.5	11	6379.1
0	0	-3173.3	17	6380.6
0	1	-3163.6	23	6373.2
0	2	-3158.3	29	6374.5
1	-1	-3155.5	22	6354.9
1	0	-3149.8	28	6355.6
1	1	-3141.4	34	6350.8
1	2	-3135.9	40	6351.8
2	-1	-3052.6	37	6179.2
2	0	-3049.1	43	6184.3
2	**1**	**-3037.0**	**49**	**6172.1**
2	2	-3031.8	55	6173.6

Table 3. *Estimates of the average of Okun's parameters (collected in* μ *) measuring the impact of the GDP dynamics on the unemployment rate dynamics for all countries, together with the estimates of the autocorrelation coefficient (* ρ *) and the stationary variance (* σ^2 *) of the error terms. "Intercept" refers to the mean of the parameters* α_i *, "Okun coefficient (contemporary)" to the mean of the parameters* β_{i0} *, "Okun coefficient (lag 1)" to the mean of the parameters* β_{i1} *, and "Okun coefficient (lag 2)" to the mean of the parameters* β_{i2} *, whereas "Differential Okun coefficient (contemporary)", "Differential Okun coefficient (lag 1)" and "Differential Okun coefficient (lag 2)" refer to the means of the parameters* γ_{i0} *,* γ_{i1} *, and* γ_{i2} *, respectively; (*) stands for significantly different from 0 at the 10%, (**) at the 5%, (***) at the 1%, and (****) at 0.1%.*

		Okun coefficient			**Differential Okun coefficient**				
L2	**Intercept**	**contemporary**	**lag 1**	**lag 2**	**contemporary**	**lag 1**	**lag 2**	**Autocorrelation**	**Variance**
-1 (no crisis effect)	0.465 ****	-0.150 ****	-0.061 ****	0.039 **	-0.085 **	0.114 ***	-0.099	0.082	1.369
	(0.093)	(0.019)	(0.016)	(0.019)	(0.036)	(0.041)	(0.066)	(0.026)	(0.052)
1 (with crisis effect)	0.399 ****	-0.146 ****	-0.058 ****	0.044 **	-0.063 *	0.124 **	-0.096	0.075	1.350
	(0.097)	(0.019)	(0.016)	(0.022)	(0.036)	(0.050)	(0.070)	(0.030)	(0.051)
1 (common, no differential effect of the crisis by group)	0.403 ****	-0.146 ****	-0.057	0.041 **	-0.070 *	0.120 **	-0.091	0.080	1.366
	(0.103)	(0.020)	(0.016)	(0.022)	(0.037)	(0.048)	(0.068)	(0.030)	(0.048)

Table 4. *Average of the predictions of random parameters of the proposed model (without financial crisis, $L_2 = -1$, with financial crisis, $L_2 = 1$, with financial crisis having the same effect for all countries, $L_2 = 1$ (common)) for Non-high and High income countries. "Intercept" refers to the mean of the parameters α_i, "Okun coefficient (contemporary)" to the mean of the parameters β_{i0}, "Okun coefficient (lag 1)" to the mean of the parameters β_{i1}, and "Okun coefficient (lag 2)" to the mean of the parameters β_{i2}, whereas "Differential Okun coefficient (contemporary)", "Differential Okun coefficient (lag 1)"," and "Differential Okun coefficient (lag 2)" refer to the means of the parameters γ_{i0}, γ_{i1}, and γ_{i2}, respectively.*

			Okun coefficient			**Differential Okun coefficient**		
L2	**group**	**Intercept**	**contemporary**	**lag 1**	**lag 2**	**contemporary**	**lag 1**	**lag 2**
-1	Non-high	0.377	-0.133	-0.052	0.049	-0.086	0.137	-0.078
	High	0.632	-0.181	-0.079	0.020	-0.082	0.070	-0.139
1	Non-high	0.334	-0.134	-0.051	0.053	-0.067	0.146	-0.076
	High	0.521	-0.170	-0.073	0.027	-0.055	0.084	-0.132
1 (common)	Non-high	0.321	-0.131	-0.049	0.052	-0.071	0.145	-0.069
	High	0.558	-0.174	-0.073	0.021	-0.066	0.071	-0.134

Table 5. *Average of the predictions of random parameters of the basic model without financial crisis ($L_2 = -1$) for the five country groups defined in Table 1. "Intercept" refers to the mean of the parameters* α_i *, "Okun coefficient (contemporary)" to the mean of the parameters* β_{i0} *, "Okun coefficient (lag 1)" to the mean of the parameters* β_{i1} *, and "Okun coefficient (lag 2)" to the mean of the parameters* β_{i2} *, whereas "Differential Okun coefficient (contemporary)", "Differential Okun coefficient (lag 1)"," and "Differential Okun coefficient (lag 2)" refer to the means of the parameters* γ_{i0} *,* γ_{i1} *, and* γ_{i2} *, respectively.*

		Okun coefficient			**Differential Okun coefficient**		
group	**intercept**	**contemporary**	**lag 1**	**lag 2**	**Contemporary**	**lag 1**	**lag 2**
1-Low income	0.386	-0.160	-0.074	0.115	-0.093	0.129	0.138
2-Lower-middle income	0.259	-0.103	-0.039	0.041	-0.095	0.163	-0.127
3-Upper-middle income	0.488	-0.155	-0.058	0.038	-0.076	0.113	-0.095
4-High-income (non-OECD)	0.353	-0.115	-0.066	0.021	-0.075	0.059	-0.160
5-High-income (OECD)	0.724	-0.203	-0.083	0.019	-0.084	0.074	-0.132
total	0.465	-0.150	-0.061	0.039	-0.085	0.114	-0.099

Table 6. *Estimates of the parameters for the crisis effects ($\delta_l^{(c)}$) under the model with $L_1 = 2$ and $L_2 = 1$; in parentheses are reported the standard errors; (*) stands for significantly different from 0 at 10%, (**) at 5%, (***) at 1%, and (****) at 0.1%.*

	Crisis coefficient				Differential Crisis coefficient		Overall sample effect (model with common effect)	
	High income		Non-high income					
	lag0	lag1	lag0	lag1	lag0	lag1	lag0	lag1
banking crisis	-0.016	**0.562 ****	0.149	0.212	0.165	-0.350	0.087	**0.315 ****
	(0.211)	(0.246)	(0.175)	(0.158)	(0.269)	(0.275)	(0.138)	(0.132)
currency crisis	0.545	**1.095 *****	-0.240	**-0.380 ***	**-0.785 ***	**-1.475 *****	-0.030	-0.012
	(0.372)	(0.381)	(0.222)	(0.228)	(0.426)	(0.434)	(0.196)	(0.173)
sovereign debt crisis	-	-	0.351	0.308	-	-	0.172	-0.073
	-	-	(0.370)	(0.344)	-	-	(0.392)	(0.330)

Table 7. *Simulation results in terms of the evolution of the unemployment rate (UR) due to different GDP change scenarios (from -5% to +5%) and the presence/absence of specific financial crises.*

GDP growth rate (scenario)	**-5.0**	**-4.0**	**-3.0**	**-2.0**	**-1.0**	**0.0**	**1.0**	**2.0**	**3.0**	**4.0**	**5.0**
UR change without a financial crises	1.45	1.24	1.03	0.82	0.61	0.40	0.25	0.11	-0.04	-0.19	-0.33
UR change in High-income countries with systemic banking crisis	2.01	1.80	1.59	1.38	1.17	0.96	0.81	0.67	0.52	0.38	0.23
UR change in high-income countries with currency crisis	2.54	2.33	2.12	1.91	1.70	1.49	1.35	1.20	1.05	0.91	0.76
UR change in high-income countries with systemic banking crisis and currency crisis	3.10	2.89	2.68	2.47	2.26	2.06	1.91	1.76	1.62	1.47	1.32
UR change in non-high-income countries with currency crisis	1.07	0.86	0.65	0.44	0.23	0.02	-0.13	-0.27	-0.42	-0.57	-0.71