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Resumen

El objetivo de esta investigación es superar las limitaciones de las estimaciones convencionales del coeficiente de Okun, destacando la naturaleza indirecta del efecto del producto sobre la tasa de desempleo. Para ello, estimamos un modelo de ecuaciones múltiples compuesto por una ecuación de demanda de trabajo, una de oferta de trabajo, y una ecuación de salarios reales. Nuestros resultados arrojan luz sobre los determinantes de la demanda, la oferta y el precio del trabajo. Encontramos que tanto la demanda como la oferta de trabajo reaccionan positivamente al PIB y negativamente a los salarios, pero la oferta lo hace con menor intensidad que la demanda respecto a ambas variables. Basándonos en simulaciones de shocks, analizamos cómo las variaciones del PIB impactan en el desempleo y encontramos que el efecto no es tan grande como el que presentaban investigaciones anteriores. Este resultado sugiere que la estimación del coeficiente de Okun que surge de un modelo uniecuacional con sólo al desempleo y al PIB como variables, sufre del sesgo de variables omitidas, ya que recoge parte de los efectos de otras variables que inciden sobre la demanda o la oferta de trabajo.

Palabras clave: ley de Okun, modelo de ecuaciones múltiples, desempleo, producto, ARDL.

Código JEL: C30, E23, E24, E27, J21, J23, J31, J51, J64

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Abstract

The objective of this research is to overcome the limitations of conventional Okun's coefficient estimations, highlighting the indirect nature of the effect of the GDP over the unemployment rate. To do so, we estimate a multiple equation model composed by a labour demand, a labour supply and a real wages equation. Our results shed light on the determinants of the demand, the supply and wages. We found that both labour demand and supply react positively to GDP and negatively to wages, but the supply side with lower intensity than demand with respect to both variables. Based on simulations of shocks, we analysed how the variations of the GDP impact on unemployment and found that the effect is not as large as previous research have presented. This result suggests that the estimation of Okun's coefficient arising from a single equation model with only unemployment and GDP as variables suffers from the omitted variables bias, as it captures part of the effects of other variables that affect labour demand and/or labour supply.

Keywords: Okun's law, multiple equation model, unemployment, output, ARDL.

JEL Classification: C30, E23, E24, E27, J21, J23, J31, J51, J64

1 Introduction

The relationship between output and unemployment, broadly known as Okun's law, is a statistically significant empirical relationship. However, it lacks any theoretical foundation that relates those two variables. The effect of economic growth over unemployment is non-direct, and the latter is a variable that summarises how labour supply and demand are performing in the labour market.

Conversely, the positive relationship between output and labour demand is theoretically well founded. Average labour productivity, average working time, and the production technology are variables that affect this relationship. Consequently, they do also affect Okun's relationship, as it was pointed by the author in his seminal work (Okun, 1962) .

With regard to labour supply, economic activity may affect it or not. Since there are two opposite effects, positive and negative, the net effect is *a priori* unknown. If economic growth induces wages to rise, and the substitution effect dominates in the individuals' preferences, then labour supply should increase. On the contrary, if the income effect prevails, labour supply should fall. Nevertheless, even without wage increase, two effects may still operate: the discouraged worker effect (pro-cyclical) and the added worker effect (anticyclical labour supply).

Another important variable in this analysis is the price of labour. How does economic growth affect wages? How do labour supply and demand react to these changes? Which will be the net effect over unemployment?

Okun's coefficient estimation, when only economic growth and unemployment are considered, summarises all the aforementioned effects (Ismihan, 2010), and to recognise each of them is of utmost importance in terms of economic policy. It is worth noting that the effect of an economic growth stimulating policy is not the same if it is accompanied by a per worker labour productivity increase or if the discouraged worker effect predominates. In the first case, economic growth enhances labour demand so that the net effect over unemployment depends on the magnitude of the average labour productivity increase. In the second case, the discouraged worker effect means that labour supply is procyclical. Hence, economic growth goes together with an increase in the supply of labour, resulting in an upward pressure on unemployment.

According to Ismihan (2010), structural changes in labour supply and demand relations, which indirectly affect the output-unemployment correlation, may lead to substantial variations of Okun's law over time. Because of this, he concludes that a more general framework which incorporates the role of demand-side and supply-side factors on unemployment is needed. In his work, he incorporates some of these aspects to the analysis. Sogner and Stiassny (2002) in their cross-country study also note certain instability in Okun's coefficients for a number of countries, so they discuss if it responds to demand-side or supply-side factors.

Additionally, it is important to bear in mind that there are other factors apart from economic growth, such as the price of other productive factors, migration, or institutional features, that do also affect the supply of and demand for labour. Hence, they also have an impact on unemployment, and omitting them could bias the estimations.

For the Uruguayan economy, Merlo and Porras-Arena (2019) find empirical evidence for Okun's relationship. Their main findings can be summarised in the following three points: (i) Okun's law is valid for Uruguay, (ii) Okun's coefficient is around -0,27, what means that for every 1% of annual GDP growth over its natural value, the unemployment rate fells by 0,27 p.p., and (iii) the non-stability hypothesis for this coefficient is rejected. Further research have arrived at similar results (Tapie et al., 2020; Porras-Arena and Martín-Román, 2021). It is particularly useful to highlight the results achieved by Tapie et al. (2020) who also estimated Okun's coefficient but using quarterly data. As long as the frequency is the same used in this study, our results are comparable. In their paper, Okun's coefficient calculated in either its difference or gap version is around -0,06. The magnitude of the effect is relatively low, compared to most developed countries and some Latin-American economies (Ball et al., 2019; Porras-Arena and Martín-Román, 2021). Thus, estimating the output-unemployment relation from a multiequational approach would allow a better understanding of the channels through which the output impacts on unemployment, providing valuable information for policy-making. Moreover, the Uruguayan labour market has undergone major transformations during the last decades. There has been a steady growth of the labour force led by female participation, more pronounced in the interior of the country since the late 1992. In this respect, there is empirical evidence that supports the added worker hypothesis at least for female participation (Espino et al., 2011). Besides, wages have experienced significant changes, particularly since Wage Councils were reinstated. It may be added that another important change in the Uruguayan labour market is the recent wave of immigration.

2 Theoretical Background

In 1962, Arthur Okun first documented the negative correlation between the economic output and unemployment. Since then, the empirical regularity found by Okun (1962) for the United States has been widely confirmed across different countries and time periods. For that reason, this short-run macroeconomic relationship became known as Okun's law.

From the three ways Okun (1962) proposed to estimate this relationship, the two most widely used are the difference and the gap versions. The difference version (equation (1)), measures the contemporaneous relationship between economic growth (Δy_t) and changes in the unemployment rate (Δu_t). The gap version (equation (2)), captures the relationship between de deviations of the GDP and the unemployment rate from their natural or potential levels ($y_t - y_t^*$ and $u_t - u_t^*$, respectively). In both cases the unemployment rate is the dependent variable (either differenced or in gaps), and the independent variable is the GDP (either differenced or in gaps). The coefficient estimated is frequently referred as Okun's coefficient and it differs among economies (Ball et al., 2019, 2017).

$$\Delta u_t = \alpha + \beta \Delta y_t + \epsilon_t \tag{1}$$

$$u_t - u_t^* = \alpha + \beta(y_t - y_t^*) + \epsilon_t \tag{2}$$

Unemployment is a summary variable for the labour market, thus, the effect of economic growth over unemployment takes place through its impacts on labour demand, labour supply and real wages. But these three variables are not only affected by economic growth. Then, estimating Okun's equations with economic growth as the single explanatory variable means incurring in an omitted variable bias. For that reason, we propose, as a starting point, to estimate a labour demand equation, a labour supply equation and a real wages equation. By so doing, we can identify the variables that have an impact on unemployment and also know what effects are contained in Okun's coefficient when estimated in a single equation with economic growth as the only independent variable.

The labour market can be modelled in a simple way using a multiple equation approach similar to the one of Karanassou and Snower (2000). Our model has got the following equations:

$$emp_t = c_e + \alpha_1 arw_t + \alpha_2 gdp_t + \epsilon_{e,t} \tag{3}$$

$$act_t = c_a + \beta_1 arw_t + \beta_2 gdp_t + \beta_3 wap_t + \epsilon_{a,t} \tag{4}$$

$$arw_t = c_w + \gamma_1 pn_t + \gamma_2 gdp_t + \epsilon_{w,t} \tag{5}$$

$$unem_t \cong act_t - emp_t \tag{6}$$

where all the variables are expressed in logarithms, except for $unem_t$ that represents the unemployment rate. On that account, the coefficients' estimations can be interpreted as short-run elasticities. Additionally, c_i and $\epsilon_{i,t}$ with $i = emp, act, arw$, are the constant and error term of each equation respectively.

Labour demand is represented by equation (3). Our dependent variable in this case is the number of workers (emp_t), while the independent variables are real wages (arw_t) and the gross domestic product (gdp_t). This functional form, arises from the costs' minimisation problem for a final goods and services demand, in the context of a CES technology (Hamermesh, 1993). As a result, we expect the sign of the effect of real wages to be negative, and the sign of the effect of the GDP, positive. The first one, because an increase in wages expands the firm's costs and, by reason of the law of demand, the quantity demanded decreases. In effect, the coefficient α_1 measures the elasticity of employment with respect to labour costs, or in other words, it represents the capital-labour substitution elasticity. The second one, because to produce a higher level of output for a certain level of real wages, it is necessary to increase the input, this is to say, the amount of labour employed in the production. Thus, α_2 represents the employment-GDP elasticity. In the case of an homogeneous production function of degree 1, $\alpha_2 = 1$.

Labour supply is given by equation (4). In this case, our explained variable (act_t) is the labour force. The explanatory variables are the real wages (arw_t), the gross domestic product (gdp_t), and the working age population (wap_t). The sign of β_1 is ambiguous, because an increase in real wages may result on either an expansion or a contraction on labour supply, as it is subject to two opposite effects: income effect and substitution effect. If the income effect dominates, we should find that β_1 is negative. On the contrary, if the substitution effect dominates, we should find that β_1 is positive. Similarly, *ex ante* we cannot determine the sign of β_2 as there are two opposite possible outcomes, depending on whether the dominant effect is the discouraged worker or the added worker effect. When the GDP falls, if most people react giving up their job search because they feel discouraged due to the lack of opportunities, the discouraged worker effect operates and β_2 is positive (labour supply is procyclical). If instead most people react entering to the labour market in order to compensate their income reduction, the added worker effect operates and β_2 is negative (labour supply is countercyclical). Finally, the sign of β_3 is positive because the working age population can be seen as the stock of people potentially active.

Real wages are represented by equation (5). Average real wages in the economy (arw_t) are a function of labour productivity (pn_t), and the gross domestic product (gdp_t). Following classical microeconomic theory, improvements in the productivity of labour should result in a higher remuneration to the factor ($\gamma_1 > 0$). Periods of economic growth should also have a positive effect on wages, because during expansion periods wage increases are more likely to happen ($\gamma_2 > 0$).

Our final equation (6) has the unemployment rate ($unem_t$) on the left-hand side. It is computed as the logarithmic difference between the active population and the occupied population. Hence, it approximates to the unemployment rate.

To summarise, what used to be a uniequational estimation of a coefficient that directly relates unemployment and GDP (Okun's law), is now a system of equations that improves our knowledge about how the GDP affects the unemployment rate. Figure (1) graphically describes how the GDP affects labour demand, labour supply and the wages paid in an economy, that together determine the unemployment rate.

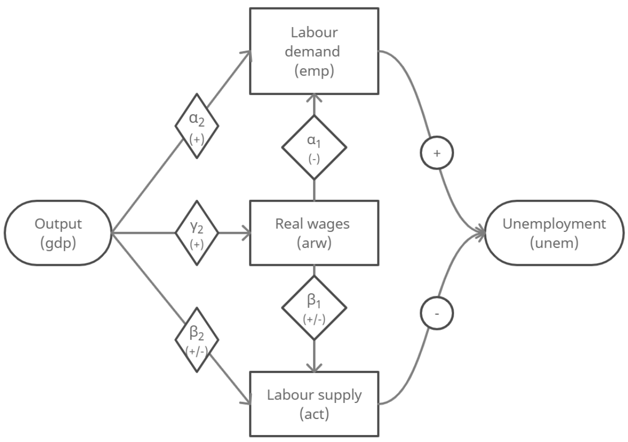

Figure 1: GDP-Unemployment diagram

From equation (6), we can get the unemployment rate variation which depends on the labour supply growth with respect to the labour demand growth:

$$unem_t - unem_{t-1} \cong (act_t - emp_t) - (act_{t-1} - emp_{t-1})$$

$$\Delta unem_t \cong (act_t - act_{t-1}) + (emp_t - emp_{t-1}) \tag{7}$$

If we define $g_{x,t} = lnX_t - lnX_{t-1} = x_t - x_{t-1}$, we can rewrite equation (7) in the following way:

$$\Delta unem_t = g_{act,t} - g_{emp,t} \tag{8}$$

From equation (3), we can also operate and get the next result:

$$g_{emp,t} = emp_t - emp_{t-1}$$

$$g_{emp,t} = (c_e + \alpha_1 arw_t + \alpha_2 gdp_t + \epsilon_{emp,t}) - (c_e + \alpha_1 arw_{t-1} + \alpha_2 gdp_{t-1} + \epsilon_{emp,t-1}) \tag{9}$$

If we assume that $\epsilon_{emp,t} = \epsilon_{emp,t-1}$, equation (9), is:

$$g_{emp,t} = \alpha_1(arw_t - arw_{t-1}) + \alpha_2(gdp_t - gdp_{t-1})$$

$$g_{emp,t} = \alpha_1 g_{arw,t} + \alpha_2 g_{gdp,t} \tag{10}$$

In a similar way, we can get the following expressions from equations (4) and (5).

$$g_{act,t} = \beta_1 g_{arw,t} + \beta_2 g_{gdp,t} + \beta_3 g_{wap,t} \tag{11}$$

$$g_{arw,t} = \gamma_1 g_{pn,t} + \gamma_2 g_{gdp,t} \tag{12}$$

Substituting (12) in (10), we get:

$$g_{emp,t} = \alpha_1(\gamma_1 g_{pn,t} + \gamma_2 g_{gdp,t}) + \alpha_2 g_{gdp,t}$$

$$g_{emp,t} = (\alpha_1\gamma_1)g_{pn,t} + (\alpha_2 + \alpha_1\gamma_2)g_{gdp,t} \tag{13}$$

Similarly, substituting (12) in (11), we get:

$$g_{act,t} = \beta_1(\gamma_1 g_{pn,t} + \gamma_2 g_{gdp,t}) + \beta_2 g_{gdp,t} + \beta_3 g_{wap,t}$$

$$g_{act,t} = (\beta_1\gamma_1)g_{pn,t} + (\beta_1\gamma_2 + \beta_2)g_{gdp,t} + \beta_3 g_{wap,t} \tag{14}$$

If we now substitute (13) and (14) in (8) we obtain an equation that relates the variation in the unemployment rate with economic growth:

$$\Delta unemp_t \cong [(\beta_1\gamma_1)g_{pn,t} + (\beta_1\gamma_2 + \beta_2)g_{gdp,t} + \beta_3 g_{wap,t}] - [(\alpha_1\gamma_1)g_{pn,t} + (\alpha_2 + \alpha_1\gamma_2)g_{gdp,t}]$$

$$\Delta unemp_t = (\gamma_1\beta_1 - \gamma_1\alpha_1)g_{pn,t} + (-\alpha_2 + \beta_2 - \gamma_2\alpha_1 + \gamma_2\beta_1)g_{gdp,t} + \beta_3 g_{wap,t}$$

$$\Delta unemp_t = \theta_1 g_{pn,t} + \theta_2 g_{gdp,t} + \theta_3 g_{wap,t} \tag{15}$$

Therefore, we obtain an expression for Okun's law that includes two more variables in addition to economic growth. In this formulation (15), θ_2 would be the Okun's coefficient, which includes the following effects:

$$\theta_2 = -\alpha_2 + \beta_2 - \gamma_2\alpha_1 + \gamma_2\beta_1 \tag{16}$$

As shown in (16), Okun's coefficient summarises multiple effects, with even opposite sign.

In conclusion, estimating Okun's relation only taking into account the output and unemployment may be causing some problems. On the one hand, the coefficient may be overestimating the relation if it includes the effect of omitted explanatory variables. On the other hand, the coefficient summarises a complex system of interactions and relations among labour market variables which are necessary to understand in order to identify the channels through which the output affects unemployment.

3 Empirical strategy

3.1 Econometric approach

For the purpose of generating our model, we first estimate each equation individually and, in a second stage, we estimate it as a system. Our estimation follows the autoregressive distributed lag (ARDL) modelling approach to cointegration proposed by Pesaran and Shin (1995), and Pesaran et al. (1996, 2001). Following this strategy presents two clear advantages over other alternatives. In the first place, the ARDL approach allows using I(0) and I(1) series, what avoids dealing with the pre-testing problems for cointegration. Secondly, the results obtained can be given a straight economic interpretation following the statistical significance criteria in every estimation.

The first step is then to know the integration order of the series. If they are I(0) or I(1) they can be used without differencing or carrying out any other transformation. To this end, we performed ADF and KPSS tests for each variable. Far from being alternative options, the two tests complement each other providing useful information to better characterise the series.

The second step consists on estimating equations (3) to (5) as an ARDL(q, q). Since we use quarterly data, per every equation we estimated four specifications with $q = 1, 2, 3, 4$. Subsequently, we estimated:

$$emp_t = c_e + \sum_{i=1}^{q} \alpha_{1i} emp_{t-i} + \sum_{i=0}^{q} \alpha_{2i} arw_{t-i} + \sum_{i=0}^{q} \alpha_{3i} gdp_{t-i} + \epsilon_{e,t} \tag{17}$$

$$act_t = c_a + \sum_{i=1}^{q} \beta_{1i} act_{t-i} + \sum_{i=0}^{q} \beta_{2i} arw_{t-i} + \sum_{i=0}^{q} \beta_{3i} gdp_{t-i} + \sum_{i=0}^{q} \beta_{4i} wap_{t-i} + \epsilon_{a,t} \tag{18}$$

$$arw_t = c_w + \sum_{i=1}^{q} \gamma_{1i} arw_{t-i} + \sum_{i=0}^{q} \gamma_{2i} pn_{t-i} + \sum_{i=0}^{q} \gamma_{3i} gdp_{t-i} + \sum_{i=0}^{q} \gamma_{4i} union_{t-i} + \epsilon_{w,t} \tag{19}$$

Regarding equation (19), we included the unionisation rate ($union_t$) as an explanatory variable, given two features of wage negotiation in Uruguay: (i) it has been bipartite between employers and unions (and tripartite since 2005) and (ii) collective agreements apply for all members and non-members of the unions. Furthermore, we estimated two additional specifications. One including the dummy variable wc_t accounting for the Wage Councils, and the other one including $inst_t$ accounting for the new institutional framework of the Uruguayan labour market.

$$arw_t = c_w + \sum_{i=1}^{q} \gamma_{1i} arw_{t-i} + \sum_{i=0}^{q} \gamma_{2i} pn_{t-i} + \sum_{i=0}^{q} \gamma_{3i} gdp_{t-i} + \sum_{i=0}^{q} \gamma_{4i} union_{t-i} + \gamma_5 wc_t + \epsilon_{w,t} \tag{20}$$

$$arw_t = c_w + \sum_{i=1}^{q} \gamma_{1i} arw_{t-i} + \sum_{i=0}^{q} \gamma_{2i} pn_{t-i} + \sum_{i=0}^{q} \gamma_{3i} gdp_{t-i} + \sum_{i=0}^{q} \gamma_{4i} union_{t-i} + \gamma_5 inst_t + \epsilon_{w,t} \tag{21}$$

The third step is to evaluate cointegration by using the bounds tests proposed by the authors. In this respect, we look at the F-statistic for the ARDL bounds test with the null hypothesis indicating no long-run relationship, and we also look at the t-statistic of the lagged dependent variable first-difference. Along with the cointegration tests, we control the behaviour of the residuals. They should be well-behaved, this implies that they should be: (i) homoscedastic, (ii) non-autocorrelated, and (iii) normally distributed. To evaluate homoscedasticity, we used the Breusch-Pagan-Godfrey and White tests. To assess serial correlation the Breusch-Godfrey LM test was applied for one and four lags. Finally, normality was tested with the Jarque-Bera statistic.

Interventions were added in atypical observations as additive outliers (AO), level shifts (LS) or transitory changes (TC). In each case we decided the type of outlier according to the criteria of the highest AIC and BIC. Besides, they were included progressively from the most deviated residuals to the least until the residuals became well-behaved. A complete list of the interventions is provided in table (A4). The insertion of seasonal variables was also evaluated using two tests: the HEGY test to evaluate the existence of seasonal unit roots and the Canova-Hansen test to assess the stability of the seasonal pattern (Hylleberg et al., 1990; Canova and Hansen, 1995; Rodríguez and Massa, 2012).

From the equations that satisfied all the requisites (cointegration and well-behaved residuals) the statistically insignificant variables were removed in order from the higher to the lower p-value.

Finally, we selected one specification for every equation. For doing so, all variables included should be statistically significant and in case of being more than one candidate, we followed the rule of the highest information criteria. With these four equations we built an equation system. Being ordinary-least-squares (OLS) estimation subject to criticism, due to the probable endogeneity or correlation with the residuals caused by the inclusion of the dependent lagged variable, we also performed two-stage (2SLS) and three-stage least-squares (3SLS) estimations [1].

The last step consists in generating a model to forecast unemployment and the other endogenous variables. The model incorporates the equations estimated in the system and the interrelationships among variables that emerge from it. Bearing those results, the model was solved statically and dynamically. Ultimately, different scenarios are generated in order to simulate how different shocks would affect unemployment. Particularly, we focus on how changes in the GDP affect unemployment, not directly (as suggested by Okun's law) but considering the indirect effect throughout the multiple variables that operate in the labour market instead.

3.2 Data

For this research we use quarterly time series from 1986Q1 to 2019Q4. The raw data comes from three main sources. First, the National Statistics Institute (INE, by its Spanish acronym), which provides the information related to the labour market. The employment, unemployment and participation rates, as well as the average real wage index and the number of hours worked, are all provided by the INE. It must be noticed that for the employment, unemployment and participation rates we only consider the urban rates, i.e. for towns over 5.000 inhabitants, as it is the data available for the entire period. Besides, from the INE's projections we got the working age population. Second, the Uruguayan Central Bank (BCU) from where the GDP series were obtained. In this paper, we use the physical volume index (2005=100). Finally, the Cuesta Duarte Institute [2] that supplies information on the number of congressmen who attended the national trade union centre (PIT-CNT) congresses.

From these data we used the following series in our empirical analysis.

1. For the labour market: the number of employed (emp_t) and people in the labour force (act_t), and the average real wage index (arw_t). The first two variables were constructed as the product of the working age population (as forecasted by the INE) multiplied by the employment or participation rate in each case. The three variables are in logarithm.

2. For the output: the logarithm of the physical volume index of the GDP (gdp_t).

3. Productivity (pn_t) is measured as the apparent productivity of labour. It is the quotient of the GDP and an index of hours worked. The latter is defined as an index (2005=100) of the average number of hours worked by individual multiplied by the total number of workers (emp_t).

4. For the unionisation level we generated a unionisation rate ($union_t$) as the ratio between the number of the unionised workers and the number of salaried employees. The numerator is the result of multiplying the number of congressmen by 200, because each congressmen represents 200 union members. Given that the last PIT-CNT congress was held on 2018, we forecasted

[1] Instrumental variables: emp_{t-1}, act_{t-1}, arw_{t-1}, gdp_t, gdp_{t-1}, gdp_{t-2}, $cwap_{t-1}$, $cwap_{t-2}$, $union_t$, $union_{t-1}$ and the interventions and seasonal variables

[2] The Cuesta Duarte Institute (Instituto Cuesta Duarte in Spanish) is a research institute that belongs to the PIT-CNT

this variable using an autoregressive model. The denominator is equal to the product of the employment rate for salaried employees multiplied by the working age population [3].

5. For the working age population (wap_t) we used the logarithmic transformation of the series.

6. Finally, we generated two binary variables which define the political and institutional context. The first one, wc_t is a dummy variable that takes the value 1 for all the periods in which the Wage Councils were regularly convened. The other one, $inst_t$, is a dummy variable that takes the value 1 from 2005 onwards, as it represents the new institutional and legal framework in the labour relations.

4 Results

4.1 Single equation estimation

After carrying out the ADF and KPSS tests, we found that all the series were either integrated of order 0 or 1 such as that no further transformations were required (see tables A1 and A2). The only exception was the working age population (wap_t), as it was I(1) but trend-stationary. In order to subtract the trend component, we applied a Hodrick-Prescott filter with a λ multiplier of 1600, from where we got the cycle component which we renamed $cwap_t$. The smoothing parameter is the standard value presented by Hodrick and Prescott (1997) and followed by Ravn and Uhlig (2002) [4].

With the I(0) and I(1) series we were able to estimate the ARDL models for each equation following the Pesaran et al. (1996, 2001) strategy to prove cointegration. The cointegration and residuals tests can be found on table (A3) of the Appendix. After the intervention analysis and once the insignificant regressors where removed, we arrived at the following equations.

4.1.1 Demand

Labour demand depends positively of its lag and the GDP, while it depends negatively of the lagged real wages paid in the market. These results are consistent with our theoretical background and previous literature.

The final functional form of the regression is:

$$emp_t = c_e + \alpha_1 emp_{t-1} + \alpha_2 arw_{t-1} + \alpha_3 gdp_t + \Phi_e D_{e,t} + \epsilon_{e,t} \tag{22}$$

where $D_{e,t}$ represents the interventions. The coefficient estimations are summarised in table (1).

The value of $\hat{\alpha_1} = 0,7891$, indicates the existence of inertia and is in line with previous studies (Leites and Porras-Arena, 2016). This phenomenon can be associated with the presence of hiring and dismissing costs, that make adjustments costly for firms. As reported by our estimation, the employment-wage elasticity is 0,26. It means that an increase of 1% in real wages, decreases in 0,26% [-0,0549/(1-0,7891)] the demand for labour. This result is slightly higher than the one obtained by Melognio and Porras-Arena (2013). The elasticity of labour demand relative to GDP was estimated at 0,52 [0,1086/(1-0,7891)]. Our estimation is consistent with other research studies, such as Amarante (2000) and Melognio and Porras-Arena (2013).

4.1.2 Supply

In the case of the labour supply, we found that it has a functional form that depends positively on its lagged value, the GDP and the working age population, and negatively on wages. The final regression equation is:

$$act_t = c_a + \beta_1 act_{t-1} + \beta_2 arw_t + \beta_3 gdp_t + \beta_4 gdp_{t-1} + \beta_5 cwap_{t-1} + \Phi_a D_{a,t} + \epsilon_{a,t} \tag{23}$$

[3] The series was compared to the one that arises from the Continuous Household Survey (ECH by its Spanish acronym) for 2007 and 2008 when this information was available. Although the level was not the same, the trend followed a similar pattern

[4] A Hamilton filter was also used with unsuccesful results

Table 1: Coefficients estimations

	Single equation	Multiple equation	
	OLS	**2SLS**	**3SLS**
	Labour demand		
emp_{t-1}	0,7891***	0,7892***	0,8037***
	(0,0322)	(0,0323)	(0,0271)
arw_{t-1}	-0,0549***	-0,0553***	-0,0528***
	(0,0133)	(0,0134)	(0,0125)
gdp_t	0,1086***	0,1090***	0,1029***
	(0,0154)	(0,0154)	(0,0133)
$c_{e,t}$	2,7032***	2,7018***	2,5162***
	(0,3872)	(0,3883)	(0,3280)
	Labor supply		
act_{t-1}	0,5829***	0,5837***	0,6852***
	(0,0549)	(0,0550)	(0,0426)
arw_t	-0,0442**	-0,0398**	-0,0510***
	(0,0174)	(0,0179)	(0,0150)
gdp_t	0,0823***	0,0822***	0,0553***
	(0,0193)	(0,0193)	(0,0158)
gdp_{t-1}	0,0762***	0,0731**	0,0752***
	(0,0237)	(0,0238)	(0,0168)
$cwap_{t-1}$	0,0177**	0,0175**	0,0171***
	(0,0088)	(0,0088)	(0,0063)
$c_{a,t}$	5,3360***	5,3185***	4,0621***
	(0,6955)	(0,6970)	(0,5414)
	Wages		
arw_{t-1}	0,6635***	0,6630***	0,6607***
	(0,0294)	(0,0295)	(0,0282)
gdp_t	0,2404***	0,2406***	0,2422***
	(0,0204)	(0,0205)	(0,0196)
$union_t$	0,3582 ***	0,3604***	0,3627***
	(0,0341)	(0,0349)	(0,0334)
$c_{w,t}$	0,4090***	0,4103***	0,4131***
	(0,0529)	(0,0532)	(0,0509)

Notes: Standard errors in parentheses.
*** Significant at the 1 percent level.
** Significant at the 5 percent level.
* Significant at the 10 percent level.

Labour supply inertia is also high, but not as much as in labour demand (0,5829). This coefficient is lower than the one estimated by Leites and Porras-Arena (2016). The negative sign of $\hat{\beta}_2$ yields an interesting result, income effect dominates the substitution effect, and by every 1% growth of real wages the supply of labour diminishes in 0,11% [-0,0442/(1-0,5829)]. When it comes to the GDP, the fact that both $\hat{\beta}_4$ and $\hat{\beta}_5$ are positive, as it can be seen in Table (1), indicates that the discouraged worker is the dominant effect for the Uruguayan labour market from a macroeconomic perspective. Namely, labour supply behaves prociclically. A 1% expansion in the GDP, results in a 0,38% [(0,0823+0,0762)/(1-0,5829)] increase of labour supply in the long-run. Finally, the cycle of the working age population ($cwap_t$) has a positive sign as expected and of a minor effect: a 1% positive deviation from its trend increases 0,04% [0,0177/(1-0,5829)]the supply of labour.

4.1.3 Wages

Finally, we reached equation (24) for average wages in which its lag and all the independent variables (gdp_t and $union_t$) have a positive effect. Contrary to the previous equations (22 and 23), in this case, the inclusion of seasonality was needed due to the presence of seasonal unit roots in the arw_t series (see table A5).

$$arw_t = c_w + \gamma_1 arw_{t-1} + \gamma_2 gdp_t + \gamma_3 union_t + \Phi_w D_{w,t} + \Gamma_w S_{w,t} + \epsilon_{w,t} \tag{24}$$

being $D_{w,t}$ the interventions and $S_{w,t}$ the seasonal dummies.

It is important to highlight the fact that the political-institutional variables wc_t and $inst_t$, where not significant and therefore, they were excluded from our analysis. Moreover, productivity (pn_t) was removed from the equations estimations because of probable multicollinearity with the GDP (gdp_t). It should be pointed out that, by construction, the apparent productivity includes the GDP, so the high correlation between the two variables is not surprising.

Wages show a relatively high inertia, with a $\hat{\gamma}_1 = 0,6635$. It is significantly higher than in the previous equation but not as high as for the labour demand. Moreover, this coefficient is lower than the one Leites and Porras-Arena (2016) estimate. Having wage inertia is reasonable in a context of staggered wage contracts. Compared to Leites and Porras-Arena (2016), our research considers a longer sample, that collects more information about the steady rise on wages experienced in the Uruguayan economy in a context of a new institutional framework since 2005. The GDP also has a positive effect and of important explanatory power. Notice that the average real wages elasticity relative to the GDP is 0,71 [0,2404/(1-0,6635)]. Lastly, an interesting finding of this estimation is the positive and relevant impact of unionisation on real wages. Our results suggest that a 1 p.p. rise in the unionisation rate increases real wages in 1,07% approximately [$(e^{0,003582} - 1) \times 100/(1 - 0,6635)$]. This is consistent with what Barth et al. (2020) found for Norway at a micro level, and is higher than the correlation estimated by Cassoni et al. (2002) for Uruguay in a sample from 1988 to 1995.

4.2 Multiple equation estimation and modelling

The aforementioned results are already highly informative about the dynamics of unemployment in Uruguay during the last decades. Nonetheless, better results are obtained by estimating the equations (22), (23), and (24) as a system by using 3SLS, and thus, improving the estimation efficiency.

By so doing, we arrive at the coefficients shown in column 3 of table (1). The only noticeable differences appear in the labour supply coefficients estimation. In particular, the dependent lagged variable has an estimated coefficient of 0,6852, that modifies all long-run elasticities. According to these results, a 1% increase in real wages reduces the supply of labour in 0,16% [-0,0510/(1-0,6852)] while a 1% expansion of the GDP rises labour supply in 0,42% [(0,0553+0,0752)/(1-0,6852)].

Furthermore, the signs of the effects remain the same and the coefficients of the other equations do barely change. The consistency of our results throughout the different methods and their coherence with the theoretical foundations, allow us to generate a model for unemployment based on our three equations (22), (23) and (24), and adding the identity (6). Within this framework, and

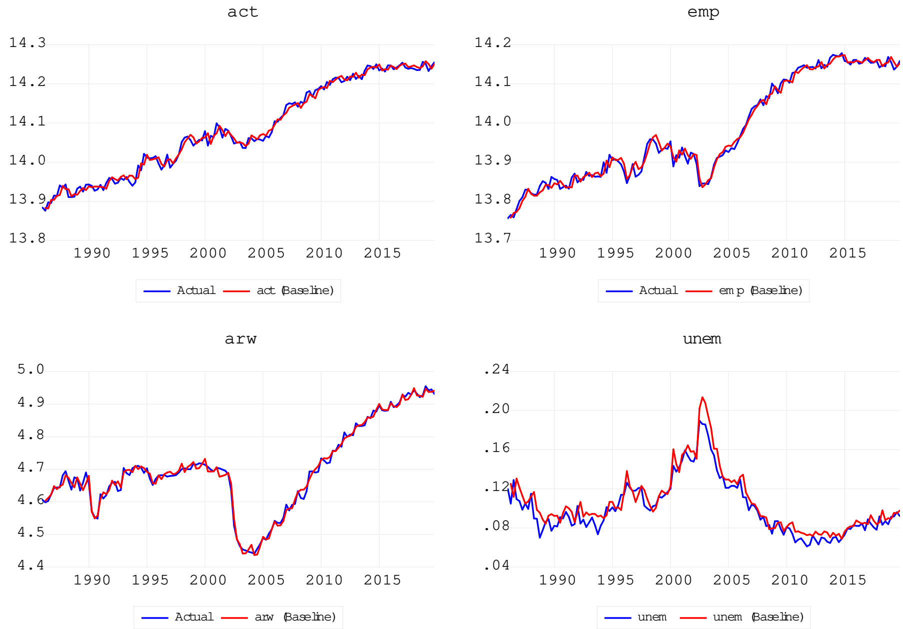

Figure 2: Endogenous labour market variables: actual and estimated values (Static model 3SLS)

using the coefficients estimated by 3SLS, we produced two models: a static model and a dynamic model.

The static solution for the model is depicted in figure (2), whereas the dynamic solution is portrayed in figure (3). From figure (2) it is notable that the model performs well as a one-step predictor. It shows no significant deviations from the actual values for any of the series. A slightly different pattern of results was obtained in the dynamic solution, in which the predicted values differ from the actual particularly between 1985 and 1995, and from 2010 to 2019. As it is visible in graph (3), the gap is mainly explained by the difference between the predicted and the actual values of employment. This difference between actual and estimated values is not surprising, because in such a long sample the model cannot capture unexpected changes or shocks that may occur.

4.3 Simulations

As we may note, apart from the output, the variables $cwap_t$ that accounts for the working age population and $union_t$ (unionisation rate), are also affecting unemployment. The former by its impact on the supply of labour, and the latter through its impact on the real wages which, in turn, has an effect on both the demand and the supply side of the labour market.

In this context, our main interest is to analyse the effect of economic growth on unemployment. As it can be seen in figure (A6), a transitory shock on the GDP affects the labour supply, the labour demand, and the wages paid in the economy. The magnitude of this effect is not only given by coefficients $\hat{\alpha_3}$, $\hat{\beta_4}$ and $\hat{\gamma_2}$, but also by the interactions between the equations. Specially, by wages as long as it is an explanatory variable for the labour demand and supply.

In consequence, as long as every variable in the labour market presents some inertia and their lags interact with each other, any shock over any of the variables should have an impact on unemployment beyond period t.

4.3.1 Exogenous positive shock in the GDP

According to our simulation, in which we generated a 1% increase of the GDP in t (*cæteris paribus*), the biggest negative effect on unemployment (-0,059 p.p.) takes place in the same period (t) due to the positive and contemporaneous impact on the demand, which is larger than the

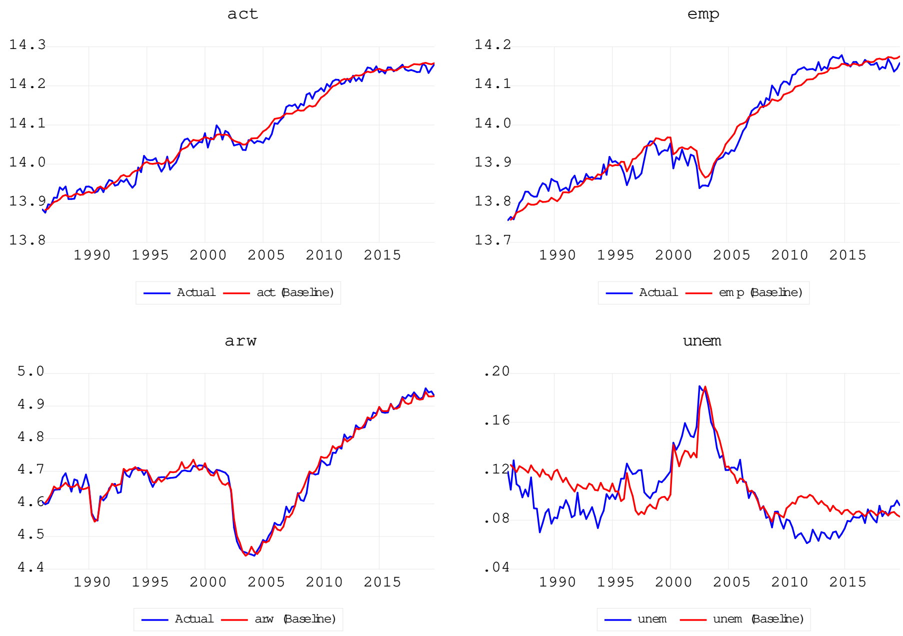

Figure 3: Endogenous labour market variables: actual and estimated values (Dynamic model 3SLS)

one on the labour supply (see figure(4)). However, in the following four periods, the effect on unemployment turns slightly positive since the labour force enlarges as it behaves prociclically. It must be underlined, that the net effect is overall negative as it can be seen on figure (5), and it stabilises in an unemployment contraction of 0,033 p.p.

These values are in line with previous results. The contemporaneous effect found in this research is the same obtained by Tapie et al. (2020) using quarterly data. Nevertheless, the main contribution of this empirical analysis is to show that when the different mechanisms that operate in the relationship between economic growth and unemployment are considered in the long term, the effect of an economic expansion on the unemployment rate is not as high as conventional contemporaneous Okun's coefficients suggest. This is particularly relevant given the fact that recent research using innovative econometric techniques have shown the existence of a long-run relationship between unemployment and GDP variations for a number of countries (Huang and Yeh, 2013; Gil-Alana et al., 2020).

The effect of the GDP on unemployment may be divided into the labour demand side, the labour supply side, and the real wages side by isolating the effect for each of these equations in our system. The graphical results are presented in (A7) - (A9). This further analysis confirms that an expansion of the output, when only labour demand is considered, has an entirely positive effect on employment, and thus, negative on unemployment. In contrast, if the shock affects the labour supply exclusively, then the effect on the unemployment is strictly positive. A third scheme, this time assuming that the effect operates through the labour demand and supply while wages remain the same, shows that the volatility of the response would be much higher. Finally, when we introduce the real wages the changes in the response function are ameliorated, indicating that price fluctuations reduce the volatility of changes in quantities.

4.3.2 Exogenous positive shock in the unionisation rate

Another major contribution of this paper is to incorporate trade unions to the analysis of unemployment for the Uruguayan case. In this sense, it is important to evaluate what effect does unionisation have on unemployment. To do so, we simulate a scenario in which the union rate increases 1 p.p.

Our study provides evidence that the unionisation does not affect significantly unemployment in the country. The effect is negligible (-0,00018 at its peak) as it can be seen in the figures (A10),

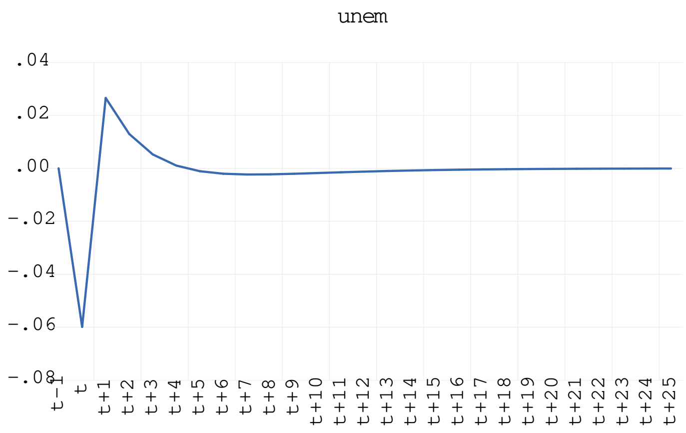

Figure 4: Unemployment response to a 1% increase of the GDP

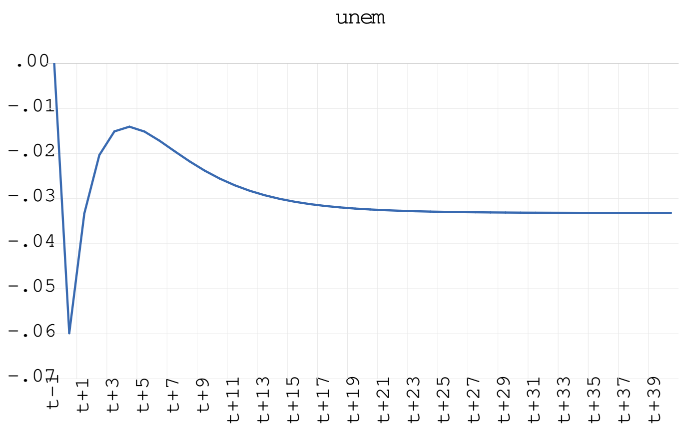

Figure 5: Unemployment cumulative response to a 1% increase of the GDP

(A11) and (A12) of the Appendix.

5 Conclusions

Our research provides a new perspective on the relationship between the GDP and unemployment that goes beyond the traditional framework of Okun's law. By estimating a multiple-equation model, we were able to identify how the GDP affects the labour demand, the labour supply and the real wages of the Uruguayan economy.

According to our estimations, the effect of GDP growth over the unemployment rate is negative, significant and lasts over various periods due to the lagged effect over the variables that determine it. Besides, it is smaller than when estimated as a contemporaneous correlation between the two. This result suggests that the estimation of Okun's coefficient arising from a one-equation model with only unemployment and GDP as variables suffers from the omitted-variable bias, as it captures part of the effects of other variables that affect labour demand and/or labour supply. It is important to outline the good performance of our model as one-step predictor of unemployment. The unionisation rate was found to have no significant effects on the unemployment rate.

Finally, our findings also open new areas of research. First, by replicating the analysis for different periods, countries and with alternative equation specifications. Second, it invites to explore the gap identified between the dynamic model and the actual values of the employment rate.

References

Amarante, V. (2000). La elasticidad producto-empleo de largo plazo en Uruguay. Documentos de Trabajo (working papers) 06-00, Instituto de Economia - IECON.

Ball, L., Furceri, D., Leigh, D., and Loungani, P. (2019). Does One Law Fit All? Cross-Country Evidence on Okun's Law. *Open Economies Review*, 30(5):841–874.

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

Barth, E., Bryson, A., and Dale-Olsen, H. (2020). Union Density Effects on Productivity and Wages. *Economic Journal*, 130(631):1898–1936.

Canova, F. and Hansen, B. (1995). Are seasonal patterns constant over time? a test for seasonal stability. *Journal of Business & Economic Statistics*, 13(3):237–252.

Cassoni, A., Labadie, G. J., and Fachola, G. (2002). The Economic Effects of Unions in Latin America: Their Impact on Wages and the Economic Performance of Firms in Uruguay. IDB Publications (Working Papers) 3283, Inter-American Development Bank.

Espino, A., Machado, A., and Alves, G. (2011). Estudio de las tendencias cuantitativas y cualitativas de la oferta laboral. Documentos de Trabajo (working papers) 11-06, Instituto de Economia - IECON.

Gil-Alana, L. A., Skare, M., and Buric, S. B. (2020). Testing okun's law. theoretical and empirical considerations using fractional integration. *Applied Economics*, 52(5):459–474.

Hamermesh, D. (1993). *Labor Demand*. Princeton University Press, Princeton.

Hodrick, R. J. and Prescott, E. C. (1997). Postwar U.S. Business Cycles: An Empirical Investigation. *Journal of Money, Credit and Banking*, 29(1):1–16.

Huang, H.-C. and Yeh, C.-C. (2013). Okun's law in panels of countries and states. *Applied Economics*, 45(2):191–199.

Hylleberg, S., Engle, R., Granger, C., and Yoo, B. S. (1990). Seasonal integration and cointegration. *Journal of Econometrics*, 44(1-2):215–238.

Ismihan, M. (2010). A New Framework for Output-Unemployment Relationship: Okun's Law Revisited. MPRA Paper 28135, University Library of Munich, Germany.

Karanassou, M. and Snower, D. J. (2000). Characteristics of Unemployment Dynamics: The Chain Reaction Approach. IZA Discussion Papers 127, Institute of Labor Economics (IZA).

Kwiatkowski, D., Phillips, P. C., Schmidt, P., and Shin, Y. (1992). Testing the null hypothesis of stationarity against the alternative of a unit root: How sure are we that economic time series have a unit root? *Journal of Econometrics*, 54(1):159–178.

Leites, M. and Porras-Arena, M. S. (2016). Unemployment dynamics in Uruguay: an analysis using chain reaction theory. *Revista CEPAL.*

MacKinnon, J. G. (1996). Numerical distribution functions for unit root and cointegration tests. *Journal of Applied Econometrics*, 11(6):601–618.

Melognio, E. and Porras-Arena, M. S. (2013). Elasticidad de la demanda de trabajo en Uruguay : 1986-2005. Documentos de Trabajo (working papers) 13-08, Instituto de Economia - IECON.

Merlo, G. and Porras-Arena, M. S. (2019). Crecimiento del PIB y desempleo: validez de la ley de Okun para Uruguay. Documentos de Trabajo IECON-FCEA, UdelaR 24/2019.

Okun, A. M. (1962). Potential GNP: its measurement and significance, Cowles Foundation Paper 190. *Cowles Foundation, Yale University, New Haven.*

Pesaran, M. and Shin, Y. (1995). An Autoregressive Distributed Lag Modelling Approach to Cointegration Analysis. Technical report.

Pesaran, M. H., Shin, Y., and Smith, R. J. (1996). Testing for the 'Existence of a Long-run Relationship'. Technical report.

Pesaran, M. H., Shin, Y., and Smith, R. J. (2001). Bounds testing approaches to the analysis of level relationships. *Journal of Applied Econometrics*, 16(3):289–326.

Porras-Arena, M. S. and Martín-Román, A. L. (2021). La relación entre el desempleo y el crecimiento económico en América Latina: Estimaciones de la ley de Okun por países. *Revista Internacional del Trabajo*, Accepted author manuscript.

Ravn, M. O. and Uhlig, H. (2002). On adjusting the Hodrick-Prescott filter for the frequency of observations. *The Review of Economics and Statistics*, 84(2):371–375.

Rodríguez, S. and Massa, F. (2012). Caracterización de la estacionalidad de los componentes del PBI uruguayo. Documentos de Trabajo (working papers) 12-04, Instituto de Estadística - IESTA.

Sogner, L. and Stiassny, A. (2002). An analysis on the structural stability of Okun's law–a cross-country study. *Applied Economics*, 34(14):1775–1787.

Tapie, P., Suárez-Cal, M., and Rodríguez, V. (2020). La relación de Okun en Uruguay: una revisión ante el shock del COVID-19. Documentos de Investigación Estudiantil 04-20, Instituto de Economia - IECON.

6 Appendix

6.1 Tables

Table A1: Unit root test: Augmented Dickey-Fuller

	ADF (t-statistic)		
	Const, trend	**Constant**	**None**
emp_t	-2,1931	-1,0756	1,9822
	(-3,4435)	(-2,8829)	(-1,9432)
Δemp_t	-13,2346***	-13,2743***	-12,9006***
	(-3,4437)	(-2,8831)	(-1,9432)
act_t	-3,6760**	-1,0287	2,8839
	(-3,4435)	(-2,8831)	(-1,9432)
Δact_t	-14,9639***	-14,9971***	-14,3243***
	(-3,4437)	(-2,8831)	(-1,9432)
arw_t	-2,4428	-1,4688	0,6177
	(-3,4448)	(-2,8838)	(-1,9433)
Δarw_t	-3,1402	-3,0443**	-2,9833***
	(-3,4450)	(-2,8839)	(-1,9433)
wap_t	-2,8763	-1,1379	1,8951
	(-3,4448)	(-2,8838)	(-1,9433)
Δwap_t	-2,2412	-2,0470	-0,7686
	(-3,4448)	(-2,8838)	(-1,9433)
$\Delta^2 wap_t$	-5,3622***	-5,3783***	-5,3897***
	(-3,4448)	(-2,8838)	(-1,9433)
$union_t$	-1,9017	-2,2552	-1,1632
	(-3,4450)	(-2,8847)	(-1,9434)
$\Delta union_t$	-10,3159***	-3,2611**	-3,2262***
	(-3,4453)	(-2,8847)	(-1,9434)
gdp_t	-2,5283	-0,6612	1,5545
	(-3,4456)	(-2,8843)	(-1,9434)
Δgdp_t	-2,6241	-2,6423*	-2,0857**
	(-3,4456)	(-2,8843)	(-1,9434)
pn_t	-1,6498	0,4112	-0,9751
	(-3,4456)	(-2,8843)	(-1,9434)
Δpn_t	-4,3096***	-4,2477***	-2,8944***
	(-3,4456)	(-2,8843)	(-1,9434)

Notes: Critical value at 5% level in parentheses. MacKinnon (1996) one-sided p-values:
*** Significant at the 1 percent level.
** Significant at the 5 percent level.
* Significant at the 10 percent level.

Table A2: Unit root test: Kwiatkowski-Phillips-Schmidt-Shin

	KPSS	
	Const, trend (I)	**Constant (II)**
emp_t	0,1656**	1,3423***
Δemp_t	0,0604	0,0716
act_t	0,0804	1,4345***
Δact_t	0,0403	0,0489
arw_t	0,2556***	0,6840**
Δarw_t	0,0842	0,1516
wap_t	0,1700**	1,4905***
Δwap_t	0,0924	0,2226
$union_t$	0,3292***	0,5863**
$\Delta union_t$	0,1307*	0,7698***
gdp_t	0,1690**	1,3589***
Δgdp_t	0,0676	0,0660
pn_t	0,1761**	1,3934***
Δpn_t	0,0648	0,0681

Notes: Kwiatkowski et al. (1992) asymptotic critical values:
1% level: 0,216 (I), 0,739 (II).
5% level: 0,146 (I), 0,463 (II).
10% level: 0,119 (I), 0,347 (II).

Table A3: Cointegration and residuals tests

	Labour demand		
	Information criteria	AIC	-5,7448
		BIC	-5.5511
Cointegration	F - test	statistic	9,6576
		signficance	***
	t - test	statistic	-4,6987
		signficance	***
Residuals	Serial correlation test	χ_2 (1) (p-value)	0,2715
		χ_2 (4) (p-value)	0,6368
		F(1) (p-value)	0.2899
		F(4) (p-value)	0,6736
	Normality	JB (p-value)	0,8561
	Heteroscedasticity	BPG (p-value)	0,3096
		White (p-value)	0,6707
	Labour supply		
	Information criteria	AIC	-5,9868
		BIC	-5,7716
Cointegration	F - test	statistic	11,5272
		signficance	***
	t - test	statistic	-7,1761
		signficance	***
Residuals	Serial correlation test	χ_2 (1) (p-value)	0,2063
		χ_2 (4) (p-value)	0,2408
		F(1) (p-value)	0,2254
		F(4) (p-value)	0,2809
	Normality	JB (p-value)	0,5040
	Heteroscedasticity	BPG (p-value)	0,3668
		White (p-value)	0,7412
	Wages		
	Information criteria	AIC	-5,8010
		BIC	-5,5212
Cointegration	F - test	statistic	34,7355
		signficance	**
	t - test	statistic	-10,9226
		signficance	***
Residuals	Serial correlation test	χ_2 (1) (p-value)	0,8021
		χ_2 (4) (p-value)	0,5572
		F(1) (p-value)	0,8128
		F(4) (p-value)	0,6131
	Normality	JB (p-value)	0,9471
	Heteroscedasticity	BPG (p-value)	0,2647
		White (p-value)	0,3386

Notes: Cointegration tests significance level taken from Pesaran et al. (2001).

Table A4: Time series intervention analysis

Date	**Type**	**p-value**	**AIC**	**BIC**	**Selected**
			emp_t		
2000Q2	AO	0,0001	-5,6349	-5,4843	*
	LS	0,6966	-5,4992	-5,3262	
	TC	0,0133	-5,5633	-5,4126	
1996Q2	AO	0,0070	-5,6777	-5,5055	*
	LS	0,1576	-5,6359	-5,4637	
	TC	0,0173	-5,6649	-5,4927	
2002Q3	AO	0,0019	-5,7393	-5,5457	
	LS	0,7143	-5,6639	-5,4702	
	TC	0,0013	-5,7448	-5,5511	*
			act_t		
1997Q1	AO	0,0024	-5,9271	-5,7334	*
	LS	0,7307	-5,8545	-5,6609	
	TC	0,0103	-5,9061	-5,7124	
2001Q1	AO	0,0069	-5,9710	-5,7558	
	LS	0,0023	-5,9868	-5,7716	*
	TC	0,0107	-5,9646	-5,7494	
			arw_t		
2002Q3	AO	0,0000	-5,0439	-4,8887	
	LS	0,0000	-5,3872	-5,2320	*
	TC	0,0000	-5,1363	-4,9811	
1990Q2	AO	0,0000	-5,5134	-5,3361	
	LS	0,1149	-5,3923	-5,2149	
	TC	0,0000	-5,5468	-5,3694	*
1993Q1	AO	0,0014	-5,6165	-5,4170	
	LS	0,6284	-5,5332	-5,3337	
	TC	0,0002	-5,6500	-5,4505	*
1999Q1	AO	0,4935	-5,6385	-5,4168	
	LS	0,1210	-5,6548	-5,4331	
	TC	0,0002	-5,7512	-5,5295	*

Table A5: Seasonality tests

	HEGY test statistic		
Frequency	emp_t	act_t	arw_t
0	-1,7637	-3,1238*	-1,8986
	(-3,34)	(-3,34)	(-3,34)
$\frac{2\pi}{4}$ and $\frac{6\pi}{4}$	67,5234***	5,6070*	3,9181*
	(8,15)	(8,15)	(8,15)
π	-5,4416***	-3,7910***	-1,1089
	(-1,92)	(-1,92)	(-1,92)
All seasonal freq.	96,5254***	8,8678**	3,0052*
	(5,89)	(5,87)	(5,88)
All frequencies	72,9594***	9,8981**	3,1710
	(5,90)	(5,85)	(5,88)
	Canova-Hansen		
LM statistic	emp_t	act_t	arw_t
Joint	0,1688	0,1986	1,1473**
	(1,01)	(1,01)	(1,01)
Season 2	0,0845	0,0620	0,1535
	(0,47)	(0,47)	(0,47)
Season 3	0,0592	0,0854	0,2291
	(0,47)	(0,47)	(0,47)
Season 4	0,0340	0,0680	0,5819**
	(0,47)	(0,47)	(0,47)

Notes: Critical value at 5% level in parentheses.
*** Significant at the 1 percent level.
** Significant at the 5 percent level.
* Significant at the 10 percent level.

6.2 Figures

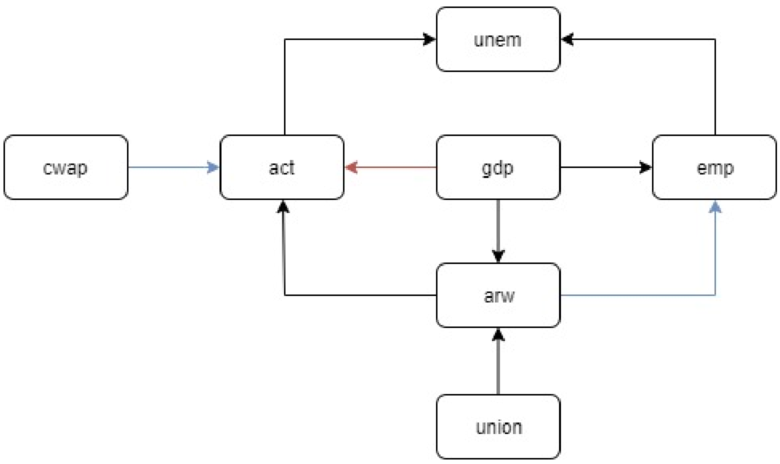

Figure A6: Dependency graph. The colour of the arrows indicate: (i) black: contemporaneous, (ii) red: lagged and contemporaneous (iii) blue: lagged

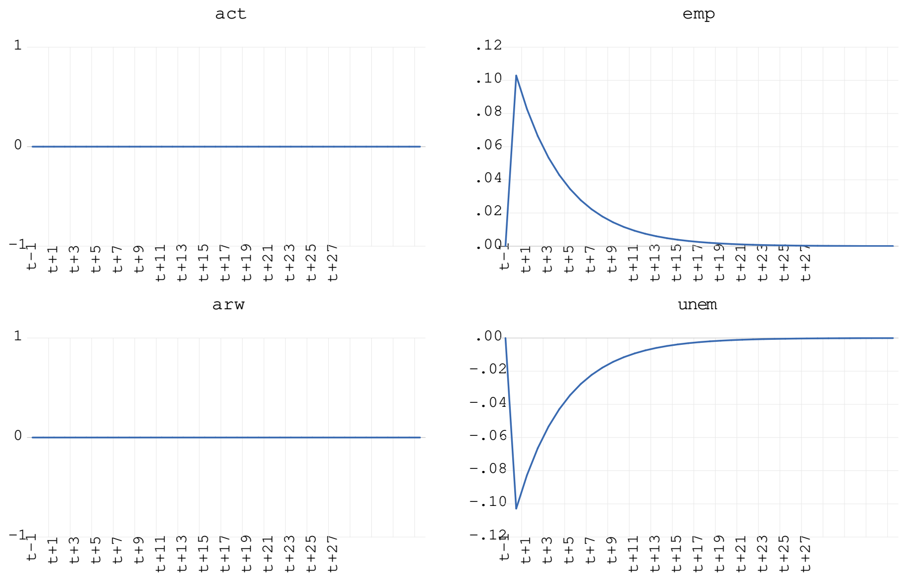

Figure A7: Labour demand side shock

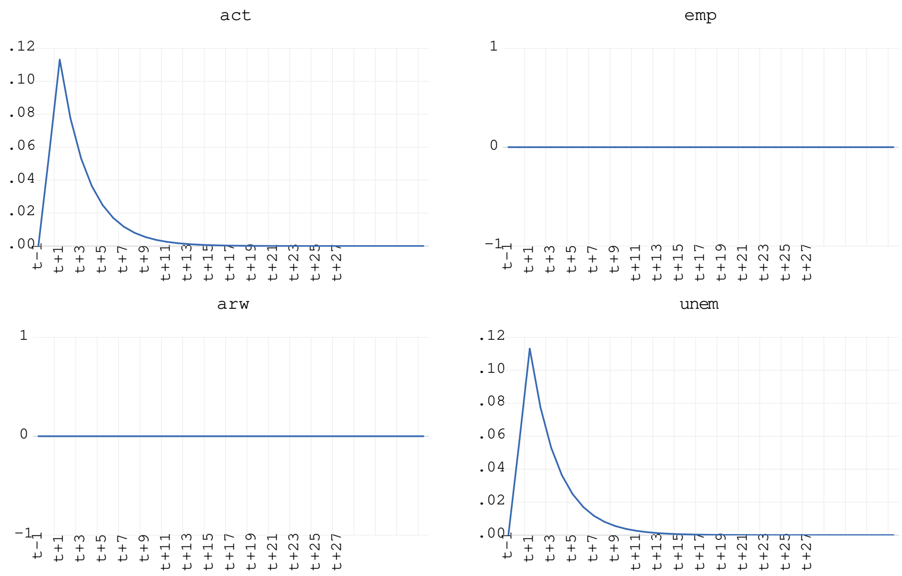

Figure A8: Labour supply side shock

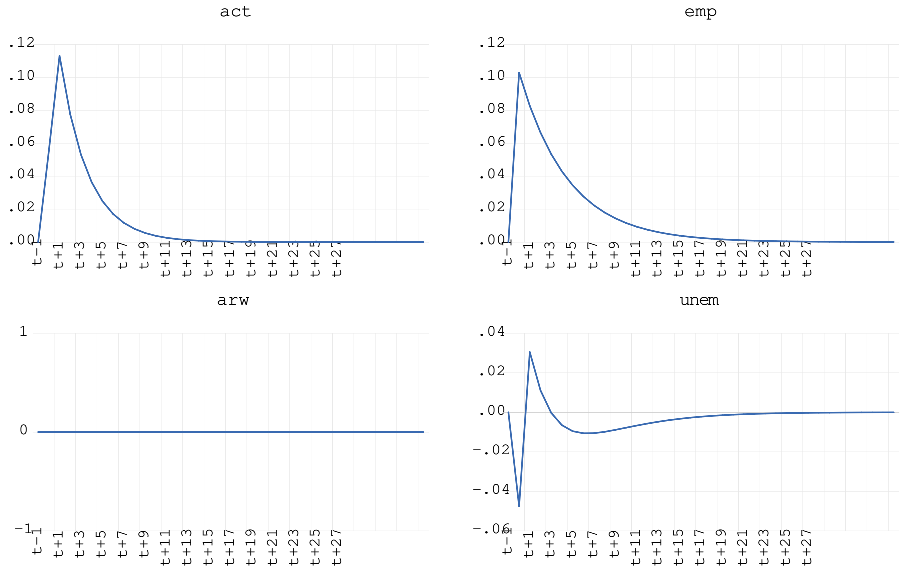

Figure A9: Labour demand and supply side shock

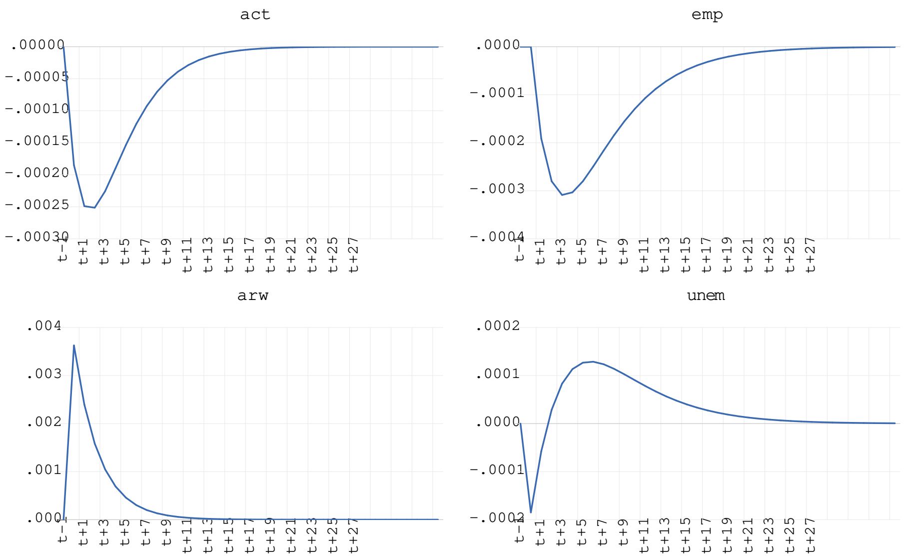

Figure A10: Endogenous variables responses to a 1 p.p. increase of the unionisation rate

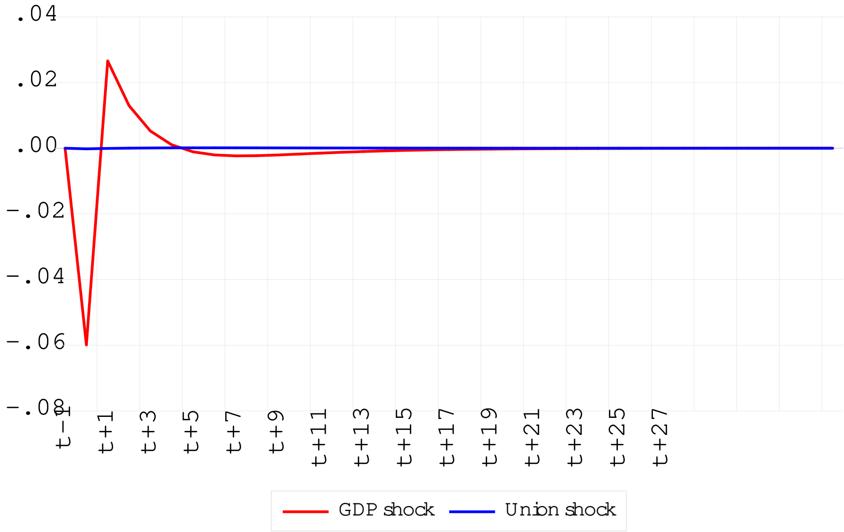

Figure A11: Unemployment response to different shocks

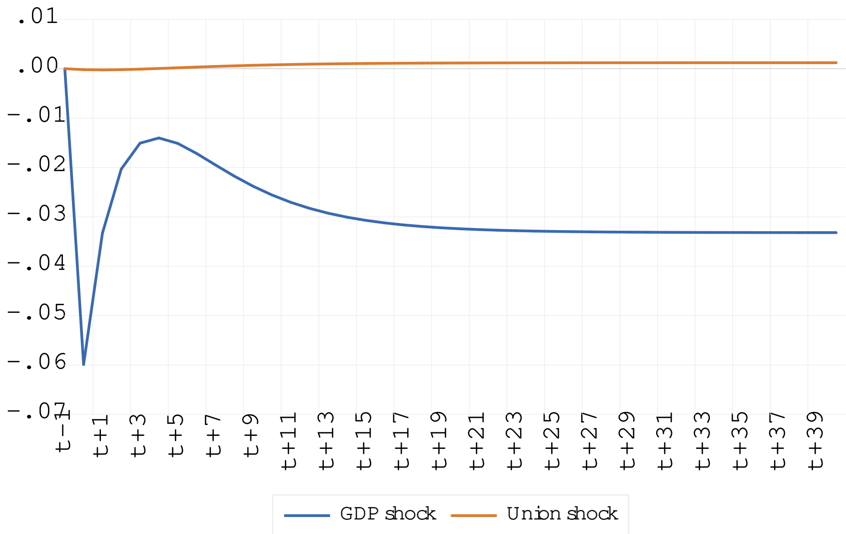

Figure A12: Unemployment cumulative response to a 1 p.p. increase of the unionisation rate and a 1% growth of the GDP