Portuguese labour market synthetic indicators

Carlos Melo Gouveia
Banco de Portugal

October 2019

Abstract
This article describes three indicators which summarize the comovements between labour market series. These are obtained by principal component analysis and are constructed with 27 monthly Portuguese variables that are published on a regular basis. The three indicators point to a sharp deterioration in labour market conditions from 2011 to 2013, with an improvement from 2013 until the end of the sample period. It is also shown that all the indicators are more correlated with inflation and economic activity than the unemployment rate. (JEL: E24, E66, J20)

Introduction

Janet Yellen, in her speech about labour market dynamics, said "The assessment of labour market slack is rarely simple and has been especially challenging recently" (Yellen 2014, page 4). Relying on a single measure may be misleading as different series sometimes give different intuitions and, as the quantity of series available is increasing, it is not straightforward to extract the common dynamics behind different variables. Therefore, an assessment of the stance of the economy based on models such as the Phillips Curve or the Okun's Law can yield very different results depending on the measure of slack used.

In recent years, more literature related to this topic has emerged, as economists are interested in finding the latent variable that drives labour market-related series. There is no simple or obvious methodology and dimension reduction techniques are used to tackle the problem and find such latent variable.

The Portuguese labour market has been having major changes over the past years. In 2009, the unemployment rate started to grow rapidly almost doubling until the start of 2013. This increase was followed by a sharp

Acknowledgements: The author is grateful for the help and comments from Ana Catarina Pimenta, António Antunes, António Rua, Cristina Manteu, Francisco Dias, João Amador, Jorge Correia da Cunha, Nuno Alves, Nuno Lourenço, Maximiano Pinheiro and Sara Serra. The analyses, opinions and findings of this paper represent the views of the author, which are not necessarily those of Banco de Portugal or the Eurosystem.

E-mail: cgouveia@bportugal.pt

decrease that was still visible in the end of 2018. Meanwhile, average nominal wages kept decreasing until the mid of 2014, being increasing ever since. In short, the Portugal was heavily affected by the Sovereign Debt Crisis, that has produced a lot of changes in the Portuguese labour market which are worth analysing.

In this article, the Portuguese labour market is analysed through three synthetic indicators. The first one focuses on the cyclical behaviour of the labour market, the second looks at its quarter-on-quarter evolution, while the third one is a year-on-year approach.

All the indicators point to a positive evolution of the labour market conditions in the recent period. The first one indicates that the Portuguese labour market is already above its trend value while the other two suggest that the labour market is improving faster than the historical average. Also, these indicators show their relevance by being more correlated with evolutions of the inflation and activity than the unemployment rate.

This article is organized as follows. In the next sections, a brief description of the literature is presented, the methodology behind Principal Component Analysis is described and a description of the data used is provided. Then, the indices are presented, along with the respective results. The indicators are then compared with the unemployment rate and some possible applications are shown. The last section concludes.

Literature review

With the increase in labour market data availability, many economists tried to get a synthetic measure of the labour market. The first contribution dates back to Barnes *et al.* (2007). They built a summary measure of labour market pressure for the U.S., which was obtained as the first principal component of 12 labour market series. Those variables were filtered with the Hodrick-Prescott filter in order to capture their cyclical movement. These authors argued that this new series is quite similar to the unemployment gap over the past 35 years. Furthermore, they show that the development of wage inflation is better linked to the summary measure than to the unemployment gap in the last years of their study.

Hakkio and Willis (2013) used the same statistical procedure with 23 labour market variables. They captured the first and second principal components in order to construct a series representing the level of activity, and another related to its rate of change. Their goal was different from the one pursued by Barnes *et al.* (2007), as the authors were more interested in the level rather than in the cyclical component. They used their indices to predict when the level of activity measure would reach its historical average.

After the argument proposed by Erceg and Levin (2013), which pointed out that the unemployment rate, although informative, may not be sufficient

for gauging overall labour market conditions, Zmitrowicz and Khan (2014) created comparable measures of labour market activity for the U.S. and Canada. The same technique as in Barnes *et al.* (2007) is used, detrending the eight series with the Hodrick-Prescott filter. Their indicator was used to assess labour market conditions and the authors concluded that, while in Canada the evolution of the labour market conditions were largely in line with the dynamics of the unemployment rate, in the U.S., the unemployment rate appeared to have significantly overstated the improvement in broader labour market conditions.

Chung *et al.* (2014) developed a measure that extracts the common movement from 19 labour market variables with a dynamic factor model. To stationarize all series, instead of using the Hodrick-Prescott filter, the authors resorted to the LOWESS filter with a bandwidth of 16 years. Since all the trends were removed, this index was, like the ones created by Barnes *et al.* (2007) and Zmitrowicz and Khan (2014), a cyclical approach. They argued that their index is one way to organize discussions of the signal value of a number of different labour market indicators in situations when the several series might be sending diverse signals. The authors also corroborated the idea that the unemployment rate has improved slightly faster than the other variables. Their index was used by the Federal Reserve until mid-2017, when it was discontinued. The reasons behind that are not totally clear, but several economists argued that the index was too perfectly correlated with the unemployment rate to be useful.

This kind of methodology inspired the Reserve Bank of New Zealand to do the same. Armstrong *et al.* (2016) used principal component analysis of 17 labour market-related series. The stationarization procedure was exclusively applied to those that are clearly non-stationary and consisted in the transformation of those variables in annual percentage changes. Their index correlation with the output gap, which was not an input variable of the procedure, was 80%. Also, they found that using their index as a predictor of most of the data used as input outperforms a baseline autoregressive model in forecasting for all horizons.

Grant *et al.* (2016) used 16 labour market variables and created an index for Australia. However, their index was more correlated with wage growth than with the unemployment rate. They stationarized their series by using 12-month differences and 12-month log-differences and argue that their index can be used as a leading indicator of wage growth.

Furthermore, with the growing literature about whether the Phillips curve is dead or not,[1] some authors started using this kind of broader labour market indices in their studies. Albuquerque and Baumann (2017) created an index with principal component analysis of eight labour market variables and used

1. For more details about the Portuguese case, see Serra (2018).

it as an alternative measure of slack. They argued that the index is among the best performing measures for forecasting inflation out-of-sample.

Principal component analysis

Principal Component Analysis is one of several methods that can be used to determine the common movement among various series. This method was popularized by Stock and Watson (2002) and is widely used as a dimension reduction procedure.

To apply this method, the input variables must be stationary and standardized. The standardization procedure is as given in equation (1), where X_i is the stationary variable, $\bar{X}_i$ and $\mathrm{sd}(X_i)$ denote its mean and standard deviation, respectively, and X_i^{std} is the standardized X_i:

$$X_i^{std} = \frac{X_i - \bar{X}_i}{\mathrm{sd}(X_i)} \tag{1}$$

Then, the N variables are arranged in a $T \times N$ matrix M, where T corresponds to the number of time periods:

$$M = \begin{bmatrix} X_1^{std} & X_2^{std} & \dots & X_N^{std} \end{bmatrix} \tag{2}$$

The following step is to form the $N \times N$ variance-covariance matrix (Ω) as in equation (3):

$$\Omega = \frac{1}{T} M'M \tag{3}$$

Since Ω is a square matrix, extracting its eigenvalues and eigenvectors is an easy task. Define Λ as the matrix with all the eigenvectors (v_i) of Ω:

$$\Lambda = \begin{bmatrix} v_1 & v_2 & \dots & v_N \end{bmatrix} \tag{4}$$

Λ is called the loading matrix and is N-by-N. This matrix should be arranged so that v_1 is the eigenvector associated with the largest eigenvalue and v_N with the smallest one.

The resulting components are linear combinations of the variables used in the analysis and each column in the principal component matrix is associated with the respective eigenvector.

$$PC = M\Lambda = \begin{bmatrix} PC_1 & PC_2 & \dots & PC_N \end{bmatrix} \tag{5}$$

There are some methods to find how many principal components are statistically significant, but our proposed indices only use the first principal component, which captures the largest fraction of the variance of the series used.

Data

The database includes 27 monthly variables, all related to the Portuguese labour market. This article uses data from January 2001 until December 2018. Every variable is seasonally and calendar adjusted.[2] The variables, their sources and the way they were grouped are presented in Table 1.

As some series refer to the quarter ended in the reference month,[3] a moving average of three months is applied to all the other variables. This reduces the volatility of the data, while making all series comparable. Since these indices will be regularly monitored, they use monthly instead of quarterly data. However, this restricts the embodiment of the Portuguese Employment Survey's variables. All nominal data are deflated using the Harmonized Index of Consumer Prices (HICP) working day and seasonally adjusted.[4]

2. The adjustment is provided by the original source, when available, or performed through a X13-ARIMA procedure, as recommended in Eurostat (2015).

3. Statistics Portugal uses centred moving quarters where the reference month corresponds to the central month of each moving quarter. In this work, a shift of one month in those series is applied in order to have the last month of the quarter.

4. This variable is retrieved from the ECB - Statistical Data Warehouse.

Categories	Variables	Source
Employment and Unemployment	Unemployment rate Employment rate Working population	Statistics Portugal
	Job vacancies Job applications First job-seekers New job-seekers	IEFP[a]
	Unemployment allowance beneficiaries	MTSSS[b]
	Employees	IISS[c]
Nominal Series	Average monthly wages Index of gross wages and salaries in services Index of gross wages and salaries in manufacturing industry Index of gross wages and salaries in construction industry Index of gross wages and salaries in retail trade	Statistics Portugal
Sectoral Employment	Index of employment in services Index of employment in manufacturing industry Index of employment in construction industry Index of employment in retail trade	
Population	Labour force participation rate Labour force Total population	
Business and Consumer Surveys	Consumers - Unemployment over next 12 months Manufacturing Industry – Employment expectations Services – Evolution of employment over the past three months Services – Evolution of employment expected over the next three months Retail trade – Employment expectations Construction industry – Employment expectations	European Commission

TABLE 1. Composition of the dataset.

a. *Instituto do Emprego e Formação Profissional* (Institute for Employment and Vocational Training).

b. *Ministério do Trabalho, Solidariedade e Segurança Social* (Ministry of Labour, Solidarity and Social Segurity).

c. *Instituto de Informática da Segurança Social* (Social Security Informatics Institute).

Labour market conditions indicators

A cyclical indicator

The indicator presented below is a cyclical approach to the Portuguese labour market, being analogous to the cyclical indicators used in other countries. Since this indicator aims to capture cyclical components, the stationarization is done by detrending.

There are several methods of detrending. Since it is the most common and well-known, a Hodrick-Prescott (HP) filter is used. The smoothing factor, λ, is 129600, as proposed by Ravn and Uhlig (2002).

Since the HP filter is two-sided, the observed data is extended with five years of data (60 months) through an autoregressive (AR) process in order to mitigate the endpoint bias. The number of AR terms is selected by the minimization of the Bayesian Information Criterion. The HP filter is applied to the extended sample and then the extended period is deleted. This procedure is quite similar to the one developed by Chung *et al.* (2014), but, instead of using the LOWESS filter, the HP filter is used.

With the detrended variables standardized, principal components are extracted. The first principal component explains 43.2% of the overall variance in the dataset.[5]

If the index value is zero at a given period, it means that the Portuguese labour market is in its trend state, as defined by the HP filter. Therefore, the distance from zero should be interpreted as the relative distance to the trend. Any level interpretation should be regarded as deviations from the cycle and intertemporal comparisons are limited because the underlying trend is changing.

The eigenvector associated with the largest eigenvalue and the correlations between the cyclical indicator and the cyclical component of each variable are presented in Table 2.

In Table 3, employment series emerge as the ones driving the behaviour of this indicator.

In Figure 1, it is visible that the maximum deviation from the trend value occurred in mid-2011. However, this implies that the labour market was overheated. Also, it is important to note that, as the HP filter is two-sided, future information affects the trend captured in each moment. This is of utmost importance when looking at the chart because it means that the downfall in 2013 affects the cyclical part of the series in 2011. Nonetheless, the

5. The second and third principal components explain 18.4% and 10.4% of the whole variance, respectively.

	Eigenvector	Correlation (%)
Unemployment rate	-0.2676	-91.4
Employment rate	0.2767	94.5
Working population	0.2810	95.9
Job vacancies	0.0668	22.8
Job applications	-0.2724	-93.0
First job-seekers	-0.2240	-76.5
New job-seekers	-0.2576	-88.0
Unemployment allowance beneficiaries	-0.2298	-78.5
Employees	0.2666	91.0
Average monthly wages	0.0695	23.7
Index of gross wages in services	0.0559	19.1
Index of gross wages in manufacturing	0.1516	51.8
Index of gross wages in construction	0.1068	36.5
Index of gross wages in retail trade	0.1727	59.0
Index of employment in services	0.2539	86.7
Index of employment in manufacturing	0.2469	84.3
Index of employment in construction	0.2495	85.2
Index of employment in retail trade	0.2657	90.7
Labour force participation rate	0.1662	56.8
Labour force	0.1805	61.6
Total population	0.1483	50.6
Consumers - Prospective evolution	-0.0876	-29.9
Manufacturing - Employment expectations	0.0827	28.2
Services - Retrospective evolution	0.0858	29.3
Services - Prospective evolution	0.0129	4.4
Retail trade - Employment expectations	0.1043	35.6
Construction - Employment expectations	0.0909	31.1

TABLE 2. Eigenvector and correlation of the indicator with filtered variables.

	Correlation (%)
Employment and Unemployment	97.8
Nominal Series	54.6
Sectoral Employment	94.9
Population	63.2
Business and Consumer Surveys	37.1

TABLE 3. Correlation between the cyclical indicator and the categories of variables.

Note: Each category's series is calculated with the weights estimated in the principal component analysis.

indicator shows that the labour market conditions suffer in crises periods, as expected.[6]

6. Using $\lambda = 622080$, following Félix and Almeida (2006), and comparing with this indicator, the correlation between them is 95.2%. Results available upon request to the author.

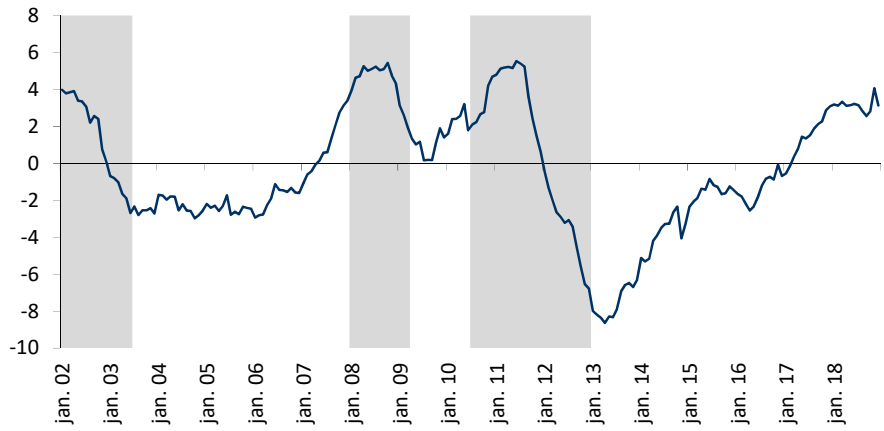

FIGURE 1: The cyclical indicator: 2002 M1 - 2018 M12.

Note: The shaded areas correspond to the periods between peaks and troughs of the Portuguese economic cycles, as defined in Rua (2017).

By looking at the most recent period, this indicator shows that the cyclical component is reaching its peak, already close to the values of the beginning of 2002 and the end of 2008 and 2011.

A quarter-on-quarter indicator

The quarter-on-quarter indicator is constructed also by principal component analysis and the key difference is the transformation performed to stationarize the variables.

Whereas in the previous index the stationarization is done by detrending, in this one it is done by differentiating. This index is, therefore, an evolution indicator that allows the policymaker to make inference on the rate of change of the labour market conditions.

This indicator is relevant for quarter-on-quarter comparisons since the differences are performed between the current value and the value three months before.

In this indicator, only inference about acceleration or deceleration of the labour market conditions can be made. One should take into account that the indicators' average is zero, which not mean that the original series are stable overall.

Applying the methodology described above, the first principal component captures 32.4% of the variance of all the series used. This number is lower than

in the case of the cyclical indicator due to the noise associated with quarter-on-quarter differences.[7]

The eigenvector associated with the largest eigenvalue and the correlations between the quarter-on-quarter indicator and the variables used are displayed in Table 4.

	Eigenvector	**Correlation (%)**
Unemployment rate	-0.2900	-85.8
Employment rate	0.2909	86.1
Working population	0.2919	86.4
Job vacancies	0.0068	2.0
Job applications	-0.3011	-89.1
First job-seekers	-0.2319	-68.6
New job-seekers	-0.2979	-88.1
Unemployment allowance beneficiaries	-0.2503	-74.1
Employees	0.3062	90.6
Average monthly wages	-0.0035	-1.0
Index of gross wages in services	0.0389	11.5
Index of gross wages in manufacturing	0.0696	20.6
Index of gross wages in construction	0.0101	3.0
Index of gross wages in retail trade	0.0974	28.8
Index of employment in services	0.2550	75.5
Index of employment in manufacturing	0.2537	75.1
Index of employment in construction	0.2483	73.5
Index of employment in retail trade	0.2804	83.0
Labour force participation rate	0.1344	39.8
Labour force	0.1302	38.5
Total population	0.0169	5.0
Consumers - Prospective evolution	-0.0763	-22.6
Manufacturing - Employment expectations	0.0751	22.2
Services - Retrospective evolution	0.0633	18.7
Services - Prospective evolution	0.0396	11.7
Retail trade - Employment expectations	0.1060	31.4
Construction - Employment expectations	0.0854	25.3

TABLE 4. Eigenvector associated and correlation of the indicator with quarter-on-quarter differences of the variables.

The correlation of the categories of series with the quarter-on-quarter indicator is presented in Table 5, which shows that the index is highly correlated with Employment and Unemployment and Sectoral Employment series.

The index is presented in Figure 2 and, as the cyclical one, it shows that the labour market conditions get worse during crises. According to this indicator, the labour market conditions have been growing above average since the middle of 2013 after a period where its evolution was sharply below average.

7. The second and third principal components explain 12.5% and 10.6%, respectively.

	Correlation (%)
Employment and Unemployment	98.3
Nominal Series	28.2
Sectoral Employment	91.8
Population	39.0
Business and Consumer Surveys	34.4

TABLE 5. Correlation between the quarter-on-quarter indicator and the categories of variables.

Note: Each category's series is calculated with the weights estimated in the principal component analysis.

During the years of 2016 and 2017, the labour market conditions were improving at the highest pace in the sample. However, during 2018 one can see that they were decelerating, but still above average.

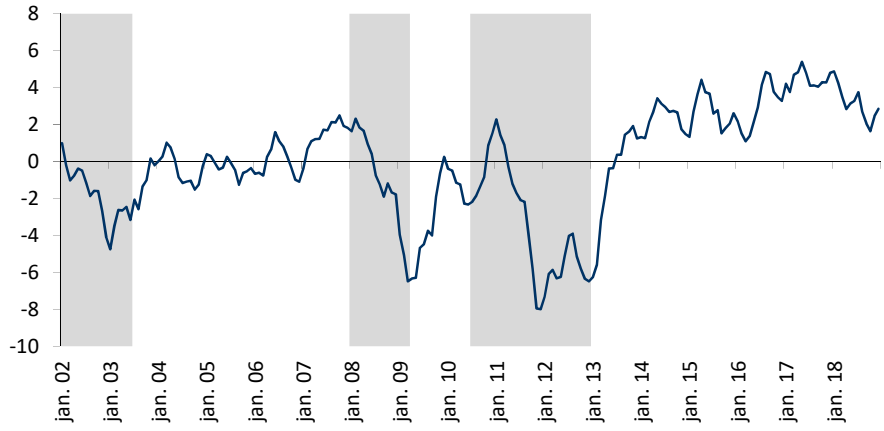

FIGURE 2: The quarter-on-quarter indicator: 2002 M1 - 2018 M12.

Note: The shaded areas correspond to the periods between peaks and troughs of the Portuguese economic cycles, as defined in Rua (2017).

A year-on-year indicator

The same methodology is applied to year-on-year differences. In this case, the first principal component explains 42.4% of the overall variance (the following principal components explain 18.8% and 13.5%, respectively).

As in the previous indicators, the eigenvector associated with the largest eigenvalue and the correlations between this indicator and the variables are shown in Table 6.

	Eigenvector	Correlation (%)
Unemployment rate	-0.2722	-92.1
Employment rate	0.2815	95.3
Working population	0.2821	95.5
Job vacancies	0.0435	14.7
Job applications	-0.2724	-92.2
First job-seekers	-0.2268	-76.8
New job-seekers	-0.2652	-89.8
Unemployment allowance beneficiaries	-0.2187	-74.0
Employees	0.2782	94.2
Average monthly wages	0.0449	15.2
Index of gross wages in services	0.1143	38.7
Index of gross wages in manufacturing	0.1618	54.8
Index of gross wages in construction	0.0369	12.5
Index of gross wages in retail trade	0.1772	60.0
Index of employment in services	0.2668	90.3
Index of employment in manufacturing	0.2167	73.4
Index of employment in construction	0.2513	85.1
Index of employment in retail trade	0.2582	87.4
Labour force participation rate	0.1516	51.3
Labour force	0.1204	40.7
Total population	0.0168	5.7
Consumers - Prospective evolution	-0.1254	-42.4
Manufacturing - Employment expectations	0.1033	35.0
Services - Retrospective evolution	0.1161	39.3
Services - Prospective evolution	0.0771	26.1
Retail trade - Employment expectations	0.1401	47.4
Construction - Employment expectations	0.1372	46.4

TABLE 6. Eigenvector associated and correlation of the indicator with year-on-year differences of the variables.

Like in the other two indices, this indicator is more correlated with Employment and Unemployment and Sectoral Employment series, as can be seen in Table 7.

	Correlation (%)
Employment and Unemployment	97.3
Nominal Series	56.1
Sectoral Employment	94.7
Population	45.0
Business and Consumer Surveys	49.5

TABLE 7. Correlation between the year-on-year indicator and the categories of variables.

Note: Each category's series is calculated with the weights estimated in the principal component analysis.

The year-on-year indicator is presented in Figure 3. The conclusions taken with this index are in concordance with the ones taken with the quarter-on-quarter index. Both point to an improvement above average of the labour market conditions since the second half of 2013 and to a deceleration in the recent years. Nonetheless, the same caveats apply.

According to this index, it is clear that from 2009 until 2013, the labour market conditions were evolving below average, assuming a notoriously negative pace during 2012. 2014 marks the year that the labour market conditions started to improve in the highest pace in the sample.

The highest value of the indicator marks 2017 as the year that the labour market conditions improved the most, however 2018 presents a deceleration.

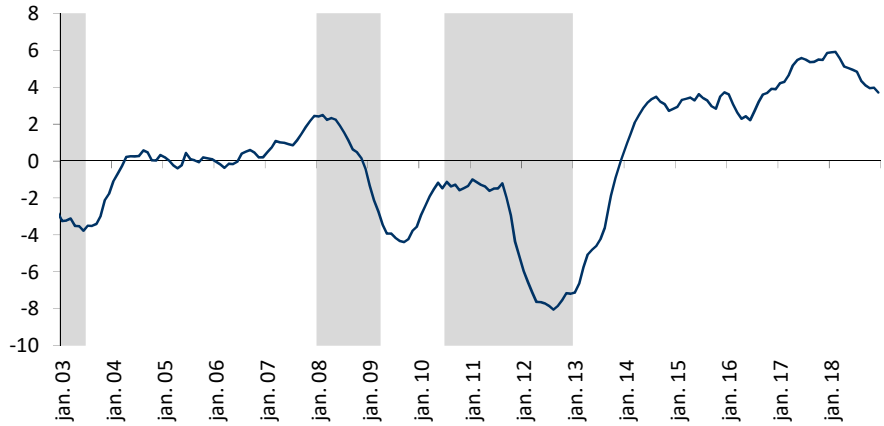

FIGURE 3: The year-on-year indicator: 2003 M1 - 2018 M12.

Note: The shaded areas correspond to the periods between peaks and troughs of the Portuguese economic cycles, as defined in Rua (2017).

Further results

With the three indices presented, one can compare them with the most used variable when assessing labour market conditions or labour market slack: the unemployment rate.

In Figure 4, the cyclical indicator is displayed with the cyclical unemployment rate in inverted scale. This cyclical variable was obtained by detrending the unemployment rate with the HP filter after an AR augmentation, just like how it was done when building the indicator.

In Figures 5 and 6, the quarter-on-quarter and year-on-year indicators are compared with the quarter-on-quarter and year-on-year differences of the unemployment rate in inverted scale, respectively.

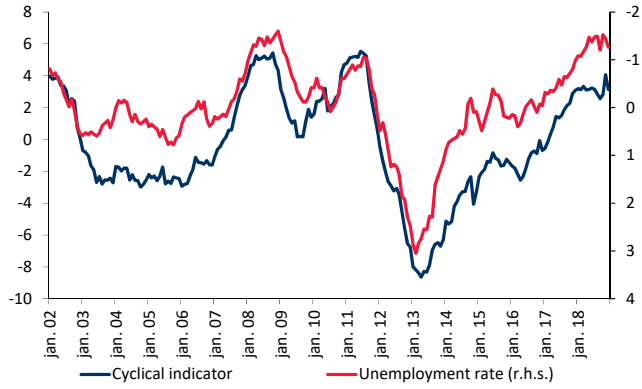

FIGURE 4: Cyclical indicator and the unemployment rate.

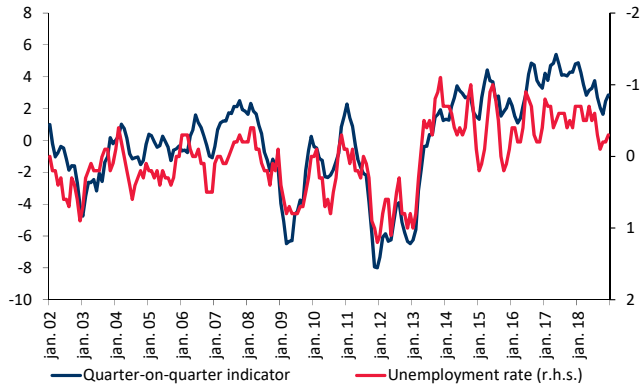

FIGURE 5: Quarter-on-quarter indicator and the unemployment rate.

The year-on-year indicator stands as the one with highest correlation with unemployment rate. However, they often show some differences such as in the beginning of 2014. The quarter-on-quarter indicator is the least correlated with the unemployment rate.

With these comparable variables, these indicators can be confronted with the unemployment rate when estimating the Okun's Law or the Phillips Curve.

Since it is not in the scope of this article to discuss how to correctly perform this estimation, only simple linear correlations will be displayed.

Okun's Law

The Okun's Law shows the empirical relationship between the labour market and activity.

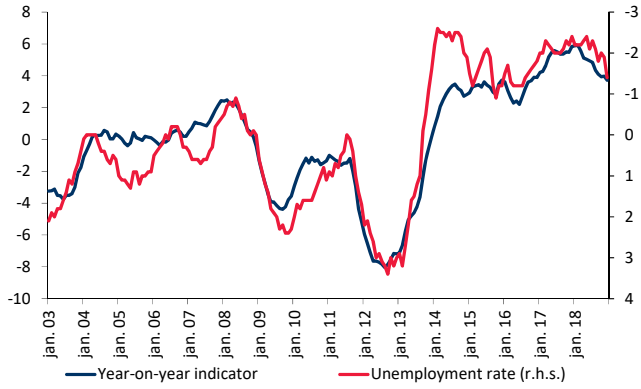

FIGURE 6: Year-on-year indicator and the unemployment rate.

Usually, as previously mentioned, the labour market variable used is unemployment rate, whereas GDP is used for economic activity.

Since GDP is published quarterly, the unemployment rate refers to the quarter ended in the reference month and all the variables used when constructing the indicators are in three-month moving averages, the values used for this comparison will be the ones refering to March, June, September and December.

To correctly perform this analysis, one should use the cyclical indicator and the cyclical unemployment rate as presented before, look at their evolution and correlate them with a comparable measure of GDP. To do this, cyclical GDP was estimated by detrending with the same procedures used previously.

By analysing Figure 7, where the correlogram is displayed, it is easy to see that the cyclical indicator is more correlated with current and past GDP than the unemployment rate. Note that in the x-axis, +1 means GDP one-quarter ahead and so on.

For the other indices, the method is more straightforward, as the correlations were taken using the index and the comparable unemployment rate variation with the quarter-on-quarter or year-on-year rates of change in GDP. The correlograms are presented in Figures 8 and 9.

In both cases, the indicator presents a higher correlation with GDP than the unemployment rate.

The Phillips Curve

A similar exercise was conducted for the Phillips Curve, which relates some measure labour market slack and inflation. In this case, the year-on-year rate of change of the Harmonized Index of Consumer Prices (HICP) is used as a measure of inflation.

FIGURE 7: Correlation between the cyclical indicator and the cyclical unemployment rate with the cyclical GDP t quarters apart.

FIGURE 8: Correlation between the quarter-on-quarter indicator and the quarter-on-quarter difference of the unemployment rate with the quarter-on-quarter rate of change of GDP t quarters apart.

As with GDP, the correlations should be taken with comparable measures of the evolution of prices. In the first case, as the indicator is cyclical, a cyclical approach to inflation should be used. So, inflation was detrended with the HP

FIGURE 9: Correlation between the year-on-year indicator and the year-on-year difference of the unemployment rate with the year-on-year rate of change of GDP t quarters apart.

filter after the augmentation through an AR process. In the other two cases, a measure of acceleration in prices should be used, so the correlations are made with the three and twelve-month difference of inflation.

Figures 10 to 12 display the correlograms. In the x-axis, +1 means the measure used for prices is one-month ahead.

In the three cases, the indicators present higher correlation with the evolution of prices than the unemployment rate.

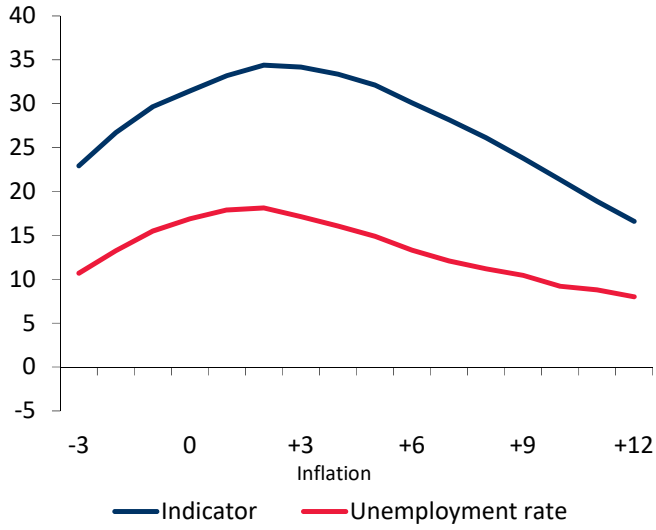

FIGURE 10: Correlation between the cyclical indicator and the cyclical unemployment rate with the cyclical inflation t months apart.

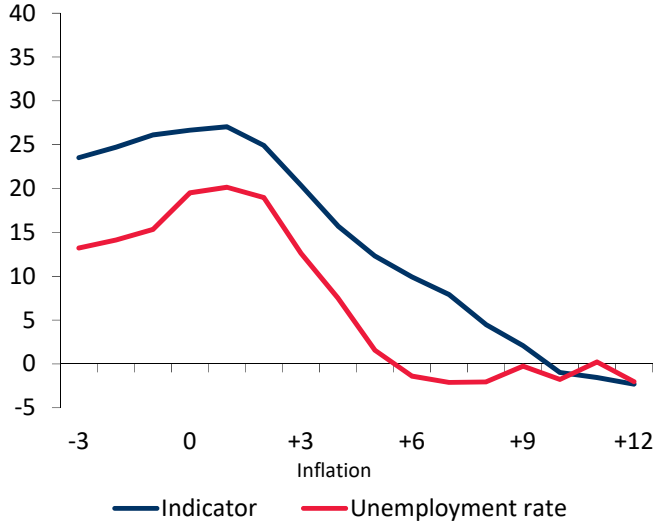

FIGURE 11: Correlation between the quarter-on-quarter indicator and the quarter-on-quarter difference of the unemployment rate with the quarter-on-quarter difference of inflation t months apart.

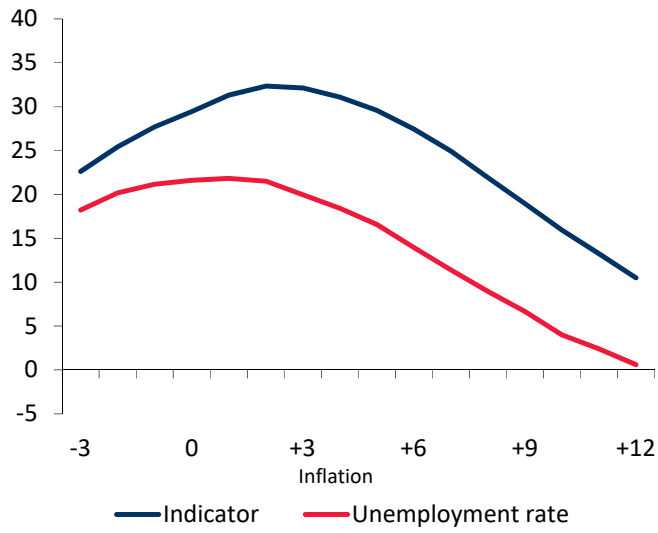

FIGURE 12: Correlation between the year-on-year indicator and the year-on-year difference of the unemployment rate with the year-on-year difference of inflation t months apart.

Main conclusions

This article presents three different indicators for the Portuguese labour market: cyclical, quarter-on-quarter and year-on-year. The three indicators are highly correlated with real series, as expected due to the large amount of employment and unemployment variables in the dataset.

Even though they have different interpretations, all point to a great deterioration of labour market conditions in the negative phases of the economic cycle in Portugal and to a deceleration in the most recent period, after some years of considerable growth.

Compared to the unemployment rate, these indicators seem to be more correlated with past and current values of GDP, but less with future values, except in the case of the quarter-on-quarter indicator. In the context of the Phillips Curve, all indicators show greater correlation with inflation than the unemployment rate, displaying some leading features over the evolution of prices.

Although all indicators can suit different purposes, the quarter-on-quarter indicator is not significantly outperformed by the unemployment rate regarding correlation with GDP, and given that it displays the same features as the other indicators in the framework of the Phillips Curve, it should be preferred for economic analysis.

References

Albuquerque, Bruno and Ursel Baumann (2017). "Will US inflation awake from the dead? The role of slack and non-linearities in the Phillips curve." *Journal of Policy Modeling*, 39(2), 247–271.

Armstrong, Jed, Günes Kamber, and Özer Karagedikli (2016). "Developing a labour utilisation composite index for New Zealand." Reserve Bank of New Zealand Analytical Notes series AN2016/04, Reserve Bank of New Zealand.

Barnes, Michelle L., Ryan Chahrour, Giovanni P. Olivei, and Gaoyan Tang (2007). "A principal components approach to estimating labor market pressure and its implications for inflation." *Public Policy Brief*.

Chung, Hess, Bruce C. Fallick, Christopher J. Nekarda, and David Ratner (2014). "Assessing the Change in Labor Market Conditions." Finance and Economics Discussion Series 2014-109, Board of Governors of the Federal Reserve System (US).

Erceg, Christopher and Andrew Levin (2013). "Labor Force Participation and Monetary Policy in the Wake of the Great Recession." CEPR Discussion Papers 9668, C.E.P.R. Discussion Papers.

Eurostat, European Commission. (2015). *ESS Handbook Seasonal Adjustment: 2015 Edition*. Manuals and guidelines, Publications Office.

Félix, Ricardo Mourinho and Vanda Almeida (2006). "Computing Potential Output and the Output Gap for the Portuguese Economy." *Banco de Portugal - Economic Bulletin Articles*, (Autumn), 73–88.

Grant, Angelia, Wilma Gillies, Ray Harris, and Melissa Ljubic (2016). "An Australian Labour Market Conditions Index." Treasury Working Papers 2016-04, The Treasury, Australian Government.

Hakkio, Craig S. and Jonathan L. Willis (2013). "Assessing labor market conditions: the level of activity and the speed of improvement." *Macro Bulletin*, pp. 1–2.

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

Rua, António (2017). "Dating the Portuguese business cycle." *Banco de Portugal Economic Studies*, 3(1), 43–58.

Serra, Sara (2018). "Is the Phillips curve dead? - results for Portugal." *Banco de Portugal Economic Studies*, 4(2), 25–44.

Stock, J.H. and M.W. Watson (2002). "Forecasting Using Principal Components From a Large Number of Predictors." *Journal of the American Statistical Association*, 97, 1167–1179.

Yellen, Janet L. (2014). "Labor Market Dynamics and Monetary Policy: a speech at the Federal Reserve Bank of Kansas City Economic Symposium, Jackson Hole, Wyoming." Speech 815, Board of Governors of the Federal Reserve System (U.S.).

Zmitrowicz, Konrad and Mikael Khan (2014). "Beyond the Unemployment Rate: Assessing Canadian and U.S. Labour Markets Since the Great Recession." *Bank of Canada Review*, (Spring), 42–53.