Oil prices and unemployment: empirical evidence from Brazil*

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RESUMO

Neste trabalho, apresentamos a evidência empírica relativa à existência de uma relação de longo prazo entre a taxa de desemprego, o preço do petróleo e a taxa de juros real, no Brasil. Depois de estabelecer a existência de cointegração entre estas variáveis, estimamos os coeficientes de longo prazo que relacionam a taxa de juros real e o preço real do petróleo à taxa de desemprego. Nossos resultados mostram que uma duplicação do preço do petróleo tende a trazer um aumento absoluto de 1,6 pontos porcentuais na taxa de desemprego.

Palavras-chave: taxa de desemprego, preço do petróleo.

ABSTRACT

In this study we present empirical evidence for the existence of a long-run relation between the rate of unemployment in Brazil and the price of energy plus the real interest rate. After establishing the existence of cointegration among those variables, we estimate the long-run coefficients relating the real interest rate and the real price of oil to the rate of unemployment. Our results show that a doubling of the price of oil tends to bring about an absolute increase of 1.6 percentage points in the unemployment rate.

Key words: unemployment rate, oil prices.

JEL classification: E24, E32.

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1 Introduction

The purpose of this paper is to determine whether there is a long run relation between variations in oil prices and the rate of unemployment in the Brazilian economy.

In section 2, we review the previous literature on this subject and discuss the model suggested by Carruth *et al.* (1998), which postulates a direct relation between oil prices and the unemployment rate. The equation we estimate is derived from their model. In sections 3 and 4, we discuss the cointegration tests and the data used in the paper and present our results. Finally, in section 5 we summarise our main conclusions.

2 Motivation

A large body of research has already identified a nexus between energy prices and the level of economic activity and/or the rate of unemployment in the American economy. Several transmission mechanisms between oil price changes and changes in output and unemployment are described by Hamilton (2001). According to this author, an exogenous increase in energy prices reduces output (increases unemployment): i) directly, by lowering productivity; and ii) indirectly, to the extent that lower wages lead to movements along the labour supply curve, changes in business mark-ups or in capacity utilization rates.

All these transmission mechanisms imply a linear relation between the real price of oil and real GDP/unemployment, with price increases leading to recessions and price decreases, through the same mechanisms operating in the opposite direction, leading to booms. However, the empirical evidence relating to the US economy suggests that, while the oil price increases of the 1970s had significant impacts on output and employment, the effects of the price declines of the 1980s and 1990s were "smaller and harder to characterize". (Hooker, 1996). This evidence has led several authors to argue that there exists a non-linear relationship between oil prices and the level of economic activity.

According to this line of argument, an oil price decrease certainly has a favourable impact on the level of activity and/or rate of unemployment, because of the production function and inflation/wage effects described before. However, it may not produce an economic boom mirroring the recession induced by an oil price increase and, under certain circumstances, may even be contractionary.

Hamilton (2001) interprets this non-linearity as originating from the fact that changes in oil prices, whether they are increases or decreases, tend to change the composition of demand, increasing the demand for some goods and decreasing it for others. For example, a major disruption in oil prices may lead to greater uncertainty about the future, so that spending in cars, housing and investment goods temporarily falls. If it is costly to reallocate factors of production (labour or capital) between sectors, oil shocks may be contractionary in the short run, irrespective of their sign.

In this paper, we follow Carruth *et al.* (1998) who examined the relation between oil prices and the unemployment rate, in the context of the Shapiro-Stiglitz efficiency-wage model. (Shapiro and Stiglitz, 1984).

The basic assumptions of the efficiency-wage model, in the version presented by Carruth *et al.* (1998), are:

- Workers are risk-averse and derive utility (u) from income (w) and disutility from effort (e):

  $$u = \log w - e$$

- Effort (e) is a fixed number determined by technology, but workers can choose to "shirk", *i.e.*, to provide zero effort, facing a probability $(1-d)$ of being detected and fired.

- If undetected, the utility of a shirker is $\log w$.

- A worker sacked for shirking and rehired cannot shirk again, because firms will closely supervise the behaviour of anyone known to have been fired by another employer, *i.e.*, a shirker who is rehired earns, with certainty, $\log w - e$. Therefore, the expected utility of a fired worker (w') is a weighted average of the utility from working at the required level of effort and of the income-equivalent value of being unemployed (b), which depends, among other things, on the value of the unemployment benefit:

  $$w' = a(U)(\log w - e) + [1 - a(U)]\log b$$

where $a(U)$, the probability of finding work, varies inversely with the rate of unemployment U.

- The no-shirking wage is the smallest wage required to persuade employees to exert effort and can be obtained by equating the utility from not shirking to the expected utility from shirking:

$$\log w - e = d(\log w) + (1-d)w'$$

Substituting the expression derived before for w' into the equation above and rearranging, gives

$$\log w = \log b + e + \frac{e\,d}{[1-a(U)](1-d)}.$$

The equilibrium wage, therefore, varies directly with the income value of not working (b), the required job effort (e), the probability of not being detected (d) and the probability of finding work $[a(U)]$.

Assuming that the product of the economy (y) is generated through a constant returns to scale technology using labour (n), capital (k) and energy (x), we have:

$$y = \alpha\, f(n,k,x)$$

where α measures the level of technology.

Under perfect competition, firms in the product market will operate at the minimum point on their cost schedules, with the unit minimum cost function

$$C = (1/\alpha)\, c(w,r,p_o),$$

where r is the price of capital (the real interest rate) and p_o is the price of energy (oil).

Setting p, the output price, equal to 1 and using the zero profit condition $p = C$, gives

$$\alpha = c(w,r,p_o).$$

Substituting the expression for the equilibrium wage into the equation above, we find that the equilibrium unemployment rate (U) varies directly with the real interest rate (r), the real price of oil (P_o), the level of on-the-job effort (e), the probability of successfully shirking (d) and the level of unemployment benefits (b).

Taking e, d and b as given, Carruth *et al.* (1998) conclude that movements in the unemployment rate depend only on variations in the input prices, that is to say, on variations of the real price of oil and the real interest rate.

Assuming that the price of oil is determined exogenously by the world market for this raw material, an oil price increase, *coeteris paribus*, brings about negative profits, *i.e.* losses for firms, causing them to leave the market. If the domestic real interest rate is determined by the world interest rate, the domestic real wage will have to be reduced to restore the zero-profit equilibrium. In order to induce workers to accept these lower wages, unemployment must increase, *i.e.*, unemployment operates as a "worker discipline device". As a result, a direct relation between oil prices and the unemployment rate sets in.

3 Estimation method

Carruth *et al.* (1998) tested for the existence of a long-term relation between the unemployment rate, the real oil price and the real interest rate in the US, using the Engle-Granger cointegration test and an error correction model.

We looked for a similar relationship in the Brazilian case, using a procedure recently proposed by Pesaran, Shin and Smith (2001), also based on an error correction specification.

There is some disagreement in the results reported in the current literature in regard to the order of integration of the three variables included in the model. It is common to find opposite conclusions – produced by different tests – concerning the presence of a unit root in the respective time series, both in the international and in the Brazilian literature.

The procedure proposed by Pesaran, Shin and Smith (2001) circumvents this problem, making it possible to test for the existence of a long-term relation (cointegration) among the variables of interest even when it is not known for sure whether the time series involved are I(0) or I(1).

According to this methodology, we may conclude that there is a long-term relation between the unemployment rate, the real oil price and the real interest rate, if an F test rejects the null hypothesis that the coefficients c_0, c_1 and c_2 in the following error correction model (ECM) are jointly equal to zero:

$$\Delta u_t = a + c_0 u_{t-1} + c_1 r_{t-1} + c_2 ln(p_o)_{t-1} + \sum_{i=1}^{n} \lambda_i \Delta u_{t-i} + \sum_{i=0}^{n} \beta_i \Delta r_{t-i} + \sum_{i=0}^{n} \gamma_i \Delta ln(p_o)_{t-i}$$

where Δ is the difference operator, 'ln' stands for natural logarithm, u is the unemployment rate, r the real interest rate and p_o the real oil price.

Pesaran, Shin and Smith (2001) present estimates of the critical values of this F statistic when all the regressors are I(0) as well as when all are I(1). If the estimated value of F in the ECM is larger than both critical values at the conventional significance levels, then the null hypothesis – of absence of a long-term relation among the levels of the variables under analysis – is rejected.

The ECM, as shown by Spanos (1986), may be seen as a specific restriction of a more general auto regressive distributed lag model (ARDL model). Therefore, following Pesaran, Shin and Smith (1996) and Pesaran and Shin (1999), after settling the question of cointegration, we used an ARDL model to obtain estimates of the long-run coefficients relating the real price of oil and the real interest rate to the unemployment rate.

This task was performed by using the Microfit® software (Pesaran and Pesaran, 1997), which permits the use of different criteria in order to choose among the many alternative lag structure specifications of such models. This means that, in estimating the ARDL model, instead of imposing the same lag structure on all RHS variables, as we did when testing for cointegration, we allowed those lag structures to differ, using, say, the Akaike Information Criterion to determine the most suitable specification of the model.[1]

4 Data and results

The unemployment measure we used was the rate of 'open unemployment', estimated in the Monthly Employment Survey (PME) conducted by the *Instituto Brasileiro de Geo-*

1 For a detailed description of this testing strategy (tests for cointegration plus estimation of an ARDL model), see Pesaran and Pesaran (1997).

grafia e Estatística (IBGE) in the six main metropolitan areas of the country, with a 30-day period of reference. This was the only series that was seasonally adjusted.

The real rate of interest was provided by the monthly rate of interest known as '*over/selic*', deflated by IBGE's National Consumer Price Index (INPC).

Finally, as a proxy for the real price of oil, we used the price index of imported fuel estimated by the *Fundação Centro de Comércio Exterior* (FUNCEX). This series was adjusted for inflation using the US GDP implicit deflator.

All the above series are quarterly averages of monthly data. They cover the 1982.3/2000.4 period and were taken from the IPEADATA database (www.ipeadata.gov.br). Since in the tests performed we used first differences and lagged values of the variables, five observations were "lost", reducing the sample period to 1983.4/2000.4. Descriptive statistics of the series that entered the exercises are presented in Table 1.[2]

Table 1
Descriptive Statistics
Quarterly data: 1983:4 – 2000:4

Variables	Mean	Standard Deviation	Coefficient of Variation	Correlation with unemployment
Unemployment (%)	5.8245	1.5760	0.2706	1.0000
Oil price index (mean 1996 =100)	105.54	32.76	0.3104	0.4318
Real Interest rate (%)	1.0452	1.8507	1.7707	0.2294

Sources: see text.

A dummy variable was included in the equation to control for the change in the long-run unemployment rate in Brazil after 1998. We gave this dummy variable a value of "zero" from the beginning of the sample period up to the fourth quarter of 1997, and a value of "one" from the first quarter of 1998 onwards.

The test equation was estimated for values of n, the number of lags taken in the three first-difference variables on the RHS of the equation, ranging from one to four.

2 Data files available from the authors upon request.

The preferred specification of the lag structure, according to the Akaike Information Criterion, was that corresponding to n = 4 (see Table 2). In this case, the value of the *F*-statistic, used to test the hypothesis that the coefficients c_0, c_1 and c_2 are jointly equal to zero, was 6.03. This value of *F* exceeds the critical values for the 2.5% level of significance, presented by Pesaran, Shin and Smith (2001), when the variables are I(0) as well as when they are I(1).

Table 2
Cointegration Tests

Value of *n*	*F*-statistic	Akaike criterion
1	4.3234	1.3507
2	3.2048	1.3781
3	4.9188	1.3206
4	6.0308	1.3023

Critical values
5.0% level: for all variables I(0), F = 3.79; for all variables I(1), F = 4.85.
2.5% level: for all variables I(0), F = 4.41; for all variables I(1), F = 5.52.

Based on these tests, therefore, it is not possible to reject the existence of a long-run relationship (cointegration) between the levels of the unemployment rate, the real interest rate and the real price of oil in Brazil.

Having established the existence of cointegration between the variables in our model, we then proceeded to estimate the ARDL model.

When the Akaike Information Criterion was used, the lag structure chosen to explain the rate of unemployment was ARDL(4,4,0), *i.e.* the set of explanatory variables included four lagged values of the dependent variable, plus the contemporaneous and four lagged values of the real rate of interest and only the contemporaneous natural logarithm of the real oil price.

The value of the error correction coefficient obtained in this case was – 0.251, suggesting that only 25% of the total value of the previous quarter's deviation from the long-run relation tends to be corrected in the current quarter. This coefficient is statistically significant at the 1% level, which, again, confirms the existence of cointegration among the variables that entered the ARDL model (see Table 3).

Table 3
ARDL Model Estimates

	ARDL(4,4,0) (Akaike Information Criterion)	
Variables	Sum of Coefficients	Long-run coefficients
u_{t-i}	0.74932	–
r_{t-i}	0.10815	0.43140 (1.9814) [0.026]
$\ln(p_o)_{t-i}$	0.00413	0.01647 (2.2568) [0.014]
Error correction term	–0.25069 (–3.5698) [0.001]	
Diagnostic tests	R^2 = 0.92568 AIC = –45.0278 LM(4) = 1.1916 [0.325] RESET = 0.2262 [0.636] Heterocedast. = 0.0274 [0.869]	

Note: Figures in parentheses are *t*-statistics; figures in brackets are *p*-values.

In order to investigate the adequacy of the estimated empirical model, we used a Lagrange multiplier test of residual serial correlation and found that the null of absence of fourth order autocorrelation was not rejected at the usual significance levels. In the same way, a Ramsey's RESET test showed that the functional form of our model is correct. Finally, the results of a White test allowed us to reject the hypothesis of heteroscedastic residuals.

The long-run coefficients associated with the real interest rate and the real oil price, presented in Table 3, are statistically significant at the 5% level. These estimates suggest that:

a. By increasing the monthly rate of interest by 232 base points, the unemployment rate suffers an (absolute) increase of 1 percentage point.

b. Doubling the real price of imported fuels leads to an absolute increase of 1.6 percentage points in the unemployment rate.

5 Conclusions

Following Carruth *et al.* (1998), we investigated in this paper the possible existence in Brazil of a long-run relation between the rate of unemployment, on one hand, and the real price of oil plus the real interest rate, on the other, adopting the estimation procedure proposed by Pesaran, Shin and Smith (2001) to test for co-integration among the levels of those variables.

Using quarterly data for the period 1983.4/2000.4, we rejected the null hypothesis of absence of cointegration. After this, we estimated several ARDL models with different lag structures, using the Akaike Information Criterion to choose the best specification. Our results showed that the price of oil and the real interest rate are significantly related to the Brazilian unemployment rate. More specifically, the doubling of oil prices is related to an absolute increase of 1.6 percentage points in the unemployment rate.

The short-run dynamics were studied by estimating an error correction model and the corresponding error correction coefficient. The latter suggests that about 25% of the total value of the previous quarter's deviation from the long-run relation tends to be corrected in the current quarter.

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