An Exploration of the Long Run Tradeoff between Inflation and Unemployment in México in the Last Fifteen Years

Alejandro Rodríguez-Arana

Department of Economics
Universidad Iberoamericana, Ciudad de México
Prolongación Paseo de la Reforma 880
Colonia Lomas de Santa Fe 01210 Ciudad de México
México

Abstract

This paper sets a partial equilibrium model of the determination of price inflation and that of wages. When there is an incomplete nominal adjustment of these variables, a long run tradeoff between inflation and unemployment arises. An ARDL version of the proposed model is estimated for the case of México. The estimation strongly rejects complete nominal adjustment of price inflation and that of wages to foreign inflation and the rate of growth of the minimum wage. We found a long run tradeoff between inflation and unemployment and also a similar relation between the rate of growth of the real wage and unemployment. These tradeoffs survive even in the hypothetical case where the rate of growth of the nominal wage and foreign inflation are perfectly indexed to both of the endogenous types of inflation described. The Phillips curve in prices is almost horizontal, a modest increase in inflation reduces unemployment considerably.

Introduction

For many years, macroeconomics has been dominated by the natural rate of unemployment´s hypothesis (Phelps (1967), Friedman (1968)). For this view, the long run rate of unemployment is independent of inflation. Though in the short run it is sometimes possible to reduce unemployment increasing inflation[1]-the so-called Phillips mechanism (Phillips (1958))-that tradeoff cannot be exploited in the long run. When central banks persist in trying to do that, the only think that they get is higher inflation and a rate of unemployment that remains relatively constant.

Together with the natural rate hypothesis, Friedman (1968) proposed the accelerationist hypothesis, which states that the relevant relation is not between inflation and unemployment, but between the acceleration of inflation and unemployment. When this last figure rises above the natural rate, the acceleration of inflation becomes negative and the other way around.

Both, the natural rate hypothesis and the acceleration´s, have generated the concept of NAIRU[2], defined as the rate of unemployment that maintains inflation constant or the acceleration of inflation equal to zero.

Between the middle of the eighties and the end of the nineties, world inflation decreased considerably. After that, it has remained relatively constant in many places. On the other hand, unemployment has varied much more. This apparent anomaly was perhaps reported for the first time by Akerlof, Dickens and Perry at the end of the nineties (Akerlof et al (1996) (2000)). Their analysis did not have many repercussions at that time, nonetheless.[3]

The 2008-2009 financial crisis in the developed world generated a clear situation where a drastic increase in unemployment was not followed by a remarkable reduction in the acceleration of inflation, as expected by the NAIRU hypothesis. Inflation fell everywhere, but soon it took levels similar to those before the crisis, while unemployment remained high for a much longer time. Then, economists that were clearly advocates of NAIRU took notice and started to do research in the topic. Galí (2011), Blanchard, Cerutti and Summers (2015), Blanchard (2016) (2018) and Galíand

[1] Neo-Keynesians and new-Keynesians as Romer (2000) and Taylor (2000) believe that it is possible to generate lower unemployment increasing inflation in the short run. New-classical economists as Lucas (1972) do not believe that this can be possible at any moment.

[2] Which is the rate of unemployment that does not accelerate inflation.

[3] Graham and Snower (2002) report similar results to those of Akerlof et al (1996) (2000).

Gambetti (2018) have now challenged NAIRU, suggesting that perhaps the relevant relation for a prolonged period of time is, after all, one where inflation depends upon negatively on the rate of unemployment, the one that was proposed by Phillips in 1958.

One question that emerges from this analysis is why the relation between inflation and unemployment could prevail instead of the accelerationist hypothesis. The critique by Phelps (1967) and Friedman (1968) was reasonable, since they asserted that people did not care about nominal magnitudes, but real ones. If that were the case, the mere existence of any Phillips curve, even the accelerationist one, would be at doubt, as new classical economists have argued (Lucas (1972)).

To answer this question, the works of people like Akerlof become again relevant (see for example Akerlof and Yellen (1985) or Akerlof et al (2000)). People behave in a different way in environments of high inflation compared to those of low inflation. Under high inflation there is almost complete nominal adjustment. Consumer and producer prices adjust in one to one basis to input prices. Also, when that is an option, input prices adjust in one to one way to expected consumer and/or producer prices. When these practices take place fast, the resultant rate of unemployment is, as the classical model predicts, completely independent of inflation. When there are lags in these decisions, the accelerationist Phillips curve may emerge.

Under high inflation, failing to adjust the nominal variables may be too costly. If nominal wages remain constant under a 100% price inflation, the purchasing power of the real wage falls 50%. However, this is different under low inflation. A constant nominal wage under 1% price inflation reduces the real wage by a bit less than 1%, something that may pass even unnoticed. The practice of complete nominal adjustment under low inflation relaxes considerably. Several economists have shown that with low inflation and expansionary policies the incomplete nominal adjustment of different prices often generate small changes in relative prices, but large changes in consumption and output. [4]For a long time, this was an explanation of why active fiscal and monetary policies had real short run effects.

Different models at the end of the nineties, and in the first decade of the XXI century, assumed short run incomplete nominal adjustment to explain large movements in the business cycle. However, the same models set equations of motion where prices became more flexible in time. The results of active policies in these models were a short run expansion that faded when time passed. The 2008-2009 financial crisis challenged this view, generating the suggestion that perhaps the price system did not become more flexible in the long run.[5]

The main purpose of this paper is to analyze whether there is a long run relation between inflation and unemployment in México of the kind proposed by Phillips in 1958.

To do that, first the paper sets a simple partial equilibrium model of wage-price adjustment where there are two endogenous variables: wage inflation and price inflation, and three exogenous ones: foreign inflation, the rate of growth of the minimum wage and the rate of unemployment. We analyze different cases where there is incomplete nominal adjustment of the endogenous as well as of the exogenous variables, complete nominal adjustment of all kind of variables or incomplete nominal adjustment of a set of variables and complete adjustment or the other set of variables.

The second part of the paper is an empirical investigation that estimates the two equations proposed in the theoretical model for the last fifteen years in México, a period of low inflation: The wage Phillips curve and the equation of inflation.[6]

In the third part of the paper we evaluate the long run results of the empirical investigation for México and compare them with the theoretical model.

I.- A simple theoretical model of the price-wage adjustment

We propose two equations: a wage Phillips curve (Phillips (1958), Tobin (1972), Blanchard (1990)) and an equation of inflation.

[4]Akerlof and Yellen (1985), Mankiw (1985).

[5] See for example McCallum and Nelson (1999), King (2000), Romer (2000), Taylor (2000), Woodford (2001), Koenig (2008), Blanchard (2008).

[6] Inflation in México has been not too far from 4% in the last years. It is certainly greater than in developed countries, but much lower of what is was in the eighties, when on average was around 100%, and in the nineties, when the average was higher than 20%.

The first equation relates the rate of growth of nominal wages, wage inflation, negatively to the rate of unemployment. The equation of inflation relates price inflation in a positive way to wage inflation and to the rate of growth of the prices of foreign inputs in production, foreign inflation.[7]

It is normally assumed (Tobin (1972), Blanchard (1990)) that there is a certain degree of indexation ofwage inflation to price inflation. In countries where there is a minimum wage, there is also a partial indexation of average wages to the increase in minimum wages, the so-called lighthouse effect (see for example Maloney and Méndez (2004), Campos and Esquivel (2020)). Therefore, the growth of nominal wages will depend positively on the rate of price inflation and the rate of growth of the minimum wageand negatively on the rate of unemployment.

$\Delta W = f(\pi, \Delta W_m, u)$ (1)

$$\frac{df}{d\pi} > 0 \frac{df}{d\Delta W_m} > 0 \frac{df}{du} < 0$$

Where W is the log of nominal wage, π is the rate of inflation W_m is the nominal minimum wage and u is the rate of unemployment.

$\pi = f(\Delta W, \Delta P^e)$ (2)

$$\frac{df}{d\Delta W} > 0 \frac{df}{d\Delta P^e} > 0$$

On the other hand, inflation π depends upon the rate of growth of both nominal wages (ΔW) and the rate of growth of foreign prices (ΔP^e), being P^e the log of the product of the nominal exchange rate and the prices in foreign currency of imported inputs. The introduction of foreign prices is based in the fact that Mexican imports of foreign inputs accounts for more than 70% of total imports.[8]

The linear version of the model conformed by equations (1) and (2) is:

$\Delta W = \beta_{0a} + \beta_{2a}\pi + \beta_{3a}\Delta W_m + \beta_{4a}u$ (3)

$\pi = \gamma_{0a} + \gamma_{2a}\Delta W + \gamma_{3a}\Delta P^e$ (4)

β_{2a} is the nominal adjustment of wage inflation to price inflation. β_{3a} is the same concept for the rate of growth of the minimum wage.

Under incomplete nominal adjustment:

$\beta_{2a} < 1;\ \beta_{3a} < 1\ and\ \beta_{2a} + \beta_{3a} \leq 1$(5)

Perfect nominal adjustment would imply that the last inequality in equation (3) becomes an equality.

The system formed by equations (3) and (4) may be considered as a model of price-wage spiral (see for example Blanchard (1986) and Flaschel and Krolzig (2002)). Wage inflation depends upon positively on price inflation and the other way around.

The parameter β_{0a}in equation (3) may represent changes in productivity that are claimed by workers. It also may represent the power of unions to increase wages independently of other factors.

Finally, the parameter β_{4a} is the adjustment of wage inflation to unemployment, which is supposed to be negative. Higher unemployment reduces wage inflation in the Phillips curve mechanism.

In the equation of inflation γ_{2a} is the nominal adjustment of inflation to wagesand γ_{3a} the same concept for foreign inflation. As in the case of the Phillips curve in wages

$\gamma_{2a} < 1;\ \gamma_{3a} < 1\ and\ \gamma_{2a} + \gamma_{3a} \leq 1$ (6)

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[7] Since the publication of the book The Wage Curve by Blanchflower and Oswald (1994) there has been a considerable discussion on the literature whether the relevant relation is between the level of wages and the rate of unemployment, as these authors propose, or between wage inflation and unemployment as Phillips (1958), Tobin (1972) and Blanchard (1990) had proposed before. See for example Blanchard and Katz (1997), Roberts (1997) and Whelan (1997).

[8] Gordon (1997) (2013) proposes a model of the Phillips curve where price inflation depends upon the growth of some key prices, for instance oil prices because oil is an important factor of production. In México, imported inputs are important factors of production.

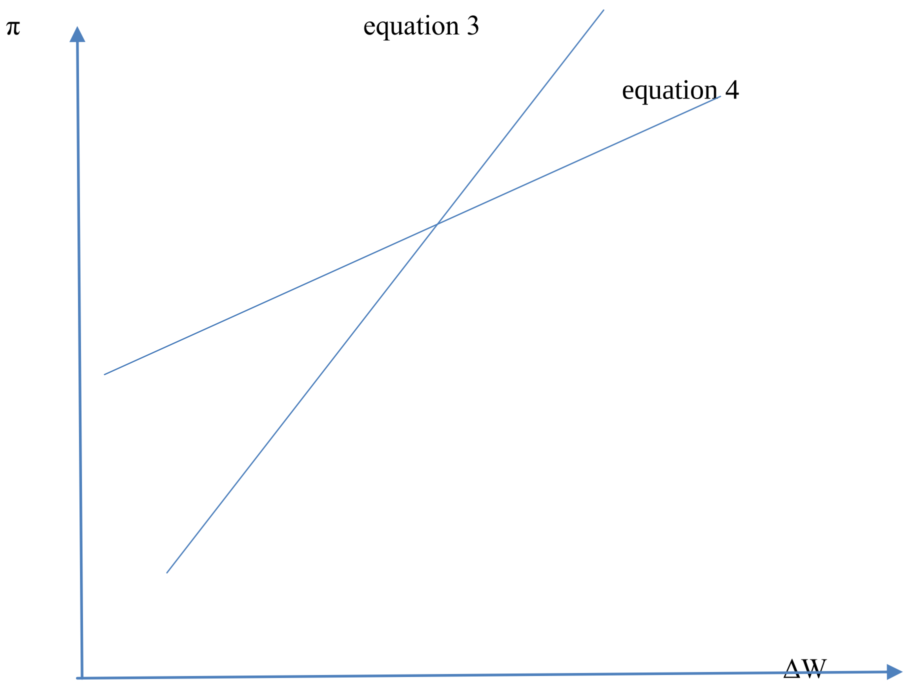
The parameter γ_{0a} may represent both changes in productivity as well changes in the monopoly power of firms. If productivity is rising and there is perfect competition, γ_0 would be negative. Instead, if the monopoly power of firms is increasing, γ_0 would be positive.

Since β_0 in the wage Phillips curve and γ_0 in the equation of inflation may be related to changes in productivity, they could be related in a negative way.[9]
A perfect nominal adjustment would imply that the last inequality in equation (6) becomes an equality.

I.1.- The relation between inflation and unemployment under incomplete nominal adjustment of all endogenous and exogenous variables.

If there is incomplete nominal adjustment of the endogenous variables, equations (5) and (6) are strict inequalities. If furthermore, there is incomplete nominal adjustment of the rate of growth of the nominal minimum wage to wage inflation and of foreign inflation to domestic inflation, so these variables are relatively independent, figure 1 shows the wage-price adjustment of equations (3) and (4)

Figure 1. The stable configuration of the wage-price adjustment´s model



The stable configuration requires than in the plane where price inflation is in the vertical axis and wage inflation is in the horizontal axis, the slope of the equation of inflation is lower than the slope of the Phillips curve in wages.

Given the assumptions, the proposed model is always stable, since

$$\frac{d\pi}{d\Delta W_{pcu}} = \frac{1}{\beta_{2a}} > 1 \quad (7)$$

[9] In a model with perfect competition suppose that we have the production function $Y = AI^{\alpha}L^{1-\alpha}$ I, where A is factorial productivity, I represents foreign inputs and L is labor. In this model the real wage w is equal to the marginal product of labor, which is $w = (1-\alpha)A(\frac{I}{L})^{\alpha}$. If the ratio of imported inputs to labor remains constant, the growth of the real wage is equal to the growth of factorial productivity. On the other hand, the same production function may be used to minimize the cost function WL+P^eI, where W is the nominal wage and P^e the price of foreign inputs. Again, if there is perfect competition, the nominal price of output is given by the equation $P = \frac{P^{e\alpha}W^{1-\alpha}}{ZA}$, where z is a constant. The equation of inflation is $\pi = -ga + \alpha\Delta\log(P^e) + (1-\alpha)\Delta\log(W)$, where ga is the growth of productivity. The equation of inflation is very similar to the one proposed in this work. At the same time, for a given inflation, the growth of the nominal wage is equal to ga. If that were the case, in the terminology of this paper β_{0a}=-γ_{0a}=ga.

$\frac{d\pi}{d\Delta W_{ei}} = \gamma_{2a} < 1$ (8)

When the rate of growth of the minimum wage and the same concept for foreign prices are independent of inflation, the slope of the wage Phillips curve (pcu) is always greater than the slope of the equation of inflation (ei).
In this case, the reduced forms for price and wage inflation are:

$\pi = \frac{\gamma_{0a}+\gamma_{2a}\beta_{0a}+\gamma_{2a}\beta_{3a}\Delta W_m+\gamma_{3a}\Delta P^e+\gamma_{2a}\beta_{4a}u}{(1-\gamma_{2a}\beta_{2a})}$ (9)

$\Delta W = \frac{\beta_{0a}+\beta_{2a}\gamma_{0a}+\beta_{2a}\gamma_{3a}\Delta P^e+\beta_{3a}\Delta W_m+\beta_{4a}u}{(1-\gamma_{2a}\beta_{2a})}$ (10)

Therefore, the rate of growth of real wages is

$\Delta W - \pi = \frac{(\beta_{0a}(1-\gamma_{2a})-\gamma_{0a}(1-\beta_{2a}))-\gamma_{3a}(1-\beta_{2a})\Delta P^e+\beta_{3a}(1-\gamma_{2a})\Delta W_m+\beta_{4a}(1-\gamma_{2a})u)}{(1-\gamma_{2a}\beta_{2a})}$ (11)

Both price inflation and wage inflation depend upon positively on the rate of growth of the nominal minimum wage and in foreign inflation and negatively on the rate of unemployment. The rate of growth of the real wage depends upon positively on the rate of growth of the nominal minimum wage and negatively in both foreign inflation and the rate of unemployment. Reducing inflation through higher unemployment also reduces the rate of growth of the real wage.

Graphically, an increase in the rate of unemployment would shift the wage Phillips curve (equation (3)) to the left in figure 1, generating a reduction in both wage and price inflation.
I.2.- The classical case: complete adjustment of all nominal variables
When the last term of equations (5) and (6) are strict equalities, there is complete nominal adjustment of wage inflation to price inflation and the rate of growth of the nominal minimum wage in equation (3) and the same concept for price inflation to wage inflation and foreign inflation in equation (4). If furthermore, the rate of growth of the minimum wage is equal to wage inflation and foreign inflation is equal to price inflation $\Delta W_m = \Delta W;\ \Delta P^e = \pi$, equations (3) and (4) become

$\Delta W = \pi + \frac{\beta_{0a}+\beta_{4a}u}{(1-\gamma_{3a})}$ (12)

$\pi = \Delta W + \frac{\gamma_{0a}}{(1-\gamma_{3a})}$ (13)

Therefore

$u = -\frac{1}{\beta_{4a}}(\frac{(1-\gamma_{3a})\beta_{0a}+(1-\beta_{3a})\gamma_{0a}}{(1-\gamma_{3a})})$ (14)

Equilibrium unemployment is independent of inflation. (14) is an equation of the natural rate of unemployment. Since the parameter β_4a is negative, equilibrium unemployment increases whenever the independent components of the wage Phillips curve and the equation of inflation rise. Even if β_{0a} reflected the growth of productivity and were equal to -γ_0, changes in the rate of productivity could still change equilibrium unemployment, since the weights (1-γ_3a) and (1-β_3a) are not necessarily equal among them.

I.3.-Incomplete nominal adjustment of endogenous variables with complete nominal adjustment of the exogenous ones.
In this case equations (5) and (6) show strict inequalities. However, there will be complete adjustment of the exogenous nominal variables to wage inflation and price inflation, in such a way that $\Delta W_m = \Delta W;\ \Delta P^e = \pi$
Therefore, equations (3) and (4) become

$\Delta W = \frac{\beta_{0a}+\beta_{2a}\pi+\beta_{4a}u}{(1-\beta_{3a})}$ (15)

$\pi = \frac{\gamma_{0a}+\gamma_{2a}\Delta W}{(1-\gamma_{3a})}$ (16)

Complete adjustment of the exogenous nominal variables may break the stability of equilibrium,since now in the plane where price inflation is the vertical axis and wage inflation is in the horizontal one, the slope of the wage Phillips curve (15) is not necessarily higher than the slope of the equation of inflation (16).

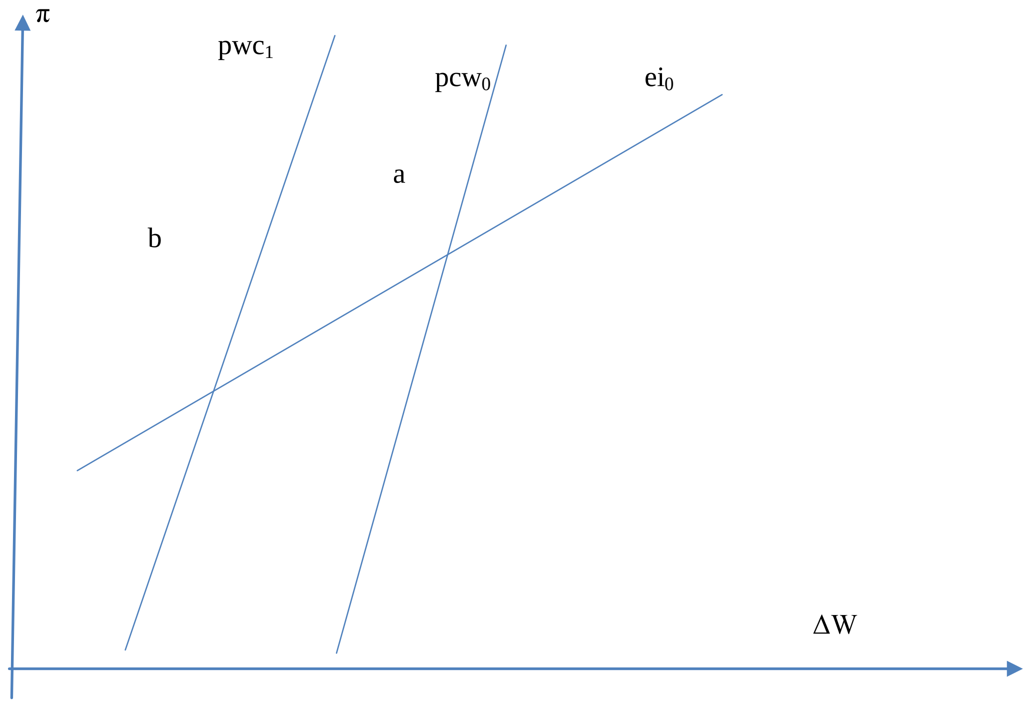
The slopes of equations (15) and (16) are:

$$\frac{d\pi}{d\Delta W_{pcw}} = \frac{(1-\beta_{3a})}{\beta_{2a}} \quad (17)$$

$$\frac{d\pi}{d\Delta W_{ei}} = \frac{\gamma_{2a}}{(1-\gamma_{3a})} \quad (18)$$

The fact that β_{xa} x=2,3 and γ_{xa}; x=2,3 are lower than one does not guarantee any more that the stability condition holds. If the model is stable, there is a long run tradeoff between inflation and unemployment, which can be seen in figure 2.

Figure 2: An increase in the unemployment rate under stability and perfect indexation



The original equilibrium is in a. An increase in the rate of unemployment shifts the wage Phillips curve to the left. The final stable equilibrium is in b, with lower inflation and lower increase in wages.

The case where there is complete nominal adjustment of the endogenous variables, but incomplete nominal adjustment of the nominal exogenous variables, provides similar results to the case where there is incomplete nominal adjustment in all variables.

II.- Estimation of the wage Phillips curve and the equation of inflation in México.

This section presents an estimation of equations (3) and (4) in México using quarterly data. In real life the mechanism of transmission of independent variables to dependent variables is not immediate, it takes time and sometimes dynamics may be relatively complex. For that reason, we estimate the structural equations (3) and (4) as ARDL (autorregresive distributive lag) stochastic processes. This econometric technique was originally developed by Pesaran and Shin (1998) and Pesaran, Shin and Smith (2001). Using it, it is possible to recover the long run effects of independent variables into dependent ones.

The ARDL version of equation (3), the wage Phillips curve, is

$$\Delta W_t = \beta_0 + \sum_{i=1}^{m_1} \beta_{1i}\, \Delta W_{t-i} + \sum_{i=0}^{m_2} \beta_{2i}\pi_{t-i} + \sum_{i=0}^{m_3} \beta_{3i}\Delta W_{mt-i} + \sum_{i=1}^{m_4} \beta_{4i} u_{t-i} + v_t (19)$$

Where v_t is a disturbance term that ideally should be normally distributed, with zero mean and constant variance.

The variable in the left side of the correspondent equation depends upon lags of itself and the contemporary value of independent variables, as well as several lags of them.

In different econometric packages, for instance in E-Views 11, there is a computational routine to determine the lags of both the dependent variable and the independent variables. The aim in this case is to minimize the Akaike criteria.[10]

The term m_1 is the number of lags of the dependent variable in the equation. m_x with x from 2 to 4 shows the number of lags correspondent to the independent variables.

For the process to be stable, a necessary condition is $\sum_{i=1}^{m1} \beta_{1i} < 1$. That is to say the sum of the coefficients of the lags of the dependent variable must be lower than one.

The long run solution for ΔW in equation (19) is

$\Delta W = \beta_{0a} + \beta_{2a}\pi + \beta_{3a}\Delta W_m + \beta_{4a}u$(20), which is exactly equal to the theoretical equation (3).

When the stochastic process (19) is stable:

$$\beta_{0a} = \frac{\beta_0}{(1-\sum_{i=1}^{m1}\beta_{1i})} \quad (21)$$

$$\beta_{2a} = \frac{\sum_{i=0}^{m2}\beta_{2i}}{(1-\sum_{i=1}^{m1}\beta_{1i})} \quad (22)$$

$$\beta_{3a} = \frac{\sum_{i=0}^{m3}\beta_{3i}}{(1-\sum_{i=1}^{m1}\beta_{1i})} \quad (23)$$

$$\beta_{4a} = \frac{\sum_{i=0}^{m4}\beta_{4i}}{(1-\sum_{i=1}^{m1}\beta_{1i})} \quad (24)$$

On the other hand, the ARDL version of the equation of inflation (4) is

$$\pi_t = \gamma_0 + \sum_{i=1}^{j_1}\gamma_{1i}\pi_{t-i} + \sum_{i=0}^{j_2}\gamma_{2i}\Delta W_{t-i} + \sum_{i=0}^{j_3}\gamma_{3i}\Delta P_{t-i}^e + \zeta_t (25)$$

Where ζ_t is again a disturbance term normally distributed with zero mean. The term j_1 is the number of lags of the dependent variable in equation (25). The terms j_x with x=2,3 represents the number of lags of the independent variables in the same equation.

As in the case of the wage Phillips curve, in the empirical equation of inflation this one depends upon lags of itself and the contemporary values and lags of wage and foreign inflation.
The long run solution for π is:
$\pi = \gamma_{0a} + \gamma_{2a}\Delta W + \gamma_{3a}\Delta P^e$ (26), which is exactly equal to the theoretical equation (4)
The stochastic process (25) needs the necessary condition for stability $\sum_{i=1}^{j1}\gamma_{1i} < 1$.
If (25) is stable, the long run effects of the independent variables in the dependent one are:

$$\gamma_{0a} = \frac{\gamma_0}{(1-\sum_{i=1}^{j}\gamma_{1i})} \quad (27)$$

$$\gamma_{2a} = \frac{\sum_{i=}^{j2}\gamma_{2i}}{(1-\sum_{i=1}^{j1}\gamma_{i1})} \quad (28)$$

$$\gamma_{3a} = \frac{\sum_{i=}^{j3}\gamma_{3i}}{(1-\sum_{i=1}^{j1}\gamma_{i1})} \quad (29)$$

Equations (19) and (25) conform the model to be estimated. Equations (20) and (26) conform the long run model of inflation and wages, equal to the theoretical equations (3) and (4).

Equations (19) and (25) are estimated with quarterly data from the first quarter of 2005 to the first quarter of 2020.[11] All variables are seasonally adjusted with the method ARIMA X-13. Inflation π is the so-called underlying inflation, which excludes prices of energy and some prices of food.[12]

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[10]The Akaike criteria balances the goodness of fit with the number of parameters. It prizes the goodness of fit and punishes the number of parameters, reaching an optimal number of lags when the Akaike statisticreaches a minimum value.
[11] It is not possible to perform the analysis before because there is not information for the rate of unemployment and the manufacturing wages.
[12] In Spanish is called inflaciónsubyacente.

Wages are those of the manufacturing industry, which are the ones that are published more frequently. Foreign prices take the nominal exchange rate and the consumer price index of the US that also excludes energy and some prices of food. Minimum wage is the official one in México and the unemployment rate is national one.

Except from the exchange rate, the minimum wage and the price index of the US, all other variables are published in the system called BIE of INEGI.[13] The exchange rate and the minimum wage were obtained in the data system SIE of Banco de México, the central bank and the price index of US is obtained in the data set of BLS.[14]

One problem in the estimation is that there is clearly simultaneity in equations (19) and (25). Therefore, a simple estimation through ordinary least squares (OLS) may yield inconsistent estimators. To avoid this problem, first we estimate the model under OLS, which is convenient because it provides the dynamic structure of the stochastic processes, namely the optimal number of lags. Then, using this structure proposed by the OLS estimation, we estimate a model under the generalized method of moments (GMM), using lags of the independent and dependent variables as instruments. If the disturbance term is with noise, it should not be correlated with the instruments, then estimations would be consistent.

Table 1 shows the estimators of the ARDL form of the wage Phillips curve (equation (19)).

Table 1: Estimation of the short run Phillips curve for wages. Equation (19)

Dependent variable ΔW_t quarterly logarithmic change in nominal wages
Quarterly data starting in the first quarter of 2005[15]
t statistic in parentheses
ARDL (4,0,0,0)[16]

	OLS	GMM
Constant β_0	0.03 (4.2***)	0.03 (6.1***)
ΔW_{t-1} (β_{11})	-0.17 (-1.3)	-0.32 (-2.6**)
ΔW_{t-2} (β_{12})	-0.27 (-2.5**)	-0.19 (-2.3**)
ΔW_{t-3} (β_{13})	-0.26 (-2.5**)	-0.28 (-4.0***)
ΔW_{t-4} (β_{14})	-0.15 (-1.5)	-0.19 (-2.2**)
π_t (β_{20})	0.82 (2.9***)	0.85 (2.2**)
ΔW_{mt} (β_{30})	0.05 (1.1)	0.08 (1.6)
u_t (β_{40})	-0.004 (-3.5***)	-0.004 (-5.0***)
R^2	0.35	0.37
F	3.6	-
DW	2.23	2.03
Box Ljung statistic ($X^2(24)$)	36.2	32.5
J statistic (probability of orthogonality in parentheses)	-	3.0 (0.88)
Sargan instrumental validity test $X^2(7)$	-	2.2

[13] BIE: Banco de Información Económica; INEGI: Instituto Nacional de Estadística y Geografía.
[14] SIE: Sistema de información económica; BLS: Bureau of Labor Statistics.
[15] Given the lags and the instruments, the OLS estimation starts in the second quarter of 2006 and the GMM estimation starts in the third quarter of 2006.
[16] The nomenclature of ARDL models is ARDL (x_1, x_2, …x_n), where x_1 is the number of lags of the dependent variable and x_j, from j 2 to n represents the number of lags of the independent variables.

*Significant at 90% of confidence
** Significant at 95% of confidence
*** Significant at 99% of confidence
R^2: Coefficient of determination
F: Fischer statistic
OLS: Ordinary least squares method
GMM: Generalized method of moments method
DW: Durbin-Watson statistic
Box-Ljung statistic of the correlogram
J statistic of the orthogonality of residuals and instruments in the GMM estimation
Instruments for the GMM estimation: ΔW_{t-x}: x: 1 to 5; ΔW_{mt-x}: x: 1,2,5; π_{t-x}: x: 1,4,5,7,8; u_{t-1}

On the other hand, table 2 shows the estimated long run effects of the independent variables on the dependent one.

Table 2: Long run values of the wage Phillips curve. Equation (3) and (20)
t statistic in parentheses
Quarterly data

t statistic in parentheses

	OLS	GMM
Constant (β_{0a})	0.016 (5.6***)	0.016 (5.2***)
π (β_{2a})	0.44 (3.2***)	0.43 (2.6**)
ΔW_m (β_{3a})	0.03 (1.2)	0.04 (1.6)
u (β_{4a})	-0.002 (-4.1***)	-0.002 (-4.4***)
Wald t test for the classical assumption of $\beta_{2a}+\beta_{3a}=1$	-4.0***	-3.5***
Pesaran, Shin, Smith´s F statistic	8.1***	-

*Significant at 90% of confidence
** Significant at 95% of confidence
*** Significant at 99% of confidence
OLS: Ordinary least squares method
GMM: Generalized method of moments method

Table 3 shows the estimators of the equation of inflation (equation (25))

Table 3: Estimation of the equation of inflation. Equation (25)

Dependent variable: Price inflation in quarterly terms
t statistic in parentheses
Quarterly data starting in the first quarter of 2005 finishing in the first quarter 2020[17]
t statistic in parentheses
ARDL (4,0,2)

	OLS	GMM
Constant γ_0	0.002 (2.0*)	0.002 (1.6)
π_{t-1} (γ_{11})	0.63 (5.2***)	0.61 (5.8***)
π_{t-2} (γ_{12})	-0.12	-0.19

[17] Given the lags and the instruments the OLS estimation starts in the second quarter of 2005 and the GMM estimation starts in the fourth quarter of 2007.

	(-0.9)	(-2.4**)
π_{t-3} (γ_{13})	0.43 (3.2***)	0.44 (5.0***)
π_{t-4} (γ_{14})	-0.33 (-2.7***)	-0.25 (-2.4**)
ΔW_t (γ_{20})	0.1 (2.7***)	0.2 (2.3**)
ΔP_t^e (γ_{30})	-0.004 (-0.8)	-0.008 (-1.0)
ΔP_{t-1}^e (γ_{31})	0.007 (1.5)	0.009 (3.2***)
R^2	0.56	0.64
F	9.5	-
DW	1.89	1.79
Box Ljung statistic (X^2(24))	28.4	24.3
J statistic (probability of orthogonality in parentheses)	-	3.3 (0.86)
Sargan instrumental validity test X^2(7)	-	3.8

*Significant at 90% of confidence
** Significant at 95% of confidence
*** Significant at 99% of confidence
R^2: Coefficient of determination
F: Fischer statistic
OLS: Ordinary least squares method
GMM: Generalized method of moments method
DW: Durbin-Watson statistic
Box-Ljung statistic of the correlogram
J statistic of the orthogonality of residuals and instruments in the GMM estimation
Instruments for the GMM equation: πt-x: x: 1 to 4; ΔP^e_{t-x}: x: 1, 2; ΔW_{t-x}: x: 1 to 7 and 10
Finally, table 4 shows the long run effects of the independent variables of the equation of inflation on this variable.

Table 4: Long run values of the equation of inflation. Equation (4) and (26)
t statistic in parentheses
Quarterly data from the second quarter of 2006 to the first quarter of 2020
t statistic in parentheses

	OLS	GMM
Constant (γ_{0a})	0.006 (3.7***)	0.004 (1.9*)
ΔW (γ_{2a})	0.25 (2.1**)	0.38 (2.1**)
ΔP^e (γ3a)	0.008 (0.5)	0.005 (0.3)
Wald t for the classical assumption $\gamma_{2a}+\gamma_{3a}=1$	-6.1***	-3.2***
Pesaran, Shin, Smith´s F statistic	4.7**	-

*Significant at 90% of confidence
** Significant at 95% of confidence
*** Significant at 99% of confidence
OLS: Ordinary least squares method
GMM: Generalized method of moments method

Many of the estimators generated by OLS are similar to the estimators produced by GMM. In tables 2 and 4 the Pesaran, Shin, Smith´s F statistic show that at least in the OLS estimations it is possible to reject the null hypothesis that the variables involved in the regression do not generate a long run relation.
Therefore, it is not possible to reject that there is a long run relation between these variables. In general, this implies that the equations follow a stable process.
There are several striking results:

In both the wage Phillips curve and the equation of inflation it is possible to reject the classical assumption of complete nominal adjustment (see the Wald t test of tables 2 and 4). Moreover, in the wage Phillips curve it is not possible to reject that the lighthouse effect is zero (see table 2 4throw). The punctual effect of the rate of growth of the nominal minimum wage over wage inflation is between 3% to 4%. Instead, price inflation has a positive and significant effect on wage inflation (punctually around 44%), but the effect is much lower than one (see table 2).

In the equation of inflation, the effect of foreign inflation has the correct sign, but it is completely insignificant. It is not possible to reject that between 2005 and 2020 the so-called passthrough of foreign prices to domestic prices in México is zero, or close to that number.[18] On the other hand, the long run effect of wageinflation to price inflation is positive and significant but relatively low, between 25% and 40% (see table 4).

Unemployment has a long run negative and significant effect on wage inflation, as theoretical models propose. The effect is low, nonetheless. A reduction of 1 percentage point in the rate of unemployment increases wage inflation by 0.2% in quarterly terms, which would be around 0.8% in annual terms (see table 2).

Perhaps the most important result of the empirical estimation is that the nominal adjustment of wage and price inflation to their determinants is incomplete, which quite possibly will generate a long run tradeoff between inflation and the rate of growth of real wages with unemployment.

III.- The long run price-wage adjustment mechanism in México.

The two estimated equations for México in the long run,which emerge from tables 2 and 4 in the GMM estimation are:

$\Delta W = 0.016 + 0.43\pi + 0.04\Delta W_m - 0.002u$ Phillips curve in wages (30)

$\pi = 0.004 + 0.38\Delta W + 0.005\Delta P^e$ Equation for inflation (31)

According to the theoretical section I of this work, the estimated model is stable since:

$\frac{d\pi}{d\Delta W_{pcw}} = 2.33$ (32)

$\frac{d\pi}{d\Delta W_{ei}} = 0.38$ (33)

In the plane where price inflation is in the vertical axis and wage inflation is in the horizontal one, the slope of the wage Phillips curve (32) is much higher than the slope of the equation of inflation (33).

The reduced forms for the system of equations (30) and (31) are:

$\Delta W = 0.0211 + 0.048\Delta W_m + 0.0025\Delta P^e - 0.0024u$ (34)

$\pi = 0.012 + 0.018\Delta W_m + 0.006\Delta P^e - 0.00091u$ (35)

Equation (35) could be considered as a type of Phillips curve of prices, where inflation is negatively related to unemployment.

Using (34) and (35) it is possible to get the reduced form for the rate of growth of the real wage

$\Delta W - \pi = 0.0091 + 0.03\Delta W_m - 0.0035\Delta P^e - 0.0015u$ (36)

An increase in one point in the rate of unemployment reduces inflation by 0.091 percentage points in quarterly terms, which is approximately 0.36 percentage points per year. It reduces the rate of growth of the real wage in 0.6 percentage points also in annual terms. Real wages and inflation seem to be both quite rigid, which means an almost horizontal Phillips curvein prices.

[18]Different studies have demonstrated that the passthrough of the exchange rate to prices in México has declined considerably (see for example Cortés Espada (2013) and Tunc (2017)).

An interesting case to study, considering the incomplete nominal adjustment found, is the one where there is a complete nominal adjustment of the rate of growth of the nominal minimum wage to wage inflation and of foreign inflation to price inflation, in such a way that $\Delta W_m = \Delta W;\ \ \Delta P^e = \pi$.

In this case, the structural form of the model in equations (30) and (31) becomes:

$\Delta W = 0.01666 + 0.448\pi - 0.0021u$ (37)

$\pi = 0.004 + 0.382\Delta W$(38)

Where (37) is the wage Phillips curve under perfect indexation of the exogenous variables of the model and (38) is the equation of inflation under the same circumstances.

It is possible to corroborate that this model is stable, since in the plane where price inflation is in the vertical axis and wage inflation is in the horizontal one, the slope of the wage Phillips curve(37) is greater than the same concept for the equation of inflation (see equation (39))

$\frac{d\pi}{d\Delta W}_{pcw} = 2.23 > \frac{d\pi}{d\Delta W}_{ei} = 0.382$ (39)

In this case, the reduced forms for price and wage inflation are

$\Delta W = 0.0223 - 0.0025u$ (40)

$\pi = 0.0125 - 0.00097u$ (41)

And therefore, the reduced form for the rate of growth of the real wage is

$\Delta W - \pi = 0.0098 - 0.00153u$(42)

As we have seen in the theoretical section of this work, when the model is stable, there is a long run tradeoff of inflation and the rate of growth of real wages with unemployment. Banco de México, the central bank of the country, has a 3% annual target of inflation. However, in the last years the average inflation has been greater, near to 4%. Using the reduced system under perfect indexation of the exogenous nominal variables of the model, conformed of equations (40) to (42), it is possible to see than reaching the targeted inflation in México would generate an equilibrium unemployment of 5.2% and an annual rate of growth of real wages of around 0.7%.

The equilibrium unemployment found under the targeted inflation is higher than the average rate of unemployment of the last years, which is around 4.0%. The rate of growth of real wages under the targeted inflation is lower than the observed one in the last fifteen years, which is around 1.0%.

If instead of targeting inflation at 3% unemployment were targeted in 4%, equilibrium inflation would be 3.5% and the rate of growth of wages would be more than the double of the one when inflation is targeted in 3% (1.5%). That would be a small increase in inflation but would avoid almost 700000 additional people unemployed and in 10 years would increase the real wage 7.5% above the figure when inflation is targeted in 3%.

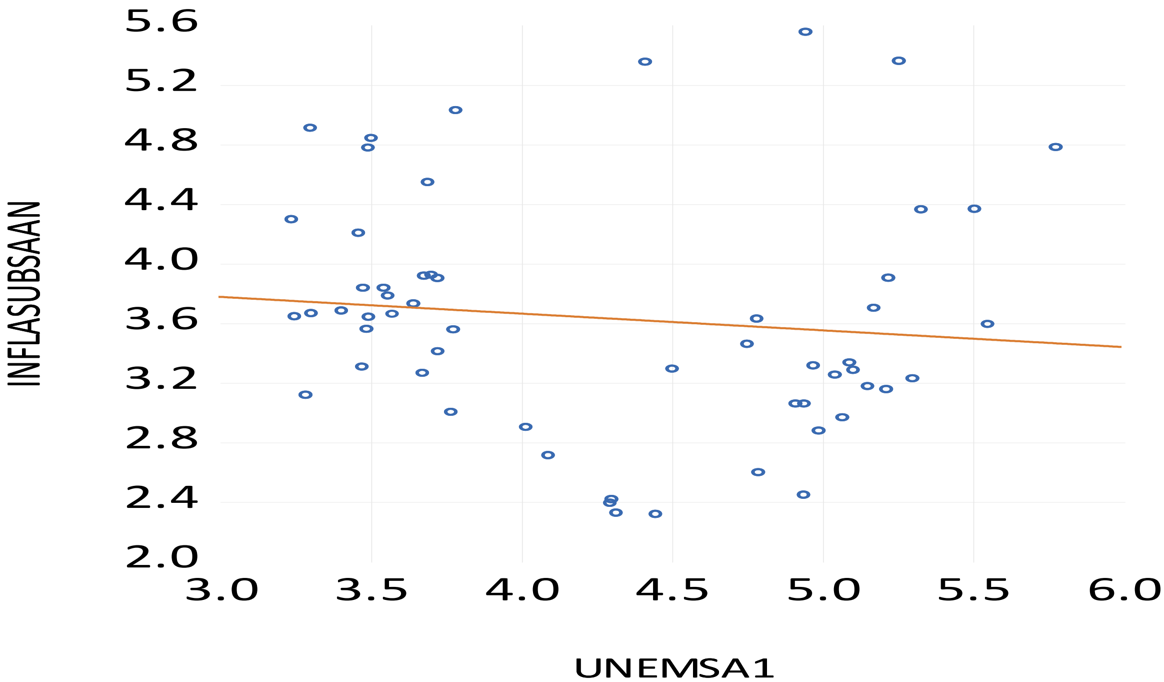
The reason why these results emerge is because the estimated long run Phillips curve is quite flat, which implies that with a very small increase in inflation the rate of unemployment may fall in a considerable way, which also generates a substantial increase in the rate of growth of real wages.

Finally, we show two graphs with observable data:

Graph 1 shows a simple diagram where annual inflation is in the vertical axis and unemployment is in the horizontal one. The regression line is quite flat. The simple correlation between these variables is -0.11 and in fact it is not significant.

Graph 1: The relation between inflation and unemployment in México

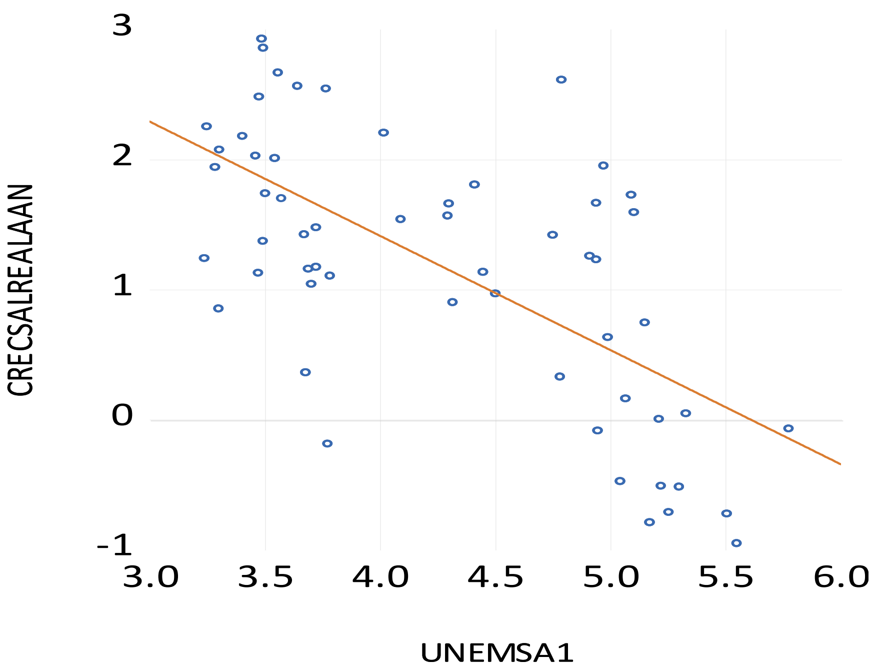
Annual inflation in the vertical axis. Rate of unemployment in the horizontal axis
First quarter in 2006 to first quarter of 2020



Source: BIE-INEGI

|On the other hand, graph 2 shows the relation between the growth of the real wage also in annual terms and the rate of unemployment. The observed relation shows a very significant negative relation with these two variables, where the linear correlation is -0.65

Graph 2: The relation between the growth of the real wage in the manufacturing industry and the rate of unemployment in México
Annual growth of the real wage in vertical axis. Rate of unemployment in the horizontal axis



Source: BIE-INEGI

Conclusions

Several studies in the last twenty years have concluded that the behavior of people under low inflation is different that under high inflation. For this reason, in a low inflation environment the old inflation-unemployment tradeoff proposed by Phillips in 1958 might re-emerge even as a long run relation.[19]

This paper proposes a partial equilibrium model where wage and price inflation are determined endogenously. The model predicts that under imperfect nominal adjustment of the endogenous variables and the same concept for the exogenous nominal variables (the rate of growth of the nominal minimum wage and foreign inflation) there will be a long run tradeoff between inflation and unemployment of the type proposed by Phillips (1958). The same model shows that when there is incomplete nominal adjustment of the endogenous variables, but perfect indexation of the exogenous nominal variables to the endogenous, the described long run tradeoff may still survive.

An empirical estimation of ARDL versions of the equations of the theoretical model for México for the last fifteen years, strongly rejects the null hypothesis of complete nominal adjustment of wage and price inflation to the rate of growth of the nominal minimum wage and foreign inflation. Therefore, we cannot reject a long run tradeoff between inflation and unemployment in that country nowadays.

The empirical study shows another important long run tradeoff, which operates between the rate of growth of the real wage and the rate of unemployment. Given the empirical results, both tradeoffs described survive even in the extreme case of perfect indexation of the rate of growth of the nominal minimum wage to average wage inflation, and of foreign inflation to domestic price inflation.

The estimated model predicts that if Banco de México, the central bank of this country, reaches its targeted inflation of 3% , it will generate a long run rate of unemployment higher than 5% and an increase in real wages of about 0.7% in annual terms. However, in the last years the rate of unemployment has been near to 4% and the rate of growth of real wages has been around 1.0% per year. Reaching the central bank target would have a considerable cost in terms of a loss of welfare for many workers in the country.

The results of this paper are similar to those of Akerlof et al (2000), Blanchard, Cerutti and Summers (2015) and Galí and Gambetti(2018) for the US and pose a question on the role of monetary policy and, specifically, over inflation targeting. If the long run Phillips curve is as flat as these works show, wouldn´t be better for central banks to target unemployment instead of inflation? That is an open question. Perhapsin the near future other works will challenge the results of this article. In any case I would be delighted if there is a serious discussion on the topic.

References

Akerlof, G and J. Yellen (1985). A near rational model of the business cycle with wage and price inertia. *Quarterly Journal of Economics*, 100, pp. 823-838.

Akerlof, G, W. Dickens and G. Perry (1996). The macroeconomics of low inflation. *Brookings Paper on Economic Activity*, 1, pp. 1-75.

Akerlof, G, W. Dickens and G.Perry (2000). Near rational wage and price setting and the long run Phillips curve. *Brookings Papers on Economic Activity*, 1, pp. 1-44.

Blanchard, O (1986). The wage price spiral. *NBER Working Paper 1771*. National Bureau of Economic Research.

Blanchard, O (1990). Why does money affect output? *Handbook of Monetary Economics*, 2, B. Friedman y F. Hahn (editores). North Holland.

Blanchard, O (2008). The state of macro. *NBER Working Paper 14259*. National Bureau of Economic Research.

Blanchard, O (2016). The Phillips curve: back to the 60´s? *American Economic Review*, Papers and Proceedings, 106, pp.31-34.

Blanchard, O (2018). Should we reject the natural rate hypothesis? *Journal of Economic Perspectives*, 32, pp. 97-120.

Blanchard, O and L. Katz (1997). What we know and do not know about the natural rate of unemployment. *Journal of Economic Perspectives*, 11, pp. 51-72.

Blanchard, O, E.Cerutti and L.Summers (2015). Inflation and activity: two explorations and their monetary implications. *IMF Working Paper/15/230*. International Monetary Fund.

Blanchflower, D and A. Oswald (1994). *The Wage Curve*. The MIT Press. Cambridge, Massachusetts.

[19]Akerlof et al (1996) (2000), Graham and Snower (2002),Galí (2011), Blanchard, Cerutti and Summers (2015), Blanchard (2016) (2018), Galí and Gambetti (2018).

Campos, R and G. Esquivel (2020). The effect of doubling the minimum wage and decreasing taxes on inflation in México. *Economic Letters*, 189, pp. 1-4.

Cortés Espada J.F (2013). Estimating the Exchange rate pass-through to prices in México. *Monetaria*1, pp. 287-316.

Flaschel, P and H.M Krolzig (2002). Wage and price Phillips curve: An empirical analysis of destabilizing wage-price spirals. Mimeo. It can be found in http://citeseerx.ist.psu.edu/viewdoc/summary?doi=10.1.1.199.9112

Friedman, M. (1968). The Role of Monetary Policy, *American Economic Review*, 58, pp. 1-17.

Galí, J (2011). The return of the wage Phillips curve. *Journal of European Economic Association*, 9, 436-461.

Galí, J and L. Gambetti (2018). Has the US wage Phillips curve flattened? A semi structural exploration. *NBER Working Paper 2547*. National Bureau of Economic Research.

Gordon, R (1997). The time varying NAIRU and its implications of economic policy. *Journal of Economic Perspectives*, 11, pp. 11-32.

Gordon, R (2013). The Phillips curve is alive and well: Inflation and the NAIRU under the slow recovery. *Working Paper 19390*. National Bureau of Economic Research.

Graham, L and D. Snower (2002). The return of the long-run Phillips curve. *IZA Discussion Paper 646*. Institute for the Study of Labor (IZA).

King, R (2000). The new IS-LM model: language, logic and limits, *Economic Quarterly*, Federal Reserve Bank of Richmond, 86/3, pp. 45-103

Koenig, E (2008). Keynesian economics without the LM and IS curves: A dynamic generalization of the Romer-Taylor model. *Research Department Working Paper 0813*. Federal Reserve Bank of Dallas.

Lucas, R (1972). Expectations and the neutrality of money. *Journal of Economic Theory*, 4, pp.103-124.

Maloney, W and J. Méndez (2004). Measuring the impact of minimum wages. Evidence from Latin America. *Law and Employment: Lessons from Latin America*. J. Heckman and C. Pagés (editors). University of Chicago Press.

Mankiw, N.G (1985). Small menu costs and large business cycle: A macroeconomic model of monopoly. *Quarterly Journal of Economics*, 100, pp. 529-539.

McCallum B. and E. Nelson (1999). An optimizing IS-LM specification for monetary policy and business cycle analysis, *Journal of Money, Credit and Banking*, 31, 3, pp. 296-316

Pesaran, H and Y.Shin (1998). An autorregresive distributive lag modelling approach to cointegration analysis. *Econometrics and Economic Theory in the 20th Century: The Ragnar Frisch Centennial Symposium*. Strom S (editor). Cambridge University Press.

Pesaran, H, Y.Shin and R. Smith (2001). Bound testing approaches to the analysis of level relationships. *Journal of Applied Econometrics*, 16, pp. 289-326.

Phelps, E. (1967). Phillips Curves, expectations of inflation and optimal unemployment over time, *Economica*, 34, pp. 254-281.

Phillips, A.W (1958). The relation between unemployment and the rate of change of money wage rate in the United Kingdom, 1861-1997. *Economica*, 25, pp. 283-299

Romer, D (2000). Keynesian macroeconomics without the LM Curve, *Journal of Economic Perspectives*, 14, pp. 149-169.

Roberts, J (1997). The wage curve and the Phillips curve. *Finance and Economics Discussion Paper Series* 1997/57. Board of Governors of the Federal Reserve Bank.

Taylor, J (2000) Teaching modern macroeconomics at the principles level. *American Economic Review*, 90-2, pp. 90-94.

Tobin, J (1972). The wage price mechanism: Overview of the conference, en O. Ekstein (ed.) *The Econometrics of Price Determination*, Board of Governors of the Federal Reserve Bank.

Tunc, C (2017). A survey on exchange rate pass through in emerging markets. *Bulletin of Economic Theory and Analysis*, 2, pp. 205-233.

Whelan, K (1997). Wage Curve vs Phillips Curve: Are there Macroeconomic Implications? *Finance and Economic Discussion Papers* Series: 1997/51. Board of Governors of the Federal Reserve System.

Woodford, M (2001). The Taylor Rule and optimal monetary policy, *American Economic Review*, 2, pp. 232-237.

Data sets

Banco de México. https://www.banxico.org.mx/ Consulted in August 2020

SIE data set: https://www.banxico.org.mx/SieInternet/ Consulted in August 2020

Bureau of Labor Statistics (BLS). https://www.bls.gov/ Consulted in August 2020

Data tools top picks: https://data.bls.gov/cgi-bin/surveymost?bls Consulted in August 2020

Instituto Nacional de Estadística y Geografía (INEGI). https://www.inegi.org.mx/

BIE data set: https://www.inegi.org.mx/app/indicadores/bie.html