011. HOW DO PRODUCTIVITY, MINIMUM WAGE AND EXOGENOUS VARIABLES AFFECT URBAN UNEMPLOYMENT IN ECUADOR?

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Abstract—

Ecuador's 2016 recession demonstrated the vulnerability of its economy due to volatility of exogenous variables such as oil prices and US dollar exchange rate. Additionally, annual increases in the minimum wage and labor productivity growth had an impact on the labor market during the last decade. This research estimates the effects of labor productivity, real minimum wage and exogenous factors—oil prices and US dollar exchange rate—in Ecuador's urban unemployment rate between June 2007 and June 2017. The main conclusions of this study are as follows: i) a reduction of oil prices and an appreciation of the US dollar cause an increase in the urban unemployment rate; ii) an increase in the real minimum wage, not taking into account labor productivity, provokes an increase in the urban unemployment rate; iii) an increase in labor productivity generates a decrease in the urban unemployment rate; iv) finally a distributed lag model including these four variables explains 68% of the change in the urban unemployment rate between 2007 and 2017.

***JEL Classification*:** E24; J08; J64; J68.

Keywords: Unemployment, Minimum Wage, Productivity, Exogenous Variables, Stepwise Regression, Distributed Lag Model.

1. INTRODUCTION

Ecuador's economy benefited from high oil prices in the past decade. However, crude oil prices registered two considerable drops between 2007 and 2017: the first one from October 2008 to September 2009 due to the financial crisis in the United States, and then as of October 2014. Nevertheless, between January 2007 and December 2015, Ecuador's oil price in real terms was higher than the previous 7 years. In fact, its quarterly average price in real terms between January 2007 and December 2015 was 46.62% higher than the average registered between January 2000 and December 2006.

The public revenue generated from oil exports and public debt was channeled primarily through government investments also known as capital expenditure. Both capital and current expenditure allowed the government to become the main engine of the Ecuadorian economy. However, this development strategy implies greater vulnerability in the case of a sharp decline in oil prices.

Capital expenditure is financed mainly by external debt and oil revenue. The latter is characterized for being volatile due to large fluctuations in its price. Between 2007 and 2016, this volatility was clearly perceived. In nominal terms, oil exports amounted to USD 7,428 million during the first year of President Correa's administration. This revenue reached its lowest point in December 2009 when crude oil exports dropped to USD 6,284 million; however, oil revenue reached its maximum in December 2013 at USD 13,412 million. Similarly, capital expenditure experienced a high level of volatility in the past decade. In the first year of the Correa administration in December 2007, the annual capital expenditure was at USD 2,627.5 million and reached its maximum of USD 11,812.4 million in December 2014. In December 2017, this amount was only 8,681.5 million.

Oil price volatility has been Ecuador's main economic risk due to the considerable influence of government expenditure in the country's economic activity. In nominal terms, the Ecuadorian crude oil price has had an average monthly price of USD 70.66 per barrel between January 2007 and June 2017. However, its maximum monthly average price was USD 117.36 in June 2008, while its monthly minimum was USD 21.58 per barrel in January 2016. These statistics demonstrate large fluctuations in oil prices and its harmful consequences for the economy in case of high dependence to this commodity.

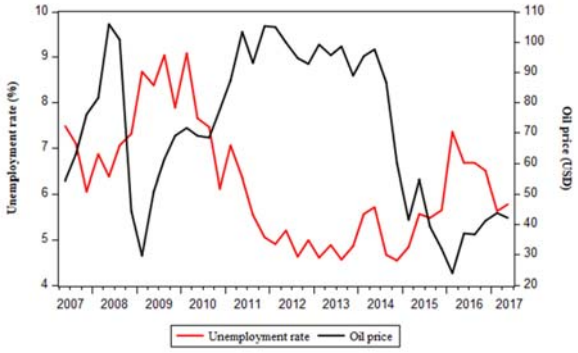
The Ecuadorian economy is not only vulnerable through oil boom and bust cycles, but also from sizeable volatility in the US exchange rate. In fact, another variable outside the control of the Ecuadorian government with a significant impact on the economy is the price of the US dollar. According to Rafael Correa (2009), a dollarized economy with a fixed exchange rate generates negative consequences in the external sector, when local inflation is higher than that of our trading partners or when the latter depreciate their currencies. Correa also argues that a fixed exchange rate impedes Ecuador's economy to stabilize external imbalances caused by exogenous shocks, such as natural disasters and a large reduction in oil prices.

Several analysts and economists have examined the impact of crude oil prices on the Ecuadorian economy, specifically on the performance of the gross domestic product (GDP). These studies find a high correlation between the price of oil and the

evolution of Ecuador's non-oil GDP (González M., 2012). By using statistical methods, González (2012) showed the impact of crude oil price on the country's non-oil GDP above its trend as of 2008. This effect was insignificant before 2005. In addition, González (2015) proved an increase in the correlation between oil price and Ecuador's non-oil economic growth between 2007 and 2012 compared to the first years of dollarization. Both Lucio Paredes (2010) and González (2012) warned in advance about the vulnerability of the Ecuadorian economy in the scenario of sharp drops in oil prices. They also highlighted the importance of having saving funds to counteract the recessive effects of a reduction in crude oil prices. Nevertheless, little research has focused on the impact of exogenous factors on Ecuador's labor market based on econometric evidence.

Quarterly statistics on urban unemployment rate show an inverse relationship with oil price and capital expenditure. In fact, the coefficients of correlation between unemployment and these two variables were negative between June 2007 and June 2017. As shown in Figure 1, the urban unemployment rate tends to decrease when real oil price increases. This inverse relationship does not mean causality; however, it warns about a potential vulnerability in the labor market when oil prices decline.

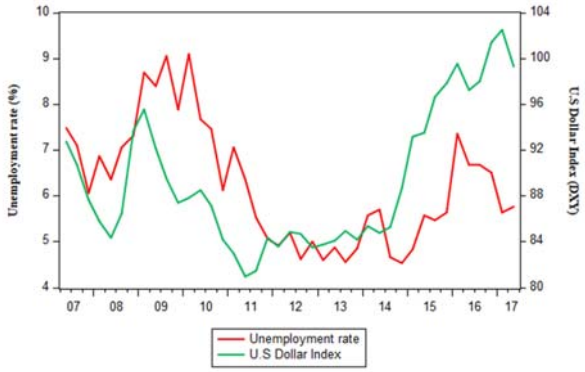
Figure 1. Evolution of urban unemployment rate and real oil price. Quarterly data.



Source: INEC (2018) and Banco Central del Ecuador (2018)

Similarly, the US dollar exchange rate measured through the Real Dollar Index (DXY) had a positive correlation with Ecuador's urban unemployment rate between June 2007 and June 2017. This linear association between both variables shows that the US dollar appreciation is related to an increase in unemployment, which is consistent with Correa's view (2009) and also with the majority of literature analyzed in this paper.

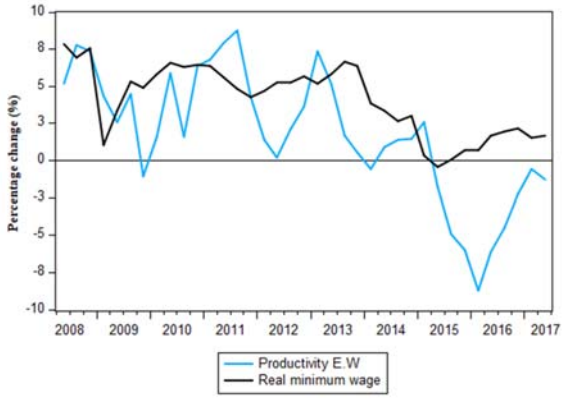
Figure 2. Evolution of urban unemployment rate and real U.S Dollar Index. Quarterly data.



Source: INEC (2018) and Federal Reserve Bank of St. Louis (2018)

Real minimum wage and country's productivity are two key factors with potential sizeable impacts on unemployment rate. Based on economic theory, an increase in minimum wage should decrease labor demand, worsening the unemployment situation. Meanwhile, productivity growth should increase labor demand, reducing the unemployment rate in a country. Figure 3 shows Ecuador's labor productivity growth and percentage change in the minimum wage relative to the same quarter of the previous year. Unfortunately, increases in the minimum wage have not been related to a sustainable growth in productivity. Based on quarterly data, Ecuador's real minimum wage has increased by 4.10% compared to the previous year between June 2007 and June 2017, while the country's productivity level—measured as the ratio between Ecuador's real non-oil Gross Value Added (GVA) and the number of employed workers—reported a 1.78% increase during the same period. In the past decade, the increase in real minimum wage has been on average more than twice larger than the labor productivity growth.

Figure 3. Annual percentage change of real minimum wage and productivity per employed worker.



Source: Banco Central del Ecuador (2018)

Despite the linear associations described previously, it is necessary to use econometric methods to demonstrate causality. Therefore, this study seeks to estimate the impact of labor productivity, ***real minimum wage*** and exogenous factors—oil

prices and US dollar exchange rate—on Ecuador's urban unemployment rate between June 2007 and June 2017. Thus, a distributed lag model is used to estimate the causal and cumulative effects of these four variables on unemployment rate in the short term.

The structure of the study is as follows: Section 2 contains the related empirical literature. Section 3 details the data and estimation strategy. Section 4 shows the empirical results and the policy implications. Finally, section 5 contains the conclusions of the work.

2. RELATED EMPIRICAL LITERATURE

The empirical literature related to this paper is divided into the three potential forces affecting Ecuador's unemployment rate, such as external shocks of commodities prices and exchange rate; increases in the minimum wage; and the country's productivity level. In fact, the regression models presented in this research describes commodity prices as a driver for Ecuador's business cycles, assuming that consumption and investment are procyclical variables. The model also assumes that income increases from a commodity price boom, driving up the domestic demand, raising the relative prices, and generating the appreciation of the country's real exchange rate. However, Ecuador is a particular case regarding its exchange rate fluctuations, because of lacking of local currency due to dollarization. Thus, US dollar fluctuations do not reflect the real state of Ecuador's economy. An initial hypothesis about the US dollar appreciation is its negative impact on the Ecuadorian labor market, which is consistent with the majority of empirical studies.

Another key assumption about the real minimum wage is its negative effect on the unemployment rate, especially when salary increases are not related to the economy's level of productivity. The last assumption is the positive impact that productivity should have in the unemployment rate by increasing the labor demand and reducing the number of unemployed workers. In this paper, these hypotheses were confirmed through the results of a distributed lag model.

2.1. **Exogenous shocks:** Commodity prices and exchange rate fluctuations

Macroeconomic research on emerging markets have done a remarkable effort in trying to understand the importance of external forces. However, there is a small number of studies estimating the impact of external forces on Ecuador's labor market. The findings of Becker and Mauro (2006) revealed that external shocks are an important factor for most countries by analyzing the relationship between output drops and various shock types. In the case of developing countries, they found a positive significant association of likelihood between output drops and real external shocks, especially terms of trade. In the same line thought, the research undertaken by Österholm and Zettelmeyer (2007) measured the sensitivity of Latin American countries to adverse external conditions including financing shocks, external growth shocks and commodity price shocks. These shocks resulted in explaining more than half of the variance (50 to 60 percent) of Latin America's growth rate. Additionally, the authors concluded that commodity prices are still an important factor of fluctuations in the short-term.

Most of the research on external forces in Latin America gives a special emphasis to commodities. Empirical studies suggested that even though Latin American economies do not export the same goods, the effects of changes in commodity prices

affect thoroughly all the countries in the region due to the co-movement of prices. A recent work by Drechsel and Tenreyro (2018) determined that an increase in commodity prices do improve the competitiveness of the economy. Similarly, Fernandez et al. (2018) stated that commodity prices fluctuations often coincide with interest rates changes in opposite directions, amplifying the effects in the real sector.

Regarding the impact of oil price shocks on exporting countries, Maji et al. (2017) performed an input–output analysis in Malaysia, and found that oil price is positively related to employment. Likewise, based on a sample of forty oil exporting countries, Koh (2017) found enough evidence to conclude that a negative oil price shock results in output decline and government consumption reduction. However, the impact on output is relatively smaller in oil exporting countries with a flexible exchange rate, which is not the case of Ecuador. According to the results of this paper, a reduction in oil prices implies an increase in Ecuador's unemployment rate in the short-term.

Additionally, there has been extensive research about the effect of exchange rate on the labor market. Burgess and Knetter (1998) argued that exchange rate fluctuations are significantly related to employment by approximately 30% at the industry level for G-7 countries. This study also concluded that real exchange rate appreciations are frequently related to employment drops in the manufacturing sector. Although this empirical evidence, Burgess and Knetter (1998) found that the employment level in Germany and Japan is substantially less sensitive to exchange rate movements. However, Dekle (1998) determined that exchange rate affects industry-specific prices in Japan, which have a long-run impact on the country's employment.

Consistent with the studies, Gourinchas (1998) found a positive relation between job creation and destruction after a real exchange rate shock. Moreover, Gourinchas (1999) studied the effects of exchange rate movements on job creation and destruction in France between 1984 and 1992. According to Gourinchas, industries in the tradable sector are more sensible to real exchange rate fluctuations. Gourinchas concluded that a 1% appreciation of the real exchange rate is associated with 0.95% destruction of tradable jobs during the following two years in France. Likewise Ribeiro et al. (2004) conducted a study in Brazil's manufacturing industry and found that exchange rate depreciations increase the number of jobs with no effects on employment destruction. In this paper, the results are consistent with these studies regarding the negative effect of an exchange rate appreciation in the labor market. The coefficients on exchange rate shows that a US dollar appreciation implies an increase Ecuador's unemployment rate in the short term.

Other recognized studies find small effects of exchange rate fluctuations on the labor market. Campa and Goldberg (2001) determined that industry wages with lower profit margins are more sensitive to exchange rates swings, especially for export-oriented industries. They also found that the effects of exchange rate on employment and hours worked are smaller and less exactly estimated. Another well-known research was conducted by Klein, Schuh and Triest (2003), in which they estimated the impact of real exchange rates on labor reallocation by applying a method of gross job creation and destruction to U.S. manufacturing industries between 1973 and 1993. The authors found that changes in trend of the real exchange rate does not affect net employment. However, they found that cyclical real exchange rates significantly impact

net employment only via job destruction. A more recent research conducted by Alexandre et al (2009) included variables such as the degree of openness and the technology level. This research showed that employment in highly open low-technology sectors are significantly affected by exchange rate fluctuations, while high-technology sectors are much less vulnerable to currency movements.

In contrast to previous studies, Haltiwanger et al. (2004) found a positive effect of real exchange rate appreciation on net employment growth. Their results showed that the effect of appreciation on employment, albeit positive, is relatively small when GDP growth is considered as a control variable. In fact, the coefficient relating real exchange rate and employment growth turns almost insignificant. The study argued that currency appreciation reduces the cost from imported inputs, while it also provided evidence about a positive relation between investment and labor demand. As a result, a currency appreciation reduces financing costs and enhances capital formation, increasing investment and rising the labor demand.

2.2. Real minimum wage

The effects of minimum wage on employment is still a controversial topic among economists. Under a neoclassical point of view, the dilemma is quite clear: an increase of labor price will reduce labor demand. In contrast, many researchers have found little to no effects on the level of unemployment related to an increase in minimum wage (Zavodny, 2000; Dube, Lester & Reich, 2010, Giuliano, 2013).

Search and matching models show the negative effect of minimum wage on job creation (Cahuc & Zylberberg, 2004). A higher minimum wage motivates extra effort from unemployed workers to find jobs, since the expected returns to employment increases compared to unemployment. This situation leads to an increase of labor supply and improves the matching process. Therefore, the effect of the minimum wage on job creation is uncertain and ambivalent (Meer & West, 2015). On one side, job creation could not be affected by an increase of minimum wage if that motivates workers to do extra effort in job searching, improving search and matching quality of labor market. On the other hand, focusing on the demand side, increasing the minimum wage will discourage hiring labor.

The literature on minimum wage effects on employment was transformed by the findings of Sorkin (2013, 2015) and Meer and West (2015) in two essential aspects. First, Sorkin (2013) introduced a model emphasized on slow adjustment of labor demand, because he considered that in the short-run labor demand lacks the ability to adjust to changes. Previous studies have considered a rapid adjustment of employment as a result of an increase in minimum wage. However, Sorkin (2015), supported by theory, advocated for a slow adjustment of the labor market. The empirical research was plagued by short-run employment effects due to minimum wage increase, but the findings resulted significantly small. Second, Meer and West (2015) evidenced that the true effect of minimum wage on employment was related to the slope or growth rate of employment, rather than its level. The previous approaches used difference-in-differences methods, which may generate incorrect inferences (Meer and West, 2015).

Meer and West (2015) found a negative relationship between minimum wage and employment; however, it is not an immediate effect, it may occurs in several years. For instance, their findings suggested that a permanent increase in real minimum wage by 10% will reduce employment by 0.7% after three years. One constraint from the study is that the data did not contain information related to large or permanent increase in the minimum wage. Therefore, dynamics responses could not be tested under these conditions, and impede researchers to analyze these type of policies' effects on employment.

One of the most relevant findings in this study is the negative effect of Ecuador's real minimum wage on its urban unemployment rate. According to the results, the positive coefficient on real minimum wage implies an increase in the urban unemployment rate six months later to a rise in the minimum salary.

2.3. Productivity

After the second half of the 1970s, the simultaneous reduction of productivity and unemployment rise in the industrialized countries has driven most of the theoretical and empirical models available on productivity and unemployment relationship. Pissarides and Vallanti (2007) found that productivity growth reduces unemployment for European countries, Japan and the United States. Similarly, using data from the United States, Mouhammed (2012) found that the productivity level is one of the most influential factors on unemployment rate. The study revealed that, under regular economic conditions, there is an inverse relationship between unemployment and productivity.

In Latin America, there are few studies determining the relationship between unemployment and productivity. Instead, there are multiple attempts of exploring the productivity's situation of Latin American countries. For instance, Busso, Madrigal and Pagés (2010) revealed that Latin America has a large number of small firms with low productivity levels. In addition, they found that Latin American firms' productivity is very heterogeneous: highly productive firms coexist with low productive firms. Also, labor is inefficiently allocated across firms, but by fixing this misallocation of resources, the productivity could increase (Busso, Madrigal and Pagés, 2013).

Misallocation of resources generally occurs in the presence of negative distortions. Negative distortions, such as lower output prices or higher factor prices, will lead firms to hire fewer resources; while positive distortions will have an opposite effect (Hsieh and Klenow, 2009). Output distortions examples include high transportation costs, bribes, or government restrictions; whilst, capital distortions involve credit constraints and labor market regulations. According to Busso, Madrigal and Pagés (2013), no distortions in an economy allows better input allocations to highly productive firms, impelling the total factor productivity to increase. This scenario implies that an efficient economy allows more productive firms to increase their market share, and as a result, hire more labor and capital in order to expand their production. However, in presence of distortions such as government favoring some especial firms, the previous relationship becomes weaker.

From the previous studies, the relationship between unemployment and productivity in Latin America is inconclusive. In the particular case of Ecuador, Busso, Madrigal and Pagés (2013) found that between productivity and firm size there is no

clear relationship. However, based on the results of this research, a higher productivity has positive effect on the unemployment rate. In fact, when measuring Ecuador's productivity as the ratio of real non-oil GVA to the labor force or the average of hours worked per quarter, both coefficients show that an increase in productivity implies a decrease on unemployment.

3. DATA AND ESTIMATION STRATEGY

This section contains the data and methodology used in the paper. This research uses quarterly data from June 2007 to June 2017. All the variables used in the regression models were from the three official sources, such as the Central Bank of Ecuador, Ecuador's National Institute of Statistics and Census and the Federal Reserve Bank of St. Louis. This research relied on various econometric techniques and methods in order to take into account all statistical assumptions including exogeneity, homocedasticity, seasonal adjustments and stationary. In regard to the methodology, this paper used a distributed lag model under an Ordinary Least Squares (OLS) regression. Similar results can be obtained by conducting a Stepwise Backward Regression.

3.1. Data

The five variables composing the distributed lag model are the following: the quarterly unemployment rate in urban areas; quarterly average price of Ecuador's barrel of oil; quarterly average of the US dollar exchange rate; Ecuador's real minimum wage and labor productivity level. The productivity variable is the ratio between Ecuador's real non-oil GVA and the labor force or the average number of employed workers.[1] In regard to the sources of the data, the urban unemployment rate was taken from the National Survey of Employment, Unemployment and Underemployment at the country's National Institute of Statistics and Census. Ecuador's oil price per barrel and the country's real minimum wage were found at the monthly bulletin of statistical data published by the Central Bank of Ecuador. The US dollar exchange rate was accessed from the Federal Reserve Economic Data (FRED) at the Federal Reserve Bank of St. Louis. Ecuador's productivity level composed by the quarterly real non-oil GVA and the labor force or the number of employed workers data were taken from the Central Bank of Ecuador and the National Institute of Statistics and Census, respectively.

Ecuador's oil price exhibited a high volatility as mentioned in the previous sections. Similarly, urban unemployment rate experienced a considerable fluctuation between June 2007 and June 2017. At the beginning of the Correa Administration, the unemployment rate was 7.5%. The average urban unemployment rate during these ten years was 6.07%. Its lowest rate was 4.54% in December 2014; while its maximum rate was 9.10% in March 2010.

Additionally, it is important to highlight that during the period under analysis the labor force in urban areas grew by 22.41% from 4.44 million in June 2007 to 5.44 million people in June of 2017. Similarly, the number of employed workers in urban zones increased by more than one million workers from 4.11 to 5.13 million during the same period, which represents a growth of 24.68% over these past ten years.

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[1] This paper presents two regression models. The first regression includes the productivity level based on the labor force and the second one is based on the number of employed workers.

Regarding the real dollar index (DXY), its price also registered considerable volatility due to the US financial crisis and the debt crisis in Europe. As a result, the dollar reported substantial fluctuations between June 2007 and June 2017. The American currency reached its minimum of 80.99 during the second quarter of 2011 and its maximum of 102.49 during the first quarter of 2017. By using quarterly data of its quotation, the interannual average appreciation of the dollar was 1.42%. However, when considering the fluctuation between the minimum and maximum quotations, the appreciation reached up to 26.5%.

Other two variables included in the regression model were Ecuador's real minimum wage and the labor productivity level. As mentioned in the previous section, Ecuador's real minimum wage experienced a 4.10% increase between June 2007 and June 2017. Meanwhile, the country's productivity level—measured as the ratio between Ecuador's real non-oil GVA and the labor force or the number of employed workers—increased by 1.90% and 1.78% respectively during the same period. In the past decade, there was a dissociation between the minimum wage growth and the increase in Ecuador's labor productivity.

Table 1
Descriptive Statistics

	Urban Unemployment rate	Real oil price	Real Dollar Index	Real minimum wage	Productivity via L.F (1)	Productivity via E.W (2)
Mean	6.25	52.69	89.29	89.3	2.84	3.02
Median	6.07	56.63	87.41	90.98	2.86	3.06
Maximum	9.1	86.15	102.49	103.83	3.19	3.35
Minimum	4.54	16.06	80.99	68.01	2.34	2.52
Std. Dev.	1.3	19	6.01	11.3	0.25	0.23
Skewness	0.53	-0.36	0.68	-0.37	-0.35	-0.49
Kurtosis	2.34	1.92	2.21	1.76	1.92	2.2
Jarque-Bera	2.67	2.88	4.23	3.53	2.85	2.73
Probability	0.26	0.24	0.12	0.17	0.24	0.26
Observations	41	41	41	41	41	41

(1) Productivity measured as the ratio between Ecuador's real non-oil GVA and the labor force.
(2) Productivity measured as the ratio between Ecuador's real non-oil GVA and the number of employed workers.

3.2. Estimation Strategy

The estimation strategy used for this paper is a distributed-lag model under the Ordinary Least Squares (OLS) method. A Stepwise Backward Regression leads to similar results. This OLS model allows to estimate the dynamic and cumulative causal effects of one or several exogenous variables "Xs" over a dependent variable "Y" during a period of time (Stock and Watson, 2012). Thus, the model enables to estimate the specific and total impact on a dependent variable in the short term, given a change in an exogenous variable in the current period (contemporary) and earlier terms (lags).

In general terms, the specification of a distributed-lag model is as follows:

(1)

$$\boldsymbol{Y_t = \beta_0 + \beta_1 X_t + \beta_2 X_{t-1} + \beta_3 X_{t-2} + \beta_{r+1} X_{t-r} + u_t}$$

In this paper, two specifications are estimated using a distributed-lag model under the OLS:

(2)

$$\Delta Unemployment\ rate_t = \beta_0 + \beta_1 \Delta log(Oil_t) + \beta_2 \Delta log(Oil_{t-2}) + \beta_3 \Delta log(Oil_{t-4}) + \beta_4 \Delta log(Dollar_t) + \beta_5 \Delta log(Dollar_{t-1}) + \beta_6 \Delta log(Dollar_{t-2}) + \beta_7 \Delta log(Wage_{t-2}) + \beta_8 \Delta log(Productivity_{t-2}) + \beta_9 \Delta log(Productivity_{t-3}) + \beta_{10} \Delta log(Productivity_{t-4}) + u_t$$

(3)

$$\Delta Unemployment\ rate_t = \beta_0 + \beta_1 \Delta log(Oil_t) + \beta_2 \Delta log(Oil_{t-2}) + \beta_3 \Delta log(Dollar_t) + \beta_4 \Delta log(Dollar_{t-1}) + \beta_5 \Delta log(Dollar_{t-2}) + \beta_6 \Delta log(Dollar_{t-4}) + \beta_7 \Delta log(Wage_{t-2}) + \beta_8 \Delta log(Productivity_{t-3}) + \beta_9 \Delta log(Productivity_{t-4}) + u_t$$

Both distributed lag models are composed of five variables with quarterly periodicity: the change in the urban unemployment rate is the dependent variable (ΔY_t). The first independent variable is the logarithmic difference of Ecuador's average oil price. In addition to the contemporary term of oil price, the model includes the following terms $\Delta log(Oil_{t-2})$ and $\Delta log(Oil_{t-4})$, which are the first logarithmic differences of the variable lagged two and four quarters. The second independent variable is the logarithmic difference of the US dollar exchange rate, which includes the contemporary term and the variable lagged one and two quarters. The third independent variable is the logarithmic difference of the real minimum wage lagged two periods. The last variable is the logarithmic difference of Ecuador's labor productivity that includes its values lagged three and four quarters.

The second regression follows a similar specification with minor changes in the number of lags and how labor productivity is measured. First, the average oil price lagged four periods was removed. Then, the US exchange rate lagged four quarters was included in the regression. Finally, this model includes a productivity variable measured as the ratio between Ecuador's real non-oil GVA and the number of employed workers in the economy, while in the first regression the productivity is measured relative to Ecuador's labor force.

As previously mentioned, each coefficient of the OLS regression allows estimating the dynamic causal effects or also known as the individual dynamic multipliers. Therefore, the cumulative dynamic multiplier or cumulative causal effect is the sum of the individual dynamic multipliers, β_1+β_2...+ β_{1r+1}, up to the last lag included in the model. Therefore, it is possible to estimate the cumulative effect of a change of a unit in the variable X over the variable Y.

The original variables experienced some transformations in order to take into account all statistical assumptions including exogeneity, homocedasticity, seasonal adjustments and stationary. The first change to the data is to remove the effect of inflation over the time. With the exception of oil prices, the rest of the data is published in real terms. In the case of oil prices, Ecuador's GDP deflator is used to remove the increase in prices over time. Otherwise, variables are not comparable over the period analyzed due to the effect of inflation. Thus, the four independent variables used in both regressions are in real terms, allowing to compare the data throughout the period studied.

The second change applied to all the variables was the X-12 seasonal adjustment. The seasonality tests showed that the regressand and regressors were seasonal in its original state, which is especially consistent with the theory regarding the decrease in unemployment and the increase in oil prices during specific months. This statistical method enables to correct this effect in the data.

Another requirement when working with time series is that the variables are stationary. In other words, they do not have a unit root. This assumption implicates that the mean and variance of the variables must be constant over time. According to the Phillips–Perron test, all the variables included in both models have a unit root. As a result, the first difference is applied to the outcome and explanatory variables in order to work with stationary data. Once the data was transformed to the first difference, the Phillips–Perron test was run again to confirm that the five variables are now stationary.

The use of logarithms for independent variables was an additional transformation, with the goal of measuring the effect of explanatory variables on the unemployment rate through percentage changes. Since the dependent variable is in percentage, we can estimate the effect that regressors have on the independent variable as elasticities. For this reason, the first logarithmic differences is applied to all independent variables, in order to work with stationary variables and to facilitate the analysis of coefficients through percentage changes.

Additionally, the distributed lag model relies on key assumptions. A conventional norm in this type of model is that independent variables are usually exogenous. An exogenous variable can be defined as one that is not under human control or is determined outside the proposed model. In this case, oil prices and the US exchange rate are exogenous variables, since the influence of any institution in Ecuador over these variables is minor and insignificant. However, real minimum wage and labor productivity can be considered as endogenous variables as both factors are affected by human decisions inside the country. Nevertheless, the main problem with endogenous variables comes when trying to explain a dependent variable in the current or contemporary period. In this paper, lags of both endogenous variables are used and no contemporary term is included in the regressions. These specifications avoid a problem of endogeneity with real minimum wage and labor productivity.

Finally, the Newey-West variance estimator or also known as the HAC variance estimator is used in both regressions. This method is a consistent estimator with heteroscedasticity and autocorrelation. The main problem when working with distributed lag models is the appearance of heteroscedasticity and autocorrelation due to omitted determinants that may also affect the dependent variable (Y_t). The independent variables omitted could be correlated over time, consequently the error term (u_t) of the regression can also be autocorrelated. This problem causes that the standard errors of OLS regressions are not consistent; and therefore, the hypothesis tests and confidence intervals of the model are erroneous. The solution consists in estimating the standard errors of regressions with the Newey-West variance estimator (HAC estimator), to correct the autocorrelation and heteroscedasticity of the model.

The formula for the HAC variance estimator for β_1 is as follows (Stock and Watson, 2012):

$$\boldsymbol{\sigma^2_{\hat{\beta}_1} = \sigma^2_{\hat{\beta}_1} f_T}$$

$\sigma^2_{\beta_1}$ is the variance estimator of β_1 in the absence of autocorrelation, while f_T is a factor that adjusts the formula for autocorrelation. This factor will depend on the size of the "T" sample. If the sample is small, only a few autocorrelations will be needed, but if the sample is large, it will be necessary to include more autocorrelations, but always less than the sample size.

4. RESULTS

Table 2 contains the results of the first distributed lag model under an OLS regression and using the Newey-West variance estimator. According to the results, the four independent variables—real oil price, real exchange rate, real minimum wage and labor productivity—explain 68% of the behavior of the urban unemployment rate between June 2007 and June 2017.

The constant (β_0) is negative and statistically significant at the 1% level. The three coefficients on oil prices are negative, implying that an increase in crude oil prices provokes a reduction of unemployment. The cumulative dynamic multiplier on oil prices indicates that a 1% increase in the log differences of crude oil prices causes a 3.32% decrease in the difference of Ecuador's urban unemployment rate during the current quarter. Coefficients on Oil_t and Oil_{t-2} are significant at the 1% level, while the coefficient on Oil_{t-4} is statistically significant at the 5%.

In regard to the real exchange rate, the coefficients on the contemporary term and on the variable lagged two periods are positive, while the coefficient on this variable lagged one quarter is negative. The cumulative dynamic multiplier for this variable implies that a 1% appreciation in the log differences of real exchange rate results in a 6.01 % increase in the difference of the urban unemployment rate during the current quarter. Coefficients on $Dollar_t$ and $Dollar_{t-1}$ are significant at the 1% level, while the one on $Dollar_{t-2}$ is statistically significant at the 10%.

The coefficient on real minimum wage lagged two quarters is positive and significant at the 1% level. The multiplier on this single coefficient implies that a 1% increase in the logarithmic difference of the real minimum wage causes a 19.57% increase in the difference of the unemployment rate. Lastly, the coefficients on labor productivity lagged two and three quarters are negative, while the coefficient on this variable lagged four quarters is positive. The cumulative dynamic multiplier for this variable implies that a 1% increase in the log differences of labor productivity results in a 0.82% decrease in the difference of the urban unemployment rate during the current quarter. The first two coefficients on productivity are statistically significant at the 5%, while third one is statistically significant at the 1%.

Table 2
Regression model 1

	Unemployment rate	Cumulative effect
Constant	-0.36***	-0.36
	(0.05)	
Real Oil price	-1.11***	-3.32
	(0.38)	
Real Oil price (-2)	-1.58***	
	(0.26)	
Real Oil price (-4)	-0.63**	
	(0.29)	
Real Dollar index	6.76***	6.01
	(1.86)	
Real Dollar index (-1)	-5.36***	
	(1.91)	
Real Dollar index (-2)	4.60*	
	(2.36)	
Real minimum wage (-2)	19.57***	19.57
	(2.54)	
Productivity by labor force (-2)	-8.63**	-0.82
	(3.88)	
Productivity by labor force (-3)	-6.20**	
	(2.50)	
Productivity by labor force (-4)	14.01***	
	(3.03)	
R^2 adjusted	0.680699	

Note: Standard error are in parentheses. *p<0.10, **p<0.05, ***p<0.01.

Table 3 contains the results of the second distributed lag model under an OLS regression. Compared to previous model specification, the main change is that the productivity variable is measured relative to the number of employed workers in the economy, while in the first regression, is measured relative to the labor force.

According to table 3, the four independent variables—real oil price, real exchange rate, real minimum wage and labor productivity—explain 64% of the variation of the urban unemployment rate between June 2007 and June 2017.

The constant (β_0) is negative and statistically significant at the 1% level. The two coefficients on oil prices are negative and both are significant at the 1% level, which is consistent with the previous regression. The cumulative dynamic multiplier on oil prices indicates that a 1% increase in the log differences of crude oil prices causes a 2.36% decrease in the difference of Ecuador's urban unemployment rate during the current quarter.

Then, three of the four coefficients on real exchange rate are positive and are significant at the 1% level, with the exception of $Dollar_{t-1}$ which is negative and statistically significant at the 5% level. The cumulative dynamic multiplier for this variable implies that a 1% appreciation in the log differences of real exchange rate results in a 18.27 % increase in the difference of the urban unemployment rate during the current quarter.

The coefficient on real minimum wage lagged two quarters is positive and significant at the 1% level. The multiplier on this single coefficient implies that a 1% increase in the logarithmic difference of the real minimum wage causes a 17.03% increase in the difference of the unemployment rate. Lastly, the coefficient on labor productivity lagged three quarters is negative and significant at the 5% level; however, the coefficient on this variable lagged four periods is positive, larger than previous one and statistically significant at the 1% level. The cumulative dynamic multiplier for this variable implies that a 1% increase in the log differences of labor productivity results in a 7.43% increase in the difference of the urban unemployment rate during the current quarter.

This last coefficient on productivity is not consistent with economic theory and with the effect found in the first regression. According to theory, productivity is positively related with an increase in labor demand and thus with a reduction of unemployment. In order to verify the impact of productivity on unemployment, I ran a third regression model including the productivity variable, but it is measured relative to the average number of hours worked per quarter. The cumulative dynamic multiplier on this new productivity variable is -15.27%, confirming that an increase in productivity reduces Ecuador's urban unemployment rate. It is also important to highlight that the cumulative effects (signs) in the rest of the variables coincide with the previous regressions.

Table 3
Regression model 2

	Unemployment rate	Cumulative effect
Constant	-0.37***	-0.37
	(0.06)	-2.36
Real oil price	-1.12***	
	(0.39)	
Real oil price (-2)	-1.24***	
	(0.34)	
Real Dollar Index	8.99***	18.27
	(2.27)	
Real Dollar Index (-1)	-5.54**	
	(2.09)	
Real Dollar Index (-2)	7.34***	
	(2.64)	
Real Dollar Index (-4)	7.47***	
	(2.69)	
Real minimum wage (-2)	17.03***	17.03
	(2.69)	
Productivity per employed worker (-3)	-6.42**	7.43
	(2.80)	
Productivity per employed worker (-4)	13.86***	
	(2.63)	
R^2 adjusted	0.6438	

Note: Standard error are in parentheses. *p<0.10, **p<0.05, ***p<0.01.

5. CONCLUSION

The distributed lag models considered in this research enabled to estimate individual and cumulative effects caused by labor productivity, minimum wage, oil prices and exchange rate fluctuations on Ecuador's urban unemployment rate. The first two regression models showed that coefficients on independent variables are consistent about their cumulative effect on unemployment, except for labor productivity. However, after running a third OLS model with a new productivity variable, the positive impact of productivity on reducing Ecuador's unemployment rate was confirmed.

According to the results of the first and third regression models, a reduction of oil prices and an appreciation of the US dollar cause an increase in the urban unemployment rate. Additionally, an increase in the real minimum wage, not taking into account labor productivity, provokes an increase in urban unemployment. Finally, an increase in labor productivity generates a decrease in Ecuador's urban unemployment rate.

This econometric evidence confirmed causal effects of oil price and the US dollar exchange rate on urban unemployment in Ecuador between June 2007 and June 2017. Furthermore, the sizeable fluctuations in oil prices and in the US dollar index worsen the vulnerability of Ecuador's labor market through adverse shocks. Additionally, an increase in the minimum wage has a negative impact on unemployment by reducing the labor demand and increasing the number of unemployed workers, especially when productivity growth is not considered. Finally, an increase in labor productivity has a positive impact on unemployment by increasing labor opportunities and reducing unemployment. The effect—directions—of the coefficients on the first and third regressions are consistent with economic theory and vast majority of empirical studies cited in this paper. Moreover, the first regression model can explain more than 68% of the change in Ecuador's urban unemployment rate between June 2007 and June 2017.

Ecuador's labor market vulnerability due to high fluctuations of oil prices requires the implementation of new macroeconomic policies, including buying financial derivatives (put options) to fix oil prices and to reduce economic uncertainty; promoting investment through private concessions and creating a stabilization fund to counteract oil price shocks. Regarding the risks of a US dollar appreciation, Ecuadorian exporters should negotiate financial derivatives including forwards and options to protect export prices against considerable appreciations. Finally, increases in the minimum wage should consider labor productivity growth to avoid a negative shock in the labor demand, and thus increasing in unemployment.

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Table 4

Regression model 3

	Unemployment rate	Cumulative effect
Constant	-0.28**	
	(0.12)	
Real oil price	-1.60***	-2.65
	(0.50)	
Real oil price (-2)	-1.05**	
	(0.43)	
Real Dollar Index	11.12***	16.33
	(3.14)	
Real Dollar Index (-1)	-13.36***	
	(4.17)	
Real Dollar Index (-2)	9.58***	
	(2.88)	
Real Dollar Index (-4)	8.99**	
	(3.35)	
Real minimum wage (-2)	19.42***	30.67
	(4.68)	
Real minimum wage (-4)	11.25**	
	(5.18)	
Productivity per hour worked	-15.27**	-15.27
	(6.03)	
R^2 adjusted	0.5149	

Note: Standard error are in parentheses. *p<0.10, **p<0.05, ***p<0.01.