The Impact of Oil Price Shocks on Economic Growth: The Case of Taiwan

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ABSTRACT

Most studies continue to analyze oil shocks. Earlier authors recognize that oil price volatility plays a critical role in the economy. There is accordingly evidence that oil price shocks negatively impact real gross domestic product (GDP) growth rates and cause higher inflation. However, this paper uses different perspectives to investigate whether it is beneficial to Taiwan’s overall economy based on a low oil price event. This study’s results reveal that an increase in the oil price leads to an increase in the consumer price index (CPI), causing higher inflation. Moreover, a long-term rise in oil prices would negatively impact the GDP growth rate. Alternatively, in the event of falling oil prices, there may not be an immediate decline in the price of goods. However, firms’ reductions in the cost of goods resulted in declining CPI, due to the decreasing oil price over the past few months. Furthermore, it was observed that GDP would decrease when there is a long-term decline in the oil price. All the previously mentioned results are almost consistent with those of previous studies of high oil price events. In addition, the economy would be negatively impacted by a long-term decline in oil prices.

Keywords: Oil Price Shocks, Oil Fluctuation, Economic Activity, Impulse Response Function

JEL Classifications: F62, M21, O11, Q43

1. INTRODUCTION

According to Blanchard and Gali (2007), who examined high oil prices as the main reason for the recession, the oil price is an important source of economic fluctuation. Previous literature indicated that high oil prices would cause several phenomena: increased costs of producing goods and services could lead to lower aggregate demand (Cunado and De Gracia, 2005; Cologni and Manera, 2008) in household consumption, thereby affecting firms’ production activities and earnings. In addition, oil price shocks affect corporate performance, further impacting financial markets. Hamilton (2005) found that oil price shocks lead to increased costs of production, worsening firms’ earnings and market valuations. On the other hand, higher energy costs decrease household demand, reducing firms’ output and further influencing the labor market (Al-Tai, 2015; Vizek et al., 2020). Furthermore, the higher energy cost reduces disposable income and increases households’ precautionary savings. Thus, reduced consumption adversely affects corporate profits (Tsai, 2013).

The high oil price event would cause low investment, influenced mainly by declining corporate profits, economic instability, and inflation, leading to diminished consumer purchasing power. Moreover, some studies claimed that oil shocks negatively impact real GDP growth rates and cause increased inflation (Adebayo, 2020; Bachmeier, 2007; Cunado and De Gracia, 2005; Darby, 1982; Gershon et al., 2019; Gao et al., 2014; Lacheheb and Sirag, 2019; Hamilton, 2005; Nusair, 2016; Shaari et al., 2012; Zhao et al., 2016). Notwithstanding the above, a decline in oil prices would have positive benefits, such as increasing the GDP growth rate, corporate profits, and consumer spending. Sadorsky (1999) suggests that depressed oil prices will cause positive shocks in stock returns, interest rates, and industrial production. Furthermore, Mohaddes and Raissi (2016) found that a drop in oil
prices brought global growth to 0.4%. However, under different market conditions, the decline in oil prices affects investor sentiment, causing stock returns to fall (You et al., 2017).

A few years ago, oil prices fell by about 50% between June 2014 and February 2016. The initial gradual slide was from $110 to $25 for each barrel of Dubai crude oil (Figure 1). In considering the period for which oil prices continued to decline, next, this paper will examine whether the low oil prices may have positively impacted Taiwan’s economy, such as increased household budgets and improved GDP.

The remainder of the paper is organized as follows: Section 2 describes the sample and data. Section 3 describes the methodology. Section 4 reports the analyses the results, and Section 5 concludes.

2. SAMPLE AND DATA
The data were collected mainly from Taiwan Economic Journal (TEJ), and the study period is 2006-2015. Table 1 describes the contents of each variable.

| Variable     | Description                                                        | Unit      |
|--------------|--------------------------------------------------------------------|-----------|
| CPI          | This is a measure that examines the weighted average of prices of a basket of consumer goods and services. | %         |
| Exchange     | USD/TWD                                                            |           |
| GDP          | This is the monetary value of all finished goods and services made within a country during a specific period. | %         |
| Household    | This refers to Taiwan’s household expenditure.                     | NTS100 million |
| TAIEX Index  | Taiwan Stock Market                                                |           |
| Oil price    | Dubai crude oil, US$ per barrel. The currency has been converted to NTD. | NTD       |
| Wage         | This refers to the total monthly salary per person in the industrial and service sectors. | NTD       |

3. METHODOLOGY
The study proposes a test of the null hypothesis where an observable time series is stationary around a deterministic trend (Kwiatkowski et al., 1992). In fact, most macroeconomic variables were probably nonstationary. The economic variables need to do the unit root test and co-integration test to avoid spurious regression, and it is important to examine the stability of this process. However, this testing procedure would apply the unit root of the Augmented Dickey-Fuller (ADF) test and Philips-Perron (PP) test, co-integration, the Granger causality test, and impulse response.

3.1. Augmented Dickey-Fuller (ADF) Test, There are Three Patterns
1. No intercept and time trend
   \[ \Delta y_t = \gamma y_{t-1} + \sum_{i=1}^{p} \beta_i \Delta y_{t-i} + \varepsilon_t \] (1)
2. Only intercept
   \[ \Delta y_t = a + \gamma y_{t-1} + \sum_{i=1}^{p} \beta_i \Delta y_{t-i} + \varepsilon_t \] (2)
3. Intercept and time trend
   \[ \Delta y_t = a + \gamma y_{t-1} + a t + \sum_{i=1}^{p} \beta_i \Delta y_{t-i} + \varepsilon_t \] (3)

Where \( y_t \) is variable, \( a \) denotes the floating items, \( t \) is time trend and \( \varepsilon_t \) is error term and then \( \varepsilon_t \sim iid (0, \sigma^2) \), \( p \) is the lag length.

The null hypothesis is \( H_0: \gamma = 0 \), when reject the null hypothesis, it indicates that this sequence is stationary time series, also known as I (0) series. However, if the original series was unable to reject the null hypothesis, it may be used the difference to stationary of time series. After the first difference, we observed the sequence is stationary, it denotes I (1).

3.2. Co-Integration Model
Two (or more) time series with long-term trends, it means that the time series have co-integrated relationship. Model is as follows:

Figure 1: Dubai crude oil, US$ per barrel (Date: 2006/01-2015/12)

Source: Taiwan Economic Journal (TEJ)
\[ Y_t = \beta_1 + \beta_2 X_{t2} + \beta_3 X_{3t} + \mu_t \]  

The variables of \( Y_t \), \( X_{t2} \), and \( X_{3t} \) are nonstationary, thus regression function as follows:

\[ y_t = \hat{\beta}_1 + \hat{\beta}_2 X_{t2} + \hat{\beta}_3 X_{3t} + \hat{\mu}_t \]  

### 3.3. Granger Causality Test

The main is that predict the relationship of variables. In order to study the causal relationship between \( X \) and \( Y \), then consider the following regression equation:

\[ X_t = \sum_{i=1}^{p} a_i X_{t-1} + \sum_{j=1}^{q} \beta_j Y_{t-j} + \mu_t \]  

\[ Y_t = \sum_{k=1}^{r} \delta_k X_{t-k} + \sum_{i=1}^{s} \delta_i Y_{t-i} + \mu_t \]  

### 4. EMPIRICAL RESULTS

We used the database of TEJ and collected data from 2006 to 2015. This study applied E-views as the analysis tools. The empirical results, as follows:

### 4.1. Descriptive Statistics

Table 2 reports the results of descriptive statistics. In this regard, the values for the maximum oil price, CPI, GDP annual growth rate, Taiwan’s household expenditure, the TAIEX index, and salary level were 3987.101, 104.43%, 13.7%, 62,1823, 29, 9,711, 37, and 88,285, respectively. The values for the minimum oil price, CPI, GDP annual growth rate, Taiwan’s household expenditure, the TAIEX index, and salary level were 1146, 398, 92.8%, −8.57%, 50,145, 98, 4,247, 97, and 38,189, respectively. In addition, from the perspective of standard deviation, the study found sharp fluctuations in the wage level, and fluctuations in the minimum United States Dollar (USD) exchange rate to the New Taiwan Dollar (NTD). Skewness and kurtosis coefficients are used to determine data patterns, for which the skewness for normal distribution is zero and kurtosis is three. In this regard, the study observed that the skewness coefficient is less than zero for the CPI, GDP, TAIEX index, and oil price; moreover, there is a tendency to the left side. On the other hand, there is a tendency to the right side for the exchange rate, Taiwan’s household expenditure, and wage level; however, the maximum skewness coefficient is 3.02 for the wage level. The elements for which the kurtosis coefficient is less than three include the CPI, exchange rate, Taiwan’s household expenditure, and the oil price.

### 4.2. Quantile-Quantile (QQ) Plot

Following the descriptive statistics, the study will examine the normal distribution of the variables. The QQ plot (Figure 2) was accordingly used to observe changes in the variables. Zivot and Wang (2007) examined a scatterplot of the standardized empirical quantiles of \( y_t \) against the quantiles of a standard normal random variable. In this regard, if \( y_t \) is normally distributed, the quantiles will lie on a 45-degree line. However, as depicted in Figure 2, the results of the QQ plot reveals a are non-linear 45-degree for each variable, reflecting a non-normal distribution.

### 4.3. Analysis the Results of Unit Root Tests

The study will examine the stability of the variables. To this end, it used the ADF and PP tests. If the P-value rejects the null hypothesis, the time series is stationary. However, for this study, it was non-stationary.

In statistics, a unit root test examines whether a time series variable is non-stationary and possesses a unit root. Based on the reported estimates, the null hypothesis was unable to be rejected for the CPI, oil price, exchange rate, household expenditure, and the TAIEX index. However, the null hypothesis of GDP and wage were rejected. The test results are shown in Table 3.

Table 4 shows that the first difference of each variable is stationary. Therefore, it is suggested that it is best described as being stationary in the first differences for each series.

### 4.4. Co-integration Test

Zakrajsek (2009) indicates that economic theory often suggests that economic variables should be linked by a long-run economic relationship. Thus, if two or more \( (1) \) variables are co-integrated, they must obey an equilibrium relationship in the long run, although they may diverge substantially from that equilibrium in the short run. Therefore, this paper used the Johansen co-integration test to estimate the trace test and the max-eigenvalue test. The study will use different perspectives to investigate the different reactions of CPI and GDP to the high oil price (April 2006 to November 2011) and low oil price (November 2012 to December 2015) events.

Tables 5-8 indicate that the trace test and max-eigenvalue test of CPI and GDP during the high oil price event have a co-integration

| Table 2: Descriptive statistics |
|-------------------------------|
| CPI  | Exchange | GDP    | Household | Index   | Oil price | Wage  |
| Mean | 99.10505 | 31.17856 | 3.690850 | 55350.77 | 7777.659 | 2574.572 |
| Median | 98.87000 | 30.85000 | 3.821481 | 54337.70 | 7884.410 | 2582.145 |
| Maximum | 104.4300 | 34.95000 | 13.70481 | 62182.29 | 9711.370 | 38189.00 |
| Minimum | 92.80000 | 28.76200 | −8.572593 | 50145.98 | 4247.970 | 38189.00 |
| Std. Dev. | 3.258106 | 1.483177 | 3.690850 | 3.258106 | 4.418137 | 4.891815 |
| Skewness | −0.142974 | 0.166328 | −0.142974 | −0.142974 | −0.142974 | −0.142974 |
| Kurtosis | 2.074480 | 1.483177 | 3.690850 | 3.690850 | 4.418137 | 4.418137 |
| Observations | 117 | 117 | 117 | 117 | 117 | 117 |

***, **, and * indicate significance at the 1%, 5%, and 10% levels.
relationship; therefore, reflecting a long-term stable equilibrium relationship. On the other hand, the results of Tables 9-12 indicate that the trace test and max-eigenvalue test of CPI and GDP during the low oil price event have a co-integration relationship; therefore, reflecting a long-term stable equilibrium relationship.

4.5. Granger Causality Test
The result from Table 13 indicates a causal relationship between the CPI, Taiwan’s household expenditure, GDP, the TAIEX index, and the high oil price event. Moreover, a significant causal relationship between the exchange rate and oil prices and Taiwan’s
The results indicate that the high oil price event causes the cost of producing goods and services to increase, leading to higher inflation. In addition, most studies show that an increase in the oil price affects production activity and corporate earnings, thus generating. It was observed that during a high oil price event, the oil price shocks are negative implications to households. In this regard, Hamilton was passed on by the firm to the consumers. After the increase in salary levels rose sharply. Possibly, the resulting price increase generation. The study uses different perspectives to investigate whether high and low oil prices impact the economy, including the CPI, GDP, Taiwan’s household expenditure, and the TAIEX index. On the other hand, changes in oil prices impact the CPI and GDP during the low oil price event.

### 4.6. Impulse Response Function

The study uses different perspectives to investigate whether high and low oil prices impact the economy differently. Therefore, this section aims to use impulse response to observe the relationship between them.

However, during the high oil price event, the oil price shocks impact the economy, including the CPI, GDP, Taiwan’s household expenditure, and the TAIEX index. On the other hand, changes in oil prices impact the CPI and GDP during the low oil price event.

### Table 5: Trace test-during the high oil price event of CPI

| Hs No. of CE (S) | Eigenvalue | Trace Statistic | 5% Critical Value | Prob.** |
|-----------------|------------|----------------|------------------|---------|
| None*           | 0.309398   | 24.06249       | 27.58343         | 0.1325  |
| At most 1       | 0.224495   | 16.52563       | 21.13162         | 0.1956  |
| At most 2       | 0.180824   | 12.96464       | 14.26460         | 0.0794  |
| At most 3       | 0.001695   | 0.110268       | 3.841433         | 0.7398  |

Trace test indicates 1 co-integrating eqn(s) at the 0.05 level. *denotes rejection of the hypothesis at the 0.05 level.

### Table 6: Max-eigenvalue test-during the high oil price event of CPI

| Hs No. of CE (S) | Eigenvalue | Trace Statistic | 5% Critical Value | Prob.** |
|-----------------|------------|----------------|------------------|---------|
| None*           | 0.309398   | 24.06249       | 27.58343         | 0.1325  |
| At most 1       | 0.224495   | 16.52563       | 21.13162         | 0.1956  |
| At most 2       | 0.180824   | 12.96464       | 14.26460         | 0.0794  |
| At most 3       | 0.001695   | 0.110268       | 3.841433         | 0.7398  |

Max-eigenvalue test indicates no co-integration at the 0.05 level. *denotes rejection of the hypothesis at the 0.05 level.

### Table 7: Trace test-during the high oil price event of GDP

| Hs No. of CE (S) | Eigenvalue | Trace Statistic | 5% Critical Value | Prob.** |
|-----------------|------------|----------------|------------------|---------|
| None*           | 0.393443   | 62.48083       | 54.07904         | 0.0074  |
| At most 1       | 0.271763   | 30.48366       | 35.19275         | 0.1475  |
| At most 2       | 0.096028   | 10.18740       | 20.26184         | 0.6214  |
| At most 3       | 0.056559   | 3.726177       | 9.164546         | 0.4544  |

Trace test indicates 1 co-integrating eqn(s) at the 0.05 level. *denotes rejection of the hypothesis at the 0.05 level.

### Table 8: Max-eigenvalue test-during the high oil price event of GDP

| Hs No. of CE (S) | Eigenvalue | Trace Statistic | 5% Critical Value | Prob.** |
|-----------------|------------|----------------|------------------|---------|
| None*           | 0.393443   | 62.48083       | 54.07904         | 0.0074  |
| At most 1       | 0.271763   | 30.48366       | 35.19275         | 0.1475  |
| At most 2       | 0.096028   | 10.18740       | 20.26184         | 0.6214  |
| At most 3       | 0.056559   | 3.726177       | 9.164546         | 0.4544  |

Max-eigenvalue test indicates no co-integration at the 0.05 level. *denotes rejection of the hypothesis at the 0.05 level.

### Table 9: Trace test-during the low oil price event of CPI

| Hs No. of CE (S) | Eigenvalue | Trace Statistic | 5% Critical Value | Prob.** |
|-----------------|------------|----------------|------------------|---------|
| None*           | 0.683626   | 62.51679       | 54.07904         | 0.0074  |
| At most 1       | 0.394556   | 24.53941       | 35.19275         | 0.4285  |
| At most 2       | 0.165453   | 7.980239       | 20.26184         | 0.8259  |
| At most 3       | 0.059139   | 2.011661       | 9.164546         | 0.7754  |

Trace test indicates 1 co-integrating eqn(s) at the 0.05 level. *denotes rejection of the hypothesis at the 0.05 level.

### Table 10: Max-eigenvalue test - during the low oil price event of CPI

| Hs No. of CE (S) | Eigenvalue | Trace Statistic | 5% Critical Value | Prob.** |
|-----------------|------------|----------------|------------------|---------|
| None*           | 0.683626   | 37.97738       | 28.58808         | 0.0024  |
| At most 1       | 0.394556   | 16.55917       | 22.29962         | 0.2604  |
| At most 2       | 0.165453   | 9.568578       | 15.89210         | 0.7915  |
| At most 3       | 0.059139   | 2.011661       | 9.164546         | 0.7754  |

Max-eigenvalue test indicates no co-integration at the 0.05 level. *denotes rejection of the hypothesis at the 0.05 level.

### Table 11: Trace test - during the low oil price event of GDP

| Hs No. of CE (S) | Eigenvalue | Trace Statistic | 5% Critical Value | Prob.** |
|-----------------|------------|----------------|------------------|---------|
| None*           | 0.491103   | 55.03828       | 54.07904         | 0.0409  |
| At most 1       | 0.314751   | 25.99135       | 35.19275         | 0.3424  |
| At most 2       | 0.146529   | 9.738486       | 20.26184         | 0.6655  |
| At most 3       | 0.065770   | 2.925414       | 9.164546         | 0.5947  |

Trace test indicates 1 co-integrating eqn(s) at the 0.05 level. *denotes rejection of the hypothesis at the 0.05 level.

### Table 12: Max-eigenvalue test - during the low oil price event of GDP

| Hs No. of CE (S) | Eigenvalue | Trace Statistic | 5% Critical Value | Prob.** |
|-----------------|------------|----------------|------------------|---------|
| None*           | 0.491103   | 29.04693       | 28.58808         | 0.0437  |
| At most 1       | 0.314751   | 16.25286       | 22.29962         | 0.2807  |
| At most 2       | 0.146529   | 6.813072       | 15.89210         | 0.6922  |
| At most 3       | 0.065770   | 2.925414       | 9.164546         | 0.5947  |

Max-eigenvalue test indicates no co-integration at the 0.05 level. *denotes rejection of the hypothesis at the 0.05 level.

household expenditures and wages was discovered. Furthermore, Table 14 presents the Granger causality tests from the low oil price event. Based on these results, a significant causal relationship was observed between the GDP, CPI, and oil prices.

The results suggest that oil price significantly affects both GDP and CPI, and the exchange rate significantly affects the oil price.
Table 13: Granger causality test- during high oil price event

| Independent variable | Dependent variable | Prob.     |
|----------------------|--------------------|-----------|
| Oil                  | CPI                | 0.0053*** |
| Oil                  | Household          | 0.0338**  |
| Oil                  | GDP                | 0.0512**  |
| Oil                  | Index              | 0.0010*** |
| Exchange             | Oil                | 0.0707*   |
| Household            | Wage               | 0.0000*** |

***, **, and * indicate significance at the 1%, 5%, and 10% levels.

Table 14: Granger causality test- during low oil price event

| Independent variable | Dependent variable | Prob.     |
|----------------------|--------------------|-----------|
| Oil                  | CPI                | 0.0947*   |
| Oil                  | Household          | 0.0279**  |
| Wage                 | CPI                | 0.0073*** |
| Index                | GDP                | 0.0393**  |
| Exchange             | Oil                | 0.0207**  |

***, **, and * indicate significance at the 1%, 5%, and 10% levels.

4.7. Regression Analysis

The impact of each variable on the CPI and GDP can be understood from the regression analysis. High oil price events are significant for both CPI and GDP. On the other hand, the same results apply to low oil price events. Particularly in Equation (4.7.3), the changes in the CPI and oil prices move significantly in the same direction, which means that when oil prices fall for a sustained period, CPI also declines: a result that applies to the impulse response.

The results are analyzed as follows:

4.7.1. Regression analysis of high oil price event to CPI

(Period: 2006/4-2011/11)

\[
\text{CPI} = 23.9833 + 0.0190 \times \text{Oil}(-1) + 0.00135 \times \text{Household}(-1) + 2.17E^{-06} \times \text{Wage}(-1)
\]
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4.7.2. Regression analysis of high oil price event to GDP (Period: 2007/1-2011/11)
GDP = −71.4343 + 0.0635*Oil(−4) + 0.0030*Index(−1) + 1.4791*Exchange(−10) (4.7.2)

(−3.84)*** (2.48)*** (6.53)*** (2.47)***

Adjusted R-square = 0.589992.

4.7.3. Regression analysis of low oil price event to CPI (Period: 2012/11-2015/01)
CPI = 62.8230 + 0.0378*Oil(−1) + 0.0006*Household(−1) − 8.04E−06*Wage(−10) (4.7.3) (19.14)*** (6.04)*** (12.83)*** (19.15)*

Adjusted R-square = 0.864168

4.7.4. Regression analysis of low oil price event to GDP (Period: 2013/02-2015/12)
GDP = −7.54918 − 0.0394*Oil(−13) + 0.0006*Index(−1) + 0.3136*Exchange(−7) (4.7.4)

(0.15) (−3.11)*** (3.52)*** (2.02)*

Adjusted R-square = 0.521366

5. CONCLUSION

Previous literature found that oil price shocks negatively impact the real GDP growth rates and inflation rates (Blanchard and Gali, 2007). However, this study mainly investigates whether low oil prices would positively affect Taiwan’s economy. This paper’s results revealed that a rise in the oil price leads to an increase in the CPI and caused higher inflation. Moreover, the long-term increase in oil prices negatively impacted the GDP growth rate. Theoretically, falling oil prices help reduce inflation and lower the price of goods. However, although the price of goods did not fall immediately, firms’ reduction in the cost of goods resulted in declining CPI, ultimately due to the decreasing oil price over the past few months. The study also found that long-term low oil prices have caused the GDP to decline. Previous studies have been based on high oil prices as the primary research focus. However, this study’s main observation is the impact of low prices on the economy, which would be negatively impacted by a long-term decline in the oil price.

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(7.32)*** (4.64)*** (20.77)*** (0.26)

Adjusted R-square = 0.922227.

4.7.2. Regression analysis of high oil price event to GDP (Period: 2007/1-2011/11)
GDP = −71.4343 + 0.0635*Oil(−4) + 0.0030*Index(−1) + 1.4791*Exchange(−10) (4.7.2)

(−3.84)*** (2.48)*** (6.53)*** (2.47)***

Adjusted R-square = 0.589992.

4.7.3. Regression analysis of low oil price event to CPI (Period: 2012/11-2015/01)
CPI = 62.8230 + 0.0378*Oil(−1) + 0.0006*Household(−1) − 8.04E−06*Wage(−10) (4.7.3) (19.14)*** (6.04)*** (12.83)*** (19.15)*

Adjusted R-square = 0.864168

4.7.4. Regression analysis of low oil price event to GDP (Period: 2013/02-2015/12)
GDP = −7.54918 − 0.0394*Oil(−13) + 0.0006*Index(−1) + 0.3136*Exchange(−7) (4.7.4)

(0.15) (−3.11)*** (3.52)*** (2.02)*

Adjusted R-square = 0.521366

5. CONCLUSION

Previous literature found that oil price shocks negatively impact the real GDP growth rates and inflation rates (Blanchard and Gali, 2007). However, this study mainly investigates whether low oil prices would positively affect Taiwan’s economy. This paper’s results revealed that a rise in the oil price leads to an increase in the CPI and caused higher inflation. Moreover, the long-term increase in oil prices negatively impacted the GDP growth rate. Theoretically, falling oil prices help reduce inflation and lower the price of goods. However, although the price of goods did not fall immediately, firms’ reduction in the cost of goods resulted in declining CPI, ultimately due to the decreasing oil price over the past few months. The study also found that long-term low oil prices have caused the GDP to decline. Previous studies have been based on high oil prices as the primary research focus. However, this study’s main observation is the impact of low prices on the economy, which would be negatively impacted by a long-term decline in the oil price.

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