The inflationary impacts of oil prices

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1. Introduction

There is an obvious causal relationship between changes in the price of oil (as a production factor) and inflation. An increase in oil prices shifts the short-run aggregate supply curve inward and puts upward pressure on the price level, making it higher than it was. A sharp increase in the price of oil causes an exogenous inflationary shock. However, this simple analysis does not tell us about the nature of the relationship. How strong is it? Are high oil prices major contributors to higher inflation? And what about the contradictory results from different countries? Answering these questions would provide a real picture of the relationship between crude oil prices and inflation. But first, it is necessary to study some initial points that would clarify the relationship taking into account that other variables have potential impacts on inflation. For example, excess demand, which could be expressed by the growth rate of GDP, and augmented expectations of inflation (Friedman – Philips curve) may also affect inflation.

This paper studies the nature of this relationship in an analytical approach starting from a snapshot of the causes of inflation in general and a look at the path through which high oil prices cause inflation. After that, this paper moves specifically to the correlation of oil prices and inflation, and their trend over time, using the necessary empirical tests.

Furthermore, this paper analyzes the inflationary impacts of high oil prices for certain groups of countries based on some classifications. It is an objective of this paper to indicate which countries would suffer the most from high oil prices and why.

In order to achieve its objectives, this paper goes through two major stages. First, it provides an analytical preface about the causes of inflation in theory, considering the arguments of Monetarists and Keynesians, and the augmented expectations theory. As

well, the paper discusses the role of oil prices in relation to the Monetarist and the Keynesian arguments. Second, after tracing the trend of oil prices and inflation over time around the world, this paper will apply the theoretical part in an empirical study that uses a multiple regressions model for 12 countries to test the significance of the oil price-inflation relationship, and the relationship between inflation and other variables. Those variables are the growth rate of GDP, and lagged inflation. The empirical study uses an econometric models with technology of Ordinary least squares (OLS).

The empirical study found significant linear relationships between the oil price and inflation rates in developed countries. Those countries are Canada, France, Germany, Italy, Japan, the United Kingdom, and the United States. In the group of developing countries, Kuwait (as an oil exporter) and Morocco (as an oil importer) are found affected significantly by the percentage change of the oil price.

Empirical evidence shows that for all selected countries either developed or developing expected inflation is the main contributor to inflation. High values of t-statistics indicate the significance of expected inflation as an explanatory variable for inflation.

The growth rate of GDP does not show any significant coefficient in all selected countries. No empirical evidence is found for the GDP growth rate-inflation relationship. More studies on this issue might clarify the reasons and justify for that.

2. Literature review

Much literature has studied topics related to the inflationary impacts of high oil prices. Some focuses on the role of oil prices in explaining high inflation rates that have occurred in the U.S or in other countries (especially European or the OECD countries). It is easy to recognize that most of these papers focus on oil price shocks in developed countries and pay little attention to what happened in developing countries, especially the oil - importing developing countries.

Hooker (1996) claims the role of the oil impacts has decreased over time since 1973. His work used three "mismeasurment explanations" to defend his claim. The first explanation is that there exists instability in many U.S. samples around 1973. The second explanation is that oil prices were treated as exogenous variables before 1973, but they turned out to be endogenous after that (as the paper claims). The third one is that the oil prices-macroeconomy relationship is found to be asymmetric in many papers. All of those "mismeasurment explanations" make previous studies unable to account for the decline in the role of oil prices in the economy.

Empirically, to test those explanations, Hooker uses the Vector Autoregression (VAR) approach. He refers the important role of oil prices before 1973 to the OPEC oil shocks. He says "if in fact oil prices were important determinants of the macroeconomy between 1948 and 1973 but not since then, it would imply that the two large OPEC oil shocks of the 1970s (OPEC I and II), in fact had little or no effect" (P. 206). The paper concludes that oil prices were major determinants of macroeconomic indicators in the United States (such as unemployment, and interest rate) before 1973 but not after that.

Hamilton (1996) wrote his article to answer Hooker's questions about what happened to the oil price-macroeconomy relationship. Hamilton proposes a new definition of an oil price increase, which is "the net increase in oil price"[1]. The reason behind this definition is that most of the quarterly oil price increases were preceded by greater oil price decreases in previous quarters, which gives the impression that these increases are correcting actions. When "the net increase in oil price" over the year is considered, it will be easy to find the correlation between oil price shock and economic recessions.

The change in oil price itself does not deserve research without understanding its influence on the global economy. Cunado and Gracia (2003) start their analysis of the oil price-macroeconomy relationship with a quick glance at oil price data discussing the difficulties behind the choice of oil price data. The authors decided to use the world oil price and the national oil price for each country from the selected, European countries. The source of the data is the International Financial Statistics (IMF). The data are quarterly data for 15 European countries including the period 1960 – 1999.

Empirically, this paper estimated the impact of oil price changes on production activities (expressed by the manufacture production index) and inflation rates using unit root tests and bivariate Granger Causality tests. The choice of the oil price variable is mostly based on the papers of Lee and Ratte (1995) and Hamilton (1996). It provides four variables as proxies for oil price shocks. The first variable is the interannual percentage change of oil prices which is defined as the change in the natural log of the oil price

[1] The net Hamiltonian price is defined as the percentage increase in oil prices if the current quarter's price exceeds the previous year's maximum and zero otherwise.

between period t and period t-4; the second variable is the oil price increases; the third variable is the net oil price increases; the fourth one is the scaled oil price increases.

The most interesting finding in this paper is the significance of the long run relationships between inflation rates and oil prices for all countries. The tests of Gregory and Hansen (1996) are used to test for cointegration in this study.

A paper prepared by International Monetary Fund (2000) studies the impacts of higher oil prices on the global economy. It divides countries into two major groups. First, it studies the impacts on industrial countries. Second, it studies the impacts on developing and transition. This work uses that MULTIMOD model that has been mentioned previously.

The paper found that for industrial countries, at the time of higher oil prices, real GDP decreases by 0.3% with comparison to "the base line case" in 2001 and 2002. Real domestic demand also declines by 0.4% in the short run. Moreover, this paper found that the impacts of higher oil prices on economic activities in the United States and Euro area are a little greater than the average for industrial countries, whereas it is the reverse case in other industrial countries. Developing and transition countries, in general, suffer as much as industrial countries. The negative impacts of oil prices appear mostly in the case of oil-importing countries. These affects differ from one oil-importing country to another depending on its dependency on oil.

Regarding inflation, the paper found that an increase in oil prices raises CPI inflation in the short run in all countries, either in industrial countries or in developing and transition countries. For example, an increase in oil prices raised the CPI inflation in the United States by 0.8 percentage points in 2000 and 0.5 percentage points in 2001. In

the Euro area, increase of oil prices raised CPI inflation by 0.7 percentage points in 2000 and 0.5 percentage points in 2001. As well, the paper estimated that a $5 oil price increase would increase inflation in China, for example, by 0.4 percentage points after one year from the oil price increase.

A paper by Hunt, Isard, and Laxton (2001) analyzes the impact of oil price shocks on the macroeconomy. This paper distinguishes between three types of oil price shocks : temporary shocks, more persistent shocks, and permanent shocks. It focuses mainly on industrial countries. The authors use MULTIMOD to test the macroeconomic effect of oil price shocks. MULTIMOD is defined in the paper as "a multi-regional macroeconometric model developed by the IMF staff for primary purpose of analyzing alternative scenarios for the World Economic Outlook (WEO)" (P. 10). This model utilizes the Philips curve framework in explaining changes in inflation rates in industrial countries.

The main contribution of this paper is that it provides several perspectives which help monetary policy makers to avoid errors. The paper states that with an immediate response from policy makers to oil price increases, the effect of oil shocks on the economy will be lower. It recommends that policy makers distinguish between the types of oil price shock in interpreting oil price shocks impacts.

LeBlanc and Chinn (2004) estimate the effects of oil price changes on inflation for the United States, United Kingdom, France, Germany, and Japan using an augmented Philips curve framework. They study mainly two aspects of the relationship between oil prices and inflation in the G5 countries. The first aspect is the nature of the effect of oil prices on inflation, the significance of the relationships. The second aspect is the variation in this effect from country to country. This study includes oil price change as a

component of the Philips curve model. The paper takes into account two possibilities. First, the oil price-inflation relationship may be asymmetric and nonlinear. Second, the relationship may be unstable. The data for this study includes the period from 1981Q1 to 2001Q4.

As a first step, this paper provides some justifications for variations in the oil price impact on inflation across the selected countries. Mainly, it points to differences in the energy intensities of production across the countries. Moreover, it suggests that differences in "after-tax retail prices" across countries have a share in explaining those variations as well. A country that has a higher "after-tax retail price" of oil is more likely to have a greater impact of oil on inflation. In addition, the paper suggests that there are two reasons that make inflation in European countries more sensitive to increases in oil prices. These reasons are: (1) European labor unions are less flexible in terms of wage reduction than those in the United States; (2) European markets are less competitive than the U.S. market, which makes extra costs transfer to inflation.

Empirically, the authors start by estimating the U.S. oil price-inflation relationship using three models. The first model is the benchmark model that considers the percentage change in nominal oil prices. The second uses the "Hamiltonian net price" to express an oil price shock. The third model allows for decreasing and increasing in the percentage change in nominal prices in order to be asymmetric. These models include inflation rates, unemployment rates, lags of interest rates, and the percentage change in nominal oil prices.

The estimation results for each model found the effect of oil prices on inflation in the United States to be significant and immediate. On the other hand, this paper also

examined the global inflationary impacts of oil prices to see whether the impacts are different across countries or not. The test includes the G5 countries except the United States. In order to make comparisons, the authors estimated the same three models for each country including the oil shock variable, and the exchange rate (for some countries). As in the U.S., the statistical estimates found that the impacts of oil prices in Europe and Japan are small. No significant differences across countries are obtained.

A paper by Barsky and Kilian (2004) reviews the macroeconomic effects of oil prices since the 1970s. The paper starts with highlighting the importance of oil to the macroeconomy. Historically, it shows the linkage between oil prices and recessions in the United States, especially after major political events in the Middle East. This linkage is evident statistically as well for the oil price increase-inflation rates relationship in the United States since 1972.

Moreover, the authors analyze "how oil price shocks affect inflation." They also explain in detail the channels through which oil price shocks potentially come: political events in the Middle East, wars (which could be considered political events), the role of embargoes, and the role of "macroeconomic conditions" (the Asian crisis in 1998 as an example).

In conclusion, the paper found no evidence to show that fluctuations in oil prices affect the U.S. macroeconomy strongly as has been thought or claimed. The analysis of the channels through which oil prices come led the authors to say that "political events in the Middle East are but one of several factors driving oil prices" (P. 23)

Another paper prepared by the International Energy Agency (IEA) (2004) provides four potential channels through which higher oil prices affect the global

economy. The first channel is terms of trade, since an increase in oil prices transfers income from oil-importing countries to oil-exporting countries. The second channel is structural rigidities in the economy, especially wage rigidity. An increase in oil prices, with wage rigidity, lead to an increase in the unemployment rate. The third channel is the balance of trade between countries. With higher oil prices, oil-importing countries suffer from depreciation their exchange rates. The fourth channel is economic : government policies that aim to reduce the macroeconomic impacts of higher oil prices.

Empirically, the paper quantifies the impact of higher oil prices on the global economy. It estimated the oil prices-macroeconomy relationships using interlink, the OECD's macroeconomic model. This model contains a sub-model model for each OECD country, whereas it has regional sub-models for non OECD countries.

For the OECD countries, the paper found that the inflation rate is 0.5% higher in what they call the "sustained higher oil price case" than in the base case.[2] The impact of higher oil prices on developing countries and transition economies is more severe and more obvious. For example, in India, the inflation rate is 2.6% points higher in the sustained higher oil price case than in the base case. These results lead one conclude from this paper that the net effect of high oil prices on the global economy is negative.

In general, most of previous papers delt with the oil price-macroeconomy relationship in developed countries using different methods. The impact of oil prices in developing countries found little attention in literature. Here, this paper comes to fill in this gap by studying the effect of oil prices in developed and developing countries.

[2] The base case definition is "when oil prices assumed to be constant at $25 per barrel over the period from 2004 to 2008" (P. 7). Based on that, the sustained higher oil prices case is when the prices are $10 higher (that is to be $35).

3. Theoretical analysis of inflation

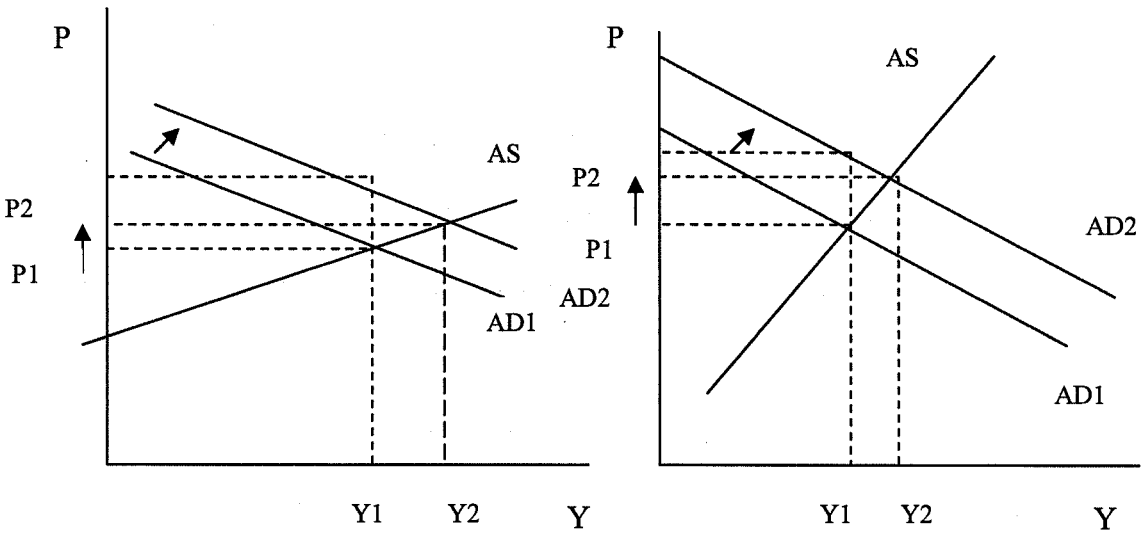
3.1. The causes of inflation

If we look at the market mechanism, we find that inflation (which is the permanent increase of the general level of prices) can come from an upward shift in the aggregate supply curve or the aggregate demand curve, or both. The type of inflation brought by an increase in aggregate demand is called Demand Pull Inflation. The type of inflation brought by an increase in the costs of the factors of production causing a decrease in aggregate supply is called Cost Push Inflation. High oil prices are claimed to cause high inflation rates through Cost Push Inflation. I will return to this point in the coming sections to analyze it and put it to an empirical test. Now let us consider these two essential causes of inflation in more detail and see how high oil prices can enter our analysis here.

3.1.1. Demand Pull Inflation (DPI) and the role of high oil prices

Raising any of the component parts of aggregate demand shifts the aggregate demand curve to the right, resulting in a higher equilibrium price. This is a simple explanation of demand pull inflation. Our interest here is to know the cause of DPI and how high oil prices can cause inflation this way. There are two schools of economic thought that try to explain what actually brings about these changes. The Monetarists essentially believe that a rise in the amount of money in the economy (the money supply) yields an increase in aggregate demand. They argue that the level of prices, and implicitly inflation, is determined by the amount of money which exceeds the capacity of the economy to produce goods and services. By using this argument, we can understand how

high oil prices result in DPI in the developing, oil-exporting countries but not in the developed countries. That is, when oil prices jump up suddenly to very high levels, the developing, oil-exporting countries receive a very high return, which means that too much money supply is transmitted into production through transmission mechanisms. This is because the production capacity of the non-oil sector in the oil-exporting developing countries is limited in comparison to the production capacity in the developed countries. This is evident in the wide gap between the gross domestic incomes for the developed countries and the developing countries. Graphically, the increase in the general level of prices in the developed countries that comes from an upward shift in the aggregate demand curve would be absorbed partly by the large, non-oil production capacity in the developed countries since the aggregate supply is more elastic (more horizontal) – whereas this is not the case for the developing countries.



Graph (1A): for the developed country

Graph (1B): for the developing country

Graphs (1A) and (1B) illustrate how high returns from high oil prices would be transmitted by the production mechanism in the economy. They show clearly that in the

case of the oil-exporting, developed countries, the increase in GDP is greater than the increase in the general level of prices, which means the returns from high oil prices are employed by the large-capacity non-oil sector in the developed economy. Whereas in the oil exporting developing country, the high returns from high oil prices would contribute to a jump in the general level of prices more than the increase in GDP since the non-oil sector is not big enough to absorb the inflation by production mechanism.[3] This depends as well on the share of oil in production. Oil-exporting countries with lower shares of oil in production are more likely to absorb somewhat the inflationary impacts of oil returns.

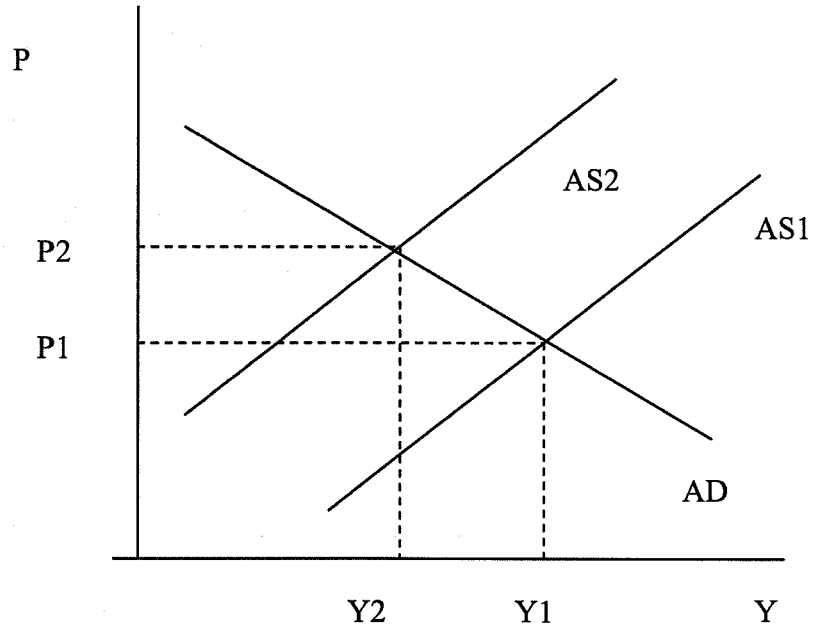
The non-monetarist (Keynesian) argument in terms of DPI is not far from the monetarists view since it holds that high returns would increase the spending in excess of full-employment-level output, which results in an increase in the general level of prices. This view could be applied to the case of high returns from oil. The only difference in the Keynesian view deals with the amount of money. The Keynesians argue that spending does not depend only on the amount of money but also on how rapidly it is used (velocity of circulation).

3.1.2. Cost Push Inflation (CPI) and the role of high oil prices

The Keynesian view continues to explain inflation on the side of production costs as well. The Keynesians suggest that one of the main causes of inflation is an increase in the costs of production factors. This view deals with the supply side. That is, an increase in the costs of production factors would shift the aggregate supply curve to the left, resulting in higher prices with less production. This analysis could be applied easily to

[3] The monetarists also identify the budget deficit as one of the main causes of inflation when government spending exceeds government income, but this is not the case here since that might occur for the oil – exporting countries when the price of oil fall or fall sharply.

case of high oil prices, since oil and energy in general are among the major factors of production. A diagram of this analysis shows a shift to the left in the short-run, aggregate supply curve when the price of oil increases (as in the diagram below).



Graph 2: Cost push inflation and the role of oil prices

The impact and the magnitude of oil as a cause of CPI depend on the relative importance of oil in the economy, as it indicates the extent of dependence on oil in production. How intensive in oil is production? This question may be answered by looking at the energy intensity of industry, and by the percentage of industry in total GDP, because oil is used intensively in industrial sectors. This leads us to say that countries with low shares of manufacturing in their GDP are most likely, all else equal, to record lower levels of CPI than those countries which have high shares of manufacturing in their GDP. Another thing that determines the role of oil prices in CPI is the elasticity of substitution of oil with respect to other energy alternatives. That is, if other energy sources can be easily substituted for oil, the role that oil price could play in CPI will be small.

3.1.3. Imported inflation and the role of high oil prices

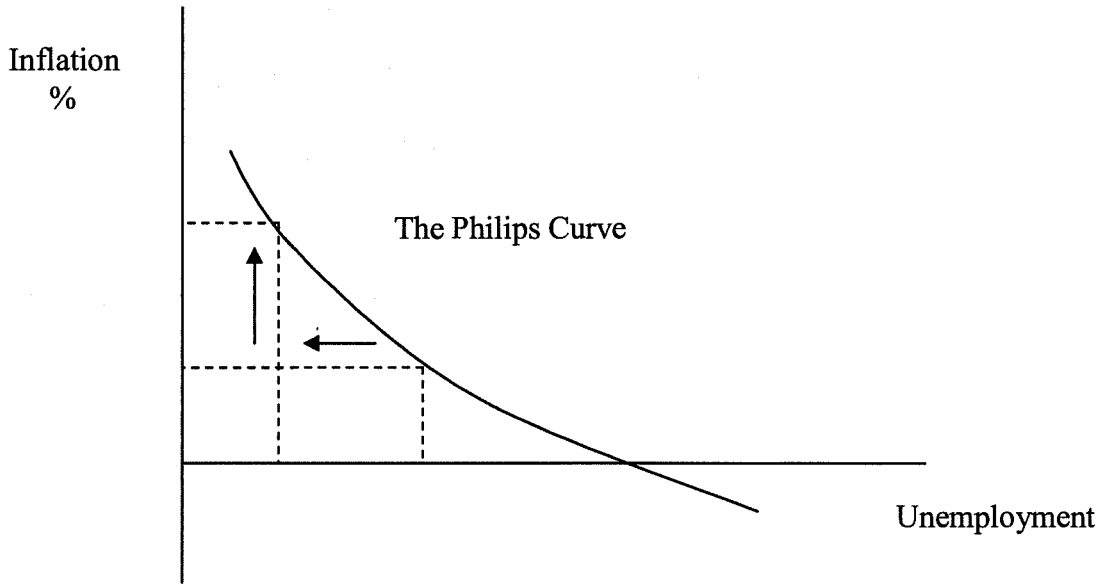
Imported inflation could be created by CPI. The inflation that comes from commodities influenced by increases in production factor prices, such as oil, would be transferred to other countries if these commodities are exported. The question here is, would that create inflation or not in the importing countries? The answer depends on countries' dependence on imported goods.

When an oil price shock occurs, it occurs for all countries as a world crisis. Whether the countries importing those goods are highly dependent on them or not, it will not protect them from being affected by high oil prices. This is because their domestic industry would be affected by the shock as well. The only thing that makes it more dangerous for the importing countries is the double influence, or the influence of CPI plus the influence of imported inflation.[4] This analysis could apply to small countries since they are mostly dependent on imported goods. In general, the higher the country's dependence on imports for the country, the more likely it will import inflation.

3.1.4. The role of expected inflation

Based on the observed data of unemployment and wage levels during the period 1861 – 1957, Professor A.W. Philips found that there is a trade-off relationship between inflation and unemployment. This trade-off put policy makers in front of two options; either to increase unemployment or find an acceptable level of unemployment associated with a certain level of inflation. This trade-off is expressed by the Philips Curve (shown below).

[4] For more details about the analysis of imported inflation, see Turnovsky and Kaspura (1974).

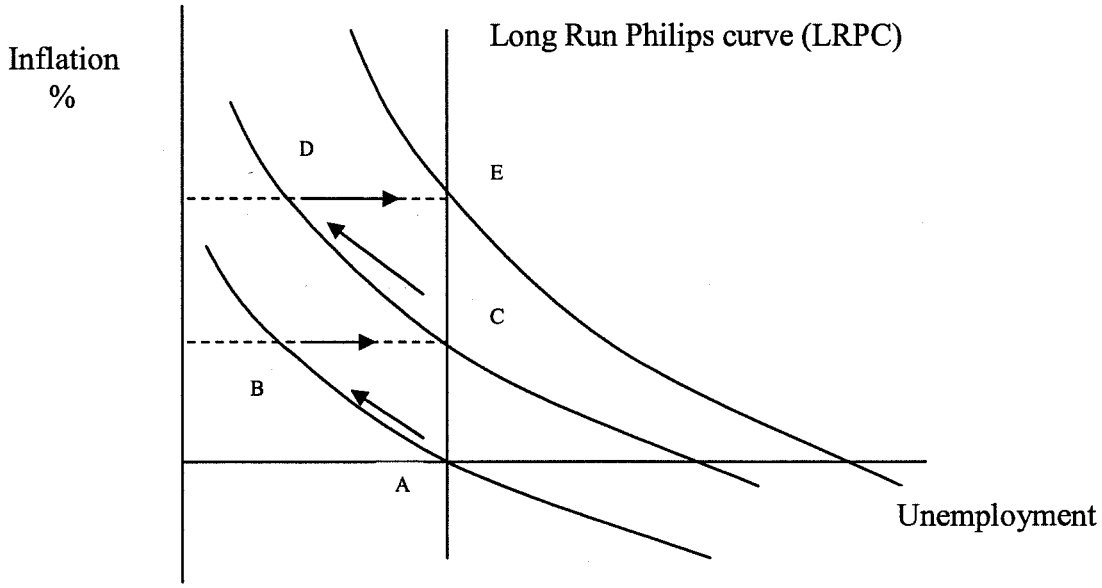


Graph 3: The Philips Curve

However, observations in the 1970s show that unemployment and inflation rising together. This means that policy makers have a simple choice between unemployment and inflation. Those observations created the need to have adjustment for Philip's argument.

A convincing adjustment came from Milton Friedman, who added the terminology "Expectations-Augmented Philips Curve" to theory. Mainly, Friedman focuses on the role that expectations of people play in the Philips Curve. In general, Friedman claims that there should be a series of different Philips curves associated with each level of expected inflation.

In more detail, if people expect inflation to occur, they would expect and ask for higher nominal wage to compensate for reduction in real wage. Friedman's argument here is in the absence of money illusion.



Graph 4: The expectations-augmented Philips curve

Graphically, the economy moves from a Philips curve to a steeper one until it reaches the long-run Philips curve (LRPC). If the economy begins at point A with a high level of unemployment and 0% expected inflation, and the government aims to lower the level of unemployment, it would implement an expansionary policy boosting aggregate demand (AD) up. In the short run, an increase in AD would lead people to expect unemployment to fall. This is illustrated in the graph above by a movement along the Philips curve from A to B. However, in the adjustment period, prices increase as a result of the shortages in the economy. Based on the absence of money illusion, wages should be raised to compensate people. This increase in wages increases costs for producers. Consequently, the aggregate supply (AS) decreases and the economy would be at point C (with higher expected inflation and the same preceded level of unemployment) because of people's expectations. If the government is still resistant to reduce unemployment, the

economy will go though the same stages (C to D to E). Yet, we can see how inflation would be greater with augmented expectations.

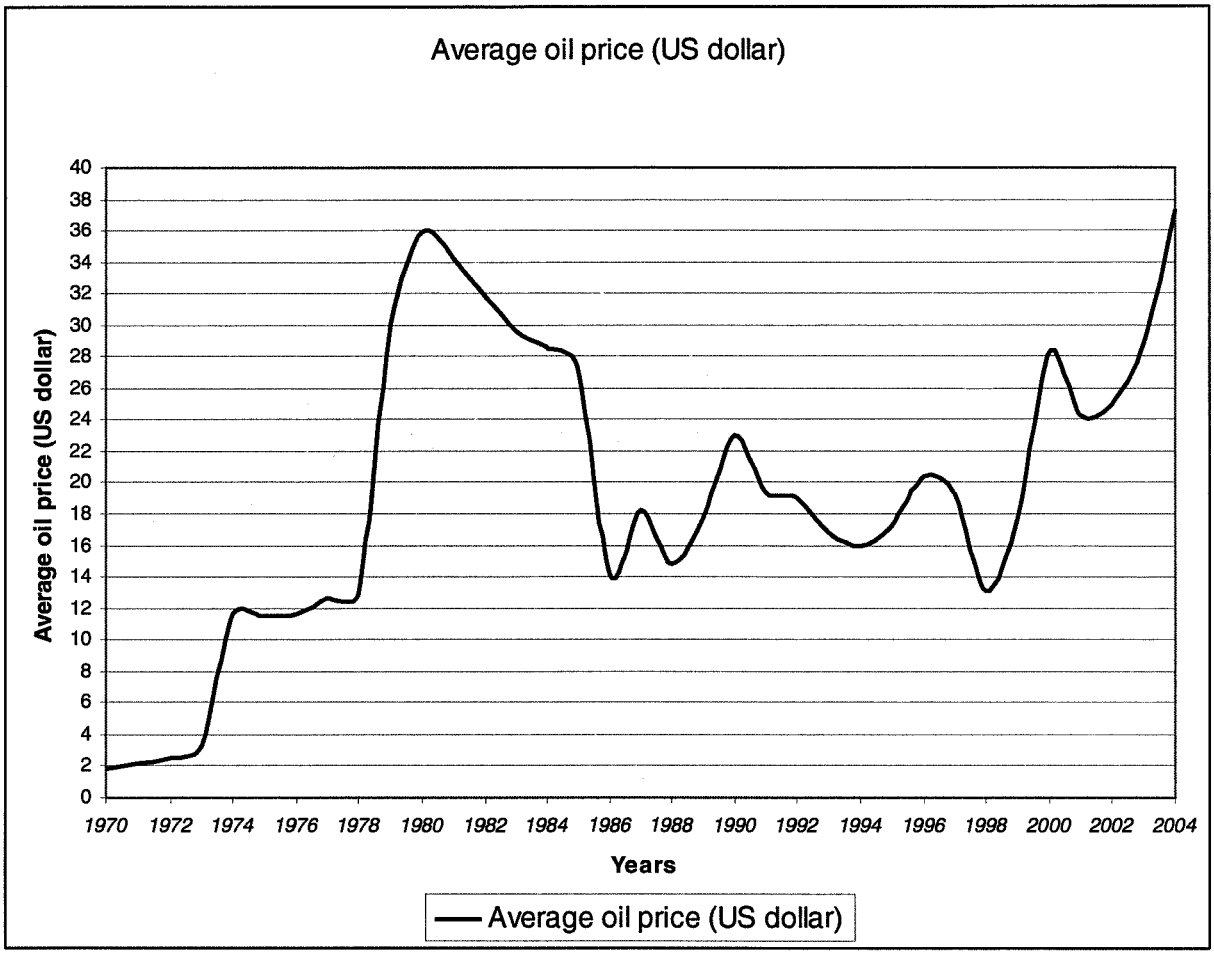
4. The data

4.1. The history of oil prices (1970 – 2004)

The world has witnessed five oil-price shocks since 1970. The first one was in 1973 – 1974, when the Organization of Petroleum Exporting Countries (OPEC) imposed an oil embargo which raised the crude oil prices from $3.29 to $11.58 per barrel. The second shock was in 1978 – 1979, after the Iranian revolution disrupted the oil market, causing a decrease in oil supply, and raising oil prices from $12.87 to $30.03 per barrel. The third shock was at the time of Iraq's invasion of Kuwait in 1990, when the oil prices jumped from $17.91 to $22.99 per barrel. The fourth one was in 1999 when the demand on oil recovered after the Asian crisis in 1998 to shift the oil price up from $13.08 to $17.98 per barrel. The most recent shock that the world witnessed was in 2004. Events in Iraq disrupted oil supplies, especially after the destruction of oil pipe lines at that time. These events, which were out of the control of OPEC,[5] allowed oil prices to reach a record $48.71 per barrel. The average price jumped from $28.89 to $37.25.[6] The historical trend of oil price over the last three decades is illustrated in the following chart.

[5] OPEC tried to stop the sharp increasing of oil prices (when prices exceed the targeting price) by increasing its production of oil but that didn't succeed to control the high prices.

[6] All prices are the average oil spot price, US dollar. Source: World Economic Outlook Database, IMF, September 2004 and September 2003.



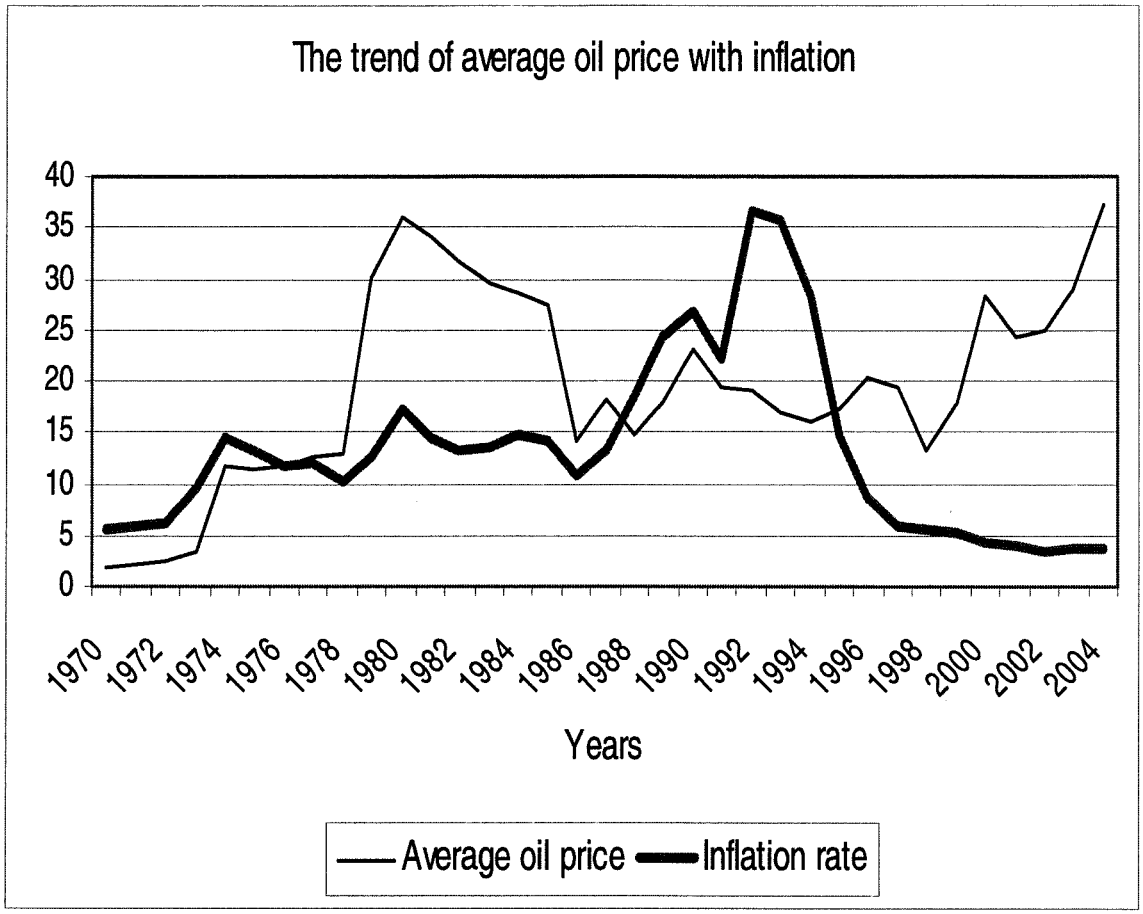
Graph 5: The history of the average oil price since 1970.

4.2. The oil price trend and inflation for the global economy (1970 – 2004)

A glance at the historical trend of the average oil price and the average world inflation rate, as shown in the chart below, shows clearly the link between them. The correlation between the oil price and the inflation rate in the early 1970s is obvious. Inflation was increasing steadily with the oil price until 1974, when oil prices jumped sharply from 3.29 in 1973 to 11.58 in 1974, and the inflation rate responded with a sharp increase from 9.6 to 14.4. The link is also clear in 1986 when the oil price decreases after years of high prices in the late 1970s and the early 1980s, from 27.37 to 14.17. The inflation rate, in

response, dropped from 14.3 to 10.8. In contrast, we find that in some years the average global inflation rate fluctuated in an opposite direction to the average oil price. For example, the inflation rate jumped from 13.2 in 1987 to 18.4 in 1988, whereas the average oil price decreased from 18.2 in 1987 to 14.77 in 1988. The most recent oil shock might be clear evidence as well. The average oil price reached the highest level in history while the world average inflation rate was at its lowest levels for the period 1970 – 2004.[7] These fluctuations of the inflation rate support claims that the price of oil is not responsible for, or the main contributor to, high levels of inflation. In addition, the contracting trends in oil prices and the global inflation rate suggest that there are other variables that have a greater impact on inflation than price of oil.

[7] We could look at the average price here as the nominal average price since the US dollar depreciated in 2004 which makes the real average price of oil less.



Graph 6: The history of average oil price and global inflation rate.

5. The Empirical study

After tracing the oil price-inflation relationship theoretically and graphically, it is necessary to examine the relationship using econometric methods. This study considers the oil price-inflation relationship along with other variables that have potential impacts on inflation. This stage clarifies the role of oil- price changes in explaining inflation rates in 12 countries (among other variables which are introduced by the theory and other scientific papers).

The twelve countries included in this study are classified as follows:

1- Seven developed countries (the G7): the United States, the United Kingdom, Canada, France, Germany, Italy, and Japan.

2- Three countries from OPEC, as examples of oil-exporting, developing countries: Saudi Arabia, Venezuela, and Kuwait.

3- Two examples of developing, oil-importing countries: Brazil and Morocco.

Data for the period 1971 – 2004 for the twelve countries were obtained from the IMF's *World Economic Outlook database*, September 2004 and September 2003.

5.1. Estimating the average oil price – inflation relationship for the global economy

5.1.1. Assumptions

Based on the previous review of theory that covers this subject, we can identify the major potential contributors to inflation. First, non-monetarist (Keynesian) thought about demand-pull inflation states that excess spending pushes the general level of prices upward. This can be expressed by excess demand in the economy (or global economy). The growth rate of GDP can be seen in this case to show the influence of excess demand.

Second, augmented expectations theory presents the expected rate of inflation, which is usually expressed as the lagged inflation rate, as a variable that has an impact on the current inflation rate. The theory assumes that when people experience high inflation rates, they expect them to continue in the future. This paper takes that into account and adds the lagged inflation rate as an explanatory variable to represent expected inflation.

Third, our interest here is to see the magnitude of the impact of the change of the world average oil price on the inflation rate. This paper suggests that the change in the oil price is a potential contributor to inflation. The paper defines the oil price variable as the percentage change in the oil price. This definition of the change in the oil price has been used previously by LeBlanc and Chinn (2004) in their benchmark, and it differs from the Hamiltonian net price that only considers the percentage increase in oil prices.

In summary, the paper assumes that there are three independent variables that are potentially responsible for explaining inflation. These variables are the change in the world average oil price, the growth rate of GDP (percentage change in real GDP),[8] the one- year lagged inflation rate (representing expected inflation). This work searches for linear relationships between the independent variables and inflation.

[8] Real GDP is measured in constant dollars to avoid the influence of inflation on GDP.

5.2. The model

A separate regression for each country is used for the empirical study, utilizing the expectations-augmented Philips curve framework. The basic linear model expresses the econometric relationship between the inflation rate as the dependent variable and the percentage change in the world average oil price, the GDP growth rate, and the one-period lagged inflation rate as independent variables. As well, the model includes an intercept term in this linear relationship. The mathematical equation for the econometric model is the following:

$$FR_{(tj)} = \alpha_{(tj)} + \beta_{1(tj)} AOP_{(t)} + \beta_{2(tj)} GR_{(tj)} + \beta_{3(tj)} FR_{(t-1)j} + \varepsilon_{(tj)}, \qquad (5\text{-}1)$$

where FR is the inflation rate, AOP expresses the percentage change in the world average oil price, GR denotes the growth rate of GDP, $FR_{(t-1)}$ represents the one-period lagged inflation rate, and ε is the random error term. In addition, the model has an intercept term for each country (α). The subscript (t) denotes the time period and the subscript (j) denotes the countries.

I expect here that the linear relationship between inflation and each of the independent variables is positive, based on the logic that has been proposed in economic theory. Since the study covers 12 countries during the period 1971 – 2004, time series data are used. The 12 countries are treated separately using the OLS estimation technique.

5.3. The econometric results

First of all, all hypothesis tests are carried out at the 5% level of significance. The empirical study tested for autocorrelation up to the second order using the Breusch-Pagan LM test, and it tested for hetroskedasticity using White's test. Breusch-Pagan LM tests found no autocorrelation problem in the models of the twelve countries at the 5% level of significance.[9] The problem of hetroskedasticity appeared in the case of Brazil, Japan, Kuwait, Saudi Arabia, the United States, and Venezuela.[10] Then, the study fixed the models of those countries that are found affected by hetroskedasticity using the robust standard errors with White's method.[11] As well, the misspecification problem for all regressions is investigated using Ramsey's RESET test with three fitted terms. Brazil and Japan are the only countries that have misspecified models at the 5% level of significance.[12] The p-values of the F-statistic for Ramsey's RESET test are 0.0003 and 0.00008 for Brazil and Japan respectively. Because of the overall significance in the model of Brazil, multicollinearity problem is investigated to see if it can justify for the insignificant coefficients for Brazil but no evidence of multicollinearuty problem is found.[13] The empirical study found no evidence that growth rate of GDP has a significant linear impact on inflation in any of the countries included in this study, either developed or developing countries.[14] The coefficient of the growth rate of GDP in Canada (0.052), for example, is insignificant with a t-statistic equal to 0.37, whereas the coefficient of the

[9] At the 10% level of significance, the model of Kuwait has autocorrelation problem.
[10] The results of these tests are shown in tables 1 and 2.
[11] If the p-value is lower than 0.05, the econometric problem does exist.
[12] The models of Morocco and Venezuela are misspecified at the 10% level of significance.
[13] The correlation matrix of the independent variables in the model of Brazil is attached in appendix 6.
[14] Italy is close to being significant, since the t-statistic of the coefficient of the growth rate of GDP equals 1.94.

growth rate of GDP in Saudi Arabia (0.253) is insignificant with a t-statistic equal to 1.38.

Moreover, most of the changes in inflation rates in the selected countries are explained by lagged inflation, except in Brazil that doesn't have any significant coefficient in its model explain the change in the inflation rate. This poor model for Brazil has might be because of the misspecification problem in the model for Brazil. For the US, the expected inflation coefficient (0.787) is significant, with 7.19 as its t-statistic's value. That means a change in the present level of inflation of 10 percentage points leads to a 7.87 percentage point change in the level of inflation in the next year. This shows clearly that in the linear model the level of inflation that people in these countries experience in the past would lead them to expect high inflation in the future, which in turn makes the present inflation higher.

In this linear model, the percentage change in the oil price has a significant impact on inflation in all developed countries.[15] For example, the significant coefficient of the percentage change in the oil price in Japan equals 4.688 and has a t-statistic equal to 3.04, whereas it equals 1.447 in Canada with t-statistic equal to 2.68. If the oil price increases from $20 to $25 per barrel (an increase of 25 percentage points), the inflation rate will increase by 1.17 percentage points in Japan and by 0.36 percentage points in Canada. In the developing countries, the results with respect to the significance of the oil price vary across Brazil, Kuwait, Morocco, Saudi Arabia, and Venezuela. The coefficient of the percentage change of the oil price is found to significantly affect inflation rates in Kuwait and Morocco, but it is not in Brazil, Venezuela, and Saudi Arabia. In Kuwait, for

[15] Although it is close to being significant in Germany, since the t-statistic of the coefficient of the percentage change in the oil price equal to 1.96.

example, the coefficient of the percentage change in the oil price (2.559) is significant with a t-statistic equal to 3.59. This coefficient means that an increase in the oil price from $20 to $25 leads to an increase in the inflation rate of 0.63 percentage points. The following tables summarize the econometric results for the selected countries.

Table 1: The econometric results for the developed countries

Variable	Canada	France	Germany	Italy	Japan	The U.K.	The U.S.
GR	0.052389	0.0281	0.127207	0.376493	0.193287	-0.44461	0.177726
t-statistic	0.379324	0.25	1.212182	1.940868	0.946201	-1.67944	0.990271
$FR_{(t-1)}$	0.862752	0.9198	0.826707	0.91059	0.62741	0.7566	0.787408
t-statistic	10.366	24.846	8.656788	16.14172	5.852373	7.92437	7.193108
AOP	1.447272	2.6915	0.767538	2.892356	4.687736	2.98955	2.789876
t-statistic	2.680252	8.6336	2.142545	3.863225	3.043254	3.01995	7.214096
Constant	0.240504	-0.175	0.1216	-0.71347	-0.166443	2.13715	-0.050279
t-statistic	0.330301	-0.453	0.267186	-0.97897	-0.327915	1.76872	-0.074079
R-squared	0.816691	0.9602	0.751592	0.906965	0.807116	0.76635	0.809086
F-statistic	44.55268	241.34	30.25643	97.48613	41.84462	32.7989	42.37956
No. of observations	34	34	34	34	34	34	34
p-value of LM test	0.790643	0.6558	0.250393	0.291447	0.100155	0.16601	0.530258
p-value of White's test	0.201758	0.5316	0.36454	0.313214	0.000076	0.26577	0.001526
p-value of Ramsey's RESET test	0.620993	0.9104	0.431573	0.773107	0.000089	0.49422	0.440805

Table 2: The econometric results for the developing countries

Variable	Brazil	Kuwait	Morocco	Saudi Arabia	Venezuela
GR	-30.02622	-0.068394	0.159782	0.253834	-1.540183
t-statistic	-1.040957	-1.350729	1.39364	1.389054	-1.868478
$FR_{(t-1)}$	0.528744	0.371557	0.595611	0.74554	0.718329
t-statistic	1.706154	2.527952	4.603556	3.160204	5.55344
AOP	56.57504	2.599191	2.87925	0.128005	1.553054
t-statistic	0.423426	3.595632	2.719754	0.057465	0.747934
Constant	281.366	2.094525	1.330832	0.023472	11.17269
t-statistic	1.977909	2.213405	1.257769	0.036365	2.097852
R-squared	0.342116	0.390828	0.500054	0.688347	0.584055
F-statistic	5.200251	6.41573	10.00216	22.08701	14.04163
No. of observations	34	34	34	34	34
p-value of LM test	0.347367	0.061417	0.399677	0.731548	0.114753
p-value of White's test	0	0.024399	0.82279	0.000002	0.000879
p-value of Ramsey's RESET test	0.000397	0.661356	0.070655	0.169152	0.077177

5.3.1. The inflationary impacts of oil price in the developed countries

The impact of oil price changes on inflation in the developed countries is significant. First of all, the type of inflation caused by the change in oil price in those countries is Cost-Push Inflation. In Europe, this is probably due to the energy intensity in industrial European countries plus the following: (a) Labor unions in European countries are strong in terms of flexibility of wage reduction. This pushes the producers in the European market to transfer the added cost coming from oil price increase to their products' prices, causing inflation. (b) What could be a complement to the first reason is that the European market is less competitive, which makes the European producer more likely to transfer the extra cost to consumers resulting in a price increase.

Regarding the other developed countries, their economies are more energy intensive, as industrial countries, than any developing country. This reason makes the change in oil price significant in explaining inflation rate in those countries.[16] Differences in the magnitude of the impact of the change in the oil price across the developed countries might be a result of differences in oil intensities in those countries, as well as differences in after-tax retail price of oil.

5.3.3. The inflationary impacts of oil price in the developing countries

This paper found no empirical evidence that changes in oil price cause inflation in the developing countries except in Kuwait and Morocco. Kuwait is an OPEC member and one of the largest oil exporters in the world, but that does not protect Kuwait from being affected by changes in oil prices. One thing might explain this result: the small size of the Kuwaiti economy. As suggested by theory, small countries with more dependency

[16] See LeBlanc and Chinn (2004).

on imports are more likely to suffer from imported inflation. Another channel that could sustain the channel of imported inflation in Kuwait is the channel of Demand Pull Inflation (DPI). The small capacity of the non-oil sector in Kuwait does not help to transfer returns from oil into production.[17] In general, this might give an indication that the channel of imported inflation is strong enough to affect inflation in developing countries if they have a small non-oil sector, since developing countries are highly dependant on imports. Morocco as an oil-importing country is likely to have imported inflation when the price of oil increases. The influence of Cost-Push Inflation on the Moroccan economy is another possibility.

[17] The small size of economy here is measured in terms of GDP. Saudi Arabia and Venezuela are small countries as well, but they are not as small as Kuwait in terms of their GDP.

7. The Findings

This paper aimed to study the relationship between oil prices and inflation in theoretical and empirical approaches. Besides the percentage change in the world oil price, the growth rate of GDP and the one-period lagged inflation rate are included in the empirical model. The empirical study included 12 countries representing developed countries, oil- exporting, developing countries, and oil-importing, developing countries.

There are three potential channels through which oil prices might affect the inflation rate. The first channel is Demand-Pull Inflation as in the case of Kuwait, even though this channel does not have any significance in the case of Saudi Arabia as the first oil exporter in the world. The second channel is Cost-push Inflation as in the case of the selected developed countries. The third channel of inflation is imported inflation. The case of Morocco might provide support for this channel. Lagged inflation – or expected inflation – is the main cause of inflation in our linear model. It is significant for all selected countries. The GDP growth rate does not show a significant coefficient for any country.

Studying economic characteristics of countries and their roles in determine the inflationary impacts of oil prices could be an interesting subject for further research, as well as the role of international trade (especially the ratio of imports to GDP). The role of the monetary policy in absorbing DPI in the oil-exporting countries is an open question for further study. Specific studies are recommended for the case of the misspecified model for Brazil.

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Appendix 1: Average oil price data (world oil price)

Years	AAOP	AOP
1971	2.21	0.2277
1972	2.46	0.1131
1973	3.29	0.337
1974	11.58	2.52
1975	11.53	-0.0043
1976	11.63	0.0086
1977	12.6	0.0834
1978	12.87	0.0214
1979	30.03	1.3333
1980	35.95	0.1971
1981	34.27	-0.0467
1982	31.76	-0.0732
1983	29.64	-0.0667
1984	28.55	-0.0367
1985	27.37	-0.0413
1986	14.17	-0.4822
1987	18.2	0.2844
1988	14.77	-0.1884
1989	17.91	0.2125
1990	22.99	0.2836
1991	19.37	-0.1574
1992	19.04	-0.017
1993	16.79	-0.1181
1994	15.95	-0.05
1995	17.2	0.0783
1996	20.37	0.1843
1997	19.27	-0.054
1998	13.08	-0.32122
1999	17.98	0.3746
2000	28.24	0.57063
2001	24.33	-0.13846
2002	24.95	0.02548
2003	28.89	0.1579
2004	37.25	0.2893

Definitions: 1- AAOP: actual oil price.

2- AOP: Annual ratio of change in oil price.

Source: The world economic outlook database, IMF, September 2004

Appendix 2: Inflation rate data for the selected countries (1)

Year	Brazi	Canada	France	Germany	Italy	Japan
1970	22.3	3.3	5.9	3.4	5	7.6
1971	20.1	2.8	5.5	5.2	4.9	6.4
1972	16.5	4.8	6.2	5.5	5.7	4.8
1973	12.6	7.6	7.3	7	10.8	11.7
1974	27.6	10.9	13.7	7	19.1	23.1
1975	28.9	10.7	11.8	5.9	17.1	11.7
1976	42	7.5	9.6	4.3	16.7	9.4
1977	43.7	8	9.4	3.7	18.5	8.2
1978	38.7	9	9.1	2.7	12	4.2
1979	53.9	9.2	10.8	3.9	14.8	4
1980	132.6	10.2	13.1	5.6	21.3	7.8
1981	101.7	12.5	13.3	6.4	19.5	4.9
1982	100.5	10.7	12	5.1	16.5	2.8
1983	135	5.9	9.5	3.3	14.6	1.9
1984	192.1	4.3	7.7	2.4	10.9	2.3
1985	226	4	5.8	2.1	9.1	2
1986	147.1	4.1	2.5	-0.1	5.8	0.6
1987	228.3	4.4	3.3	0.3	4.7	0.1
1988	629.1	4	2.7	1.3	5.1	0.7
1989	1430.7	5	3.5	2.7	6.3	2.3
1990	2947.7	4.8	3.4	2.7	6.5	3.1
1991	477.4	5.6	3.2	3.7	6.3	3.3
1992	1022.5	1.5	2.4	5	5.3	1.7
1993	1927.4	1.8	2.1	4.5	4.6	1.2
1994	2075.8	0.2	1.7	2.7	4.1	0.7
1995	66	1.9	1.8	1.7	5.2	-0.1
1996	15.8	1.6	2.1	1.2	4.1	0
1997	6.9	1.6	1.3	1.5	1.9	1.7
1998	3.2	1	0.7	0.6	2	0.6
1999	4.9	1.8	0.6	0.7	1.7	-0.3
2000	7	2.7	1.8	2.1	2.6	-0.8
2001	6.8	2.5	1.8	2.4	2.7	-0.7
2002	6.5	1.8	1.8	1.4	2.4	-1
2003	4.3	2.1	1.4	1.1	1.8	-0.6
2004	6.6	1.9	2	2.4	1.8	2.1

Source: The world economic outlook database, IMF, September 2004 and September 2003.

Appendix 3: Inflation rate data for the selected countries (2)

Year	Kuwait	Saudi Arabia	Morocco	The United Kingdom	The United States	Venezuela
1970	8.3	0.2	1.3	6.4	5.9	2.5
1971	8.3	4.5	4.1	9.5	4.2	3.2
1972	8.3	4.3	3.8	7.1	3.3	2.8
1973	9.2	16.5	4.1	9.2	6.3	4.1
1974	14.6	21.4	17.5	15.9	11	8.3
1975	6	34.6	7.9	24.3	9.1	10.3
1976	4.4	31.5	8.5	16.7	5.8	7.6
1977	8.4	11.4	12.6	15.8	6.5	7.8
1978	7.2	11.2	9.7	6.6	7.6	7
1979	7.1	1.2	8.3	12.6	11.3	12.5
1980	6.9	4.4	9.4	16.8	13.5	21.4
1981	7.3	2.8	12.5	12.2	10.4	16.2
1982	8.1	1	10.5	8.5	4	9.6
1983	4.3	0.2	6.2	5.2	5.3	6.2
1984	1.3	-1.6	12.4	4.4	4.4	12.2
1985	1.4	-3.1	7.7	5.2	3.5	11.3
1986	1	-3.2	8.7	3.6	1.9	11.6
1987	0.7	-1.6	2.7	4.1	3.6	28.2
1988	1.5	0.9	2.4	4.6	4.1	29.4
1989	3.4	1	3.1	5.9	4.8	84.5
1990	-6	-1	6	8.1	5.4	40.7
1991	9.1	4.6	9	6.8	4.2	34.2
1992	-0.5	-0.4	5.7	4.7	3	31.4
1993	0.4	0.8	5.2	3	3	38.1
1994	2.6	0.6	5.1	2.4	2.6	60.8
1995	2.7	5	6.1	2.8	2.8	59.9
1996	3.6	0.9	3	3	2.9	99.9
1997	0.7	-0.4	1	2.8	2.3	50
1998	0.1	-0.2	2.7	2.7	1.5	35.8
1999	3	-1.3	0.7	2.3	2.2	23.6
2000	1.7	-0.6	1.9	2.1	3.4	16.2
2001	2.5	-0.8	0.6	2.1	2.8	12.5
2002	2.5	0	2.1	1.9	1.5	22.7
2003	2.5	1.1	2.1	2.1	2.3	25.2
2004	-0.2	2.5	1.7	1.6	3	23.7

Source: The world economic outlook database, IMF, September 2004 and September 2003.

Appendix 4: Growth rate data for the selected countries (1)

Year	Brazil	Canada	France	Germany	Italy	Japan
1971	12.2	4.1	4.8	3.1	1.6	4.4
1972	10.9	5.4	4.4	4.3	2.7	8.4
1973	13.5	7	5.4	4.8	7.1	8
1974	9.7	3.7	3.1	0.2	5.4	-1.2
1975	4.2	1.8	-0.3	-1.3	-2.7	3.1
1976	9.8	5.2	4.2	5.3	6.6	4
1977	4.6	3.5	3.2	2.8	3.4	4.4
1978	5	4	3.4	3	3.7	5.3
1979	6.8	3.8	3.2	4.2	6	5.5
1980	9.2	2.2	1.8	1	4.2	9.8
1981	-4.4	3.5	1.1	0.1	0.6	3
1982	0.6	-2.9	2.5	-0.9	-0.1	3.1
1983	-3.4	2.7	1.2	1.8	1.2	2.3
1984	5.3	5.8	1.6	2.8	2.8	3.7
1985	7.9	4.8	1.5	2	3	4.4
1986	7.5	2.4	2.3	2.3	2.5	3
1987	3.6	4.3	2.5	1.5	3	4.5
1988	0.3	5	4.2	3.7	3.9	6.3
1989	3.2	2.6	4.3	3.6	2.9	5.3
1990	-4.3	0.2	2.6	5.7	2	5.5
1991	1	-2.1	1	5	1.4	3.1
1992	-0.5	0.9	1.3	2.2	0.8	0.9
1993	4.9	2.3	-0.9	-1.1	-0.9	0.3
1994	5.9	4.8	1.9	2.3	2.2	0.9
1995	4.2	2.8	1.8	1.7	2.9	1.7
1996	2.7	1.6	1.1	0.8	1.1	3.6
1997	3.3	4.2	1.9	1.4	2	1.8
1998	0.2	4.1	3.5	2	1.8	-1.2
1999	0.8	5.4	3.2	2	1.6	0.8
2000	4.4	4.5	4.2	2.9	2.9	2.4
2001	1.5	1.5	1.8	0.6	1.8	-0.3
2002	1.5	3.4	1.2	0.5	0.7	-0.5
2003	3	3.4	2.3	2	2.3	1.1
2004	2.9	4	2.8	2.6	2	1.4

Source: The world economic outlook database, IMF, September 2004 and September 2003.

Appendix 5: Growth rate data for the selected countries (2)

Year	Kuwait	Saudi Arabia	Morocco	The United Kingdom	The United States	Venzuela
1971	7.9	14.4	5.8	2	3.3	3
1972	5.6	15.4	2.1	3.5	5.4	2.7
1973	-2.9	19.7	3.8	7.4	5.8	6.3
1974	-6.5	15.1	14.3	-1.7	-0.6	6.1
1975	-1.7	0.3	4.3	-0.7	-0.4	6.1
1976	11.7	15.1	7.2	2.8	5.6	8.8
1977	3.5	5.9	3.9	2.4	4.6	6.7
1978	5.9	6.7	5.4	3.4	5.5	2.1
1979	8.2	10.1	5	2.6	3.2	1.3
1980	-20.4	7.9	3.8	-2.1	-0.2	-1.9
1981	-18.9	1.7	-2.8	-1.5	2.4	-0.4
1982	-9.5	-10.8	9.6	2	-2	0.7
1983	5.3	-0.1	-0.6	3.6	4.3	-5.5
1984	5.2	-2.2	4.3	2.5	7.3	1.2
1985	-4.3	-4.1	6.3	3.6	3.8	0.2
1986	8.6	5.6	8.3	3.9	3.4	6.5
1987	8.1	-1.4	-2.5	4.5	3.4	3.6
1988	-10	7.6	10.4	5.2	4.2	5.8
1989	25.9	0.2	2.4	2.2	3.5	-8.6
1990	-26.2	10.7	4	0.8	1.8	6.5
1991	-45.3	9.2	6.9	-1.4	-0.5	9.7
1992	47.4	2.9	-4	0.2	3.1	6.1
1993	46	-0.6	-1	2.5	2.7	0.3
1994	-7.1	0.5	10.4	4.7	4	-2.3
1995	20.1	0.5	-6.6	2.9	2.7	4
1996	-2.7	1.4	12.2	2.6	3.6	-0.2
1997	1.2	2.6	-2.2	3.4	4.4	6.4
1998	3.2	2.8	7.7	2.9	4.3	0.2
1999	-1.7	-0.8	-0.1	2.4	4.1	-6.1
2000	3.8	4.9	1	3.1	3.8	3.2
2001	-1	1.2	6.5	1.9	0.3	2.8
2002	-1	0.7	4.4	1.7	2.2	-6.2
2003	1.7	3.3	4.1	2.4	2.6	2.2
2004	4.4	3	3.6	3.4	4.3	12.1

Source: The world economic outlook database, IMF, September 2004 and September 2003.

Appendix 6: correlation matrix of the model of Brazil

	GR	FR	AOP
GR	1	-0.19196	0.299896
$FR_{(t-1)}$	-0.19196	1	-0.16612
AOP	0.299896	-0.16612	1