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The Impact of Oil Prices Fluctuations on Industrial Production in G20 Countries

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ABSTRACT

This paper analyzes the impact of oil prices fluctuations on industrial production in G20 countries, since it includes the largest economies in the world, and it also, consists of major oil exporters and importers countries. Therefore, an industrial production function is estimated with an Autoregressive Distributed Lags model (ARDL) and explained with a set of economic variables such as foreign direct investment, trade openness, the economic freedom index, and gross fixed capital formation, in addition to real oil prices, for the period (1979-2020). This study uses the Pooled Mean Group Dynamic Panel Data estimator (PMG) because it considers the hypothesis of long-term homogeneity between countries, given their interconnection in terms of the size of their economies and the volume of trade exchange. On the other hand, this method assumes heterogeneity in the short term because countries differ within the oil position and adopt policies in response to oil price changes. The main result is that thanks to the energy source diversification policies adopted since the 1970th oil shocks, these countries have successfully minimized the impact of these fluctuations. Thus, in the short term, oil prices do not affect the dependent variable; this impact becomes negative but very limited in the long term.

Keywords: Industrial Production, Oil Prices, G20 Countries, Dynamic Panel Data, Autoregressive Distributed Lags Model, Pooled Mean Group Estimator
JEL Classifications: C5, C23, F5

1. INTRODUCTION

The industrial sector still constitutes a primordial unit of economy and is an important source of growth and progress. In addition to the direct effect on global GDP (its contribution represents more than 27% of the total GDP in 2022), industrial production growth should lead to the development of nonindustrial sectors. Indeed, if industrial production increases, the need for support services provided by other economic sectors also increases. In this case, demand for education, health, transport, and banking services increases. The greater the increase in industrial production, the greater is the necessity to employ larger numbers of qualified workers in other sectors. Therefore, the industrial sector is considered the most important sector that contributes to achieving development at the aggregate level and has positive effects on all macroeconomic indicators.

However, industrial production depends on the primary commodities. Oil is considered the most important source of energy and one of the main engines of growth for the global economy. Furthermore, the need for energy has increased with population growth, urbanization, and industrialization. Hence, Changes in global oil prices caused by political and economic events affect international economic stability, particularly the supply chains of industrial production, regardless of the oil position of countries (producing or importing). This situation urges countries to elaborate strategies for energy source diversification to attenuate the impact of sudden changes in oil prices.

Therefore, since the 1970s, the impact of oil price variations on economic indicators such as production, inflation, and employment has received considerable attention. Several studies (Hamilton, 1983), (Hooker, 1999), (Blanchard and Gali, 2007), (Bjørnland, 2009), (Mehrara and Sarem, 2009), (Majid and Mehdi, 2023) analyze these effects and consider alternative energy sources that may reduce the consequences of oil price fluctuations on the economy. Thus, it was indispensable for economies, especially in the case of the G20 countries, to secure provisions of production factors and ensure stability in their global commodities markets. Indeed, this group represents 80% of the global gross national product and approximately 75% of international trade volume. It also includes the largest oil-importing countries (United States, Europe, and major Asian countries), as well as the largest oil-producing and-exporting countries (Saudi Arabia, Russia, and Mexico).

Nevertheless, some of these studies examined the impact of oil price shocks on aggregate economic growth and not on industrial production, and the field of study was limited to the United States or only some exporting oil or importing oil countries. Hence, the goal of this study is to analyze whether the diversification of energy source policies in G20 (the most industrialized country) has achieved the objective of minimizing the impact of oil price fluctuations on industrial production. To do this, this study attempts to examine the dynamic effects of these changes on the dependent variable in our panel countries between (1979 and 2020), using a Model ARDL and adopts a PMG estimator that assumes heterogeneity of units in the short run and homogeneity in the long run.

The paper is organized as follows. The first section reviews the main empirical studies analyzing the impact of oil price changes. The second section presents some stylized facts about final oil consumption and the energy sources used in industry in the G20 countries. The third section uses an econometric model to explain industrial output variations in the G20 during the period (1979-2020) with a set of economic variables, including real oil prices. The final section concludes this paper.

2. EMPIRICAL LITERATURE REVIEW

Studies on changes in oil prices appeared specifically after the seventieth's oil shocks. The pioneering studies are (Hamilton, 1983), (Lee et al., 1995), and (Hooker, 1996), but they focused on the impact on economic growth only in the United States and the Organization for Economic Co-operation and Development (OECD) countries. Hamilton found that seven of eight postwar recessions in the USA States were preceded by an increase in crude oil prices, usually with a lag of about to 3-4 quarters. However, (Lee et al., 1995) and (Hooker, 1996) showed that oil prices typically fail to Granger-cause macro variables when data samples are extended past the mid-1980s.

Nevertheless, (Lee et al., 1995), (Hamilton, 1996), and (Bernanke et al., 1997) explain that oil prices continue to Granger cause a macroeconomy by considering the asymmetric and nonlinear relationship between them. Furthermore, (Hooker, 1999) suggested that the existence of a Granger causal relationship from changes in oil prices to production or unemployment requires some refinements to the series and equations, which are output expressed in year-over-year changes, which are smoother than the usual quarterly series, and equations exclude variables such as interest rates and inflation.

Moreover, (Blanchard and Gali, 2007) re-evaluated the macroeconomic impacts of four oil shocks from the 1970s to the first decade of the 21st century for a group of industrial economies. They conclude that the effects of oil price shocks have changed over time, with steadily smaller effects on prices and wages as well as on output and employment. This result can be explained by a decrease in real wage rigidities, and such rigidities are needed to generate large stagnation in response to adverse supply shocks, such as those that took place in the 1970s. The second cause of these changes may be the increased credibility of monetary policy, which substantially attenuates the response of expected inflation to oil shocks over time. The last plausible cause of these changes is a decrease in the share of oil in consumption and production. This decline was sufficiently large to have quantitatively significant implications.

Recently, (Majid and Mehdi, 2023) investigated the relationship between oil price changes and industrial production in the G7 countries. To investigate the heterogeneity of this impact, this study used a panel smooth transition regression model with fixed individual effects for analysis over two consecutive periods, namely 1980-1999 and 2000-2017, as well as the combined period of 1980-2017. The results indicate that an increase in oil prices has a positive (negative) impact on oil-exporting (oil-importing) countries. The impact across time periods differs from that of the 1980-1999 sample, revealing a larger negative impact compared to 2000-2017. This result gives a slight indication of the effectiveness of the energy diversification strategies employed post-2000, which resulted in lowering dependence on oil.

Some studies focus on industrial production, oil production, and exporting countries. (Mehrara and Sarem, 2009) reviewed the relationship between oil price shocks and industrial production in three oil-exporting countries, Iran, Saudi Arabia, and Indonesia, using annual data for the period 1970-2005 using Granger causality. The study concluded that Iranian and Saudi production was more affected by oil price shocks than Indonesian ones, thanks to the diversification economic policy adapted by the Indonesian government.

(Bjørnland, 2009) also discussed the economic impact of energy sector shocks on industrial production in two producing countries, Norway and the United Kingdom. This study investigated the existence of a "Dutch disease" through three types of shocks, namely, demand, supply, and price shocks, using the VAR model. The study concluded that there is no evidence of Dutch disease in Norway, but that the phenomenon exists in the long run in the United Kingdom. In fact, the oil sector plays a much larger role in Norway than in the UK in promoting manufacturing production during supply or price shocks.

In addition, many studies have analyzed the impact of oil price changes on industrial production in oil-importing countries. (Bayar and Kilic, 2014) studied the effects of 18 members of the Euro area during the period from 2001 to 2013 using a panel data regression model. The study concludes that oil and natural gas prices have a negative impact. In fact, a 1% increase in oil and natural gas prices caused industrial production to decrease by 1.9% and 1.8%, respectively. However, (Kalymbetova et al., 2021) using quarterly data for the period from (2000 to 2019) for the most ten oil-importing countries (China, Germany, India, Italy, Japan, the Netherlands, South Korea, Spain, the United Kingdom, and the United States), concluded that a positive long-term relationship exists between changes in oil prices and industrial production due to the high level of industrialization in these countries, which allows them to produce to foreign countries more profitably in shock periods.

(Al-Risheq, 2016) studied 52 developing countries using annual data for the period (1970-2012). The study explained industrial production with some important determinants, such as oil prices, exchange rates, trade openness, foreign direct investment, interest rates, gross capital formation, and the workforce. The study concluded that oil prices have a negative impact on industrial production and that both industrial production and aggregate economic growth in developing countries are vulnerable to oil price shocks mainly because they depend heavily on oil, which represents the largest part of their imports.

Finally, Dohyoung (2024) found that since the shale oil revolution, US industrial production has become more sensitive to oil price fluctuations and has emerged as a positive effect of oil demand shocks, stimulating aggregate economic activity. Furthermore, industry-level analysis indicated the existence of strong positive spillover effects from an oil price increase to different sectors, primarily through direct purchases of inputs for oil production and investment. Hence, the author suggests that economic policy needs to consider that the reaction of US economic activity to oil price shocks resembles that of an oil exporter, rather than an oil importer.

In conclusion, the results of these studies differ in the impact of changes in oil prices on industrial production and the panel of countries used. That is, only oil-exporting countries or oil imports. Therefore, this study examines a group of oil-producing and oil-importing countries, namely the G20, and covers the period from 1979 to 2020. Thus, we can explain the short- and long-term effects of oil price changes on industrial production in G20. The explained model uses a dynamic panel data methodology that considers the heterogeneity between G20 countries, as they differ in their oil position, sectoral composition, and economic structure.

3. DATA AND MODEL

The G20 countries group is composed of the world's largest oil-producing and exporting countries (Saudi Arabia, Russia, Canada, Indonesia, Argentina, Mexico, and Brazil) and the largest oil-importing countries (United States, China, France, Germany, India, Japan, Korea, the United Kingdom, Italy, Turkey, Spain, Australia, and South Africa). Table 1 exhibits the repartition of the final energy use of oil in the main sectors of the G20 countries for the period (1990-2020). The sectors are transport, residence or households, commerce, and industry. We note that the transport sector is the largest consumer of oil energy in all countries, and it takes over at least one-third of oil consumption in Korea (34%) and up to 75% in the USA. Thus, we can assume that transport is the sector that is most elastic to oil price changes. The industrial sector's utilization of oil products as energy varies between 4% in the USA and 17% in Japan, with an average of 10.45% and a median of 10.4%. Finally, using oil as the final energy source in the residential or household sector is highly dispersed between G20 countries. <1% is in South Africa or Australia, and >13% in Germany (14%), Indonesia (16%), and India (17%).

Table 2 represents the distribution of the final energy consumed in the industrial sector. It demonstrates the diversification of energy used in industrial production in G20 countries, such as: (oil, natural gas, electricity, crude oil, coal, heat, and biofuels). Natural gas and electricity have the highest percentage of consumption

Table 1: Final energy use of oil by sectors in G20 (1990-2020)

Country	Industry	Transport	Residential or households	Commercial
Saudi Arabia	15	43	2	-
Russia	12.4	49	6	1
Canada	7.3	61	3.6	1.7
Mexico	10.5	60	10	2.2
Argentina	3.4	57	7	1.7
Indonesia	18.3	55	16	1.8
Brazil	13.5	57	7	1.13
U S A	4	72	3.2	2
China	14.5	48	6	22
France	6	54	11	5
Germany	4.7	43	14	7
India	14.7	41	17	0.6
Japan	17.02	43	8	9.8
Korea	10.4	34	3.2	8
United Kingdom	8.7	66	5	3
Italy	9	62	8	1.2
Turkey	11.2	54	7	0.5
Spain	10.4	60	7.5	3
Australia	9.3	72	0.9	1.3
South Africa	8.7	72	0.97	1.3

Source: Based on energy information administration data (IEA)

Table 2: Percentage of the final energy consumption in the industrial sector in G20

Country	Oil products	Natural gas	Crude oil	Biofuels	Heat	Coal	Electricity
Saudi Arabia	52	36	4	-	-	-	6
Russia	11	25	0.05	0.8	27	16	19
Canada	12	32	-	14	1	5	33
Mexico	17	36	-	3	-	9	34
Argentina	23	42	-	6	-	1.4	26
Indonesia	22	25	-	13	-	24	13
Brazil	13	11	-	44	-	9	21
U S A	7	47	-	11	1.7	6	25
China	8	5	0.06	-	-	50	30
France	8	34	-	6	5	8	36
Germany	4	36	-	7	7	11	35
India	15	9	-	15.5	1.11	43	19
Japan	23	13	-	4.3	-	24	34
Korea	7	15	-	6.6	5.9	15	48
United Kingdom	17	33	-	4	13.14	6	34
Italy	7.8	35	-	2.52	11.4	2.84	39
Turkey	13	31	-	-	3.16	21.2	30
Spain	15	36	-	7.6	-	3.84	36
Australia	15	31	-	13.16	-	11.16	28.7
South Africa	8.7	6.9	-	6.5	-	-	42

Source: Based on IEA, World Energy Balances, 2008, 2013, 2017, 2019

in all countries of the G20, except in Saudi Arabia (KSA). The share of oil does not exceed fourth for all panels except the KSA (52%), with 13.5% as the mean and 13% as the median. This result indicates a decrease in the consumption of oil as energy in industry and evidence of successful implementation by G20 countries of energy diversification and sustainable development policies.

The study covers the period from (1979 to 2020), and the data are issued from the annual database of World Development Indicators (WDI) for the following variables: (the added value of industrial production, foreign direct investment to GDP, gross capital formation to GDP, the trade openness index, the economic freedom index variable from (www.heritage.org), and the real oil prices for the OPEC basket from the Saudi Central Bank. The study sample consisted of the Group of Twenty (USA, China, India, Japan, Korea, Germany, France, Britain, Italy, Turkey, Brazil, Spain, Australia, South Africa, Saudi Arabia, Russia, Canada, Mexico, Argentina, and Indonesia). Table 3 summarizes the descriptive statistics of the variables.

The estimated model is as follows:

$$IAV_{it} = B_{i0} + B_{i1}ROBOP_{it} + B_{i2}\ FDI_{it} + B_{i3}\ TOI_{it} + B_{i4}IEF_{it} + B_{i5}GCF_{it} + \mu_{t,i} \quad (1)$$

Variables used in the estimation are:
The dependent variable (IAV) is measured by the added value of industrial production as a percentage of gross domestic product.

Otherwise, independent variables are:

1. Real prices of the OPEC basket crude oil (ROBOP): The increase in oil prices leads to higher production costs, which prompts companies to reduce industrial production (Jiranyakul, 2006) Likewise, high oil prices negatively affect oil revenues in exporting countries by reducing demand for oil and goods from these countries.(Bjørnland, 2009). Therefore, it is expected that the rise in real oil prices will reduce industrial production in the G20, regardless of the oil position of the countries (exporting or importing).
2. Foreign direct investment (FDI): Is measured as the percentage of net foreign investment flows to GDP. Foreign direct investment effects have been mitigated in the literature. FDI can increase industrial production in the host country through technology transfer. However, since multinational firms benefit from economies of scale, FDI can also negatively affect domestic industrial production through competition effects (Aitken and Harrison, 1999). In conclusion, we expect FDI to have positive effects, especially in the long run.
3. Trade openness (TOI) was calculated as the sum of exports and imports to GDP. We thus suggest that trade openness positively affects industrial production. It can enhance both production value and investment returns (Jawaid and Waheed, 2011). In addition, trade openness enables developing countries to gain technology and promote R and D (Coe et al., 1997).
4. (IEF) The Economic Freedom Index measures the degree of market liberty among countries. It covers 12 freedoms from property rights to financial freedom in our panel, each of which is graded on a scale of 0-100. A country's overall score is derived by averaging these 12 economic freedoms, with equal weights given to each. Thus, the greater the score, the freer is the country's market. Several researches (Berggren, 2003; Brkić et al., 2020) illustrated the positive impact of economic freedom on economic activity in all sectors.
5. (GCF): Gross fixed capital formation (GFCF) has a positive impact on the industrial production demonstrated by several papers as (Plosser, 1992).

4. ECONOMETRIC METHODOLOGY

We estimate an industrial production function as explained in equation (1) for G 20 countries during the period 1979-2020. To analyze the dynamic effects of the explaining variables, this study

Table 3: Summary statistics

ROBOP	GCF	IEF	TOI	FDI	IAV	Variables
860	868	564	868	867	749	Obs
46.19884	24.46873	64.15631	45.9323	1.633018	30.70091	Mean
22.30185	6.247681	10.91317	18.78201	1.685049	9.199107	Std.Dev
15.18	10.85391	0.8288172	9.1	−3.60894	16.49544	Min
92.4	46.66012	83.1	110.58	12.7315	71.21,866	Max

uses an autoregressive distributed lag model (ARDL). We assume a single lag and the same short-run dynamics for all series (ARDL (1,1,1,1,1)). Thus, we can write the dynamic panel specification as follows:

$$IAV_{it} = a_{0i} + \delta_{i1}ROBOP_{it} + \delta_{i2}ROBOP_{it-1} + \delta_{i3}FDI_{it} + \delta_{i4}FDI_{i,t-1} + \delta_{i5}TOI_{it} + \delta_{i6}TOI_{i,t-1} + \delta_{i7}IEF_{it} + \delta_{i8}IEF_{i,t-1} + \delta_{i9}GCF_{it} + \delta_{i10}GCF_{i,t-1} + \lambda_{i1}IAV_{i,t-1} + \mu_i + \xi_{t,i} \quad (2)$$

Where i = 1, 2……, N, represents the number of countries in the panel, t = 1, 2,………, T is the number of periods, δ_{ij} are the k × coefficient vectors of independent variables $X_{i,t-j}$, and $\lambda_{i,1}$ is the coefficient of the dependent variable lag, μ_i is the group-specific fixed effect,T must be large enough such that the model can be fitted for each group separately, and time trends and other fixed regressors may be included.

And the error correction model is:

$$\Delta IAV_{it} = \varphi_i (IAV_{i,t-1} - B0 - B_{i1}ROBOP_{it} - B_{i2}FDI_{it} - B_{i3}TOI_{it} - B_{it}IEF_{it} - B_{i5}GCH_{it}) + \delta_{i1}\Delta ROBOP_{it} + \delta_{i3}\Delta FDI_{it} + \delta_{i5}\Delta TOI_{it} + \delta_{i7}\Delta IEF_{it} + \delta_{i9}\Delta GCF_{it} + \mu_i + \xi_{t,i} \quad (3)$$

To estimate the model, approaches differ for dynamic panels with large N and T, compared to traditional approaches with large N and Small T. Estimations with small T data usually use fixed or random-effects estimators, or a combination of fixed-effects estimators and instrumental-variable. Thus, the generalized method of moments (GMM) method elaborated by (Arellano and Bond, 1991) and (Arellano, 2003) represents the best alternative of estimation. However, in the case of a large T, the variables could be nonstationary, which may lead to biased results.

In addition, with the emergence of large panel data (large N and T), the assumption of parameter homogeneity has become inappropriate. Therefore, a new generation of estimation methods has emerged. Therefore, (Pesaran et al., 1999) and (Pesaran and Smith, 1995) demonstrated that in the case of large panel data and with the hypothesis of variable stationarity, the parameters could be heterogeneous between the economic units. Hence, the model can be estimated using the following methods:

4.1. Mean-Group (MG) Estimation

The Mean Group estimator proposed by (Pesaran and Smith, 1995) supposes that the model can be fitted separately for each economic unit (country). The model coefficients were then calculated as an arithmetic average of the estimated parameters for each country. Therefore, the model is unrestricted, and the intercept, parameters, and error variance are heterogeneous in the short and long run among all groups. The model requires a large T and large N. Otherwise, when N is small, the estimators are sensitive to outlier data (Favara, 2003).

4.2. Dynamic Fixed-Effects (DFE) Estimation

Time series data for each of the groups were pooled, and only the intercept as an individual fixed effect was allowed to differ across groups. This method imposes a restriction on the homogeneity of parameters and the variance of errors for all units in the short and long terms. Thus, in the case of heterogeneity of the slope coefficients, the approach (DFE) produces inconsistent results. Moreover, (Baltagi et al., 2000) explained that in the case of smaller samples, the model may suffer from a correlation problem between the error term and the lag of the dependent variable.

4.3. Pooled Mean Group (PMG) Estimation

The estimator proposed by (Pesaran, 1997) and (Pesaran et al., 1999) represents an intermediate method because it combines both pooling and averaging, and the intercepts, short-run coefficients, and error variances are heterogeneous across groups (as in the MG estimator), but in the long run, coefficients become homogeneous (as in the FE estimator). This hypothesis is consistent with the economic reality. That is, the impact of crises and economic policy shocks varies between countries; therefore, the speed of returning to equilibrium in the short run differs among countries, but in the long run, the effect of the independent variables on the dependent variable turns into heterogeneity between countries. However, the application of this method requires two conditions. First, the error correction parameter should be negative and >−2. Second, the independent variables must be exogenous.

To estimate the regression parameters, (Pesaran et al., 1999) developed the maximum likelihood method as follows:

$$1_T(\theta', \varphi', \sigma') = -\frac{T}{2}\sum_{i=1}^{N} \ln\left(2\pi\sigma_i^2\right) - \frac{1}{2}\sum_{i=1}^{N}\frac{1}{\sigma_i^2} \left\{\Delta y_i - \varnothing_i \xi_i(\theta)\right\}' H_i \{\Delta y_i - \varnothing_i \xi_i(\theta)\} \quad (4)$$

For (i = 1.2 …. N) r (i = 1,2… N) where $(\xi_i(0) = y_{i.t-1} - X_i\theta_i)$' $(H_i = I_t - W_i(W_i'W_i)W_i)$, I_T is an identity matrix of T, and $W_i = (\Delta y_{i,t-1}, \ldots \Delta y_{i,t-p+1}, \Delta X_i, \Delta X_{i,t-1}, \ldots, \Delta X_{i,t-q+1})$

5. ECONOMETRIC RESULTS

5.1. Unit Root Tests for Panel Data

The first step consisted of testing the stationarity of the panel data series used in the model. To apply the ARDL model, variables must be integrated in the order of 0 or 1 (I (0) or I(1)); otherwise, estimations could be fallacious. For unbalanced data, we used (Im et al., 2003) (IPS) and (Maddala and Wu, 1999) (MW) methods. The null hypothesis of the tests suggests that all panels contain unit roots, but there is a small difference in the alternative hypothesis. That is, the IPS test proposes that some panels are stationary and the MW test suggests that at least one panel is stationary. Table 4 presents test results are presented in Table 4. We conclude that the variables IAV and ROPOB are not stationary in terms of level. In fact, the value of P-value is greater than the level of significance $\alpha = 0.05$ and therefore, we do not reject the null hypothesis, but variables are stationary in the first difference with both tests (IPS and MW), and they are I (1). Moreover, the variables GCF and FDI are stationary at the level, and thus I (0) with IPS and MW tests. As for the variables TOI and IEF, they are stationary at the level with the test IPS, but not with the test MW, but TOI and IEF become stationary at the level and I (1) in both tests.

Table 4: IPS and MW unit roots tests for the variables

In the level		
Variables	Test MW	Test IPS
IAV	28.8010 (0.9060)	1.0948 (0.8632)
FDI	216.0012 (0.0000)	−6.0099 (0.0000)
TOI	98.6134 (0.0000)	−0.8496 (0.1978)
IEF	132.5910 (0.0000)	−0.8187 (0.2065)
GCF	63.1693 (0.0112)	−2.9490 (0.0016)
ROPOB	32.4015 (0.7980)	−0.8361 (0.2016)
First difference		
ΔIAV	123.3782 (0.0000)	−6.2441 (0.0000)
ΔTOI	443.0036 (0.0000)	−15.5429 (0.0000)
ΔIEF	206.8742 (0.0000)	−5.3479 (0.0000)
ΔROPOB	176.6724 (0.0000)	−9.5471 (0.0000)

5.2. Cointegration Tests for Panel Data

After the stationarity test, the next step consists of checking for a cointegration relationship between the panel data variables in the model. That is, there is a long-term equilibrium relationship between the added value of industrial production, real oil prices, and foreign direct investment, trade openness, economic freedom index, and gross fixed capital formation. For this purpose, we use (Kao, 1999), (Pedroni, 1999 and 2004) and (Westerlund, 2005) tests. The null hypothesis suggests that there is no co-integration relationship between the model variables. Tables 5-7 present the test results. The majority of tests reject the null hypothesis, and we suggest the existence of a cointegration relationship in the model.

Table 5: Cointegration Kao test

Test	Statistic	P-value
Modified Dicky-Fuller test	−2.5314	0.0057
Dicky-Fuller test	−2.2645	0.0118
Augmented Dicky-Fuller test	−2.5156	0.0059
Unadjusted modified Dicky-Fuller test	−3.1740	0.0008
Unadjusted Dicky-Fuller test	−2.5603	0.0052

Table 6: Cointegration Pedroni test

Test	Statistic	P-value
Modified Phillips-Perron test	4.1613	0.0000
Phillips-Perron test	−0.5379	0.2953
Augmented Dickey-Fuller test	−0.2383	0.4058

Table 7: Cointegration Westerlund test

Test	Statistic	P-value
Variance ratio	4.1613	0.0000

5.3. Selection of Estimators

We estimate equation (1) using (MG, DFE, and PMG) estimators. The PMG estimator seems to reflect economic reality because we assume that the model parameters are heterogeneous in the short run. Indeed, G20 countries' reactions differ to shocks or variations in explaining variables, especially changes in oil prices. However, in the long term, the parameters should be homogenous. Therefore, we applied the Hausman test to choose a more statistically appropriate estimator. The results presented in Tables 8 and 9 confirm our intuition, and we interpret the regression output of the PMG estimators in the next paragraph.

Table 8: Hausman test comparison (PMG vs. DFE)

Test Hausman	Coefficient	P-value
PMG versus DFE	1.83	Prob>χ^2=0.8728

Table 9: Hausman test comparison (PMG vs. MG)

Test Hausman	Coefficient	P-value
PMG versus MG	6.22	Prob>χ^2=0.2850

5.4. Model Estimation Results

Table 10 exposes the long run estimations. It contains DFE, MG, and PMG output results, but as explained in the previous paragraph, we interpret only the PMG estimators' parameters. The effect of (FDI) is positive and statistically significant at the 10% level. This indicates that net foreign investment flows have a positive relationship with the value added to industrial production to GDP in the G20 in the long run and that increasing the explanatory variable by 1% point leads to an increase in the dependent variable in the G20 group (0.34%). This result was consistent with our expectations. As expected, the slope coefficient for the trade openness index (TOI) is also positive and statistically significant at the 1% level, and increasing the trade openness index by 1% point will lead to an increase in the explained variable by 0.32 point of percentage. This result indicates that trade openness increases industrial production through growth channels led by exports and imports as innovations and competition. Likewise, the economic freedom index (IEF) has a positive and significant impact on the added value of industrial production in the G20 at a significance level of 1%. The results indicate that the dependent variable increases by 0.159% points as a result of increasing the economic freedom index by one point in the long term. In addition, the coefficient (GCF) was positive but insignificant. This result agrees with neoclassical growth theories, which assume that, in the long run, capital and labor effects become insignificant and technological progress becomes more significant and influential. The effect of the study interest variable (ROBOP) was negative and statistically significant at the 5% level. When oil prices rise by one monetary unit, the added value of industrial production in G20 decreases by 0.0267 points in the long run. Therefore, its impact remains limited. This may be due to the fact that the percentage of

Table 10: Estimations results in the long run

Variables	DFE		MG		PMG	
	Coefficient	Standard error	Coefficient	Standard error	Coefficient	Standard error
Estimation long run						
FDI	0.113	0.302	0.0862	0.749	0.344*	0.207
TOI	0.173***	0.0513	−0.00502	0.0331	0.320***	0.0480
IEF	0.0353	0.108	−0.243**	0.111	0.159***	0.0475
GCF	−0.113	0.153	0.0559	0.470	0.0990	0.131
ROBOP	−0.0489***	0.0197	0.0372	0.0314	−0.0267**	0.0117

***Significant at the 1% level, ** significant at the 5% level, * significant at the 10% level

Table 11: Estimations results in the short run

Variables	DFE		MG		PMG	
	Coefficient	Standard error	Coefficient	Standard error	Coefficient	Standard error
Estimation short run						
Error correction	−0.154***	0.0229	−0.345***	0.0688	−0.120***	0.0276
D.FDI	−0.00165	0.0402	0.0655	0.0578	0.0948*	0.0517
D.TOI	0.0683***	0.0138	0.0341	0.0213	0.0643***	0.0216
D.IEF	−0.0319	0.0319	0.0128	0.0260	−0.0225	0.0217
D.GCF	−0.0793**	0.0355	0.102**	0.0468	0.0124***	0.0446
D. ROBOP	0.0325***	0.00497	0.0171*	0.00907	0.0151	0.0102
Cons	3.322**	−1.309	9.415***	−3.442	0.193	0.358
Number of observations	513	513	513	513	513	513

***Significant at the 1% level, ** significant at the 5% level, * significant at the 10% level

consumption of oil products as energy in industry did not exceed (20)% in each country of the G20 during the study period. These results confirm the findings of (Hooker, 1996), (Blanchard and Galli, 2007) and (Majid and Mehdi, 2023) findings. However, the negative effect can be explained by the indirect impact of oil price changes on industrial production in the transport sector. This branch of economic activity is the largest consumer of oil. Thus, if oil prices increase, transport will be affected, production costs will rise in the long run, and industrial production can decrease.

The short-term results presented in Table 11 display the existence of error correction (EC) relationship in the model. EC is negative and statistically significant at the 1% level. Additionally, the coefficient of (FDI) is positive and statistically significant at the 10% level. This indicates that an increase in this variable by 1% point increases the dependent variable by 0.948% points. The coefficient of the trade openness index (TOI) is positive and statistically significant at the 1% level in the short term. And a variation of the trade openness index by 1 point of percentage vary in the same direction as the explaining variable by 0.0643% points. The economic freedom index variable (IEF) does not affect industrial production in the short term because changes in the degree of market liberty, as laws and procedures, require more time to affect economic activities. As for the variable of gross fixed capital formation, its coefficient is significant and positive at the 1% level in the short term, meaning that gross capital formation affects the value added to industrial output in the G20 in the short term by increasing the stock of capital in the economy, but it does not affect industrial output in the long term. Concerning the main variable of the study, the results suggest that there was no effect from real oil prices ROBOP on industrial production in the G20 in the short term, and the variable coefficient is insignificant. As explained earlier (Table 2), variations in oil prices have no impact on industrial production since countries tend to vary their energy sources used in the industrial sector.

6. CONCLUSION

This study investigates the impact of oil price changes on industrial production in the G20 during the period (1979-2020), using dynamic panel data models. Indeed, to explain variations in the added value of industrial production to GDP, we use an ARDL model estimated by a Pooled Mean Group (PMG) estimator which represents a combination of pooling and averaging methods and in the one hand, it suggests a heterogeneity of coefficients and error variances between groups in the short run, but in the other hand, parameters become homogeneous in long term. This suggestion is consistent with the economic reality, where the impact of crises, shocks, and economic policies varies between countries. However, in the long term, the impact becomes homogeneous.

The main result is that oil price changes have no impact on the dependent variable in the short run in G20 countries, but the effect becomes negative but limited in the long run. This finding agrees with (Hooker, 1996), (Blanchard and Galli, 2007) and (Majid and Mehdi, 2023) studies where who explained that the effects of oil price shocks have changed over time, with steadily smaller effects on prices on output because of the decrease in the share of oil in consumption and production. Moreover, the finite negative effects in the long run are derived from an indirect channel through the transport sector as a component of production costs, which represents a larger consumer of the oil energy sector. These findings prove changes in energy policies after the seventeenth shocks whatever the oil position of the countries. However, further country-level analysis in future studies would be valuable to compare the effects of oil prices between the countries of our panel, especially among exporting and importing countries.

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