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Paul Krugman (2020):
"*Let's be clear: we knew or should have known, that something like COVID-19 was going to happen*"

Energy Prices and COVID-immunity: The Case of Crude Oil and Natural Gas Prices in the US and Japan

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- Aruga & Nyga-Łukaszewska (2020): IAEE Energy Forum, *Are Oil and Gas Prices Immune to COVID-19?*, Special issue 2020

Are Oil and Gas Prices Immune to COVID-19?

BY KENTAKA ARUGA AND HONORATA NYGA-LUKASZEWSKA

Coronavirus and global society/economy

COVID-19 pandemic has far reaching consequences for our day-to-day activities. The spread of social distancing which was introduced as a measure to fight the virus influenced our families, work and lifestyles. A survey carried out by Statista (2020) between 26 March and 1 April 2020 on a sample of 2900 respondents from China, Germany, the United Kingdom and the United States supports such impact. It turns out that the majority of respondents (ranging from 73% to 84%) staved at home after the spread of

we have experienced so far. Firstly, because of the shale gas fever that had transformed the energy markets, both oil and gas, and secondly as this is, one of those critical moments – when the global oil demand in 2020 is forecasted to contract for the first time since the global recession of 2009 (IEA, 2020). This dramatic energy

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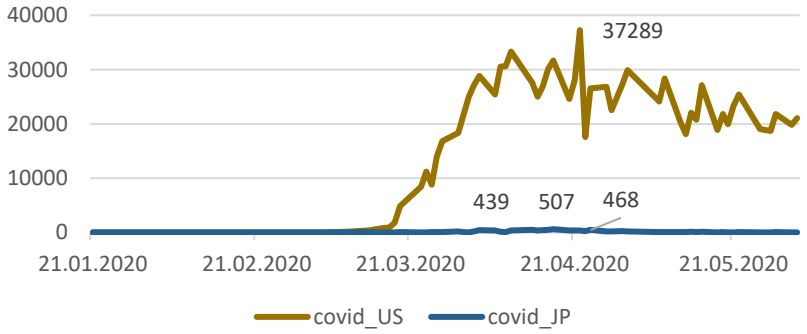
Graph. COVID-19 cases in the US and Japan between January 2020 and June 2020
Source: own elaboration



Graph. DJ and Nikkei indexes between January 2020 and June 2020
Source: own elaboration

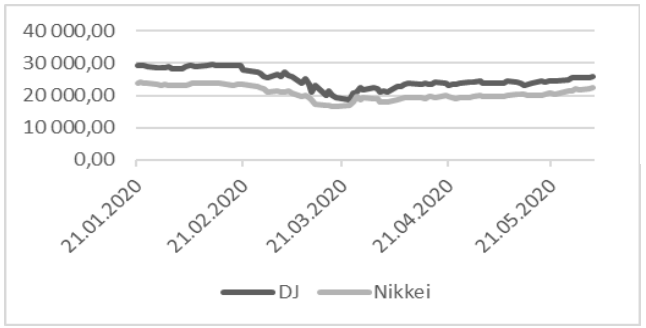


Table. Unemployment rate in the US and Japan between January 2020 and June 2020 (in %)
Source: own elaboration

Unemployment Rate	US	Japan
January 2020	3.6	2.4
February 2020	3.5	2.4
March 2020	4.4	2.5
April 2020	14.7	2.6
May 2020	13.3	2.9
June 2020	11.1	no data available

Table. Number of oil and gas rigs in operation in the US between December 2019 and June 2020.
Source: own elaboration

Period	Number of Oil and Gas Rigs
December 2019	805
January 2020	790
February 2020	790
March 2020	728
April 2020	465
May 2020	301
June 2020	265

- COVID-19 multidomensional impact: energy exporters/importers
- **Research question**: How did the COVID-pandemic influence energy prices?
- **Research sample**: US and Japan
- **Research horizon**: from January 21, 2020, to June 2, 2020 („first pandemic wave”)

- oil prices–GDP nexus, oil price determinants: Barsky and Kilian (2001; 2004); Baumeister and Kilian (2016), Hamilton (2003; 2009; 2011), Kilian (2008, 2009), and Kilian and Cheolbeom (2009)

- Hamilton (2009) underlines that the real price of oil historically tends to be difficult to predict, and is governed by very different regimes at different points in time (COVID-19?)

- Gas prices/ oil-gas price relationship: Jadidzadeh and Serletis (2017), Nguyen and Okimoto (2017) and Atil et al. (2014)

- Few studies specifically tackling a pandemic's effects on energy markets: Kelley and Osterholm (2008), Aruga et al. (2020); **research gap**:
    - 1) oil and gas market
    - 2) pandemic-induced energy shocks
    - 3) energy exporting and energy importing nations
    - 4) daily data to achieves a relatively high-frequency (similar approach: Baumeister et al. 2014)

- ARDL - which became popular in studies assessing disease effects:
  - Aruga et al. (2020) tested COVID-19's influence on Indian energy consumption,
  - Laguna et al. (2017) investigated the influence of climatic variables on malaria outbreaks,
  - Upshur et al. (1999) examined the link between pneumonia and influenza cases.

- Auto-Regressive Distributive Lag (ARDL) approach proposed by Pesaran et al. (2001) on the number of US and Japanese COVID-19 cases and energy prices

- $$Ln(Energy\ price) = Intercept + \beta_1 COVID19 + \Sigma_{i=2}^{4} \beta_i Ln(Other\ energy)_i + \beta_5 Ln(Economic\ indicator) + \beta_6 Ln(Transportation\ index) + \beta_7 Ln(Power\ and\ gas\ index) + \beta_8 Ln(Unemployment\ index) + e_t$$

- Model built upon theoretical assumptions/with limitation due to lack of daily data, and is a modification of a similar model designed in Aruga and Nyga-Łukaszewska (2020)

Table. Description of variables

Variable	Description	Source
WTI	WTI crude oil price (USD/BBL)	Markets Insider
Dubai	Platts Dubai Crude Oil (USD/BBL)	Tokyo Commodity Exchange
HH	Henry Hub natural gas price (USD/MMBtu)	Markets Insider
JKM	Platts Japan Korea Market LNG price (USD/MMBtu)	TradingView
COVID US	The cumulative COVID-19 cases in the US.	Our World in Data
COVID JP	The cumulative COVID-19 cases in Japan.	Our World in Data
DJI	Dow Jones industrial average index	Markets Insider
DJUSAU	Dow Jones U.S. Automobiles Index	ADVFN
DWCELC	Dow Jones U.S. Electricity Total Stock Market Index	ADVFN
NI225	Tokyo Stock Exchange Nikkei-225 Stock Average	Nikkei Inc.
JP transport	Tokyo Stock Exchange Transportation Equipment index	CEIC Data
JP Power	Tokyo Stock Exchange Electric Power & Gas index	CEIC Data
UE US	The cumulative US unemployment index	Google Trends
UE JP	The cumulative Japanese unemployment index	Google Trends

Variables	WTI and COVID US			Variables	HH and COVID US		
	Coef.		t-Stat		Coef.		t-Stat
Intercept	−1.0032		−0.341	Intercept	−1.2459		−1.366
Ln(WTI)(-1)	0.4670	***	3.734	LnHH−1)	0.5916	***	5.391
Ln(WTI)(-2)	−0.0036		−0.027	LnHH(−2)	−0.0163		−0.128
Ln(WTI)(-3)	−0.0236		−0.182	LnHH(−3)	-0.1721		−1.665
Ln(WTI)(-4)	0.2293	**	2.213	**Ln(COVID US)**	**0.0233**	**	2.243
Ln(COVID US)	**−0.0769**	**	−2.338	Ln(WTI)	0.0454		1.541
Ln(Dubai)	0.3456	**	2.431	Ln(Dubai)	−0.1041	**	−2.460
Ln(HH)	0.4052		1.365	LNJKM	−0.1598	**	−2.128
Ln(JKM)	0.4615	*	1.970	Ln(DJI)	0.2141		1.342
Ln(DJI)	1.1158	*	1.984	Ln(DJUSAU)	0.0583		0.853
Ln(DJUSAU)	−0.0008		−0.004	Ln(DWCELC)	−0.0157		−0.113
Ln(DWCELC)	−1.5038	***	−3.250	Ln(UE US)	−0.0987	***	−3.002
Ln(UE US)	0.2803	***	2.653				
Variables	Dubai and COVID JP			Variables	JKM and COVID JP		
	Coef.		t-Stat		Coef.		t-Stat
Intercept	−1.1475		−0.501	Intercept	3.6891	***	3.820
Ln(Dubai)(-1)	0.6501	***	5.987	LNJKM(-1)	0.7716	***	12.137
Ln(Dubai)(-2)	−0.2200	**	−2.044	Ln(COVID JP)	−0.0003		−0.025
Ln(COVID JP)	0.0297		0.495	Ln(Dubai)	0.0406		0.878
Ln(COVID JP)(-1)	0.0497		0.659	Ln(WTI)	0.0547	*	1.826
Ln(COVID JP)(-2)	−0.1820	**	−2.433	Ln(HH)	0.0133		0.150
Ln(COVID JP)(-3)	0.0926	*	1.695	Ln(NI225)	−0.3430		−1.553
Ln(WTI)	0.2068	***	3.481	Ln(JP transport)	−0.0692		−0.291
Ln(HH)	−0.1741		−0.876	LN(JP Power)	0.0722		0.445
Ln(JKM)	0.1480		0.990	Ln(UE JP)	−0.0421		−1.389
Ln(NI225)	−0.3443		−0.759				
Ln(JP transport)	1.2955	***	2.707				
LN(JP Power)	−0.7202	*	−1.879				
Ln(UE JP)	0.0200		0.232				

Table. ARDL estimations.
Note: ***, **, and * denote significance at 1%, 5%, and 10% levels, respectively. ARDL stands for Auto-Regressive Distributive Lag, coef. – coefficient, *t*-Stat – t-statistic.

Table. Bounds F-test for cointegration

Model	F-Stat.	
WTI vs. COVID US	5.7683	***
Dubai vs. COVID JP	10.7793	***
HH vs. COVID US	13.2265	***
JKM vs. COVID JP	5.5742	**

Note: *** and ** denote rejecting the null hypothesis of no cointegration (I(1)) at the 1% and 5% levels, respectively. The 1% and 5% lower bound (I(0)) critical values are 4.94 and 3.62 and those of the upper bound (I(1)) critical values are 5.58 and 4.16, respectively.

Both the crude oil and natural gas prices are cointegrated with the US and World COVID-19 cases

Table. Long-run coefficients estimation

Models	Variables	Coef.		t-Value
WTI vs. COVID US	Intercept	−3.0324		−0.3399
	Ln(COVID US)	−0.2324	**	−2.0161
Dubai vs. COVID JP	Intercept	−2.0137		−0.5068
	Ln(COVID JP)	−0.0177		−0.3474
HH vs. COVID US	Intercept	−2.0878		−1.3271
	Ln(COVID US)	0.0391	**	2.1462
JKM vs. COVID JP	Intercept	16.1497	***	5.8927
	Ln(COVID JP)	−0.0014		−0.0247

Note: *** and ** denote significance at the 1% and 5% levels, respectively.

Only the US COVID-19 cases that have long-run impacts on the energy prices

Japan's oil and gas markets were not affected by the number of Japan's COVID-19 cases

Table. Conditional error correction ARDL estimations

Variables	WTI and COVID US			Variables	HH and COVID US		
	Coef.		t-stat		Coef.		t-stat
Intercept	-1.0032		-0.3408	Intercept	-1.2459		-1.3662
Ln(WTI)(-1)	-0.3308	***	-3.3928	Ln(HH)(-1)	-0.5968	***	-5.9691
Δ(Ln(COVID US))	-0.0769	**	-2.3380	Δ(Ln(COVID US))	0.0233	**	2.2429
Δ(Ln(WTI))(-1)	-0.2022	*	-1.7261	Δ(Ln(HH)(-1))	0.1883	*	1.7894
Δ(Ln(WTI))(-2)	-0.2058	*	-1.9395	Δ(LN(HH)(-2))	0.1721		1.6646
Δ(Ln(WTI))(-3)	-0.2293	**	-2.2128	Ln(WTI)	0.0454		1.5411
Ln(Dubai)	0.3456	**	2.4310	Ln(Dubai)	-0.1041	**	-2.4602
Ln(HH)	0.4052		1.3648	Ln(JKM)	-0.1598	**	-2.1281
Ln(JKM)	0.4615	*	1.9699	Ln(DJI)	0.2141		1.3419
Ln(DJI)	1.1158	*	1.9844	Ln(DJUSAU)	0.0583		0.8528
Ln(DJUSAU)	-0.0008		-0.0037	Ln(DWCELC)	-0.0157		-0.1134
Ln(DWCELC)	-1.5038	***	-3.2500	Ln(UE US)	-0.0987	***	-3.0015
Ln(UE US)	0.2803	***	2.6532				

Note: ***, **, and * denote significance at 1%, 5%, and 10% levels, respectively.

US model:

There was a negative impact from COVID-19 cases on crude oil prices, while the natural gas market had a positive impact from the COVID-19 cases.

Model diagnostics:

- serial correlation and heteroskedasticity of the residuals – OK - 5% significance level
- CUSUM (cumulative sum) diagnostic test for parameter stability – OK - 5% significance level

- In the US, both crude oil and natural gas markets were affected by the COVID-19 pandemic, with both short-run and long-run relationships
- In the US, the cumulative number of COVID-19 cases had a negative impact on the crude oil price while it positively affected the natural gas price
- In Japan, only a short-run shock with a lag was apparent in the crude oil market and no evidence from that shock was visible in the natural gas market

- **Possible explanations for differences in the US and Japanese oil and gas market reactions to the pandemic maybe:**
- 1) the severity of the spread of the virus in the US as compared to Japan
  - US COVID-19 cases is more than a hundredfold greater than in Japan
  - US severe stay-at-home policies vs. Japan - commuting by public transportation even in a state of emergency

- 2) US: a supplier and consumer of oil and gas vs. Japan: importer of oil and gas

- **Possible explanations for differences in diverse oil and gas markets reactions to the COVID-pandemic might be:**
  - greater stability in gas prices being the consequence of preceding warm winters (exporters, have been less optimistic and more cautious about future investments as they had already expected lower gas sales)

- For energy exporters, the pandemic might be a trigger to diversify their economies and decrease reliance on energy exports
- For energy importers like Japan, it could be the case that little will change in that respect

- **Study limitations:**
  - literature strings on energy shocks and the pandemic's effects on energy markets, here limited to hydrocarbons
  - high-frequency data, which became one of the important factors that delimited our empirical investigation

- **Next research steps:**
  - extending the period or range of the data sample (when available)
  - compare the results with other countries

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