Does renewable energy substitute LNG international trade in the energy transition?

2020, *Energy Economics*, 92, 104964
https://www.sciencedirect.com/science/article/pii/S0140988320303042?dgcid=author

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ENERGY, COVID, AND CLIMATE CHANGE. 8th, June 2021
Concurrent Session 67: LNG Economics
#IAEE2021ONLINE

Background – key statistics (BP, 2019)

- Global reliance on fossil fuels despite the rise of renewable energy
  - 84.7% of primary energy consumption (natural gas: 28.2%)
- Demand for natural gas is rising as a bridge towards the energy transition
  - Annual growth rate: 2.7% in 2007-2017 and 5.3% in 2018
- The share of LNG trade is increasing (2000: 28.6% in 2000, 2018: 45.7%; and LNG trade is expected to dominate future natural gas trade dynamic
- But natural gas is losing its appeal as a climate change mitigation solution

This study investigates…

- The impact of energy transition policies, measured by the share of renewable energy to total energy usage, on LNG international trade

- A panel global dataset between 1988 and 2017

- A trade gravity framework using econometric methods (FE and GLS)

Quick main findings

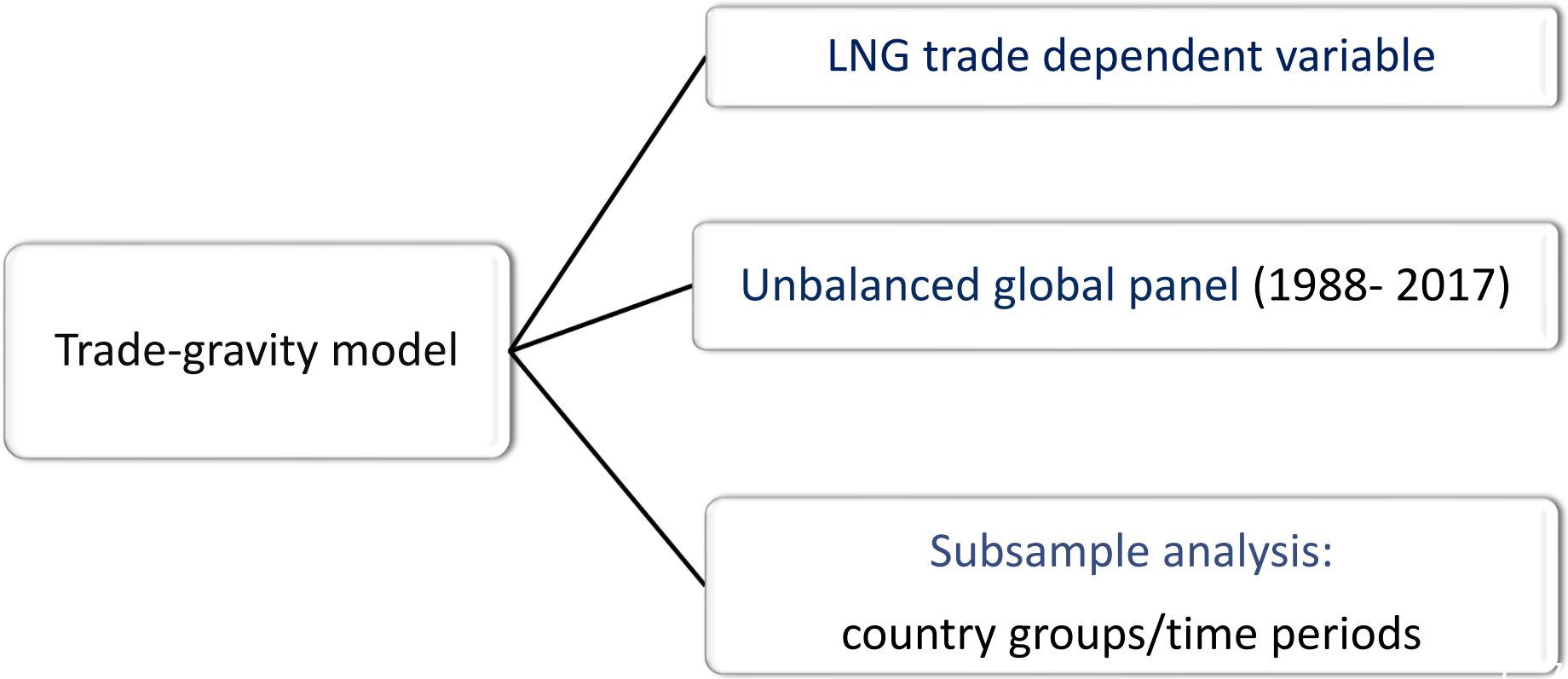
Does renewable energy substitute LNG international trade in the energy transition?

Outline

- Contribution
- Dataset
- Empirical framework
- Estimation results
- Conclusion
- Policy implication and further work

Contribution

Econometric framework



Empirical framework

- Fixed-effect econometric model:

$$\ln(y_{kt}) = C + \beta_1 \ln(GDP\_exp_k) + \beta_2 \ln(GDP\_imp_k) + \beta_3 \ln(Green_{kt}) + \beta_{4kt} X_{kt}^{-1} + \theta_k + \zeta_t + \varepsilon_{kt} \quad (3)$$

- y_{kt} is LNG trade between trading-partner pairs *k* in year *t*
- *X* is a vector of the control variables (i.e., *Price*, *Degree_days*, and *WTO*),
- ϑ_k is a country pair fixed effect,
- ξ_t is a year fixed effect,
- ε_{kt} is an error term,
- *C* is a constant,
- β_1, β_2, β_3, and β_4 are coefficients.

Variables: dependent variable

- *Trade_value_LNG* – main variable
- *Trade_volume_LNG*
- *Trade_value_per_GDP*
- *Trade_volume_per_GDP*

Variables: independent variable

- *Green*: green energy index (the ratio of renewable energy consumption to the total energy consumption in the importing country)
- *WTO*: dummy variable for being a member in the WTO
- *Price*: LNG price
- *GDP_exp* and *GDP_imp*: GDP of exporters and importers
- *Degree_days*: degree days of importing countries

Descriptive statistics and data sources

Variables	Mean	Std. Dev.	Min.	Max.
Trade_value [a]	2.36e+08	1.13e+09	1	2.66e+10
Trade_volume [a]	4.56e+09	8.54e+10	1	3.11e+12
Trade_value_per_GDP [a]	.0002938	.0019557	1.99e-13	.0659291
Trade_volume_per_GDP [a]	.0052211	.1202197	5.99e-14	7.355247
GDP_exp [b]	1.88e+09	4.00e+09	30332.2	1.73e+10
GDP_imp [b]	1.73e+09	3.19e+09	31703.09	1.73e+10
Price [a]	84.40889	3305.161	.0000119	228245.6
Degree_days [b]	7.140269	3.946778	.0084467	33.17567
WTO [c]	0.81	.3924989	0	1
Green [b]	16.60	24.27	0	96.84

*The number of observations is 5021.

a: UN Comtrade, b: World Bank, c: World Trade Organization

Estimation results

Results

Dependent variable: value of LNG trade

	(1)	(2)	(3)	**(4)**
	Model 1	Model 2	Model 3	**Model 4**
ln(*GDP_exp*)		0.560	-0.704	**0.00110**
		(0.472)	(0.866)	**(0.874)**
ln(*GDP_imp*)		0.794	0.703	**0.484**
		(0.517)	(0.565)	**(0.588)**
ln(*Green*)	-0.436**		-0.534**	**-0.485****
	(0.198)		(0.222)	**(0.223)**
ln(*Price*)				**-0.0293**
				(0.0517)
ln(*Degree_days*)				**0.167**
				(0.395)
WTO				**0.681**
				(0.513)
Constant	16.41***	-11.59	17.41	**6.895**
	(1.777)	(12.91)	(18.56)	**(19.00)**
Observations	4,168	5,134	4,168	**4,076**
R-squared	0.036	0.068	0.038	**0.042**
Number of cross sections	1,184	1,359	1,184	**1,165**

*Two fixed effects are included; Clustered robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Results

Dependent variable: volume of LNG trade

	(1)	(2)	(3)	**(4)**
	Model 5	Model 6	Model 7	**Model 8**
ln(*GDP_exp*)		2.747***	3.943***	**0.157**
		(0.703)	(1.295)	**(0.876)**
ln(*GDP_imp*)		1.058	0.448	**0.261**
		(0.778)	(0.862)	**(0.613)**
ln(*Green*)	-1.259***		-0.751**	**-0.466****
	(0.309)		(0.326)	**(0.223)**
ln(*Price*)				**-1.029*****
				(0.0517)
ln(*Degree_days*)				**0.162**
				(0.396)
WTO				**0.723**
				(0.512)
Constant	24.61***	-56.99***	-63.58**	**8.023**
	(2.825)	(20.71)	(29.08)	**(19.08)**
Observations	4,168	5,134	4,168	**4,076**
R-squared	0.041	0.055	0.051	**0.429**
Number of cross sections	1,184	1,359	1,184	**1,165**

*Two fixed effects are included; Clustered robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Dependent variable: value of LNG trade per GDP

	(1)	(2)	(3)	**(4)**
	Model 1	Model 2	Model 3	**Model 4**
ln(*Green*)	-0.445**		-0.534**	**-0.485****
	(0.197)		(0.222)	**(0.223)**
Observations	4,168	5,134	4,168	**4,076**
R-squared	0.027	0.047	0.028	**0.029**
Number of cross sections	1,184	1,359	1,184	**1,165**

Dependent variable: volume of LNG trade per GDP

	(1)	(2)	(3)	**(4)**
	Model 1	Model 2	Model 3	**Model 4**
ln(*Green*)	-0.916***		-0.624**	**-0.489****
	(0.290)		(0.314)	**(0.223)**
Observations	4,071	5,020	4,071	**4,071**
R-squared	0.095	0.099	0.098	**0.447**
Number of cross sections	1,165	1,341	1,165	**1,165**

*Two fixed effects are included; Clustered robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1
*The results of the other variables are identical with the previous estimates.

GLS estimation results

	(1)	(2)	(3)	(4)
	Trade value	Trade volume	Trade value per GDP	Trade volume per GDP
ln(*GDP_exp*)	0.166	0.279**	0.166	0.209
	(0.129)	(0.134)	(0.129)	(0.132)
ln(*GDP_imp*)	0.480***	0.432***	-0.520***	-0.497***
	(0.107)	(0.114)	(0.107)	(0.108)
ln(*Green*)	**-0.443*** **	**-0.451*** **	**-0.443*** **	**-0.446*** **
	(0.0405)	**(0.0426)**	**(0.0405)**	**(0.0425)**
ln(*Price*)	-0.0246***	-1.027***	-0.0246***	-1.036***
	(0.00700)	(0.00772)	(0.00700)	(0.00495)
ln(*Distance*)	-1.966	-0.211	-0.828	0.344
	(2,405)	(0.673)	(0.668)	(1,015)
ln(*Degree_days*)	0.132***	0.138***	0.132***	0.126***
	(0.0472)	(0.0469)	(0.0472)	(0.0478)
WTO	0.775***	0.810***	0.775***	0.788***
	(0.110)	(0.117)	(0.110)	(0.115)
Observations	3,585	3,585	3,585	3,580
Number of cross sections	674	674	674	674

*Two fixed effects are included; Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Sub-sample analysis

Country groups:

- OECD and non-OECD importers

Time periods:

- 1988-1997 1998-2007 2008-2017

Sub-sample analysis

Fixed-effects estimation results by country group (OECD and non-OECD)

		(1) OECD	(2) Non-OECD
Trade value	ln(*Green*×1000)	-0.616*	0.0510
		(0.289)	(0.349)
	Observations	1965	2111
	R-squared	0.059	0.047
	Number of cross-sections	475	703
Trade volume	ln(*Green*×1000)	-0.619*	0.125
		(0.287)	(0.357)
	Observations	1965	2111
	R-squared	0.42	0.46
	Number of cross-sections	475	703
Trade value per GDP	ln(*Green*×1000)	-0.616*	0.0510
		(0.289)	(0.349)
	Observations	1965	2111
	R-squared	0.053	0.029
	Number of cross-sections	475	703
Trade volume per GDP	ln(*Green*×1000)	-0.619*	0.0511
		(0.287)	(0.349)
	Observations	1965	2106
	R-squared	0.43	0.49
	Number of cross-sections	475	703

Note: Clustered robust standard errors in parentheses; ** p<0.01, * p<0.05; all independent variables are included in the estimations.

Sub-sample analysis

Fixed-effects estimation results by time period

		(1) 1988–1997	(2) 1998–2007	(3) 2008–2017
Trade value	ln(*Green*×1000)	-1.038	-2.615**	0.466
		(1.039)	(0.903)	(0.285)
	Observations	480	1446	2150
	R-squared	0.076	0.062	0.044
	Number of cross-sections	235	624	808
Trade volume	ln(*Green*×1000)	-1.039	-2.605**	0.495
		(1.039)	(0.901)	(0.288)
	Observations	480	1446	2150
	R-squared	0.53	0.45	0.18
	Number of cross-sections	235	624	808
Trade value per GDP	ln(*Green*×1000)	-1.038	-2.615**	0.466
		(1.039)	(0.903)	(0.285)
	Observations	480	1446	2150
	R-squared	0.070	0.052	0.039
	Number of cross-sections	235	624	808
Trade volume per GDP	ln(*Green*×1000)	-1.039	-2.605**	0.473
		(1.039)	(0.901)	(0.285)
	Observations	480	1446	2145
	R-squared	0.54	0.46	0.19
	Number of cross-sections	235	624	808

Note: Clustered robust standard errors in parentheses; ** p<0.01, * p<0.05; all independent variables are included in the estimations.

Conclusion

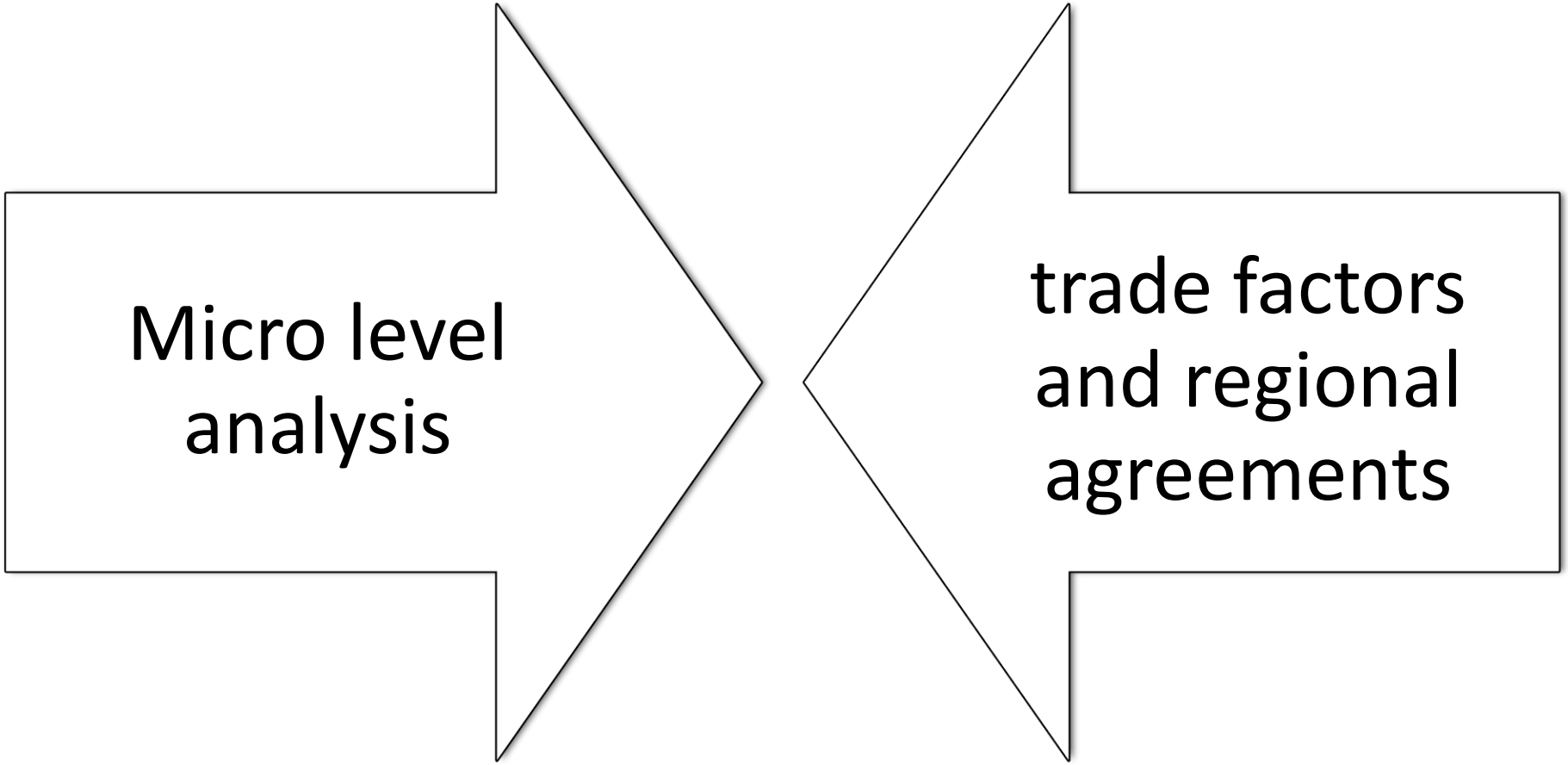
- We explored the impact of energy transition policies on LNG trade
- We used fixed effects to account for unobserved heterogeneity
- The results indicate that the rise of renewable energy reduces LNG trade

→ **Renewable energy and LNG represent partial substitutes in LNG importing countries at the global level. We obtain additional insights based on subsample analysis.**

Policy implications

- Economic structure and trade matter in the climate debate
- Further coordination is needed between conventional and unconventional fossil-fuel industries
- Less developed economies may hinder the speed of the energy transition

Further work



Thank you for your time!

Questions?

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