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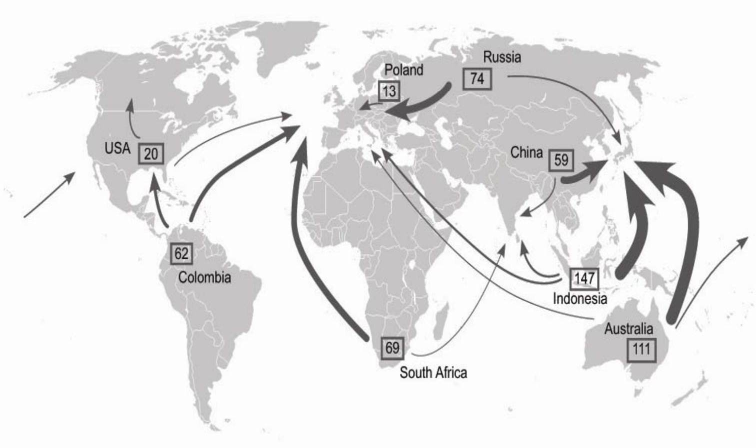

The Globalization of Steam Coal Markets and the Role of Logistics – An Empirical Analysis

EMEE 2010
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Agenda

Why are we interested in Steam Coal Prices?

- Steam coal is an important commodity, mainly used for electricity generation
  - Coal prices have a significant impact on electricity prices
- Coal markets are less transparent than generally thought
  - No systematic analysis of global coal price dynamics exists
  - Price formation in the coal trade is unclear
  - How does the lack of transparency impact the functioning of markets?
  - Is the steam coal trade integrated regionally or even globally?
- Logistics an important aspect of steam coal trade, since freight costs are a significant part of total import cost
  - The oil price is a major part of freight costs
  - Are coal prices and oil prices linked through logistics?

➔ We are interested in co-movement, not causality

State of the Literature

- Integration of international coal prices:

  - Warell (2006): import prices of both steam and metallurgical (coking) coal are generally cointegrated (except for steam coal in the 1990s)

  - Li (2007): export prices of steam coal are cointegrated

- Price convergence of energy commodities:

  - Asche et al. (2008): oil prices drive prices for power and natural gas in the U.K.

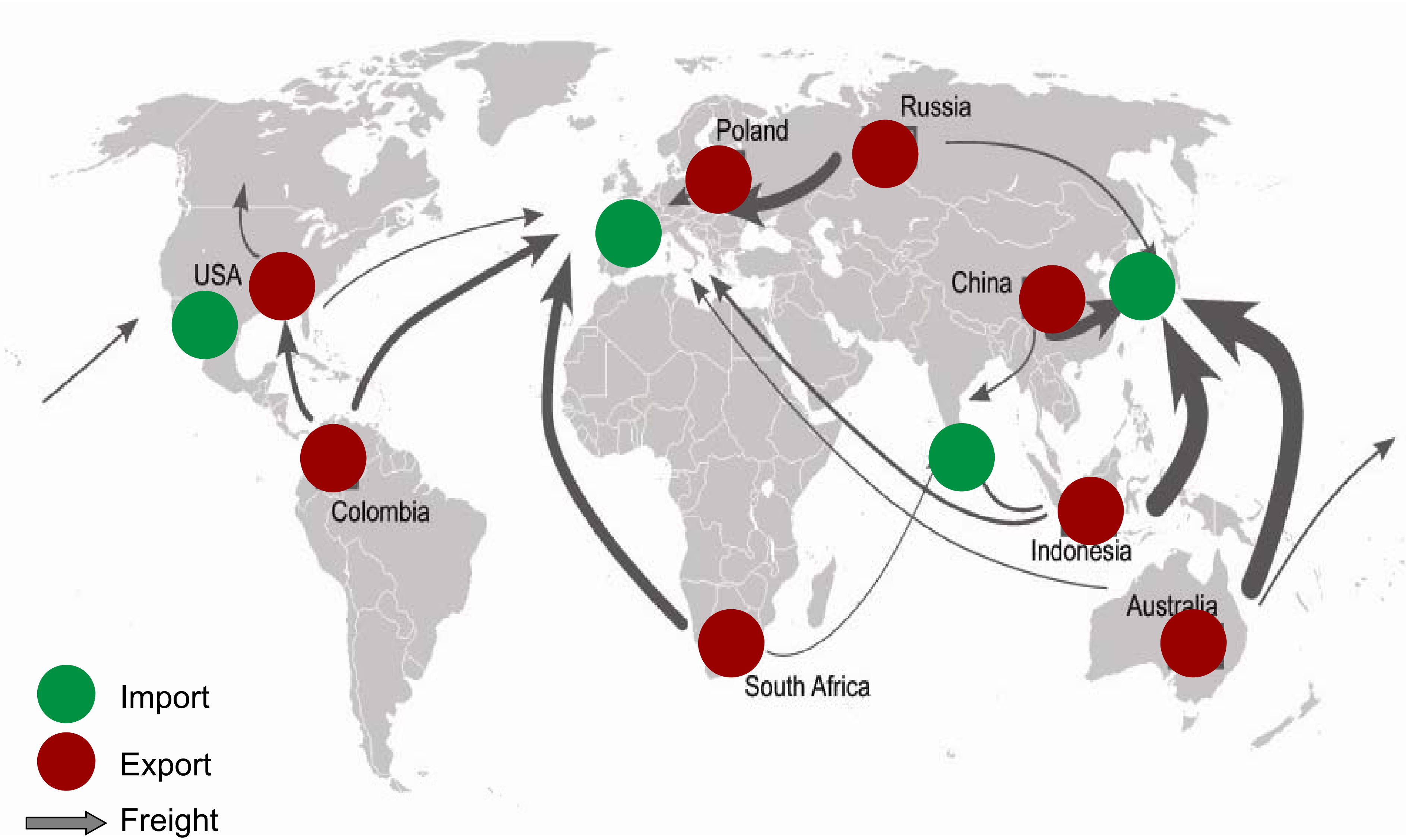
  - Bachmeier and Griffin (2006): integrated international oil markets; split in U.S. natural gas prices, weak integration of oil, natural gas and coal prices in the U.S.

Agenda

1. Introduction
2. Data and Hypotheses
3. Methodology and Empirical Evidence
4. Conclusions

References

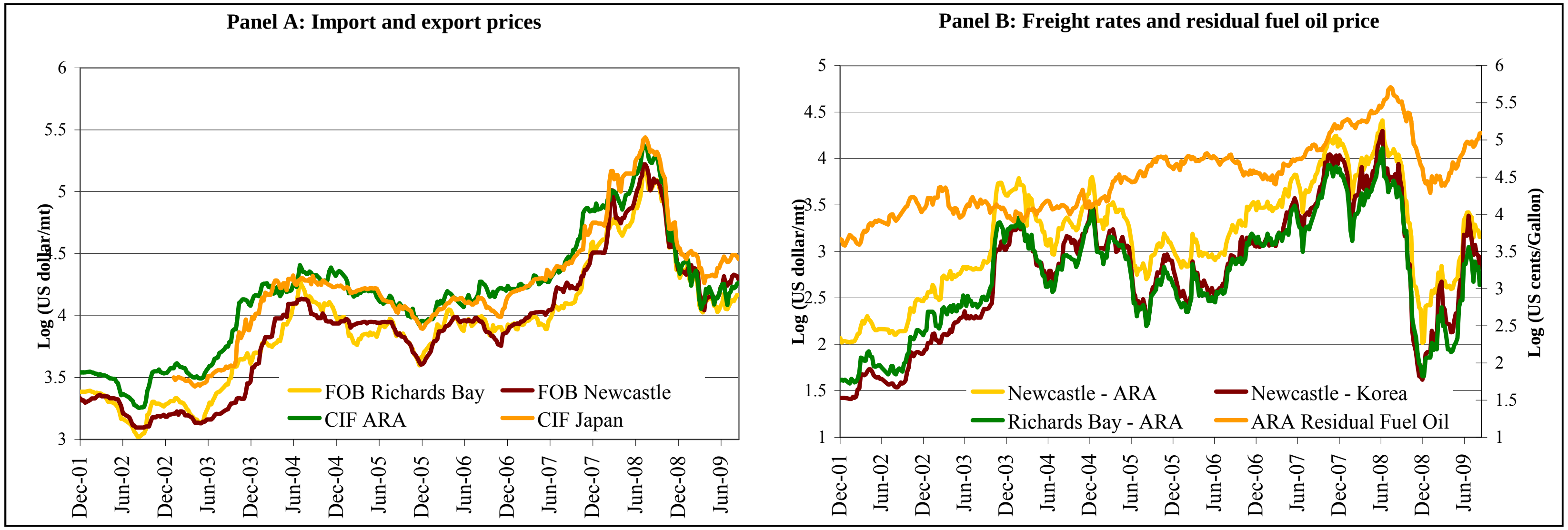
Seaborne Steam Coal Trade – Major Players



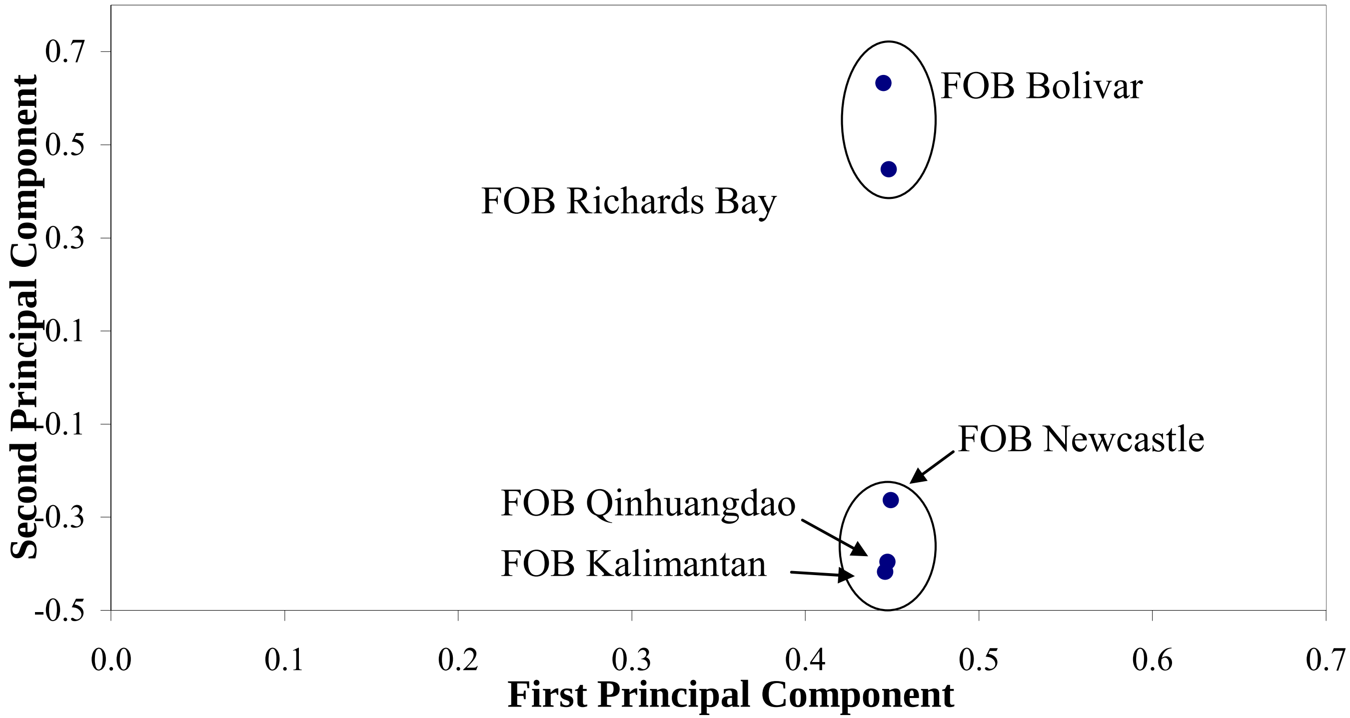
Source: IEA (2009)

Data

- 33 series, weekly observations from December 2001 until September 2009 from Platts
- CIF, FOB and freight rate data
  - ~ 390 observations each for the longest series
- Platts is collecting data on benchmark prices and freight rates
  - No standardization undertaken, e.g. according to quality
  - Data is collected by interview with “reliable” traders



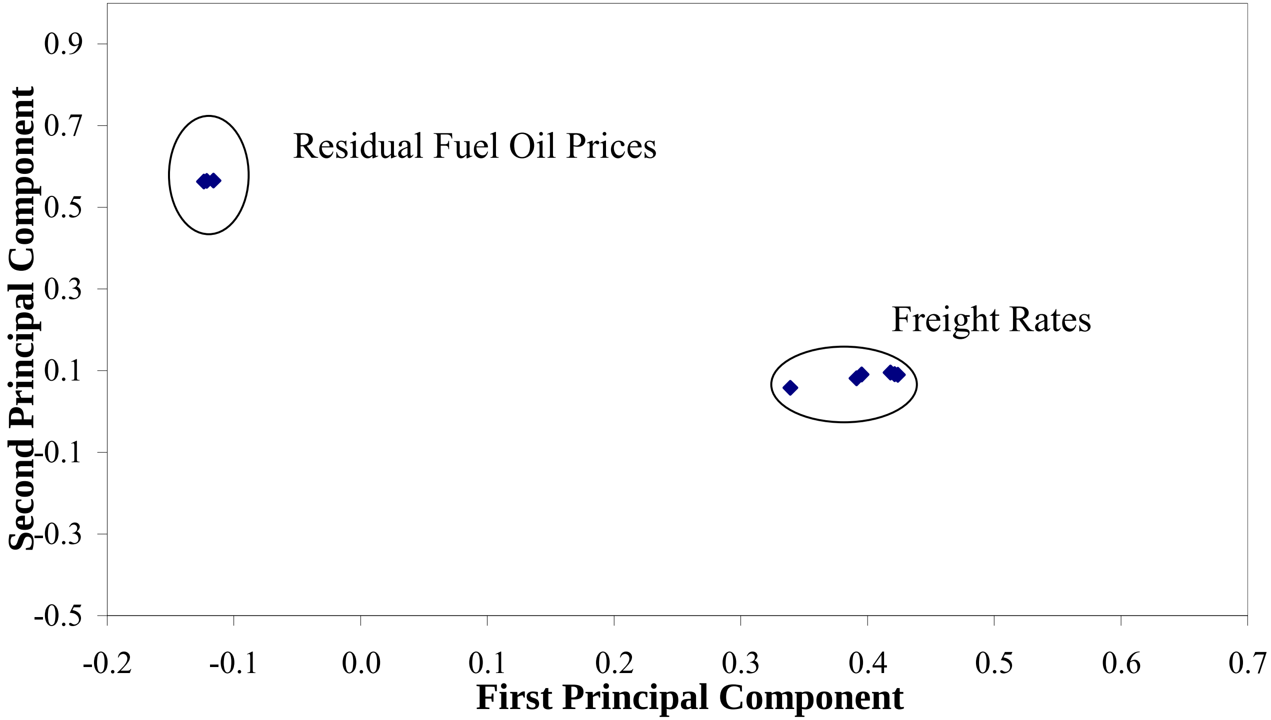
Principal Component Analysis (PCA): Export Prices



- First component almost identical, differences in second component

  → Signs of significant integration of export (and import) prices

PCA: Freight Rates and Residual Fuel Oil Prices



- Heterogeneity in both first and second component

  →No obvious relationship between (residual) oil prices and freight rates

Hypotheses

- Hypothesis 1: Prices for steam coal exports, transport and imports, respectively, are integrated to a significant degree.

- Hypothesis 2: Coal prices and freight rates are not directly related to oil prices.

- Hypothesis 3: International steam coal market integration is not (yet) complete.

Agenda

Method: Johansen VEC Methodology

- Preparative: Augmented Dickey Fuller tests show that all time series are I(1)
- Vector error correction (VEC) representation of process X_t:

$$\Delta X_t = \alpha\beta X_{t-i} + \sum_{i=1}^{k-1} \Gamma_i \Delta X_{t-i} + \upsilon + \delta t + \varepsilon_t, \text{ where } \upsilon = \alpha\mu + \gamma \text{ and } \delta t = \alpha\rho t + \tau t$$

Thus:

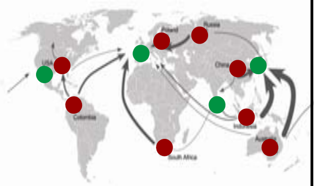
$$\Delta X_t = \alpha(\beta X_{t-i} + \mu + \rho t) + \sum_{i=1}^{k-1} \Gamma_i \Delta X_{t-i} + \gamma + \tau t + \varepsilon_t, \text{ where we set } \tau = 0 \text{ and } \rho = 0$$

Therefore:

$$\Delta X_t = \alpha(\beta X_{t-i} + \mu) + \sum_{i=1}^{k-1} \Gamma_i \Delta X_{t-i} + \gamma + \varepsilon_t$$

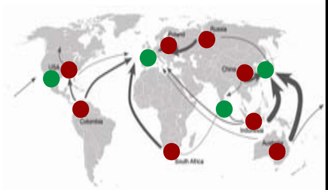
- $\alpha\beta' = \Pi$ is the long-run impact matrix
  - Its rank determines the number of cointegration relationships
- β is the matrix of cointegrating vectors describing the long-run equilibrium of the system
- α is the matrix of short-run adjustment parameters

Pairwise Cointegration of Export Prices and Freight Rates …



			$H_0: r = 0$		$r \leq 1$		$r \leq 2$	
Variables	Obs.	Lags	λ_1	Trace statistic	λ_2	Trace statistic	λ_3	Trace statistic
FOB Bolivar 6300, FOB Richards Bay 6000	386	2	0.030	**13.418**	0.005	1.745	--	--
FOB Bolivar 6300, FOB Richards Bay 6000, ARA Residual Fuel	386	2	0.038	**23.654**	0.016	8.841	0.007	2.517
FOB Bolivar 6300, FOB Qinhuangdao 6200	332	2	0.024	**11.151**	0.009	3.153	--	--
FOB Bolivar 6300, FOB Qinhuangdao 6200, ARA Residual Fuel	332	2	0.047	**22.776**	0.018	6.821	0.003	0.847
FOB Bolivar 6300, FOB Kalimantan 5900	378	6	0.033	**14.872**	0.006	2.309	--	--
FOB Bolivar 6300, FOB Kalimantan 5900, ARA Residual Fuel	378	6	0.067	33.820	0.015	**7.804**	0.006	2.097
FOB Bolivar 6300, FOB Gladstone 6500	202	2	0.046	**11.332**	0.009	1.760	--	--
FOB Bolivar 6300, FOB Gladstone 6500, ARA Residual Fuel	201	3	0.088	31.674	0.052	**13.171**	0.012	2.405
FOB Bolivar 6300, FOB Newcastle 6300	386	2	0.027	**12.146**	0.004	1.686	--	--
FOB Bolivar 6300, FOB Newcastle 6300, ARA Residual Fuel	386	2	0.052	**28.028**	0.015	7.504	0.005	1.810
FOB Richards Bay 6000, FOB Qinhuangdao 6200	332	2	0.047	18.823	0.009	**2.976**	--	--
FOB Richards Bay 6000, FOB Qinhuangdao 6200, ARA Residual Fuel	332	2	0.066	30.599	0.021	**7.907**	0.003	0.977
FOB Richards Bay 6000, FOB Kalimantan 5900	378	6	0.041	18.092	0.006	**2.174**	--	--
FOB Richards Bay 6000, FOB Kalimantan 5900, ARA Residual Fuel	378	6	0.064	34.653	0.019	**9.656**	0.006	2.407
FOB Richards Bay 6000, FOB Gladstone 6500	202	2	0.082	19.115	0.009	**1.802**	--	--
FOB Richards Bay 6000, FOB Gladstone 6500, ARA Residual Fuel	200	4	0.099	35.426	0.058	**14.642**	0.013	2.608
FOB Richards Bay 6000, FOB Newcastle 6300	386	2	0.046	19.906	0.004	**1.599**	--	--
FOB Richards Bay 6000, FOB Newcastle 6300, ARA Residual Fuel	386	2	0.071	36.932	0.016	**8.318**	0.005	1.914
FOB Qinhuangdao 6200, FOB Kalimantan 5900	332	2	0.067	25.392	0.008	**2.514**	--	--
FOB Qinhuangdao 6200, FOB Kalimantan 5900, Singapore Residual Fuel	331	3	0.079	34.926	0.018	**7.729**	0.005	1.602
FOB Qinhuangdao 6200, FOB Gladstone 6500	202	2	0.044	**11.104**	0.010	2.108	--	--
FOB Qinhuangdao 6200, FOB Gladstone 6500, Singapore Residual Fuel	200	4	0.076	**29.525**	0.055	13.780	0.013	2.564
FOB Qinhuangdao 6200, FOB Newcastle 6300	332	2	0.046	19.237	0.010	**3.486**	--	--
FOB Qinhuangdao 6200, FOB Newcastle 6300, Singapore Residual Fuel	332	2	0.053	**25.097**	0.016	7.154	0.005	1.815
FOB Kalimantan 5900, FOB Gladstone 6500	202	2	0.086	19.774	0.008	**1.644**	--	--
FOB Kalimantan 5900, FOB Gladstone 6500, Singapore Residual Fuel	201	3	0.077	30.294	0.058	**14.121**	0.011	2.145
FOB Kalimantan 5900, FOB Newcastle 6300	381	3	0.060	25.363	0.004	**1.629**	--	--
FOB Kalimantan 5900, FOB Newcastle 6300, Singapore Residual Fuel	381	3	0.062	33.063	0.016	**8.489**	0.006	2.301
FOB Newcastle 6300, FOB Gladstone 6500	197	7	0.078	19.906	0.020	3.971	--	--
FOB Newcastle 6300, FOB Gladstone 6500, Singapore Residual Fuel	199	5	0.099	32.104	0.044	**11.417**	0.012	2.412

… as well as Import Prices and Freight Rates

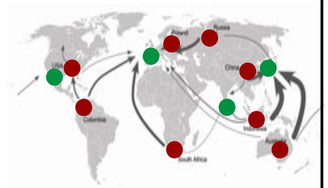


			$H_0: r = 0$		$r \leq 1$		$r \leq 2$	
Variables	Obs.	Lags	λ_1	Trace statistic	λ_2	Trace statistic	λ_3	Trace statistic
CIF ARA, CIF Japan	336	2	0.045	18.856	0.010	**3.418**	--	--
CIF ARA, CIF Japan, ARA Residual Fuel	335	3	0.074	31.919	0.014	**6.214**	0.005	1.540
CIF ARA, CIF Korea	309	3	0.055	21.995	0.014	4.422	--	--
CIF ARA, CIF Korea, ARA Residual Fuel	310	2	0.075	30.959	0.019	**6.928**	0.004	1.118
CIF Japan, CIF Korea	310	2	0.101	37.053	0.013	4.036	--	--
CIF Japan, CIF Korea, Singapore Residual Fuel	309	3	0.084	34.215	0.016	**7.157**	0.007	2.098

			$H_0: r = 0$		$r \leq 1$		$r \leq 2$	
Variables	Obs.	Lags	λ_1	Trace statistic	λ_2	Trace statistic	λ_3	Trace statistic
Colombia-Rotterdam, South Africa-Rotterdam	384	4	0.054	28.793	0.020	7.665	--	--
Colombia-Rotterdam, South Africa-Rotterdam, ARA Residual Fuel	385	3	0.091	49.049	0.020	**12.529**	0.013	4.847
Queensland-Rotterdam, New South Wales-Rotterdam	385	3	0.105	48.838	0.015	5.974	--	--
Queensland-Rotterdam, New South Wales-Rotterdam, Singapore Residual Fuel	385	3	0.111	56.160	0.018	**11.048**	0.011	4.098
Queensland-Japan, New South Wales-Korea	384	4	0.047	24.884	0.017	6.502	--	--
Queensland-Japan, New South Wales-Korea, Singapore Residual Fuel	385	3	0.056	35.025	0.020	**12.855**	0.013	4.883

- Find pairwise cointegration, except for the Colombian export price
- Find that fuel oil prices do not belong to the coal price and freight rate cointegration space

Integration of routes, basins and globally



Routes

Variables	Obs.	Lags	$H_0: r = 0$		$r \leq 1$	
			λ_1	Trace statistic	λ_2	Trace statistic
Atlantic basin						
CIF ARA, FOB Bolivar 6300+FR Colombia-Rotterdam	381	7	0.058	26.393	0.009	**3.602**
CIF ARA, FOB Richards Bay 6000+FR South Africa-Rotterdam	386	2	0.087	37.674	0.006	**2.446**
CIF ARA, FOB Qinhuangdao 6200+FR China-Rotterdam	325	7	0.031	**13.829**	0.011	3.722
CIF ARA, FOB Gladstone 6500+FR Australia/Queensland-Rotterdam	202	2	0.068	16.603	0.011	**2.280**
CIF ARA, FOB Newcastle 6300+FR Australia/New South Wales-Rotterdam	386	2	0.058	25.737	0.007	**2.572**
Pacific basin						
CIF Japan, FOB Gladstone 6500+FR Australia/Queensland-Japan	200	4	0.077	18.984	0.014	**2.867**
CIF Korea, FOB Newcastle 6300+FR Australia/New South Wales-Korea	310	2	0.072	28.958	0.019	5.872

Basins and global system

Variables	Number of variables in system	Obs.	Lags	$H_0: r \leq 2$		$r \leq 3$		$r \leq 4$		$r \leq 5$	
				λ_3	Trace statistic	λ_4	Trace statistic	λ_5	Trace statistic	λ_6	Trace statistic
Atlantic system	6	200	2	0.106	49.846	0.065	**27.339**	0.046	13.859	0.022	4.374
Pacific system	4	201	3	0.049	**15.384**	0.026	5.294	--	--	--	--
Global system	10	200	2	0.243	200.337	0.187	144.703	0.164	103.218	0.127	**67.304**

Estimating cointegrating vectors and short-term dynamics by route
Example: ARA

Colombia

CIF ARA, FOB Bolivar, FR Colombia/Puerto Bolivar-ARA (CI Rank = 1)

Cointegrating vector (coefficient on ln(CIF ARA) normalized to 1)

Beta	Coefficient	p-value
ln(CIF ARA)	1.000	n/a
ln(FOB Bolivar)	-0.450	0.000
ln(FR Puerto Bolivar-Rotterdam)	-0.521	0.000

Adjustment coefficients

Alpha	Coefficient	p-value
D(ln(CIF ARA))	-0.045	0.000
D(ln(FOB Bolivar))	-0.035	0.004
D(ln(FR Puerto Bolivar-Rotterdam))	0.128	0.000
Lags	6	
Observations	382	

South Africa

CIF ARA, FOB Richards Bay, FR South Africa/Richards Bay-ARA (CI Rank = 1)

Cointegrating vector (coefficient on ln(CIF ARA) normalized to 1)

Beta	Coefficient	p-value
ln(CIF ARA)	1.000	n/a
ln(FOB Richards Bay)	-0.664	0.000
ln(FR Richards Bay-Rotterdam)	-0.340	0.000

Adjustment coefficients

Alpha	Coefficient	p-value
D(ln(CIF ARA))	-0.123	0.000
D(ln(FOB Richards Bay))	-0.113	0.000
D(ln(FR Richards Bay-Rotterdam))	0.200	0.003
Lags	4	
Observations	384	

China

CIF ARA, FOB Qinhuangdao, FR Qinhuangdao-ARA (CI Rank = 1)

Cointegrating vector (coefficient on ln(CIF ARA) normalized to 1)

Beta	Coefficient	p-value
ln(CIF ARA)	1.000	n/a
ln(FOB Qinhuangdao)	0.184	0.394
ln(FR Qinhuangdao-Rotterdam)	-1.525	0.000

Adjustment coefficients

Alpha	Coefficient	p-value
D(ln(CIF ARA))	-0.014	0.000
D(ln(FOB Qinhuangdao))	-0.008	0.011
D(ln(FR Qinhuangdao-Rotterdam))	0.042	0.000
Lags	5	
Observations	327	

Australia

CIF ARA, FOB Newcastle, FR Australia/New South Wales-ARA (CI Rank = 1)

Cointegrating vector (coefficient on ln(CIF ARA) normalized to 1)

Beta	Coefficient	p-value
ln(CIF ARA)	1.000	n/a
ln(FOB Newcastle)	-0.384	0.000
ln(FR New South Wales-Rotterdam)	-0.608	0.000

Adjustment coefficients

Alpha	Coefficient	p-value
D(ln(CIF ARA))	-0.043	0.000
D(ln(FOB Newcastle))	-0.027	0.005
D(ln(FR New South Wales-Rotterdam))	0.052	0.036
Lags	2	
Observations	386	

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References

Conclusions

- Export prices are generally cointegrated
- Import prices and freight rates are also cointegrated
- Trading routes are integrated, and systems of trading routes are integrated regionally and globally

  → Fail to reject Hypothesis 1
- (Residual fuel) oil prices are not systematically related to coal prices and/or freight rates, i.e. logistics enter in a more complex manner

  → Fail to reject Hypothesis 2
- Speeds of adjustment to long-run equilibrium differ substantially
  - Government policies appear to have caused significant disintegration of Chinese exports from the global market

  → Fail to reject Hypothesis 3

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Thank you for your attention!

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German Institute for Economic Research

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