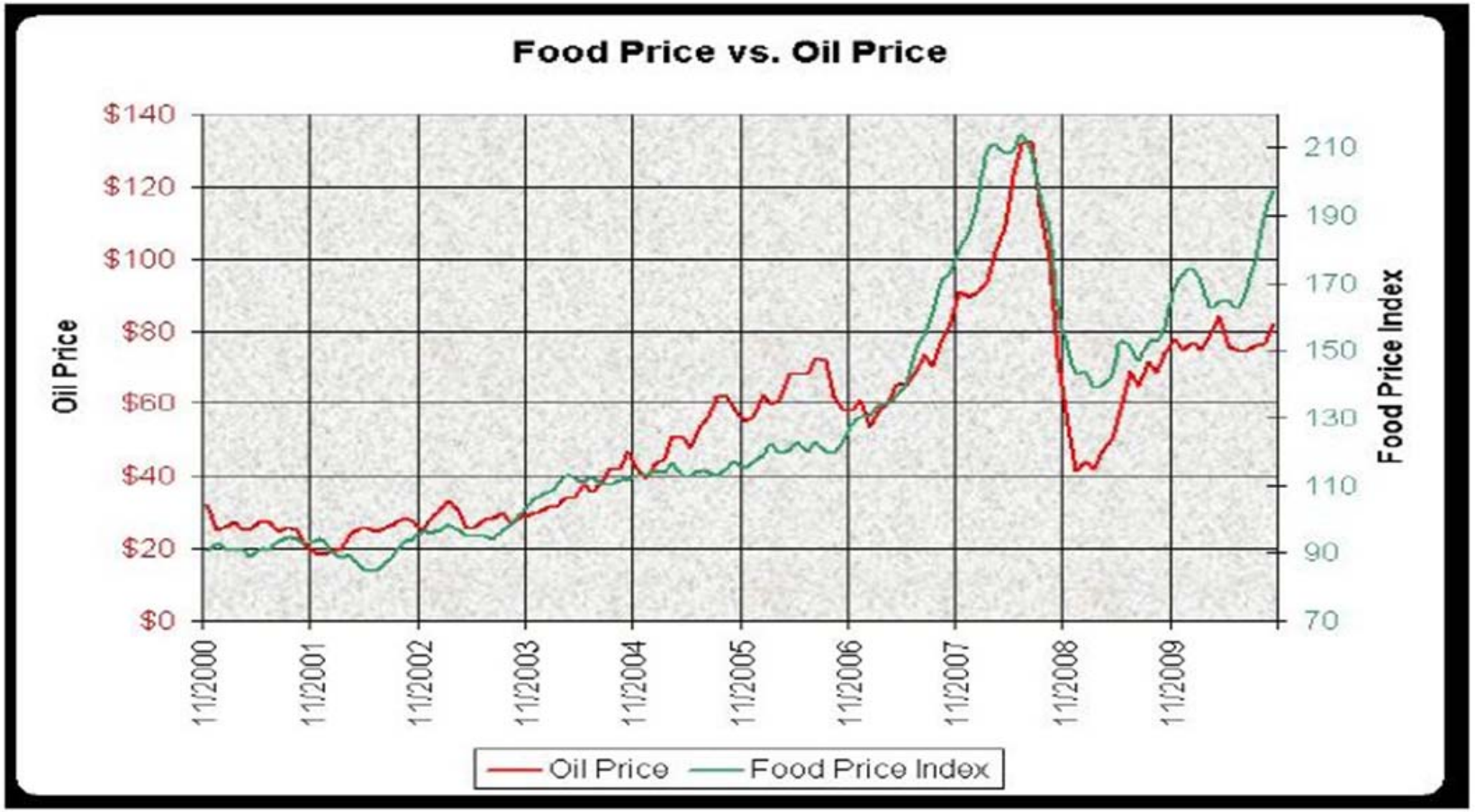
On the effects of fossil fuel prices on the transition towards a low carbon energy system

Andreas Papandreou and Franco Ruzzenenti

Time correlation 1



Source: UN Food and Agriculture Organization and the US Energy Information Agency

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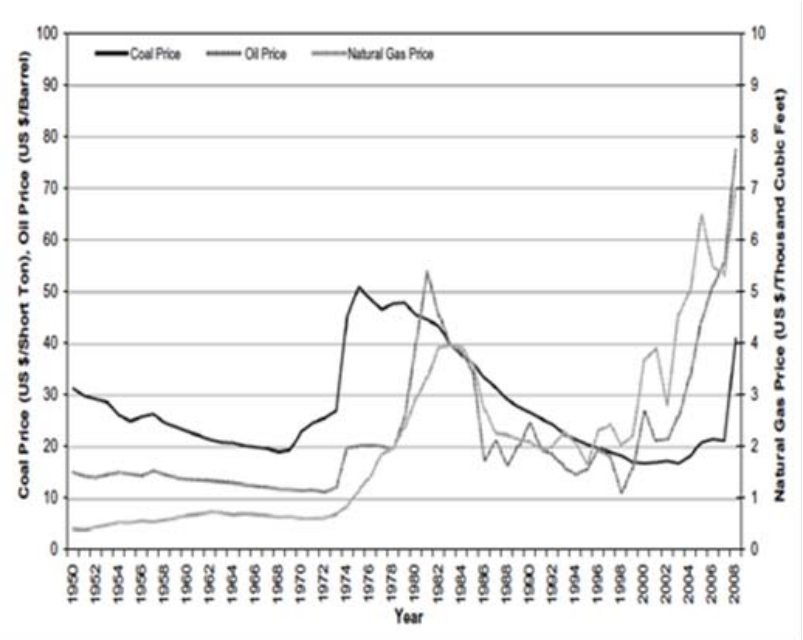
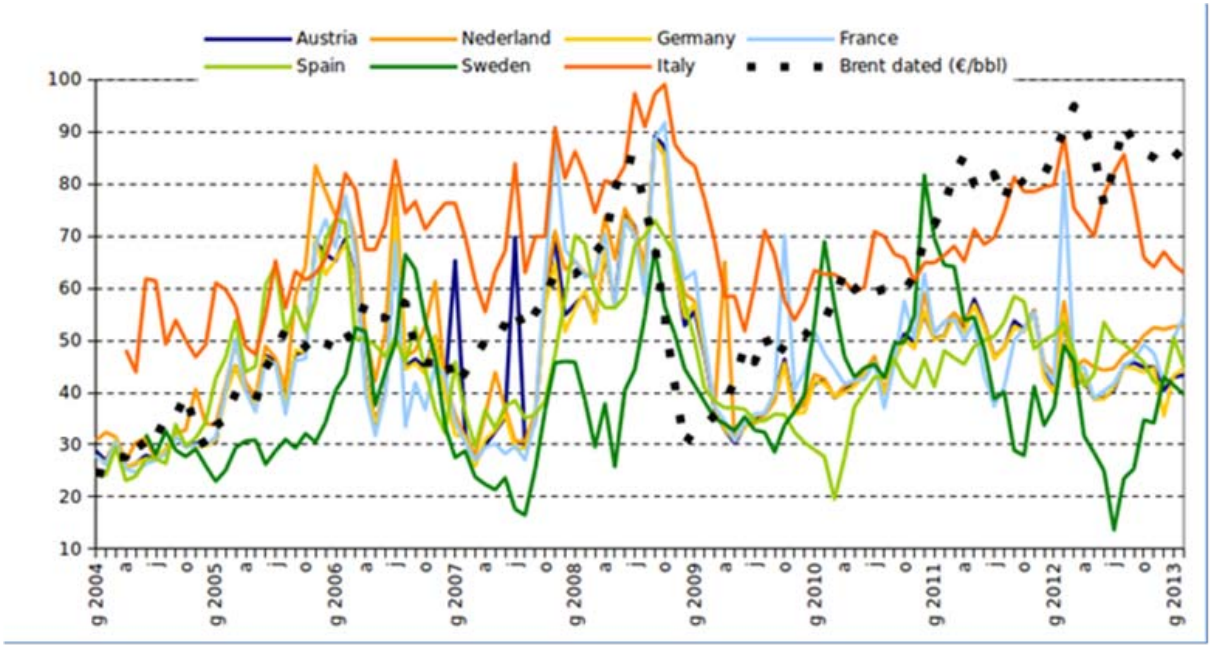
Time correlation2





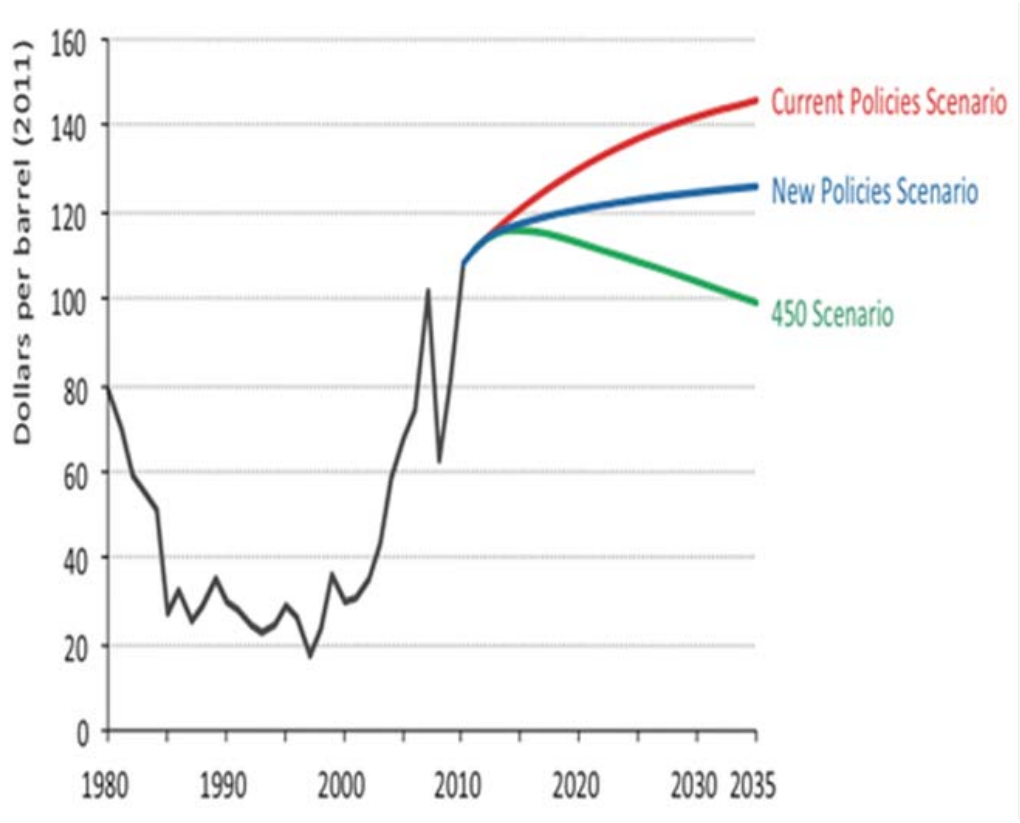
Energy prices are correlated to Oil

High energy prices (oil) driver for decarbonization of economy?

A lesson to draw from this analysis when it comes to a transition to sustainable energy systems is that the prices that are likely to have a more important bearing on a move to low carbon energy sources are the prices of energy services associated with fossil fuel inputs.

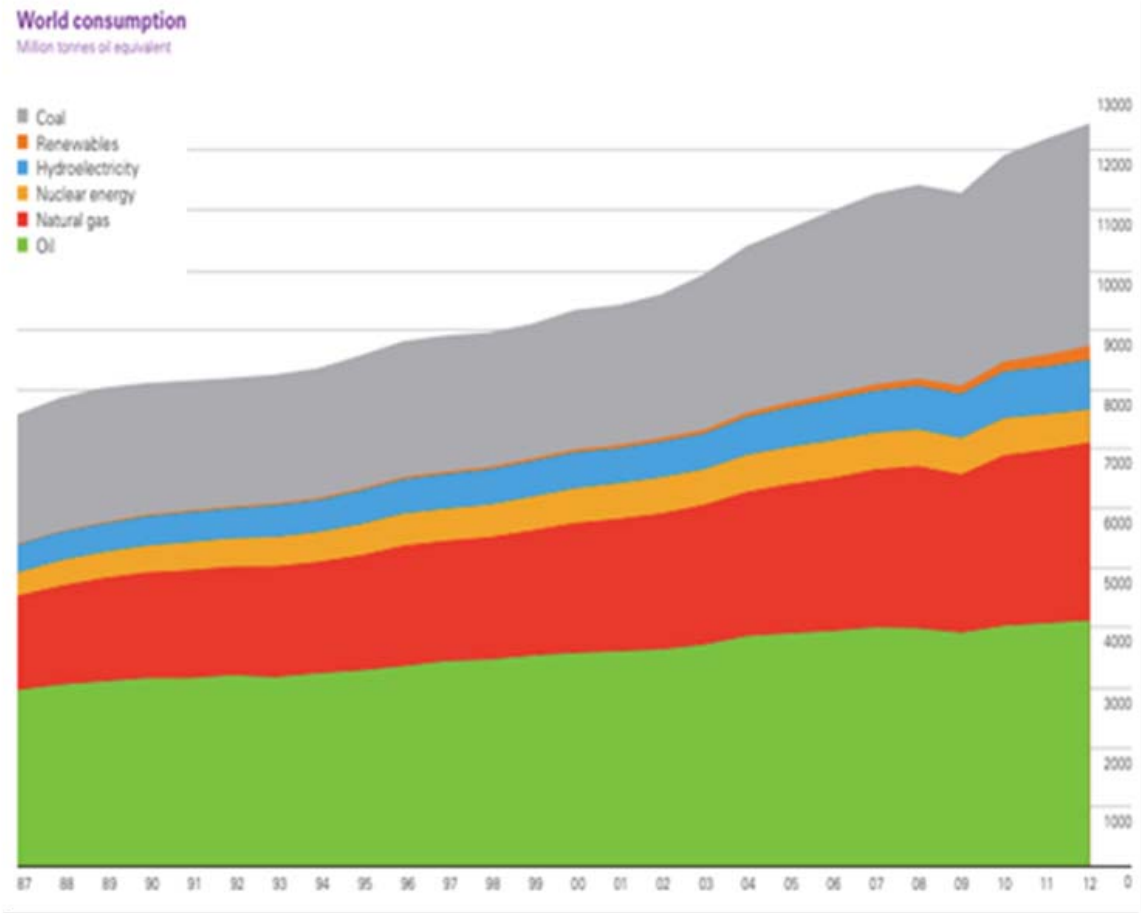
A strong historical relationship between fuel efficiency and fuel prices has been found across regions (Schipper 2008). The transport sector is likely to see the greatest efficiency gains. (Rout et al 2008)

Oil prices are determined in a global market while natural gas and coal prices are determined regionally

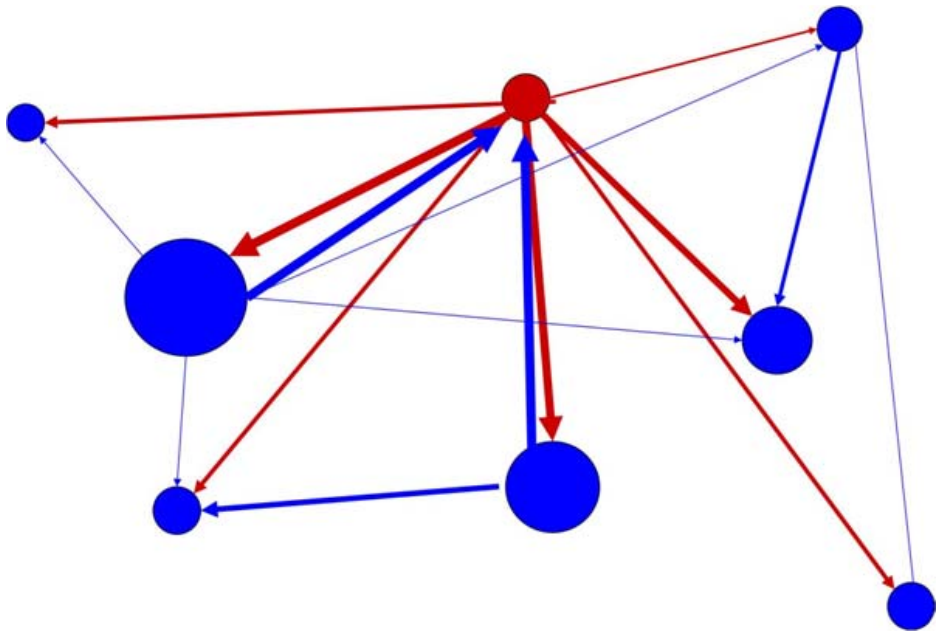


Oil prices and growth are linked: why?

Hamilton (2013) (who also provides a survey of this literature) shows that an oil price increase takes some time to show up in real GDP (a drop appearing a full year after initial oil price increase) but the size of the effect is quite large, e.g., a 10% increase in the price of oil (over the three previous years' high) GDP growth would be 0.42% slower (at quarterly rate). This is somewhat puzzling given that the energy expenditure share is a small number (4% of total GDP in the US in 2010) and the short run price elasticity of demand is also small. So the significant observed response to oil price increases cannot be attributed to the direct effects of decreased energy use on productivity.



Spatial correlation



- The conceptual framework behind a network analysis of the productive space is the same behind the too-interconnected-to-fail theory (in place of the too-big-to-fail) that places more attention on the most interconnected nodes and on their role in spreading contagion, rather than on the merely largest ones. Likewise, energy sources that most enter the productive structure world-wide are more important in affecting goods prices.

$$\phi_t^{c,c'} = \frac{\sum_{t=1}^{T}\left[p_t^c - \overline{p_T^c}\right] * \left[p_t^{c'} - \overline{p_T^{c'}}\right]}{\sqrt{\sum_{t=1}^{T}\left[p_t^c - \overline{p_T^c}\right]^2 \sum_{t=1}^{T}\left[p_t^{c'} - \overline{p_T^{c'}}\right]^2}}$$

$$\phi_w^{c,c'}(t) = \frac{\sum_{i \neq j}\left[w_{ij,t}{}^{c} - \overline{w_{ij,t}{}^{c}}\right] * \left[w_{ij,t}{}^{c'} - \overline{w_{ij,t}{}^{c'}}\right]}{\sqrt{\sum_{i \neq j}\left[w_{ij,t}{}^{c} - \overline{w_{ij,t}{}^{c}}\right]^2 \sum_{i \neq j}\left[w_{ij,t}{}^{c'} - \overline{w_{ij,t}{}^{c'}}\right]^2}}$$

Binary Structure of the Oil Market (year 2010)

Binary structure (2007):	Binary reciprocity	Link density	Filling	Rho	Phi
WTW ($)	0.84	0.56	0.34	0.21	-0.10
Oil ($)	0.53	0.16	0.25	0.19	-0.17
Coal ($)	0.38	0.05	0.23	0.13	-0.13
Gas ($)	0.35	0.04	0.22	0.16	-0.19
Electricity ($)	0.17	0.02	0.19	0.10	-0.28
Food 2	0.68	0.28	0.32	0.17	-0.13
Food 3	0.70	0.35	0.33	0.16	-013

Spatial correlation: weighted structure- $ (2010)

Table 3 Networks snapshot (2010): weighted structure, monetary flows

Networks	Reciprocity	Corr. Index: exp	Corr. Index: imp	W tot	links
WTW($)	0.69			2.5*10^12	2.4*10^4
Oil ($)	0.25	0.32	0.37	1.1*10^11	6.6*10^3
Coal($)	0.07	0.24	0.18	1.5*10^10	2.2*10^3
Gas ($)	0.08	0.18	0.16	3.2*10^10	1.9*10^3
Electricity($)	0.09	0.23	0.16	5.4*10^7	7.6*10^2
Food($)	0.36	0.48	0.48	6.5*10^10	1.2*10^4

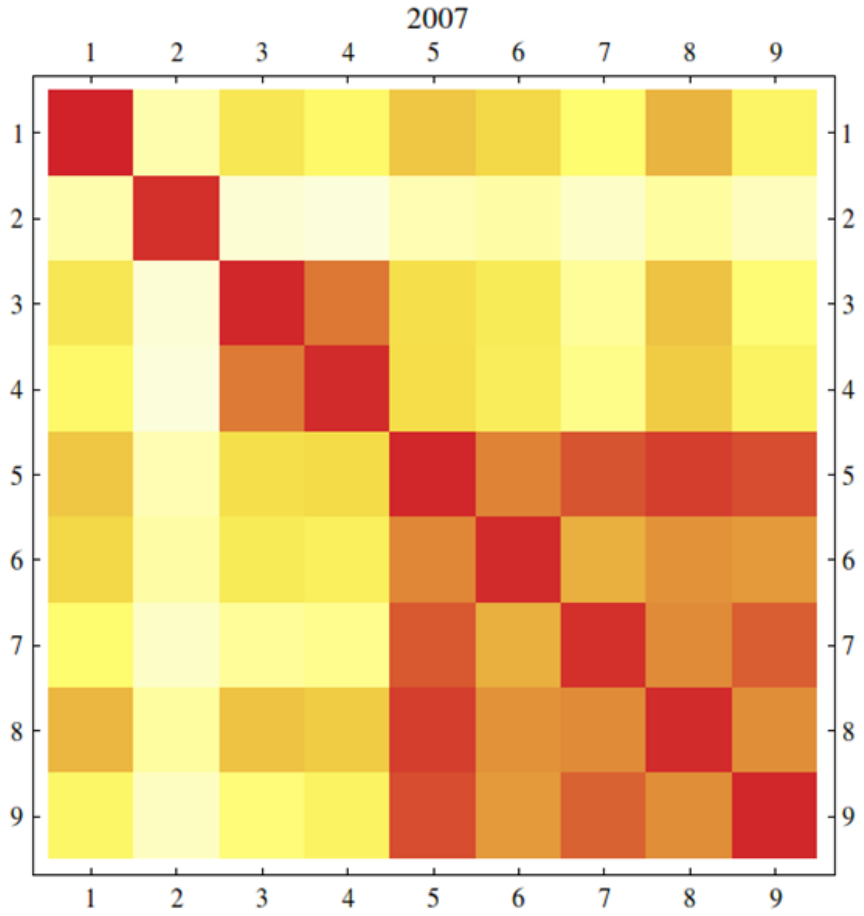
Spatial correlation: weighted structure -ton (2010)

Table 4 Networks snapshot (2010): weighted structure, mass flows

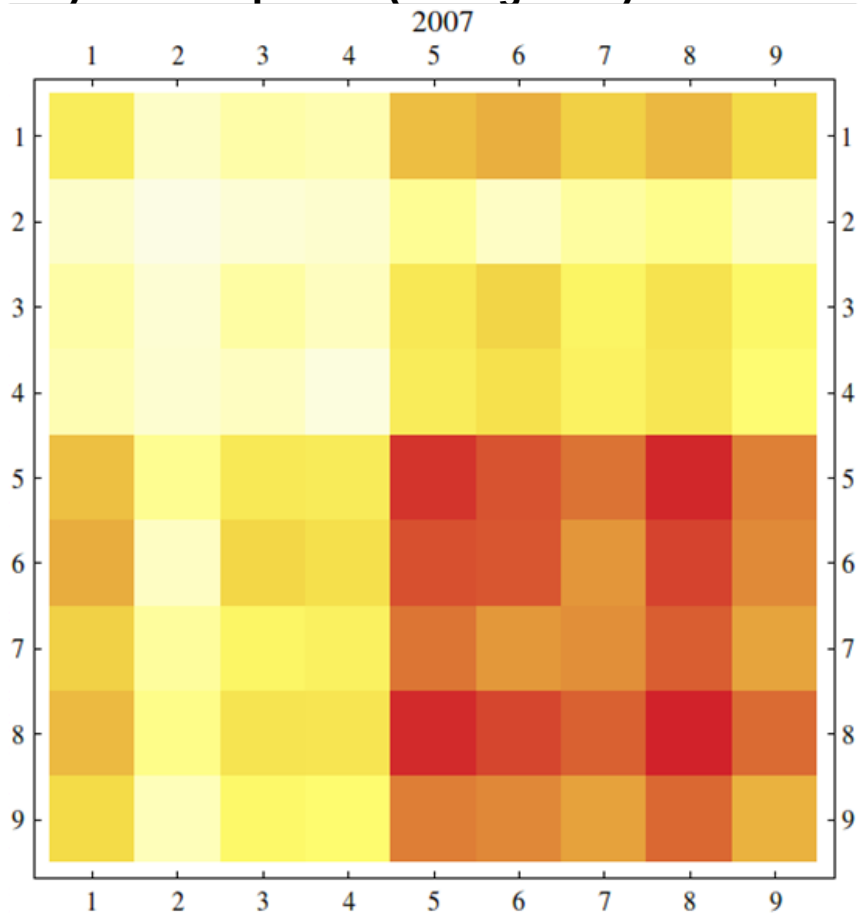
Networks	Reciprocity	Corr. Index: exp	Corr. Index: imp	W tot	links
WTW(ton)	0.39			2.3*10^12	2.4*10^4
Oil (ton)	0.20	0.23	0.28	2.1*10^11	6.6*10^3
Coal (ton)	0.03	0.16	0.10	2.0*10^11	2.2*10^3
Gas (ton)	0.06	0.12	0.10	1.6*10^11	1.9*10^3
Food (ton)	0.21	0.34	0.29	1.4*10^11	1.2*10^4

Energy commodities: syn and rev correlations ($-2007)

1) Oil 2) Coal 3) Gas 4) Elect.

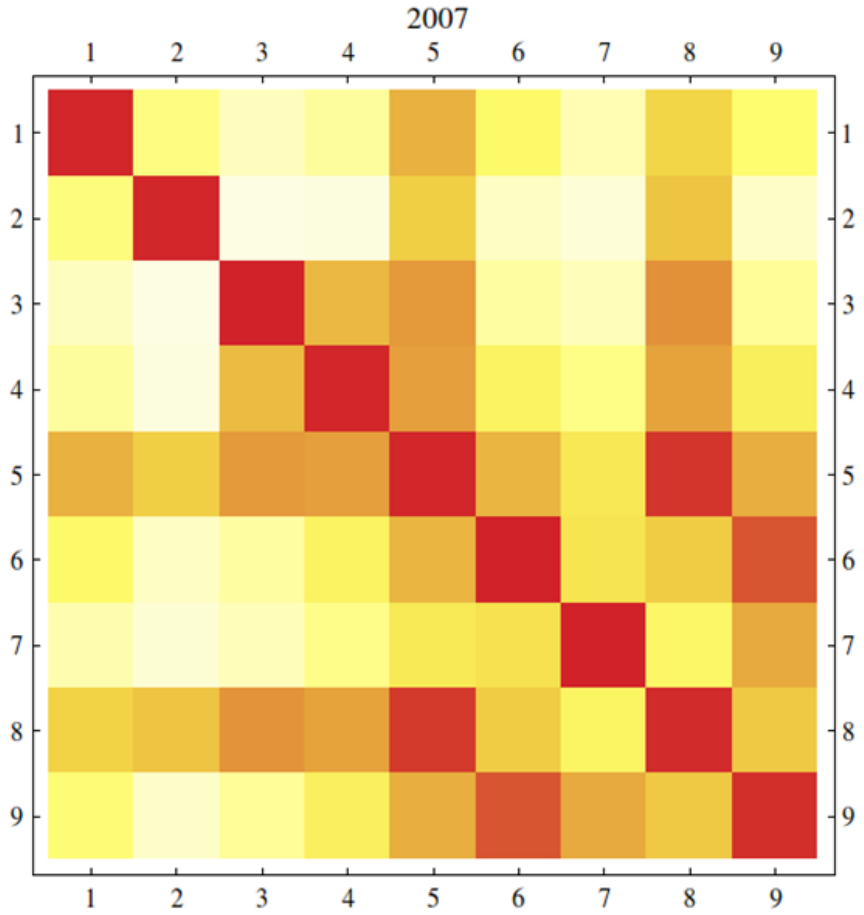


5) WTW 6)Food 7) Capital goods 8) Intermediate goods 9) consumptions (final goods)

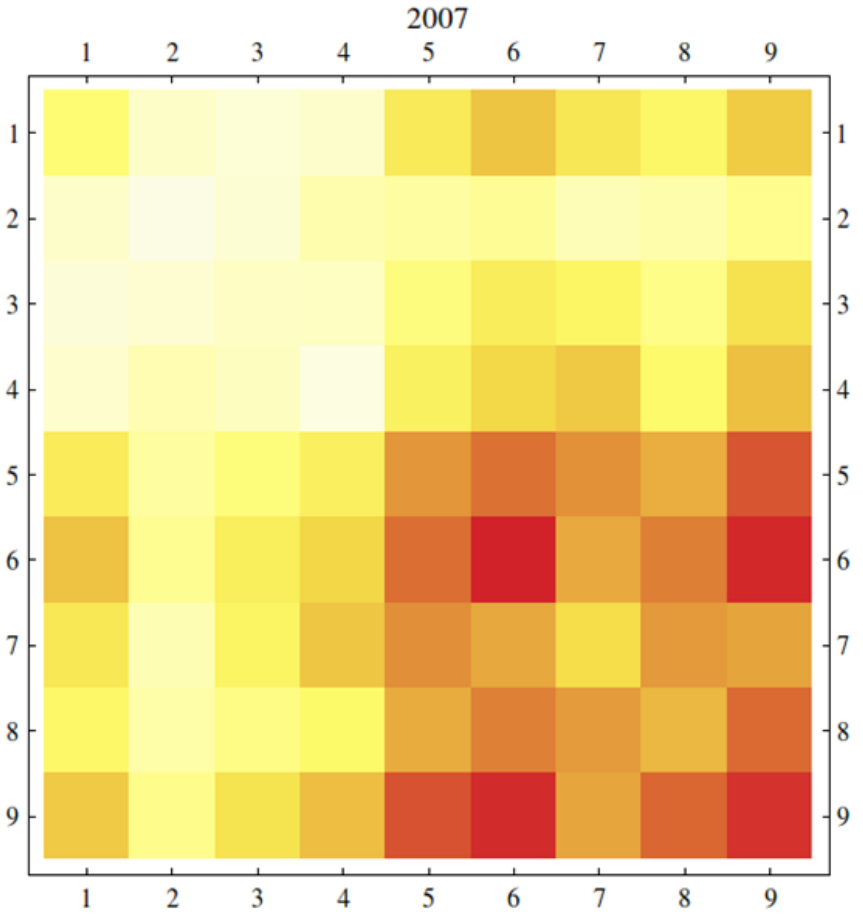


Energy commodities: syn and rev correlations (Tons)

1) Oil 2) Coal 3) Gas 4) Elect.



5) WTW 6)Food 7) Capital goods 8) Intermediate goods 9) consumptions



Mass balance

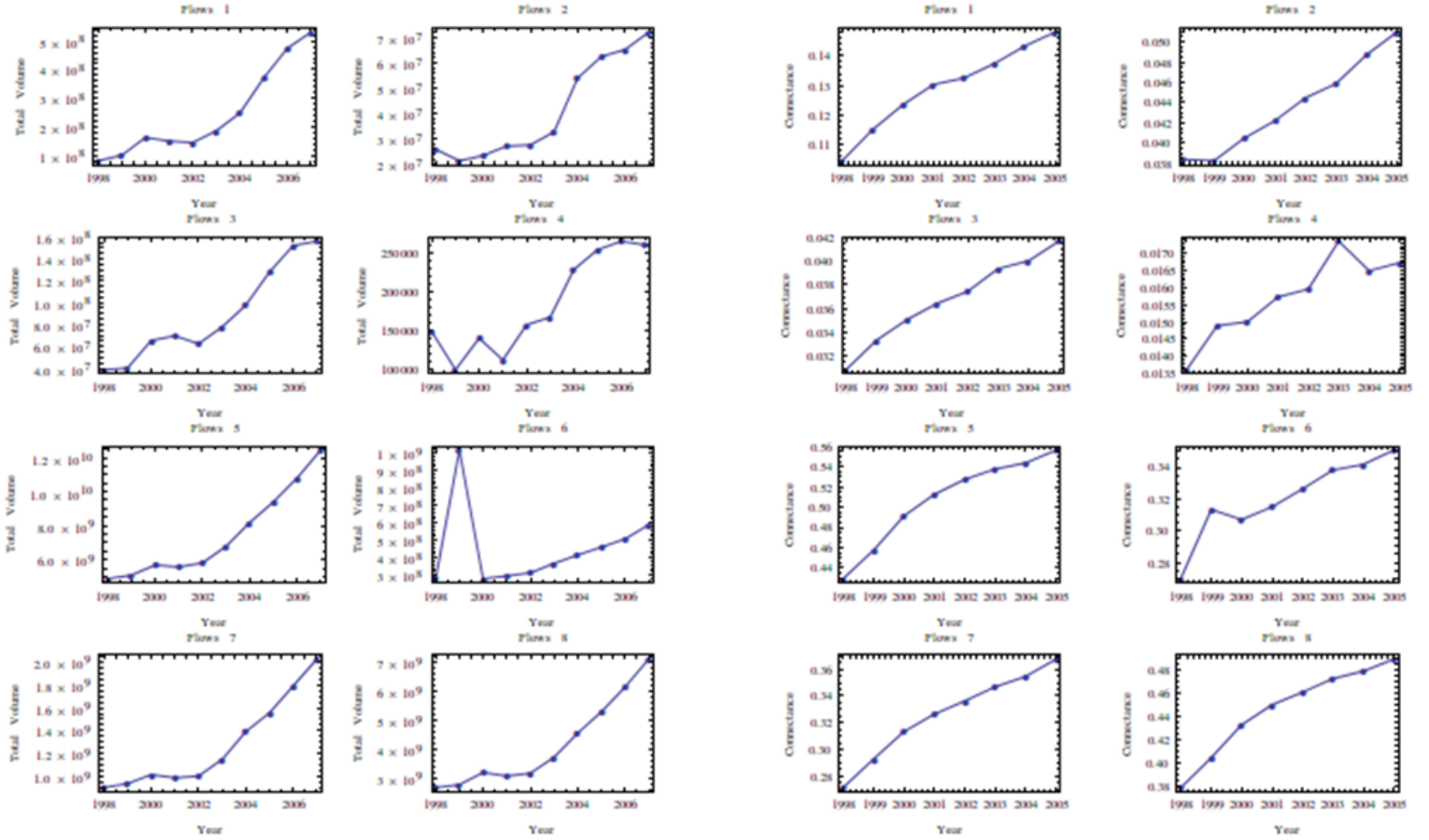
Year	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
I	*Indon.*	*Rus.Fd.*	*Rus.Fd.*	*Rus.Fd.*	*S.Arab.*	*Indon.*	*N.Zeal.*	*Rus.Fd*	*Rus.Fd.*	*Rus.Fd.*
II	*Rus.Fd.*	*Latvia*	*Austral.*	*Usa*	*Rus.Fd.*	*Rus.Fd.*	*Rus.Fd.*	*Austral.*	*Austral.*	*Austral.*
III	*S.Arab.*	*S.Arab.*	*S.Arab.*	*Austral.*	*Austral.*	*S.Arab.*	*S.Arab.*	*S.Arab.*	*S.Arab.*	*S.Arab*
IV	*Kuw.*	*Austral.*	*Canada*	*S.Arab.*	*Brazil*	*Brazil*	*Austral.*	*Can.*	*Can.*	*Brazil*
V	*Austral.*	*Iran*	*Norway*	*U.A.Emir.*	*Norway*	*Norway*	*Can.*	*Brazil*	*Brazil*	*Can.*

Tabella 1: I primi cinque paesi esportatori netti di materia (in valore assoluto)

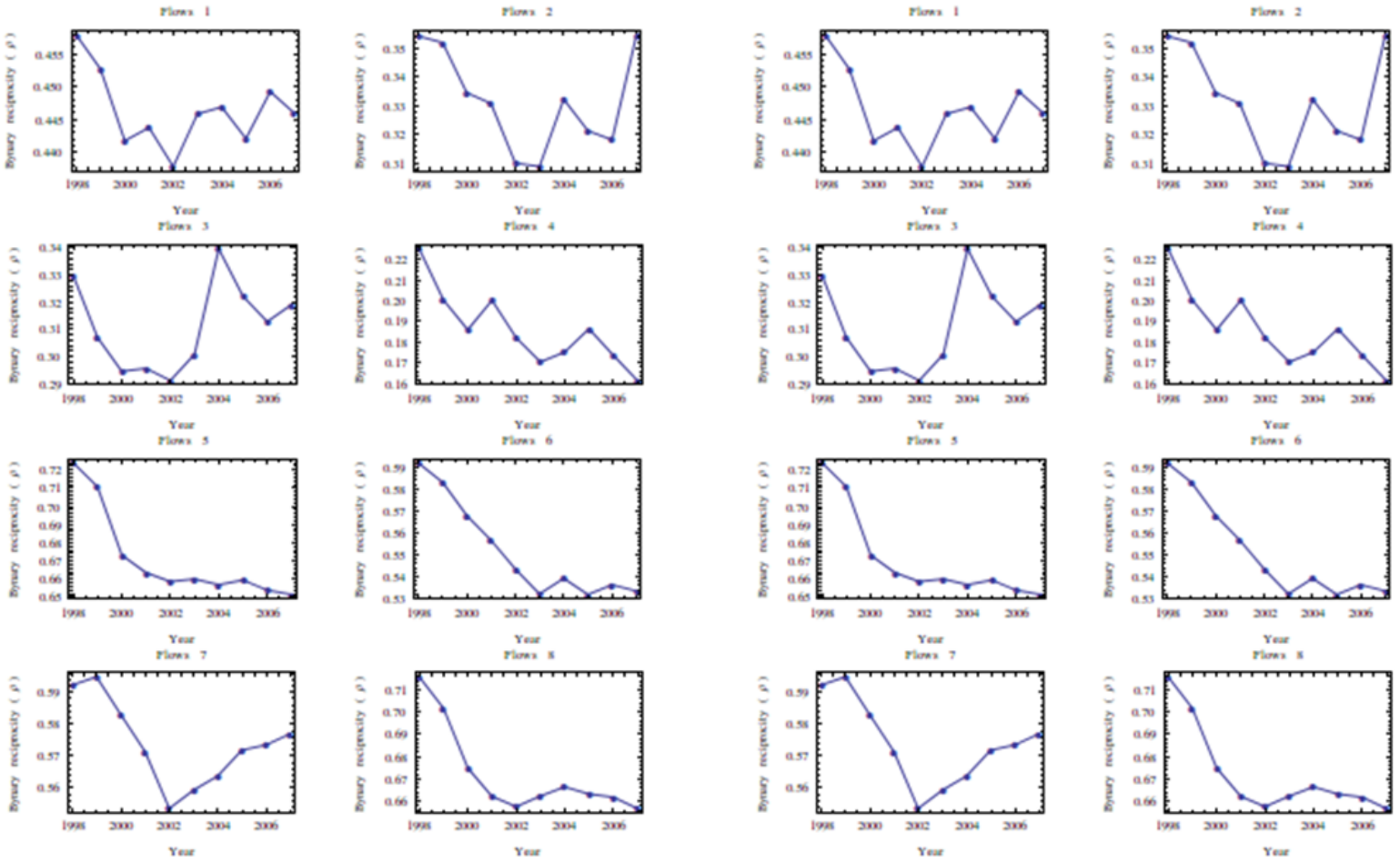
Year	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
I	*India*	*Japan*	*Japan*	*Mexico*	*Mexico*	*China*	*China*	*USA*	*USA*	*Japan*
II	*Japan*	*Georgia*	*Usa*	*Japan*	*Japan*	*USA*	*USA*	*Japan*	*Japan*	*USA*
III	*USA*	*USA*	*R.Kor.*	*R.Kor.*	*R.Kor.*	*Japan*	*Japan*	*China*	*China*	*China*
IV	*Germ.*	*Germ.*	*Mexico*	*Germ.*	*Italy*	*R.Kor.*	*Yemen*	*R.Kor.*	*R.Kor.*	*R.Kor.*
V	*R.Kor.*	*Italy*	*Germ.*	*Italy*	*China*	*Turkey*	*R.Kor.*	*Italy*	*Italy*	*Italy*

Tabella 2: I primi cinque paesi importatori netti di materia (in valore assoluto)

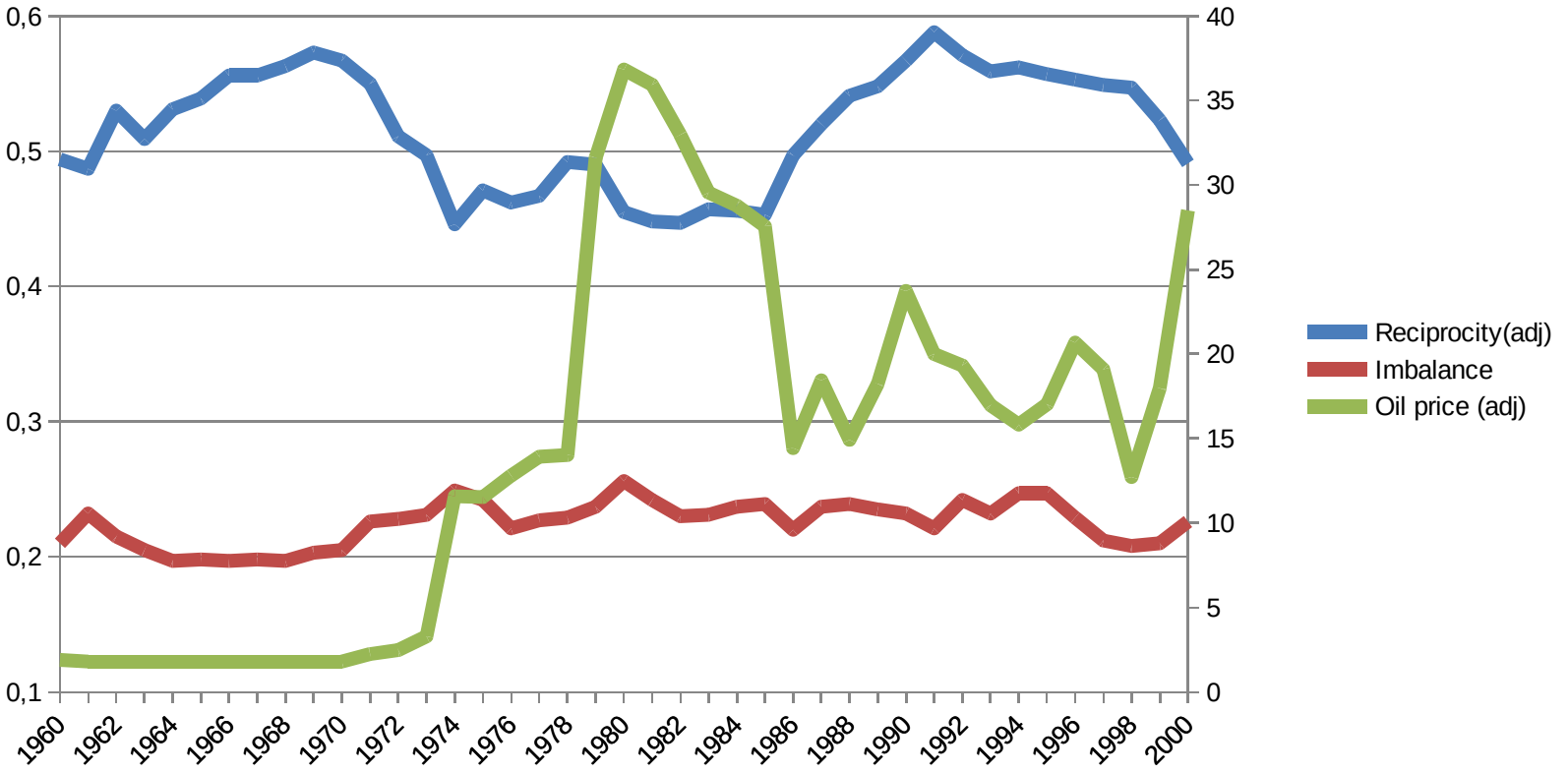
Total volumes and connectance



Reciprocity (weighted and binary)

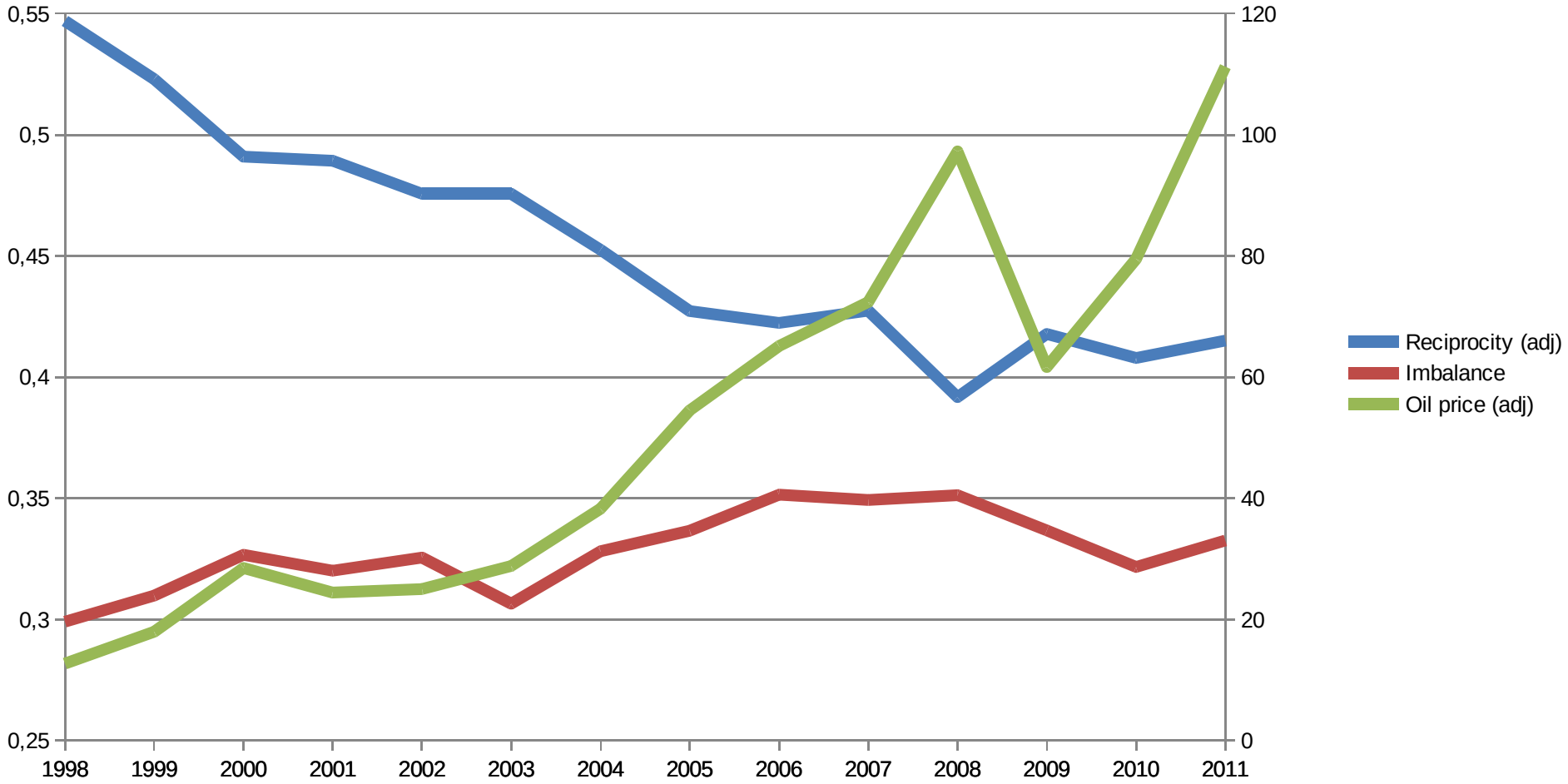


Reciprocity is more correlated to oil price than *imbalace*



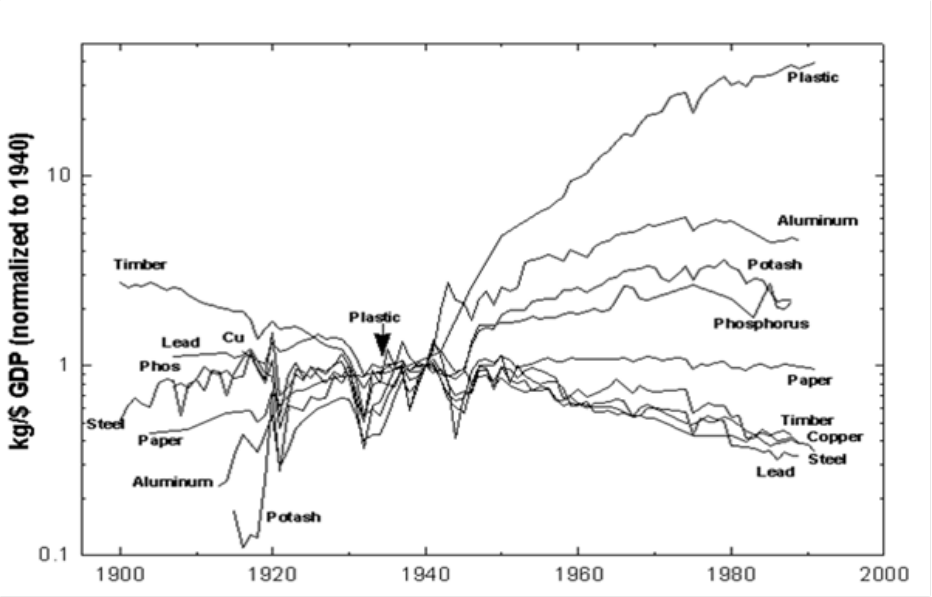
correlation	1960-2000 (COMTRADE)	1997-2011 (BACI)
Imbalance	-0.63	-0.73
Reciprocity (Weighted)	-0.56	-0.87
Adjusted reciprocity	**-0.69**	**-0.89**

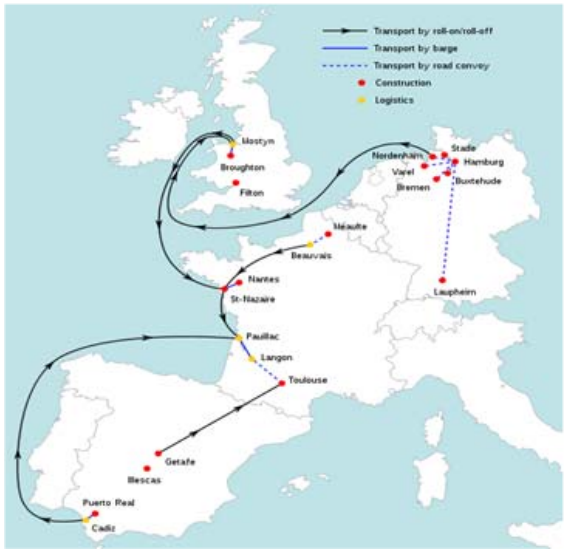
Reciprocity and Imbalance, 1988-2011

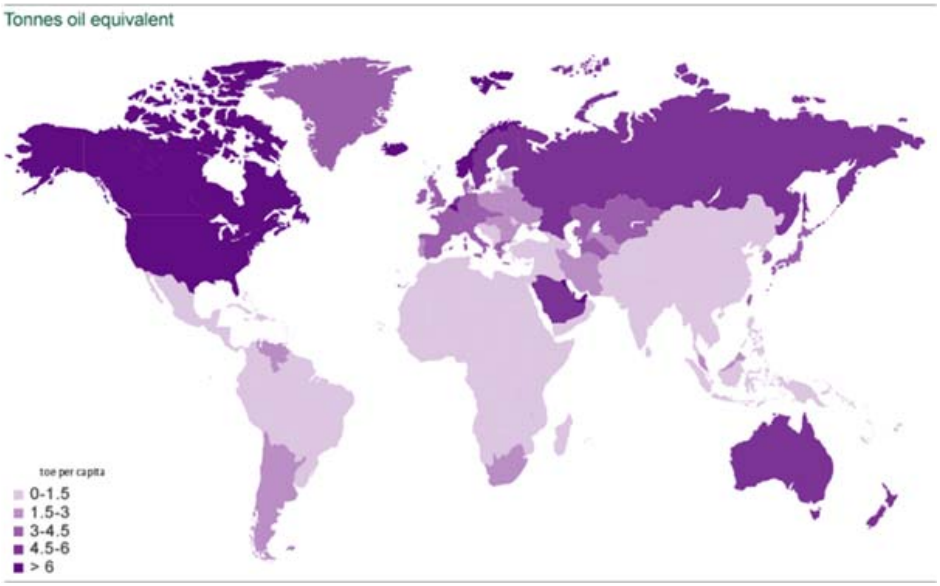


Why?

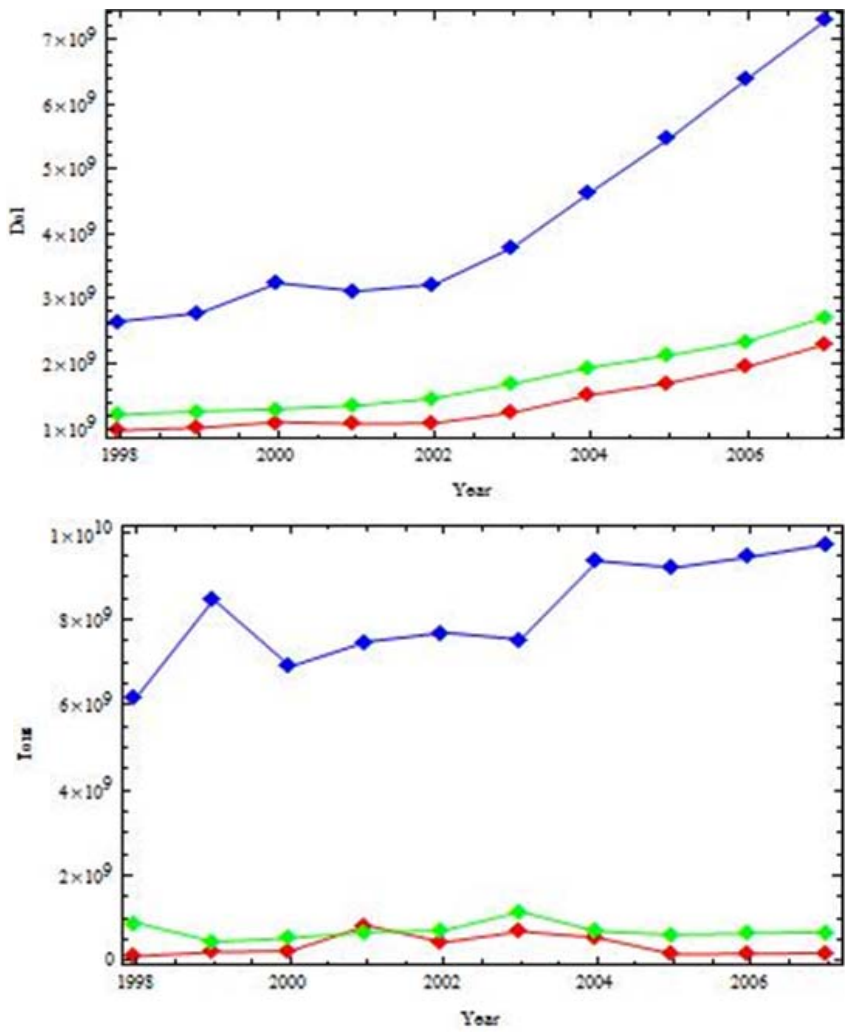
- Energy
- Monetary
- Merceology
- Transports
- Production





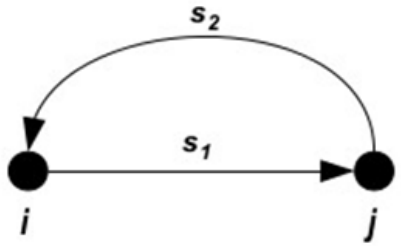


Trades are production means



- *International trades in monetary ($) and mass units (ton)*
- Capital goods (Red)
- Intermediate (Blue)
- Consumption (Green)

Cycling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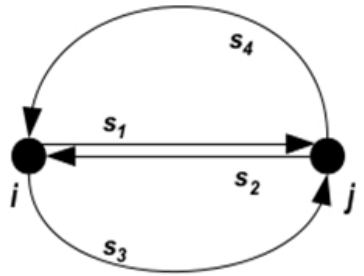
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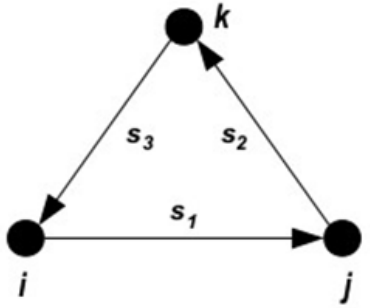
s3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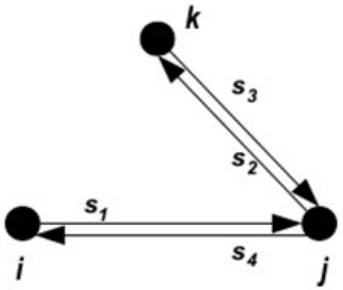
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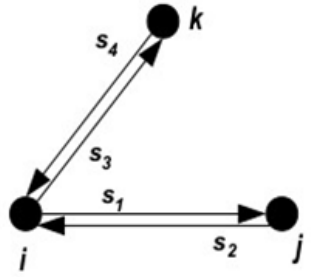
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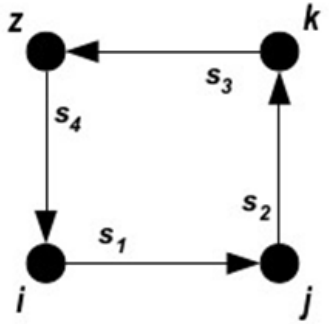
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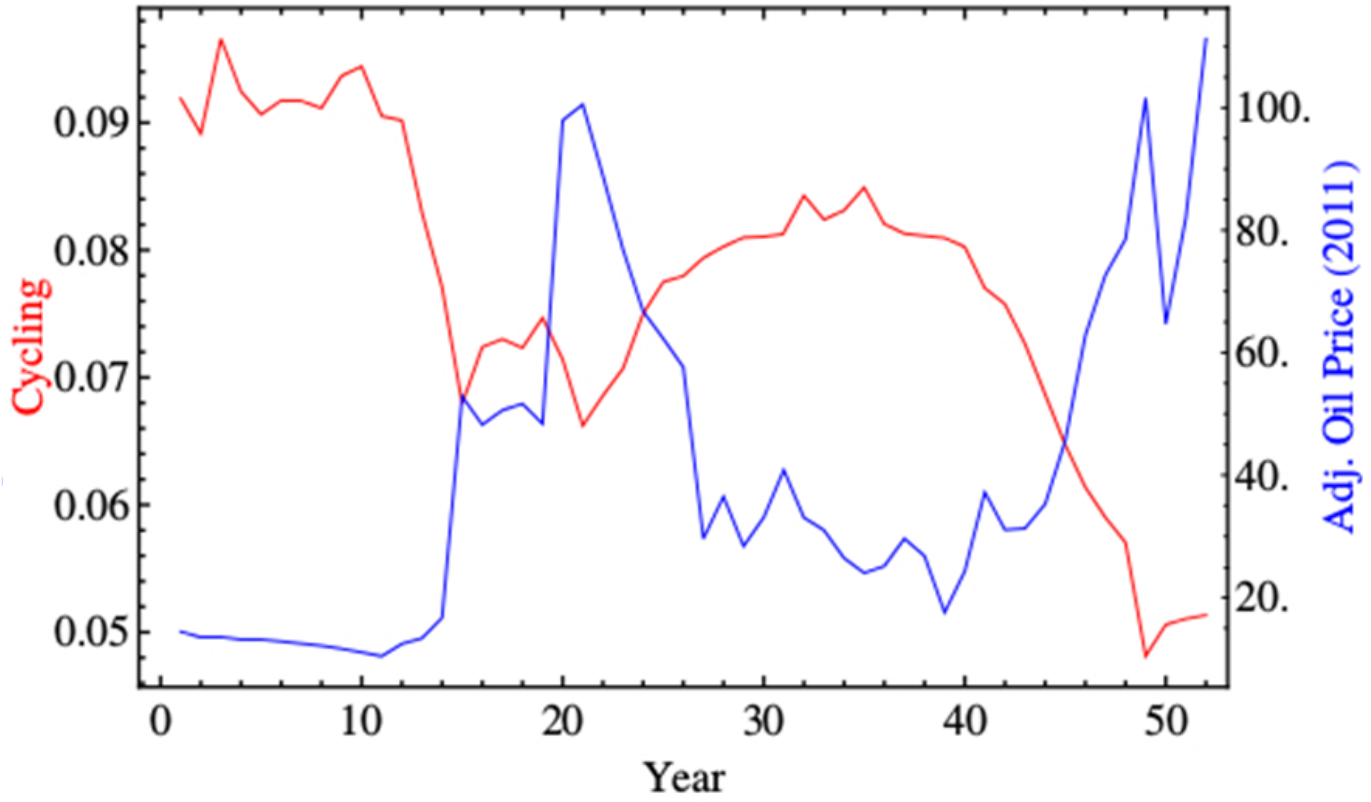
Cycling: oil corr.



Correlation between cycling and oil oprice: -0.82

Thanks

- Garlaschelli, D.; Ruzzenenti, F.; Basosi, R. Complex Networks and Symmetry I: A Review. Symmetry 2010, 2, 1683-1709.
- Ruzzenenti, F.; Garlaschelli, D.; Basosi, R. Complex Networks and Symmetry II: Reciprocity and Evolution of World Trade. Symmetry 2010, 2, 1710-1744.
- F. Ruzzenenti, F. Picciolo, D. Garlaschelli and R. Basosi. Spatial effects in real networks: measures, null models, and applications. PHYSICAL REVIEW E 86, 066110 (2012).
- T. Squartini, F. Picciolo, F. Ruzzenenti and D. Galraschelli. (2013) Reciprocity of weighted networks. Sci. Re.

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