The Network View on Input-Output Analysis for Australia*

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Abstract

- The relationship between sectoral shocks and aggregate volatility
- Supply side productivity **shocks propagate downstream** from supplier to user industries.
- The effect of the **input-output structure** on the **aggregate fluctuations**.
- If **out-degree distribution** exhibits **power law**, inter-sectoral shocks may **cause significant volatility.**
- The Australian economy exhibits qualitative **features similar to the US data.**
- The **out-degree** distribution exhibits **heavy tails** which may lead to significant effects of the sectoral shocks to the aggregate fluctuations.

- In this paper we use the **most recent input-output tables for years 2012-2013** provided the **Australian Bureau of Statistics (ABS).**
- We find that the **most influential first order suppliers** are **professional services**, **wholesale trade**, **finance**, **construction services** and **road transport**.
- However, the maximum weighted out-degree **is much smaller** in Australia comparing to the US data.
- This implies that shocks to the Australian **“hub"** industries will have a **smaller aggregate effect**.

Assume that the economy consists of n sectors linked via the network of intermediate inputs, with sectors production described by the Cobb-Douglas production function with constant returns to scale. The total production of industry j (with $j = 1, \ldots, n$) is given by

$$y_j = e^{z_j} \ell_j^{\alpha_j} \prod_{i=1}^{n} x_{ij}^{a_{ij}} \,, \tag{1}$$

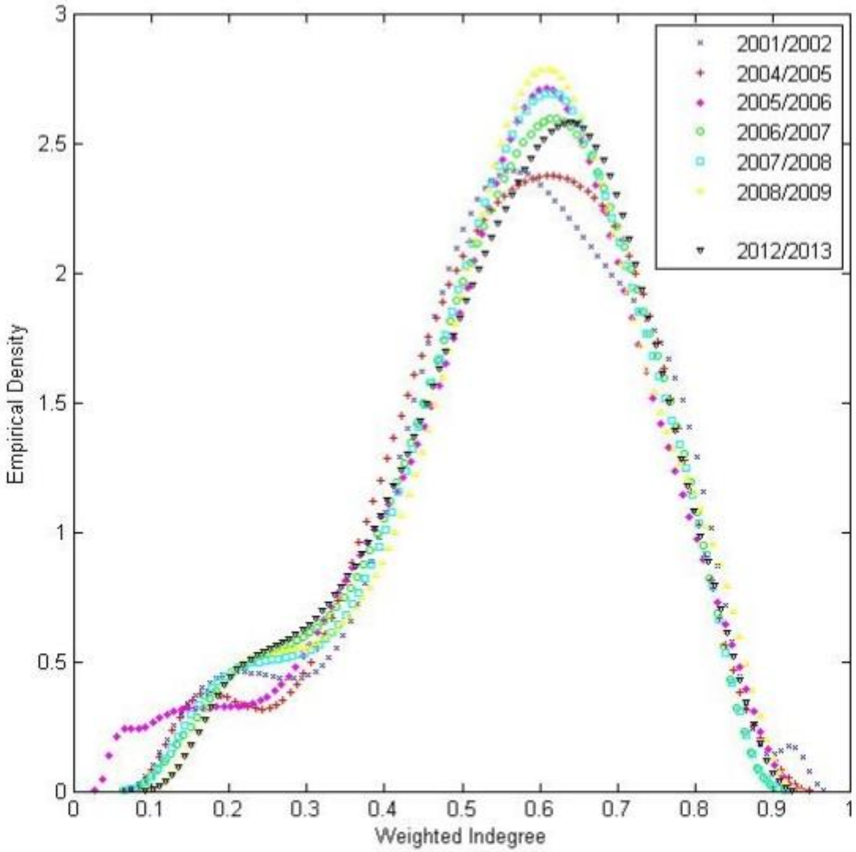
We assume the constant returns to scale in the technology function of each sector j, that is, we assume that for every j

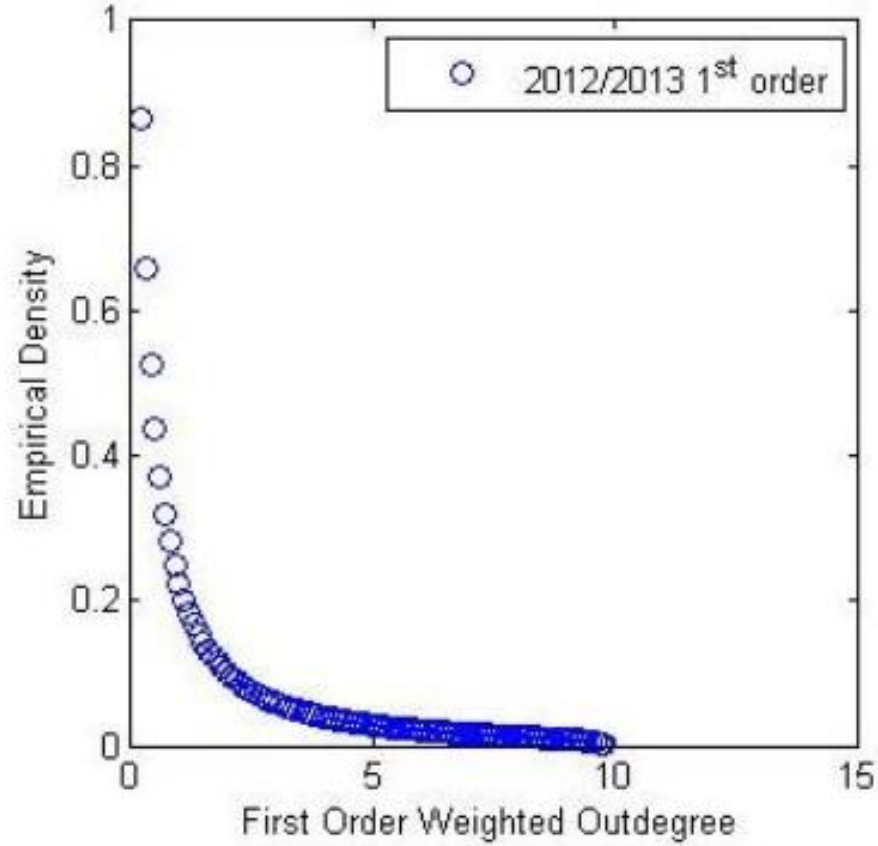
$$\alpha_j + \sum_{i=1}^{n} a_{ij} = 1 \,. \tag{2}$$

The output of industry j, y_j, can be used either in the final consumption, or as an intermediate product for other industry, or being purchased by the government. Let c_j denote the final consumption of the goods produced by industry j, and g_j denote the government purchases from output y_j. Then the market clearing condition for the output of industry j becomes

$$y_j = c_j + \sum_{i=1}^{n} x_{ji} + g_j \,.$$

$$d_j = d_j^{out} = \sum_{i=1}^{n} a_{ji} \, .$$





$$
\mathrm{GDP} = w\ell = \sum_{i=1} \alpha_i p_i y_i \,.
$$

$$
\log \mathrm{GDP} = \mathbf{v}^T \mathbf{z} \,, \tag{4}
$$

where vector $\mathbf{z} = (z_1 \; z_2 \; \ldots \; z_n)^T$ is the vector of technological shocks and $\mathbf{v}^T$ is the transposed on an *influence vector*. The influence vector is defined as

$$
\mathbf{v} = \frac{1}{n} \left(\mathbf{I} - \mathbf{A}\right)^{-1} \mathbf{1}, \tag{5}
$$

Thus the log of GDP is a linear combination of the technological shocks hitting different sectors. Matrix $(\mathbf{I} - \mathbf{A})^{-1}$ that appears in (5) is the *Leontief inverse* matrix and it permits the following representation (see Appendix A)

$$
\left(\mathbf{I} - \mathbf{A}\right)^{-1} = \mathbf{I} + \mathbf{A} + \mathbf{A}^2 + \ldots \,, \tag{6}
$$

which allows splitting the effect of shocks on those that are direct and those that are transmitted through the network.

$$\mathbf{Var}(XY) = \mathbf{E}(X^2Y^2) - (\mathbf{E}(XY))^2 = \mathbf{Var}(X)\mathbf{Var}(Y) + \mathbf{Var}(X)(\mathbf{E}(Y))^2 + \mathbf{Var}(Y)(\mathbf{E}(X))$$

Proposition 1. *Assume that for the sequence of economies corresponding to the different levels of aggregation, the counter-cumulative function satisfies the* power law *property with* tail parameter $\beta \in (1, 2)$. *This means that there exist a sequence of numbers c_n with a property $0 < \lim_{n\to\infty} \inf c_n \leq \lim_{n\to\infty} \sup c_n < 1$ and function $L(\cdot)$ with a property that $\lim_{t\to\infty} L(t)t^{\delta} = \infty$ and $\lim_{t\to\infty} L(t)t^{-\delta} = 0$ for all $\delta > 0$, such that, for all $n \in \mathbb{N}$ and all $k < \max_i\{d_i\}$, it is*

$$P_n(k) = ck^{-\beta}L(k)\,.$$

Then the aggregate volatility vanishes at rate not faster than $n^{-(\beta-1)/\beta}$. More precisely, for any $\delta > 0$ it is

$$\lim_{n\to\infty} \inf \frac{\sqrt{\mathrm{Var}\,\mathrm{GDP}}}{n^{-(\beta-1)/\beta-\delta}} > 0\,.$$

The tail parameter β thus represents a lower bound for the rate at which the aggregate volatility disappears. The smaller this parameter is, i.e., the fatter the tails of the degree distribution, the slower the convergence should be.

Table 1: ML Estimates of $\hat{\beta}$ and $\hat{\zeta}$

	01/02	04/05	05/06	06/07	07/08	08/09	09/10	12/13
$\hat{\beta}$	1.880	1.652	1.352	1.206	1.218	1.062	1.136	1.150
	(0.349)	(0.297)	(0.182)	(0.169)	(0.172)	(0.131)	(0.139)	(0.139)
$\hat{\zeta}$	1.333	1.167	1.161	1.190	1.136	1.506	1.122	1.084
	(0.229)	(0.184)	(0.164)	(0.179)	(0.169)	(0.337)	(0.159)	(0.158)

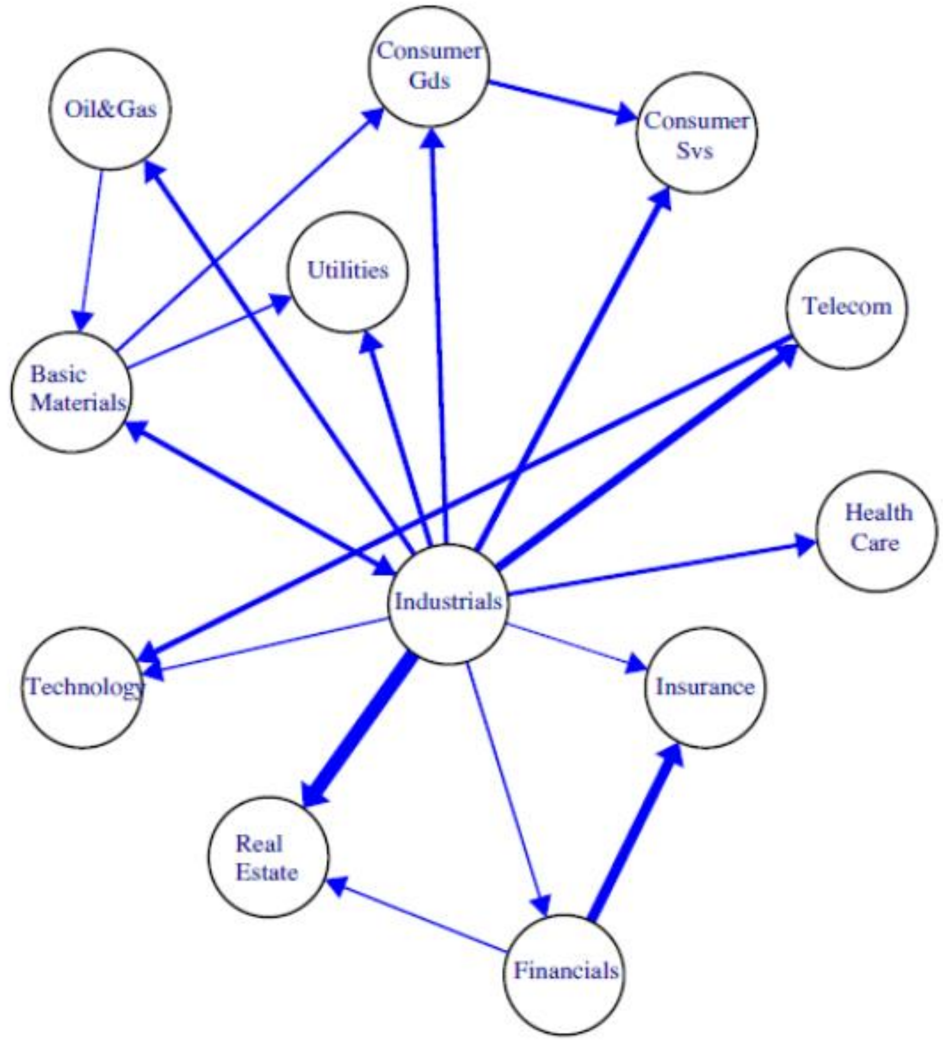


Figure 2: Aggregate level network.

Figure 2 shows an aggregate view of the Australian input-output network. It is apparent from the figure that Industrials take a central position in this network.