It's a Small World after all: Using social network analysis to investigate systemic risk in the Australian superannuation sector

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Abstract

Australia's superannuation (pension) sector is extraordinarily large by almost any measure. The system is the fourth largest in the world with assets under management exceeding $A2 trillion (€1.3 trillion). Approximately two thirds of the system ($A1.2 trillion) is managed in the large-scale intermediated superannuation funds that are the subject of this study. At one level, these funds appear to be functionally and financially independent of each other. However, they are linked by the common use of service providers. Indeed, the regulatory approach, for those entities that are actually regulated is to treat each of the service providers in separate silos.

This paper examines the effects of the service provider linkages using a network science approach. It demonstrates that social network analysis and network science theory can be used to describe the level of interconnectedness within the Australian superannuation sector. It shows that the system has some 'small world' characteristics and analyses the consequences of these characteristics. In particular, it concludes that a more holistic regulatory approach is required in order to be able to identify systemic risk, which is not apparent from the current silo-based analysis.

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1 Introduction

Australian superannuation, as a compulsory occupational pension system, assumes a central role in the nation's retirement income policy and represents a cornerstone of Australia's financial market. The Australian superannuation sector manages world's fourth largest pension pool with $A1.8 trillion in assets under management (APRA 2014c). In context, this is larger than the gross domestic product of Australia or the sum of the market capitalisation of all listed equities in the country.

The growing importance of the superannuation in the Australian financial, economic and public policy landscape has led to increasing attention to the systemic resilience of the superannuation sector, especially the prudentially regulated institutional fund component. This paper is concerned with the $A1.2 trillion of assets which are managed funds with more than four members that form this component.

An initial view of the Australian superannuation sector would suggest a sector with a low degree of market concentration. The superannuation sector is not highly concentrated and superannuation funds are independent from each other. As a result, the sector does not seem to be one in which a network analysis would be fruitful.

However, the sector is characterised by the use of a limited number of critical outsource providers. These providers create connections between the funds and transform what might be considered to be a large group of independent entities into a system of funds linked by common service providers. This linkage is made more complex by the fact that some of the service providers are horizontally integrated. That is, some service providers deliver more than one outsourced service.

There are no direct connections between the intermediated funds. However, there is a network of shared connections through the outsourced service providers. The effect of this understanding of the superannuation sector is that there is certainty that the network exists. However, the challenge that this paper investigates is the nature of the dynamics between the nodes that are well characterised. If the nature of this interconnectedness can be modelled using the tools provided by network theory, then the consequences of the failure of a node can be examined. Further, the model can be used to investigate the consequences of the transmission of an error through a system. In particular, whether there is the potential for error amplification arising from the structure of the system. That is, the use of a system model may assist in determining the nature and consequences of systemic risk.

This leads to the hypothesis that the sector could be described as a system with characteristics determined by the nature of the interconnectedness. This paper describes the research method used to analyse the connectedness of the Australian superannuation sector. The object of the work is to determine the sources of systemic risk in the sector, with a view to making recommendations on approaches to reduce that risk. The potential benefit of using network science and social network analysis is that social networks represent the relationship between the players and is thus potentially useful in identifying systemic risk. In particular, it may help regulatory agencies to consider systemic risk on a more holistic basis.

This paper starts by positioning the work in the context of on network models, network systems and complex adaptive systems. The review also examines each of these theoretical topics in the context of application to the analysis of the financial sector. The next section describes the creation of a simple network model. This is done by analysing the actors in the superannuation sector, describing the roles played by each of the actors and then using a subset of the data to create a network model. The model is described in terms of both the selected actors that form the nodes and their relationships, which form links.

The next section of the paper provides the results obtained from the social network analysis of the superannuation sector and the following section analysis the information that can be established from that analysis. The paper then considers the implications for regulation before drawing some conclusions and recommendations for further work.

2 Positioning the work

2.1 Building a system model

Conceptually, the superannuation sector can be considered as a number of funds and their service providers. It is useful to apply the terminology applied in network science (Barabási 2014) to examine the system as a series of funds and service providers which are the nodes of a network and their interconnection using links. A network in which the funds in the Australian superannuation sector are the only nodes has no links, as the funds are not related to each other.

In small networks, the easiest way of looking at some of the characteristics of the network is to draw it using dots or circles to represent nodes and lines to represent links. As long as the number of nodes and edges is reasonably small, the human eye can detect patterns (Newman 2003). The concept of social network analysis is one that has a very long history dating back at least to Jacob L. Moreno's 1934 book introducing sociometry described in Richard Alba's review of social network analysis work in 1982 (Alba 1982). Although early work in social networks was drawn by hand, the availability of computer processing power means that networks can be readily analysed using computer software. Available software can by used to analyse social networks as well as a variety of complex interconnected systems in a wide range of disciplines. The results presented in this paper used the open source software package 'Gephi' (Bastian, Heymann, and Jacomy 2009). Gephi provides rapid visualisation of complex data resulting in the ability to identify key actors in the network.

For the purposes of this paper, it is useful to note that a link can be "directed" or "undirected". A link is directed if it runs in only one direction (for example, making a bank deposit is directed from the depositor to the bank). The "degree" of a node is an expression of the number of links connected to that node.

There are a variety of forms of network that could interconnect nodes with links. One approach would be if every node were connected to every other node. This form of network is described as fully connected (Panchenko, Gerasymchuk, and Pavlov 2013). The nodes could be connected to each other on a random basis and this is known as an Erdős-Rényi model after the authors who described it first (Erdös and Rényi 1959). In addition, other network types include those where there is ordered connectedness (for example, where each node is connected to a common number of its nearest

neighbours) and this is called a regular lattice. In a regular lattice, the degree for each node is identical (Panchenko, Gerasymchuk, and Pavlov 2013). Watts and Strogatz formulated the concept of a 'small world' as being a regular lattice where links are removed from adjacent nodes and reconnected at random to alternative ones (Watts and Strogatz 1998). The authors used probability p for the removal and reconnection of links. As a result, a regular lattice remains when $p = 0$ and an Erdős-Rényi model is created when $p = 1$. The system in the bounds $0 < p < 1$ is described as a 'small world'. What is clear from this approach is that regular lattice, small world and Erdős-Rényi are mechanisms for describing how to construct a network. It is often useful to take a real world network and analyse its characteristics, in order to be able to gain further insights into its behaviour.

2.2 Network system issues

Real world systems can react in different ways to the failure of an input. A system can exhibit "self healing" properties where a potentially catastrophic failure leads to alternate pathways being established to maintain the stability of the system. Duncan Watts provides an example of the Toyota supply chain exhibiting emergence characteristics in response to the failure of a single exclusive supplier (Watts 2003, 265). This is particularly the case where the failure is random. However, systems also exhibit failure mechanisms in response to coordinated attacks or coordinated failures (Reka, Jeong, and Albert-Laszlo 2000). The issue for the superannuation sector in Australia is to determine the extent to which the system is vulnerable to coordinated failure. This failure does not need to be anything more than the use of inaccurate or incorrect data.

Systems have the potential for non-linear effects in transmission of either good or harm. System models are used to examine contagion effects in epidemiology (Meyers et al. 2005) and have also been used in the financial system in the analysis of counter party effects. Some of these effects are investigated in the context of chaos theory and other emergent phenomena. Even a relatively simple system, such as that described by the logistic equation, can show strong linearity or periodicity before collapsing into incoherence (Yang 2001).

Using network science in the financial sector is not new (Nier et al. 2007, Martínez-Jaramillo et al. 2010). However, this modelling has traditionally been applied to contagion issues. Allen and Babus suggest that there are many applications of network analysis to financial systems and argue that the application goes beyond the traditional analysis of contagion (Allen and Babus 2008). Allen et al. subsequently examined the literature on financial crises (Allen, Babus, and Carletti 2009). There is specific work which follows on from the proposition that limited interconnectedness is beneficial during contagion risk (Allen, Babus, and Carletti 2010). Acemoglu et al. identify two separate streams of thinking on the benefits of interconnectedness (Acemoglu, Ozdaglar, and Tahbaz-Salehi 2013). The first suggests 'a more equal distribution of interbank claims enhances the resilience of the system to the insolvency of any individual bank'. The second takes an opposite view and models interbank contagion as an epidemic. Subsequent work has suggested a strong welfare loss for small amounts of 'over-linking' (Blume et al. 2013) and that there are non-linear effects, especially on smaller but well-connected institutions (Chinazzi et al. 2013: 1707). The Acemoglu approach demonstrates that both of these approaches are correct. For small perturbations, interconnectedness provides stability. However, for large shocks, weakly connected networks show the highest resilience.

Although the construction of a model of the Australian superannuation system is helpful, there is a risk that the construction of nodes and the edges that interconnect them will lead to unintended assumptions. Two of these risks are easily identified. The first is that the information, which is used by the actors represented as nodes, does not form part of the constructed system. Information passes between nodes and may use links between nodes to effect that transmission. Informational (or relationship) linkages are important because they can indicate the extent to which there is homogeneity across the superannuation sector which creates risk by minimising portfolio effects (Beale et al. 2011). However, information is an important input to the system. The second issue is that the boundaries between nodes are blurred. Member benefit administrators provide services beyond member benefit administration. Custodian banks may also be a fund's deposit taker and may facilitate securities lending (Donald and Nicholls 2015). This blurring of responsibilities is a particularly important issue to address in expanding the work presented in this paper.

2.3 Complex adaptive systems

Acemoglu et al. refer to the proposition by Haldane that the interconnection might best be described as a complex adaptive system (Acemoglu, Ozdaglar, and Tahbaz-Salehi 2013, Haldane 2009). The relationship between networks and complex systems has been one of the core areas of work at the Santa Fe Institute (for example, Mitchell 2006).

John Holland offers a useful definition of complex adaptive systems (Waldrop 1992):

> *A Complex Adaptive System (**CAS**) is a dynamic network of many agents (which may represent cells, species, individuals, firms, nations) acting in parallel, constantly acting and reacting to what the other agents are doing. The control of a CAS tends to be highly dispersed and decentralized. If there is to be any coherent behaviour in the system, it has to arise from competition and cooperation among the agents themselves. The overall behaviour of the system is the result of a huge number of decisions made every moment by many individual agents.*

The application of complexity to economic and financial equilibria is not new. The approach potentially provides an alternative view that is not based on equilibrium but on a dynamic environment where an equilibrium model may be a first order approximation (Arthur 2013). There is also cross-disciplinary enthusiasm: 'Complex systems analysis and agent-based modelling are so different from the standard approach that a practical success in this domain could trigger a sea-change in the way economics is done' (Farmer et al. 2012: 320). Although challenged as to whether a complex systems approach is required (Rosenow 2012), in the context of resilience, Walker and Cooper provide a useful insight (2011: 157):

> *Almost by definition, complex systems internalize and neutralize all external challenges to their existence, transforming perturbation into an endogenous feature of the system and a catalyst to further self-differentiation.*

Complex adaptive system models have been used to examine of the stability of financial sector (Bookstaber 2012, Georg 2011). The Bank of England has also developed a model (Anand et al. 2012) of a financial system with N agents split into domestic banks, overseas banks or firms. Each agent is represented by a node in a directed network system and linked to each other through their assets, liabilities and equity holdings. This model can be used to examine catastrophic failure and stress

testing. An alternative model includes the concept of a 'tipping point' to contagion and the paper looks at both simulated experiments on stakeholder action and policy responses (Gai, Haldane, and Kapadia 2011).

However, both of these models assume connectedness based on either a debt or credit between the agents. This limits the value of the models in the context of the Australia superannuation system where there are no counter-parties.

The potential to construct an agent-based model of the superannuation system is attractive, as it potentially provides a platform on which potential systemic risk issues can be modelled. However, the agent-based model requires that the interaction of the agents or actors in that model are understood. This paper does not present an agent-based model. Instead it shows the results of testing of the characteristics of the Australian superannuation sector network.

2.4 Australian financial regulation

The Australian financial regulatory system is based on a "twin peaks" approach. That is, there is a corporate and securities regulator, the Australian Securities and Investment Commission (ASIC) and a prudential regulator, the Australian Prudential Regulatory Authority (APRA). APRA regulates superannuation entities. APRA also regulates deposit taking institutions (banks) and insurers. However, APRA is structured in deep silos where a number of groups regulate (or supervise) the relevant regulated entities. Regulatory peers are only found at the most senior level within the organisation.

In respect of custodian banks, the situation is more complex (Donald and Nicholls 2015). Section 10 of the SIS Act defines a "custodian" in the context of a superannuation fund as:

> *a person (other than a trustee of the entity) who, under a contract with a trustee or an investment manager of the entity, performs custodial functions in relation to any of the assets of the entity*

APRA regulates bodies under the SIS Act, which does not define the term "custodial functions".

"Custody" is, however, defined in the *Corporations Act 2001* (Cth). APRA regulates bodies under the *Corporations Act*. Section 766E of that Act provides:

> *a person (the provider) provides a custodial or depository service to another person (the client) if, under an arrangement between the provider and the client, or between the provider and another person with whom the client has an arrangement, … a financial product, or a beneficial interest in a financial product, is held by the provider in trust for, or on behalf of, the client or another person nominated by the client.*

That is, custody is regulated by APRA via the SIS Act and indirectly, if the custodian bank is deposit taking institution. However, the function of providing custody services is regulated by ASIC.

Member benefit administrators are only regulated if they also hold an Australian Financial Services (AFS) licence. These licences are issued by ASIC, rather than APRA. A custodian must hold an AFS licence and some administrators do hold such a licence. ASIC supports "imposing Australian financial services licensing requirements on the providers of investment administration and fund

administration services" and "regulatory oversight of technology service providers of sufficient scale" (ASIC 2014). However, no such requirement is in place currently and APRA has not made such calls.

3 Creating the network model

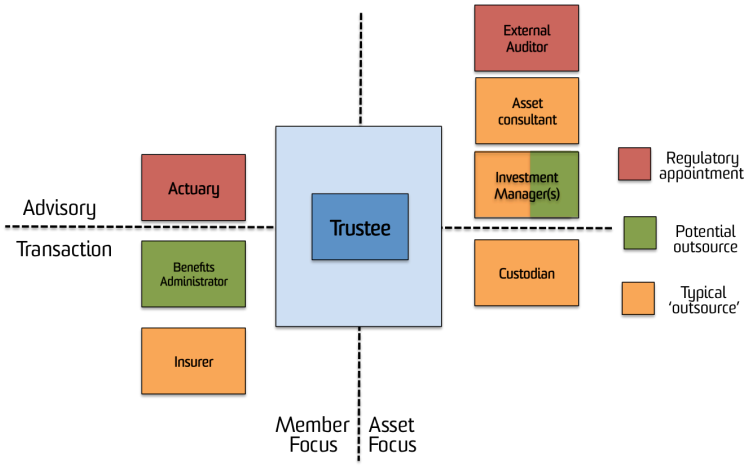
3.1 The data

APRA reports that there were 310 registered superannuation entities on 31 December 2013 (APRA 2014a). In 2012, the top 200 funds represented more than 98% of Australia's total prudentially regulated pension fund assets. This paper uses a dataset created by collecting and matching fund and service provider arrangement information for all superannuation funds with publicly available annual reports, broadly corresponding to these 200 funds. To examine the linkages in the superannuation sector, we have constructed, for the first time, a database of superannuation linkages by collecting service provider arrangement information from the largest 150 superannuation funds, comprising over 95% of the prudentially regulated assets in the system. The data is drawn from publicly available annual reports, product disclosure statements and other regulated disclosures[4]. All data is at 30 June 2012.

3.2 Simplified model of a superannuation entity

It is helpful to use a simplified model of a superannuation entity and its service providers in order to examine the potential linkages. A superannuation fund is a trust which is typically managed by a corporate trustee and which has a management entity for day-to-day operations. The fund outsources certain major functions and these include custody, member insurance, legal advisory and audit services. The fund may also outsource its administration function and investment management. Outsourcing is chosen when there are economies of scale beyond the reach of individual funds or in which specialist skills are required (Liu and Arnold 2010). A simplified view of a superannuation fund and its service providers is set out in Figure 1.

Figure 1: Simplified view of a superannuation fund



[4] Data was available in respect of between 85% and 95% of funds' service providers, with two exceptions. Not all funds require actuarial services and retention of an asset consultant is not mandatory. It is reasonable to assume that some of those not reporting the identity of their actuary or asset consultant may simply not have appointed one.

The superannuation sector is not highly concentrated. APRA reports that there were 310 registered superannuation entities on 31 December 2013 (APRA, 2014). That is down about 10% over the past twelve months but still the sector has an Herfindahl-Hirschman Index (HHI) (Hirschman 1964), using the methodology of the United States Department of Justice (DOJ and FTC 2010) of less than 300. That is because the largest ten funds by assets comprise just 34% per cent of the market share of the superannuation industry (APRA 2014c). The largest retail fund, AMP Superannuation Savings Trust, administers approximately $53.2bn on behalf of 2.9 million members. The largest not-for-profit fund, Australian Super, administers $52.3bn on behalf of 2.1 million members. Each has a market share of approximately 6.5%.

One of the interesting features of the service providers in the Australian superannuation sector is that there are a limited number of providers in each area of service supply and a number of these are horizontally integrated. That is, some service providers provide multiple services at a single level in the supply chain associated with transactions. There is less evidence for vertical integration, where a sing supplier provides services at multiple consecutive levels of the supply chain.

This paper uses each of the funds and certain major service providers as the nodes in setting up a network model. The nodes used and the associated links are set out in the next parts of the paper.

3.3 The potential nodes

3.3.1 Introduction and issues

As mentioned above, the 150 funds that are used in setting up the network are not related to each other and form a system with no connections. A diagram would show 150 nodes with no interconnection and this would not provide much of an insight. Instead, the network is constructed using the funds and each funds' major outsource providers. For each type of provider, the paper describes the function and the extent of outsourced sector concentration. It is likely that potential sources of systemic risk will flow from transactions as opposed to advisory services and this paper focuses on the sources of systemic risk arising from transactional actors.

3.3.2 The funds

In Australia, a superannuation fund is established as a trust. The consequence of this is that the fund is not an entity that can sue or be sued in its own right. There is a corporate trustee that manages the trust on behalf of the fund members in accordance with the trust deed that establishes the trust and which may be amended from time to time. That is, the governance of the fund is significantly a matter of trust law (Donald 2011) as well as the legislation that governs the sector in Australia, the *Superannuation Industry (Supervision) Act 1993*, (Cth) (SIS Act). The SIS Act broadly requires that superannuation funds have trustees and that the trustee entity is registered and holds appropriate licences. The linkage between the trustee and the fund is not one that is likely to lead to systemic risk. If the corporate trustee becomes insolvent, then a new trustee can be appointed (Athanasiou 2010). It is typical for the trust deed to specify how the replacement trustee will be appointed in the case of insolvency. Each of the funds has a level of assets under management, which are held for its members. Each of the corporate trustees is broadly independent from any other superannuation fund corporate trustee. There are board members common to more than one trustee. APRA reports that of the 974 directors who sit on the boards of registered superannuation trustees, only 69 or seven per cent sit on more than one board (APRA 2014a, 14). Most sit on two boards (about 43), 19

have 3 directorships and about seven have four or more directorships. The network constructed for this paper does not use individual corporate trustee board members as nodes.

3.3.3 Custodians

Custodians look after the financial securities of a superannuation fund. In general, there is one provider of custodian services for each superannuation fund. The custodian is appointed by the superannuation fund on the basis of a 'bare trust'. That is, the beneficial ownership of the securities remains with the fund and the custodian holds those securities on the fund's behalf (Donald and Nicholls 2015). The custodian establishes omnibus nominee companies that hold securities on behalf of a number of the custodian's clients. The custodian establishes omnibus nominee companies that hold securities on behalf of a number of the custodian's clients. In practice, custodians hold assets other than just securities for the fund. In many cases, custodians also manage cash on deposit for the fund. That deposit may be with the custodian, acting as deposit taker or with another bank where the custodian acts as agent for the fund. There is a potential for there to be no systemic risk issues with custody as the assets remain the property of the fund. However, as the administration of Lehman Brother in the UK has demonstrated, through a split decision of the Supreme Court of England and Wales, the timing of the formation of the statutory trust is a complex issue (Greenwood and Miles 2013). Custodian services are always provided by a bank entity that is distinct from the trustees or management of the fund. In 2012, 16 custody providers served 96% of funds. The top five providers represented 84% of assets under management and the top ten providers accounted for 98% of assets.

3.3.4 Member benefit administrators

Member administration is the process by which people join or exit a superannuation fund and receive information about the funds performance while they are members. Member administration is provided as a web-based service as well as by telephone and mail. Many superannuation funds use unit pricing to enable members to see the value of their investment. The manager provides the unit value to the administrator (acting on the direction of the trustee). The member is presented with an investment valuation determined by multiplying the number of units held by the unit selling price. An incoming member will acquire units at the unit buying price and the spread reflects transaction costs. A member seeking information will usually be presented with a password protected website where they can see the value of their investment and the sources of funds (employee and employer contributions) as well as the payments made for administration and insurance. The majority of superannuation funds outsource member administration although a few funds provide member benefit administration themselves, the largest of these are QSuper and UniSuper. The sector is not very concentrated. Using data from annual reports of superannuation funds in 2012, 95% of funds were served by 46 administration service providers. The top five providers represented 45% of assets under management and the top ten providers accounted for 73% of assets.

3.3.5 Insurers

Superannuation funds provide members with three forms of insurance, as determined by the member. These are life insurance, total plus permanent disability (TPD) insurance and salary continuance insurance. The funds provide this insurance by contracting with insurance providers. That is, insurance services are always provided by another entity. The insurance services are predominately provided by external insurance providers. The life and TPD insurance industry in Australia is quite concentrated and there has been significant consolidation in the last decade (APRA

2011). We find that 85% of sample funds were served by 12 insurers in 2012. The top five insurance providers represented 74% of assets under management and the top ten providers accounted for 99% of assets.

The Australian insurance industry is unusual in that the leading retail banks also provide insurance services. When APRA determined that the four major retail banks were domestic systemically important financial institutions (D-SIFI) in December 2013 (APRA 2013), the regulator did not examine those banks' systemic importance in the insurance sector.

3.3.6 Advisory services

External auditors provide audit services to superannuation funds in similar fashion to those provided to public listed companies. Many funds also have an internal auditor. A number of superannuation funds employ an asset consultant. These consultants advise on asset allocation and asset manager selection to enhance relative fund performance. Actuarial services are particularly required by funds that offer 'defined benefit' plans. There are a limited number of actuaries, but none of the auditing firms offer actuarial services, limiting potential for overlap.

Superannuation funds use investment managers to make investments in securities held by the custodian and owned by the fund. In an industry fund, there are typical a large number of investment manager appointed and each has responsibility for investment in a specified asset class. Large retail superannuation funds do not outsource this function and may be the providers of investment management services to industry funds. There are more than 3,000 investment manager entities in Australia and there is little market concentration.

3.3.7 Concentration

There is significant concentration in a number of areas of service provision. This is summarised in Table 1 below.

Table 1: Market concentration of key service providers in the superannuation industry

	No of providers	Market share		HHI		Sample coverage
		Top 5	Top 10	Members	AuM	
Member benefit administration	46	45%	73%	612	630	95%
Asset consulting	10	96%	100%	2,296	2,358	57%
Auditing	16	92%	99%	1,728	2,469	95%
Custodial services	16	84%	98%	2,094	1,982	96%
Insurance	12	74%	99%	1,249	1,379	85%
Actuarial services	20	71%	89%	2,271	1,268	52%

Table 1 demonstrates that there is considerably more concentration in the custody, member benefit and insurance industries that serve the trustees of funds, than in the list of superannuation funds themselves. The importance of concentration to a network analysis is that the network is likely to be highly connected, even though the funds themselves are not connected.

3.3.8 Horizontal integration

There is no horizontal integration of audit service providers (by the nature of their work). The extent of horizontal integration can be seen from

Table 2. This sets out the multi-service providers and their market shares in each sector by fund assets under management.

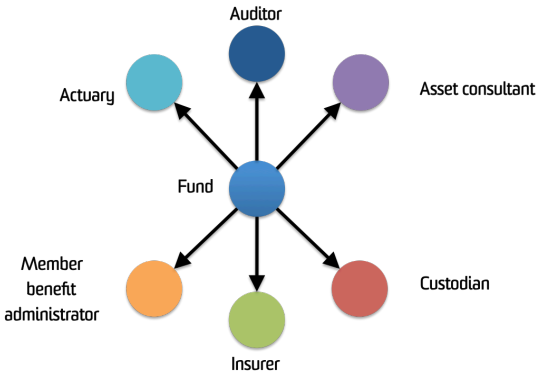
Table 2: Integration in transactional and advisory services share expressed as assets under management

Name	Custodian	Administration	Insurance	Asset consultant	Actuary
AMP		6.00%	11.00%		
ANZ		4.00%	8.00%		
CBA	6.00%	8.00%	17.00%		
Macquarie	1.00%		2.00%		
Mercer		8.00%	7.00%	10.00%	18.00%
NAB	28.00%	8.00%		37.10%	
Russell		7.00%		1.10%	22.00%
Towers Watson				20.00%	5.00%
Westpac	5.00%	3.00%	6.00%	9.30%	

3.4 Selecting the nodes

The effect of these arrangements is that the network associated with any one fund is as set out in Figure 2.

Figure 2: Potential network elements – the fund



It would be possible to create a network which uses all of these connections. However, this may not be the most fruitful path, as the next step is to identify systemic risk. In seeking to create a smaller network, one approach would be to look at the service providers that every fund must have to meet its obligations to both its members and under the legislation. This means that actuaries and asset consultants could, potentially be eliminated. The rationale behind each elimination is distinct. Actuaries are generally employed by funds that have a defined benefit obligation to members. As set out above, this is a limited set of funds. Assets consultants are used by a larger number of funds. However, there is no obligation on funds to adopt the advice provided by the assets consultant and the potential for asset consultants to contribute to systemic risk appears, at this stage, to be limited.

All funds require an auditor and many funds elect to have both an internal and an external auditor and different firms provide these audit services. Although the audit function is critical to regulatory oversight, audit only provides a limited source of systemic risk. That risk would likely arise from an approach to an accounting standard that was applied in a way that led to a poorer member

outcome. In practice, the level of coordination between audit firms in their implementation of generally accepted accounting standards has the risk of a homogenous (but incorrect) application of an accounting standard. While such an error would have a systemic effect, it is not clear that this effect would cause instability in the system.

As a consequence, the simplified network to be modelled consists of three types of node:

(a) funds;
(b) member benefit administrators; and
(c) custodians.

3.5 The links

3.5.1 Options for link weighting

The links between the nodes are base on the supply of services and, as a consequence, there are a limited number of ways in which the links between nodes can be weighted. The single common mechanism for weighting is the fund's assets under management. Consequently, all link weighting uses this parameter. The data for each service provider differ as set out in Table 1.

3.5.2 Directionality

As the funds are independent of each other, all links are established as directional. As a practical matter, the direction is set to be from the fund to the service provider.

4 Results

4.1 The simplified model

If we simply take the fund, its custodian and its administrator, we arrive at a simple network with three nodes, two links and directionality of those links towards the service providers. If we add another fund to the network, there are four possible network configurations. These are that the two funds share:

(a) both service providers;
(b) a custodian, but not a member benefit administrator;
(c) a member benefit administrator, but not a custodian;
(d) neither service provider.

These four configurations are shown in Figure 3, Figure 4, Figure 5 and Figure 6.

Figure 3: Shared service providers

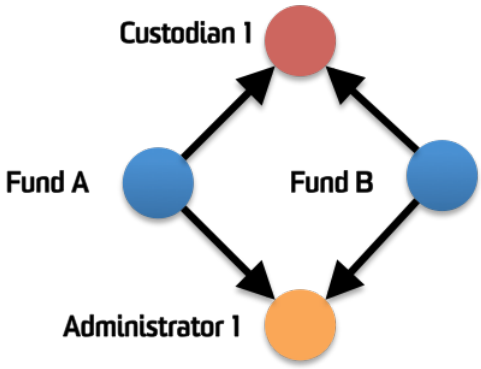


Figure 4: Common custodian

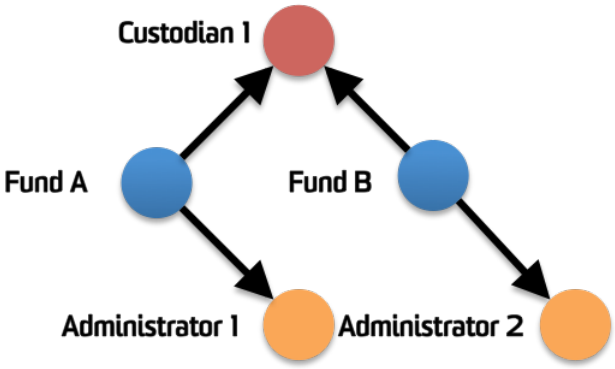


Figure 5: Common administrator

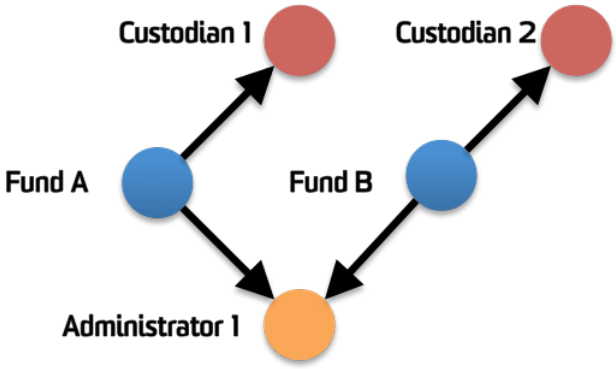
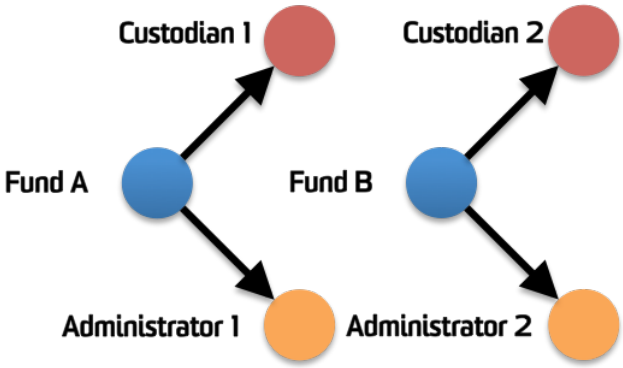


Figure 6: No common service provider

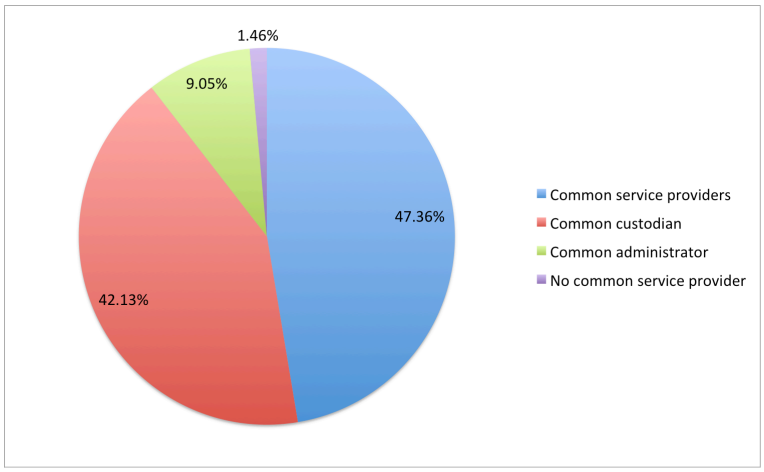


The order in which this assessment is made is important. The test is done first using custodian data and then by member benefit administrator. The outcome of the test is set out in Table 3 and Figure 7.

Table 3: Network element type distribution by fund assets

Common Service Providers	Common Custodian	Common administrator	No common Service Provider
47.36%	42.13%	9.05%	1.46%

Figure 7: Network element type distribution by fund assets

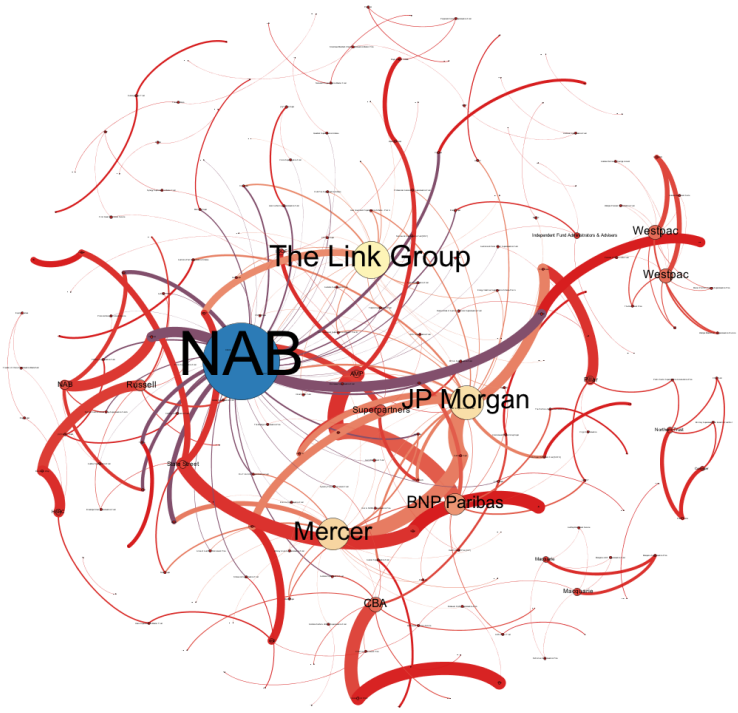


The effect is that only 3.05% of the funds (by assets under management) do not share a single service provider. The next step would be to find how disconnected this small section of the industry is. That is, to determine if there are other linkages beyond those shown in Figure 3, Figure 4, Figure 5 and Figure 6. However, an analysis of these funds shows that two funds self-provide both administrator and custodian services (Suncorp and Netwealth) accounting for a significant proportion of the "no common service provider". It is reasonable to expect that these funds, along with the other funds that indicate no common service provider, use a one of the major custodians for sub-custody. This suggests that the finding that 98.54% of funds share a custodian, an administrator or both means that materially all funds fall into this level of closeness.

4.2 Overview

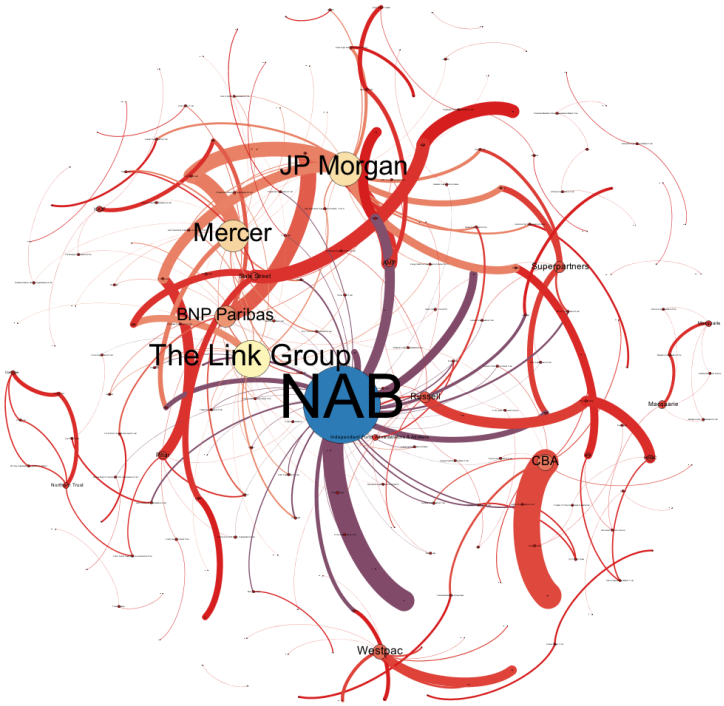
In the network of funds, custodians and member benefit administrators there are 211 nodes and 263 links. An overview of the network, constructed using the Fruchterman-Reingold force directed placement are shown in Figure 8 (Fruchterman and Reingold 1991).

Figure 8: Network of funds, custodians and member benefit administrators



It is interesting to note that there are areas associated with Westpac, CBA and NAB having more than one function. This is a reflection of horizontal integration and is consistent with the outcome expected from Table 2. Consolidating the position of the multi-service providers creates a network set out in Figure 9.

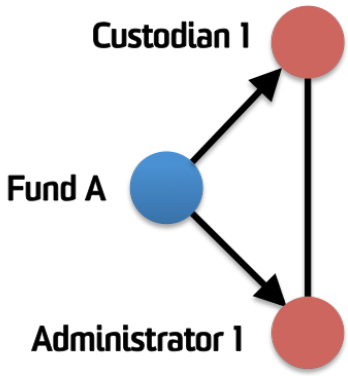
Figure 9: Multi-service provider network



4.3 Closeness

One issue that arises from the analysis based on funds and outsource providers is the absence of "triangles". That is, the fund has a custodian and an administrator but there are no linkages in shown in Figure 3, Figure 4, Figure 5 and Figure 6. However, A number of custodians also provide member benefit administrator services. That is, the fund has directed links to a custodian and to a member benefit administrator and the custodian and the member benefit administrator have an undirected link arising from common ownership. This is shown in Figure 10.

Figure 10: Creating triangles



4.4 Clustering

Barrat and Weigt (Barrat and Weigt 2000) define clustering in small world networks using the concept of triangles formed between nodes. Using data which includes the triangles set out in Figure 10, the clustering coefficient is 0.184. This level of clustering is significantly higher than that found in a random network of a similar number of nodes. This approach of using triangles in a weighted network is supported by others as an approach to determining small world characteristics (Opsahl and Panzarasa 2009, 158).

5 Analysis

5.1 Small worlds

The simplified superannuation network has characteristics that are different from a random network. It has an average degree (the number of links connected to a node) of 1.246. However, once a model is created incorporating Figure 10, the average degree rises to 2.54. A comparable random network with 211 nodes and a wiring probability of 0.05 would have an average degree of 2.493, significantly higher than that of the network described in this paper.

Generating a small world using the Watt and Strogatz (1998) approach with 211 nodes produces 422 links with an average degree of 4. The implication is that the model that incorporates the linkages between service providers, rather than counting common service providers as a single service provider suggests that a small world model of the superannuation system approaches the field evidence. To confirm that the small world is the closest model, a Barabasi-Albert scale free network with 211 nodes and 263 links (Albert and Barabási 2002) was generated. This has a significantly smaller clustering coefficient (0.019) than any of the networks described in this paper.

5.2 Implications

By treating the data as being focussed on separate but potentially linked service providers, there is an increasing likelihood that a model of the superannuation system that exhibits small world characteristics is the one, which is most appropriate. This is useful to examine transmission effects. However, the simplicity that flows from the mathematics of a random network is not available.

5.3 Regulatory issues

Australia has a highly concentrated retail banking sector with four major banks, maintained by a government policy referred to as the "four pillars" policy (Wu 2008). APRA has determined that these four banks (ANZ, CBA, NAB and Westpac) are the domestic systemically important banks in Australia (APRA 2013). Three of these four banks are readily identifiable in Figure 9. However, APRA did not consider the systemic importance of those banks from the perspective of the pension sector. In practice, there are two systemic effects that arise. The first is the importance of the banks as outsource providers to the pension funds. The second is that Australian pension funds have significant investments in Australian equities and these four banks are all in the top five largest companies by market capitalisation and are collectively weighted more than 27% of the major Australian equities index, the ASX200.

These systemic effects are not ones that can be resolved by increasing regulatory capital. They may be addressed by structural reform. The problem can be summarised (Donald and Nicholls 2015, 38):

> *ASIC and APRA are increasingly aware of the potential for local risks to have systemic implications, but … for a variety of institutional, political and jurisdictional reasons they appear to be ill-equipped currently to address the threat.*

The number of service providers in the Australian pension sector is declining. One of the largest member benefit administrators, Superpartners, has been disposed of by way of a trade sale to Link Group, the owner of Australian Administration Services (AAS). This move merges the firms with the largest and second largest market share (measured by assets under management) to create a single administration outsource provider with greater than 22% market share by assets under management. With the fourth largest administration outsource provider, NAB looking at strategic reviews and the sixth, Russell, having been bought by the London Stock Exchange for its index business, it seems likely that there will be consolidation in the sector. The Australian Competition and Consumer Commission (ACCC) has not challenged consolidation in the sector. Presumably, the ACCC considers that insourcing provides enough competitive tension to define any member benefit administration market in terms of the whole of the superannuation sector. However, the ACCC may find that the degree of horizontal integration that can be seen with a network model would be beneficial in its analyses.

6 Conclusions and recommendations for further work

This paper presents a network analysis of the superannuation sector in Australia. The work helps to identify the key service providers in the sector and this information is useful to analyse systematic risk associated with the Australian superannuation sector.

In particular, there are potential benefits for regulatory agencies to use this type of network analysis to avoid the problems that arise from regulatory silos.

The next stage includes using the nature of the system described in this paper as the basis for considering the transmission and amplification of risk. To the extent that there are non-linear outcomes, then a logical next step would be to build an agent-based model of the Australian superannuation sector using the insights provided by the network analysis.

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