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Marketisation of Climate Change Services

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Abstract

Governments both in Australia and abroad are showing increasing interest in facilitating growth in the adaptation services market to help communities to prepare for and respond to the impacts of climate change. This review appraises evidence of the effectiveness and efficiency of these markets and the role that governments play in their establishment and operation. We found that the majority of empirical work on climate service markets concentrates on demand related aspects, such as user preferences, and less on the supply and policy aspects of the market. We propose that this stems from an assumption that by increasing demand, suppliers will follow. As climate service markets are generally policy-based imperatives, they do not emerge according to conventional market rules, and act more like a quasi-market or public service market. We suggest that, due to the normative goals of climate service markets to aid climate change adaptation, governments would do well to steward these markets into more robust systems. We conclude by recalling that the exchange of climate service information is not limited to market arrangements, and that government's choice to use markets to help exchange climate service data is another example of the legacy of new public management paradigms as we shift into a new public governance era.

This review will appraise evidence of the effectiveness and efficiency of market-based approaches to the provision of climate services and the role that governments provide as a steward of those markets. Climate services are a relatively new concept and as such their definition is yet to be fixed. However, a working definition is to consider climate services as the processes that give rise to information and data about changing climatic conditions, and factors that relate to this (Stegmaier and Visscher, 2017). Such services include long term weather predictions, agricultural predictions, climate change adaptation information and strategies, climate change mitigation information and strategies and disaster risk management (Stegmaier and Visscher, 2017). By a climate services market we mean a market of public and private information and data that aids both public and private climate change adaptation efforts. Commonly, a climate service market is a market (or quasi-market) created by governments through contracting and tendering processes to generate efficiencies through increased competition between providers, such as found in the European Union (Hood, 2005; Klijn and Koppenjan, 2000). It should be noted that some climate services have been marketized for a long time, including seasonal weather patterns and some are transferred in non-market arrangements such as short-term weather predictions and meteorological information. However, there has been a recent push to formalizing climate service markets as a climate change adaptation strategy, and in most cases such climate change service markets are supported by government through quasi-market arrangements, subsidies and other supportive economic policies. The establishment of markets to support the exchange of climate services is the subject of this review. Particularly, we examine 'what works' in the provision of climate change adaptation

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services and the strategies/approaches that governments use to effectively and efficiently implement and steward these adaptation markets.

Research questions are:

What comprises a climate service market, in Australia and abroad?

What strategies/approaches are governments employing worldwide to effectively and efficiently steward these adaptation markets?

The distribution of services through markets is popular within the new public governance approach that characterizes governments worldwide (Osborne, 2010). This is also apparent in the climate change adaptation space in Australia, with the NSW Government recently announcing that it is interested in facilitating growth in the adaptation services market to help NSW communities to prepare for climate change (New South Wales government, 2016). It is working to establish an adaptation innovation fund to support innovation around adaptation services. Similarly, the Victorian government, in their Climate Change Adaptation Plan 2017–2022, states that it "will also assist Victorian businesses and industries identify existing gaps and new opportunities in emerging markets and new technologies for adaptation". There remains significant scope to explore exactly what a climate adaptation services market might be, the different kinds of services it could provide and how governments can work to support their emergence and operation.

At the outset, it is worth asking the question of why governments should be involved in creating this market. As others have noted, the shift to markets is not only widespread, but highly controversial and contested (Carey et al. 2017). Markets have been treated by some as a panacea for contemporary public sector challenges, "it provides incentives for providers to provide both high quality and greater efficiency; and it is likely to more equitable than the alternatives" (LeGrand, 2007, 42). However, the evidence of whether market mechanisms work to improve the delivery of public goods is sparse and contradictory (Considine et al. 2011; Gash et al. 2013). There are ongoing debates in the economics community about the ability of governments to successfully create and regulate markets, and how governments should manage the risks of market failure. We acknowledge these debates as ongoing and contested. Regardless, governments around the world are turning to market-based approaches to the provision of climate change services, which necessitates a focus on understanding 'what works' in the provision of climate change adaptation services and the strategies/approaches that governments use to effectively and efficiently implement and steward these adaptation markets.

Search protocol

The following bibliographic databases were used to search for relevant material: ProQuest, Sociological Abstracts, PubMed, Web of Science, Science Citation Index, Social Sciences Citation Index, MEDLINE, Academic Onefile, ScienceDirect, Expanded Academic, EBSCO and Google Scholar.

The search terms used were:

- Climate service(s) AND market
- Climate service(s) AND investment
- Climate service(s) AND product
- Climate change adaptation market
- Climate adaptation market
- Climate change AND service(s) market
- Climate adaptation AND service(s) market
- Climate innovation AND service(s) market
- Climate change AND insurance
- Adaptation market
- Adaptation market AND insurance
- Adaptation market AND service(s)

The initial search yielded 87 promising articles based on titled and a brief scan of abstracts. A further 69 were deemed unsuitable based on the inclusion criteria listed below, usually because they were non-empirical work. There is a significant body of non-empirical work on climate change adaptation services (hereafter CCAS) which advises policy makers to consider or better support CCAS markets, however there is comparatively fewer empirical studies on 'what works' in supporting the design and operation of these markets.

Inclusion criteria were:

- Work based on empirical research, including empirical social science methods such as interviews and document reviews
- Work written in English
- Work appearing from 2000 (note: the phrase climate adaptation services, or climate change services, are quite recent and emerge from the literature around 2010)

We classified our research according to:

1. demand, referring to studies that concentrate on potential or real demand and on users of climate services,
2. supply, referring to studies that concentrate on potential or real supply and on providers of climate services, and
3. policy, referring to studies that concentrate on policy-based aspects of climate service markets.

We allowed research to span categories if it produced empirical data relating to more than one category. Table 1 summarises the articles included in the review, identifies the methods used, the main findings and the category of climate service markets that the findings relate to.

Quality of evidence

The evidence about 'what works' in climate adaptation service markets is currently clustered around two European institutions – MARCO and EU-MACS – and the academic journal *Climate Services*. We identified two research institutions dedicated to CS markets: MARCO (Market Research for a Climate Services Observatory) and EU-MACS (European Market for Climate Services). At the time of writing, the MARCO team had published just five of its 35 predicted research reports. EU-MACS, which works in conjunction with MARCO, has published four of their expected six reports of the emergence of climate service markets. The quality of work published by MACRO and EU-MACS projects are high, both institutions provide detailed reports, including study limitations. Common limitations in the study of the European climate service market are limited availability of data such as purchase histories. For example, Howard (2018) observed limitations despite heavy data mining efforts of climate service transaction records. We predict that further information about the climate service market in the EU will be available as MACRO finishes their planned reports.

Overall, the research is often limited to European analysis of climate service markets, and there remains the task of establishing stronger climate service information for Australia and New Zealand. Some of this information will provide ideas and innovations for supporting climate service markets in Australia and New Zealand.

From our categorization of the research into demand, supply and policy-based foci, we were able to observe that the majority of research targets the demand of climate services. Sixteen articles in our review concentrate on demand, with seven focusing on supply and six on policy. There is overlap within the documents, and some work produces empirical evidence for more than one category, with six articles focusing on supply and demand, two on supply and policy, two on demand and policy and one on all three. Some studies are worth particular mention when considering research quality. These are: Cortekar et al. (2017) who reach participants from across the spectrum of climate change service users; Bruno Soares et al. (2018) who have a particularly high participant rate relative to other surveys in the review, with online surveys ($n = 462$) and interviews ($n = 80$) with potential users of climate information; and Howard (2018) who provides a thorough depiction of climate markets in Europe using the KMatrix methodology.

Focus of evidence: Demand

Of those reviewed, a total of sixteen papers held empirical evidence about the demand side of climate service markets. This work covered multiple aspects of climate service demand, including user designed climate services (Christel et al. 2018), transactions within climate services markets (Howard, 2018) and maps of climate service markets (Máñez et al. 2014). Two key messages that come from the literature is that the demand for climate services does not stem from a homogenous group of buyers (Bruno Soares et al. 2018; Cortekar et al. 2016; Groot et al. 2014) and that it is important to consider the varied needs of the climate service market users, and hence tailor services accordingly (Christel et al. 2018).

The review shows that climate service users are not homogeneous, but that government and international private organisations are often major features. One of the most comprehensive studies on climate service markets in the EU is Cortekar et al. (2017). The authors examined climate service documents and conducted interviews and surveys with participants from across the climate service supply chain. They focused on user profiles, and who climate service market users are considered to be by others in the supply chain. They found that users are expected to be people in decision-marking positions in business, policy and public administration roles with local to international scope. Further to this, in the findings from their user engagement strategy, Swart and others (2017) highlight the importance of considering the heterogeneity of climate user groups,

Table 1. Literature matrix of empirical climate service papers

Journal citation (chronological order)	Empirical study design	Category
1. Hussey et al. (2013)	Empirical findings based on policy document analysis, provides insight into legislative and policy-based preparedness for climate change adaptation markets	Policy
2. Máñez et al. (2014)	Empirical findings based on mapping of providers and questionnaires about user knowledge	Supply Demand
3. Goosen et al. (2014)	Empirical findings based on meteorological data and economic assessment	Supply
4. Goransson and Rummukainen (2014)	Empirical findings based on mapping of providers	Supply Demand
5. Cortekar et al. (2016)	Empirical findings based on case studies, workshops interviews and document analysis	Demand
6. Swart et al. (2017)	A user engagement strategy was set up to (a) map experiences from other projects, (b) identify and prioritize user categories, (c) collect user requirements by questionnaire; (d) involve users panels in testing subsequent portal versions#	Demand
7. Räsänen et al. (2017)	Empirical findings based on survey of Finnish local government	Policy
8. Cavalier et al. (2017)	Review of existing reports on the market of climate services, and on interviews of 68 climate service providers and users in public and private organizations.	Demand Supply
9. Cortekar et al. (2017)	Literature reviews, interviews and survey to establish possible market for climate services in the EU	Supply Demand Policy
10. Stegmaier and Visscher (2017)	Literature reviews, reviews of prior EU-MACS studies	Policy
11. Vaughan et al. (2017) Creating an enabling environment for investment in climate services: The case of Uruguay's National Agricultural Information System Climate Services, Volume 8, Pages 62–71	Document analysis and 43 interviews with local stakeholders	Policy
12. Larosa and Perrels (2017) Assessment of the existing	Semi-structured interviews with stakeholders from public, private and co-production organisations	Supply Policy
13. Soares et al. (2018)	Online survey (n = 462) and interviews with (potential) users of climate information (n = 80)	Demand
14. Christel et al. (2018)	Modelling based on a fully working climate services prototype developed within the European project EUPORIAS	Supply Demand
15. Howard (2018)	Matrix methodology used to identify sellers and purchasers of climate services in Europe between 2014-2016	Supply Demand
16. Skougaard Kaspersen et al. (2018)	Mapping of data from international disaster databases on recent historical extreme climate events in Europe	Demand Policy
17. Lamich et al. (2018)	Interviews and document analysis of awareness about climate services in the energy sector in Germany	Demand

observing that "'users' are considered to be homogeneous and primarily policy or decision makers … climate impacts researchers and intermediate knowledge purveyors (e.g., consultants or environmental agencies), are generally not distinguished as separate target groups, while they play an increasingly important role in providing climate information". In prospective climate service markets there may be a tendency to assume an active buying group. When considering emerging markets, Brassuer and Gallardo observe that "climate services have been established with the assumption that an active market of users and stakeholders is in place to rapidly benefit from science-based information. Unfortunately, the market has only been partially established and the relation between climate services and potential stakeholders remains weak or ad-hoc in many cases". (2016, 82).

Through surveys and interviews, Soares et al. (2018) break down the economics centers that use climate service data. There were generally large private companies or government agencies working at a national scale. The highest users in the European context are energy, agriculture, and water, while the lowest uptake is in the finance and insurance, forestry and tourism sectors. They also find that users draw their climate service data from multiple sources. The use and demand for climate change projections or scenarios is high in Europe, representing 36 per cent of use (Bruno Soares et al. 2018). Overall, this study offers a high volume of information about use of climate service data in Europe, and it is recommended that a similar study is commissioned in Australia and New Zealand to support the uptake of climate service markets there.

Currently, demand for climate services in the European market is predominantly focused on weather and meteorological services. Lamich et al. (2018) found that of market users interviewed "75% use weather services only, while 25% additionally employ climate services as a support tool for the strategic planning of their enterprises and as background information for lobbying". In a study of the European market, customers of climate services were larger organisations and government. Detailed analysis of the climate service market in the EU identified "113 major suppliers of climate services across the 28 countries of the EU" (Howard, 2018, 8) who account for 40 per cent of the climate service sales in Europe over the past three years. These buyers were characterized as larger organisations or 'household names',[1] within the European economy (Howard, 2018).

To stimulate demand in climate service markets, Howard (2018) outlines a set of goals likely to be applicable worldwide:

1. Have a strategy to increase numbers of first-time users
2. Have a strategy to ensure that first time users graduate to second time users, this also encourages annual users
3. Annual users are the high value purchasers, therefore increasing the number of annual purchasers increases the health of the climate service market overall.

The review shows that information traded in climate service markets is most useful when specifically tailored to the needs of the customers. This suggests the need for multiple actors in climate service markets, ones to provide large scale and general information, and other consultants and researchers able to translate that information into specific and usable information and direct further data collection. Cortekar et al. (2016) develop a series of climate service prototypes and use these modules to develop a framework for flexible and customisable support for cities from climate service providers. Their results show that climate service markets must be addressing actual need, fit in to existing decision making processes, provision must be flexible to changing stakeholder needs, and that human and financial resources are limiting factors (Cortekar et al. 2016, 45). They highlight their most important finding as the fact that "one-size-fits-all solutions do not exist in practice due to varying preconditions, city characteristics, and involved stakeholders" (Cortekar et al. 2016, 45). They add that while it is easiest to focus on particular sectors (i.e. water or atmosphere) there are limitations to this scoping for effective adaptation, which is likely to require whole of system actions and information.

The need for specifically tailored information to support climate adaptation decisions is an important point for establishing climate service markets in Australia, a limitation of understanding the how to support climate service markets in Australia is a lack of complete information about potential supply and demand. The potential climate service market uptake in specific countries has been explored through existing climate service market reports, and interviews with climate service providers, and users in public or private organizations (Cavelier et

[1]Examples provided elsewhere in the document are "Houston Consulting, PwC, KPMG, Deloitte and Boston Consulting Group" (Howard, 2018, 9).

al. 2017). Such an analysis is recommended for the Australian and New Zealand context, but does not currently exist. Such work could support Australia and New Zealand specific recommendations for user uptake. In the context of the French economic and ecological conditions, the researchers recommend that the conditions for climate service market uptake comprise of (Cavelier et al. 2017, 34):

> (1) a coordinated delivery of data, information, expertise and training by public research institutes concerned with climate change and its impacts;
>
> (2) the inclusion of adaptation in the regulation and in public and private tenders.

Such principles are likely to be useful in most emerging climate market contexts such as Australia and New Zealand.

Further to this point, in mapping climate change service providers in Germany Máñez et al. (2014) identified quality and transparency as the most important consideration for the demand side of CSM. Upon finding that 83% of climate suppliers surveyed did not base their climate data on credible sources,[2] Máñez et al. (2014, 24) observe that there is "no framework for the evaluation of climate services exists, which makes it difficult for users to identify high quality climate services; especially, when providers do not provide information on databases, methods used, etc.". This highlights potential issues around transparency of data quality between suppliers and users, an issue for all aspects of climate service markets. Problems of quality of climate service information persists across studies, with participants in Lamich et al. (2018, 27) explaining that "We do not just need more data and an inflationary production and use of these data, what we need is more quality".

Larosa and Perrels (2017) investigate issues around quality assurance of existing climate service data in Europe through semi-structured interviews with public and private organisations involved in the climate service data supply chain. They conclude that the greater part of climate service data transitions occur in non-market settings, with public funding higher than private, but that "this can change significantly as more CS become operational and more user segments get activated" (Larosa and Perrels, 2017, 8).

Focus of evidence: Supply

Of the studies reviewed, a total of seven papers included empirical evidence about the supply side of climate service markets. Topics covered in this section include market share in the European climate service market (Howard, 2018), collaborative practice between suppliers (Máñez et al. 2014) and heterogeneity of suppliers (Cavelier et al. 2017).

Like the work that established the heterogeneity of climate service users, there is similar evidence to show the heterogeneity of climate service providers. Research on the French climate service market found a diversity of research organisations providing climate service data from meteorological offices, research centres, network of universities, research institute on engineering or energy and geological surveys, with large differences in organisation size ranging from 80 to 12,000 employees (Cavelier et al. 2017). This heterogeneity is a consideration for market stewardship of climate service markets in other countries, as it highlights that there will never be a 'one size fits all' approach to supporting an emerging climate service market. Further to this point, Howard (2018, 8) identified "113 major suppliers of Climate Services across the 28 countries of the EU". The top five suppliers of climate services in the EU are different across four randomly chosen countries for each year, and changes each year, indicating that competition is highly fluid and also country-specific (Howard, 2018). Howard (2018) concludes that "The evidence of persistent high growth for this cohort of suppliers and their increase in market share year- on-year suggests that the emerging market for Climate Services is, and will remain, highly competitive". The currently changing dominance suppliers in climate service markets in Europe suggests a fluid market, without clear monopolies, and without clearly established business niches.

A review of potential users of climate service markets can also establish the challenges that providers are likely to face. Cortekar et al. (2017) compiled a report based on literature reviews, interviews and surveys to establish possible markets for climate services in the EU and found that providers are facing challenges around financial resources, lack of available technology for data analysis and storage, and difficulties involving stakeholders.

[2]Examples listed are "German Climate Computing Center (Deutsches Klimarechenzentrum), the German Meteorological Organization (Deutscher Wetterdienst), Max-Planck-Institute for Meteorology, Climate Service Center, Potsdam Institute of Climate Impact Research and so on". (Máñez et al. 2014, 24).

Partnerships and collaboration between providers is one way to deal with these challenges. Máñez et al. (2014) investigated collaborative practice between climate service providers, often a key aspect of a well-functioning market. They found that 90% of providers in Germany collaborate with other providers in some way, but this is often due to specific project work rather than long term formal partnerships (Máñez et al. 2014). However, the majority of providers indicated that they were interested in more continuous communication, with just one provider indicating that they had no interest in ongoing collaboration (Máñez et al. 2014). Göransson and Rummukainen (2014) also found cooperation between providers of climate services in Sweden and the Netherlands, and note that these can vary from limited to irregular collaborations. Further, in their survey of climate service providers and users in the Netherlands and Sweden, Göransson and Rummukainen (2014, 69) also found that the most common types of climate services in Sweden are: "guidance, workshops or similar activities and synthesis reports or other knowledge reviews", while in the Netherlands these are "graphics and maps, adaptation strategies and processed data", suggestion further variation of climate service markets between countries, even between those with similar geographies.

Also relevant to the supply side are lessons for providers about best practice engagement with users. For example, in their prototype climate service case study Christel et al. (2018, 120) establish that a "human-centered approach can engage the end -user throughout all stages in the design of a climate service, and also other relevant actors in the science, industry and design sector".

Focus of evidence: Policy aspects

Of those reviewed, a total of six papers included empirical evidence about the policy aspects of climate service markets. Larosa and Perrels (2017) outline an important perspective in climate service markets – that the exchange of climate service information and data still often are driven and motivated in non-market settings.

By this they mean that there is a difference between the climate service field which involves a broad network of climate service researchers sharing (publicly funded) data, and the climate service market, which involves the monetisation of climate data. They argue that "Public funding of CS activities has been hitherto clearly more significant than private funding, but this can change significantly as more CS become operational and more user segments get activated" (Larosa and Perrels, 2017, 8). They observe that, despite legislation in many EU member states to account for climate change in planning (especially in land, energy, water and infrastructure), there are few guidelines for quality of climate service data, or even that it ought to be utilized. Thus, standards as set according to developments in industry and practice, rather than through regulatory lenses (Larosa and Perrels, 2017).

A study into the climate adaptation preparedness of Australia's regulatory structures revealed "detailed information, data and response strategies is patchy, not fit-for-purpose and lacks accreditation processes" (Hussey et al. 2013, 4). In this research, seven Australian case studies of statutory frameworks or institutional arrangements were assessed against seven criteria for climate change preparedness, including market arrangements (Hussey et al. 2013). The work on market arrangements, while generally focusing on carbon markets rather than climate service markets, shows where a climate service market can fit into the Australian context, given that publicly funded climate information remains free to use (Hussey et al. 2013, 42):

> There are policy options that would complement the existing low-carbon policy framework and which comprises three elements: (1) a central national information repository; (2) non- coercive adaptation policy that encourages climate finance for adaptation, recommendations include co-financing arrangements and the use of market policy mechanisms such as tax credits, grants, feed-in-tariffs, and Climate Bond; and (3) coercive adaptation regulation that mandates how financial actors must facilitate adaptation, taxation and prescriptive mechanisms.

In particular, the Hussey et al. (2013) vision of a central national information repository suggests a central space for climate services with a blend of data that is either free to use or requires payment to access. Such a vision aligns with work by Larosa and Perrels (2017) who advocate for continued royalty systems in an open data system.

Finally, Skougaard Kaspersen et al. (2017) take climate data from across Europe and analyses the climate related risks for each country, in order to give an indication of the areas of application for climate services. The work quantifies risk in terms of economic loss by region, finding that Eastern Europe suffers the most economic loss from climate and weather related events (Skougaard Kaspersen et al. 2017). The report highlights that industries sensitive to climate changes are not

evenly distributed across Europe, for example "agriculture is found in most parts of Europe, whereas irrigation is only required regularly in the most southerly areas, in particular in Spain and southern France, leading to higher vulnerabilities for such regions" (Skougaard Kaspersen et al. 2017, 53). While such an analysis is not immediately applicable to the Australia and New Zealand context, we can recommend that a similar study is conducted here.

Discussion

In our review of empirical work in climate service markets, we framed the market according the demand, supply and policy related categories. This simple framework allowed us to categorise the research, and understand that the majority of the work focusses on demand aspects. While some climate service information has been marketized for a long time, such as seasonal weather predictions, and some is transferred using non-market arrangements, such as freely available weather predictions, the recent push towards formalizing climate service markets worldwide is seen to constitute a comprehensive implementation of climate adaptation policy. This marks a distinction between the previous, more 'organic' formation of climate service markets and the formalisation of climate service markets as a distinct governmental action to support climate change adaptation.

We found that research into climate service markets worldwide is predominantly focused on the demand aspects of the market. There are a number of possible reasons for this. First, from a market management perspective, potentially an adequate supply of climate services is taken as a 'given' or expected to arise as long as demand is adequately stimulated and communicated. However, Brasseur and Gallardo (2016, 82) observe that:

> Climate services have been established with the assumption that an active market of users and stakeholders is in place to rapidly benefit from science-based information. Unfortunately, the market has only been partially established and the relation between climate services and potential stakeholders remains weak or ad-hoc in many cases.

This points to a perennial problem, links between climate service users and climate service providers may not be strong, and highlights a point of intervention for governments interested in stewarding climate service markets. The assumptions about the supply of a climate change market simply 'arising' in response to demand potentially stem from the fact that climate service markets are generally policy-based imperatives, as they relate to the social good of climate change adaptation that governments have cause to invest in, rather than 'natural' or unregulated market arrangements. Such a push towards the marketisation of climate services fits within a broader paradigm of new public management, whereby the work of government sis pushed towards market based efficiencies (Osborne, 2010).

The marketisation of services that are explicitly driven towards advancing public good, such as welfare markets, carbon reduction markets or climate service markets, are fundamentally different to conventional markets (LeGrand and Bartlett, 1993). As such, they require higher levels of government stewardship, including stimulation, intervention and monitoring, than conventional markets. Our review found that users rarely employ climate services repeatedly (Howard, 2018), and due to the levels of specialty and infrequent demand, climate service markets are likely to be 'thin' markets where supplier and user connectivity is low. There was almost no explicit discussion found in this review on the stewardship of climate service markets from a policy implementation perspective. We suggest that research is needed to understand how to administer and support climate service markets from a policy perspective, and particularly in the Australian and New Zealand context. For example, this could involve empirical research on how different government agencies are working to implement market-based approaches or stimulate supply and demand of particular services. In particular, it is clear from the evidence that information sharing mechanisms are a key part of a functioning climate change market and can be provided by governments to stimulate demand (Larosa and Perrels, 2017).

Current work in Australia on thin market management in non-conventional markets such as these suggests that market *stewardship*, a more active approach than market regulation, will be needed to help emerging markets to become robust (Carey et al. 2018; Moon et al. 2017). We understand from emerging climate markets in Europe that, in order to progress to a robust level of functioning, these systems for climate service data exchange will need stimulation and stewardship from local governments. Possible stewardship actions can include (Carey et al. 2018):

- Set price standards
- Establish trading protocols
- Provide consumers with information about suppliers
- Stimulate markets via grants/seed funding
- Supplement markets to address gaps
- Monitor service quality
- Regulate for and foster best practice

Alongside such market stewardship approaches, we should also remember that the exchange of climate service data has historically occurred in both market and non-market settings (Larosa and Perrels, 2017), reminding us that climate service markets cannot and need not be designed in a vacuum, sperate from other climate, environmental and adaptation policy measures. An exchange of climate service information need not occur in marketized settings, we can take the insight in Hussey et al. (2013) of a central national information repository, and speculate that such a repository could be accessible via subscription, or free to not for profit organisations, and maintained via a series of grants and commissioning to climate service producers. This is just one example of possible ways to make climate information transferable in society.

More targeted empirical work on climate service markets is needed for Australia and New Zealand. With the MARCOS and EU-MACS projects, much current information about climate service markets is European focused. While we maintain that many findings from these projects will be generally applicable to other nations and trade groups, Australia and New Zealand specific information is sparse. Research from MARCOS and EU_MACS can provide blueprints for similar research in Australian/New Zealand contexts; studies into market transactions such as Howard (2018), and into profiling climate service users such as Soares et al. (2018) and mapping current climate change markets such as Cortekar (2017) will help gain understanding about the patterns of climate service exchange in Australia and New Zealand. More targeted empirical work about 'what works' in climate service markets and their stewardship is needed. We suggest that this research be comparative, evidence driven, and may include:

- ways to effectively provide information to both buyers and sellers about market conditions,
- transparency of data quality between suppliers and users,
- effectiveness of different human centered design approaches,
- effectiveness of scenario planning as a design approach, and
- lack of clarity about open data, more work on contextual outcomes that drive one way or the other.

Conclusion

Governments in Australia and New Zealand seem committed to the establishment or entrenchment of marketised approaches to climate change services (New South Wales government, 2017; Victorian government, 2016). The evidence on the operation of climate service markets, and their impact on climate change adaptation, is mixed and rarely Australia or New Zealand specific. Policy makers are left to draw conclusions from work predominantly based in the European union context. We predict that further information about the climate service market in the EU will be available as MACRO finishes their planned reports, and that some of these findings will be generalizable to Australia and New Zealand contexts. Nonetheless, this review of relevance both to climate service markets but also of pushes to marketise other environmental public goods.

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