



RESERVE BANK OF AUSTRALIA

Speech

Climate Change and the Economy

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'I love a sunburnt country, a land of sweeping plains, of ragged mountain ranges, of droughts and flooding rains.'

As Dorothea Mackellar eloquently put it in 1908, the weather has always had a significant impact on the Australian economy. One example that I recall vividly from my primary school days in Adelaide is the Goyder Line. Goyder was the Surveyor-General of the colony of South Australia in the second half of the 19th century. In 1865, he rode across the colony to determine what part of the state was arable. He plotted the Goyder line, or the 10-inch rainfall line. Areas to the south of the line were arable, those to the north were not. In the years just after Goyder drew his line, there was a period of high rainfall. Farmers pushed north of the Goyder line, building farmhouses and planting crops. But then, normal rainfall returned and Goyder's line reasserted itself. The legacy of that is still evident today with the ruined farmhouses.

Droughts and floods have had a large effect on the Australian economy for many, many years. In the 1990s, the model of the Australian economy at the Reserve Bank developed by David Gruen and Geoff Shuetrim had the Southern Oscillation Index as a significant determinant of GDP in Australia. ^[1] Today, while agriculture is a much smaller share of the economy than it used to be, the effect of climate on that sector is still evident in aggregate GDP. The current drought has already reduced farm output by around 6 per cent and total GDP by about 0.15 per cent. Even assuming that rainfall returns towards average soon, the drought will continue to weigh on aggregate GDP during 2019.

However, the effect of the drought on aggregate output and inflation is finite, though its impact on the people and businesses affected can last much longer. We are used to climate having a temporary effect (though sometimes severe) on output and prices in Australia.

Agriculture is the prism through which we have historically thought about the effect of climate on the economy. Today, climate change presents significant risks and opportunities for a broader part of the economy than agriculture, though the impact on agriculture continues to be significant.

I will talk about how climate change affects the objectives of monetary policy and some of the challenges that arise in thinking about climate change. Then I will use two current examples of how climate change is affecting the economy to illustrate these issues. Finally, I will also briefly discuss how climate change affects financial stability.

Let me start by highlighting a few of the dimensions that we need to consider:

- We need to think in terms of trend rather than cycles in the weather. Droughts have generally been regarded (at least economically) as cyclical events that recur every so often. In contrast, climate change is a *trend* change. The impact of a trend is ongoing, whereas a cycle is temporary.
- We need to reassess the frequency of climate events. In addition, we need to reassess our assumptions about the severity and longevity of the climatic events. For example, the insurance industry has recognised that the frequency and severity of tropical cyclones (and hurricanes in the Northern Hemisphere) has changed. This has caused the insurance sector to reprice how they insure (and re-insure) against such events.
- We need to think about how the economy is currently adapting and how it will adapt both to the trend change in climate and the transition required to contain climate change. The time-frame for both the impact of climate change and the adaptation of the economy to it is very pertinent here. The transition path to a less carbon-intensive world is clearly quite different depending on whether it is managed as a gradual process or is abrupt. The trend changes aren't likely to be smooth. There is likely to be volatility around the trend, with the potential for damaging outcomes from spikes above the trend.
- Both the physical impact of climate change and the transition are likely to have first-order economic effects.

The United Nations' Intergovernmental Panel on Climate Change (IPCC) report documents that 1 degree of warming has already occurred from pre-industrial levels as a result of human activities. [\[2\]](#) It provides strong evidence that another half degree of warming will occur in the next 10 to 30 years if warming continues at the current rate. That is the average outcome, with some areas experiencing greater warming.

There is also likely to be significant volatility around that outcome, with an increase in the frequency of extreme temperatures. This volatility is highlighted in the first graph in the recent Bureau of Meteorology (BoM) and CSIRO report, *State of the Climate*. The report states that 'Australia's climate has warmed by just over 1 degree C since 1910, *leading to an increase in the frequency of extreme heat events*', and expects further warming over the next decade. [\[3\]](#) These extreme events may well have a disproportionately large physical impact.

There is also a greater possibility of compound events, where two (or more) climatic events combine to produce an outcome that is worse than the effect of one of them occurring individually. Combined with the increased volatility, this increases the likelihood of non-linear impacts on the economy.

Both the IPCC and the BoM/CSIRO reports highlight the changed environment that the economy will need to adapt to. They also provide evidence on what change is predetermined and what can be affected by actions to strengthen the global response to the threat of climate change.

These issues are central to businesses, households and government. The policy environment has a key effect as well as the climatic environment. It is worth noting that the effect on the Australian economy is not just a function of the domestic political environment, but also that of other countries, most notably our trading partners. I will return to this later.

Climate Change, Economic Models and Monetary Policy

The economics profession has examined the effects of climate change at least since Nobel Prize winner William Nordhaus in 1977. Since then, it has become an area of considerably more active research in the profession. [\[4\]](#) There has been a large body of research around the appropriate design of policies to address climate change (such as the design of carbon pricing mechanisms), but not that much in terms of what it might imply for macroeconomic policies, with one notable exception being the work of Warwick McKibbin and co-authors. [\[5\]](#)

How does climate affect monetary policy? Monetary policy's objectives in Australia are full employment/output and inflation. Hence the effect of climate on these variables is an appropriate way to consider the effect of climate change on the economy and the implications for monetary policy. The economy is changing all the time in response to a large number of forces. Monetary policy is always having to analyse and assess these forces and their impact on the economy. But few of these forces have the scale, persistence and systemic risk of climate change.

A longstanding way of thinking about monetary policy and economic management is in terms of demand and supply shocks. [\[6\]](#) A positive demand shock increases output and increases prices. The monetary policy response to a positive demand shock is straightforward: tighten policy. Climate events have been good examples of supply shocks. Indeed, droughts are often the textbook example used to illustrate a supply shock. A negative supply shock reduces output but increases prices. That is a more complicated monetary policy challenge because the two parts of the RBA's dual mandate, output and inflation, are moving in opposite directions. Historically, the monetary policy response has been to look through the impact on prices, on the presumption that the impact is temporary. The banana price episode in 2011 after Cyclone Yasi is a good example of this. The spike in banana prices and inflation was temporary, although quite substantial. It boosted inflation by 0.7 percentage points. The Reserve Bank looked through the effect of the banana price rise on inflation. After the banana crop returned to normal, prices settled down and inflation returned to its previous rate.

The response to such a shock is relatively straightforward if the climate events are temporary and discrete: droughts are assumed to end; the destruction of the banana crop or the closure of the iron ore port because of a cyclone is temporary; things return to where they were before the climate

event. That said, the output that is lost is generally lost forever. It is not made up again later, but rather output returns to its former level.

The recent IPCC report documents that climate change is a trend rather than cyclical, which makes the assessment much more complicated. What if droughts are more frequent, or cyclones happen more often? The supply shock is no longer temporary but close to permanent. That situation is more challenging to assess and respond to.

A relevant question for monetary policy is how quickly and easily the economy adjusts to climate-related shocks, particularly if the shocks are more extreme. Both the impact of the shocks together with the adjustment to those shocks affect the macroeconomic trajectory. The timing and speed of the response by households, businesses and governments is likely to affect the economic outcomes. In economic terms (borrowed from physics), this is described as hysteresis or path dependence. Decisions that are taken now can have significant effects on future climate trends and can limit or eliminate the ability to mitigate the effect of those trends.

Hysteresis is complicated for macroeconomic policies such as monetary policy to deal with. Research into hysteresis in the labour market has documented the long-lasting effects of large rises in unemployment and the difficulty in reversing those effects. [\[7\]](#) To me, that research seems a useful framework to think about the effect of climate on the economy.

How can we gain insights into the potential impacts of climate change on output and inflation? One avenue is to use scenario analysis. There are some useful studies that look at the impact of climate change on particular sectors of the economy. They are often, by design and necessity, partial equilibrium; that is, taking into consideration only a particular market to analyse the impact. But the effect on the overall economy depends on what else is happening.

General equilibrium analysis provides the opportunity to consider how prices adjust and how people respond to price signals in the whole economy. The analytical approach of looking at things in general equilibrium is a critical part of the economics tool kit. It is an important contribution the economics profession can make to the climate change discussion. However, general equilibrium models often provide only a comparative static view. That is, the economy is in one equilibrium now and in the future it will be in another equilibrium. But for monetary policy, we very much care about the dynamics of moving from one equilibrium to another (and also we are generally not dealing with an economy in equilibrium). How long will it take the economy to adjust? Monetary policy has its maximum effect over a horizon of two or so years. Much of the adjustment may be taking place beyond that horizon but we very much need to be alert to when it is having a material influence within that horizon. To do that, we need to have an understanding of what the transition path might look like.

Thus for monetary policy we need to assess both the direct physical impact of climate change and also we need to assess the transition (adjustment) path. What will the inflation and output outcomes be along that adjustment path? How should monetary policy respond to these outcomes? We also need to be aware that decisions taken now by businesses and government may have a sizeable

influence on that transition path. Both the physical impact of climate and the transition path can cause both shocks *and* cause the trend to change.

The challenges we have to address are to take the outcomes from climate modelling and map them into our economic modelling. Similarly, the scenario analysis from climate models needs to be translated into the horizons of our economic models, taking account of price changes and how that affects decision-making.

General equilibrium analysis also doesn't always take account of adjustment burdens and costs. I see that as one lesson from the debate around trade liberalisation. Trade theory clearly acknowledges that there are winners and losers from trade but that the winners can compensate the losers. But it is clear from the current debate that, in practice, the compensation generally has not occurred. The adjustment costs have fallen on groups that have not received their share of the benefits.

A similar situation is present in the case of climate change. The transition path poses challenges, but it also presents opportunities. Particular industries and particular communities that are especially exposed to the costs of changes in the climate will face lower costs if there is an early and orderly transition. Others will bear greater costs from the transition to a lower carbon economy. While others still, such as the renewables sector, may benefit from that transition. But unlike the example of trade, it may not be possible for the winners to compensate the losers in a way that leaves no-one worse off. In economic jargon, it may not be possible to find a Pareto improving outcome, at least in the narrow monetary sense.

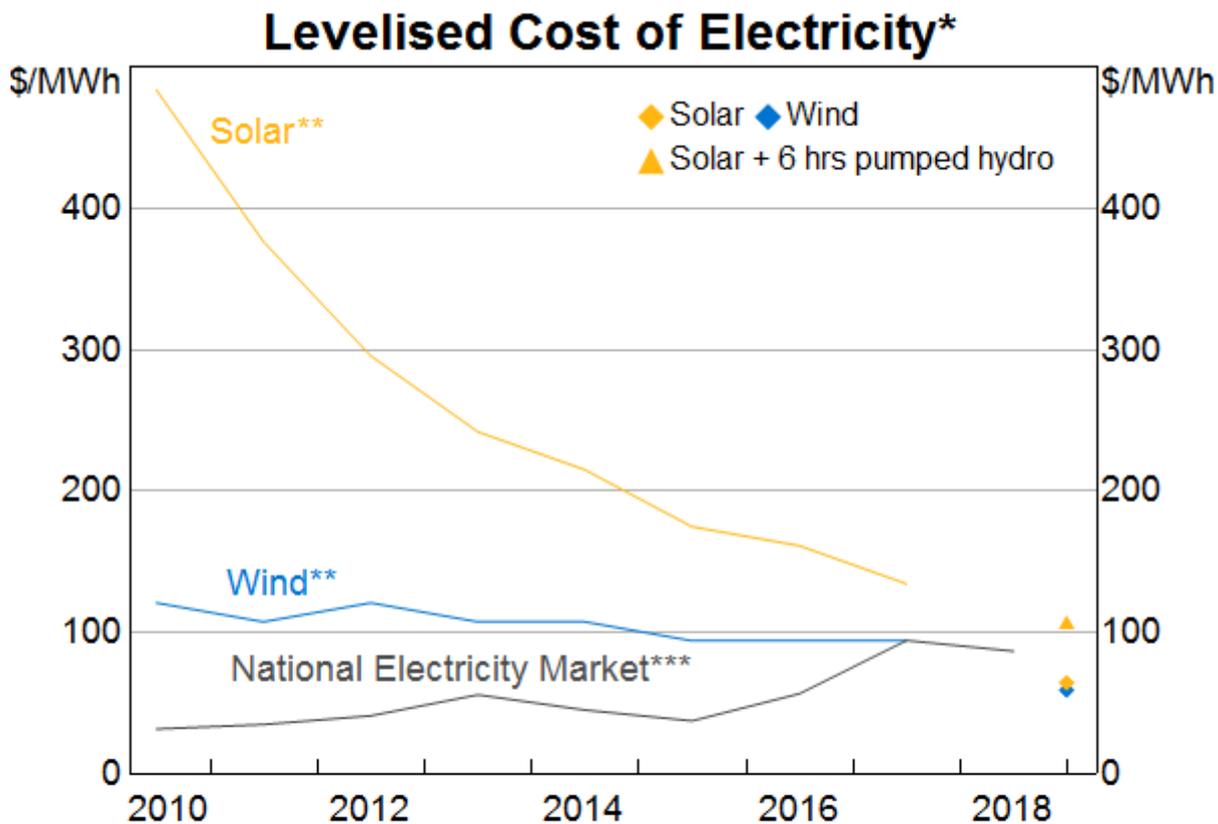
Current Examples of Climate-related Effects on the Australian Economy

I will now turn to two current examples of how climate is affecting the economy that illustrate some of these issues. I will firstly talk about investment in renewable energy sources in the Australian economy. I will then talk about how environmental policy decisions taken in China have had a direct effect on the Australian economy.

There has been a marked pick-up in investment spending on renewable energy in recent years. It has been big enough to have a noticeable impact at the macroeconomic level and affect aggregate output and hence the monetary policy calculus. It is a good example where price signals have caused significant behavioural change. [\[8\]](#) There has been a rapid decline in the cost of renewable energy sources, in part because of extensive spending on research and development in renewable energy technology around the world occurring both because of government policies and private actors anticipating the transition to a lower carbon economy. As a result of the price decline, the investment cost-benefit analysis has changed and continues to change quite rapidly.

Graph 1 shows the levelised cost of generating electricity and how that has declined in the case of wind and solar to the point where they are now cost-effective sources of generation. However, we also know that the cost of generation is not the whole story. Storage and transmission are also relevant costs. [\[9\]](#) But the cost of storage of electricity through batteries is also declining rapidly, and pumped hydro storage can effectively operate as a very large battery.

Graph 1



* Discounted lifetime cost of ownership and use of a new generation asset as average cost per unit of electricity

** Global weighted average values

*** Wholesale electricity price (not levelised cost of electricity)

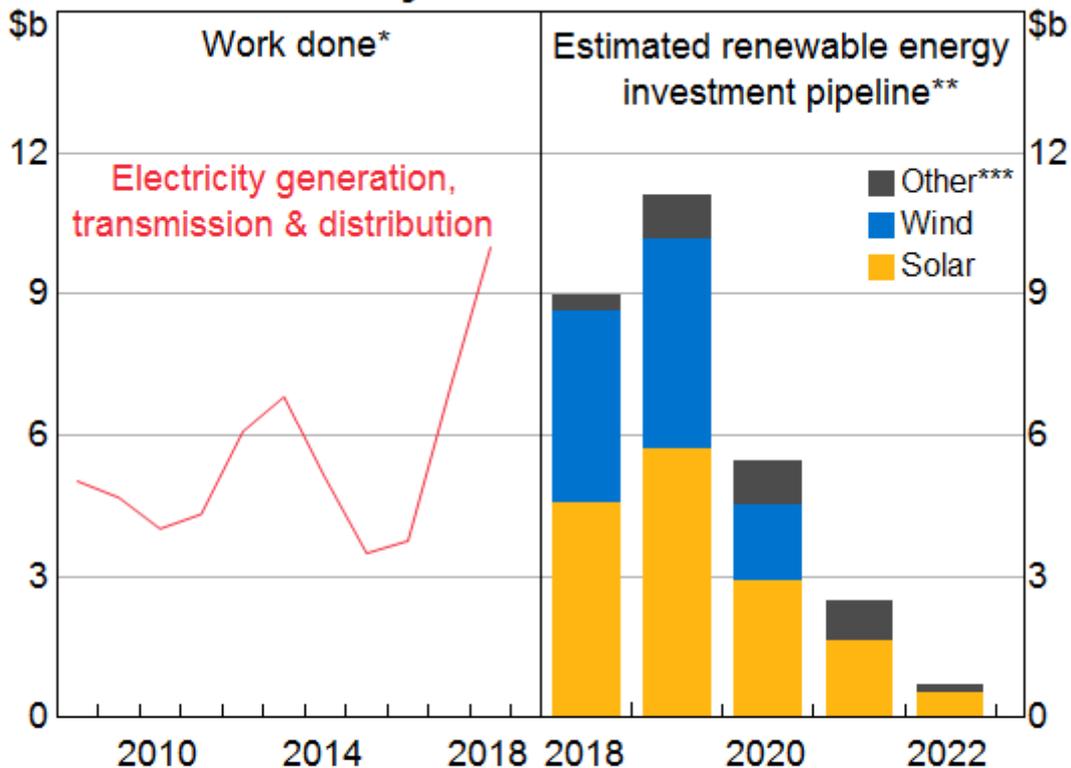
Sources: AEMO; CSIRO; International Renewable Energy Agency; RBA

Transmission is a more complicated picture. As more households and businesses have installed rooftop solar, they are putting electricity into a grid that was primarily designed to distribute energy from a wholesale-scale source of generation. It was not designed to receive and redistribute power from multiple (small) generators at one part of the day and then go back the other way at night. Moreover, large-scale renewable generators can be located far away from traditional fossil fuel generators, requiring additional investment in transmission infrastructure. This is another example of needing to think in a general equilibrium sense about how people respond to changing price signals.

Changes in behaviour in response to these price changes are now occurring within the horizon period where monetary policy cares about. Hence we need to gain a better understanding of what is driving those changes and what is in prospect to affect future changes. The Reserve Bank's business liaison program has been a very useful source of information to help us gain that understanding. The most recent capital expenditure survey from the ABS shows there is more investment in renewables in prospect over the next two years in a way that has a noticeable influence on the aggregate business investment profile. This is also apparent when looking at available information on the probable spending planned or committed and underway now for specific renewable generation and storage projects (Graph 2).

Graph 2

Electricity-related Investment



* By private sector for private sector; 2018 observation annualised

** Includes large-scale probable, committed, under construction and completed projects; capex is distributed equally over the project's life

*** Combined wind & solar, biomass, battery, pumped hydro and hybrid

Sources: ABS; Clean Energy Council; Clean Energy Regulator; company websites; Deloitte Access Economics; public reports; RBA

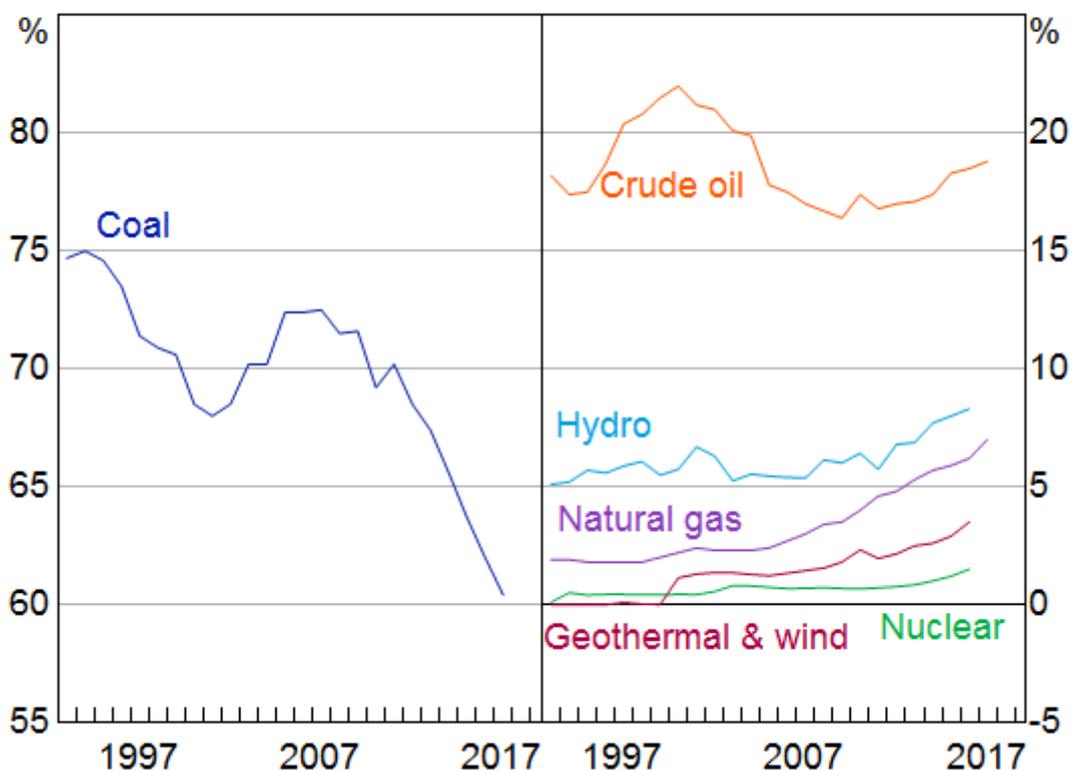
How these price and investment developments evolve over the coming years is something we are playing close attention to, given the importance of the cost of electricity in inflation both directly to households and indirectly as a significant input to businesses.

I mentioned earlier that the policy environment is important. An example of that is the effect of China's environmental policies. Environmental concerns have been elevated in the current five-year plan. There has been a policy directive to move to cleaner sources of energy (Graph 3). This trend has provided benefits to Australia, as Australian coal tends to be of higher quality. A long held policy aim has been to gradually reduce overall coal usage. This illustrates that the time frame, the policy incentives and the transition path are important influences on the actual effect on the economy. As China transitions away from coal, natural gas is expected to account for a larger share of its energy mix, and Australia is well placed to help meet this increase in demand. More generally, Australia is also benefitting from the increased demand for battery inputs (especially lithium) and other metals that are used intensively in renewable generation.

Graph 3

China – Energy Consumption by Source

Share of total



Sources: CEIC Data; RBA

Finally, while China is most prominent in thinking about this issue at the moment, India matters too. How energy demand in India is likely to evolve is something the Reserve Bank is spending time thinking about as well.

Climate Change and Financial Stability

Having talked about the macroeconomic impact of climate change and how that might affect monetary policy, I will briefly discuss climate through the lens of financial stability implications. [\[10\]](#) Financial stability is also a core part of the Reserve Bank's mandate. Challenges for financial stability may arise from both physical and transition risks of climate change. For example, insurers may face large, unanticipated payouts because of climate change-related property damage and business losses. In some cases businesses and households could lose access to insurance. Companies that generate significant pollution might face reputational damage or legal liability from their activities, and changes to regulation could cause previously valuable assets to become uneconomic. All of these consequences could precipitate sharp adjustments in asset prices, which would have consequences for financial stability.

The reason that I will cover the implications of climate change for financial stability only briefly today is that they have been very eloquently discussed by Geoff Summerhayes (APRA) and John Price (ASIC) including at this forum over the past two years. [\[11\]](#) I would very much endorse the points that Geoff and John have made. Geoff stresses the need for businesses, including those in the financial sector, to implement the recommendations of the Task Force for Climate-related Financial

Disclosures (TCFD). [\[12\]](#) I strongly endorse this point. We have seen progress on this front in recent years, but there is more to be done. Financial stability will be better served by an orderly transition rather than an abrupt disorderly one.

One area that Geoff highlighted in a recent speech is that there is a data gap which needs to be addressed: [\[13\]](#) 'The challenge governments, regulators and financial institutions face in responding to the wide-ranging impacts of climate change is to make sound decisions in the face of uncertainty about how these risks will play out.' In that regard, Geoff mentions one challenge that I spoke about earlier in the context of monetary policy. Namely, taking the climate modelling and mapping that into our macroeconomic models. For businesses and financial markets, that challenge is understanding the climate modelling and conducting the scenario analysis to determine the potential impact on their business and investments.

Conclusion

To help us try to address this data deficit, we are talking with businesses through our business liaison program. We are talking with climate modellers. We share a common understanding with them about looking at these issues in general equilibrium and the importance and challenges in modelling non-linearities. We are working through the challenge of taking this information and translating it to the economic models and frameworks that inform our monetary policy decision-making. Last but not least, last year the RBA joined the Network for Greening the Financial System (NGFS), a group of central banks that are examining climate issues. [\[14\]](#)

Through all of these channels, we are trying to learn and benefit as much as possible from the expertise of others to understand and contribute to the discussion around the serious challenge of climate change.

Endnotes

- [\[*\]](#) Thank you to David Wakeling in particular and Timoth De Atholia for their input, and to Paul Fisher, Alex Heath and Geoff Summerhayes for helpful comments and discussions. Alexis Tan provided the material on China.
- [\[1\]](#) Gruen D and G Shuetrim (1994), '[Internationalisation and the Macroeconomy](#) [PDF](#)' in P Lowe and J Dwyer (eds) *International Integration of the Australian Economy*, Proceedings of a Conference, Reserve Bank of Australia, Sydney, pp 309–363.
- [\[2\]](#) Allen, MR *et al* (2018), 'Framing and Context', in V Masson-Delmotte *et al* 'Global Warming of 1.5°C'. An Intergovernmental Panel on Climate Change (IPCC) Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty. Available at <https://www.ipcc.ch/site/assets/uploads/sites/2/2019/02/SR15_Chapter1_Low_Res.pdf>.
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- [5] See for example, McKibbin W, A Morris, A Panton and P Wilcoxon (2017), 'Climate Change and Monetary Policy: Dealing with disruption', available at <https://cama.crawford.anu.edu.au/sites/default/files/publication/cama_crawford_anu_edu_au/2017-12/77_2017_mckibbin_morris_panton_wilcoxon_0.pdf>, CAMA Working Paper 77/2017.
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- [7] Blanchard, OJ and LH Summers (1986), 'Hysteresis in Unemployment', NBER Working Paper No 2035, October. Available at <<https://www.nber.org/papers/w2035>>.
- [8] These price signals have also reflected policies promoting investment in renewables.
- [9] Graham PW, J Hayward, J Foster, O Story and L Havas (2018), *GenCost 2018*, CSIRO Australia. Available at <<https://www.csiro.au/~media/News-releases/2018/Annual-update-finds-renewables-are-cheapest-new-build-power/GenCost2018.pdf>>.
- [10] A final area that we have been involved in through the G20 process is green finance, which I will not discuss today. For more information, see reference.
- [11] Price J (2018), 'Climate Change', Keynote address at the Centre for Policy Development: Financing a Sustainable Economy, Sydney, 18 June. Available at <<https://asic.gov.au/about-asic/news-centre/speeches/climate-change/>>. Summerhayes G (2017), 'Australia's new horizon: Climate change challenges and prudential risk'. Available at <<https://www.apra.gov.au/media-centre/speeches/australias-new-horizon-climate-change-challenges-and-prudential-risk>>.
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- [14] See NGFS <<https://www.banque-france.fr/en/financial-stability/international-role/network-greening-financial-system>>