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AUSTRALIA

SELECTED ISSUES

December 2024

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November 13, 2024

Approved By
Asia and Pacific Department

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MONETARY POLICY TRANSMISSION IN AUSTRALIA[1]

Recent years have seen unprecedented monetary policy tightening across advanced economies, including Australia, to combat significant inflationary pressures. As the Reserve Bank of Australia (RBA) navigates the last mile of disinflation, Chapter 1 of the Special Issues Paper, ***Monetary Policy Transmission in Australia,*** *examines monetary policy transmission via three lenses: (a) assessing how aggregate economic dynamics in the current monetary tightening cycle in Australia compare with experiences in other major advanced economies (AEs) and in previous RBA monetary tightening cycles; (b) highlighting recent evidence on the strength and speed of monetary policy transmission via the housing sector in Australia; and (c) assessing the strength and speed of monetary policy transmission via corporate balance sheets in Australia, including to capture differences from other AEs and to account for heterogeneity among firms and sectors. We find that while macroeconomic dynamics in Australia in the current tightening cycle have not differed significantly from historical experience and from experiences in other major AEs, the resilience of Australia's economy in recent years is remarkable, as evidenced by persistently tight labor markets. Second, several features of the Australian housing market, most notably the high prevalence of variable rate mortgages, may strengthen monetary policy transmission to households relative to other AEs. Lastly, we find that firm investment in Australia's non-extractive sector is strongly sensitive to monetary policy changes; the sensitivity is more pronounced for firms with less liquidity, higher leverage, and higher reliance on bank and short-term financing. We highlight how resilience in Australian corporate balance sheets in recent years may have helped soften monetary policy transmission to investment in the current cycle.*

A. Is the Current Australia Monetary Tightening Cycle Different?

1. **In this section, we examine the evolution of key macroeconomic indicators during the current monetary tightening cycle in Australia.** In particular, we assess whether the economic dynamics signal transmission may differ from previous tightening cycles or from experiences in other major AEs in the contemporary tightening cycle. We consider select indicators of prices, national accounts, and labor markets for this purpose.

Comparison with Previous Australia Tightening Cycles

Table 1. Australia: Monetary Tightening Cycles

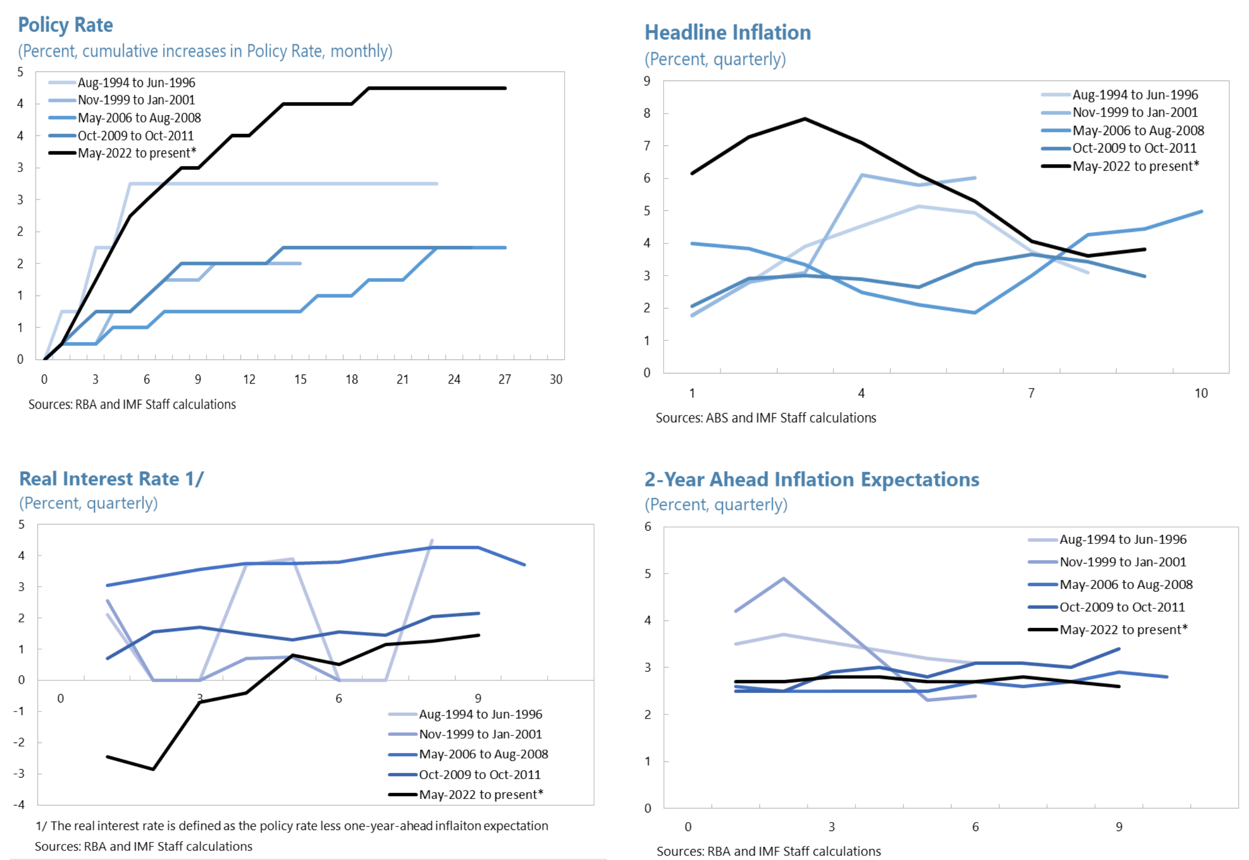
Cycle*	Duration (months)	Total Rate Increases	# of Rate Hikes	Peak inflation**
Aug-1994 to Jun-1996	23	2.75 ppt	3	5.1
Nov-1999 to Jan-2001	15	1.50 ppt	5	6.1
May-2006 to Aug-2008	27	1.75 ppt	7	5.0
Oct-2009 to Oct-2011	25	1.75 ppt	7	3.5
*May-2022 to present****	*29*	*4.25 ppt*	*13*	*7.8*

* A tightening cycle (except the current one) is defined from the month of the first rate hike to the last month before the first rate cut.
**Inflation reflects EOP annual inflation. End inflation is measured in the quarter of the first rate cut.
*** As of October 2024.

[1] Prepared by Monica Petrescu.

2. The current episode marks the RBA's most aggressive monetary tightening cycle. We identify four previous (pre-pandemic) monetary tightening cycles, where the RBA raised rates two or more times in a row, as summarized in Table 1.[2] In the current tightening cycle, the RBA raised interest rates 13 times from May 2022 to November 2023, for a total increase of 4.25 percentage points in the cash rate. This marks by far the largest cumulative rate increase and highest number of hikes of any tightening cycle in Australia; prior to the pandemic, the largest cumulative rate increase in a single cycle had been just 2.75 percentage points, and the maximum number of rate hikes per cycle only seven (Table 1). The scale of the tightening was commensurate with the unprecedented size of the inflation shock, helping to bring down inflation from a peak of 7.8 percent in 2022Q4, to faster pace of disinflation than witnessed in any previous cycle. Despite the large cumulative tightening, real rates were not as restrictive as previous cycles; given elevated inflation (and high one-year-ahead inflation expectations), real rates were actually negative for the first year of the current cycle. While the change in the cash rate was of a large scale, the level reflected the need for restrictive policies to bring inflation back to target while aiming to preserve as much of the gains in the labor market as possible (weighing the RBA's dual mandate). Medium-term (market-implied 2-year ahead) inflation expectations remained well anchored throughout the cycle.

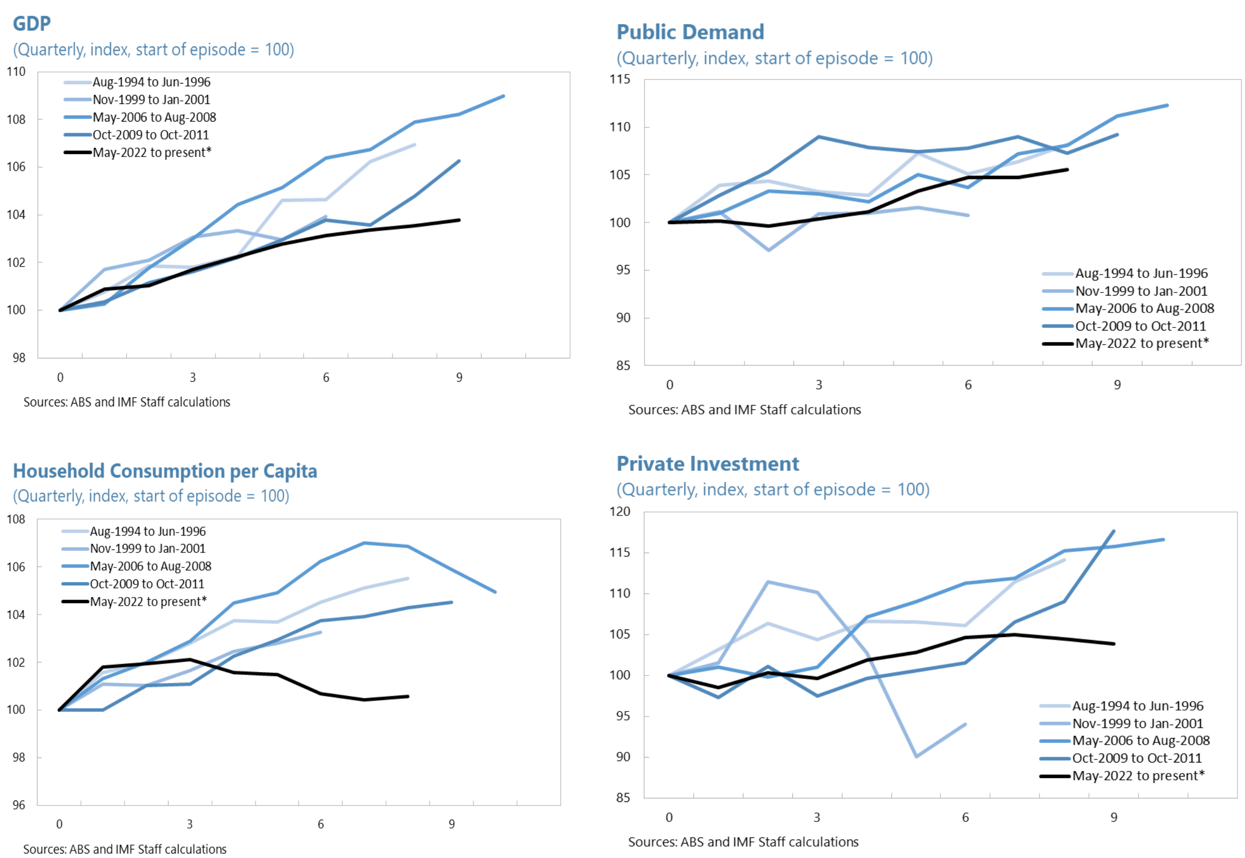
Figure 1. Policy Rates and Inflation



[2] Tightening in 2002 and 2003 is excluded as it reflected a normalization from an expansionary policy (see Nov 2003 Statement), and was not followed by rate cuts.

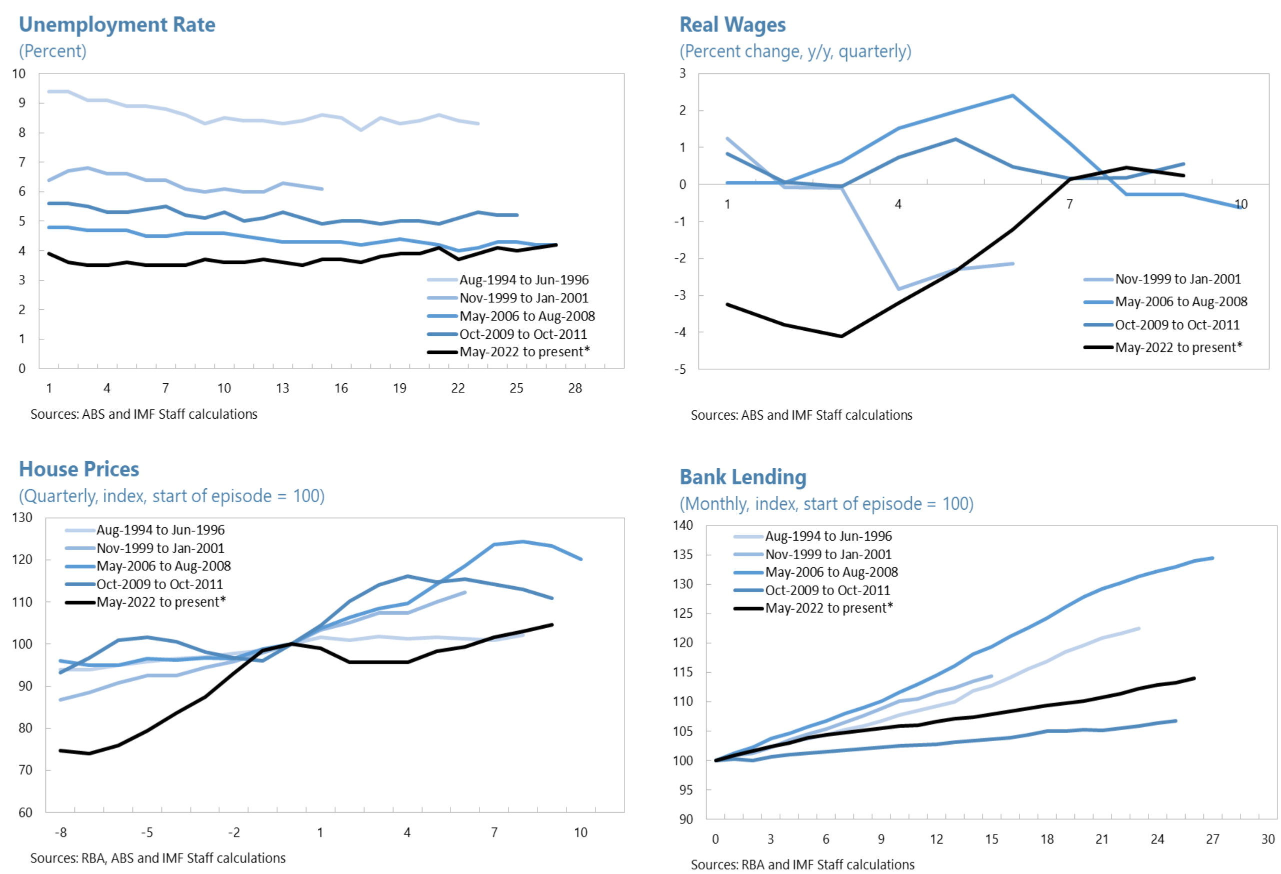
3. Macroeconomic dynamics in the current monetary tightening cycle in Australia have been broadly similar to those in past cycles, once accounting for the larger scale of policy rate hikes. Economic growth has been soft-for-longer relative to previous cycles (Figure 2), consistent with the deeper and longer monetary tightening in this cycle; in fact, given the unprecedented scale of current tightening, the fairly narrow gap in growth with past cycles may be interpreted to signal resilience. While growth in public demand has been strong in the current cycle, it has not been stronger than in past cycles. On a per capita basis, the impact on consumption – while showing up with a lag – has been more protracted and severe than in the past; per capita consumption growth fell into negative territory in the latter part of the current cycle (unprecedented in previous cycles). The delay in the reaction of consumption relative to previous monetary tightening cycles may be linked to changes in the maturity of mortgages (see Section B). Weak consumption this cycle has been consistent with weak real income growth. The reaction of private investment in the current cycle also appears delayed relative to previous cycles – with investment contracting in the last two quarters, following moderate growth. In previous cycles, private investment had slowed immediately as the monetary tightening began, before picking up in the latter part of the cycle.

Figure 2. Evolution of Macroeconomic Variables



4. The labor market has been notably tighter than during previous monetary tightening cycles, while the financial sector has remained resilient. Labor market tightness early in the current cycle can be partly attributed to the curtailment of immigration during the pandemic, which exacerbated demand supply imbalances; this source of imbalances eased gradually with the return of migrants. As migrants returned and the impact of monetary policy transmitted through the economy during the current cycle, unemployment rates have been adjusting up slowly from record lows, but still remain below those observed in previous monetary tightening cycles. It is worth noting that past monetary tightening cycles in Australia have not seen significant adjustment up in unemployment. This may reflect the RBA's dual mandate, which weighed the need for restrictive policies to bring inflation back to target with the aim to preserve as much of the gains in the labor market as possible. Despite the tight labor market, real wage growth has been negative for much of the current cycle, as wage rises failed to keep up with significant price pressures – contrasting experiences in most previous tightening episodes. This puzzle may be in part explained by conjunctural factors, such as the transitory nature of supply side shocks driving some of the recent inflation, softening productivity, or structural factors, such as changes in collective bargaining in recent decades.[3] House prices – coming off a period of exceptionally rapid growth – have cooled more and faster during this monetary tightening cycle than in previous cycles, but have then picked up again, with post-pandemic gains preserved. Bank lending in the current cycle has continued to expand, broadly in line with trends in previous cycles.

Figure 3. Labor Market and Financial Indicators



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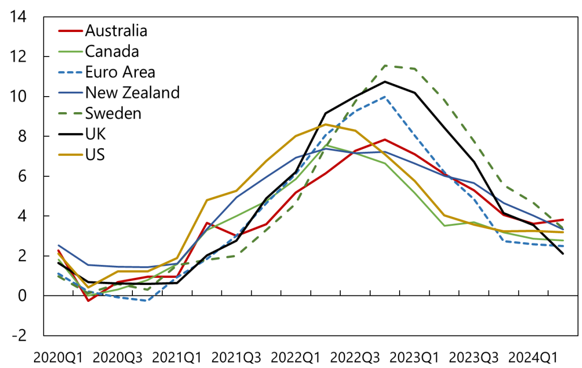
[3] See [Collective Bargaining and Wage Growth in Australia (australiainstitute.org.au).](https://australiainstitute.org.au)

Comparison with Other Major Advanced Economies in the Contemporary Cycle

5. **In the current tightening cycle, both inflation and the scale of policy rate hikes have been relatively contained in Australia compared to other major AEs.** Most AEs faced unprecedented inflation post-pandemic, with central banks raising policy rates in response. Inflation in Australia peaked at the lower end of the scale when compared to peers (peak inflation was only lower in New Zealand); in turn, maximum cumulative policy rate hikes were also lower than for most peers (except Sweden). Australia has also seen a slower pace of disinflation than other AEs. While the RBA is one of the last central banks to cut rates among peers (along with the Norges Bank), this also reflects a later peak in inflation and a subsequent later tightening of rates than in some peers. At first glance, there is no clear correlation between the scale of the rate hikes and the pace of disinflation among AEs, the EA and Sweden. The evolution of real interest rates in Australia during the current tightening cycle has been broadly similar to that in peers. The price pressures seen in Australia's rental markets are not unique, with rent inflation also elevated in Canada, the UK, and the US, and similarly persistent in the former two.

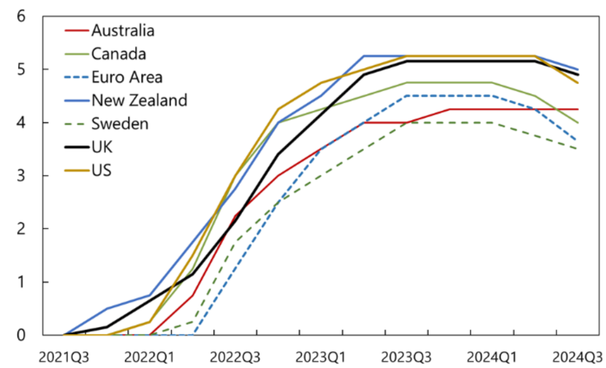
Figure 4. Policy Rates and Inflation in Advanced Economies

Inflation
(Percent)



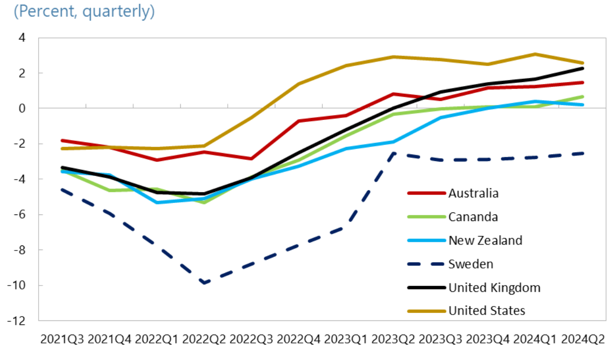
Sources: Haver Analytics and IMF staff calculations.

Policy Rate
(Percent, cumulative increase since 2021Q3)



Sources: Haver Analytics and IMF staff calculations.

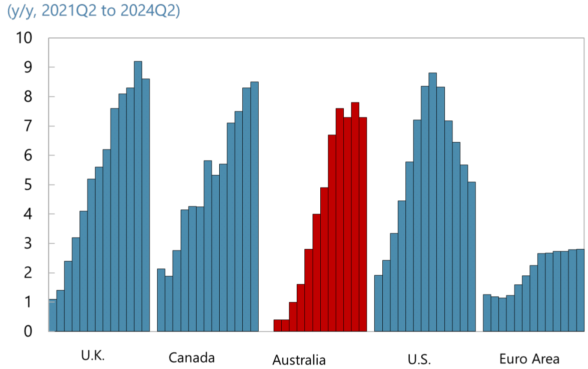
Real Interest Rate 1/
(Percent, quarterly)



1/ The real interest rate is defined as the policy rate less one-year-ahead inflaiton expectations

Sources: Haver and IMF Staff calculations

Rent Inflation
(y/y, 2021Q2 to 2024Q2)

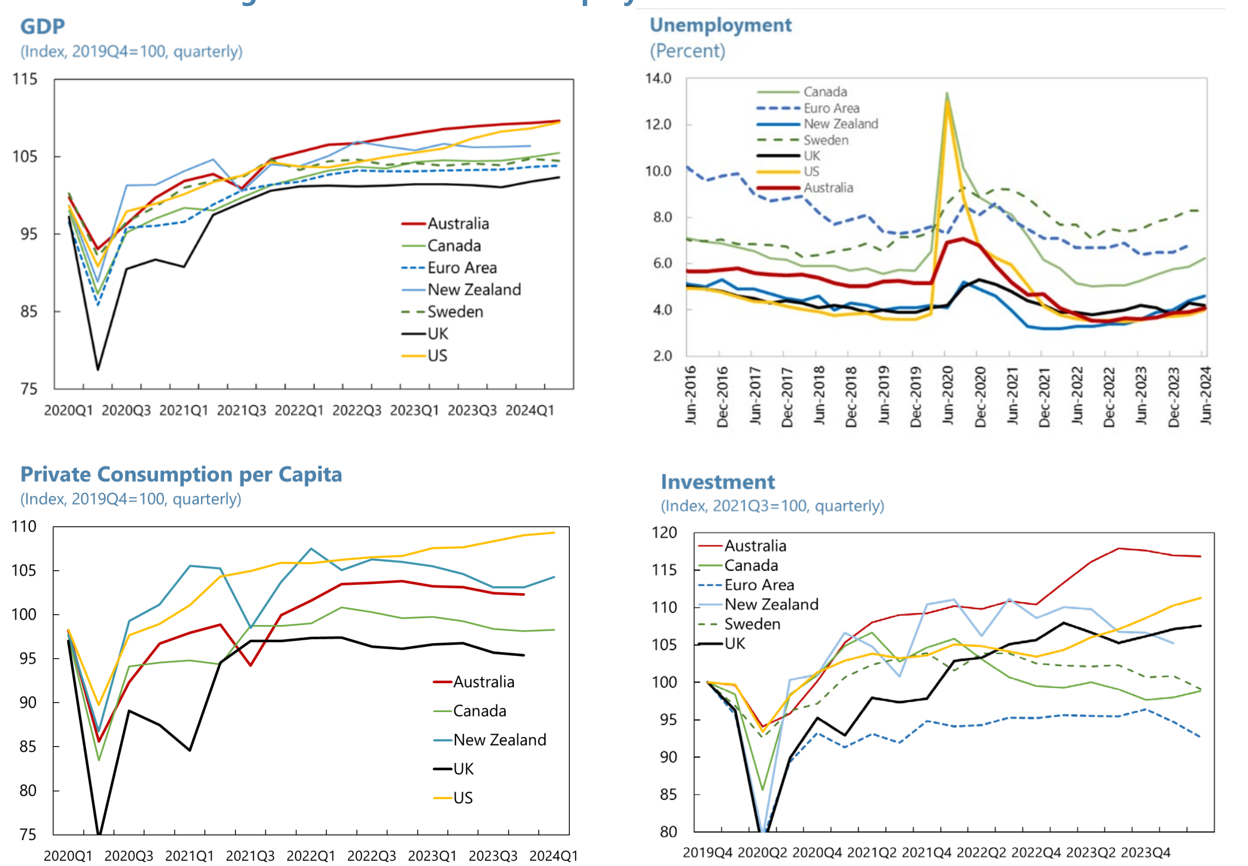


Note: Rent inflation in Australia measured after rental assistance.
Sources: ABS, FRED, Eurostat, Office for National Statistics, Statistics Canada.

6. Australia's economy has been more resilient than peers during the current monetary tightening cycle.

- Consistent with more moderate policy rate hikes, the growth slowdown in Australia has been softer than in AE peers undergoing a similar cycle (except the US, which has seen similarly robust growth amid deeper tightening). The evolution of per capita consumption in Australia has been in line with peers, but investment has been much stronger – reflecting in part the surge in public investment. Despite robust public demand supporting growth, Australia was one of the only AEs experiencing fiscal surpluses during the current tightening cycle, reflecting strength in revenues linked to commodity prices.

Figure 5. Growth and Unemployment in Advanced Economies



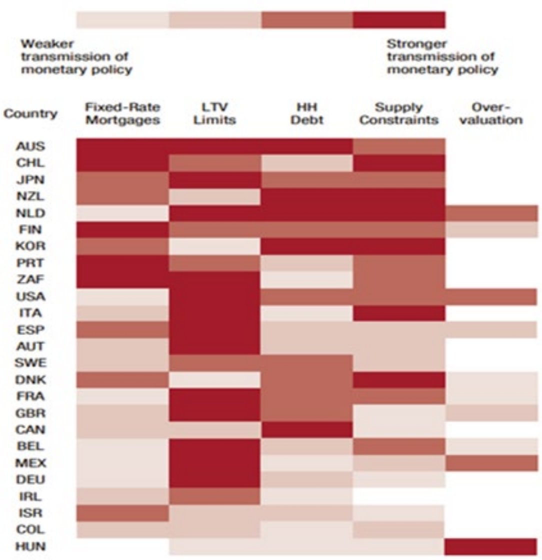
Source: Haver Analytics and IMF staff calculations

- Labor markets have also been more resilient in Australia, even as labor market tightness has been a near-universal experience in recent years for peer AEs. In most peers, unemployment fell near record lows and vacancies rose sharply after economic reopening, with the latter coming down only gradually (see Staff Report Annex V). Unlike in peer economies, however, where unemployment has broadly returned to pre-pandemic levels after one-two years of monetary tightening, labor markets in Australia remain tight by historical standards, with unemployment still well below pre-pandemic levels. This likely reflects, at least in part, the RBA's efforts to set policy rates which, while sufficiently restrictive to bring inflation back to target, also helped preserved as much of the gains in the labor market as possible .

B. Transmission via the Housing Channel

7. **Australian households are strongly susceptible to the impact of changes in policy rates due to features of the housing market**. Rising policy rates increase interest expenses on mortgages, in turn reducing consumption. Recent empirical analyses confirm that the strength of this transmission channel varies depending on the frequency of mortgage interest rate resets – with higher reliance on variable rate mortgages strengthening transition (April 2024 World Economic Outlook, Chapter 2). Other factors that strengthen transmission via this channel include the absence of loan-to-value (LTV) limits, which result in more leveraged buyers, high household debt, housing supply constraints, and overvaluation.[4] These factors also reinforce each other to further strengthen the impact on consumers. Thus, the transmission of monetary policy via the housing channel has been found to be stronger in Australia than in other peer advanced economies, due to high reliance on variable rates, high household debt, low LTV ratios, and a higher share of the population living in supply-constrained areas. This channel only applies, however, to mortgage holders, which account for around 40 percent of Australian households.

Figure 6. Heterogeneity in Monetary Policy Transmission to Households



Source: IMF World Economic Outlook, April 2024.

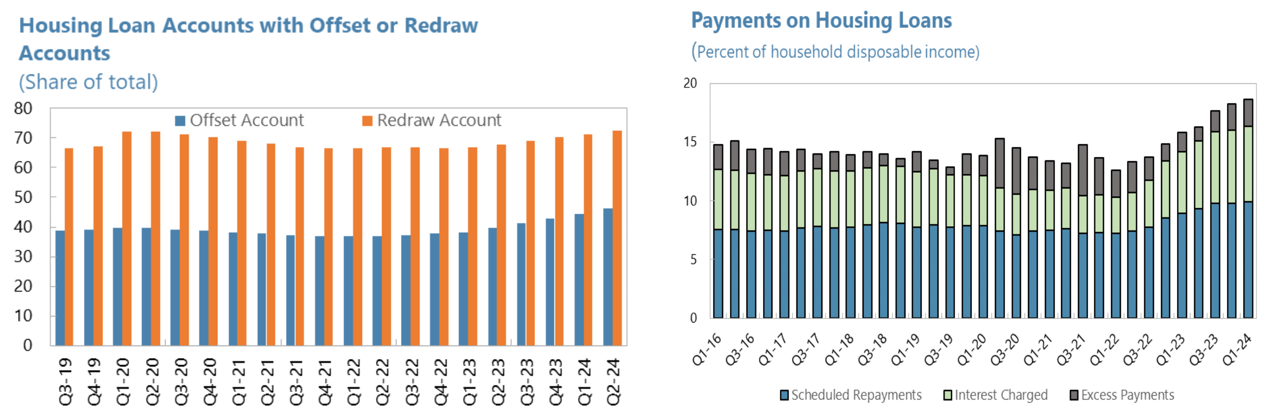
8. **Transmission to household consumption in Australia may be amplified by incentives to save against mortgage costs.** As policy rates have risen, interest costs in Australia have been taking up a larger share of disposable income, from 4.8 at end-2022 to 6.5 percent in 2024Q1 (Figure 7). At the same time, rising policy rates are creating incentives for early repayments in order to reduce debt service costs for borrowers holding variable rate mortgages; the share of early repayments has also risen as a share of real household disposable income from 1.5 to 2.3 percent over the same period. Mortgage offset and redraw accounts – both of which allow mortgage holders to save against their loans and interest costs, while still preserving access to the savings – are not common outside Australia, but becoming increasingly popular within Australia. These products, which offer a *de facto* interest rate equal to the mortgage interest rate, which (for

[4] Despite the absence of LTV limits, other policy measures might not directly target LTV but achieve the same end (e.g., appropriately calibrated risk weights linked to LTVs, combined with Australia's serviceability buffers).

households where rates reset frequently) is higher than interest rates that can be obtained through savings, raise incentives to save and may further reduce consumption for the marginal household. Currently, around 48 percent of mortgage accounts in Australia have associated offset accounts, and 74 percent have redraw accounts.

9. Monetary policy transmission in Australia via the housing channel may have softened slightly in the current cycle due to a higher share of fixed-rate mortgages. RBA analysis shows that pass-through from cash rates to the average outstanding mortgage rate has been slightly slower than in previous tightening episodes; they attribute this to a larger share of the loans outstanding at the start of the pandemic having with a two-year or longer fixed-rate component.[5] The higher share of fixed-rate mortgages may partly explain the delay in the reaction of per capita consumption to monetary policy in this cycle relative to previous tightening cycles, identified in section A. However, the often short maturity of the fixed-rate element in these loans, combined with the still high policy rate, suggests pass-through to households could continue.

Figure 7. Mortgage Rates and Repayments



Sources: Haver Analytics and IMF staff calculations.

C. Transmission via Corporate Balance Sheets

10. Another important channel in the transmission of monetary policy to the real economy is via corporate balance sheets and investment. In recent decades, a growing body of economic literature has investigated how corporate investment responds to monetary policy, and how this response differs by sector or by firm characteristics. However, fewer analyses have investigated this transmission channel in Australia, potentially due to the large footprint of the mining sector, whose lumpy investment is driven by external factors and might mask developments in other sectors. In this section, we seek to understand (i) how firms adjust their investment in response to monetary policy; (iii) how monetary policy fluctuations affect firm earnings; and (iii)

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[5] See [Fixed-rate Housing Loans: Monetary Policy Transmission and Financial Stability Risks | Bulletin – March 2023 | RBA]

whether the transmission differs across firms with different balance sheet characteristics. As we explore these topics, we also assess whether and how transmission differs in Australia compared to other AEs, and ascertain implications for Australia's economy going forward.

11. Economic literature has proposed several mechanisms via which monetary policy can affect corporate investment, with implications for the heterogeneity of transmission across firms and sectors. One is the interest rate channel, where monetary tightening raises real rates and consequently decreases consumer and firm demand for durable goods or investment. Another is the credit channel, whereby due to financial frictions in credit markets, monetary tightening leads to an external financing premium which impacts borrowing and investment (Bernanke and Gertler, 1989; Bernanke et al., 1999). The interest rate channel is most relevant for firms in sectors where consumer demand is most sensitive to interest rates – such as durable goods producers. The credit channel primarily impacts firms with financial constraints, which have been proxied in recent literature through various balance sheet characteristics (e.g., size, leverage, liquidity, and debt composition). Studies on firms in the US, UK, and Europe have found evidence of heterogeneity in the impact of monetary policy on firm investment consistent with the presence of both channels – including findings that smaller firm, younger firms, those with more leverage, less liquidity, or more reliance on short-term or bank debt, but also those in the durable goods sectors, see investment respond more strongly to monetary policy.[6]

12. In Australia, the importance of the corporate balance sheet channel has been subject to debate. The large footprint of the extractive sector, where investment is lumpy and driven by external factors and actors, may obfuscate to an extent the effect of domestic monetary policy on investment. In addition, some have argued that sticky hurdle rates render investment less sensitive to monetary policy transmission, with firms effectively 'looking through' the business cycle (Edwards & Lane, 2021; Lane and Rosewall, 2015).[7] On the other hand, Hambur and La Cava (2018) look at firm-level data in Australia and find a significant inverse relationship between the cost of debt and corporate investment not evident in aggregate data. More recently, Nolan et al (2023) have used administrative data to document that investment in the non-mining sector does respond to monetary policy shocks, both at the intensive and extensive margin; they find the response peaks after around two years, and is broadly similar across firms of different age and sizes, contradicting the hypothesis that some, especially larger, firms do not respond to monetary policy due to sticky hurdle rates. The authors also find tentative evidence of financial frictions, with the investment of

[6] Consistent with the presence of financial frictions, several studies find investment is more sensitive to monetary policy for firms with higher leverage (Jeenas, 2023; Ottonello and Winberry, 2020), firms more reliant on bank loans (Alder et al, 2023; Crouzet, 2021), or on floating rate or shorter term debt (Holm-Hadulla and Thurwachter, 2021; Gurkaynak et al, 2022; Ippolito et al, 2018), firms in industries with assets more difficult to collateralize (Choi et al., 2023) and firms with lower liquid assets holdings (Jeenas, 2023). Other proxies for the external financing premium that have been shown to impact the transmission of monetary tightening to investment include size (Gertler and Gilchrist, 1994) and age (Cloyne et al, 2023, among others). Investment and output in durable goods sectors has also been found to be more affected by monetary policy relative to other sectors (Choi et al., 2023; Durante et al, 2022; Dedola and Lippi, 2005). Financing frictions

[7] This is consistent with findings by Sharpe and Suarez (2013) that some US firms do not actively respond to fluctuations in corporate debt rates, especially those with abundant cash reserves and no near-term plans to borrow.

firms in sectors more reliant on external financing and of firms that report financial constraints more responsive to monetary policy shocks. Majeed and Breunig (2023) also document that monetary policy can affect innovation (R&D spending, trademarks) in Australia, especially for small firms.

Empirical Analysis of the Transmission of Monetary Policy to Corporate Investment

13. To shed further light on the corporate balance sheet channel of transmission in Australia, we develop an empirical framework to assess the reaction of corporate balance sheets to monetary policy shocks. We first consider how firm earnings react to monetary policy shocks, which can *inter alia* indicate the extent to which firms pass through the cost of tightening to consumers. We also consider whether earnings across different firms react differently. Next, we consider the scale and timing of the reaction of corporate investment to monetary policy shocks. Finally, we assess which firm characteristics affect transmission to investment. In Annex II, we also consider the pass-through of monetary policy to effective interest rates for firms. Throughout these analyses, we consider how the scale and timing of transmission differs in Australia compared to in peer AEs.

14. Data and methodology. The data and empirical specifications are described in more detail in Annex I. In brief:

- For this analysis, we use a panel of firm-level balance data from across 22 AEs covering 2001Q1 to 2023 Q1. The data is sourced from Capital IQ.

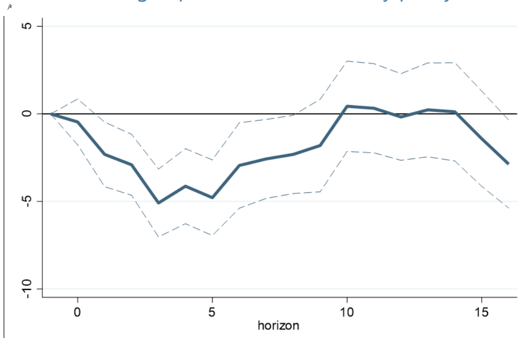
- Our methodology relies on a local projections framework and uses monetary policy shocks identified by Deb et al (2023), which are orthogonal to other macroeconomic developments, to limit reverse causality and omitted variable bias. A positive (negative) monetary policy shock indicates policy tightening (loosening); for Australia, shocks are available from 2001Q1 to 2022Q4. The impulse response functions generated illustrate how variables of interest evolve after a monetary policy shock.

- To assess heterogeneity across firms in the strength and timing of monetary policy transmission, we divide firms into two groups for each variable of interest: firms that are, on average, above vs. those that are, on average, below the median sector value for that variable. We consider leverage, liquidity, debt composition, size, asset tangibility, and age as variables of interest. We then use a dummy variable to separate these two groups, and interact it with the monetary policy shock. The coefficients of this interaction term show the *differential* impact of monetary policy on firms with *higher* values of the variable of interest versus those with lower values.

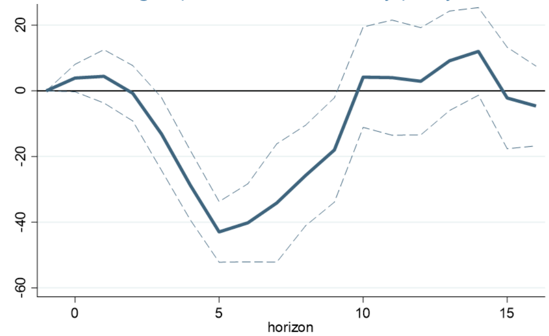
15. The earnings of Australian firms appear more sensitive to monetary policy than the earnings of firms in other AEs. In line with expectations, earnings decline (increase) after a tightening (loosening) monetary policy shock. In other AEs, the impact lasts for about two years, and peaks around one year after the shock; at peak, a 100 basis point shock generate a five percent change in real earnings. In Australia, the impact of monetary policy shocks on earnings is not significant when all sectors are considered; however, when limiting the analysis to non-extractive sectors, the impact on earnings is strong and significant. The impact on earnings in Australia's non-extractive sector starts and peaks around one quarter later than in other AEs. At peak, earnings change by 40 percent following a 100 bps policy shock.[8] This higher sensitivity suggests Australian firms are either facing stronger adjustments in demand after policy shocks (consistent with the strong pass-through to household consumption via the housing sector, discussed in section B), or that they are less able to adjust prices to pass on the costs (benefits) of monetary tightening (loosening) to consumers.

Figure 8. Evolution of Firm Earnings after a Monetary Policy Shock

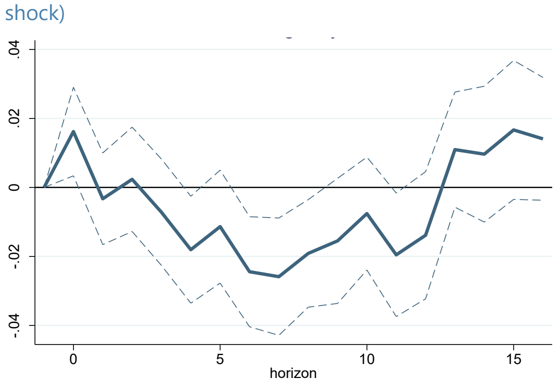
AEs: EBIT
(Percent change, quarters after monetary policy shock)



Australia: Non-Extractive Sector: EBIT
(Percent change, quarters after monetary policy shock)

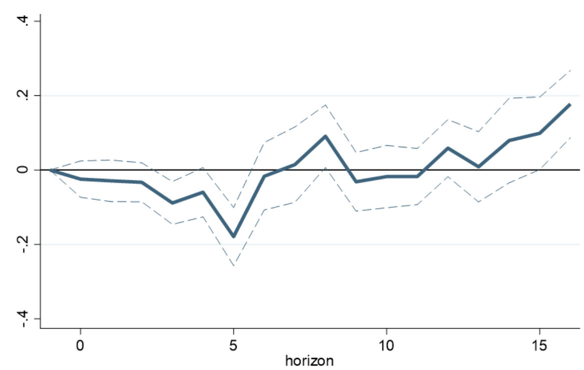


AEs: EBIT for Firms with High vs. Low Asset Tangibility
(Difference in percent change, quarters after monetary policy shock)



Australia: EBIT for Firms with High vs. Low Age

(Difference in percent change, quarters after monetary policy shock)



Sources: Capital IQ and IMF staff calculations.

16. **We find some evidence that the sensitivity of firm earnings to monetary policy differs across firms with different characteristics.** A more positive reaction of earnings to policy shocks for a subset of firms signals a weaker transmission for these firms (e.g., earnings decline by less in a monetary tightening). In other AEs, firms with more tangible assets see a stronger impact of monetary policy on their earnings; this may reflect the stronger impact of the interest rate channel

[8] This is unsurprising as earnings in the extractive sector are unlikely to respond to domestic factors, given they are primarily driven by global commodity prices and demand.

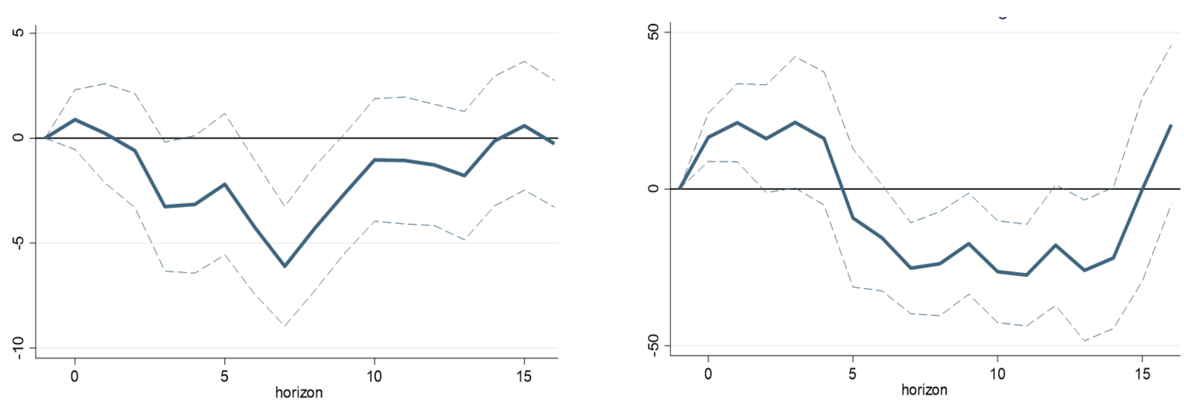
on durable goods sectors, which are also highly reliant on tangible capital. We find no evidence of this pattern in Australia's non-extractive sectors. However, we do find some evidence that the earnings of older firms in Australia's non-extractive sectors are more sensitive to monetary policy than those of younger firms, which contradicts potential priors that older firms have more established consumer bases and thus face less elastic demand.

17. We find evidence that corporate investment is sensitive to monetary policy, including for firms in the non-extractive sector in Australia. Investment reacts slowly: in other AEs, the impact on investment peaks almost two years after the initial policy shock, when a 100 basis point tightening (loosening) monetary policy shock is associated with a 5 percent decline (increase) in real investment. In Australia, while results are not significant when including the extractive sector, there is evidence that investment is sensitive to monetary policy shocks in the non-extractive sector. Investment reacts with a lag in this sector in Australia relative to trends in other AEs, but the reaction is more persistent; at its peak (which occurs around 2-3 years after the policy shock) the impact is much larger than for other AEs, with a 100 basis point monetary policy tightening (loosening) shock translating to a 20 percent decline (increase) in investment. This is consistent with the stronger reaction of earnings to monetary policy shocks in Australia's non-extractive sector, documented above.

Figure 9. Evolution of Investment after a Monetary Policy Shock

AEs: Investment
(Percent change, quarters after monetary policy shock)

Australia: Investment
(Percent change, quarters after monetary policy shock)

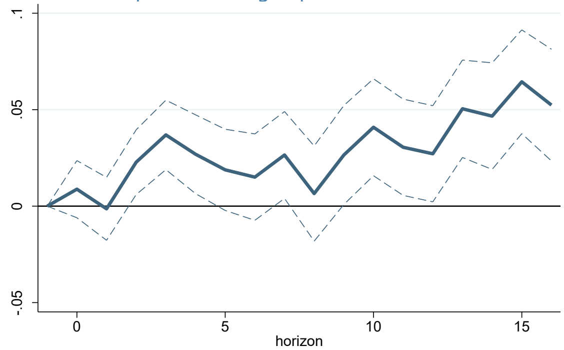


Sources: Capital IQ and IMF staff calculations.

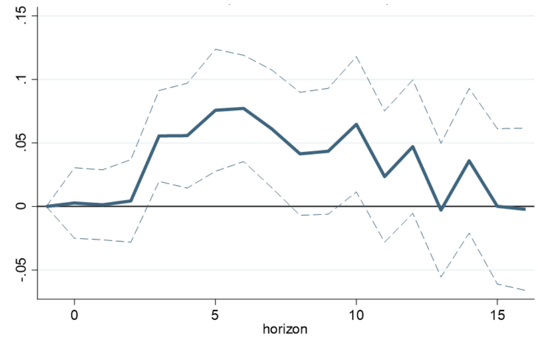
18. We also find the sensitivity of firm investment to monetary policy shocks varies with balance sheet characteristics that may be considered proxies for financial constraints. For any subset of firms, a more positive reaction of investment to policy shocks than in other firms signals weaker transmission (e.g., investment declines by less in a monetary tightening, or increases by more during a monetary loosening).

Figure 10. Heterogeneity in the Evolution of Investment after a Monetary Policy Shock

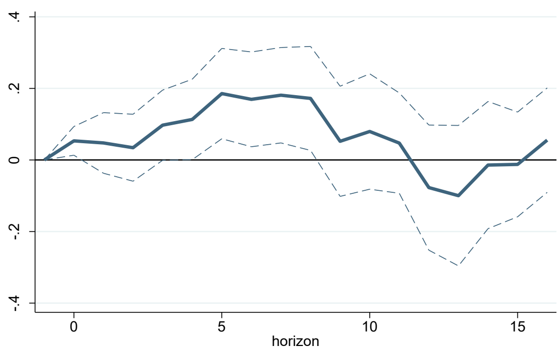
AEs: Investment for Firms with High vs. Low Cash
(Difference in percent change, quarters after MP shock)



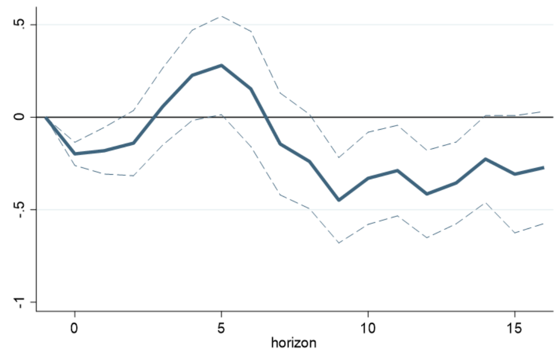
AEs: Investment for Firms with High vs. Low Size
(Difference in percent change, quarters after MP shock)



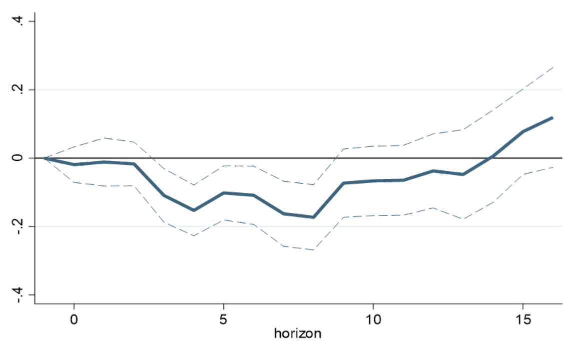
Australia: Investment for Firms with High vs. Low Size
(Difference in percent change, quarters after MP shock)



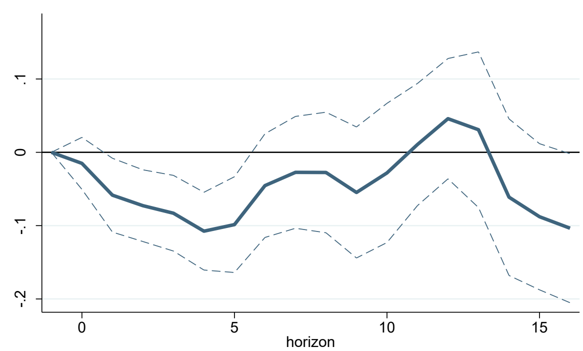
Australia: Investment for Firms with High vs. Low Leverage
(Difference in percent change, quarters after MP shock)



Australia: Investment for Firms with High vs. Low Bank Debt
(Difference in percent change, quarters after MP shock)



Australia: Investment for Firms with High vs. Low Short-Term Debt
(Difference in percent change, quarters after MP shock)



Sources: Capital IQ and IMF staff calculations.

- Across advanced economies, the investment of larger firms and of firms with more liquid assets is found to be less sensitive to monetary policy shocks; for the former, the differential impact manifests in the first two years after a policy shock, while for the latter, it is only significant around three years after the shock. The smaller sensitivity of investment to monetary policy for larger firms in Australia and in other AEs is not surprising, as these firms often have greater availability of internal finance;[9] however, it raises the question of whether growing market concentration may be reducing the strength of monetary policy transmission globally.

- Within Australia's non-extractive sector, we also find evidence that the sensitivity of firm investment to monetary policy is higher for firms with higher leverage, and for firms with more reliance on bank-funded or short-term debt. The differential impact by leverage is significant two to three years after a policy shock. The higher sensitivity of investment to monetary policy shocks for firms more reliant on bank debt is consistent with findings in economic literature that bank lending rates are more responsive to monetary policy than corporate bond market rates. The higher sensitivity of investment to monetary policy for firms with more short-term debt is unsurprising given these firms are more exposed to shifting financial conditions as they roll over debt more frequently. While the differences in the response of investment between firm groups identified in this exercise are in some cases fairly small in scale, the difference in the response of investment between firms at the bottom and top ends of the distribution may be much larger.

Implications for the Current Tightening Cycle

19. Firm earnings and investment have declined during the current tightening cycle. In Australia, the median firm has seen a decline in real pre-interest pre-tax corporate earnings (EBIT) of around eight percent in 2023; in other AEs, the decline has been larger, potentially reflecting the larger scale of the tightening (as elaborated in Section A).[10] The decline in EBIT signals that firms have not been able to fully pass through the impact of high inflation and lower demand to consumers. At the same time, firms have also decreased investment; capex spending for the median firm declined in real terms across AEs, including in Australia in 2023 (in the latter, by around five percent).

20. The current tightening has raised corporate debt servicing costs, although the net effect has been partially mitigated by rising interest earnings. Higher interest rates have translated into higher effective interest rates paid by firms across AEs, with effective interest rates paid by Australian firms rising by almost 1.5 percentage points in 2023.[11] At the same time effective interest rates earned by Australian corporates on their liquid assets rose by around the same amount, with even stronger increases in other AEs undergoing monetary tightening. This increase in earned interest rates, together with substantial cash holdings, has helped mitigate the impact of higher paid interest rates on balance sheets, reducing the increase in net effective interest rates; net effective interest rates only increased by around half a percentage point in Australia in 2023. A

[9] Foda et al. (2024) confirm that among older firms, size is a strong predictor of the likelihood of facing financial constraints, but this is not the case for younger firms.

[10] The unusually large decline in Korea partly reflects the global downturn in the technology cycle.

[11] Effective paid interest rates capture interest cost divided by the previous period's debt. Effective earned interest rates capture interest earnings divided by the previous period's holding of cash and cash equivalent assets. Net effective interest rates capture interest paid net interest earned, divided by the previous period's debt.

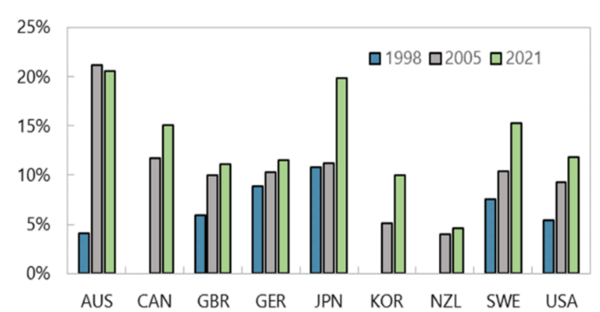
similar pattern is observable for Australian households, where interest receivable also increased during the recent tightening cycle, softening the rise in net interest income.

Figure 11. Corporate Balance Sheets in the Current Tightening Cycle

Sources: Capital IQ and IMF staff calculations.

21. The high cash holdings of Australian corporates may be softening the transmission of monetary policy to investment. At the start of the tightening cycle, Australian firms had significant cash buffers relative to most other advanced economies. Based on the results of our empirical may have helped partly mitigate the impact of monetary tightening on investment. With higher cash holdings relative to 25 years ago, Australian firms are also likely to be more resilient than they were during the 1999 tightening cycle. Cash holdings at the start of the current tightening cycle were, however, uneven

Figure 12. Cash Holdings
(Percent of assets, median firm)



Source: IMF analysis of Capital IQ data.

across sectors; lower cash holdings in the consumer goods and industrial sectors may make investment in these sectors more vulnerable in the current context.

22. **Shifts in leverage and debt composition may have also rendered Australian corporate investment less sensitive to monetary policy in this tightening cycle relative to previous cycles.** Empirical results suggest investment to be more sensitive to monetary policy for more leveraged firms, and for firms with more reliance on bank and short-term debt. At the start of the current tightening cycle, the median firm in most sectors in Australia was less leveraged than in the past. The share of bank debt has also decreased significantly over the last two decades across most sectors, likely rendering investment less vulnerable to monetary policy overall. Differences in financing across sectors also suggest differences in sensitivity to monetary policy. At the start of the current cycle, leverage was more elevated in the consumer goods, industrial, and communication sectors, signaling the potential for more volatile investment. While short-term and bank debt remain elevated in the material and energy sectors, these are less likely to be impacted by monetary policy overall, as discussed above.

23. **While stronger balance sheets may have so far softened the impact of monetary policy on corporate investment, caution is warranted given transmission lags.** The relative balance sheet resilience of Australian firms, both compared to peers and compared to previous decades, may indicate a softer transmission. This resilience may ease financial frictions and continue to allow firms to limit cyclical adjustments to investment. However, going forward, caution is warranted, as Australia has seen long lags in the transmission of monetary policy to investment, suggesting further downturns in investment as a result of the current tightening cycle are possible.

Figure 13. Balance Sheet Characteristics at the Start of the Current Cycle

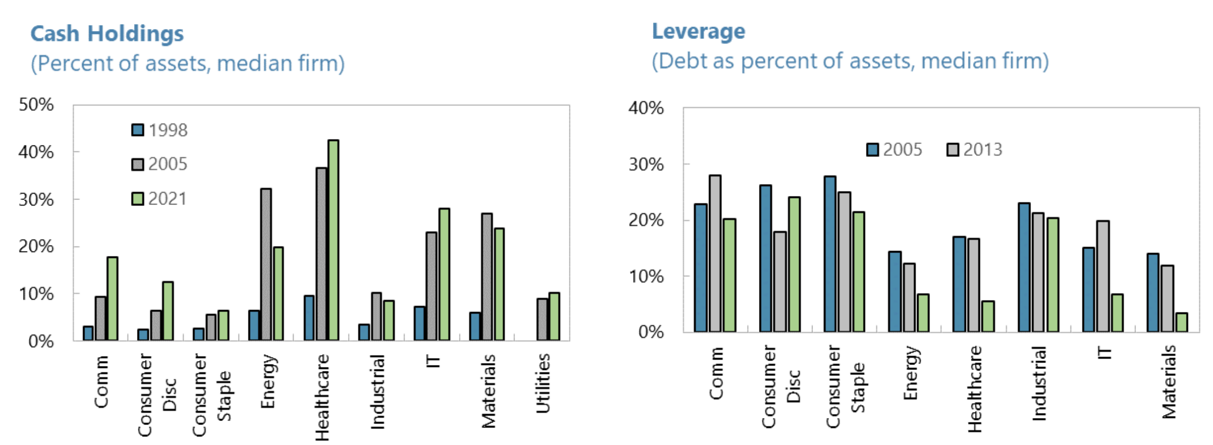
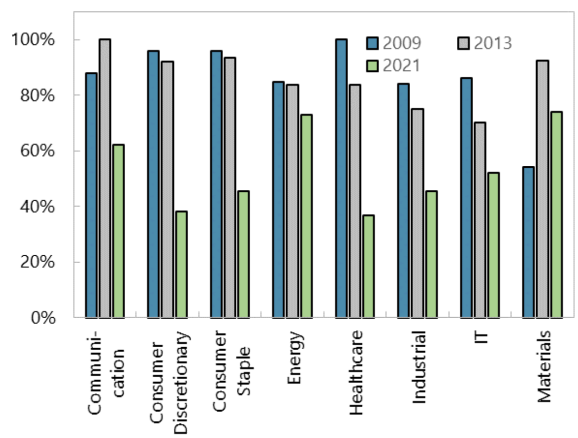
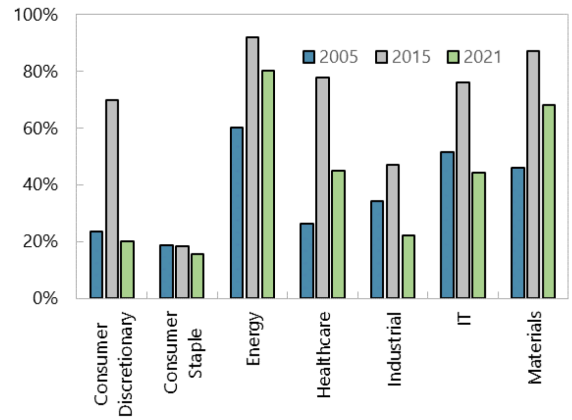


Figure 13. Balance Sheet Characteristics at the Start of the Current Cycle (concluded)

Bank Debt
(As percent of total debt, median firm)



Short-Term Debt
(As percent of total debt, median firm)



Sources: Capital IQ and IMF staff calculations.

D. Conclusions

24. We find macroeconomic dynamics in Australia in the current monetary tightening cycle to be broadly consistent with experiences in peer AEs and in previous RBA tightening cycles, while taking note of the remarkable resilience of the Australian economy in recent years. After accounting for the larger scale of inflation and commensurate policy rate hikes, the dynamics of Australia's economy in the current cycle have not differed substantially from dynamics in past tightening cycles, beyond some evidence of lags in transmission to both household consumption and private investment. While it has experienced slightly slower disinflation than many peers in the current tightening cycle, Australia has also benefitted from more economic resilience than most other AEs, as reflected both in a moderate growth slowdown and persistent tightness in labor markets; this may in part be attributed to prudent monetary and fiscal policies, the former supported by the RBA's dual mandate.

25. Recent literature finds monetary policy transmission via the housing sector is strong in Australia, due in part to the prevalence of variable rate mortgages. However, during the current cycle, the higher prevalence of mortgages with a fixed-term component may have helped delay or soften transmission via this channel. Constrained housing supply, high household debt, and no LTV limits, as well as the popularity of offset and redraw accounts which increase savings incentives, may amplify transmission to consumption via this channel.

26. We find evidence of strong monetary policy transmission via corporate balance sheets in Australia's non-extractive sectors. We show both earnings and, more critically, investment in this sector are sensitive to monetary policy shocks – potentially more sensitive than in other AEs. We also find that the sensitivity of investment to monetary policy in Australia's non-extractive sector varies across firms depending on their size, cash holdings, leverage, and debt composition. As such, the more resilient balance sheets of Australian corporates at the start of the current tightening cycle may have softened transmission via this channel in the last two years.

27. There are several questions raised by the analysis above that, while outside the scope of this paper, could be of interest in further research. This includes (i) better understanding the drivers of the slightly delayed transmission to household consumption and corporate investment in Australia; (ii) assessing whether structural factors explain some of the cross-country heterogeneity in monetary policy transmission via corporate balance sheets (iii) considering interactions in the drivers of heterogeneity in transmission of monetary policy across firms;[12] (iv) in the context of increased market concentration across economies and sectors, assessing how market structure plays a role in monetary policy transmission.

[12] For example, assessing whether the differential impact of policy shocks on investment for high vs. low cash firms differs depending on whether these firms are highly leveraged or not.

Annex I. Data and Methodology

1. The empirical analysis in Section C relies on a panel of quarterly firm-level balance sheet data from Capital IQ. This dataset, frequently used in the literature on monetary policy transmission to corporates, includes publicly listed non-financial corporates—firms that are larger and more systemic, contributing more to national account aggregates, but that may not be representative of small and medium enterprise experiences. To the extent financial constraints are tighter for private firms than for publicly listed firms, our findings might represent a lower bound for the role of financial frictions in the transmission of monetary policy to corporates. Quarterly data is better suited to identify reactions to monetary policy shocks. The data covers 22 advanced economies from 2001Q1-2023Q4, over broad range of sectors. We follow Kim (2019) and Kim et al. (2020) to clean the data. The resulting panel is highly unbalanced, with varied coverage for different firm characteristics. We omit the US from the sample, as US firms appear to respond differently (in earnings and investment) to monetary policy shocks compared to firms in other AEs, likely due to deeper capital markets and different financing alternatives, but are also significantly more abundant in the dataset and could bias the results.

2. We use a local projection method following Jordà (2005) to generate impulse response functions to assess the reaction of investment and other variables of interest to monetary policy shocks. We estimate the regression:

$$y_{n,c,s,t+k} - y_{n,c,s,t-1} = \mu^k\, MP\ shock_{c,t} + \sum_{j=1}^{4} \theta_j^k MPshock_{c,t-j} + \sum_{j=1}^{4} \Gamma_j^k \Delta y_{n,c,s,t-j} + \sum_{j=1}^{4} \Psi_j^k X_{n,c,s,t-j} + \alpha_{csq}^k + \varepsilon_{n,c,s,t}^k$$

for different horizons k, where $y_{n,c,s,t}$ is variable of interest for firm n in country c and sector s at time t over the next k quarters (adjusted for inflation as relevant); $MP\ shock_{c,t}$ are monetary policy shocks; $X_{n,c,s,t-j}$ are other control variables and α_{csq}^k are country-sector-quarter fixed effects. Standard errors are clustered by firm and country-time. We allow the shock to enter the model directly, similar to Durante *et al* (2022), rather than using it as an instrument for changes in the cash rate. We control for four lags of each the dependent variable and monetary policy shocks.

3. To identify how the transmission of monetary policy to variables of interest differs for firms with different balance sheet characteristics, we estimate the following regression, using local projection methods following Jordà (2005), to generate impulse response functions :

$$\mathrm{y}_{n,c,s,t+k} - \mathrm{y}_{n,c,s,t-1} = \mu_0^k \mathrm{MP\ shock}_{c,t} + \beta^k\, \mathrm{MP\ shock}_{c,t} \times \varphi_{n,s} + \sum_{j=1}^{4} \theta_j^k \mathrm{MPshock}_{c,t-j} + \sum_{j=1}^{4} \Gamma_j^k \Delta \mathrm{y}_{n,c,s,t-j} + \sum_{j=1}^{4} \Psi_j^k \mathrm{X}_{n,c,s,t-j} + \alpha_{csq}^k + \varepsilon_{n,c,s,t}^k$$

for different horizons k, where, for any firm characteristic, $\varphi_{n,s}$ is an indicator variable that takes on the value of 1 if the firm has, on average, a higher-than-sectoral-median value of that firm characteristic, and 0 otherwise. Figure 8 and Figure 10 plot β^k , the differential impact for firms with $\varphi(n,s)$ = 1 vs. $\varphi(n,s)$ = 0.

4. For this analysis, we use monetary policy shock derived in Deb et al. (2023). They authors identify monetary policy shocks in two steps. First, they calculate forecast errors in short-term rates by subtracting interest rates forecasts from realized interest rates. Next, they extract the part of these forecast errors that is orthogonal to the state of the economy by regressing the forecast errors on changes and forecasts of growth and inflation, as well as other pre-determined macroeconomic variables. They show the monetary policy shock series obtained in this manner are highly correlated with the shocks generated for the U.S. (Romer and Romer 2004) and the U.K. (Cloyne and Hurtgen 2016) following a similar approach. Since these shocks are exogenous to the macroeconomic environment, there is no need to include further macro controls.

5. Variables of interest are defined consistently with the literature. Investment is measured as capital expenditures (in log terms), adjusted for inflation. EBIT – earnings before interest and taxes – are also adjusted for inflation and used to measure earnings, and taken in log form. Tangibility is measured by the share of net plant, property, and equipment in the total capital stock. Effective interest costs are defined as interest (gross paid, earned, or net), divided by the previous period’s debt or liquid asset holdings, respectively. We also use information on leverage (total debt to total assets), short term debt (as a share of total debt), bank debt (as a share of total debt), size (assets as a share of GDP), and age (years since incorporation), based on information reported in Capital IQ.

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GLOBAL AND DOMESTIC ENERGY TRANSITION RISKS: AUSTRALIA[1]

A. Introduction

1. **The 28th Conference of the Parties of the UNFCCC (COP28) included a historic call to transition away from fossil fuels in the energy system.** This was further emphasized in April 2024 by the G7 announcement to phase out "existing unabated coal power generation during the first half of the 2030s or in a timeline consistent with keeping a limit of 1.5°C temperature rise within reach, in line with countries' net-zero pathways".[2] The global clean energy transition will have profound economic implications for countries around the world spanning the full global value chain. Fossil fuel exporters will face complex and interlinked challenges of adjusting to economic transformation while seeing declines in revenues and increased financial sector risks from stranded assets.[3]

2. **While there is broad agreement that an energy transition will change demand for fossil fuels, the speed and the composition of demand changes remain highly uncertain (Figure 1).** The UN's IPCC Sixth Assessment Report (AR6) database provides projections from 3000+ global scenarios from Integrated Assessment Models (IAMs) for the supply of fossil fuels under different global warming pathways. Figure 1 presents the fossil fuel supply projections for a scenario that aligns with global temperatures rising by about 2.7°C above pre-industrial levels by the year 2100. This scenario is in line with the IMF's proposed baseline scenario, reflecting the temperature trajectory to be expected under existing policies (net of implementation risks).[4] Projections made under the International Energy Agency's (IEA) Stated Policies Scenario (STEPS), as detailed in the World Energy Outlook (2023), have been included due to this scenario's widespread use by countries as a benchmark.[5] Due to the high carbon content of coal, most forecasters anticipate that thermal coal will be one of the first fossil fuels to decline during the clean energy transition.[6] The IPCC AR6 median model estimate projects coal production will decline by around 30 percent by 2050 from 2022 levels. However, the range of outcomes is very large, with projections varying from

[1] Prepared by John Spray and Sneha Thube with contributions from Jaden Jonghyuk Kim and Alice Tianbo Zhang and guidance from Florence Jaumotte, and Pritha Mitra.

[2] Climate, Energy and Environment Ministers' Meeting Communiqué (Torino, April 29-30, 2024)

[3] IMF 2024 Staff Climate Note "Key Challenges Faced by Fossil Fuel Exporters during the Energy Transition" for more discussion.

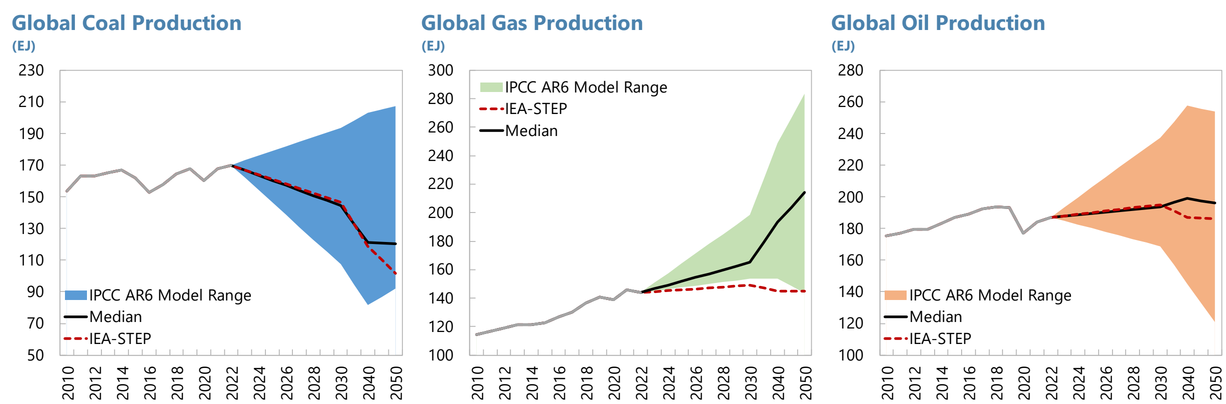
[4] See SPR Departmental Paper on Climate Change and Macroeconomic Frameworks (forthcoming) for details on the IMF baseline scenario and IMF Staff Climate Note "Is the Paris Agreement Working? A Stocktake of Global Climate Mitigation" (2023) for details on current temperature projections under global mitigation scenarios.

[5] IEA anticipates an increase in global temperatures of 2.6°C above pre-industrial levels by 2100. It is also the key input informing projections made in the Australian government's 2023 Intergenerational Report on the global coal transition.

[6] The carbon content per GJ of Bituminous coal is 1.76 times higher than natural gas (US Energy Information Administration, Carbon Dioxide Emissions Coefficients by Fuel, 2023).

a 22 percent increase to a 46 percent decline. The relatively lower carbon content of natural gas and oil coupled with limited alternative technologies for replacing demand in the transportation sector might sustain the demand for these fuels. These fuels can serve as "bridge fuels" while technology needed for system-wide low carbon electricity and transport and/or carbon dioxide removal (CDR) technologies like carbon capture, utilization and storage (CCUS) are being developed and made economically viable. As a consequence, the median model projection for demand for natural gas by 2050 is a 49 percent increase from 2022 levels, with a range from 97 percent increase to 0.2 percent decrease. Similarly, oil demand is expected to increase by 5 percent from 2022 levels, with a range from a 36 percent increase to a 35 percent decrease. The IEA-STEPS scenario, which assumes strong growth of renewables, projects a sharper fall in global natural gas production by mid-century than is typically estimated by the median of IPCC AR6 models.

Figure 1. Global Fossil Fuel Demand Is Set to Shift During the Energy Transition in Unpredictable Ways



Sources: IPCC AR6, IEA STEP, and IMF Staff Calculations

Note: fan shows max, min, and median from each model

Note: These graphs show the projected global coal, natural gas and oil supply from the IPCC AR6 database aligned with warming under the Shared Socioeconomic Pathway (SSP) SSP2-4.5 scenario. The SSP describes potential future pathways of societal development, focusing on factors like population and education; urbanization; and economic development and their impact on greenhouse gas emissions. Combined with a given radiative forcing level, called Representative Concentration Pathways (RCPs), the scenarios in the IPCC AR6 database characterize the uncertainty of future global warming. The SSP2-4.5 scenario represents a "middle-of-the-road" scenario in terms of socioeconomic development and climate change mitigation. It aligns with historical emission and temperature trends and corresponds to an average global warming of 2.7°C by 2100 relative to preindustrial levels under current policies.

3. **The global energy transition will impact Australia's industrial base.** Australia has commodities spanning the full range of the phases of the energy transition (Figure 2A). Australia exports significant fossil fuels (coal, gas, and a small volume of oil), minerals needed for electrification (iron ore, nickel, copper), and minerals required for renewable energy (lithium, rare earth metals, cobalt). The economic consequence of the transition will, therefore, depend crucially on which goods are demanded at which time, the ability of the global economy to meet these demands, and the resulting commodity price dynamics. These supply and demand patterns will hinge on shifts in both domestic and international policy and the realization of unpredictable technological development.

4. **On the domestic side, Australia's ambitious climate mitigation targets will necessitate a rapid economic transition.** In September 2022, the Climate Change Act formally legislated

Australia's Net Zero by 2050 target. It also legislated the 2030 Nationally Determined Contribution emissions targets of a 43 percent reduction in emissions from 2005 levels (Figure 2B). A range of measures have been proposed to assist Australia in fulfilling its NDC pledge, like initiatives to expand and decarbonize the power grid, backing the production of renewable energy sources, rolling out low-emission technologies, support for development of clean energy industries, the safeguard mechanism, and promoting the adoption of electric vehicles. The most significant near-term target continues to be the aim of securing an 82 percent share of renewable energy in electricity generation by 2030.[7] This will require a rapid transformation in Australia's energy sector which in 2023 had only about a third of generation from renewables (Figure 2C).

5. **While there is some consensus on the pace of decline of domestic thermal coal demand, uncertainty on the pace of the global energy transition is reflected in the wide range of future global demand for Australian coal.** The difference between the actual global power additions and model projections highlights the uncertainty surrounding the expected global demand for fossil fuels. As shown in Figures 2E and 2F, coal power additions have increased in recent years and outstrip even the most pessimistic climate change model scenarios. The global uncertainty about coal demand translates into a range of potential outcomes for the coal industry in Australia. Figure 2D shows the range of future coal production in Australia using four sources. From the Australian government, projections are plotted from the Department for Industry, Science and Resources' (DISR) Resources and Energy Quarterly.[8] From international agencies, projections are plotted from the UN's IPCC AR6 database as well as the IEA STEPS.[9] All four sources reflect quite different assumptions on demand for Australian coal.[10]

6. **This paper seeks to investigate the economic implications of both a domestic and global transition on the Australian economy.** This chapter has three main findings:

(i) Australia is likely to meet its 2030 NDC target if it is able to scale up its renewable energy share to 82 percent and implement its stated policies.

(ii) The domestic and global transition will create significant adjustment costs for coal and natural gas extraction including in the labor demand (-250 to -8800 and -4900 to 1250 relative to baseline, respectively), capital stock (-4 to -22 and -18 to +12 percent relative to baseline, respectively) and to export revenues (-4 to -12 percent relative to baseline for coal).

(iii) Australia faces risks from reduced global fossil demand, while also having opportunities in green metals and critical minerals under the energy transition.

[7] Speech by Anthony Albanese "Labor's Plan For a Better Future", December 2021.

[8] The Resource and Energy Quarterly projects demand based on a bottom-up estimate of mine production.

[9] In order to translate the global forecast from the IEA and IPCC, Australia's share in global coal production is assumed to remain at 2022 levels. However, several factors could lead to a change in this share like changing geopolitical contexts, differential in extractions costs in the future and so on. This is discussed in more detail in Section F.

[10] The variation in models can be explained through a combination of assumptions on growth in renewables, Carbon, Capture, Utilization, and Storage (CCUS), assumptions on the relative costs of different fuels, assumptions of policy, and technological change.

7. This chapter relates to a long-running literature on the economic implications of the energy transition in Australia. Garnaut (2008a) and McKibbin (2015a) use a suite of models to demonstrate that domestic and global climate mitigation can be achieved with relatively modest impacts on economic growth but leading to changes in Australia's comparative advantage away from emissions-intensive industries. The Garnaut Climate Change Review (2008b) provides a comprehensive overview of the direct impacts of climate change, implications from global policy action, and Australia's policy options. Among many other findings, the review finds that the cost of inaction greatly outweighs the cost of mitigation and that Australia's environment will likely experience considerable drying, temperature change and shifts in rainfall. The paper also suggests that the risks from carbon leakage are relatively small at low levels of emissions pricing. Modelling from CSIRO (2015) and CSIRO (2024) shows that Australia can significantly reduce greenhouse gas emissions through measures including improved energy efficiency and renewable energy, and the use of new technologies, while containing the impact on prices.[11]

8. The literature also provides a balanced outlook of the risks and opportunities for Australia in the global energy transition. The implications of a global energy transition are analyzed in McKibbin (2015b), Kemp, McCowage and Wang (2021) and the Intergenerational Report (2023) finding that while global climate action will lower exports in Australia's fossil fuels sectors, stronger global action provides modest benefits to many of Australian export sectors, with increases in exports from mining, durable goods manufacturing, and agriculture. Auger et al. (2021) investigates the future investment, trade, and risk of stranded assets in the global coal industry under various scenarios. It highlights that a sustainable development scenario could lead globally to 2.2 million coal job losses and a 6-fold increase in the levels of stranded assets. They find a 5-fold increase in Australia's trade deficit. Financial sector risks from the energy transition have also been covered in detail by the RBA.[12] This chapter builds on the preceding literature by using a granular global CGE framework calibrated to updated data and simulating scenarios based on the latest policies announced by Australia and other G20 countries. This allows the observation of the range of economic impacts in Australia from different speeds of global transition.

9. The remainder of this chapter is organized as follows. Section B provides summary stats and context for Australia's exposed industries. Section C outlines the model, calibration and the scenarios chosen. Section D presents model results on the implications of the domestic transition. Section E presents results on the implications of the global energy transition. Section F presents a number of mitigating factors. Finally, Section G provides conclusions and policy recommendations.

B. Context on Exposed Industries in Australia

Australia's Mining Sectors

10. Australia produces two main types of coal for electricity generation or iron and steel production. Australian coal is used either for electricity generation or for the production of steel

[11] In related work, the Intergenerational Report 2023 includes an assessment of climate damages and associated payments, commodity exports and the impact of electric vehicles on fuel excise.

[12] See for instance Kurian, Reid and Sutton (2023).

depending on its quality, carbon content, moisture content, and other mineral properties.[13] Australian coal is known for its high quality, particularly its low sulfur and low ash content, making it less environmentally harmful compared to coal from other regions and particularly well suited for production of steel.[14] As shown in Figures 3A, Australia was the largest exporter of coal briquettes in value terms in 2022[15] with 89 percent of Australia's coal exported to Asia and Japan and India constituting the largest export partners (Figure 3B).[16] In volume terms, Australia's coal production has grown over the last 2 decades but more recently has flattened out (Figure 3C). As shown in Figure 3D, Australia has 10 percent of the world's proven resources of black coal, 23 percent of brown coal, and is in the top six producers globally of both.

11. While still substantially smaller than coal, natural gas production has been growing as a share of total energy production. In 2022, Australia produced 5.5 million TJ of natural gas up from 1.9 million TJ in 2012, primarily for the purpose of power generation as well as residential heating and cooking, industrial processes and mining (Figure 3C). Typically, around 75 percent of production is exported, especially to the Asia-Pacific region.[17] Australia has the 13th largest proven reserves of natural gas in the world.[18] Australia also produces a small amount of crude oil for domestic use and export especially in the transport sector.

12. Australia's vast reserves of critical minerals could optimally position it to be a key player in the global energy transition. Australia is in the world's top 2 for resources of nickel, lithium, and cobalt, all of which are used in the production of batteries. It produces over half the world's lithium which is used in the creation of lithium-ion batteries for electric vehicles and energy storage systems. It is the third largest producer of rare earth elements which are essential in the creation of magnets used in wind turbines and electric vehicle motors. It also has the second largest reserves of copper which is needed for wiring, motors, and renewable energy generation technologies such as solar panels and wind turbines.

13. In addition to critical minerals, many other commodities are expected to be needed in the transition. Australia produces a third of the world's iron ore, which is essential for steel production, a critical component of the global renewable energy infrastructure. Furthermore, as the largest store of uranium, the country is well placed should global nuclear power demand expand. Finally, Australia is making progress towards developing commercially viable green hydrogen. The government's green hydrogen strategy aims to grow the sector, including developing the capabilities to produce green metals using hydrogen.

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[13] When used for steel it is typically called metallurgical coal. In 2020, around 40 percent was metallurgical (DCCEEW, 2023).

[14] See [Best in Class: Australia's Bulk Commodity Giants (minerals.org.au)]

[15] Data from IEA suggests Indonesia may have been the largest exporter by volume and energy terms in 2023.

[16] Note that in 2022 China banned the import of Australian coal. In 2020, China was the second largest trading partner in volume terms. In 2023-24, China was the second largest export partner for thermal coal (DISR, Sept 2024)

[17] Australia Energy Update 2024

[18] US EIA 2021.

Figure 2. Drivers of the Energy Transition

(A) Australia's export basket includes coal, gas, crude oil, critical minerals and metals which will be impacted by changes in global policy

Export Composition

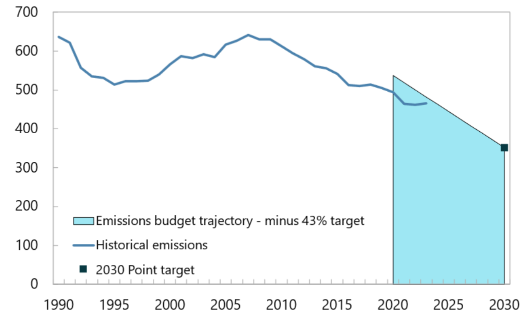
(Percent of total, 2022)

Source: OEC and IMF Staff Calculations

(B) 2030 target of 43 percent reduction in emissions from 2005 levels

GHG Emissions and 2030 Targets

(Percent of total, 2022)

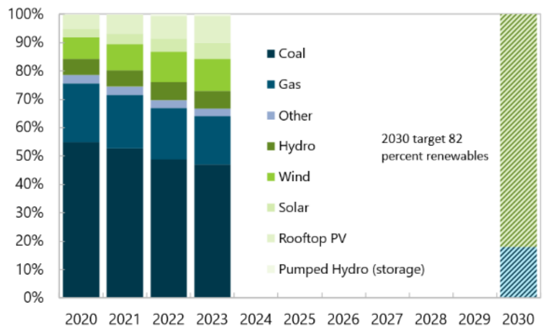


Sources: Australian Authorities

(C) Including through a rapid change in the electricity generation mix

Electricity Generation Mix in Australia

(Percent of total, 2022)

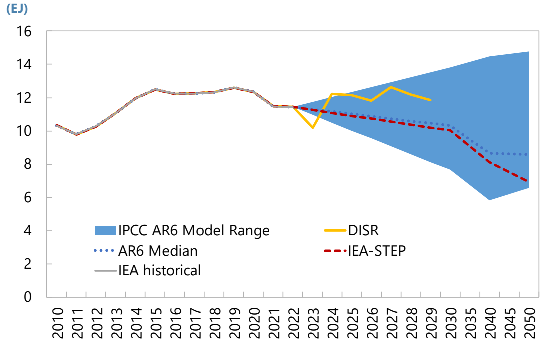


Sources: Australian Authorities

(D) Australia's coal demand will likely fall, but projections vary substantially

Coal Production in Australia

(EJ)



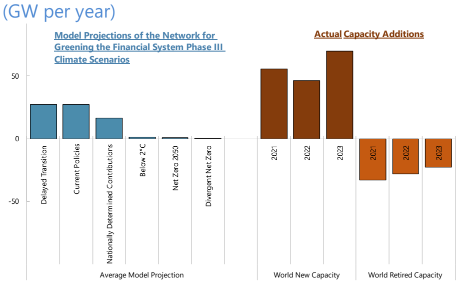
Sources: IPCC AR6, IEA STEP, DISR and IMF Staff Calculations

Note: Global coal supply projections are downscaled for Australia assuming Australia's share in global production remains constant at its 2022 values. Differences in historical values are corrected by rebasing the global projections to 2022 historical production data from IEA.

(E) There is also disagreement between modelled coal power additions and recent capacity additions

Coal Power Capacity Additions

(GW per year)

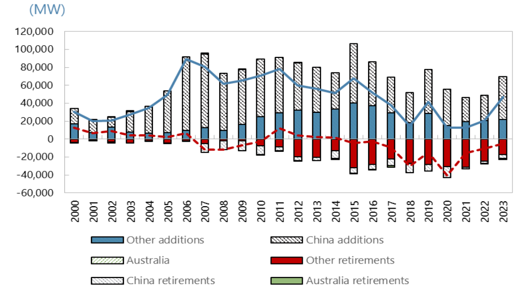


Sources: Global Coal Plant Tracker (2023) and NGFS Climate Scenarios Data Set Version 3.0. Chart updated based on original work in Gardes-Landolfini, C., Grippa, P., Oman, W., & Yu, S. (2023). Energy Transition and Geoeconomic Fragmentation: Implications for Climate Scenario Design. Staff Climate Notes, 2023(003)

(F) Coal power additions have risen, driven by China and India

Annual Change in Coal-Fired Power Capacity

(MW)



Sources: Global Coal Plant Tracker and IMF Staff Calculations

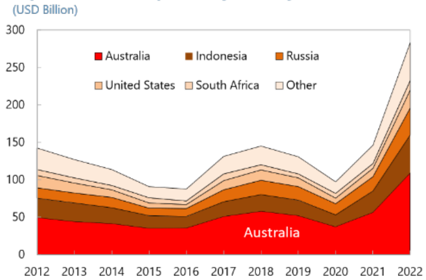
Policy Environment

14. The policy environment has begun incentivizing the transition towards domestic renewables growth and becoming an exporter of materials needed for a global energy transition. Australia's Safeguard Mechanism sets legally binding limits on the country's largest greenhouse gas emitters. Applying to facilities emitting more than 100,000 tonnes of CO2-equivalent greenhouse gases per year, annual baselines are production adjusted and initially set based largely based on the facility's historical emissions intensity but transitioninig to prescribed industry average emissions intensity values by 2030 with a gradual tightening designed to align emissions reductions with the country's climate targets. Excess emissions can be offset through purchasing carbon credits.[19] Policy is also supporting renewables growth and growth in the critical minerals sector. The Capacity Investment Scheme (CIS) in Australia is a national framework aimed at fostering new investments in renewable energy sources, including wind and solar power, by providing incentives and support measures.[20] Additionally, the scheme emphasizes the development of battery storage to enhance the reliability and stability of the energy grid while transitioning towards a more sustainable and low-carbon economy. The Future Made in Australia (FMiA) program aims to grow Australia into a renewable energy superpower. Notable measures to be available between 2027-28 and 2039-40 include the provision of production tax incentives for renewable hydrogen (AU$6.7 billion over ten years) and processed critical minerals (AU$7.0 billion over 11 years), and support for battery manufacturing (AU $549 million over 8 years). Although not designed with the intention of supporting the energy transition, Australia has a Petroleum Resource Rent Tax (PRRT) which taxes profits at a rate of 40 percent for profits generated from the sale of marketable petroleum commodities. Between 2012 and 2014, Australia had a parallel Minerals Resource Rent Tax (MRRT) which levied a 30 percent tax on profits from the mining of iron ore and coal on companies with profits exceeding AUD75 million.[21]

Figure 3. Australia's Resource Sector

(A) Australia was world's largest exporter of coal briquettes in value terms in 2022

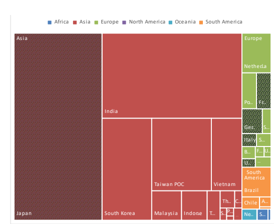
Exports of Coal Briquettes by Country
(USD Billion)



Sources: OEC and IMF Staff Calculations

(B) Coal goes to Asia (89%) and G7 (37%), coal to China 17% in 2020.

Export Destinations for Coal
(USD, 2022)



Sources: OEC and IMF Staff Calculations

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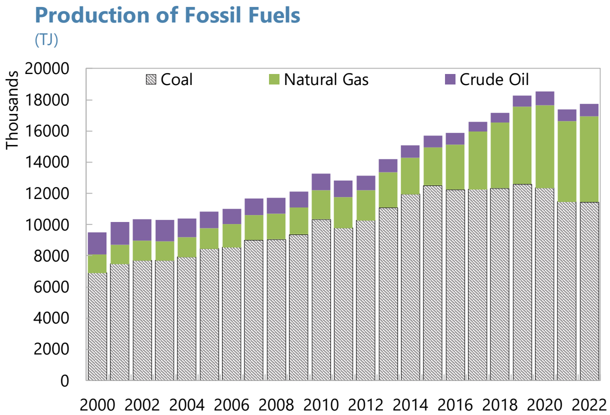
[19] The scheme covers approximately 28 percent of total emissions.

[20] Several additional renewable energy policies and targets have been announced by States and Territories.

[21] It was repealed in 2014 following an election promise.

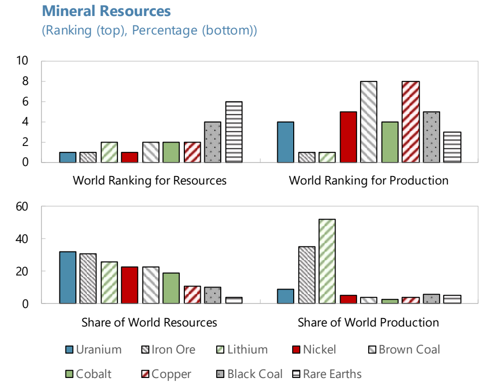
Figure 3. Australia's Resource Sector (concluded)

(C) Australia's coal production has been largely flat, while natural gas has been growing



Sources: IEA World Energy Balances 2024

(D) Large deposits of minerals needed for the transition



Source: Australia Identified Mineral Resources, 2023

C. Methodology & Data

15. This paper utilizes a global dynamic computable general equilibrium model (IMF-ENV[22]) to capture the macroeconomic dynamics of mitigation policies. The model is built primarily on the near global database of input-output tables of 160 countries and 76 commodities and solves recursively. IMF-ENV provides a flexible framework that is well suited to analyze policies that generate large structural changes like those resulting from ambitious decarbonization goals. The model has a high level of sectoral and country granularity, the flexibility to incorporate many different types of policy instruments, and the capacity to analyze the general equilibrium effects of policies, as well as their cross-border effects through a detailed representation of trade flows. For the purposes of this paper, the model has three core strengths:

- Macroeconomic dynamics up to 2035;
- Rich detail on inter-sectoral economic linkages and sectoral emissions; and
- Accounting of interactions between domestic and international policies.

a) ***Macroeconomic and sectoral dynamics are defined for each sector in a region.*** Production activities are represented by a regionally calibrated nested CES production function and rely on primary factors (land, labor, capital, and natural resources) and intermediate inputs.[23] The outputs from each production activity could enter as intermediate demand in other domestic sectors, direct demand by households and/or be internationally traded. A key characteristic of the model is that it considers frictions in domestic reallocation

[22] Model described in more detail in Annex 1 and Chateau et al. (forthcoming).

[23] Land is used as input in the agriculture sector. Natural resource is necessary for economic activities associated to forestry, fisheries, minerals, and fossil extraction sectors.

of capital and provides more realism by differentiating capital by vintage types. This feature of the model is particularly relevant when considering the rapid transition in domestic extraction and energy sector given that continued investments and unplanned retiring of capital risks is costly to retire while gradually decommissioning capacity could lower the costs.

b) ***Inter-sectoral economic linkages and sectoral emissions***: The model provides rich detail on economic impacts and related GHG emissions for each of the 36 production activities and 28 internationally traded commodities. Emission intensive sectors including fossil fuel extraction (coal mining, crude oil, refined oil, gas extraction), fossil power generation (coal, oil and gas-powered electricity) and energy intensive and trade exposed (EITE) sectors (iron and steel, non-metallic minerals, chemical, pulp and paper, and non-ferrous metals) are separately represented in the model. Under mitigation there is a structural change towards less emission intensive activities or emission-free activities. Emission-free activities are available only in the power generation sector and include generation from renewables like solar PV, wind, hydropower, nuclear and others. Negative emissions are allowed for the LULUCF sector though in the standard model specification, the evolution of emissions from LULUCF is exogenously determined and not affected by the policy setting. This means that the model can track the path of global and regional greenhouse gas emissions, including the changes in global commodity prices. In the case of Australia, all the LULUCF emissions are taken from DCCEEW projections and remain identical in all scenarios. Global climate mitigation and transition efforts imply a rapid increase in demand for inputs like critical minerals that are necessary for a shift towards clean energy sources and manufacturing. This presents an opportunity for meaningful expansion opportunities for countries that have natural endowments of these inputs like Australia. Given the absence of granular data in the underlying database, we use external estimates to gauge the potential for scaling up mining activities in the critical minerals sector for Australia.

c) ***Accounting for domestic and international policies:*** Each of the G20 countries are individually calibrated in the model and the rest of the world is aggregated into six model regions. Model regions are linked to one another via bilateral trade across commodities. Thus, the model captures the cross-border spillovers of policies via changes in bilateral trade volume and prices across commodities and can quantify the global impact of domestic and international policy changes on international trade, international commodity prices, and global GHG emissions. This feature is particularly important when considering the implications of a global or sub-global mitigation scenario.

16. **Baseline calibration:** There are two primary components of the calibration process-macroeconomic and energy sector dynamics. For all model regions, the historical years in the baseline are calibrated for regional GDP growth rates and population growth rates (IMF's World Economic Outlook (WEO)), regional GHG emissions (GHG inventory data from UNFCCC and EDGAR), and electricity generation (IRENA) between 2017 to 2021. Medium term macroeconomic projections are taken from IMF's WEO while long-term ones are based on the SSP2 scenario[24]. For Australia, the long-term trajectory of emissions and electricity sector composition under current policies is based on the projections published by Australia's DCCEEW. In the additional policy scenarios, new policies are introduced starting 2023 and the model solves for an equilibrium in commodities and factor markets both domestically and globally in each year from 2023, allowing us to map out the trajectory of macroeconomic impacts from domestic and international adjustments over the next decade. Given that the focus of this paper is on the decarbonization from coal in Australia, global and Australia's coal supplies under current policies have been calibrated to match the IEA's global coal demand projections, which are also used as inputs by Australia's DCCEEW.

17. While the model has rich detail in its treatment of the local and global macroeconomic structures, there are also important caveats. First, it has less detail in its incorporation of microeconomic frictions for labor. For example, the model assumes that labor can move between sectors without frictions that could arise from the need to retrain or migrate. This means the model may underestimate the cost of policy changes in the short run by not including these adjustment costs. Second, the model does not explicitly model the role of technological change, potentially leading it to overestimate the cost of the transition in the long term. For instance, if green hydrogen becomes economically viable, this could make reducing GHG emissions less costly. Third, the underlying database does not have granular detail on critical minerals production. Instead, this is grouped with a broader category of minerals. Finally, the model does not capture the distributional impacts, physical impacts of climate change nor co-benefits like the improvements in human health which could result from climate change mitigation policies. In section F of this chapter, we discuss the likely magnitude of some of the unmodelled factors.

D. Economic Implications of Australia's Domestic Energy Transition

18. The 2023 DCCEEW baseline projection predicts a small emissions gap relative to Australia's NDC and that the renewables share will fall below the 82 percent target. Under current policies in 2023, DCCEEW forecast that emissions would be 37 percent below the 2005 levels by 2030 which implies a 35MTCO2e gap relative to the NDC target of 43 percent[25]. Similarly, baseline estimates show renewable energy[26] will be approximately 70 percent of total electricity production in 2030 as coal power declines from 46 percent in 2023 to 19 percent in 2030 (Figure 4A), falling short of the 82 percent target for the renewables share.

19. Alongside current policies, increasing the share of renewables from 70 to 82 percent would keep Australia on track to meet its 2030 NDC target. To bridge the gap, a production subsidy for renewables (solar and wind) is modelled in IMF-ENV to approximate a scale up of the

[24] References to the databases - IMF's WEO World Economic Outlook Databases (imf.org), GHG data based from UNFCCC (Annex-I), EDGAR (non-Annex-I) and FAO (LULUCF) and accessed via Climate Change Indicators Dashboard , IRENA renewables database Data (irena.org).SSP database IXMP Scenario Explorer developed by IIASA

[25] This baseline emissions forecast excludes the capacity investment scheme that would bring the emission trajectory under current policies closer to the NDC trajectory.

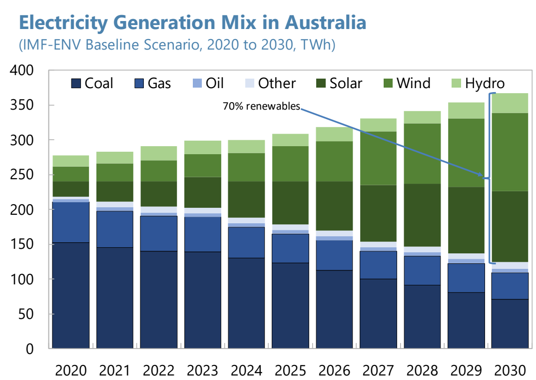
[26] Renewables in this context refers to solar and wind power generation in Australia.

existing capacity investment scheme. The policy is funded from an increase in wage taxes. When the current policies are complemented by the increase in the renewables share to 82 percent of power generation, the resulting impact on emissions would keep Australia aligned with its NDC target of reducing emissions by 43 percent relative to 2005. As a result of the supply-side policy intervention, overall electricity generation increases under this scenario, with similar generation levels from solar and wind technologies. This is accompanied by a large decrease in power generation from coal and gas. Implementation risks pertaining to the ability of the power sector to scale up all renewables quickly from 36 percent in 2023 to 82 percent by 2030 remain however very relevant and need to be addressed. They include the lengthy permitting and administrative processes, supply chain bottlenecks and capital costs. Model estimates suggest that this policy entails a small GDP level cost of 0.5 percent relative to the baseline in 2030. The costs arise because supply-side policies impose fiscal cost that is financed by increase in payroll tax and this affects household incomes and consumption. However, there are co-benefits of mitigation as well as avoided damages with mitigation which are not accounted for in IMF-ENV and which could outweigh the costs by far.

20. Domestic energy transition will generate other structural transformation across sectors and labor markets. Incentives to expand renewables' sectors directly affect the fossil-based power generation but they also have second-order impacts on fossil extraction sectors[27]. There is a decline in labor demand within fossil extraction sectors- coal and natural gas extraction. This is accompanied by fall in labor demand in fossil-based power generation while there is an increase in labor demand in the electricity transmission and distribution sector and in renewable power generation (Figure 4C). Sectoral outputs also see similar trends. Output as a share of GDP falls in the fossil extraction sector with the largest fall in coal extraction. In parallel, there is an increase in the green energy sectors in the model (Figure 4D). Thus, overall, the Australian economy would shift away from carbon-intensive sectors towards less carbon-intensive or no-carbon sectors.

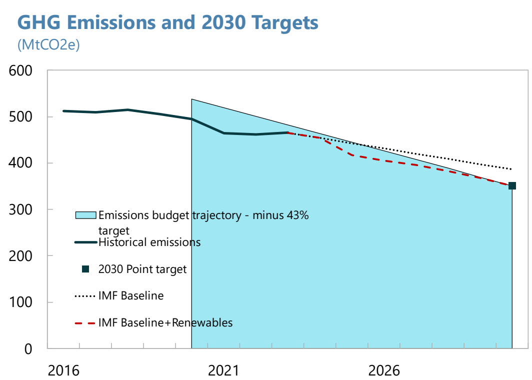
Figure 4. Implications of the Domestic Transition

(A) Under the baseline calibration substantial progress is made towards the renewables target



Sources: IMF Staff Calculations using IMF-ENV

(B) Under the baseline, there will likely be a small positive emissions gap to the NDC, which would be closed if the renewables target is met.



Sources: Australian Authorities and IMF-ENV

[27] Consequently, the energy-intensive and trade exposed sectors also see a fall in output (0.3 percent to 2.7 percent relative to baseline).

Figure 4. Implications of the Domestic Transition (concluded)

(C) Decline in employment in coal and natural gas, growth in electricity sector and renewables

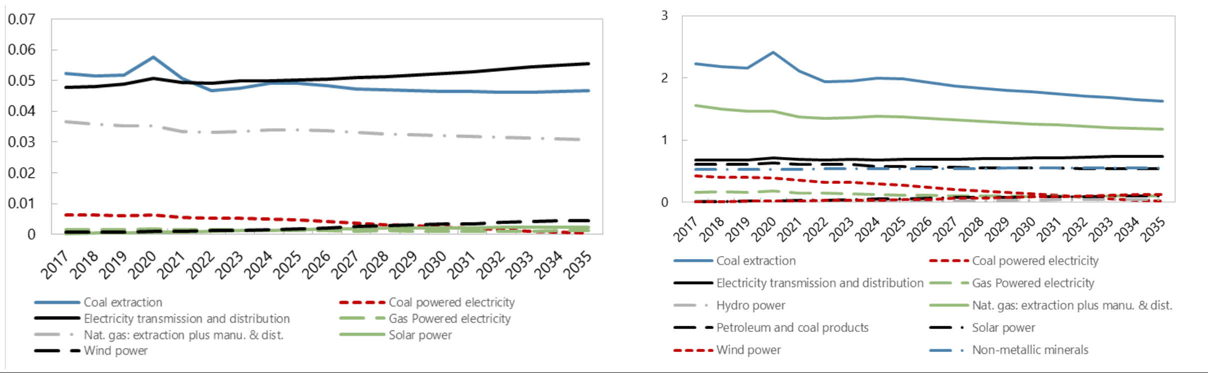
Employment

(Percent of Total Labor Demand)

(D) Decline in coal powered electricity though overall electricity supply in Australia grows

Real Output

(Output Shares)

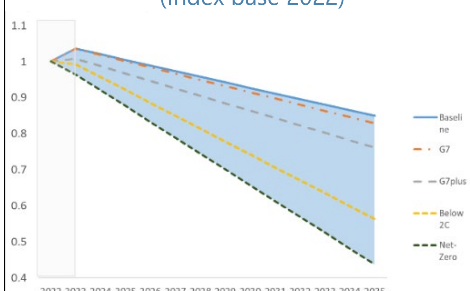


E. Economic Implications of the Global Energy Transition

21. We study the impacts of the global transition away from fossil fuels, especially coal, through the modelling exercise. Being the largest exporter of coal in the world in value terms amplifies the domestic risks from the global energy transition for Australia (see Figure 3 B). Though both exports of coking and thermal coal are important for Australia as discussed in Section B, in IMF-ENV the distinction between coal types cannot be made and therefore, we model scenarios of global transition as a shift away from aggregate coal. Scenarios vary along two dimensions, first the scale of global mitigation ambition and second the fossil fuel that is targeted for a phasedown. The scenarios are presented and described below.

Figure 5. Global Coal Demand

(Index base 2022)



Sources: IEA and IMF-ENV

- *G7*: In this scenario coal demand for power generation falls to zero in the G7 economies by 2035 as communicated by the G7 communique in March 2024.[28] Note that the phasedown from the G7 communique is targeted towards unabated coal and by phasing down all power generation from coal we implicitly assume that there will be no significant level of coal power generation with emissions that are abated via CCUS over the next decade.
- G7 *plus*: This refers to a scenario where along with the G7 there is also a reduced demand for coal from China and India.[29] Demand of coal for power

[28] Available at https://www.g7italy.it/wp-content/uploads/G7-Climate-Energy-Environment-Ministerial-Communique_Final.pdf. In the scenario all G7 countries complete the phaseout in 2035 though in practice there could be differences in the pace of transition across countries.

[29] Since it is unlikely that either China or India could be completely weaned off coal power generation by 2035 in a manner like the G7 commitment, we model a more modest scenario for reduced coal demand from these two countries.

generation from China and India declines such that these countries are aligned with their 2030 NDC target[30].

The following two scenarios[31] do not particularly focus on coal transition but a broader decarbonization strategy away from all fossil fuels towards power generation from renewable sources.

- *Below 2C*: In this scenario, all countries are constrained by a regional emissions budget that is aligned with a 2C temperature target.
- *Net-Zero*: In this scenario, all countries are constrained by a regional emissions budget that is aligned with a net-zero by 2050 target.

Each of these scenarios implies a progressively lower level of coal demand at the global scale (See Figure 5). The regional composition of the demand is endogenous in IMF-ENV. In all the above scenarios, we assume that there is no abated fossil fuel power generation by the year 2035. Section F.3 provides a discussion of the current state of the CCUS technology and expert and model forecasts about its scaleup.

22. A ramping up in mitigation efforts reduces sectoral output in coal extraction while there may be a medium-term expansion in natural gas. The *G7* and *G7 plus* scenarios target coal power specifically, leading to a greater impact on the coal extraction sector than other fossil fuels. Differently, more stringent global mitigation efforts affect all fossil fuels which also implies reduction in output from coal extraction sector so that countries can remain within their GHG budgets. When global efforts are coordinated across fuels, there is a also a fall in the domestic natural gas extraction sector, though the sector could potentially expand if the global transition efforts are only focused on coal. It is important to note that the expansion in natural gas extraction would depend on the ability of the sector to expand under the domestic policies and political preferences in Australia, which are not explicitly considered in our analysis. In IMF-ENV the shift towards natural gas is largely driven by the lower carbon intensity of natural gas compared to coal. Finally, global decarbonization does not directly affect the power sector in Australia and therefore, there is a marginal impact on the domestic power generation output.

23. All scenarios indicate a decline in coal labor demand with a mixed effect on labor demand from the natural gas extraction sector. The patterns in output are matched by qualitatively similar impacts in the production factors. Labor supply in Australia remains broadly similar across policy scenarios relative to the baseline[32]. However, under global mitigation and transition actions, there are changes in the composition of labor demand across sectors, with substantial shifts away from coal extraction seen in all scenarios. The *G7* and *G7 plus* scenarios have

[30] The NDC emission trajectory is taken from the NGFS Phase 4 scenarios.

[31] These scenarios are consistent with scenario data published by the Network for Greening the Financial System (FS) Phase 4. The regional emission trajectories for each scenario correspond to the projected impact on temperature by the end of the century.

[32] The labor supply elasticity in Australia is set to 0.15 as a result labor supply could respond to changes in wages. Across the policy scenarios there is only a marginally small increase in domestic labor supply.

relatively lower impacts on the labor demand in the coal extraction sectors, while they also feature a small increase in the labor demand by the gas extraction and distribution sector. Differently, ramping up global mitigation reduces the labor demand in both fossil extraction sectors. There are only marginal impacts on power generation.

24. The varying impacts on the capital stock underscore the challenges investors encounter when deciding between short-term and long-term investments in fossil fuels. The capital stock in the coal extraction sector reduces between 4 to 22 percent across the scenarios. This is partly because there is a fall in new investments being directed to this sector and a depreciation of the existing capital stock. Differently, there could be an economic rationale to make new investments in natural gas extraction when the decarbonization is done fuel-by-fuel and focused on coal while this incentive disappears with a fuel agnostic mitigation and transition plan. This implies a range of capital stock in natural gas ranging from a fall of 18 percent under a *net-zero* scenario to a rise of 12 percent with a phaseout focused on coal under *G7 plus*. Significant uncertainties regarding global ambition and coordination on decarbonization policies create a challenging investment environment, raising the risk of over- or under-investment. This challenge is exacerbated by uncertainties related to technology. While investments in Australia's coal extraction sector have mostly stabilized (see Figure 1.8 in the June REQ (2024) report[33]), there is still a need to maintain investments to maintain the operations of existing mines. The investment outlook for natural gas remains more uncertain with investments in natural gas extraction picking up between 2021-2024.

25. Coal exports from Australia are expected to decline in all scenarios, although there is potential for gaining market share. Exports of Australian coal to the rest of the world fall by about 4 percent to 12 percent across scenarios by 2035 relative to the baseline. Most of the decrease in coal usage in the G7 scenario results from the decarbonization of Japan's power sector, which receives the largest share of coal exports from Australia among the G7 economies. At the same time, the market share of Australian coal could increase with a high degree of global coal drawdown because of low production costs.[34]

26. While mitigation may lead to some GDP impacts, the benefits—such as co-benefits and avoided climate damages—will significantly surpass the costs. Model estimates suggest that the annual change in GDP level would be very small, between -0.01 to -0.14 percent over the next decade. However, increasing global mitigation means that gains from avoided global climate damages will be realized while also improving local environmental and health outcomes commonly referred to as co-benefits (see Black, Parry and Zhunussova (2023)).

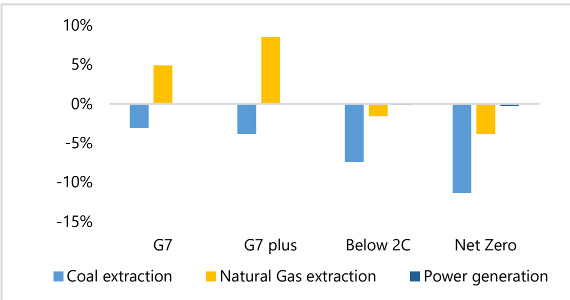
[33] Resources and energy quarterly: June 2024 | Department of Industry Science and Resources

[34] Additional factors, such as the superior quality of Australian coking and thermal coal, could also contribute to Australia sustaining a significant market share in the coal industry, especially in the Asia markets, during the global transition and are discussed in section F.

Figure 6. Impacts of the Global Energy Transition

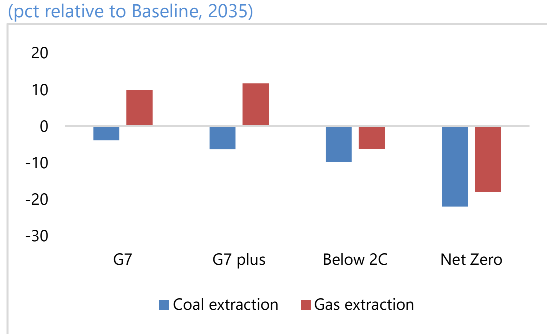
(A) Targeting only coal for mitigation could increase natural gas output, yet greater climate ambitions would lower output in both

Sectoral Output
(pct relative to baseline, 2035)



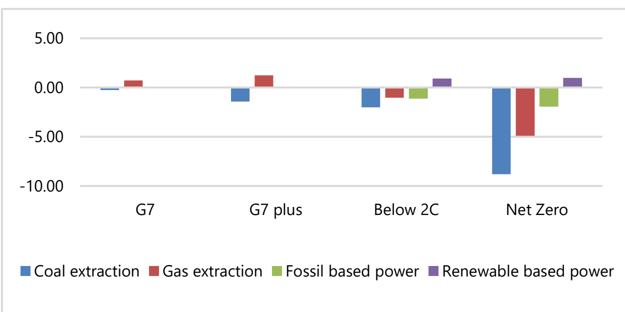
(B) Patterns in sectoral output changes are reflected in capital stock accumulation

Capital Stock
(pct relative to Baseline, 2035)



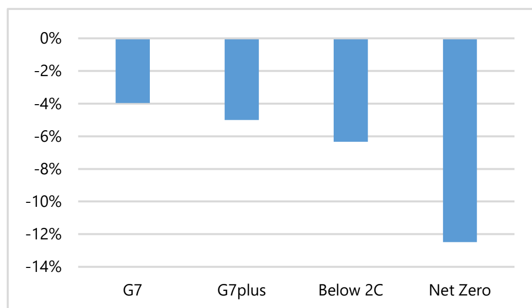
(C) And labor demand across the fossil extraction sectors with marginal impacts on domestic power sector

Labor Demand
(in thousands relative to Baseline, 2035)



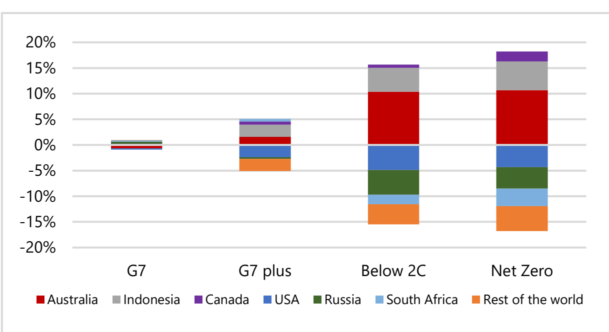
(D) Coal exports from Australia are expected to decline in all scenarios

Exports of Coal from Australia
(pct relative to baseline, 2035)



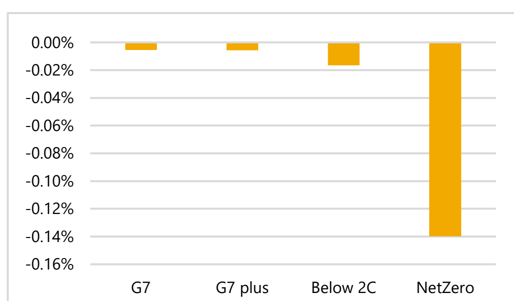
(E) Although there is potential for gaining market share given low extraction costs in Australia

Market Shares in Coal Extraction in Major Exporters
(pp change relative to baseline, 2035)



(F) While there will be small GDP costs, unmodelled costs include economic gains from co-benefits and avoided damages which could be substantial

GDP Level Change in Australia
(annual in pct relative to baseline, 2035)



Source: Model estimates from IMF-ENV.

F. Potential Mitigating Factors

27. This section explores three important factors that may serve as buffers for the Australian economy during the global and domestic energy transition. By examining these elements, we highlight that the overall economic impacts in Australia could be less severe than those projected by the model. These factors include the potential for expanding critical minerals, variations in extraction costs and grades of coal and development of green fuels and carbon dioxide removal (CDR) technologies. Collectively, these aspects may help mitigate the negative impacts of the transition and support the diversification of the economic landscape in Australia.

Demand for Critical Minerals Offsets Losses

28. Australia possesses substantial critical minerals whose demand is inversely correlated with global demand for fossil fuels creating an upside risk if prices rise. Figures 7A and 7B show projections from the IEA's Critical Mineral Report. Figure A shows projected demand in 2030 for four critical minerals under three increasing intensity mitigation scenarios simulated by the IEA. In all instances, demand is expected to increase substantially between 2023 and 2030. In the more ambitious global mitigation scenario, demand is projected to increase further indicating that critical minerals needed for renewable energy and fossil fuels are substitutes. However, the IEA projects that Australia's critical mineral supply will make up a relatively modest share of this market in the baseline. This is largely due to new sources of critical minerals expanding in other countries. Figure 3B shows the market value of the sum of energy transition minerals by global region. While Australia's market value is expected to approximately double, the scale of the gains is far smaller than the current size of their fossil fuel exports.

Low Average Extraction Costs and Coal Quality Allow Australia to Grow its Global Coal Market Share

29. Low average extraction cost and high quality of Australian coal creates upside risks to the country's coal market share during the transition, beyond what is captured by the model. As global demand for coal falls in the global transition, it is expected to result in declines in the price of coal. This will likely cause exit in the market, starting with mines with the highest extraction cost. Australia benefits from an average coal extraction cost below the world average (Figure 3C) as well as having coal with a lower carbon content than the global average.[35] Moreover, half of Australia's coal exports are in metallurgical coal which is currently an essential input to steel manufacturing. This suggests that Australia may see an initial impact on prices more than on quantities of coal exports, and an increase in Australia's global market share relative to the baseline IMF-ENV

[35] The model accounts for variations in production costs across different sectors by incorporating a representative extraction sector for each country, reflecting the average production cost. In reality, however, each country has a variety of mines with a range of extraction costs that may respond differently to fluctuations in international commodity prices. Additionally, there are other non-cost based drivers of demand.

assumption.[36] However, even though the average Australian mine has a low extraction cost, some of Australia's coal mines sit higher on the cost curve and would likely be impacted by shifts in global prices (Figure 3D).[37] The model accounts for variations in production costs across different sectors by incorporating a representative extraction sector for each country, reflecting the average production cost. In reality, however, each country has a variety of mines with a range of extraction costs that may respond differently to fluctuations in international commodity prices.[38] A downside risk to Australia's market share, beyond the scenarios presented in Section E, could arise if key trading partners disproportionately cut coal demand. 37 percent of Australia's coal exports in 2022 were exported to G7 countries which have committed to drawing down unabated coal by 2035. A further risk to the sector comes from geoeconomic fragmentation or if countries prioritize more expensive domestic production over imports. A Chinese ban on Australian coal imports imposed in late 2020 reduced bilateral coal imports from 17 percent in 2020 to close to zero in 2021-2022. Although Australian coal exporters largely managed to find alternative buyers for the coal, further global fragmentation could present a risk to Australia's coal market share, especially during a period of shrinking global market.

30. The average extraction cost of critical minerals varies substantially which means Australia's critical mineral market share could increase or decrease during the transition. Copper and lithium extraction costs are below the global average while nickel and cobalt extraction costs are above the global average (Figure 7C). In the latter two minerals, there are several mines near the top of the extraction cost distribution; and recent announcements of closures of nickel mines highlight risks in the sector (Appendix Figure 1). By contrast, there are several large graphite projects coming online that are expected to be low cost globally. Figure 2D shows that Australia has substantial additional resources which could be mined should prices increase.

Technological Change Impacts Demand for Australia's Exports

31. Reaching the global net-zero target will require innovation and large technology scaling up creating uncertainty over demand for renewables, critical minerals, and fossil fuels. Technological uncertainty remains high and innovation is needed in several key aspects. Carbon dioxide removal (CDR) options like CCUS will allow for use of fossil fuels in the hard-to-abate sectors. Meanwhile, battery storage would support higher integration of renewables in the power sectors. Additionally, green hydrogen can play a significant role in decarbonizing the steel production sector while also providing a clean fuel alternative for aviation.

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[36] For the purposes of being globally consistent IMF-ENV baseline calibration assumes countries maintain their 2022 market share for coal. In the policy scenarios, composition of the exports varies and therefore, the market share can change subject to the changing global conditions (see Figure 6E).

[37] In the short-term Australia is unlikely to be constrained by the available reserves of coal. Estimates suggest the resource life (Measured and Indicated Mineral Resources + Inferred Mineral Resources) ÷ Production of black coal at operating mines in 2022 is 93 years (AIMR, 2023). It is likely that costs could rise the closer the country comes to depleting reserves.

[38] Additionally, there are other non-cost based drivers of demand.

32. CCUS could allow the continued use of fossil fuels while also lowering the level of emissions. CCUS has long been regarded as a promising solution to maintain fossil fuel use while advancing decarbonization efforts. However, significant uncertainty still surrounds its potential for large-scale deployment by 2050. This uncertainty is demonstrated in Figure 7E which shows a range of estimates for coal with CCUS according to a range of models. The cause of the uncertainty is due to three main factors. Firstly, the high cost and energy requirements of current CCUS technologies make widespread adoption challenging, especially in a context where alternates to fossil fuel-based power like renewable energy sources are becoming more competitive. Secondly, policy and regulatory environments globally are highly variable and uncertain, impacting the incentives for innovating and deploying such technologies. Most recently, several large G7 economies have provided incentives towards CCUS under green industrial policy packages which could potentially provide a more predictable policy pathway for this technology. Lastly, technological advancements and breakthroughs in CCUS are difficult to predict, adding another layer of uncertainty to future projections. Over the last decade within expert groups, the optimism regarding a substantial scaling up of coal with CCUS in the second half of the century has declined[39], with current estimates projecting the coal with CCUS to be about a third of the estimates from last decade (see Figure 7E).

33. Technological change that eases the deployment of existing green technologies like a scaling up of battery storage to complement renewable energy can support the transition. In addition to technologies that could complement fossil use in the hard-to-abate sectors, a faster pace of technological advancement is also essential for other solutions. This acceleration would facilitate the scaling up of existing green technologies, such as battery storage, to better support a grid powered by high levels of renewable energy. The pace of innovation in these options will likely be driven by the variability in government policies and incentives around the world, the technological and infrastructural challenges associated with integrating renewable sources into existing energy systems, and the readiness of countries to transition away from fossil fuels.

34. Green hydrogen could replace the use of coal in steel manufacturing creating both up- and downside risks to Australia's exports. Currently, Australia has some of the highest quality metallurgical coal in the world, which is an essential input in the production of steel. This might suggest that demand for coking coal will remain robust, even while thermal coal demand falls. Indeed, the IEA forecasts that over the next 15 years metallurgical coal will decline more slowly than thermal coal (Figure 7F).[40] Should new technological development reduce the need for coal use in steel production, then Australia's coal demand could fall more rapidly. One of the most promising technologies to achieve this goal is green hydrogen which can substitute the need for metallurgical coal in the production of steel. If it is made economically viable, the domestic production of green hydrogen would hedge some of the risks from a declining coal sector. More broadly, clean hydrogen can help generate new employment and help lower emissions. Modelling undertaken by

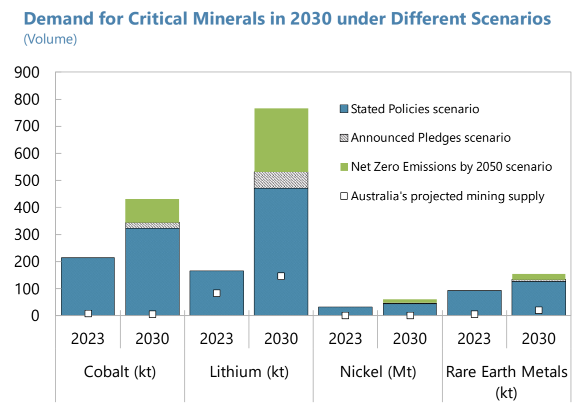
[39] The previous large scale IAM modeling exercise undertaken under the SSP-RCP Version 2 (SSP Database) scenarios projected about 125Mt of coal with CCUS by the end of the century.

[40] IEA World Energy Outlook 2024 projects that relative to 2023 levels steam coal will fall by 32 percent and coking coal will fall by 11 percent by 2035.

DCCEEW suggest that, alongside CCUS technologies, clean hydrogen will need to contribute about 50 percent of the emissions reductions in heavy industry to meet the Net Zero 2050 target (DCCEEW, 2021).

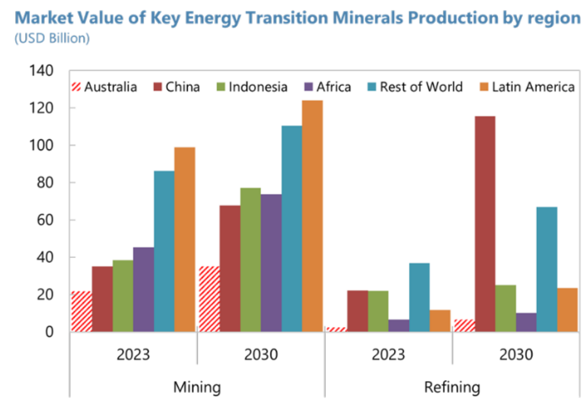
Figure 7. Potential Mitigating Factors

(A) Demand for critical minerals forecast to increase



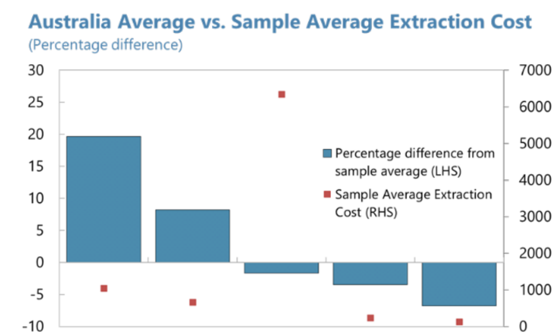
Sources: IEA Critical Minerals Report

(B) but expected increase in market value set to fall short of export revenues from fossil fuels



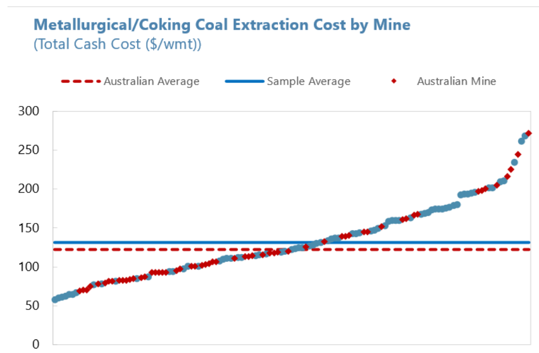
Source: IEA Critical Minerals Report

(C) Average extraction costs for coal and copper below market average



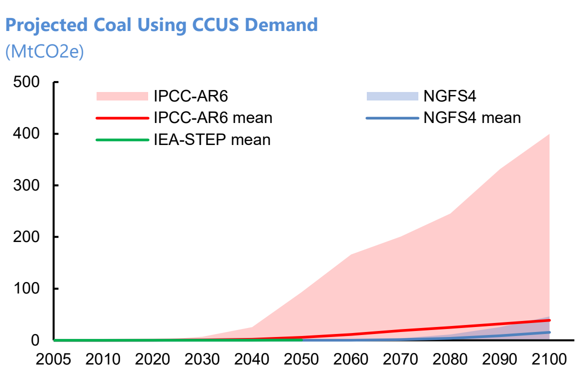
Sources: S&P and IMF Staff Calculations
Note: Average costs vary by mineral - Copper, Cobalt & Nickel (c/lb), Coal ($/wmt), Lithium ($/LCE)

(D) Some mines will still be vulnerable.



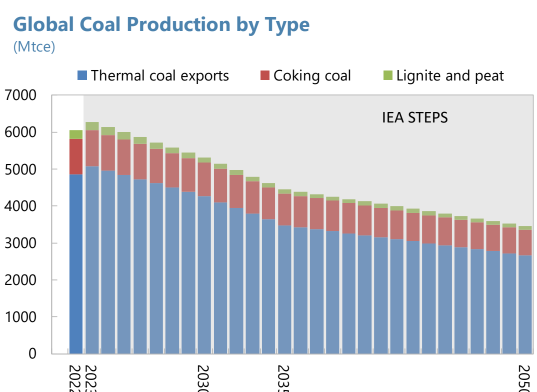
Sources: S&P
Notes: sample includes mines in Australia, Canada, Mozambique, and USA

(E) Large uncertainty on coal using CCUS



Sources: IEA, NGFS, UN IPCC

(F) Coal of all types expected to decline



Sources: IEA World Energy Outlook 2024

G. Conclusions

35. This chapter has three main conclusions:

(i) Australia is likely to meet its 2030 NDC target if it is able to scale up renewable energy share to 82 percent and implement its stated policies.

This chapter has a baseline emissions projection which would see a modest gap to Australia's NDC point target. In the baseline, the proportion of all renewable electricity will reach 70 percent of total electricity generation by 2030, a 34 percentage point increase from 2023 levels. The model predicts that the emissions gap to the NDC could be closed by scaling up renewable energy to meet the 82 percent renewable energy share target with a small level cost to GDP.

A combination of financial incentives and addressing difficult issues with community consenting for renewable energy infrastructure can help to meet this goal. The Capacity Investment Scheme and the 2024 Community Engagement Review are well placed to help. More broadly, policy can focus on generating a predictable policy environment to minimize uncertainty for investors. Finally, a broad-based carbon pricing instrument would likely be the most efficient option even if it is politically challenging.

(ii) *The transition will create significant adjustment costs including in the labor market, financial sector and to export and fiscal revenues.*

The domestic energy transition will cause output and employment losses especially in the fossil fuel power sector, which are at least partly offset by gains in employment in the renewable energy sector. The global transition's impacts are concentrated in the extractive sectors. The scale and direction of impacts depends on the type of fuel and the specific scenario, emphasizing the high level of uncertainty.

During the transition, social assistance can help those displaced in declining industries while active labor market policies can help workers to retrain and reenter the labor force. There may also be a limited role for industrial policy to support the entry of new industries into impacted locations. In order to maximize revenues which are needed for the transition and to incentivize a gradual decline of the fossil fuel sector, the country could consider reforming the resource rent tax to raise additional revenue from the fossil fuel industry.

(iii) Australia faces both risks and opportunities from the domestic and global energy transition.

Financial sector risks will need to be closely monitored, including exposure to stranded assets. Narrowly targeted green industrial policy, if well designed, can help Australia maximize its natural comparative advantage in the critical minerals sector.[41] The Critical Minerals Strategy 2023-2030 provides a clear guide; however, the rapidly changing landscape of technological development will require policy to remain highly nimble.

[41] See IMF Article IV Staff Report for Australia Annex

Annex I. IMF-ENV

1. The IMF-ENV model is a global dynamic computable general equilibrium (CGE) model. The model is built primarily on the near global GTAP database of input-output tables of 160 countries and 76 commodities and solves recursively. IMF-ENV provides a flexible framework that is well suited to analyze policies that generate large structural changes (i.e., changes in the sectoral composition of economies) like those resulting from ambitious decarbonization goals. The model has a high level of sectoral and country granularity, the flexibility to incorporate many different types of policy instruments, and the capacity to analyze the general equilibrium effects of policies, as well as their cross-border effects through a detailed representation of trade flows. Policies that can be simulated include different carbon pricing schemes (carbon taxes on different activities, sources and gases, national and regional ETS, CBAM), energy policies (subsidies, feebates, direct and indirect regulations), sectoral regulations (overall and sector-specific energy efficiency standards, requirements to install household heat pumps, regulatory policies on land, fisheries, and forestry sectors), and new green technologies (CCUS, EV penetration). IMF-ENV can provide impacts of climate mitigation policies on emissions, real macroeconomic variables, sectoral economic activity, and international trade patterns.

2. IMF-ENV is based on a neoclassical framework that optimizes the behavior of households and firms to provide the general equilibrium effects of policy shocks. Production functions are defined as nested CES functions that allow to simulate the substitution possibilities between different production factors, and domestic and international intermediate inputs, including different energy sources. A prominent feature of IMF-ENV is that it features vintage capital stocks to capture frictions in capital mobility in such a way that a firm's production structure and behavior are different in the short and long term. In each year, new investment is flexible and can be allocated across activities until the return to the "new" capital is equalized across sectors; the "old" (existing) capital stock, on the contrary, is mostly fixed and cannot be reallocated across sectors without costs. Consequently, short-term elasticities of substitution across inputs in production processes (or substitution possibilities) are much lower than in the long term and make adjustments of capital more realistic. In contrast, labor (and land) market frictions are limited: in each year, labor (land) can shift across sectors with no adjustment cost until wages (land prices) equalize, while the labor (land) supply responds with some elasticity to changes in the net-of-taxes wage rate (land price). The model assumes that all markets attain equilibrium in each period, and hence, it is not well suited to analyze potential disequilibrium that could arise in the short term, especially in the labor market. The magnitudes of labor sectoral reallocations and relative wage changes are, however, indicative of the size of the needed adjustment and frictions that can be expected in the transition.

3. The model links economic activity to environmental outcomes. Emissions of greenhouses gases (GHGs) and other air pollutants are linked to economic activities either with fixed coefficients, such as those for emissions from fossil fuel combustion, or with emission intensities that decrease (nonlinearly) with carbon prices—marginal abatement cost curves. This latter case applies to emissions associated with non-energy-input uses (e.g., nitrous oxide emissions resulting from fertilizer uses) or with output processes (like methane emissions from waste management or carbon dioxide emissions from cement manufacturing).

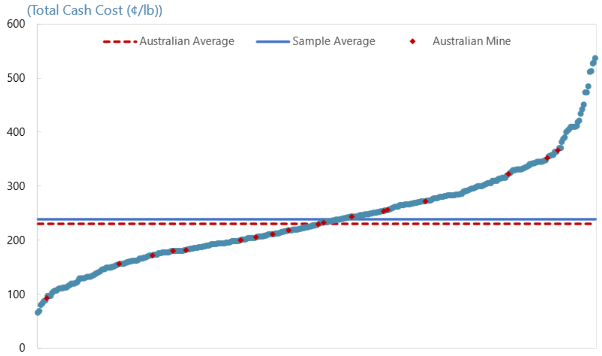
4. IMF-ENV undergoes continuous development. Recently, two model versions with regional focus on the Sub-Saharan Africa and Middle East and Central Asia regions have been developed. Ongoing model development work focuses on creating an R&D and technology diffusion module and incorporating international capital flows in the model. Moreover, several model extensions are possible conditional on data availability and relevance for a country. IMF-ENV can be soft-linked to specialized sectoral models like for the energy, agricultural or land-use sectors. The model can also include damages from climate change, either at a sectoral or factor level (i.e., agricultural labor and/or capital, transportation services, energy supply) and/or at the aggregate level (real GDP effects, overall labor productivity reductions). This applies to both slow-moving long-term shifts in climate and changes to the intensity and frequency of extreme weather events. In both cases, the model requires country-specific information on the specific damages that need to be modeled. Finally, the model can also be linked to household microsimulation models and/or use household survey data to provide detailed poverty and inequality effects through both household incomes and expenditures for all the macro policies simulated.

5. The IMF-ENV model has been widely used in a variety of contexts, including multi-country studies on international climate policy cooperation (see Chateau et al. (2022a) and Black et al. (2022)), cross-border effects of asymmetric climate policies (see Fournier et al. (2024)), energy security (see Dolphin et al. (2024) and Rojas-Romagosa (2024)), climate financing (Black et al. (2022) and Cai et al. (forthcoming)), and supporting climate policy analysis within individual countries. It has been applied for the analysis of climate mitigation and decarbonization policies in many AIV consultations (see, for example, applications for Canada, India, Indonesia, Italy, Mexico, Poland, Saudi Arabia, South Africa, USA) and several FSAPs (see applications for Germany, Kazakhstan, Mexico and Japan). In the context of G20 countries, it has been used to assess the macroeconomic impacts of domestic mitigation policies, exploring a range of policy instruments, and conducting research on competitiveness and carbon leakage, emphasizing the importance of simultaneous climate policy implementation across countries (see Barrett et al. (2021), Chateau at al. (2022b), Chateau et al. (2023)).

Annex II. Additional Figures

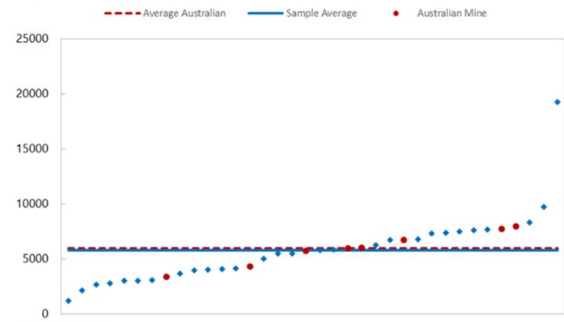
Figure 1. Mine Level Extraction Costs

Copper Extraction Cost by Mine
(Total Cash Cost (¢/lb))



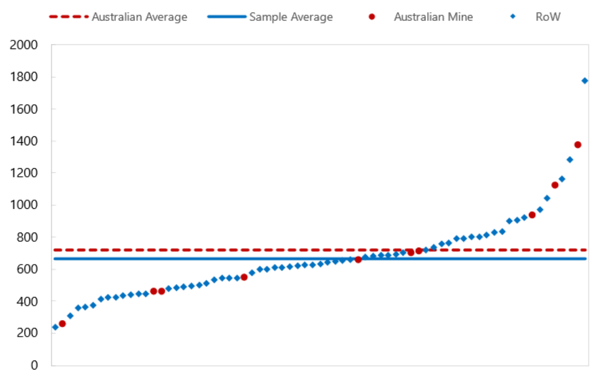
Sources: S&P
Notes: sample includes mines in Argentina, Australia, Armenia, Bolivia, Botswana, Brazil, Bulgaria, Canada, Chile, China, DRC , Ecuador, Finland, Indonesia, Iran, Kazakhstan, Laos, Mauritania, Mexico, Mongolia,PNG, Peru, Philippines, Poland, Portugal, R ussia, Saudi Arabnia, Serbia, South Africa, Spain, Sweden, Tanzania, Türkiye, USA, Zambia, and Zimbabwe

Lithium Extraction Cost by Mine
(Total Cash Cost ($/LCE))



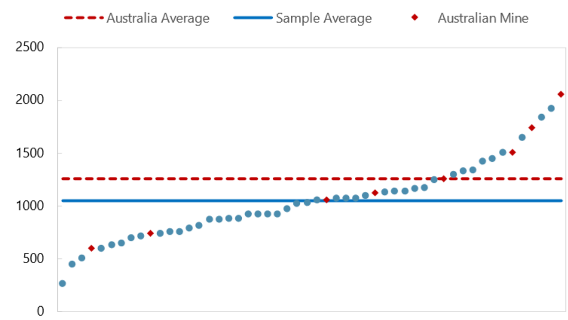
Sources: S&P
Notes: sample includes mines in Argentina, Australia, Brazil, Canada, Chile, China, Mali, Portugal, USA, and Zimbabwe

Nickel Extraction Cost by Mine
(Total Cash Cost (¢/lb))



Sources: S&P
Notes: sample includes mines in Australia, Brazil, Canada, China, Colombia, Cuba, Dominican Republic, Finland, Indonesia, Japan, Madagascar, New Caledonia, PNG, Philippines, Russia, South Africa, USA, Zambia, and Zimbabwe

Cobalt Extraction Cost by Mine
(Total Cash Cost (¢/lb))



Sources: S&P
Notes: sample includes mines in Australia, Brazil, Canada, China, Cuba, DRC, Finland, Madagascar, New Caledonia, PNG, Philippines, Russia, South Africa, USA, Zambia, and Zimbabwe

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