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Market-Based Approaches to Achieve Australia's Emissions Reduction Targets

Liam McFadzean-Lodge

Abstract

With Australia recently legislating a 2030 emissions reduction target, market-based approaches (such as carbon pricing) should be considered as a policy approach to achieve these reductions at least cost to the economy. This paper begins by delving into the economic theory behind carbon pricing and why it is considered the least cost emissions reduction method, then synthesises the literature on the outcomes of carbon pricing implemented in other jurisdictions to inform a potential Australian policy. This paper then explores market-based approaches in the Australian context by analysing Australia's previous attempt to implement carbon pricing. Empirical analysis in the paper demonstrates what level of emissions reductions can be expected for different levels of carbon tax, for instance, a carbon tax of AUD$112/tCO2 would reduce emissions by 41.18% from 2005 levels by 2030 (Australia's target is 43%). These findings inform policymakers determining the best policy mix to achieve emissions reduction targets, and what level of reductions should come from a carbon price compared to other policy measures. This paper also highlights the importance of accompanying carbon pricing with policies addressing the inequality effects to increase the longevity of the policy and to avoid mistakes of previous failed attempts to implement carbon pricing.

JEL classifications: Q41, Q48, Q54

Key words: climate change, energy demand, government policy

1. Introduction

With the 2012 introduction of Australia's carbon pricing scheme, Australia appeared to have finally succeeded in rectifying the world's greatest ever market failure (Garnaut, 2008). Australia had implemented a policy instrument which would take advantage of market incentives to reduce carbon emissions at least cost to businesses and consumers. Yet those aspirations fell short, as the policy was repealed within 2 years, which gave Australia the unfortunate ignominy of being the first country to repeal a carbon price (Rabe, 2018). This repeal highlighted the capacity of organised political opposition to undermine environmental policy, which in turn stresses the importance of maintaining public support through minimising economic disruptions. The importance of urgently implementing effective and efficient climate policies is compounded by the global failure to achieve emissions reduction targets (Bearak & Popovich, 2022).

This paper analyses this issue in the Australian context, by exploring the question of how Australia should move forward with its climate policy. The recently elected Albanese government committed to reducing emissions by 43% from 2005 levels by 2030, a commitment which has now been legislated by the Australian Parliament. The task of the government will then be to achieve these significant reductions whilst minimising the burden on the Australian economy, an extremely difficult balancing act. If a policy prioritises economic stability, it may not function as effectively at reducing emissions, resulting in Australia falling short of its emissions reduction target. If emissions reductions are prioritised, with insufficient consideration paid to economic impacts and public opinion, the policy could worsen Australians' welfare through increased costs and jeopardise future support for environmental policies.

This paper explores whether the best way for Australia to achieve its emissions reduction target is to revisit carbon pricing and, if so, what impact such a policy would be expected to have on Australian emissions. To answer this question, my chosen approach has two sections. The first section will delve into theoretical and practical analyses of non-market and market-based approaches to reducing emissions, with the intention of identifying what factors have contributed to the success, or lack thereof, of these policies. The second section will narrow its focus to Australia's environmental policy, first by analysing Australia's previous effort in 2011 to implement carbon pricing, and secondly by conducting an empirical analysis of likely responses of Australian emissions to three levels of carbon tax, ($25, $75, and $112 per tonne of CO_2), utilising the price elasticities of demand for the main fuel inputs in the Australian economy. The analysis finds that a carbon tax of $112/t$CO_2$ would result in a 41.18% reduction in Australian emissions compared to 2005 levels by 2030, meaning that a price slightly above this would be needed to achieve Australia's existing 2030 target. This level of carbon price would be necessary if policymakers wanted the carbon price to be responsible for all its emissions reductions without complementary policies. Although that would be the most economically efficient option, it is common in other jurisdictions for carbon prices to be complemented by other emissions reduction policies. In that case, the estimated reductions associated with a $25/t$CO_2$ tax (21.80%) and a $75/t$CO_2$ tax (34.98%) should inform policymakers what level of emissions reductions they would need to obtain from other policy options. It should be noted that higher carbon prices could be considered to reach more aggressive reduction targets, such as those proposed by the Intergovernmental Panel on Climate Change (IPCC) of a 45% reduction from 2010 levels by 2030.

The ultimate intent of this project is to contribute to the literature assessing the viability and effectiveness of carbon pricing. It is also intended to inform the development of environmental policy in Australia, especially related to achieving emissions reductions at least cost. This is particularly important given the destructive nature of climate policy debate in Australia, to the extent that it has been referred to as the 'Climate Wars' (Pearse, 2022).

2. Analysis of Market-Based Approaches

This section will provide an overview of the existing evidence base for market-based carbon reduction policies. It will explore the theoretical arguments for why market-based policies are preferred, then analyse real world examples of carbon pricing to draw lessons for future implementations.

2.1 Theory behind market-based approaches

Before looking into real world examples of how emissions reduction policies have been implemented, it is important to understand the economic theory explaining why certain policies are preferred by economists. Most policies to reduce emissions are considered as either market-based or non-market-based approaches. Non-market-based approaches include promoting technological development, subsidising the adoption of clean technology, prohibiting the use of certain substances, or developing methods of adaptation to the effects of climate change (UNFCCC, 2014).

Market-based approaches typically take the form of carbon taxes or emissions trading schemes (ETSs), the latter sometimes being referred to as cap-and-trade schemes. Although these policies are designed differently, they are both based on the fundamental idea that the negative externalities of emissions are an unpriced cost (Institute for Policy Integrity, 2017). Without pricing this cost, transactions involving emissions are too cheap, as the costs associated with the emissions are not considered (Weisbach & Metcalf, 2019). This means that currently, the marginal cost to society of additional emissions is exceeding its marginal benefit. Market-based approaches price carbon to reflect the true social cost of emissions and ensure that the cost is internalised by emitting firms (Stern, 2008). The underlying idea of these approaches is that if these costs are factored into decision-making by firms and reflected in market dealings, then emissions would be reduced to the point where the marginal cost to society of additional emissions equals the marginal benefit, which would achieve the socially optimal level of emissions. Carbon taxes approach this by setting the cost of carbon (typically per tonne of emissions) and allowing the market to generate the desired corresponding quantity in response. ETSs, on the other hand, set the quantity of emissions and allow the market to determine the cost, with firms being able to trade allocations to pollute up to that level (Harrison, 2012).

The key attraction of these policies is that they are theoretically the most economically efficient method to achieve emissions reduction targets as they set the private costs of emitting equal to the social costs of climate change (Ekins & Barker, 2001). Market-based approaches facilitate carbon emitters reducing emissions across a range of sectors and sources, as there is an economic incentive to reduce emissions in any way possible (Carbon Pricing Leadership Coalition, 2017). This ensures that the impact of the policy is proportionate to each sector's contribution to carbon emissions. As each emitting firm has knowledge about its marginal costs of increasing or reducing emissions, they can determine how to achieve the reductions in the most cost-effective way, meaning that changes in emissions should be achieved at least cost (Wills, 2020). The efficiency of these policies for businesses is crucially important, as increased costs experienced by businesses are likely to be passed on to consumers. It is important that any additional costs to business that are passed through to consumers are kept as low as possible to maintain public support for environmental reform.

It is also considered that market-based approaches, by increasing the costs of emissions-intensive technologies relative to cleaner technologies, would spur innovation of less carbon-intensive technologies and business practices (da Cruz, 2022). It is expected that firms would be incentivised to gain a competitive advantage over rivals by developing technologies that are not subject to a carbon tax or require the purchase of pollution permits.

In ideal settings, if policymakers have accurately set the ideal level of pollution or the true cost of pollution, this should result in the optimum level of pollution being reached at least cost to businesses and consumers. This has been referred to as the socially optimal 'first best' outcome (Fowlie et al., 2016).

Of course, there are a number of reasons why policymakers may not be able to achieve this outcome.

One difficulty is setting the appropriate tax or cap on emissions. If the price is set higher than the true cost of emissions, then the cost to the economy will be disproportionate to the social costs of carbon emissions. If the price is set too low, then emissions will not be reduced to safe levels. Patnaik and Kennedy (2021) reported that the US environmental protection agency estimated the true cost to be US$36 per tonne of carbon in 2015, US$46 in 2025, and US$50 by 2030. Alternatively, the International Monetary Fund suggested that US$75 per tonne would be appropriate. However, very few existing carbon prices fall within that broad range, with only 3.76% of global emissions being subject to carbon prices between US$40 – 80 per tonne of emissions (Patnaik and Kennedy, 2021). This shows that carbon pricing is being under-utilised, as a limited amount of emissions are subject to it, and to the extent that it is being used, it is being set considerably lower than is necessary to reduce emissions to socially optimal levels.

Another issue is that unless these policies are implemented and enforced across countries and regions, they can result in 'emissions leakage' (Cullenward, 2014). In order to avoid the increased costs, firms may shift the emitting portions of their business to jurisdictions which do not charge, or do not charge as much, for emissions. If a firm is incentivised to shift operations to a jurisdiction with weak enforcement controls, then these policies risk increasing net emissions.

The following section will analyse in greater detail how successful these policy approaches have been in practice.

2.2 Evaluation of implementations

The strong theoretical support for market-based policy approaches has resulted in many examples of governments implementing such policies. Currently, 70 carbon pricing initiatives have been implemented, covering 47 national jurisdictions (The World Bank, 2023). This provides a great opportunity to evaluate these policies to identify what results these policies have achieved.

A 2018 study (Narrassimhan et al., 2018) assessed the implementation of ETSs across eight jurisdictions (The European Union (the EU), Switzerland, the Regional Greenhouse Gas Initiative, California, Québec, New Zealand, the Republic of Korea and China).

The study attributed emissions reductions across all jurisdictions to the respective schemes, although it noted that identifying the amount of reduction caused by the scheme was difficult due to other concurrent emissions reduction policies. The overall environmental effectiveness of the program ultimately depended on how ambitious the program design was, with programs such as those in California and Quebec which had the broadest coverage and emissions caps which tightened over time resulting in the greatest emissions reductions. Programs in China and New Zealand had significant exemptions and consequently performed worse. In assessing the economic efficiency of the programs, the study concluded that economic efficiency was improved when the program was implemented economy wide.

Analysis of the EU's ETS is complicated by the significant co-occurring economic disruptions, including the 2008 Global Financial Crisis (GFC) (Alessi et al., 2011). Bel and Joseph (2015) sought to distinguish ETS and GFC effects in contributing to EU emissions reductions. The paper suggests that much of the reduction in emissions that had been attributed to the ETS was due to the significant downturn in economic activity following the crisis, with only approximately 11-14% of total emissions reductions over the period being attributable to the ETS. The authors concluded that policymakers need to be more willing to adjust the emissions cap and allocations in line with market conditions, to ensure that the allocations are sufficiently scarce to incentivise transitions away from emissions.

Another prominent example of an ETS is the cap-and-trade program which came into effect in the US state of California in 2013. The program was part of a suite of policies designed to reduce emissions to 40% below 1990 levels by 2030. Martin and Saikawa (2017) found that the policies had caused significant reductions to California's emissions, however they were unable to disentangle the effect of the cap-and-trade program from other policy initiatives such as mandatory emissions reporting and emissions performance standards. Da Cruz (2022) assessed the program's effect on promoting innovation related to cleaner technology, which is one of the theoretical advantages of market-based approaches. He found that the program caused the number of successful patent filings for clean technology to increase each year over 2011 -2015, concluding that the program resulted in increased eco-innovation in the state. Importantly, this covers a period before the program came into effect (2011-2012), which indicates that significant environmental innovation occurred in anticipation of the program. However, Cullenward (2014) suggests that there has been significant leakage of carbon emissions out of California's carbon market, indicating that, even if the program did reduce the emissions for California, its effect on emissions in general may have been minimal.

Although less common than ETSs, there is also evidence on the effectiveness of carbon taxes.

The foremost of these is the carbon tax implemented by the Canadian province of British Columbia in 2008, set at C$30 per tonne of CO2. The carbon tax was found to have resulted in a reduction of between 5 – 15% of overall emissions for the province by 2015 (Murray & Rivers, 2015), over which time it had little to no adverse effect on the overall economy, although there was some evidence that emissions had increased over this period in other provinces. Interestingly, the research also found that public attitudes went from being initially against the tax, to being supportive of the tax 3 years post-implementation. This suggests that public concerns about economic and job impacts may be eased by evidence and experience that the scheme has minimal adverse impact on the economy and jobs. The observation that the carbon tax had little impact on the aggregate economy of the province was supported by Yamazaki (2017), who suggested that the carbon tax increased employment in the province by 0.74 percent annually, which included a transition from carbon-intensive and trade-sensitive industries towards clean service industries. Pretis (2022) is slightly less bullish on British Columbia's carbon tax, finding that, although the tax reduced carbon emissions in the transport sector, impacts on aggregate emissions were minimal. The authors suggest that the price of the carbon tax was too low to achieve rapid aggregate emission reductions.

There has also been evaluation of the United Kingdom carbon tax, introduced as the Carbon Price Support for the UK electricity sector in 2013. Abrell et. Al (2019) used a machine learning approach to conduct an ex-post analysis of the policy and found that it reduced emissions from the electricity by 6.2% from 2013 – 2016. Over this period there was a cost of €18.2 to consumers and businesses for each tonne of carbon reduced. Leroutier (2019) found that the policy had an even stronger effect, asserting that it caused a reduction of 41 – 47% in UK power generation emissions from 2013 – 2017.

This suggests that market-based approaches have successfully reduced emissions, although not as significantly as might have been expected. Given the time pressure of acting on climate change, this may be of significant concern. This is consistent with some academic research which suggests that the strengths of market-based instruments have been overstated.

Green's (2021) review of ex-post analyses of carbon pricing found that although carbon pricing did result in emissions reduction, the magnitude was extremely small, in the range of 0 - 2% per year. The paper contrasts this with the IPCC position of emissions needing to fall 45% below 2010 levels by 2030 to suggest that carbon pricing as currently operating is not enough to achieve carbon reduction goals. The paper also notes that carbon taxes achieve greater reductions than ETSs. Rosenbloom et al., (2020) builds on this point to suggest that the time imperative of climate change means that the overall reduction of emissions should take precedence over the efficiency of the reduction, meaning that if market-based approaches are not achieving the desired results, more drastic interventions should be preferred (Patt & Lillistam, 2018).

A potential explanation for why a carbon tax or an ETSs may not achieve sufficient reductions is that, although carbon pricing does incentivise reducing the carbon intensity of business practices, the reduction may come from optimising existing practices rather than transforming practices entirely. If this is the extent of carbon reductions then there may not be the broadscale transformation away from carbon reliance needed to avert the most significant impacts of climate change (Tvinnereim & Mehling, 2018).

All this does not suggest that the theory behind market-based approaches is wrong and that the policies cannot account for these factors, but rather that the policies have not been appropriately designed (Weisbach & Metcalf, 2009). Although, as will be discussed in 2.3, this may not be easily fixable, given the political challenges of these policy issues (Rosenbloom et al., 2020).

There is evidence, however, that jurisdictions have been applying learnings from other examples of market-based approaches (Haites, 2018) in designing their own policies, indicating that the effectiveness of policies may improve over time.

The following section will look at what lessons jurisdictions looking to implement market-based approaches can learn from existing schemes.

2.3 Lessons learnt

The most important conclusion from 2.2 is that merely implementing a carbon tax or ETS is not a solution for reducing emissions, but it is rather the design of the policy that determines its success. Evidence suggests that the closer carbon pricing is set to the true social cost of carbon and to full coverage of the economy, the greater the emissions reduction. However, too often the carbon price has been set too low, or confined only to certain sectors, such as power generation or transport. Across the board, this has prevented emissions targets from being reached, as emissions from sectors not covered by the price scheme will continue to be priced lower than the true social cost.

The difficulty that many jurisdictions have experienced with administering their carbon prices highlights the importance of considering what level of administrative capacity a government has. Carbon taxes are considered easier to implement and operate than ETSs

(Patnaik & Kennedy, 2021). This is because carbon taxes allow governments to utilise their extensive experience in setting and collecting taxes, whereas establishing an ETS requires governments to set the desired cap of carbon emissions, distribute allocations, and establish and supervise a platform for the trading of these allocations (Green, 2021).

More broadly, however, the conservative way these schemes have been implemented does point to the fact that the policies are relatively new, creating a desire to proceed cautiously in case there be unintended consequences. It also demonstrates that political considerations can hinder the implementation of carbon pricing given the often-toxic nature of climate change politics.

Obtaining popular support for carbon pricing can be extremely difficult, as governments are sometimes required to impose short-term costs on consumers to avoid long-term consequences. As these long-term consequences can be difficult for some people to comprehend and in some cases would not be fully realised until future generations, there can be a lack of willingness from people to accept higher costs. Mildenberger (2020) argues that these consumer concerns have been effectively exploited and weaponised by carbon polluters to form fierce opposition to efforts to price carbon or otherwise regulate emissions. Harrison (2012) in their evaluation of Baldwin's (2008) assertion that ETSs are more politically viable than carbon taxes, concluded that, even when a popular leader holds a parliamentary majority, carbon pricing by stealth is still preferred due risk of public opposition to carbon taxes.

Raymond (2020) suggested that clear communication to the public about how the policy is reducing emissions can lead to increased support, as well as 'environmental earmarking' of revenue from such schemes. Other potential approaches to garner popular support include using revenue to address public health issues caused by pollution and to promote green economic development. Amdur et al. (2015) similarly observed that publicly earmarking funds for 'green' research and development could achieve support across the political spectrum. Raymond (2020) did, however, caution policy makers not to focus too heavily on these aspects at the expense of helping consumers deal with potential energy cost increases. Raymond argued that the Canadian state of Ontario ultimately failed in their effort to implement carbon pricing due to their failure to address concerns about consumer prices.

This supports the strategy proposed by Carrattini et al. (2019) to build support for carbon pricing, which is to transfer revenues to people in the form of per-capita pay-outs, which they have termed 'climate dividends'.

However, accompanying carbon pricing with financial support may not guarantee public support, as Mildenberger et al. (2022) found that carbon pricing rebates in Switzerland and Canada had little effect, largely due to low public awareness. Even when researchers informed people of the rebate amounts, the effect was minimal in Switzerland and negative in Canada as some subjects took the rebate as a signal that the carbon pricing was increasing household costs. Researchers concluded that opposition to carbon pricing was largely driven by partisan allegiances rather than the impact of the scheme on an individual voter.

Bergquist et al. (2020) studied efforts to build public support for carbon pricing in the US by bundling it with a package of other economic policies. They found that support for climate pricing increased when it was bundled with social and economic reforms such as affordable housing, a $15 minimum wage, or a job guarantee. Clean energy standards were also found to increase support for climate policies. Researchers also noted that the support for the reforms which accompany the carbon pricing is key to its support.

These challenges highlight the importance of not relying on a single market-based approach as a panacea for emissions reduction, showing that there is still a place for other instruments to supplement the core policy. Other instruments may also help ensure that emissions reductions continue if there is insufficient popular support for market-based approaches.

Tvinnereim and Mehling (2018) observed that although carbon prices have constrained emissions, such policies have not yet resulted in significant reductions. They proposed that a strong carbon policy platform would involve multiple instruments, including technology mandates and support for innovation, alongside carbon pricing. Georgiev et al. (2011) made a similar observation, noting that the EU ETS on its own was unlikely to achieve desired emissions reductions and that it should be coupled with other instruments, such as those encouraging green technology.

Similarly, Wara (2014) found that, in relation to California's climate policy, although its cap-and-trade program gets most of the attention, it is the other energy and climate programs (including tailpipe emissions standards, low carbon fuel standard for gasoline, energy efficiency standards, and a renewable portfolio standard for electricity utilities) which do most of the work in achieving emissions reductions. Martin and Saikawa (2017) found that US states who employed regulatory instruments such as mandatory greenhouse gas reporting and public benefit funds achieved significant emissions reductions. Cullenward and Victor (2020) stated that regulation is "doing most of the real work in cutting emissions." Other non-market instruments have achieved success, such as Germany's subsidisation of renewable energy sources in 2000 resulting in increased uptake in renewable energy and a reduction in costs (United Nations, 2014).

This suggests that non-market approaches should play a role alongside market approaches. The difficulties associated with successfully setting allocations for market instruments, as well as the leakage risk associated with the lack of a consistent global carbon price mean that non-market approaches can play an important role in the overall suite of carbon reduction policies (UNFCCC, 2014).

However, on balance, for countries with the capacity to establish robust carbon markets, market-based approaches will achieve the greatest reduction in emissions at least cost to consumers and businesses. This suggests that while there is likely still a place for non-market approaches, market-based approaches should be considered as the cornerstone of a country's carbon policy. The key is then to ensure that the cap is set correctly.

3. Application

Having established the theoretical framework for market-based approaches and assessed previous implementations, the next section will assess Australia as a case study for implementing such a policy. It will first provide an overview and analysis of Australia's previous attempt at implementing a carbon price. It will then conduct an empirical analysis of the likely impact of a carbon price on Australia's emissions.

3.1 Australia's 2011 carbon price

To gauge the appropriateness of Australia implementing a carbon pricing policy to reduce carbon emissions, it is important to first assess what happened when Australia last attempted it. Through the *Clean Energy Act 2011* (the Act), it appeared that Australia had managed to implement a form of carbon pricing which would achieve its emissions reductions targets at least cost to the Australian economy. Although commonly referred to as a 'carbon tax', the main objective of the Act was to introduce a cap-and-trade ETS beginning in the 2015-16 financial year (Centre for Public Impact, 2017). In the lead up to the scheme commencing, industries subject to the scheme were required to pay a tax per tonne of carbon emitted between 2012 – 2015. The cost of a carbon unit was set to $23 in 2012-13 and rose to $24.15 in 2013-14. This carbon price applied to entities emitting more than 25,000 tonnes of carbon per year, with carve-outs for agriculture and transport. It was estimated that the price covered approximately 60% of Australia's carbon emissions (Clean Energy Regulator, 2021)

At the time of introduction, there was significant concern about the politics of pricing carbon. Attempts by the Rudd government to implement an ETS in 2009 had failed and resulted in then-opposition leader Malcolm Turnbull being replaced by Tony Abbott, who pledged to prevent its implementation (Sydney Morning Herald, 2009). To mitigate public opposition and ensure that households would not be worse off, a range of measures were introduced alongside the tax, including:

- The Jobs and Competitiveness Program and coal fired generation assistance (The Act) which gave free carbon units to 'emissions-intensive trade-exposed activities' and coal-fired electricity generators.
- Reductions to personal income tax for earnings below $80,000 (Sampson, 2011).
- Increases to government payments (such as pensions, payments to students, and unemployment benefits) by approximately $7 billion (Centre for Public Impact, 2017).

Ultimately, however, these measures were unsuccessful as the Liberal/National Party opposition campaigned, and were elected, on a 'pledge in blood' to 'axe the tax' (SBS, 2013), which they duly fulfilled by repealing the Act on 17 July 2014. Understanding what contributed to this public opposition is key to building support for future climate policy.

Crowley (2017) highlighted how Abbott's focus on "folksy wisdom" promoted the idea that carbon pricing would significantly increase household costs by increasing expenses associated with traditional energy sources such as coal. Copland (2017) argued that the opposition to the scheme arose from ‘anti-politics,’ in which the policy was framed as appealing to wealthy liberal elites at the expense of regular working people. Opposition campaigns ultimately resulted in widespread misunderstanding of the impacts of the scheme. For instance, 50% of voters thought that the scheme would significantly increase fuel costs (fuel was exempt from the scheme) and 40% of voters thought it would significantly increase grocery costs (actual increase was forecast as under $1 per week) (The Centre for Policy Development, 2012).

Interestingly, however, support for the scheme grew over the course of its implementation. Disapproval of the scheme dropped from 52% in 2012 to 30% in 2014, with approval increasing from 28% to 34% over this period (Cox & Arup, 2014). This is consistent with observations made by Murray and Rivers (2015) that public support for the carbon tax implemented in British Columbia increased over time as initial fears of significant cost increases failed to eventuate.

Hammerle et al. (2021), now several years removed from the ‘carbon tax’ debate, found that Australians broadly trusted the government to operate such a scheme and that there was a negligible preference between framing the policy as ‘carbon tax’ or carbon price’, suggesting that the tax label may no longer be toxic. They also found that public support was increased when the policy was accompanied by support for low-income households and when tax revenue is clearly devoted to development of cleaner technology.

Unfortunately, due to the premature repealing of this policy, it is difficult to assert whether or not the program was a success. However, there is some evidence that there was a reduction in emissions due to the scheme. O’Gorman and Jotzo (2016) found that over the 2 years that the carbon price was in effect, overall emissions in Australia decreased by 8.2% compared to the two years prior, which they attributed to households and businesses responding to a 10% increase in nominal retail household electricity prices and 15% increase in industrial electricity prices. However, they also noted that due to the significant uncertainty about the longevity of the scheme, there was very little transition of investment from coal to cleaner technologies. The conclusion that the scheme was causing reductions in emissions was supported by the significant increase in electricity emissions which immediately followed the repeal of the carbon price (Taylor, 2014).

Even if it is unclear how much emissions reduction was caused by the carbon price, Freebairn (2014) suggests that it was more effective than the alternative policy suggested by the opposition which would provide subsidies to firms who opted to reduce their emissions. Freebairn favoured carbon pricing as being more cost effective, simpler, and having better distributive outcomes.

3.2 Predicted impact of carbon pricing scheme

For Australia to consider introducing a major carbon pricing scheme, it is important to understand what effect it would have on Australia's emissions, to ensure that it is set at an appropriate level.

Fortunately, there is a significant research base in this field. The American Congressional Budget Office (2021) has published research forecasting how carbon dioxide emissions would respond to a carbon tax. These estimates are derived from the price-sensitivities of various sources of carbon emissions, which refers to the magnitude by which emissions will reduce in response to a unit increase in price. The analysis then models the responses of emissions to various tax levels across different emissions sources. If conducted accurately, this will show both what price increase is required to achieve the desired reductions, as well as what the emissions will be under the scheme, to inform revenue estimates.

The Australian Treasury published similar research (2011) to support the release of its carbon price, comparing different price levels for impact on Australian emissions and the economy.

For the calculations in this paper, the methodology published by the World Bank (2020) for calculating the impact of a carbon tax will be used. The World Bank's paper seeks to provide a straightforward and easily replicable methodology for estimating the impact of a carbon price on fuel use. The formula used to represent the change in consumption due to the introduction of a carbon price is:

$$Q_{Ctax,i} = Q_{BAU,i} * \left(\frac{P_{Ctax,i}}{P_{BAU,i}}\right)^{\varepsilon_i}$$

Where:

- $Q_{Ctax,i}$ is the quantity of fuel (of type i) used under the carbon tax
- $Q_{BAU,i}$ is the quantity of fuel (of type i) used under business as usual (BAU) settings
- $P_{Ctax,i}$ is the price under a carbon tax
- $P_{BAU,i}$ is the BAU price
- ε_i is the price elasticity of fuel i.

3.2.1 2030 BAU projections for fuel prices and consumption

The first step is to obtain projections for Australia's 2030 fuel prices and consumption to act as a baseline for later comparisons.

Table 1: 2030 BAU projected fuel prices and consumption

Australia, BAU Projections, 2030	Projected Fuel Prices 2030 Price, post-GST ($AUD/GJ)	Projected Fuel Consumption 2030 Current Policy Scenario (Petajoule(PJ)/y)
Coal	3.696	1251

Natural gas	10.428	1833
Crude oil	15.928	1866.3

Price projections: The World Bank (2021), subject to 10% goods and services tax (GST)
Fuel consumption: Department of Climate Change, Energy, the Environment and Water (2022), average growth from 2014 – 2021 (since repeal of carbon tax) extrapolated until 2030.

3.2.2 Calculate carbon tax

The next step is to define the carbon tax. This paper will compare three levels of tax:

- \$25/tC02, approximately the level of Australia's 2014 carbon price
- \$75/tC02, Patnaik and Kennedy's (2021) estimation of an appropriate carbon price (US\$50)
- \$112/tC02, the IMF's estimation of an appropriate carbon price (US\$75).

The tax is represented per gigajoule (GJ) of fuel by multiplying the tax per tonne of CO2 by the emissions factor of each fuel.

The emissions factor is the amount of carbon emitted for each GJ used of a fuel (IEA, 2018).

E.g., for coal under a \$25/tCO2 tax, the carbon tax per GJ would be:

$$Carbon\ tax = 25 * 0.0946 = 2.365$$

Table 2: Carbon tax calculations \$25/tCO2

Fuel	Emissions Factor (tCO2/GJ)	Carbon Tax per GJ
Coal	0.0946	\$2.365
Natural Gas	0.0561	\$1.4025
Crude Oil	0.0733	\$1.8325

Table 3: Carbon tax calculations $75/tCO2

Fuel	Emissions Factor (tCO2/GJ)	Carbon Tax per GJ
Coal	0.0946	$7.095
Natural Gas	0.0561	$4.2075
Crude Oil	0.0733	$5.4975

Table 4: Carbon tax calculations $112/tCO2

Fuel	Emissions Factor (tCO2/GJ)	Carbon Tax per GJ
Coal	0.0946	$10.5952
Natural Gas	0.0561	$6.2832
Crude Oil	0.0733	$8.2096

3.2.3 New prices

As Australia's goods and services tax (GST) applies (in effect) to the final market prices of products, the increased cost due to a carbon tax needs to be calculated in a manner that incorporates GST. The new fuel price is:

$P_{WithCtax,i} = P_{BAU,i} + (1 + GST)(\, t * EF_i)$
(Noting that the $P_{BAU,i}$ already incorporates GST)

For example, for coal under a $25 carbon tax, the new price would be:
$P_{WithCtax,coal} = 3.696 + (1.1\ x\ 2.365) = 6.2975$

This represents a price change factor: $\frac{6.2975}{3.696} = 1.7038$

Table 5: Post-tax estimated prices $25/tCO2

Fuel	Post-tax price	Price change factor
Coal	$6.2975	1.7038
Natural Gas	$13.0136	1.2479
Crude Oil	$19.5366	1.2266

Table 6: Post-tax estimated prices $75/tCO2

Fuel	Post-tax price	Price change factor
Coal	$11.8701	3.2116
Natural Gas	$16.0991	1.5438
Crude Oil	$23.5681	1.4797

Table 7: Post-tax estimated prices $112/tCO2

Fuel	Post-tax price	Price change factor
Coal	$15.7203	4.2533
Natural Gas	$18.3823	1.7628
Crude Oil	$26.5514	1.6670

3.2.4 Estimate 2030 fuel usage under a carbon tax

The next step estimates the effect of the new prices on the demand for, and ultimately the usage of, these fuels. These estimates use the following estimates for the price elasticities of different fuel types, which are based on the work of Labandeira, Labeaga and López-Otero (2017).

Table 8: Price elasticities by fuel types

	Short term elasticities (under 1 year)	Long term elasticities (over 5 years)
Coal	-0.2	-0.6
Natural gas	-0.17	-0.68
Oil products	-0.2	-0.6

As the forecast year is 2030 (over 5 years from present), the long-term estimates are used.

The calculation methodology is as follows:

Fuel use compared to BAU: $Price\ Change\ Factor^{Fuel\ Elasticity} = Usage\ Change\ Factor$

For coal under a $25 carbon tax, this would be $1.7948^{-0.6} = 0.7040$

New fuel use becomes: $Original\ Projected\ Fuel\ Use * Usage\ Change\ Factor$

Table 9: Post-tax estimated fuel use $25/tCO2

Fuel	Usage change factor	Projected fuel use (PJ/y)
Coal	0.7040	880.7399
Natural Gas	0.8602	1576.7405
Crude Oil	0.8847	1651.0479

Table 10: Post-tax estimated fuel use $75/tCO2

Fuel	Usage change factor	Projected fuel use (PJ/y)
Coal	0.4966	621.1900
Natural Gas	0.7443	1364.3336
Crude Oil	0.7905	1475.2895

Table 11: Post-tax estimated fuel use $112/tCO2

Fuel	Usage change factor	Projected fuel use (PJ/y)
Coal	0.4195	524.8337
Natural Gas	0.6801	1246.6496
Crude Oil	0.7359	1373.4729

3.2.5 Estimated change in emissions

Emissions are calculated as follows:

$$Emissions_i = Q_i * EF_i$$

For coal under a $25 carbon tax, this would be $880.7399 * 0.0946 = 83.3180$

The following tables present the projected emissions under BAU settings and under the different levels of carbon tax, showing the expected emissions reduction.

Table 12: Estimated post-tax emissions reduction $25/tCO2

Fuel	BAU emissions projection for 2030 (MTC02/y)	Emissions projection with carbon price for 2030 (MTC02/y)	Difference (MTC02/y)	Percentage Reduction
Coal	118.3446	83.3180	37.1642	29.5971%
Natural Gas	102.8313	88.4551	14.3762	13.9804%
Crude Oil	136.8000	121.0218	15.7782	11.5338%
Total	357.9760	292.7949	68.7648	18.2082%

Table 13: Estimated post-tax emissions reduction $75/tCO2

Fuel	BAU emissions projection for 2030 (MTC02/y)	Emissions projection with carbon price for 2030 (MTC02/y)	Difference (MTC02/y)	Percentage Reduction
Coal	118.3446	58.7646	59.5800	50.3445%
Natural Gas	102.8313	76.5391	26.2922	25.5683%
Crude Oil	136.8000	108.1387	28.6613	20.9512%
Total	357.9760	243.4424	119.827	31.9948%

Table 14: Estimated post-tax emissions reduction $112/tCO2

Fuel	BAU emissions projection for 2030 (MTC02/y)	Emissions projection with carbon price for 2030 (MTC02/y)	Difference (MTC02/y)	Percentage Reduction
Coal	118.3446	49.6493	68.6953	58.0469%
Natural Gas	102.8313	69.9307	32.8943	31.9886%
Crude Oil	136.8000	100.6756	36.1244	26.4068%
Total	357.9760	220.2556	137.7204	38.4720%

Table 15: Estimated post-tax emissions compared to 2005 levels

Tax rate ($/tCO2)	2005 Emissions from Coal, Natural Gas, and Oil (MTC02)	Emissions projection for 2030 with carbon price (MTC02)	Percentage Reduction
$0	374.43	357.9760	4.3944%
$25	374.43	292.7949	21.8025 %
$75	374.43	243.4424	34.9832%
$112	374.43	220.2556	41.1758%

4. Discussion

As expected, in line with the general theory around pricing externalities, implementing a tax on carbon decreases demand for carbon intensive fuels, with a higher tax resulting in greater reductions. The calculations in 3.2 highlight the importance of setting a carbon price appropriately high to meet international emissions reduction targets. As controversial as the carbon price implemented in Australia in 2012 was, if a new carbon price were set at that level, without other emissions reduction policies, Australia would fall significantly short of its emissions target, only reducing emissions by 21.80% by 2030 compared with 2005 levels. In fact, to achieve its emissions reduction target, Australia would need to slightly exceed the IMF's estimated tax ($112), with an even higher tax required to achieve emissions reductions more in line with the IPCC's recommendation of reducing emissions 45% below 2010 levels in 2030.

The necessity for a higher price than suggested by the literature is likely caused by the delay in introducing a carbon price. This is because the longer that the negative externalities of emissions are unpriced, resulting in higher emissions, the higher the environmental cost of additional emissions will be. This would need to be reflected in the carbon price.

The imperative for implementing a price as soon as possible is further illustrated by the price elasticities of demand for fuels, as the work of Labandeira, Labeaga and López-Otero (2017) shows a large discrepancy between short- and long-term elasticities. The emissions reductions associated with various tax levels presented in this paper assume the long-term elasticity as 2030 is over 5 years from present. However, if the implementation of a carbon price is delayed such that the actual elasticity is closer to the short-term elasticity, then higher tax rates would be required to achieve the same reduction in emissions. This is concerning as a higher tax would result in significant costs being imposed on consumers, placing financial pressure on low-income households and reducing the political viability of a carbon price. It should also be noted that even without the introduction of a carbon price, Australia's emissions are forecast to fall 4.39% by 2030 compared to 2005 levels due to changing fuel mixes and uses.

Also of interest, is how the consumption of different fuels is expected to change in response to a carbon price. Table 14 shows that for a $112 carbon tax, coal use would decline by 58.05% from its current projection by 2030, compared with a 31.99% reduction for natural gas. This discrepancy is predominantly due to differences in the emissions factors of the fuels, with coal being highly carbon intensive and thus more affected by a carbon price. This holds significant implications for sectors and communities reliant on coal.

Although the primary interest of economists is to develop a policy which reduces emissions at least cost, the political failure of previous attempts to implement carbon pricing makes it important to consider the political implications of re-introducing carbon pricing in Australia. It is likely that such a policy would require some level of bipartisan support so that it is not repealed or weakened when there is a change of government. If not, and the tax is repealed or reduced before 2030, then emissions will revert closer to BAU forecasts.

An important element of minimising public opposition is to acknowledge, and develop policies to address, the inequality effect of a carbon price. Carbon prices are a regressive form of tax (Nielsen, 2010), and increasing the cost of fuel will place financial pressure on low-income households. Fortunately, the revenue-raising nature of a carbon price (either through collecting tax or selling emission permits) gives policymakers a number of options to develop targeted measures that compensate people adversely affected. Policies that could be considered include lump sum payments, energy rebates, or tax subsidies. Although such policies would change the relative price of energy, they would be important to minimise adverse welfare impacts for low-income households and to reduce opposition to the scheme. The research discussed in 2.3 suggests that transfers have had mixed results in increasing support for carbon pricing. However, given how potent the economic campaign was against Australia´s 2011 carbon tax, it is likely that some form of compensation would be necessary. The key lessons for building support for carbon pricing is that there should be clear communication about the policy and its aspirations, as well as about any complementary policies, especially those designed to reduce the burden of the tax. Additionally, research has found that support for carbon pricing tends to increase when revenue is used to fund green technology research and development. The work of Hammerle et al. (2021) suggests that accompanying a carbon price with support for low-income households and devoting tax revenue to clean technology would increase support in an Australian context. In many ways the design of these approaches will be as important as the design of the carbon price, as they will strongly influence the longevity of the scheme.

Policymakers may also wish to maintain non-market-based instruments, such as subsidising the uptake of newer technologies like solar panels, electric vehicles and more efficient or non-gas appliances, alongside a carbon price. Such policies have been shown to successfully reduce emissions, even if not at least cost, and tend to be more popular than carbon pricing. It would also ensure that the government would not be placing all of its emission reduction ´eggs´ in the carbon pricing ´basket´, which may be appropriate if there is significant concern that the carbon price may be at risk of repeal.

In this case, the results in Table 15 show that with a carbon tax of $25/tCO2 and $75/tCO2, for Australia to reach its 2030 target, non-carbon price policies would need to account for a

21.1975% or 8.0168% reduction from 2005 levels respectively. Whilst this is not a least cost approach, for policymakers who may be limited in their ability to implement an appropriately high carbon price, these findings inform their understanding the level of emissions reductions that would be required from non-market-based policies.

Another point to consider is how to avoid leakage of emissions outside the jurisdiction of an Australian carbon price. This will likely involve international collaboration to ensure that other countries are similarly implementing strong emissions reduction policies to reduce the incentive for firms to move business and potentially expanding the Carbon Border Adjustment Mechanism that was recently adopted by the EU and places a tariff or tax on imports of carbon intensive goods that are produced in countries that do not have stringent climate policies are in place (European Commission, Carbon Border Adjustment Mechanism (2023)).

5. Conclusion

Economic theorists have long held that carbon pricing would be the least costly method to reduce emissions to optimal levels, by pricing the negative externalities associated with emissions.

This is consistent with the results of empirical analysis conducted in this paper, which finds that introducing a carbon price would significantly reduce Australian emissions. If Australia were to implement and sustain a carbon price until 2030, in the absence of other emissions policies, a price of slightly above \$112/tCo2 would achieve Australia's target of reducing emissions 43% by 2030 compared to 2005 levels. If policymakers do not opt for all emissions reductions to be achieved by a carbon price, lower prices of 25/tCO2 and \$75/tCO2 would achieve reductions of 21.80% and 34.98% from 2005 levels by 2030 respectively. In such cases, the remaining reductions would need to be achieved by non-market-based policies.

There should be a note of caution to these results, however, which is that the success of global carbon prices in reducing emissions has been tempered by the challenging political landscape that regularly accompanies carbon pricing. Organised opposition, typically on economic grounds, has routinely reduced the effectiveness of carbon pricing by resulting in the price being set too low, only covering limited sectors or, as was the case in Australia, being repealed entirely.

To increase the likelihood of a carbon price succeeding in Australia, it is important that policies are designed to counter potential opposition. This should include policies which address the inequality effects of carbon pricing, as well as a clear public communication campaign explaining the rationale for the policy and how revenues will be used to compensate low-income households and promote green technology.

As stated above, these supplementary policies will be as important as the design of the carbon price, due to their influence over public opinion and support for a market-based scheme, and in turn the longevity of such a scheme. Further, due to the time required to implement a market-based approach and the urgency of the climate crisis, although a carbon price should be the cornerstone of global environmental policy, it is likely that it will need to be one piece in a broader, international framework of meeting emissions reductions targets, that includes a range of market and non-market-based strategies.

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