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Identifying Market Capitalization as a Leverage for Low Carbon Economy in Australia

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ABSTRACT

This study explores the relationship between market capitalization of the top listed energy companies in Australia with their CO_2 emission. The data is secondary in nature taken from World development indicators for annual records of Australia ranging from 2010 till 2022. The paper attempts to check similarities in the behaviour of the two variables through the prism of cointegration and VAR technique. Initial tests for stationarity are done through correlograms and unit root tests before applying Co-integration or VAR Approach. VAR was possible to apply due to stationarity achieved for both the variables in the same order of integration. Final results suggest an untapped leverage in the form of market capital available to redirect the flow of financing towards green initiatives.

Keywords: Energy, Investment, Market Capitalisation, Emission, Vector Autoregression
JEL Classifications: C3, G1, Q2,Q4, Q48

1. INTRODUCTION

The progress of a nation is dependent on adequate and continuous supply of energy sources. Energy is considered to be the lifeline of Australia's economy. Australia's attempt to shift from the fossil fuel sector to the clean energy is facing bumps on the road. The country's soaring demand for energy sources is finding difficult to keep parity with the supply, and therefore needs to generate and supply multiple times more of its current energy generation in the future. (Piñeiro Chousa et al., 2017). Australia is primarily dependent on conventional oil and gas energy sources for its energy needs. But it is imperative for the country to break this pattern, deviate towards green financing in order to alleviate carbon dioxide emissions. Shifting investments towards the renewable energy sector can potentially solve the issue of carbon emissions and the environmental dangers associated with it. (Dietz and Rosa, 1997). There is an urgent need to identify the market capitalization as a hidden leverage to transition into the renewable sector. There are several countries that are currently attempting to bring this behavioural change in the capital market. But this paper especially deals with market capitalization of the Australia as the sole developed nation in the southern hemisphere. But the high cost of installation and storage capacity create unreasonable pressure for investors and companies to act otherwise.

1.1. Market Capitalisation as an Indicator of the Health of the Australian Energy Sector

The market capitalisation of the energy sector has acted as a major boost in Australia's stock market with energy segment returns an averaging at 37.0% YTD compared to the overall market index weakening by 3.6% (Dec, 2022 data). The acute energy crisis is reshaping trade flows and the financial situation for the southern side of the hemisphere as well. The top energy stocks on the ASX are still led by the fossil fuel exporters (primarily natural gas and coal). Natural resources are a major reason for inflation and had higher returns than average. CO_2 emission intervention could impact future performances of the market capitalisation and vice versa.

Table 1 reflects the market capitalization of the top energy companies as listed on ASX in Australia.

Table 1: Source: https://www.listcorp.com/asx/sectors/energy

Company name	Stock price	YTD (%)	Market cap
Santos Limited	$7.10	7.49	$23.62b
Whitehave Coal Limited	$9.56	246.01	$8.62b
Origin Energy Limited	$7.25	35.26	$12.49b
Paladin Energy Ltd	$0.69	−21.59	$2.06b
Ampol Limited	$27.56	−7.22	$6.58b
Yancoal Australia Limited	$5.98	113.57	$7.90b
Woodside Energy Group Ltd	$35.09	54.79	$66.63b
Strike Energy Limited	$0.33	48.64	$706.18m
Renascor Resources Limited	$0.27	81.67	$637.48m

The above list from Listcorp.au shed light on the volume of market cap these companies hold and can therefore have huge power over influencing market valuation, including renewable energy policies, oil price volatility, environmental performance, government policies, and corporate governance. Collectively, top listed companies can lead a comprehensive understanding of these factors to redirect the key stakeholders to make informed decisions and foster sustainable growth within the Australian energy sector. Further research is needed to explore emerging trends, technological advancements, and the evolving policy landscape between market capitalisation and CO_2 emissions to ensure a sustainable and resilient energy market in Australia.

1.2. Role that Market Capitalisation can Play Towards a Carbon Free Future

Market capitalization has the potential to empower businesses the right to use the funding and to invest in carbon free technologies. It can enable the supply side the chance to transition to the renewable energy usage more smoothly. The initial knee jerk reaction of heightened economic activity of businesses can apparently show increased emissions. But with time and with increased financial freedom achieved, however, when investor confidence grows, businesses can access more affordable borrowing. This is how Market cap has the prospective power to change the energy scape to a cleaner future. Lack of finance is the primary deterrent when it comes to adoption of green technology. This creates an opportunity for market capitalisation to step up and significantly contribute to the goal of reducing carbon emissions by using green resources.

Previous studies draw mixed conclusions on the connection between capitalization and environmental impact of CO_2. Results for some studies show a positive role of the stock market in lowering emissions in industrialised economies (Paramati et al., 2018). Dauda et al. (2021) also indicates stock market enabling clean energy adoption. In this regard, Raza et al. (2020) found that stock market capitalization enhances the consumption of renewable energy, while Alam et al. (2021) found that the stock market improves the consumption of clean energy in thirty OECD nations. Le et al. (2020) and Mhadhbi et al. (2021) identify on a similar line that financial inclusion lowers carbon emissions and environmental deterioration, respectively. Contrarily, few studies (Zakaria and Bibi, 2019) reveal the conclusion that stock market capitalisation increases it.

In addition to prevailing studies, this paper explores the impact of the financial dimension through the prism of market capitalisation on environmental degradation. The research offers contributions in both theoretical and empirical fields, the most significant of which is bidirectional nature of relationship. With the new perspective, a deeper policy debate can be forged on the relationship between capitalization and the carbon dioxide emissions. The direction of causal relationship is tested using Australia's country-level time series data for the proposed relationship's validity, which is uncommon in the literature at this time. There has not been any concerted effort to combine rising stock market capitalization and CO_2 emissions from a policy standpoint. Creating a synergised secondary market to prop clean energy funding is particularly beneficial for a developed high-energy consuming nation such as Australia that rely heavily on traditional fuels.

The author in this paper highlights the time series patterns of Carbon dioxide emissions and Market capitalization and also deal with how Australia can achieve energy security, economic development and environment sustainability by redirecting market capital towards green financing (Renzhi and Baek, 2020). The issue of making economies less carbon dependent with less emission has garnered significant attention in recent years due to its role in climate change and global warming. The rest of the paper is divided into Literature Review, Methodology, Analysis and Discussion sections.

2. LITERATURE REVIEW

By synthesizing the findings of scholarly publications in this domain, it becomes evident that urgent and concerted efforts are required at the national level to mitigate CO_2 emissions and address the challenges posed by the only developed nation of the southern hemisphere. The reviewed literature provides a strong foundation for policymakers, researchers, and stakeholders to develop effective strategies and interventions aimed at curbing carbon dioxide emissions and ensuring a sustainable future for generations to come. The linkage between economic growth and environmental degradation is examined in many studies providing mixed evidence. Some of them find that the relationship between CO_2 emissions and economic growth is negative, sometimes it is initially positive then turns negative, other papers reports a positive relationship instead. Some more recent papers have used the autoregressive distributed lag (ARDL) model and a non-linear version of the same to analyse the relationship between economic growth and CO_2 emissions and concluded that there has been a positive long-term relationship between these two variables.

Several papers discuss the factors causing Carbon Dioxide Emissions. For instance, the papers by Balogh and Jambor (2017) or Jardon et al. (2017) all try to capture the factors affecting CO_2 in the southern side of the Equator. Balogh's paper uses GMM model on panel dataset of 168 countries across 24 years including the tourism sector, financial development, energy usage, trade and agriculture along with economic growth to approach the topic in a multidimensional manner. Regression results were found positive, significant for per capita GDP and negative for per capita squared GDP, confirming the standard EKC hypothesis. Moreover increase in international tourism and trade also contributes to environmental degradation by raising CO_2 levels. It has been concluded that only financial development can stimulate adoption of environment-friendly technologies to less developed countries at global level.

Liu et al. (2022) in their paper referred to the relationship between economic development and carbon-dioxide emissions on the basis of survey data of 21 European Nations for a period of 12 years from year 2006 to 2018. According to empirical findings, no regulatory interactions linking increasing economic development and reducing CO_2 emissions were found. This research examined almost all of the variables ie. earnings, power consumption, urbanization, industrial growth, foreign direct investment, and financial inclusion under consideration.

Analysis of Latin America and Caribbean countries by Ji et al. (2021), analyses the relationship between CO2 emissions per-capita and economic growth in a group of 20 Latin American and Caribbean countries over the period of 40 years from 1971 to 2011. This empirical relationship known as Environmental Kuznets Curve (EKC) hypothesis, suggests that the relationship between these variables, in the long run, follows an inverse U-shape, that is, from a certain level of per-capita income, an increased economic growth would be accompanied by improvements in environmental quality. Cederborg and Snöbohm (2016) paper aims to examine the relationship between per capita GDP and per capita emissions of the Greenhouse Gas Carbon-dioxide (CO_2) in order to observe the possible influence of economic growth on environmental degradation. Using Cross sectional data Sachs et al. (2019) conduct a study on 69 Industrial Countries and as well as 45 poor countries the relationship between economic growth and environmental degradation. The empirical results are shown interestingly different as correlation is positive, which suggests growing per capita GDP leads to increasing carbon-dioxide emissions. Economic growth is often pointed out to be the cause of environmental issues based on the notion that increased production equals increased pollution. In this paper correlation between per capita GDP and CO_2 emissions is statistically supported for both advanced nations as well as emerging countries. Haque and Rashid (2023) works on projects that have implemented clean diffusion technology adoption over the last 20 years. As Bangladesh is also one of the energy-intensive country of the global south, utilising diffusion theories shows a path towards an innovation system. Similar to Bangladesh and India, China is experiencing a rapid economic growth in recent decades, it basically relies on fossil fuels like coal and oil that emits CO_2, making it the largest emitter of carbon-dioxide in the world. According to the paper by Ouyang and Li, (2018), univariate results indicate that the two series are linked in the long run. According to this study, policymakers in China should work on environmental policies aimed at reducing emissions during the periods of economic growth. If China wants to be on a sustainable development path, decisive environmental policies are necessary, as this type of Green.

Simshauser and Gilmore (2022) deserve special mention in Australia's investment scenario for climate change domain. A constricted gas market, coal plants shutting down are all indicators of the direction of investments moving towards the renewable sectors comprising of 135 variable renewable energy projects. Despite this investment super cycle, the projects are facing unforeseen adversities such as production constraints, ex-post remediation costs, system frequency careering outside normal operating bands, and rising system operator interventions. These are mostly supply-side issues related to operational inadequacy, power-system ramping up etc. My paper however focusses more on the financial resilience of the interaction and not so much on the system interventions. The effect has even been apparent on the demand side with sharp increases in the electricity prices as well. Another demand-side study by Apergis and Leu (2015) discusses the role of climate policy uncertainties affecting the weekly wholesale electricity prices across a duration of 6 years (2008-2014). Theoretically speaking, if policies around reduction of CO_2 emissions are not robustly executed, the ambiguity around future regulations affects risk-averse investor confidence. This in turn engenders sustainable energy and economic growth. Qualms about policy regulations create confusion and discourages investments in less carbon intensive technologies. Energy (electricity) investors believe that every aspect of any risk around carbon or climate policy should be taken into account in the policymaking process. These concerns mostly include the imposition of carbon restrictions, as well as stringent legislation and the circulation of emission permits. Similar framework has also been studied previously by Laurikka and Koljonen (2006), who enumerates the value of clean energy investments under the European Union Emission trading and how it creates considerable uncertainties for potential clean technology investors. Studies by Siddiqui et al. (2007) or Lin et al. (2007), all point at a direction of policy adoption once the combined disruption of ecological and economic uncertainties, surpasses a threshold limit. Siddiqui et al. (2007) comes to this conclusion with respect to renewable energy development while Kuper and van Soest (2006) explore the disruptions in oil markets. But these studies dates back to almost a decade back and those thresholds have been crossed long back. So it is time reconsider and relook at the policies at this present context.

The path to renewable energy adoption is nonlinear, encompassing both natural and anthropogenic factors. Due to the increasing concerns on global environment due to high consumption of the fuel, the countries across the world are working on the adoption of the strategies that provide clean energy as well as conservation to the Environment. (Degiannakis et al., 2018; Le. et al., 2020). Another set of literature deal with the probable determinants of Renewable adoption (Anton and Nucu, 2020; Aguirre and Ibikunle, 2014; Karacan et al, 2021; Tambari et al., 2020). Aguirre and Ibikunle's work studies a group of countries (BRICS) on factors affecting renewable energy growth. Government backed policy designs are identifies as impediments to renewable adoption failures. Policies are inconsistent, uncertain. This research direction uses time series vector models on macro variables such as oil price, Income and CO_2 emissions on the national renewable consumption. In Karacan et al. (2021) paper the particularly the country is Russia, where it is shown a positive and statistically significant influence of real GDP per capita (as a proxy of income) on renewable energy consumption. On the other hand, carbon dioxide emissions have shown negative and statistically insignificant influence on renewable energy consumption. The ADF, PP and KPSS unit root tests are used before applying the VECM and CCR methods in the evaluation of a long-run relationship. Cases of oil price rise in several countries is distressing as it acts as an impediment to the shift from the conventional means to the Renewable Sources. It has also been noted that one of the factors that is preventing the expansion and shift towards renewable energy adoption is the countries with unfavourable climate and landforms. To counter such difficulties appropriate industrial infrastructure investments needs to be given priority as efficient renewable energy production with the traditional equipment cannot be achieved. Introducing incentive policies such as tax relief, land allocation, low interest, and long-term credit facilities can definitely go a long way in achieving the adoption process. Tambari et al. (2020) paper discusses oil price as a determinant of renewable adoption in the African country of Nigeria. Factors considered in this case study includes sensitivity to change in oil prices, Gross Domestic Product (GDP), Interest rate and oil price volatility on the Renewable Energy Investment (REI) and if there is any significant influence from oil price shocks. Vector Regressive Models are used on annual data spanning 28 years that covers period between the year 1990 and 2018. Results highlight that REI exhibited immediate positive response to oil shocks while initial immediate negative response to oil price volatility but became positive eventually after the second period. Implications again points towards macro policies from several government of Nigeria to disincentivise Oil fuel usage by removing subsidies on Oil prices and to improve financial supports for the Renewable Energy Projects along with inducting policies that supports commercialization of renewable resources. The interesting aspect of the study is that the policies do not only restrict to public spending, rather it talks about reducing public spending along with commercialising the process and hence let the forces of the market also take part in the adoption process. This also aligns with our study attempting to introduce Renewable as an investment channel.

The consequences of adopting clean energy technology are far-reaching and encompass various environmental, social, and economic dimensions. Case Study conducted by Katarina et al. (2023) demonstrate how the state's implementation processes face several hurdles in Sweden green policies. It is only expected that the subsequent higher CO_2 levels in the atmosphere leading to ocean acidification, endangering marine ecosystems and biodiversity. But in this paper, we shall focus more on the supply side financial impact of CO_2 emissions that are evident, as highlighted by Kuvshinov and Zimmermann (2022) who discusses the detrimental effects on agriculture, human health, and economic stability. These findings underscore the urgent need to reduce CO_2 emissions to mitigate these adverse effects.

Although there are limited studies to refer for finding factors that will facilitate the increase of Renewable Energy Investment (REI), some papers do investigate the factors that will influence the investment and Business Opportunities to boost Renewable Energy Sector. Factors considered by Piñeiro Chousa et al. (2017), includes sensitivity to change in oil prices, Gross Domestic Product (GDP), Interest rate and oil price volatilities on the Renewable Energy Investment (REI) and if there is any significant influence from oil price shocks in Africa. Models used are Vector Regressive Model and an Annual Data of 28 years spanning across variables that covers period between the year 1990 and 2018.

(Paramati et al., 2021) Research paper highlighted that REI exhibited immediate positive response to oil shocks, finally it exhibited immediate negative response to oil price volatility but became positive after second period. Research paper thus concluded that Government of Africa should increase financial supports for the Renewable Energy Projects such as removing subsidies on Oil prices, reduce public spending to subsidize renewable energy and inducting policies that supports commercialization of renewable resources.

With regards to literature related to the mitigation Strategies for Carbon Dioxide Emissions, most studies (Sharma et al., 2021) address through implementation of effective mitigation strategies across various sectors. Research conducted by IPCC (2018) emphasizes the importance of transitioning to renewable energy sources, such as solar and wind power, to reduce reliance on fossil fuels. Additionally, the adoption of energy-efficient technologies and practices in industrial processes can significantly contribute to carbon dioxide reduction. Studies related to afforestation and reforestation in carbon sequestration is not considered in this study as it is beyond the scope of the study. Studies that collectively advocate for a comprehensive approach combining clean energy adoption technology, policy interventions, and behavioural changes of the energy sector is to achieve substantial CO_2 emissions reductions. (Paramati et al., 2018) As a reference to industry behaviour changes and policy interventions, plenty of literature is available for North America (S&P, Dow Jones etc.) and European investment market. While Australia is also a developed continent in itself, studies of policy interventions in the energy sector are scarce. (Paramati et al., 2017) This literature review has particularly tried to examine the direction of investment behaviour through market capitalisation in the Australian energy sector. Most of the published papers on carbon dioxide emission, highlights the causes, impacts, and mitigation strategies associated with the global north. The Australian energy sector plays a crucial role in the pacific economy, driving growth, innovation, and sustainability. Understanding the dynamics of market capitalization within this sector is essential for policymakers, investors, and industry stakeholders for mitigating CO_2 emissions.

The reviewed literature has demonstrated the significant contribution of fossil fuel combustion, deforestation, and industrial processes to anthropogenic CO_2 emissions. (Velte et al., 2020). The consequences of rising CO_2 levels encompass adverse environmental, social, and economic impacts. Mitigation strategies, such as transitioning to renewable energy sources, adopting energy-efficient technologies, and promoting signalling, have been identified as crucial steps in reducing carbon dioxide emissions. When it comes to factors causing CO_2 emissions, the variables that fairly come up are income, population, tourism, urbanization or financial development which if increases, there will be proportional rise in CO_2 emission in the country. But papers have not yet addressed how to convert these weaknesses into strengths by leveraging them into clean energy adoption.

Conversely, companies that effectively manage and disclose their emissions data are more likely to attract investor confidence and witness a positive impact on market capitalization.

3. METHODOLOGY AND ANALYSIS

In this paper we try to establish a long-term pattern emerging between Market capitalisation (of listed companies in ASX) and CO_2 (metric tons per capita) through Time Series cointegration and VAR. (Ozturk and Acaravci 2013) The data range could not be taken prior to 1990 since emissions data is unavailable and market capital was made available only from 1979 to 1980 (Zhang, 2011). In such kind of an unbalanced data series the trend and structural breaks will show lack of parity and make the analysis complicated. Hence, we refine the annual range for 30 years (World Bank) starting from 1990 to show the similar trends in the pattern of the annual data taken from world development indicator for Australia between 1990 and 2020.

Figure 1 shows the market capitalization of energy in Australia from 1990 to 2020. As we can see in the graph MKCAP has been increasing since 1990 and it shows a steady rise till 2002, after which it went up till 2007 and due to global recession, it fell down badly from 2007 to 2009 but recovered and recorded the highest value in 2010. And since then, is showing an increasing trend till 2020.

Figure 2 graph is showing the CO_2 emission in Australia from 1990 to 2020. The country has been increasingly emitting CO_2 since 1990, it can be seen that the graph shows stationary till 2011 and then fluctuation occurs but again took raise high after taking a small dip in 2014. The descriptive of both the time series are also mentioned in Table 2.

Figure 1: Time series trend of market capitalization

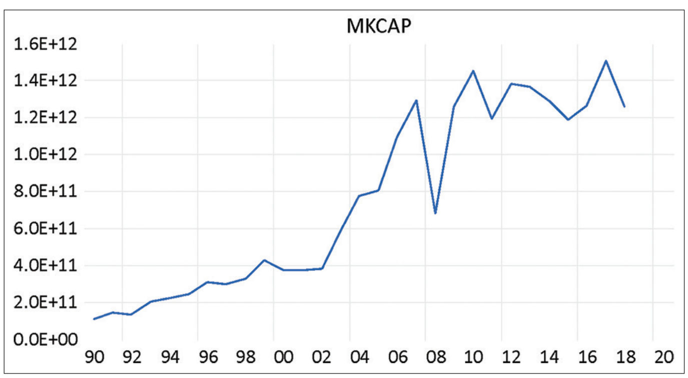
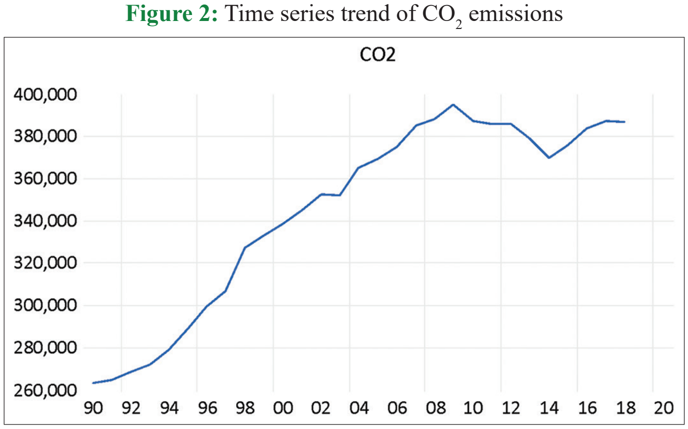
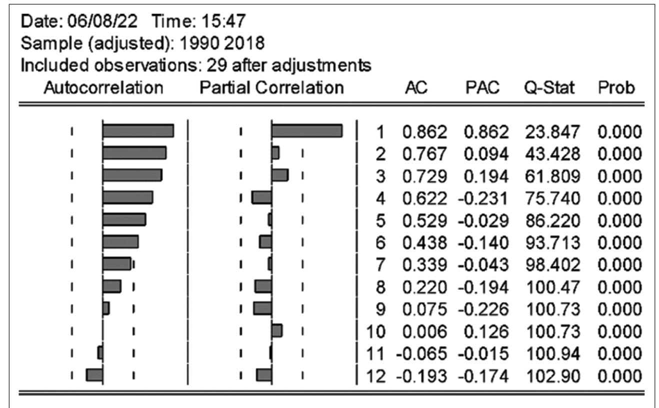


Figure 2: Time series trend of CO_2 emissions



We further visualise the data using correlograms (Figures 3-6) to display non-stationarity at level data and eventual stationarity at the first level difference. Before applying cointegration and VAR, the data range is also put through Unit root test (ADF test) for statistical validity of series (Tables 3-6) stationarity integrated at order 1 (Sadorsky, 2010, 2011).

Figure 3: Correlogram of MKCAP

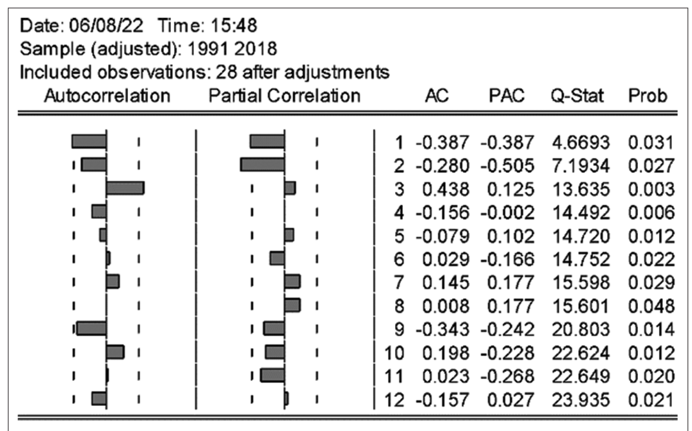


Date: 06/08/22 Time: 15:47
Sample (adjusted): 1990 2018
Included observations: 29 after adjustments

	AC	PAC	Q-Stat	Prob
1	0.862	0.862	23.847	0.000
2	0.767	0.094	43.428	0.000
3	0.729	0.194	61.809	0.000
4	0.622	-0.231	75.740	0.000
5	0.529	-0.029	86.220	0.000
6	0.438	-0.140	93.713	0.000
7	0.339	-0.043	98.402	0.000
8	0.220	-0.194	100.47	0.000
9	0.075	-0.226	100.73	0.000
10	0.006	0.126	100.73	0.000
11	-0.065	-0.015	100.94	0.000
12	-0.193	-0.174	102.90	0.000

Level

Figure 4: Correlogram of MKCAP at 1st difference

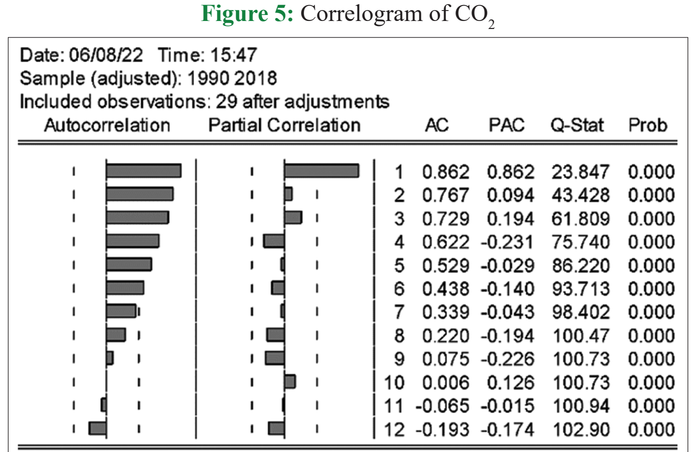


Date: 06/08/22 Time: 15:48
Sample (adjusted): 1991 2018
Included observations: 28 after adjustments

	AC	PAC	Q-Stat	Prob
1	-0.387	-0.387	4.6693	0.031
2	-0.280	-0.505	7.1934	0.027
3	0.438	0.125	13.635	0.003
4	-0.156	-0.002	14.492	0.006
5	-0.079	0.102	14.720	0.012
6	0.029	-0.166	14.752	0.022
7	0.145	0.177	15.598	0.029
8	0.008	0.177	15.601	0.048
9	-0.343	-0.242	20.803	0.014
10	0.198	-0.228	22.624	0.012
11	0.023	-0.268	22.649	0.020
12	-0.157	0.027	23.935	0.021

1st Difference model

Figure 5: Correlogram of CO_2



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10	0.006	0.126	100.73	0.000
11	-0.065	-0.015	100.94	0.000
12	-0.193	-0.174	102.90	0.000

Level

On achieving stationarity at the first difference I(1), eventually Vector Autoregressive model is applied as shown in Table 7.

H_0: Market capitalization has no long term cointegration relationship with carbon dioxide emissions.

To express the relationship in its Matrix Equation form we write equation 1 as follows

Table 2: Descriptive statistics

Parameters	MKCAP	CO2
Mean	722559684027	345271.379
Median	683871560000	365270
Mode	107935970000	385770
Standard deviation	534511753542.85	45002.1877
Skewness	0.076469935	−0.72965702
Kurtosis	−1.746140953	−0.9864

$$\begin{bmatrix} CO2t,1 \\ MKCAPt,1 \end{bmatrix} = \begin{bmatrix} \alpha 0,1 \\ \alpha 0,2 \end{bmatrix} + \begin{bmatrix} \alpha 11,1 & \cdots & \alpha 12,1 \\ \vdots & \ddots & \vdots \\ \alpha 21,2 & \cdots & \alpha 22,2 \end{bmatrix} \begin{bmatrix} CO2t-1,1 \\ MKCAPt-1,2 \end{bmatrix} + \begin{bmatrix} et,1 \\ et,2 \end{bmatrix} \qquad (1)$$

The hypothesis corresponding to this research design is as the follo-

Where CO_2 measures emission in metric tons per capita and MKCAP signifies market capitalisation of listed companies in Australia (to signify robustness of financial market).

α0=intercept for variables 1 and 2,
e_t,i=error term at time t for ith variable 1 (i=1,1)
$\alpha 1t$,i=1st coefficient for CO_2 at t=1,i=1,2; t-1= lag period of 1

Granger Causality is exercised which shows statistical bidirectional significance as shown in Table 8. Although bidirectional, it is self-

Table 3: ADF test: I (1): MKCAP model I: Trend without intercept

Null hypothesis: MKCAP has a unit root					
Exogenous: Constant					
Lag length: 0 (Automatic- based on SIC, maxlag=1)					
			t-Statistic	Prob*	
Augmented Dickey-Fuller test statistic			−7.142112	0.0000	
Test critical values:	1% level		−3.711457		
	5% level		−2.981038		
	10% level		−2.629906		
Augmented Dickey-Fuller test equation					
Dependent variable: D (MKCAP,2); least square method					
Variable	**Coefficient**		**Std Error**	**t-Statistic**	**Prob**
D (MKCAP [−1])	−2.16572		0.303232	−7.142112	0.0000
D (MKCAP[−1],2)	0.54676		0.184564	2.962442	0.007
C	1.00E+11		3.75E+10	2.674348	0.0135
R-squared	0.776189	Adjusted	R-squared		0.756727
S.E. of regression	1.76E+11		F-Statistic		39.88262
Prob (F-statistic)	0		AIC		54.73072
SIC	54.87588		D-W Stat		1.822411

Table 4: ADF test: I (1): MKCAP model II: Trend with intercept

Null hypothesis: MKCAP has a unit root					
Exogenous: Constant, Linear Trend					
Lag length: 0 (Automatic- based on SIC, maxlag=1)					
			t-Statistic	Prob*	
Augmented Dickey-Fuller Test statistic			−6.991011	0	
Test critical values:	1% level		−4.356068		
	5% level		−3.595026		
	10% level		−3.233456		
Augmented Dickey-Fuller test equation					
Dependent variable: D (MKCAP,2); Least square method					
Variable	**Coefficient**		**Std Error**	**t-Statistic**	**Prob**
D (MKCAP [−1])	−2.163413		0.309456	−6.991011	0.0000
D (MKCAP [−1],2)	0.546753		0.188298	2.903654	0.0082
C	1.23E+11		8.18E+10	1.499942	0.1478
@Trend (1990)	−1.46E+09		4.69E+09	−0.311123	0.7586
R-squared	0.777169	Adjusted	R-squared		0.746783
S.E. of regression	1.79E+11		F-Statistic		25.57656
Prob (F-statistic)	0.000000		AIC		54.80325
SIC	54.9968		D-W Stat		1.834106

Table 5: ADF Test: I (1): CO2 Model I: Trend without intercept

Null Hypothesis: D (CO2) has a unit root					
Exogenous: Constant					
Lag length: 0 (Automatic- based on SIC, maxlag=1)					
			t-Statistic	Prob*	
Augmented Dickey-Fuller test statistic			−3.618987	0.0121	
Test critical values:	1% level		−3.699871		
	5% level		−2.976263		
	10% level		−2.62742		
Augmented Dickey-Fuller Test Equation					
Dependent variable: D (CO2,2); Least square method					
Variable	Coefficient		Std Error	t-Statistic	Prob
D (CO2[-1])	−0.694322		0.194345	−4.42512	0.0002
C	3115.861		1488.791	2.09288	0.0467
R-squared	0.343782	Adjusted	R-squared		0.317533
S.E. of regression	6246.499		F-Statistic		13.09707
Prob (F-statistic)	0.0013098		AIC		20.38862
SIC	20.48461		D-W Stat		2.100514

Table 6: ADF test: I (1): CO2 Model II: Trend with intercept

Null hypothesis: D (CO2) has a unit root					
Exogenous: Constant, Linear Trend					
Lag Length: 0 (Automatic- based on SIC, maxlag=1)					
			t-Statistic	Prob*	
Augmented Dickey-Fuller Test statistic			−4.42512	0.0082	
Test critical values:	1% level		−4.33933		
	5% level		−3.587527		
	10% level		−3.22923		
Augmented Dickey-Fuller test equation					
Dependent variable: D (CO2,2); Least square method					
Variable	Coefficient		Std Error	t-Statistic	Prob
D (CO2[−1])	−0.860002		0.194345	−4.42512	0.0002
C	8989.173		3029.622	2.967094	0.0467
@Trend (1990)	−340.9913		156.3435	−2.18104	0.0392
R-squared	0.452332	Adjusted	R-squared		0.406693
S.E. of regression	5824.188		F-Statistic		9.911098
Prob (F-statistic)	0.000728		AIC		20.28187
SIC	20.42585		D-W Stat		2.096119

Table 7: Vector autoregression

Vector autoregression estimates		
	MKCAP	CO2
MKCAP(−1)	0.526605	−9.20E-09
	(0.14811)	(4.5E-09)
CO2 (−1)	4643458	1.031910
	(1624892)	(0.04972)
C	−1.20E+12	228.1562
	(4.7E+11)	(14280.7)
R-squared	0.870462	0.984321
Adj R-squared	0.860099	0.983067
Sum Sq Resids	8.34E+23	7.81E+08
S.E. equation	1.83e+11	5588.453
F-Statistic	83.99691	784.743
Akaike AIC	54.80047	20.19575
Schwarz SC	54.94321	20.33849

explanatory how CO_2 may affect Market capitalisation. There have been multiple studies which has shown the effects of financial development, economic growth (Caporale et al., 2021). But this paper establishes novelty in showing the premise of market capitalisation affecting CO_2. This can have long-term and far-reaching implications.

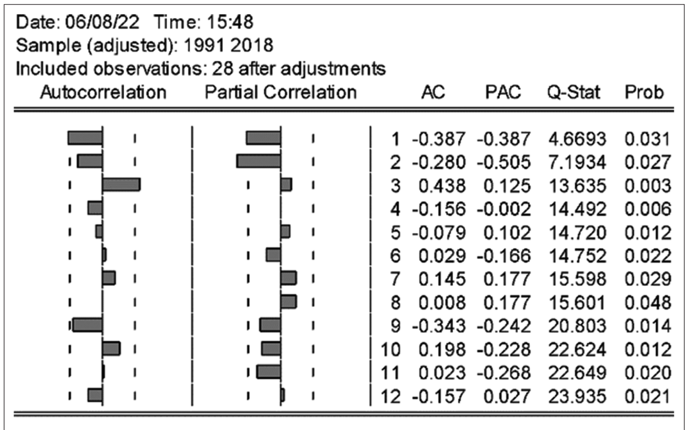
Table 8: Granger causality

Pairwise granger causality tests			
Sample: 1990-2022			
Lags: 1			
Null hypothesis	Obs	F-Statistic	Prob
MKCAP does not Granger cause CO2	28	4.12008	0.0531
CO2 does not Granger cause MKCAP		8.16646	0.0085

4. CONCLUSION AND POLICY IMPLICATIONS

VAR results interestingly show how Market capitalisation has a strong, positive cointegration with CO_2 scores at 1% level of confidence. If we delve deeper into these insights; large capitalised companies have a certain degree of expertise and the knowhow to invest in sustainable opportunities that would reduce carbon footprints. They have the leverage to take analytical and informational advantage of green possibilities due to their scale of operation and capacity. By contrast, reducing CO_2 might be an

Figure 6: Correlogram of CO_2 at 1st difference



1st Difference model

added pressure for smaller companies (unlisted with less market capital), (McGreevy et al., 2021; Nguyen et al., 2021) with less cushion to withstand high fixed costs of installing environment friendly processes or hiring analysts which often results in more information available. McGreevy's paper reemphasises this stand where public policies around privatised market system can essentially be leveraged to bring targeted transition in Southern Australia. Although Southern Australia has seen drastic measures such as half of the region's electricity generation sourced from wind and solar, yet issues have been criticised and politicised. Therefore, it is essential to bring all stakeholders to the same plane. The case study by Hosein et al. (2023) talks about the possibility of establishing a low carbon economy in the northern territory of Australia with time-appropriate and sequential usage of tapping High Energy Growth (HIG) and Renewable Energy Export (REE) as effective channels to achieve 2050 clean energy targets. Another study (Srianandarajah, 2022) in the eastern part of Australia reflect national electricity market shows the market designs aims to capture investment through spot and forward prices which is essentially a market for private players. Factors such as spot market price (investment) risk or marginal losses are identified as deterrents to the bankability of wind and solar project deployments.

In fact, the joint statement from the Australian Prudential Regulation Authority and the Reserve Bank of Australia have expressed proactive support for ways to ensure transition of financial systems toward a low-carbon economy. APRA and RBA are aware that climate transition is going to impact economic output prices and employment and the stability of the financial system of the country. Australian Securities and Investments Commission and the Australian Government Treasury which collectively comprise the Australian Council of Financial Regulators (CFR) agencies are engaged in capacity building to withstand the potential impact of climate risk. A sector specific instance is that of Australia's steel industry (Venkatraman et al., 2022) attempting to provision for co-locating iron-ore deposits with renewable energy resources for large-scale clean energy capacity building. This kind of sweeping change requires modifications in core-processes and cannot work without industry-level policy changes, funding for research and development and project financing.

Effective national as well as regional legislative frameworks are essential for promoting the clean energy adoption and achieving emission reductions. Significant measures have been undertaken by Australian government to promotion installation of electricity production infrastructure from clean energy technology. However, the success of a coordinated national effort to install renewables has been facing a lot of administrative disruptions. (Byrnes et al., 2013). The reason is due to the fact that in the current legislative environment, established technologies have received preference over developing alternatives that would offer better efficiency and carbon reduction advantages since they carry the lowest investment risk. Emerging technologies' ineffective adoption and the development of a highly trained labor pool are delayed until the medium to long term due to a lack of support. This paper outlines the alternative framework to acquaint with the private equity investors with reduced dependence on government intervention which can fulfil the efficiency requirement of the renewable energy sector.

A majority of Australian retail investors are pensioners or insurers have a high asset allocation in equities. Hence this sector is a great opportunity to channelize investment in green transition and renewable funds. In this regard, the financial markets have shown resilience in terms of fixed income securities such as green bonds while the equity market remains with untapped potential.

Greater attention to the need for institutional financing can be addressed by the IGCC (Investor group of Climate Change comprising of Australia and New Zealand with a combined AUM of $ 30 Tr. Multiple international bodies (Europe based IIGCC, Asia based AIGCC, US based INCR) have assessed the need for international finance to modernise infrastructures, renewable energy etc.

Future Direction- The country needs to successfully integrate transition measure despite facing challenges like blackouts and insufficient power sources. The paper does not expand on the underachievement or weak policy implementation which has been quite routine in countries undergoing transitions. Another premise that this present study does not address is that it focuses primarily on the link between market capital and hence the stock market of Australia. Another set of studies can also work on the relationship of the bond market wherein Australia has a fairly developed Bond (sovereign or green etc.) market in place. As per the Global Sustainable Alliance Report, Australia scores one of the highest achievers in terms of certain sustainable investment parameters (GSAR reports YOY responsible investment growth is above 40% or the ratio of responsible assets to total professionally managed assets as high as 60%). This aspect of Australia in terms of the effects of such investment orientation (Boffo, and Patalano, 2020) can also be benchmarked with that of Europe and United States.

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