

Emission Trading between Two Countries (South Africa and Malta) in a Global Cap and Trade Game

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How to cite this paper: Koroma, V., Mabea, G. A., & Sitali, M. (2025). Emission Trading between Two Countries (South Africa and Malta) in a Global Cap and Trade Game. *Low Carbon Economy*, 16, 166-182. <https://doi.org/10.4236/lce.2025.164008>

Received: October 20, 2025

Accepted: November 24, 2025

Published: November 27, 2025

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Abstract

Effective climate change mitigation requires innovative, scalable policy solutions, with market-based mechanisms like cap-and-trade systems playing a pivotal role. This study critically examines the effectiveness of emissions trading through a case study of South Africa and Malta, two fossil fuel-dependent nations with differing marginal abatement costs. Using 2013 data, the analysis demonstrates how emissions trading optimizes cost-efficiency by capitalizing on these differences—Malta, with a marginal abatement cost of €21 per ton of CO₂, generates a surplus of 887 million tons (Mt) of CO₂ reductions, which it trades with South Africa, where abatement costs are €38 per ton. A market price of €29.5 per ton incentivizes both nations, reducing total compliance costs and generating net economic benefits of €40278.5 million for Malta and €67389.5 million for South Africa. While the findings confirm the economic efficiency of cap-and-trade systems in reducing emissions at minimal cost, they also expose significant equity concerns. The disparity in net benefits between nations raises questions about the fairness of trading systems, particularly for smaller economies. Furthermore, the system's limitations in addressing diffuse emissions and achieving transformative decarbonization underscore the necessity for complementary policies, such as targeted technology investments, carbon pricing mechanisms, and stringent regulatory frameworks. This research contributes to the evolving literature by providing empirical insights into the complexities of market-based climate policies, emphasizing the need for adaptive governance structures that ensure inclusivity, equity, and long-term sustainability in global climate governance.

Keywords

Kyoto Protocol, Cap-and-Trade Systems, Greenhouse Gas Emissions, Climate

Change

1. Introduction

During the 2015 Paris Agreement on Climate Change, an international target to keep the average global surface temperature increases to below 2°C was reached. Stabilising temperature requires long-lived greenhouse gas emissions to be net zero (UNFCCC, 2015). To mitigate such profound externalities, robust infrastructures should be put in place and frameworks that support the effort of achieving the targets (Hepburn, Nicholas, & Joseph, 2020). To combat these externalities, nations ought to negotiate without including vested self-interests but with an aim of promoting cooperation.

Carbon emission has been scientifically believed to be the principal cause of global warming. For this reason, a series of global climate summits concerning emission-related issues have been held. The Kyoto Protocol, as the deepening of UNFCCC, provides a 'cap-and-trade' framework for greenhouse emissions in the transnational trade and gradually nurtures a new greenhouse emission trading market. Here, countries were allowed to choose their abatement level and hence encouraged countries to choose their quantity based on self-interest which eventually led to opportunistic behaviour (Cramton & Stoft, 2012). Emission abatement benefits are long-term and a public good, in that, any reduction of emission by one country benefits all even if the country does not abate: *free riding*¹. For this reason, countries will choose to emit more so they can yield whatever benefit they can now, even if it will lead to future catastrophes (Böhringer & Vogt, 2003). This is considered the main reason why the Kyoto Protocol has proved not so successful.

Several recent studies have been carried out supporting the subject of emission trading, the majority of which are focused on EU-ETS or SO₂ trading in America and Asia (Liu, et al., 2022b; Weisbach, 2023; Fu, 2024; Huang, et al., 2022; Liu, et al., 2022a; Zhang & Zheng, 2024; Tan, et al., 2024; Bounou & Dufau, 2024). However, some have criticized the inefficiency of EU-ETS as unable to achieve its required objective some (Kalaitzoglou, 2024; Bolat, et al., 2023).

This paper uses the proposition of Cramton and Stoft (2012) to conceptualize a framework for negotiating an agreement on a global cap and trade game between South Africa and Malta. These countries were chosen specifically because of their extensive dependence on fossil fuels² to meet their energy demand. For South Africa, their historically low cost of energy supply, together with the predominance of extractive industries, have combined to create a highly energy-intensive

¹The concept of an economic agent benefiting from a good without contributing to its provision or supply. This will lead to a situation where each consumer will expect others to pay for the supply and in the process nobody or very few will pay.

²Fossil fuel contribute over 80% of global GHG emission (ESMAP, 2011).

economy and the largest contributor to GHG in Africa. Malta's sole dependency on oil and oil products to meet its energy demand also makes them high emitters. Each country was given a target-reduce emissions to 40% below the business-as-usual level³. A certain amount of emission allowance was freely given to the countries which they could choose to trade; emissions are from electricity generation only and not all sources of emissions. The paper theoretically analyses the incentive (net benefit) provided by the cap-and-trade game.

The contribution of this study is to assess whether the global cap and trade game between the two countries provide enough incentive to both countries to encourage trade and that it is vital to focus on directly negotiating a global price.

2. Uniform Global Carbon Price

Carbon pricing has been implemented in many jurisdictions with great success. However, in some areas, it has not been received well politically. The variation is not pronounced in some countries and regions depending on institutional governance and public attitude. The reason for such disparity is hinged on the varying drivers of carbon prices. Such drivers stem from environmental, social, political economic drivers, national climate policy and country's level of development (Levi, Christian, & Michael, 2020).

The determination of proper price for pricing carbon is vital in ensuring a country benefits from the intended objective. Application of a global uniform price is considered optimal when applied at differentiated social and private discount rates. Intuitively, non-uniform pricing may promote capital accumulation (Kalsbach & Rausch, 2024; Bento & Gianfrate, 2020; Drupp, et al., 2023). According to Olijslagers, et al., (2023), there is also a direct correlation between Carbon prices and economic growth. However, when comparing the two most discussed instruments (carbon tax and Cap-and-Trade), Stavins (2022) concludes that when these two are well designed, their characteristics and outcomes give similar results and could be fully equivalent. This conclusion is disputed by other research such as Chen, et al. (2020) that show Cap-and-trade system having higher efficiency than carbon taxes on global climate change control.

Negotiation of a global price has been discussed intensively by many researchers who promote the use of uniform global price, especially where the cap and trade is considered efficient due to its property of guaranteed cost effectiveness (Weitzman, 2014). However, other studies construe that application of such uniform global price may give progressiveness while in some, it may be regressive (Sager, 2023).

Therefore, Cramton and Stoft (2012) proposed that to overcome this problem, the most efficient global climate policy is to price carbon because a uniform global price provides a focal point for cooperation.

³Directive 2003/87/EC of the European Parliament and of the Council of 13 October 2003 setting up a system for greenhouse gas emission allowance trading within the Union and amending Council Directive 96/61/EC (Text with EEA relevance) (EU Emissions Trading System (EU ETS) Directive).

3. Instruments For Reducing Carbon Emissions

Several instruments: market (cap and trade, pollution levy, carbon taxes) and non-market (technology, command, and control) systems have been proposed to reduce emissions (Krupnick & Ian, 2012). Economists argue that a market-incentive system is more effective, efficient, and equitable than traditional command and control (Wang, Muhammad, Menggang, & Shan, 2023). Microeconomics, an idea at its core is that incentives affect behavior and thereby ultimately affect the material outcome. However, the issue of market failure is considered one reason for the limited influence of environmental policies. Therefore, policymakers are faced with a dilemma of which regulatory instrument to employ for GHG control.

Market-based instruments such as cap-and-trade function to reduce regulatory costs, but because they provide no guarantee that costs will be reduced to acceptable levels it is infeasible to set caps at sustainable levels and has limited innovation (Zaklan, 2023; Calel, 2020). Emission taxes provide cost certainty, but their comparatively high cost makes it infeasible to set tax rates at levels commensurate with sustainability goals. Johnson (2007) proposed that if the priority objective of the policy is environmental sustainability, then the cap-and-trade system would be the proper regulatory instrument. This will cap emissions at a sustainable level and seeks to achieve the cap at a minimum cost. But if political imperatives favour cost acceptability over environmental goals, then a suitable instrument might be an emission tax. A tax effectively caps costs by mandating an emission price, although there is no guarantee that the tax incentive would be sufficient to achieve environmental sustainability (Agnolucci, et al., 2024).

Several studies have been done on the subject of emission trading, the majority of which are focused on EU-ETS or SO₂ trading in America. Most authorized the inefficiency of EU-ETS as it was unable to achieve its required goal. At the end of the first commitment period of 2007, the spot price for carbon eminent went to zero and this was attributed to the over-allocation of an emission allowance. However, Parsons, et al. (2009) argued that the price reaching zero may be a result of over-allocation. Ellerman, et al. (2008) support the argument that freely allocated emission allowance undoubtedly gave profits to firms compared to if the allowance were auctioned. In addition, the empirical study conducted by Soleille (2006) compares the effectiveness of both command and control and carbon trading to know their ability to reduce emissions. The study concluded that it is hard to justify which of the two is better than the other because the effectiveness depends on their goal-setting strength and not the police themselves. Kuik & Mulder (2004) proposed that at a national level, an intelligent system of energy taxation is probably the most efficient policy instrument for reducing emissions. Similarly, Agnolucci, et al. (2024) developed a methodology for calculating a total carbon price applied to carbon emissions in a sector, a fuel, or the whole economy. We recognize that rarely is a single carbon price applied across an economy; many direct carbon pricing instruments target specific sectors or even fuels, much like indirect taxes on fossil fuels; and carbon and fuel taxes can be substituted for one another.

In the recent times, the focus has shifted towards understanding economic impact of consumption-based CO₂ emissions (CCO₂) on the economic and non-economic indicators of a country or region (Wang, Muhammad, Menggang, & Shan, 2023).

However, the emission trading system has been widely regarded as an indispensable policy pillar of climate change mitigation and will eventually constitute a key building block of future climate policy. Due to the public good problem that arose from the benefit of climate protection, in the absence of any supranational authority, countries behave non-cooperatively, that is, each country decides on its GHG abatement according to a comparison of own benefit from abatement and its own cost of abatement (Cramton & Stoft, 2012). In fact, in standard game theory, no country should have an incentive to abate GHG emission above its non-cooperative level in the short and medium run, since the cost of emission occurs instantly but (rather uncertain) benefits will arise only in the far distant future. However, Cramton and Stoft (2012) proposed an optimistic approach to this problem, where countries will vote for a single global price for carbon and all countries will abate until their marginal cost of abatement equals that single carbon price.

4. Cap-and-Trade Regulation

The cap-and-trade system is one of the most widely discussed market-based mechanisms for controlling greenhouse gas (GHG) emissions. Under this system, a cap is set on the total level of emissions that can be emitted by regulated entities, such as industries, power plants, or entire countries. This cap is progressively reduced over time, aligning with international or national climate goals. The total allowances for emissions are distributed among entities in the form of carbon credits, which represent the right to emit one ton of CO₂ or its equivalent in other GHGs. The key characteristic of a cap-and-trade system is that it allows these entities to trade emission allowances with one another, creating a market for carbon credits.

The Cap-and-trade regulation has in most countries proved to be effective in mitigating the impact of carbon emissions in many jurisdictions. For example, the US, the implementation of Cap-and-Trade in the California's State, primarily driven by a switch from natural gas to renewables contributed to a reduction of CO₂ emissions in the power sector (Lessmann & Kramer, 2024). The application of Cap-and -Trade is widely modelled in various sectors such as waste management, energy, banking, insurance, manufacturing and even at multisectoral levels with profound effectiveness (Ghosh et al., 2023; Ivanov et al., 2024; Chen, et al., 2023; Sun et al., 2023; Zhang et al., 2024).

The cap-and-trade system works through a straightforward mechanism: governments or regulatory authorities set a cap on the total allowable emissions, and companies are granted a certain number of allowances based on their historical emissions or other criteria. The companies that can reduce their emissions below their allocated cap can sell their surplus allowances to others who are unable to

meet their targets. This creates a financial incentive for companies to lower their emissions, as they can generate revenue by selling unused allowances.

This system has proven to be an effective tool in driving emission reductions while maintaining flexibility for businesses to operate efficiently. For instance, power companies that invest in renewable energy or carbon capture technologies can reduce their emissions, generating allowances to sell. Companies that struggle to meet their targets, on the other hand, have the option to purchase allowances from others, allowing them to comply without immediately investing in expensive technologies.

Among the leading nations in implementing this scheme include Europe which, through the European Union Emissions Trading Scheme, EU ETS is considered the largest carbon trading market in the world. As the European ETS market established itself, the China government moved to start their own trading market which has been in operation since 2021. But there are so far eight carbon trading pilots established (Cai & Jiang, 2023).

5. International Cap-and-Trade Game

In the proposed cap-and-trade agreement between Malta and South Africa, both countries are given specific targets to reduce emissions by 40% below their business-as-usual (BAU) levels. This target serves as a reference point for determining their respective emission caps. The agreement recognizes the differing economic structures, energy dependencies, and developmental needs of each country, which leads to different marginal abatement costs for each.

South Africa's High Abatement Costs: South Africa's reliance on coal for electricity generation means that its marginal abatement costs—the cost to reduce an additional ton of CO₂—are relatively high. Switching from coal to renewable sources of energy or improving energy efficiency in its industrial sector would require substantial investments in new infrastructure, technology, and skills. Given the country's heavy reliance on fossil fuels and the importance of cheap energy for its economy, it faces a significant challenge in reducing its emissions in a cost-effective manner.

Malta's Lower Abatement Costs: In contrast, Malta's energy sector, while still heavily reliant on oil imports, is comparatively smaller and more flexible. The country has greater potential for relatively low-cost emission reductions, particularly in its transport and residential sectors. Investments in energy efficiency, solar energy, and switching to lower-carbon fuels could yield more immediate and less expensive reductions in emissions. Given Malta's smaller scale and its geographic advantage in solar energy, the country could reduce emissions more quickly at a lower cost than South Africa, which benefits from a lower marginal abatement cost for reduction projects.

These disparities in abatement costs create an opportunity for both countries to engage in mutually beneficial trade. South Africa, with higher abatement costs, can purchase emissions allowances from Malta, which, due to its lower abatement

costs, can reduce emissions more efficiently and generate surplus allowances to sell.

The model considers two countries, South Africa and Malta which are jointly covered under quantity regulation by cap-and-trade. Each country has an emissions target and needs to reduce its emissions below some business-as-usual level.

To do this, the overall pollution load of both countries based on their historical analysis must be known. [Department of Energy and Climate \(2024\)](#) offers a way for calculating the historical analysis in Equation 1.

$$x = \sum(a.EFCO_2) \quad (1)$$

where E is the emission-as-usual for the country, a is the activity data (quantity of fuel used in electricity generation in KW), and FCO_2 is the emission factor of the country.

Based on this historical analysis, an overall cap is established that is lower than the business-as-usual emissions for both countries. This cap reflects the emissions level required to achieve a targeted level of environmental quality ([Behn, 2011](#)).

Each country is then allocated a permissible emission quantity, which is proportionate to its historical emissions, with a 40% reduction from the BAU level. These allowances permit the countries to emit up to this level but no more. The free allocation of allowances helps ensure a level playing field and reduces the economic burden of participating in cap-and-trade ([Holtmark & Martin, 2020](#)).

Finally, both countries are allowed to trade their emission allowances. This is possible because the marginal abatement costs for both countries differ ([Jiang et al., 2022](#)). The optimal market price and the net benefit for each country are determined using the model presented by [Cramton and Stoft \(2012\)](#), as shown in Equation 2:

$$NB_j = b_j A - C_j A_j^2 + P(A_j - T_j) \quad (2)$$

where:

j is the name of the country; NB is the net benefit; b is the benefit of abatement, c is the cost of abatement, P is the market price for emission trading, A is the total abatement, A_j is the abatement of the country j , T_j is the target of country j .

The first term gives the climate benefit which increases with the overall cap A , which in turn, increases with A_j . The second term gives the cost of abatement. The third term represents the gains from selling carbon credits when a country's abatement differs from its target.

The model gives a "single price" on carbon as a condition for efficiency in many situations. If countries minimize costs, and if there are no market distortions, marginal costs will be equated among all sources of emissions given the single price, which is a least-cost solution ([William & Wallace, 1988](#); [Baumol, 1972](#)). Thus, it is to be expected that the overall cost of reducing emissions is higher if the marginal cost of abatement effort differs between countries.

The marginal abatement cost (MAC) curves for both countries were determined using [McKinsey & Company's \(2010\)](#) MicroMAC curve, which considers

their primary energy sources for electricity generation. The year 2013 was selected as the baseline for this analysis because it represents a period with comprehensive and comparable emissions and energy data for both South Africa and Malta, as reported by the World Bank and McKinsey & Company. Additionally, the marginal abatement cost (MAC) estimates are drawn from McKinsey & Company's 2010 Global Greenhouse Gas Abatement Cost Curve, which provides sectoral data suitable for comparative modelling. Using this combination ensures analytical consistency while acknowledging that real-world MACs may evolve over time.

This focus is justified by the sector's dominant role in national emissions profiles. Around the 2013 baseline year, the electricity sector accounted for approximately 45% - 50% of South Africa's total greenhouse gas (GHG) emissions and around 60% of Malta's national emissions, reflecting both countries' high dependence on fossil fuels for electricity generation. Concentrating on this sector therefore captures a significant share of their overall emissions while maintaining analytical tractability.

6. Limitations of the Study

This analysis is based on a simplified theoretical model that assumes constant marginal abatement costs (MAC) for both countries. In reality, MACs are typically dynamic and tend to increase with the level of abatement, reflecting diminishing returns to emission reduction efforts. This simplification may therefore underestimate the total compliance costs and overstate the potential efficiency gains from trading. Future research could address this limitation by incorporating variable or sector-specific MAC functions to better capture real-world abatement dynamics.

7. The Game Framework for Increased Cooperation

The model was used to develop a framework of a joint cap and trade for two countries, South Africa and Malta. These countries share similar characteristics in terms of their carbon emission, electricity consumption, and primary energy use. On one hand, South Africa heavily relies on fossil fuels, especially coal, whereby in 2022, fossil fuels accounted for approximately 94.24% of the country's energy consumption (Bekun, 2024). On the other hand, Malta around the same period, had 75% on fossil fuels for electricity generation (Maccanti, et al., 2023).

The cap-and-trade include emissions from only the electricity sector of these countries. This assumption in several studies of Cap and Trade which focus on only a single sector or few sectors (Li et al., 2015; Chen et al., 2023). Another reason for limiting the cap and trade to only the electricity sector is for it to be effective as the more disperse the pollution, the more monitoring and measurement become difficult. Each country is also expected to reduce its emission to 40% its Business-as-usual level (Zhang & Wei, 2011). Both countries have almost the same business-as-usual the only difference is in their cost of pollution control.

According to Cramton and Stoff (2012) in the global cap and trade game, the

strategic variable that countries can control is the abatement and target. But in this case, since the target is already fixed, the only variable that can change is the abatement.

South Africa a country that uses about 87.6% coal to meet its electricity demand has a marginal cost of €38 (World Bank, 2013). Malta, on the other hand, uses 90% of oil to meet its electricity demand and hence has a marginal cost of €21 (McKinsey & Company, 2010). This set the platform for trading due to the varying cost of pollution control. See **Table 1**.

Table 1. Summary of variables in the cap and trade between South Africa and Malta.

	South Africa (S/A)	Malta (Mal)
% of fossil fuel used for electricity	87% coal	98.6% oil
Electricity emission conversion factor (KgCO ₂)	0.85728	0.86605
Electric power consumption (MWh)	4547	4783
Business-as-usual (BAU)	3898	3938
Marginal Abatement Cost (MAC) = b = c (€)	38	21
Target (40% of BAU)	1559	1575
Abatement	2462.01	887

This study investigates the economic and environmental implications of emissions trading between Malta and South Africa, emphasizing the role of marginal abatement costs and the efficiency gains derived from market-based mechanisms. The findings demonstrate that Malta, due to its lower marginal abatement costs, exceeds its assigned CO₂ reduction target, achieving an abatement surplus of 887 Mt of CO₂. This surplus is subsequently traded to South Africa, where abatement costs are significantly higher. South Africa benefits economically by purchasing emission allowances at €29.5 per unit, a cost well below its internal marginal abatement threshold.

Comparative Economic Outcomes: Disparity in Net Benefits

Malta's opportunity cost of forgoing emissions trading is substantial. Without exceeding its target and engaging in trade, Malta incurs a cost of €33,075 million. Conversely, by utilizing its comparative advantage in abatement, Malta achieves additional gains of €26166.5 million through trading, resulting in a total net benefit of €40278.5 million. For South Africa, the economic calculus is even more compelling. Non-participation would impose a compliance cost of €59,242 million, whereas trading reduces this cost to €25,536 million, resulting in a total net benefit of €67389.5 million.

These results confirm that cap-and-trade mechanisms can deliver substantial efficiency gains by equalizing marginal abatement costs across nations. However, the disproportionate total benefits for South Africa underscore the structural asymmetries inherent in international carbon markets, raising concerns about equity and fair distribution of economic gains among smaller economies.

Policy and Theoretical Implications

The dynamics between Malta and South Africa reflect broader theoretical insights into cap-and-trade systems as instruments for achieving environmental and economic efficiency. The fundamental premise underpinning such systems is that emissions reduction targets can be met at the lowest aggregate cost by equalizing marginal abatement costs across participants. By allowing nations with lower abatement costs to generate surplus reductions for trade, cap-and-trade mechanisms align market incentives with environmental objectives.

The empirical evidence from this analysis aligns with prior successes in emissions trading. Notable examples include the Montreal Protocol's achievements in phasing out ozone-depleting substances, the U.S. Clean Air Act's market-based solutions to acid rain, and the European Union Emissions Trading System's efforts to curb greenhouse gas emissions. The adoption of similar systems in sub-national jurisdictions, such as California and several U.S. states, further underscores their global applicability and appeal (Peace & Ye, 2020). These examples highlight the adaptability of cap-and-trade frameworks across diverse regulatory and economic contexts.

While the efficiency of cap-and-trade systems is widely recognized, this analysis raises critical questions about equity and distributional impacts. The disproportionate net benefits realized by South Africa, despite its higher marginal abatement costs, invite scrutiny of the structural inequities inherent in international trading systems. Nations with larger economies or greater capacity to absorb transaction costs may consistently capture a larger share of the gains from trade. This asymmetry raises ethical and policy concerns, particularly for smaller nations like Malta, whose absolute economic benefits, though positive, remain modest in comparison. Toyama (2024) concludes that it is possible for emissions tax policy to achieve an outcome close to dynamic cap and trade without transaction costs.

To address the equity concerns arising from uneven distribution of gains, redistributive mechanisms can be embedded within the cap-and-trade framework. For instance, initial allowance allocations could be adjusted based on each country's historical responsibility for emissions or economic capacity to absorb mitigation costs, thereby ensuring that wealthier or higher-emitting nations shoulder a proportionally greater burden. Alternatively, a climate equity fund financed through a fraction of trading revenues could be established to support smaller or less-developed participants in building low-carbon infrastructure and technological capacity. These mechanisms would not only enhance fairness but also strengthen participation incentives, promoting a more balanced and sustainable global trading system.

Additionally, the success of emissions trading relies on robust institutional frameworks, transparency, and mechanisms to prevent market distortions such as price volatility or carbon leakage. For example, ensuring that the €29.5 price per unit accurately reflects the marginal abatement cost across the trading system is essential to maintain market confidence and incentivize continued participation.

Future research should explore how regulatory design, market oversight, and complementary policies (e.g., carbon taxes or renewable energy subsidies) can mitigate these risks.

8. Conclusion

The Kyoto Protocol, a legally binding agreement aimed at reducing greenhouse gas (GHG) emissions, has spurred countries worldwide to adopt strategies for addressing climate change. Among the array of policy instruments available, this paper focuses on market-based approaches, particularly cap-and-trade systems. These mechanisms harness the forces of supply and demand to drive cost-effective emission reductions while promoting environmental sustainability.

This study conceptualizes a cap-and-trade negotiation framework between South Africa and Malta, two countries heavily reliant on fossil fuels for energy production. South Africa's high-energy-intensity economy, fuelled by historically low energy costs and a reliance on extractive industries, makes it the largest GHG emitter in Africa (World Bank, 2013). Similarly, Malta's dependence on oil to meet 98.6% of its electricity demand positions it as a high emitter. The comparative analysis of these nations is further justified by their similarities in emission factors and electricity consumption, creating a meaningful benchmark for evaluation.

The divergence in energy sources—Malta's reliance on oil versus South Africa's use of coal—plays a critical role in shaping their respective marginal costs of abatement. As per McKinsey & Company (2010), abatement costs for oil and coal power plants are €21 and €38 per ton of CO₂, respectively. Consequently, South Africa faces a higher compliance cost (€59,242 million) compared to Malta (€33,075 million). Despite this, South Africa's net benefit (€67389.5 million) surpasses Malta's (€40278.5 million), highlighting the interplay between abatement costs, trading incentives, and economic scale.

The analysis identifies €29.5 as the optimal market price for carbon, which is above Malta's marginal abatement cost (€21) but below South Africa's (€38). This pricing structure incentivizes both nations to engage in emissions trading, maximizing gains for Malta and reducing compliance costs for South Africa. Opting for domestic abatement without trading would result in significantly higher costs for both countries, reaffirming Cramton and Stoff's (2012) assertion that carbon pricing can drive innovation and reward cost-effective conservation strategies.

The case study of Malta and South Africa highlights the transformative potential of emissions trading as a cornerstone of climate policy while exposing key challenges in implementation. The observed disparity in economic gains raises concerns about equity, particularly for smaller economies like Malta, whose absolute benefits remain modest despite its comparative advantage in abatement costs. Addressing these equity concerns requires the integration of governance reforms and redistributive mechanisms that ensure fair benefit distribution without undermining market efficiency.

Moreover, the sustainability of cap-and-trade systems hinges on robust institu-

tional frameworks to prevent carbon leakage, ensure price stability, and maintain transparency. Policymakers must also explore the interplay between market-based mechanisms and alternative strategies to support a just transition to sustainable development. Investments in green infrastructure, energy efficiency, and low-carbon technologies should be prioritized alongside market instruments to create a more resilient and inclusive climate governance model.

The findings contribute to the growing evidence supporting market-based solutions while emphasizing the need for equity and inclusivity in global climate policy. Future research should focus on refining cap-and-trade mechanisms, addressing their limitations, and exploring their integration with complementary tools. By harmonizing efficiency, equity, and innovation, cap-and-trade systems can play a pivotal role in building a sustainable and equitable future.

Data Availability Statement

Data available on request from the corresponding author upon reasonable request.

Author Contribution Statement

Veronica Koroma, Geoffrey Aori Mabea and Mulope Sitali: Conceptualization, methodology, software, validation, formal analysis, investigation, resources, data curation, writing-original draft, writing-review & editing, visualization, supervision, project administration.

Conflicts of Interest

The authors declare that they have no conflicts of interest to this work.

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Appendix

BAU: Business As Usual;

DECC: Department of Energy and Climate Change;

MAC: Marginal Abatement Cost;

CF: Cost Function;

NB: Net Benefits;

DECC (2015) provides away for calculating the historical analysis.

$$BAU_x = \sum(a.EFCO_2)$$

$$BUA_x = \sum(a.EFCO_2)$$

$$BUA_{S/A} = 0.885725 * 4547 = 3898$$

$$BUA_{Mal} = 0.86605 * 4783 = 3938$$

This gives us the business-as-usual for both countries. Each country is expected to reduce emissions by 40% below business-as-usual.

$$BUA_{S/A} = 1559$$

$$BUA_{Mal} = 1575$$

From Cramton and Stoft (2012)

$$B_j = b_j A - C_j A_j^2 + P(A_j - T_j) \text{ assume } b_j = C_j = MAC_j \quad (1)$$

Optimal carbon price

$$P^* = \frac{1}{N} \sum b \quad (2)$$

From McKinsey (2010) $MAC_{S/A} = €38$, $MAC_{Mal} = €38$ therefore

$$P^* = \frac{1}{N} \sum 38 + 21 = €29.5$$

$$\text{Let } A_T = 0.4(BAU_{S/A} + BUA_{Mal}) = 3134 \quad (3)$$

Equation 3. represents the total joint abatement target (40% of combined BAU emissions).

The abatement for each country will be determined by their cost function, the second term in Equation 1. If each country chooses to abate the same amount as their target domestically. The Abatement costs without Trade will be represented as

$$CF_{S/A} = 38 * 1559 = €59,242m$$

$$CF_{mAL} = 21 * 1575 = €33,075m$$

For the two countries to trade the credit sold by one country must equate to the credit bought by the other. Therefore, the trade equilibrium is given by

$$P \left(\frac{A_S - T_S}{A} \right) = P(A_{Mal} - T_{Mal}) = 26,167$$

$$29.5(A_{Mal} - 1575) = 26,167 \Rightarrow 2462.01$$

$$\text{Surplus (Malta)} = 2462.01 - 1575 = 887 \text{ Mt } CO_2 .$$

This surplus will be sold to South Africa, therefore

$$A_{S/A} = T_{\frac{S}{A}} - \text{Surplus of Malta} = 672 \text{ Mt } CO_2 .$$

Net Benefits:

$$A_T = (BAU_{S/A} + BAU_{Mal}) = 3134$$

$$NB_{S/A} = 38(3134 - 672) + 29.5(-887) = \text{€}67,389.5\text{m}$$

$$NB_{Mal} = 21(3134 - 2462) + 29.5(887) = \text{€}40,278.5\text{m}$$