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# Internal Carbon Pricing: Possibilities and Challenges

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**Abstract**

Internal carbon pricing is an effective management approach to guide corporate activities towards society's decarbonisation. This study explores and summarises research arguments on the possibilities and challenges for companies in setting internal carbon pricing, since the current focus is its implementation and disclosure under the current development of the international sustainability disclosure standards. The main contribution of this study is a structured interdisciplinary discussion on internal carbon pricing, providing the discussion of relevant issues for companies, and proposes an agenda for future research. With the different purposes, methods, base prices, and characteristics of internal carbon pricing, companies involved in setting and disclosing internal carbon prices encounter many challenges. As an effective institutional framework for internal carbon pricing information disclosure can be increasingly important due to investors' increasing information demand, future research should build a sound institutional framework for meaningful disclosure.

**Keywords:** *climate change, carbon risk, carbon management, disclosure, greenhouse gases*

## 1. INTRODUCTION

Carbon pricing (a concept of a carbon price as part of companies' planning for achieving reductions in greenhouse gas (GHG) emissions; CDP, 2013) is expected to be implemented as an effective strategy to reduce climate change's impact. Among other types of carbon pricing, internal carbon pricing is considered an essential mechanism for companies to manage risks and take advantage of new opportunities associated with transitioning to a low-carbon economy.

The International Sustainability Standards Board (ISSB), founded by the IFRS Foundation on 3 November 2021, is an international disclosure standard that could significantly impact companies' internal carbon pricing practices. The ISSB has published the S2 Climate-related Disclosure Standard on 26 June 2023 (ISSB, 2023). In this standard, companies shall disclose their physical and transition risks beside climate-related opportunities available. The standard leads companies to ultimately disclose their carbon price as the quantitative disclosure of information on their risks and opportunities. This is because this internal carbon price information will be one of the

seven cross-industry indicator categories across all companies involved in the ISSB's disclosure requirement. Specific indicators (i.e., the price per metric ton of GHG used by companies to assess their emissions costs) and an explanation of how companies apply carbon pricing to their decision-making (e.g., investment decisions, transfer pricing, and scenario analysis) should be disclosed. This implies that companies involved in the ISSB's disclosure requirement must implicitly use these prices. Therefore, these companies should better understand internal carbon pricing practices to meet the ISSB requirement. However, comparing issues regarding carbon pricing systems and regulatory frameworks across regions and nations as environmental policy instruments, there have been little arguments on companies' practices; this is because these are essentially internal management issues depending on companies' complex contexts, and thus the practice's details are usually a sensitive business matter (UNGC et al., 2015).

Some literature suggests various advantages of setting internal carbon prices; these advantages include revealing hidden carbon risks and opportunities, providing a management tool and incentive to transition to a low-carbon business model deliberately, legitimising companies with high carbon emissions by demonstrating to the world that they are taking corrective actions, and providing investment decision-making materials for decarbonisation (Ecofys et al., 2017; TCFD, 2017a; UNGC et al., 2015). However, no uniform approach to setting it exists, and different internal carbon pricing aims, methods and pricing bases are present, possibly making it difficult to interpret the information.

Financial institutions and investors are increasingly demanding information on companies' carbon risks and opportunities. This growing pressure is affecting the introduction of internal carbon pricing by companies, especially among carbon-intensive sectors. The previous literature suggests that carbon emissions affect stock returns and company values and that investors demand a higher premium if they perceive a company's high carbon risk (Bolton and Kacperczyk, 2021). In this context, it can be argued that investors, including financial institutions, who are concerned about economic impacts regarding carbon risks, are likely to demand information on corporate carbon risk management, including information how a company's internal carbon price is set. For example, the International Finance Corporation (IFC), a member of the World Bank Group, has recognised the importance of initiating an assessment of the impact of internal carbon pricing on investment. The Task Force on Climate-related Disclosures (TCFD) (TCFD, 2017a) has also identified companies' internal carbon management information as a climate risk management tool. Under the context of these external recognitions, some forward-looking companies may exist to strategically use internal carbon pricing to demonstrate externally that their business models are 'future-oriented' regarding climate change risks. However, there is scepticism about whether a company's public announcement that it has set an internal carbon price can be used to identify whether it has established a management system to manage carbon risks and opportunities. The scepticism also extends to determining the extent to which an internal carbon price will contribute to achieving the Paris Agreement's targets. That is, the question is about the potential and limitations of internal carbon pricing. Therefore, this study will analyse the recent academic debate on the possibilities and limitations of setting a corporate internal carbon price. This will be possible through reviewing previous studies and identifying future research questions. This research's contribution is to prevent the use of corporate internal carbon pricing for 'greenwashing', a phenomenon defined as 'the intersection of two firm behaviours: poor environmental performance and positive communication about environmental performance' (Delmas and Burbano, 2011, p. 65) and to provide insights into meaningful disclosure of corporate internal carbon pricing. It is also valuable in providing a recent and meaningful discussion for companies seeking an introduction to internal carbon pricing and investors and other stakeholders seeking meaningful climate risk information. The paper is structured as follows: Section II presents the methodology, Section III provides a literature review, and Section IV has the discussion and conclusions.

## 2. METHODOLOGIES

This study (a) explores debates on different possibilities and challenges of internal carbon price setting by companies identified in the literature, (b) summarises the empirical findings of both processes and consequences of internal carbon pricing, and (c) identifies several interesting directions for future research. This study critically explored and organised the literature on internal carbon pricing published within the past ten years leading up to and following the 2015 Paris Agreement. Through the internet, we conducted an extensive interdisciplinary literature search. It explored more than 200 articles in the fields of accounting and finance and environmental management, environmental economics, and energy policy, with corporate the keywords 'internal carbon pricing,' 'internal carbon prices,' 'internal carbon price,' 'proxy carbon pricing,' 'carbon pricing,' or 'ICP' present in the title and the abstract—moreover, several reports of international organisations or initiatives dealing with internal carbon setting issues. Consequently, while the number of papers relevant to a broad range of carbon pricing issues seems to be increasing within ten years, the number of papers directly addressing internal carbon pricing disclosure issues seems very limited. This implies that the companies' management issues debate is not yet conclusive.

This study mainly focuses on companies' internal carbon pricing set by companies. Therefore, it does not fully address the broader policy issues, such as the carbon pricing system and programme applicable in regions and nations.

## 3. LITERATURE REVIEW

### *Carbon pricing as a policy instrument*

The concept of carbon pricing originates from the concept of social carbon pricing as a policy instrument. As an essential concept in understanding and implementing climate change policies, the social cost of carbon is the economic cost, or its equivalent, of a ton increase in carbon emissions (Nordhaus, 2014). The social cost of carbon estimation is crucial as they guide appropriate emissions regulation and carbon pricing at the national or international level. Nordhaus (2014) estimated it at 18.6 USD per ton of $CO_2$ in 2005 and 2015 international prices. In an abstractly optimised climate policy, the social cost of carbon is considered equal to the carbon price, namely, the marginal cost of emission reductions and the present value of the damage resulting from emissions per unit. The social cost of carbon is utilised to evaluate actions to reduce carbon emissions as a shadow price in cost-benefit analyses of policies and companies' internal prices (Stern and Stiglitz, 2021). However, in the real world, it is generally calculated as the marginal damage of emissions consistent with real-world transactions when climate policy is not optimised (Nordhaus, 2014).

Carbon pricing schemes are policy tools used to price carbon and change emitters' behaviours. Nations and regions have adopted the schemes as an essential policy mechanism to promote the reduction of GHG emissions and mitigate against the dangerous consequences of climate change. The number of countries and regions adopting carbon pricing policies has increased as they work to implement the Paris Agreement. Among the approximately 200 countries that participated in the COP21 conference at which the Paris Agreement was adopted, more than 90 countries plan to set a carbon price to reduce carbon emissions (I4CE, 2016). More than 40 countries and 25 regional governments have also introduced specific carbon pricing schemes, equivalent to 15% of global GHG emissions (CDP, 2017).

Carbon pricing instruments include carbon taxes, domestic emissions trade instruments, credit trade instruments, market mechanisms by international organisations, and internal carbon pricing. Putting a monetary value on these carbon emissions is well explained by economic theory, which holds that climate change management is a public good (Harpankar, 2019). However, while carbon pricing measures can be considered practical policy tools in achieving a low-carbon economy, their effectiveness is limited in the absence of other policies that can be strengthened and complemented to address other climate change issues and market failures (World Bank, 2021). That is, carbon pricing is a strategy to reduce climate change that is expected to be effective in reducing carbon emissions, along

with other methods through legislation and market mechanisms (Harpankar, 2019). However, research evidence on the effectiveness of carbon pricing is inconclusive. For example, some studies claim that carbon taxes are effective or partially effective in reducing GHG emissions, while others claim no causal link between carbon taxes and lower GHG emissions. Indeed, a study conducted by Nar (2020) using annual data from 36 OECD countries from 1990–2018, analysing whether carbon taxes effectively reduce GHG emissions, found that carbon taxes do not affect GHG emissions. In this regard, the expected benefits from a carbon tax could relate to other areas, such as a nation's policy to transition to a lower carbon economy by subsidising energy-efficient essential home electronics to homeowners using the collected funding from the tax. Considering the potential benefits of a carbon tax, carbon pricing should receive significant focus in research, as it forms the foundations of the topic.

### *Incentives of internal carbon pricing*

Internal carbon pricing is an instrument that companies undertake independently among different policy instruments for carbon pricing. An internal carbon price can be defined as a monetary value placed on GHG emissions that can be reflected in a company's investment decisions and business operations. TCFD defines internal carbon price as an estimated cost internally developed as a planning tool to identify revenue opportunities and risks associated with energy efficiency to reduce costs and capital investment to transition to a lower carbon practice as the ultimate goal (TCFD, 2017a).

It is believed that organisations can adopt this internal carbon price to reveal the 'hidden costs' of GHG emissions in their business management by estimating the cost of emitting one ton of $CO_2$. More than 660 institutions in the US are committed to carbon neutrality, although the uptake of carbon pricing in the higher education sector remains relatively low, although it has increased recently (Barron et al., 2020). However, Barron et al. (2020) showed that, in the 11 higher education institutions they selected, internal carbon pricing had been applied regardless of the size or organisational structure. This suggests there can be economic and other benefits to exploring the application of an internal carbon price as incentive.

Voluntary internal carbon pricing can be explained using economic theory. It is argued that companies can manage the regulatory, supply chain, and financial risks associated with transitioning to a lower-carbon economy by setting a sufficiently high internal carbon price. If carbon emissions are regarded as a production cost, this can be expected to generate changes in company emissions-related activities (Bent et al., 2021). This practice strengthens cooperation within companies, and internal stakeholders' awareness of climate-related risks can be increased (Harpankar, 2019). Introducing an internal carbon price is also expected to demonstrate a company's climate change awareness and policy to external parties more transparently (Harpankar, 2019). Additionally, if the internal carbon price is an internal cost embedded in the cost of production, it may also impact customers. Therefore, structured arguments on different benefits and formulations of internal carbon pricing are essential for the public benefit.

Indeed, an increasing number of companies worldwide are taking action on climate change by setting their internal price for carbon (Bent et al., 2021; World Bank, 2021). Corporate internal carbon pricing efforts are recognised to be triggered by corporate the Climate Governance Initiative. An increasing number of companies are making climate change pledges in response to international initiatives, such as the Climate Governance Initiative (World Bank, 2021). According to CDP (formerly the Carbon Disclosure Project) (2017), an international carbon disclosure initiative, as of 2014, the number of companies using internal carbon pricing to assess and manage carbon-related risks and the number of companies using internal carbon pricing had increased from approximately 150 in 2014 to more than 1,300 in 2017. They were either already using internal carbon pricing or planning to do so within the next two years. The World Bank (2021) also reported that, in 2020, 853 companies across a range of industries worldwide were expected to introduce internal carbon pricing to integrate climate risks and opportunities into their business strategies and corporate governance. A further 1,159 companies planned to do so within the next two years. In this context, the World Bank

(2021) recognised that companies are integrating climate risks and opportunities into their long-term strategies and see internal carbon pricing as an effective tool for investment decision-making.

Several benefits of companies adopting an internal carbon pricing system have been identified. By setting an internal carbon price, companies can prepare for uncertainty associated with future external carbon emissions (Kuo and Chang, 2021). Uncertainty, in this context, refers to the uncertainty in a climate-related external business environment. This arises when the various carbon pricing schemes already underway in the countries are further expanded and strengthened. Other benefits of internal carbon pricing for companies include the ability to finance the deployment of renewable energy and corporate programmes for climate change mitigation and adaptation (Ben-Amar et al., 2022; World Bank, 2021). It can also be used as a tool in investment analysis to protect future assets (Aitken, 2022). Moreover, further arguments about the benefits include managing transitions to a low-carbon future, providing incentives to low-carbon activities, reducing regulatory risk, building social capital, and helping achieve the mission (Chang, 2017; Ecofys et al., 2017; Gajjar and Vivek, 2018; Gillingham et al., 2017). However, it has been revealed that the effects of internal carbon pricing are limited in terms of its potential to equalise the marginal costs of climate change mitigation across firms and in terms of economy-wide benefit improvements (Hansen, 2023). Moreover, in the case of voluntary internal carbon pricing initiatives by companies, there is no enforcement or penalty from an international framework. In this situation, there is scepticism regarding the feasibility of achieving the goals of the Paris Agreement using such a voluntary tool (Harpankar, 2019).

The purpose and incentives for companies to set an internal carbon price have been the focus and subject of debate in previous studies. Chan (2017) analysed data from 562 companies participating in CDP and interviewed sustainability officers. He concluded that companies set internal carbon pricing to capture new markets and prepare for regulation. According to Harpankar (2019), companies voluntarily set internal carbon prices for internal decision-making and as a management tool to achieve their internal carbon strategy goals. He argued that setting an internal carbon price is one of several carbon risk management strategies that can be used to strategically prepare for future uncertainties to improve a company's external reputation.

Internal carbon pricing information is positioned as providing useful forward-looking information for investors' decision-making (TCFD, 2017b). Approximately 500 of the world's leading companies are expected to be affected by national carbon pricing regulations (CDP, 2017; World Bank, 2021). Under this situation, investors seek information on whether companies have set any internal carbon price to assess and analyse the competitiveness of companies as they migrate towards a low-carbon society (Kuo and Chang, 2021). However, the analysis of internal carbon pricing information has certain limitations. Specifically, a lack of transparency and consistency regarding methodology, price levels and the use of internal carbon pricing makes it difficult to deepen the analysis and assessment of internal carbon pricing (World Bank, 2021). It is difficult to evaluate an internal carbon price unless companies explain its setting purpose, how it is used, and what impact it has (World Bank, 2021).

### *Possibility of using SBT in combination*

Carbon pricing is a tool to help achieve a science-based target (SBT) for carbon emission reduction (UNGC et al., 2015), indicating that this SBT may also impact the internal carbon price. Companies are now required to voluntarily set an internal carbon price and the SBT in the context of global climate change, which can provide the rationale supporting it. For example, under the Paris Agreement, SBTs for carbon emissions have been set in each country's climate change policy. Additionally, companies are required to meet these policy targets, and financial institutions and other stakeholders have been observed to strongly demand that carbon-emitting companies set SBTs. Specifically, 317 financial institutions and multinational corporations with USD 37 trillion in financial assets and spending/buying power have called for the top 1,000 or more high-impact global emitters to set emissions targets consistent with the Paris

Agreement's 1.5°C target. They must set emission reduction targets supported by the SBT Initiative (SBTi), an industry standard for credible climate targets covering all emissions from a company's value chain (CDP, 2022a). In the US, it is proposed that significant suppliers to the federal government will be required to disclose GHG emissions and climate-related financial risks and set SBTs (CDP, 2022b). If companies recognise that demonstrating successful compliance with this SBT setting and internal carbon price could lead to an enhanced external reputation, this could incentivise companies to set internal prices. Based on a sample of 1,994 Japanese companies from 2016 to 2019, Kuo and Chang's (2021) study suggests that Japanese firms with strategies utilising either SBT or ICP have a higher reputation for carbon management, especially for high carbon emitting firms. In contrast, using both is more effective for firms that do not, but implementing both is not cost-effective. As Japanese companies are under pressure to respond to a low-carbon society under government guidance, management can adopt SBT or internal carbon price, or both, depending on the carbon emission characteristics of the company (Kuo and Chang, 2021). Through the adoption, they will effectively reduce risks from climate change and strategically mitigate the risks associated with changes in climate change policy regulations (Kuo and Chang, 2021).

### *Approaches and terminologies*

While companies use various terminologies in their internal carbon pricing practice (CDP, 2013), three typical carbon pricing implementations exist: 'shadow pricing,' 'implicit pricing,' and 'internal carbon fee (or internal carbon tax)' (UNGC et al., 2015). Although internal prices provide carbon-related long-term price signals for companies' long-term investment decisions (Peace et al., 2015) by quantifying climate risks, these have differing effectiveness concerning corporate carbon management targets (Harpankar, 2019).

First, 'shadow pricing' is a hypothetical or assumed cost for carbon emissions to evaluate potential investment (UNGC et al., 2015). Differences exist between companies' internal use of 'shadow pricing' and the political use of the pricing implemented within climate change policies across the region outside of companies (Hansen, 2023). For companies, shadow pricing is an assumed value that they add to their carbon emissions to assess the risk of their business investments (Gajjar and Vivek, 2018). This approach remains the most common form of internal carbon pricing (World Bank, 2021). Generally called proxy carbon pricing can help ease companies' landing in achieving a low-carbon economy (Cassidy and Taraska, 2016). Although companies can use deductively explicit carbon prices (Ministry of the Environment, 2022), they can use various assumptions, probabilities, and discount rates to create different shadow prices with discount rates, test sensitivities, and incorporate them into financial models (UNGC et al., 2015). Carbon shadow pricing could be based on the carbon price of established carbon trading schemes or other government policies that implicitly provide a carbon price, such as renewable energy prices or prescribed taxes.

An advantage of carbon shadow pricing is that companies can use a range of prices in a highly regulated market, depending on their exposure to carbon-related risks in investment projects (Harpankar, 2019). If it is to be used in long-term investment planning, the same discount rate should be applied considering other investment projects (Aitken, 2022). The extent to which shadow pricing is transformative and effective depends on the application method and the level of prices assumed. Therefore, information on these application methods and price levels is also required when announcing the application of shadow pricing (World Bank, 2021).

Second, 'implicit pricing' is calculated based on 'the cost of a company's activities to achieve emissions-reduction goals' (Gajjar and Vivek, 2018); that is, how much a company spends on renewable purchases or energy-efficiency projects is calculated. Although companies do not establish an explicit carbon price in an implicit pricing approach, they calculate a ton of carbon as the marginal abatement cost of reducing GHG emissions (UNGC et al., 2015). Implicit pricing is similar to shadow pricing in terms of no actual fund transaction (Ministry of the Environment, 2022) but is different from shadow pricing because implicit

pricing uses information based on companies' past decisions on investment and achieved emission reductions (Gajjar and Vivek, 2018; Harpankar, 2019). The purpose of using an implicit carbon price is for companies to assess their recent investments and determine whether they are consistent with their objectives (Gajjar and Vivek, 2018).

Third, an 'internal carbon fee' is a price that a company attaches to GHG emissions generated during business activity (Gajjar and Vivek, 2018). An internal carbon fee approach introduces a carbon fee per unit of GHG emissions by creating formal internal financial incentives and programmes, including internal tax or internal trading programmes (UNGC et al., 2015). In this case, the addition of this charge to business expenditure is expected to be an effective method of creating incentives for short-term emission reductions and generating long-term innovation regarding energy efficiency improvements. As business units can explicitly reflect the carbon fee in their decision-making in research and development investments, adopting the carbon fee creates autonomy and incentives for climate change mitigation action at each unit within the company. The level of a carbon fee is likely to be set low to encourage actions by individual departments. The carbon fee collected internally using internal emission trading systems could be used to fund carbon reduction targets that require another source of funding, which can create an actual internal investment stream. For example, Microsoft stated that it will apply an internal carbon fee to its emissions and invest the revenue collected in sustainability and carbon reduction activities (CDP, 2013; World Bank, 2021). However, it has been noted that the carbon fee approach has certain limitations. First, the approach requires management resources and expertise to measure carbon emissions in a standardised manner within a company. Second, no appropriate carbon price information exists to benchmark against when no national or regional carbon price has been set (Harpankar, 2019).

Finally, in setting internal carbon pricing, companies must be clear about their objectives, enabling them to choose between the three approaches and set appropriate prices (UNGC et al., 2015). Using the internal carbon price, they can create pathways to reduce emissions, but implementation must be simple (UNGC et al., 2015). The approach to companies' internal carbon prices can be very diverse. Companies can use several carbon pricing methods simultaneously and apply a uniform price to all their operations. Large companies apply internal carbon prices dynamically across the organisation to accommodate differences by region and business (World Bank, 2021). Companies can also use multiple internal carbon prices or a sliding scale of carbon prices to reflect different or increasing carbon prices and regulatory environments.

### *Characteristics of internal carbon pricing*

Internal carbon pricing is introduced in all regions. Internal carbon pricing has increased, particularly in regions where governments have recently introduced carbon pricing regulations (World Bank, 2021). The carbon prices set by companies range from 1 USD to 800 USD per ton of $CO_2$ emissions (Harpankar, 2019), or from 6 USD to 918 USD per ton of $CO_2$ emissions, depending on the company and region, with a wide variation depending on the sector the company belongs to (World Bank, 2021). Where there is a clear price due to regulation, companies tend to use that price, but where there is a mix of regulation or no regulation, there is a variation in prices (Harpankar, 2019). The internal carbon price of companies in countries that explicitly price carbon through taxation or cap-and-trade programmes is significantly higher than in countries that do not (Bent et al., 2021). Regarding specific geography, the median internal carbon price is lower for companies operating in Africa than in Europe and Asia. This may be due to the lack of widespread regulatory pricing and therefore, less urgent for companies to apply internal pricing to get ahead of the carbon price. Internal carbon pricing and application methods are becoming more sophisticated, reflecting the geographical and regulatory context. However, internal carbon prices are often set at prices above the regulatory price of the past year, although not close to the price required to meet the Paris Agreement target (from 40 USD to 80 USD per ton of $CO_2$ emissions) (World Bank, 2021).

Regarding sectors, utilities and energy sectors are the most frequent users of internal carbon

pricing. Financial institutions, information technology, and consumer goods manufacturers also use it (Harpankar, 2019). Regarding the number of companies, the energy sector has the highest number of companies. However, the financial sector recently has overtaken the energy sector and now has the highest number of companies, and the rate of increase has been significant (World Bank, 2021). Additionally, highly carbon-dependent industries and companies face greater carbon regulation risk, in which case there is specific logic in using shadow pricing (Harpankar, 2019).

While the extent of exposure to external carbon regulatory risk depends on the industry sector, the use of internal carbon pricing is unique as it is linked to this risk. The use of internal carbon pricing can be described as a practice where companies voluntarily add a fictitious cost to their carbon emissions to help prioritise low-carbon investment projects (Trinks et al., 2022). This practice has been facilitated by exposure to carbon-related constraints and carbon pricing schemes external to the company (Ben-Amar et al., 2022; Trinks et al., 2022). For example, it has been found that companies that consider themselves to be at high risk from external carbon restrictions are more than five times more likely to adopt an internal carbon price than those that do not (World Bank, 2021). Meanwhile, it has been argued that a predictable process must be demonstrated under strict climate policy for companies to use internal carbon pricing to steer future investments towards a low-carbon economy (Trinks et al., 2022).

### *Criticisms of internal carbon pricing*

The internal carbon price is also unique, because it is hypothetical and has no real financial impact (Carbon Tracker Initiative, 2018). In 1998, BP (Gillingham et al., 2017) and Rio Tinto (CDP, 2013) established internal carbon pricing as the early introduction of corporate efforts. However, there is little evidence of the potential value of such a project (Gillingham et al., 2017). Instead, internal carbon pricing programmes are broadly considered part of corporate social responsibility efforts (Gillingham et al., 2017). Moreover, it has been suggested that internal carbon price information can be used as forward-looking information and that no one can predict the future state of the global environment. Thus future projections cannot be a legal subject and ultimately fall outside the legal constraints of traditional information disclosure (Aitken, 2022).

### *Considerations for internal carbon price disclosure*

Considering the merit of carbon disclosure, internal carbon pricing information could be helpful for companies to improve their carbon performance. In the study conducted by Alsaifi (2021), data from UK FTSE 350 companies and their carbon disclosures from 2007 to 2015 by UK-listed companies were examined. They showed that having the incentive to disclose information to the CDP carbon disclosure initiative voluntarily is associated with improved carbon performance in terms of GHG emissions. Moreover, the relationship between carbon disclosure and carbon performance is more pronounced in carbon-intensive industries. Therefore, even if it is voluntary, it can be that international carbon disclosure flamework can be an effective incentive for management (Alsaifi, 2021). Furthermore, when publishing internal carbon pricing information in response to external information needs, such as the CDP project, incentives for management action are created within companies. Additionally, Topping (2012) argued that a link should be present between the disclosure process and actual carbon performance, as the need for carbon information tends to intensify, both in the internal management of companies and by demand from external investors.

Meanwhile, concerns that internal carbon pricing information could be used for corporate greenwashing and measures to prevent this have been highlighted. In particular, companies in carbon-intensive industries have been found to disclose environmental information more voluntarily than companies in less carbon-intensive industries considering the reputation and stakeholder management (Hasseldine et al., 2005; Patten, 1991; Roberts, 1992). Using carbon prices to review investment plans has little financial impact on companies (Carbon Tracker Initiative, 2018) and is insufficient to confirm a company's resilience. Therefore, whether the internal carbon pricing system discloses information useful for investors' decision-making

should be considered. Whether the concerns raised in the internal carbon pricing system are linked to operations is also worth considering (Harpankar, 2019). To ensure that internal carbon pricing information is not used for greenwashing, high-quality reporting should be implemented on the actual effects in companies that have set internal carbon prices (Harpankar, 2019). For internal carbon pricing disclosure to be meaningful, companies should be transparent regarding the various assumptions used in the carbon pricing operational process and the scope and scale of application (Harpankar, 2019). Some companies that have implemented internal carbon pricing schemes have reported how internal carbon pricing has influenced budget allocations and the creation of new business functions or has led to allocating capital to energy efficiency, low carbon, and energy purchasing (Bartlett et al., 2016). However, methods for reporting carbon-related information are recently developed and mixed without a definitive one (Dechezleprêtre, 2022), which may create different interpretations of the information disclosed.

Implementing an internal carbon pricing system requires expertise and resources within a company since a lack of these may prevent meaningful internal carbon pricing disclosure (Harpankar, 2019). For companies in developing countries with weak governance structures, internal carbon pricing may be an effective driver of change in corporate behaviour (Earnhart et al., 2014; Harpankar, 2019). However, suppose no regulation of carbon pricing exists, in that case, there may be concerns about whether the short-term costs associated with internal carbon pricing can be justified by management as a corporate expenditure, which may discourage its introduction (Harpankar, 2019).

The nature of internal carbon pricing and stranded asset disclosure is considered a pressure and constraint placed on companies in their quest to reduce GHG emissions. Due to social norms or environmental shocks, stranded assets have lost economic value beyond their expected useful life (Bos and Gupta, 2019). The critical takeaway of internal carbon pricing is how to protect stranded assets (Aitken, 2022). Stranded assets can be avoided by valuing investment projects by companies using carbon pricing. They can also avoid stranded assets that would be disposed of within their useful life and recognised as a loss on the balance sheet (Cassidy and Taraska, 2016). Both internal carbon prices and stranded assets can be recognised as products of unreal expectations in the unknown future, contrasting climate futures in conventional work and practice by financial economists, investors, and those interested in the 'foreseeable future' (Aitken, 2022). It has also been noted that internal carbon prices are expressed in financial documentation to understand and cope with climate uncertainty. At the same time, such formalisation is a unique task of expressing uncertain climate risks under uncertain climate change (Aitken, 2022). Knight (1921) distinguished between uncertainty, which is indeterminate and unpredictable, and risk, which is manageable as a knowable probabilistic certainty. Regarding the different natures of measurable and unmeasurable future events (Knight, 1921, p. 103), whether climate risk is measurable becomes crucial.

## 4. DISCUSSION AND CONCLUSION

Internal carbon pricing is an internal management tool to support companies transitioning into lower carbon operations. It provides information on emissions generated, and at a more advanced level, the costs, opportunities, and the potential for carbon reduction. Since it assists companies in disclosing emission values and monetary risks and opportunities, it also can lead to broader green security markets and thus, a new type of investing and financing. The release of international sustainability disclosure standards by the ISSB is timely to minimise risks and optimise benefits from having carbon emission disclosures based on different carbon pricing methods. This study examines and summarises research arguments on the possibilities and challenges companies face when setting internal carbon pricing.

TCFD (2017a) stated that companies could utilise internal carbon prices in three ways. First, it is a planning tool to help identify revenue opportunities and risks related to climate change, depending on the nature of businesses. Second, as it puts a carbon price on the emissions generated, internal carbon pricing may incentivise increasing energy efficiency to reduce costs. Third, when presented

transparently and consistently, it can assist capital investment decisions. As a planning tool, companies can integrate information on carbon prices into scenario analysis. This is the analysis to assess companies' strategic climate change resilience. Using this assessment's result, the company can analyse the demand for energy, fuel, and technology (Harpankar, 2019; TCFD, 2017b). Therefore, from the shareholders' perspective, an internal carbon price could provide them with forward-looking information (Harpankar, 2019; TCFD, 2017b). However, the methods of internal carbon pricing vary widely, and thus the resulting level of internal carbon pricing varies considerably. Therefore, investors may find it challenging to assess companies' risk management skills, recognitions, and activities undertaken for carbon risk management (Harpankar, 2019).

The decision to use internal carbon prices may depend on whether companies are carbon-intensive, have an impact on minimising carbon emission across different industries, or are vulnerable to the impact of carbon-related regulations. Internal shadow pricing would further impact business expenditures in carbon-intensive industries than carbon fees. A shadow price is generally higher than a carbon fee (UNGC et al., 2015). If a specific reliable carbon price is adopted as a shadow price, this shadow price can become a standard metric among companies in similar industries. Internal carbon pricing is also found in the financial sector, which, instead of being carbon-intensive, is the kind of industry that can assist in minimising carbon emissions across different industries through green financing schemes.

As a considerable range of carbon prices exist, certain limitations exist to using the carbon price as an indicator to compare within or between industries or companies. If scenario analysis becomes more widespread in corporate practice, setting an internal carbon price need not be limited to the assessment of individual company projects (Harpankar, 2019; TCFD, 2017b). Scenario analysis can involve geographical assumptions where several companies may contribute to the same regions. If this interrelation between projects is considered in a scenario analysis, a comparable or generally approved standard of internal carbon pricing across industries for the region is a critical factor.

On the regulatory side, investors may perceive companies to be more exposed to carbon regulatory risk if they cannot internalise the costs of carbon regulation. Investors may assess companies' vulnerability to carbon regulation to increase when carbon pricing is increasingly set in national policy frameworks worldwide. Consequently, investors seek information on whether climate-related regulations could negatively impact companies. To meet these investors' information needs, companies have incentives to provide positive market signals to investors. Companies must send signals that they can minimise climate-related risks, possibly by modifying, if not compromising, their internal carbon pricing. However, information on internal carbon pricing can be misleading if companies lack the expertise or resources while wishing to signal good performance in carbon emissions. Therefore, companies should explain their pricing methods and effects when publishing internal carbon pricing information.

The negative impact of arbitrary internal carbon pricing can expand, since the demand for useful information disclosure on internal carbon pricing for investors' decision-making is increasing. However, the disclosure is currently voluntary and thus, is likely vulnerable to greenwashing. This condition raises concerns as it could lead to a mere corporate impression management strategy. It is challenging for investors to compare information on climate change as it is inherently an event involving uncertainty. The disclosure of climate-related information in financial documents through scenario analysis also involves uncertainty and assumptions. Similarly, internal carbon pricing contains assumptions and uncertainty. Therefore, the purpose of setting an internal carbon price and the extent to which it is used is an issue that should be assessed comprehensively in terms of its cost related to climate risks and opportunities, financing issues, and reputational management.

Major international climate information disclosure frameworks, including the TCFD recommendations (TCFD, 2017a), have called for the disclosure of internal carbon prices used within companies as a component of climate information disclosure. Regardless, without assurance, it does

not go beyond case studies and may lead to greenwashing, which is designed to legitimise existing corporate carbon management practices rather than improving them (Greer and Bruno, 1996). Assurances regarding climate information disclosure can be taken on internally, and eventually externally, faster in a regulated environment than in a less regulated environment, because regulatory legitimisation is the kind of pressure companies feel more compelled to comply with. However, there should be clearer guidelines on transparency and methods allowed across industries for internal carbon pricing to ensure quality assurance. Considering the potential of greenwashing through internal carbon prices (Bento et al., 2021; Greer and Bruno, 1996; Harpankar, 2019; Trinks et al., 2022), the issue needs to be addressed in the future by policymakers and researchers.

This study reviews and organises arguments using the recent interdisciplinary literature published during the past decade leading up to and following the 2015 Paris Agreement regarding internal carbon pricing. Based on the arguments, it proposes a research agenda for future research, and a structured discussion of relevant company issues. A significant contribution of this study is its organisation of arguments concerning internal carbon pricing. Since the ISSB has issued the S2 standard on climate-related disclosures, business practices, disclosure practices, and future research must change significantly.

Internal carbon pricing approaches, and characteristics vary depending on the decision-making process of companies. Therefore, there are many challenges to using and disclosing internal carbon pricing. With different methods, base prices, and characteristics of internal carbon pricing, companies involved in setting and disclosing internal carbon prices encounter many challenges. As an effective institutional framework for internal carbon pricing information disclosure can be more critical due to investors' increasing information demand, future research should build a sound institutional framework for meaningful disclosure. This study further highlights the need for companies to have a clear view of the cost of their GHG emissions and strategies to reduce them. It emphasises the importance of carbon pricing in transitioning to a more sustainable economy. Finally, the study calls for more research and guidance on implementing carbon pricing in line with the new sustainability disclosure standards. This includes understanding the implications of different price levels, the most effective ways to ensure compliance, and the potential risks associated with carbon pricing. Policymakers and regulators should also consider the potential effects of carbon pricing on different industries and regions.

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