TASK FORCE ON CLIMATE, DEVELOPMENT AND THE INTERNATIONAL FINANCIAL ARCHITECTURE

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Carbon Price Equivalents of Non-Pricing Mitigation Policies

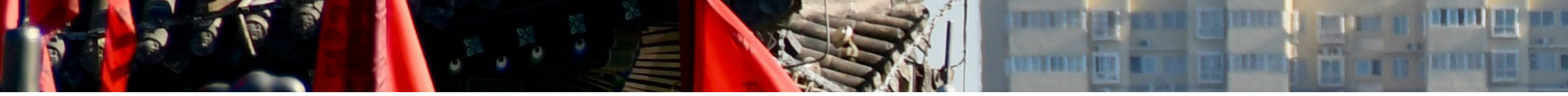
A STUDY OF CHINA

HE XIAOBEI, MA JUN AND GUO FANG

ABSTRACT

While carbon pricing is widely regarded as the most important tool for climate mitigation, many countries prefer non-pricing mitigation policies due to political and social constraints. Recognizing the importance of non-pricing mitigation policies is crucial for achieving inter-national coordination. The International Monetary Fund (IMF) and the Organization for Economic Cooperation and Development have made initial efforts to document and com-pare carbon pricing and non-pricing mitigation policies. In this paper, we build on existing studies by conducting a pilot study on China's non-pricing policies. Our findings suggest that, in China, non-pricing measures have played a meaningful role in emission reductions — a contribution that has not be documented by previous research. Specifically, non-pricing measures in the power and industrial sectors implemented during 2018-2023 are compara-ble to a carbon price of $10.0/ton. Our results indicate that relying solely on carbon prices when designing mechanisms such as the Carbon Border Adjustment Mechanism or the international carbon price floor proposed by the IMF risks underestimating and distorting the true mitigation contributions of countries that favor non-pricing approaches. A more inclusive assessment framework accounting for the emission effects of non-pricing policies is therefore critical to ensuring equitable and effective international climate cooperation.

Keywords: Non-pricing policies; price equivalents; emission reductions



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INTRODUCTION

Background

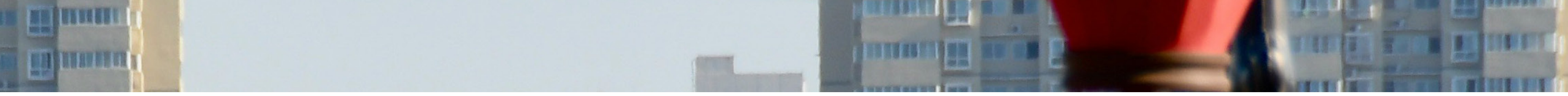
Carbon pricing is widely regarded as the most efficient instrument for climate mitigation, and the carbon prices of individual countries are often used as the primary indicator of climate policy strength. For example, carbon border adjustment mechanisms introduced by the European Union (EU) and United Kingdom (UK) rely on the "explicit" carbon prices set by domestic policies, comparing these with the carbon prices in exporting countries. Some international climate policy cooperation initiatives, such as the international carbon price floors proposed by the International Monetary Fund (IMF), also operate under the assumption that carbon prices are the sole relevant measure of climate policy.

There are at least two reasons why carbon prices are often prioritized as the primary measure of climate policy strength. First, from a theoretical standpoint, carbon pricing is widely seen as the most efficient instrument for reducing emissions. Second, using price as a metric is convenient, particularly because comparing the effects of various non-pricing policies is challenging.

However, in practice, both advanced and developing countries implement a combination of carbon pricing and non-pricing measures to reduce carbon emissions. Many countries, especially those in the developing world, favor non-pricing policies because traditional pricing instruments can be difficult to implement due to domestic political, institutional and social constraints (Asian Development Bank 2023; CSEP 2023).

Recognizing the significance of non-pricing mitigation measures is crucial for two main reasons. First, it is essential to design an effective policy mix that combines carbon pricing and non-pricing measures tailored to the specific conditions and constraints of each country. Second, from a global perspective, a comprehensive metric that includes non-pricing measures is needed to assess mitigation efforts across countries, which is vital for achieving international cooperation.

Research efforts have been made in this direction. For example, the IMF, Organization for Economic Cooperation and Development (OECD) and renowned think tanks like the Centre for Social and Economic Progress (CSEP) have developed various approaches to compare diverse mitigation policies, although these approaches and their results differ significantly. This research aims to complement existing studies by conducting a pilot study on China. We focus on China for two reasons: 1) China is the largest emitter among developing countries but has not been explicitly studied by the IMF or OECD in their approaches; and 2) China frequently uses subsidies, regulatory policies and administrative measures that may impact emissions and therefore warrant assessment. As China continues to develop its climate action agenda, a better understanding and comprehensive comparison of different policies can inform effective policy design.



Related Literature

The importance of non-pricing measures in addressing climate change has been recognized in the academic literature. It is widely documented that carbon taxes are regressive, imposing adverse distributional effects, as energy constitutes a larger portion of consumer expenditure for low-income households. This issue makes carbon pricing politically unattractive. Given that carbon pricing is often unpopular, the IMF (2023) identifies a trilemma among achieving climate goals, fiscal sustainability and political feasibility.

Cullenward and Victor (2020) emphasize the need for industry-specific regulations rather than market-based mechanisms to reduce emissions, particularly in light of significant political constraints. Stiglitz(2019) advocates for a nuanced policy approach where carbon pricing is complemented by regulations and other non-pricing interventions, which can alleviate adverse distributional impacts by allowing for lower necessary carbon prices. The literature also provide further justifications for employing non-pricing instruments. For example, Finon (2019) argues that non-pricing instruments and policies, such as efficiency standards, market-oriented regulations and subsidies for clean technologies, can address market and regulatory failures, which are more prevalent in developing countries than in developed ones.

Kohli and Karun (2023) provide a comprehensive review of non-pricing policies worldwide and develop a policy stringency index. However, they do not delve into comparing non-pricing sectoral policies with carbon pricing, noting that pricing and non-pricing policies often overlap, making it difficult to isolate the effects of individual policies.

To address this issue, the OECD and IMF have adopted contrasting approaches. The OECD aims to provide comprehensive documentation of mitigation policies across countries. However, integrating such an extensive list into a theoretical model poses challenges. The OECD has indicated plans to use a Computable General Equilibrium (CGE) model for evaluation but has yet to disclose specific results. The OECD also established the Inclusive Forum for Comparing Mitigation Approaches (IFCMA), which includes over 50 member countries; however, China has not participated in this forum.

In contrast, an IMF research paper (Black et al. 2022) proposes novel methods for estimating the "price equivalents" of various non-pricing policies, using a simplified approach that integrates sectoral policies into a cohesive framework. To facilitate cross-country comparisons, Black et al. (2022) estimate the emission impacts of sectoral policies based on the "announced emission targets" for major sectors in each country for the year 2030. They then translate these emission impacts into "carbon price equivalents" using the Climate Policy Assessment Tool (CPAT) model, a reduced-form model used to estimate future fuel use and emissions in major sectors.

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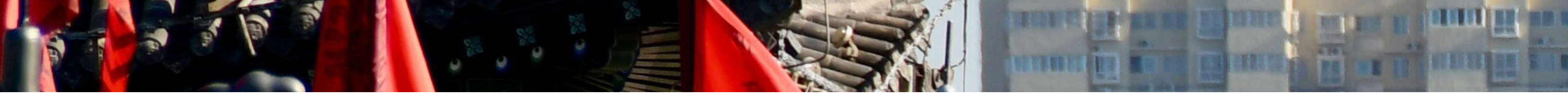

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While using "announced targets" simplifies cross-country analysis, this approach may yield misleading results for at least two reasons. First, unlike many advanced economies, some developing countries do not announce emission targets for 2030, either at the economy-wide or sectoral levels, despite implementing industrial policies and sectoral regulations that contribute to energy transition or industry upgrades. Second, "announced targets" can be directly influenced by carbon pricing schemes and other policies. As a result, an economy-wide price equivalent that combines announced targets with other climate policies may overestimate the effects of non-pricing policies.

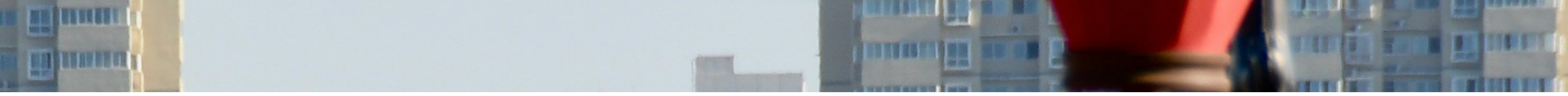
This paper addresses gaps in existing studies by conducting a pilot study on China. Our approach balances the IMF and OECD methods. Specifically, we do not aim to document every non-pricing instrument in detail; instead, we consider the combined effects of non-pricing mitigation policies, focusing only on selected sectors. Rather than estimating policy strength based on announced emission targets, as the IMF paper does, we infer the emission impacts of non-pricing policies from historical data.

To compare non-pricing measures with carbon pricing, it is necessary to translate the non-pricing measures into price equivalents. Unlike many non-pricing measures, carbon pricing affects the economic system in more complex ways, as agents' behaviors change in response to price fluctuations. We believe that a computable general equilibrium (CGE) model with interacting agents is essential to understanding the effects of policy, accounting for both direct and indirect impacts. Compared to other general equilibrium models like dynamic stochastic general equilibrium (DSGE) models, CGE models incorporate inter-sectoral linkages across industries and detailed sector specifications. Therefore, we estimate the carbon prices needed to achieve the desired emission reductions using a CGE model.

Two points are worth noting here. First, we derive the price equivalents based on emission impacts, recognizing that the economic impacts of different policies can vary significantly. Our underlying assumption is that economic costs are not the only factors considered by policymakers; social and political costs are important but vary across countries and are difficult to quantify. Second, while we intentionally avoid making assumptions about future policy stances, we acknowledge that drawing emission effects from historical data may not yield accurate insights into committed mitigation efforts.

METHODOLOGY

In this section, we first introduce the concept of "explicit carbon prices," which serves as the foundation for our analysis. Next, we provide an overview of China's non-pricing mitigation policies and explain our approach to calculating the emission impacts of policies in selected industries. Finally, we describe how we convert these emission impacts into their price equivalents using a CGE model.



China’s Non-Pricing Mitigation Measures

A nationwide emissions trading system (ETS) was introduced in China in 2021 following a series of pilot programs at the local level. The nationwide ETS currently covers the power sector, with an average carbon price of $10/ton of CO_2 in 2023. However, it is not a cap-and-trade system; rather, it operates under a tradable performance standard with 100 percent free allowances. Under a cap-and-trade system with an equally stringent cap, the carbon price would be much lower, as the cap-and-trade system is more effective in reducing emissions by lowering total output (Long 2024).

While progress in China’s ETS is slow, numerous sectoral policies and administrative measures with potential emission impacts have been widely adopted for much longer. China’s mitigation policies have distinct “Chinese characteristics.” Many of these sectoral policies are embedded in the Five-Year Plans, with the latest, the 14th Five-Year Plan, running until 2025. But no specific sectoral emission targets have been set for 2030.

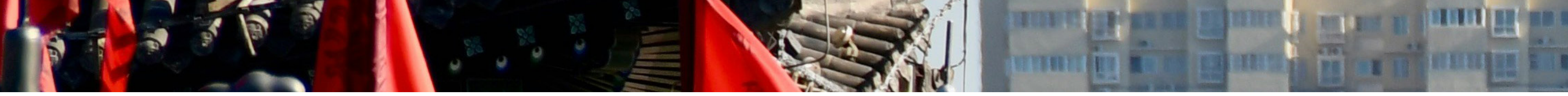
Following the OECD IFCMA taxonomy, we consider sectoral policies for four major emitting sectors, as well as cross-sectoral policies. The most relevant policies are listed in Table 1.

TABLE 1 Important Non-Pricing Mitigation Policies in China

Sectoral polices				Cross-sectoral policies
Power	Industry	Transport	Building	
Renewable portfolio standard (RPS) and green certificate	Energy performance standard	Electric vehicle (EV) subsidies (phased out)	Energy performance standards/improvement targets	Green financial policies
Renewable energy (RE) subsidies	Technology ban/improvement	EV targets	Electrification target	Government procurement
Feed-in-tariff (phased out)	Sectoral regulation (shut down factories)	Support for charging infrastructure	RE rate target	
	Subsidies for green equipment renewal		Local government subsidies/procurement	

Source: Compiled by authors.

Instead of covering all four sectors, we focus on two: the power sector and the industrial sector. The reasons for selecting these sectors are threefold. First, they are major emitters, with the power sector accounting for 40 percent of total emissions and the industrial sector contributing 25 percent. Together, they represent 65 percent of China’s total emissions. Second, sector-specific mitigation policies are widely adopted in these sectors, with details provided in the following sections. Third, there is minimal overlap in policy instruments between these sectors, making it easier to disentangle the emission impacts of policies in each sector.



In contrast to the IMF's approach (Black et al. 2022), which relies on "announced targets for 2030," we investigate the price equivalents of non-pricing policies using historical data. Similar to the IMF's method, we do not aim to isolate the emission impacts of specific policies within a sector. Instead, we consider the aggregate impact of various policies on each industry. We calculate the emission reductions between 2018 and 2023 relative to the business-as-usual (BAU) scenario for each of the three industries as follows.

Model

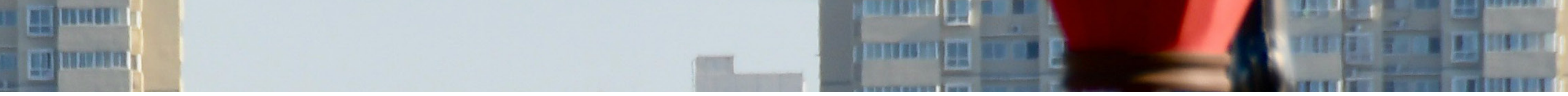
We use a recursive dynamic CGE model to study the emission impact of non-pricing measures and estimate the carbon price level required to achieve the same amount of emission reductions. The model is calibrated using China's input-output table for 2018, which emcompasses 153 sectors, along with data from the China Statistical Yearbook on Energy, China Statistical Yearbook and other pertinent sources. The model is solved annually from 2018 to 2060 . We aggregate the production sectors in the database into 21 economic sectors (See Appendix A1), and disaggregate the electricity sector in the input-output table following Peters et al.(2016) .

Below is a brief introduction to the CGE model. Production technology is modeled using seven layers ofr nested constant elasticity of substitution (CES) functions. A typical output is produced by combining intermediate demand and a value-added bundle. Intermediate demand is split into each commodity according to Leontief production function. The value-added bundle is produced by production factors such as labor, capital, land and energy. Within each resource-dependent sector, a sector-specific factor is integrated into the production function to account fo natural resource constraints. Capital and labor are fully mobile across sectors within a region.

The energy bundle is split into fossil fuels and power. Fossil fuels are further disaggregated into solid and non-solid energy, and the power bundle is split into thermal power and composite renewable energy, which is further divided into hydro, wind, nuclear and solar. Each level of production has a unit cost function that corresponds to the CES aggregator function and demand functions for the respective inputs. The top-level unit cost function defines the marginal cost of sectoral output.

In the model, representative consumers (households and the government) derive income from supplying production factors and collecting taxes, which they allocate to consumption, savings, and investment. Consumers maximize utility using the extended linear expenditure system (ELES), incorporating the saving decision into the utility function.

Producers supply final goods to both the domestic market and for export. Domestic demand is satisfied through both domestic output and imports. Exports are modeled using the constant elasticity of transformation (CET) function, whereby domestic producers determine the optimal allocation of domestic supply and export volumes. Imports are characterized by the Armington assumption, and domestic consumers allocate their expenditures between imported and domestic goods based on cost minimization principles.



In each period, aggregate capital stock is predetermined by the investment and savings decisions of previous periods. The supply of land and sector-specific factors is assumed to be elastic, responding to changes in their respective prices. The supply of labor is fixed in each period, with the market clearing through wage adjustments.

We follow Qi et al. (2023) in setting up the carbon emission module. The emission trading system (ETS) covers the power sector, with 100 percent of carbon allowances being auctioned. The government regulates the supply of carbon allowances according to specific emission reduction targets, resulting in equilibrium carbon prices that are endogenously derived when the emissions of the power sector equal the supply of allowances.

We use carbon price data from the World Bank to characterize each country's actual climate policy. For simulations of non-pricing policy scenarios, we derive the carbon prices endogenously by imposing an emission cap on the economy.

Governments collect taxes on production factors as well as on emissions. They operate with balanced budgets in all periods. Government consumption and savings are exogenous. Any changes in government budgets are automatically balanced by changes in transfers to households. Foreign savings are set exogenously. Changes in investment are determined by changes in household savings levels.

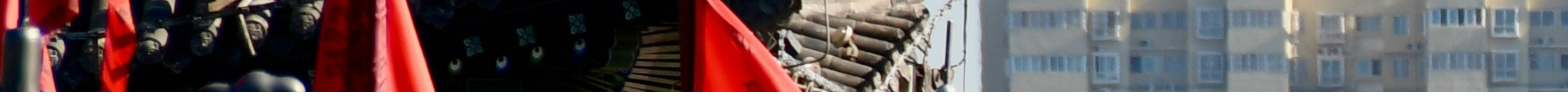
The model is recursively dynamic. The dynamics of the model are driven by exogenous population and labor growth, labor-augmented technological progress and capital accumulation. Population and labor force projections are based on United Nations forecasts. Technological progress is assumed to be labor-augmented, allowing the model to reach a steady state in the long run.

SCENARIOS AND SIMULATION RESULTS

To investigate the impact of non-pricing measures, we use historical data and set the simulation scenario for the period between 2018 and 2023. To produce the BAU projection for this period, we assume pre-existing policies remained fixed in 2018. We run simulations under three different policy scenarios.

Non-Fossil Fuels Target in the Power Sector

As of this date, China hasn't announced specific renewable energy targets for the power generation for 2030. Over the past decade, there has been a steady increase in the share of non-fossil fuels, with an average annual increase of 1.5 percentage points. In particular, between 2018 and 2023, the share of non-fossil fuels in China's power generation rose from 30.9 percent to 38.2 percent. Therefore, it is safe to say that the energy transition in China is driven by non-pricing mitigation measures, including subsidies for renewables and feed-in tariffs, among others.



To model the increase in the non-fossil fuel share in the CGE model, we follow Chen et al. (2023) and introduce a parameter that measures the production efficiency of renewable energies, namely hydro, wind, nuclear and solar. The parameters are calibrated to match the increase in the renewable share of power generation between 2018 and 2023. A parameter value greater than 1 indicates that the sector's production efficiency has improved, allowing the same level of output to be obtained with less input.

Simulation results suggest that the accumulated emission reductions from 2018 to 2023 amount to 1.43 gigatons (Gt), or 2 percent of the BAU level.

To estimate the price equivalents of the non-pricing measures, we remove the non-fossil fuels target and simulate the model that incorporates an ETS covering the power sector. The simulation results are presented in Table 2: a carbon price of $7/ton during this period would achieve the same level of emission reductions (as a percentage of the BAU level).

TABLE 2 Simulation Results: Non-Fossil Fuels Targets

Accumulated emission reductions relative to the BAU	1.43 Gt
Percent lower than BAU	2 percent
Price equivalents	$7/ton

Source: Compiled by authors.

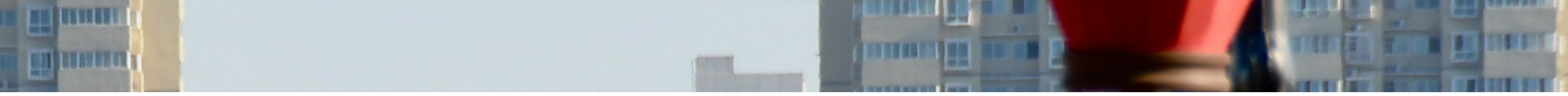
Enhancing Energy Efficiency in the Industrial Sector

Although China has not announced any official emission reduction goals for the industrial sector or specific industries for 2023, many sectoral policies are in place, including energy performance standards, administrative measures such as closing factories with poor energy performance and subsidies for green equipment upgrades. Since energy consumption is the major source of emissions in the industrial sector, we focus on measures aimed at enhancing energy efficiency in this area.

According to data from China Energy Statistical Yearbook 2019-2024 and China Statistical Yearbook 2019-2024, the average energy intensity of the industrial sector, measured in tons of coal equivalent (tce)/10,000 Yuan, decreased from 0.9 in 2018 to 0.77 in 2023, indicating an average annual decline of 2.9 percent.

Using 2018 as the BAU, and if pre-existing policies remained fixed at 2018 levels, the reduction in energy intensity from 2018 to 2023 can primarily be attributed to non-pricing policies. To model this reduction in the CGE model, we follow Jia and Lin (2022) and introduce a parameter that measures the energy efficiency improvements driven by non-price factors.

Simulation results suggest that enhancing energy efficiency in major industries leads to an economy-wide emission reduction of 0.53 Gt between 2018 and 2023, or 0.75 percent of the BAU level.



To estimate the price equivalents of the non-pricing measures, we remove the non-fossil fuels target and simulate the model that incorporates an ETS covering the power sector. As shown in Table 3, a carbon price of $2.5/ton during this period would achieve the same level of emission reductions.

TABLE 3 Simulation Results: Enhancing Energy Efficiency in the Industrial Sectors

Emission reductions relative to the BAU	0.53 Gt
Percent lower than BAU	0.75 percent
Price equivalents	$2.5/ton

Source: Compiled by authors.

Non-Pricing Measures in Both Sectors

As all measures discussed above are implemented simultaneously, we integrate actions in both sectors into a single framework and simulate the model between 2018 and 2023.

Simulation results (Table 4) indicate that when non-pricing measures are in place in both sectors, the economy-wide emission reduction amounts to 1.97 Gt, or 2.8 percent of the baseline level. This is equivalent to a carbon price of $10/ton during this period.

TABLE 4 Simulation Results: Both Sectors

Emission reductions relative to the BAU	1.97 Gt
Percent lower than BAU	2.8 percent
Price equivalents	$10.0/ton

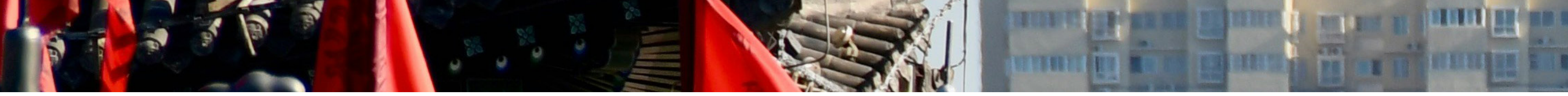
Source: Compiled by authors.

The price equivalent of $10 is higher than the carbon prices in the US, Japan and many G20 countries for the period 2018-2023. This finding indicates that non-pricing mitigation measures have significantly contributed to emission reductions in China.

CONCLUSIONS AND POLICY IMPLICATIONS

Many countries, particularly developing ones, tend to favor non-pricing mitigation policies. Recognizing this preference is crucial for fostering collective climate action. Understanding the impact of these non-pricing policies is essential for designing effective domestic climate strategies and improving international policy coordination.

This research addresses this issue with a focus on China, one of the world's largest emitters, which has not been extensively covered in existing studies. Our study complements existing research by shifting the focus from announced emission targets to actual outcomes using historical data. We adopt a simplified approach to explore this complex question. Our findings indicate that the carbon price equivalent of China's non-pricing mitigation policies



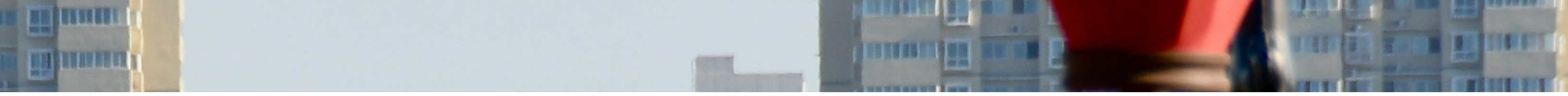
in the two major sectors is $10/ton—higher than the carbon price in many G20 countries. While our analysis is limited to two specific sectors, it is important to note that there are significant measures not covered, such as public investments and procurement in the transport sector. Additionally, the emission impact of technological progress driven by public policies is difficult to quantify.

Our results have important policy implications. First, relying solely on carbon prices from ETS or carbon tax rates for mechanisms like the CBAM or the international carbon price floors proposed by the IMF can underestimate the efforts by countries that prefer non-pricing mitigation instruments. Failure to recognize the importance of diverse mitigation instruments therefore disincentivizes international cooperation. Second, non-pricing mitigation policies can achieve meaningful carbon reductions. While non-pricing measures may not be as economically efficient as carbon pricing, they often encounter less political and social constraints and are generally easier to implement. Consequently, to ensure equitable and effective international climate cooperation, it is crucial for the IMF and international organizations to develop more inclusive assessment framework that adequately considers the emission effects of non-pricing policies.

APPENDIX A1. ECONOMIC SECTORS

TABLE A1 Economic Sectors in the Model

Abbr.	Sector in the model
AGR	Agriculture related sectors
COL	Coal production
COLP	Coal processing
O_G	Oil andgas production
REFO	Refined oil
REFG,	Refined gas
OMIN	Other mining products
LGT	Light industry
CMC	Chemicals
BMTL	Building materials
STL	Steelmaking
MLT_P	Metal and the products
MFT	Manufacturing
THP	Thermal power
HYP	Hydropower
WDP	Wind power
NCP	Nuclear power
SOP	Solar power
CST	Construction
TSPT	Transportation
SER	Service



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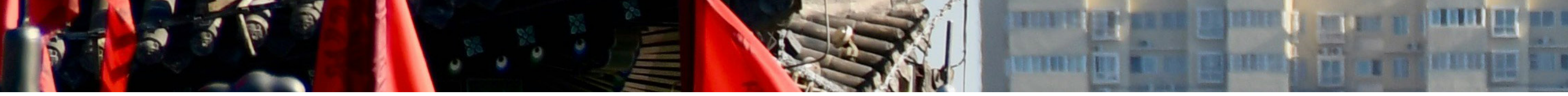

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