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BY LAWRENCE H. GOULDER, XIANLING LONG, CHENFEI QU, AND DA ZHANG

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ECONOMIC AND ENVIRONMENTAL IMPACTS OF CHINA'S NEW NATIONWIDE CO_2 EMISSIONS TRADING SYSTEM

Results from a Numerical General Equilibrium Model

ABOUT THE AUTHORS

Lawrence H. Goulder is the Shuzo Nishihara Professor of Environmental and Resource Economics at Stanford University and a Research Associate at the National Bureau of Economic Research.

Xianling Long is Assistant Professor in Economics at the National School of Development, Peking University.

Chenfei Qu is a Ph.D. candidate at the Institute of Energy, Environment, and Economy, Tsinghua University

Da Zhang is Associate Professor at the Institute of Energy, Environment, and Economy, Tsinghua University.

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EXECUTIVE SUMMARY

China has launched an ambitious nationwide program to reduce CO_2 emissions and address climate change. The program has already become the world's largest emissions trading system and it is expected to contribute substantially toward meeting China's pledge to peak its carbon emissions before 2030 and achieve carbon neutrality before 2060.

The new system is a tradable performance standard (TPS), a rate-based system under which each covered facility receives from the government in each compliance period a certain number of emissions allowances based on its output and the government's assigned "benchmark" ratio of emissions per unit of output.

The TPS will be introduced in phases. The first began in 2021 and covered only the power sector (which accounted for about 43 percent of China's total CO_2 emissions in 2020). In the second phase, which is likely to begin in late 2023 or early 2024, coverage will expand to include the cement and aluminum sectors and possibly the iron & steel sector as well, so that overall coverage will amount to about 67 percent of China's CO_2 emissions. At least one further phase is expected, under which the TPS will expand to cover additional manufacturing sectors, including pulp & paper, other non-metal products, other non-ferrous metals, chemicals, and petroleum refining, finally covering nearly 75 percent of China's CO_2 emissions.

This issue paper describes the results from a multi-sector multi-period general equilibrium model designed to assess the potential impacts of China's new venture, considering the effects on emissions, production costs, and incomes over the interval 2020–2035, by sector and province and in the aggregate. Results from the model indicate that over the interval 2020–2035, the TPS will yield a significant share of the nationwide emission reductions that a plausible path to net zero emissions by 2060 would recommend. We find that the climate-related benefits from the TPS's CO_2 emissions reductions over the interval 2020–2035 exceed its costs by a factor of five. Taking account of the health benefits from improved local air quality increases the TPS's benefit-cost ratio to 25.

The impacts of the TPS vary significantly across sectors, influencing prices, output

The TPS promotes the transition away from fossil-generated to renewables-based electricity by raising the effective price of using carbon-intensive fuel inputs.

levels, and emissions in both the sectors covered by the TPS and in the sectors not covered. Relative to baseline, electricity output declines by 4 percent as a result of the compliance costs to electricity generators under the TPS. The output of coal decreases by 14 percent, reflecting the reduction in demand for coal in the sectors covered by the TPS. In contrast, the output of the natural gas sector increases by 4 percent, reflecting the reduction in the relative price of natural gas.

The TPS promotes the transition away from fossil-generated to renewables-based electricity by raising the effective price of using carbon-intensive fuel inputs. Over the interval 2020–2035, the policy leads to a 5 percent increase in wind- and solar-electricity generation relative to what would occur in the absence of the policy.

Several significant changes to China's TPS are being contemplated by the central planners, including the transition from the TPS to cap and trade and supplementing the TPS with an auction as a mechanism for supplying emissions allowances. The model's simulation results provide support for these policies, as both can lower the costs of achieving China's emissions-reduction goals.

INTRODUCTION

China has launched an ambitious nationwide program to reduce CO_2 emissions and address climate change. The program has already become the world's largest emissions trading system, and it is expected to double the amount of CO_2 covered by emissions pricing worldwide when it expands to cover other emissions-intensive sectors. It is expected to contribute substantially toward meeting China's pledge to peak its emissions before 2030 and achieve carbon neutrality before 2060.

The new system is a tradable performance standard (TPS), a rate-based system under which each covered facility receives from the government in each compliance period a certain number of emissions allowances based on its output and the government's assigned "benchmark" ratio of emissions per unit of output. In general, the benchmarks are set below the average initial emissions intensities across the covered facilities, which implies that the TPS will require an overall reduction in the emissions-output ratio.

China's TPS will be introduced in phases. The first began in 2021 and covered only the power sector (which accounted for about 43 percent of China's total CO_2 emissions in 2020). In the second phase, which is likely to begin in late 2023 or early 2024, coverage will expand to include the cement and aluminum sectors and possibly the iron & steel sector as well, so that overall coverage will amount to about 67 percent of China's CO_2 emissions. At least one further phase is expected, under which the TPS will expand to cover additional manufacturing sectors, including pulp & paper, other nonmetal products, other nonferrous metals, chemicals, and petroleum refining, finally covering nearly 75 percent of China's CO_2 emissions. Along with the coverage expansions, the benchmarks are expected to be continuously tightened to align with China's national emissions-reduction targets.

This issue paper describes the results from a multi-sector, multi-period general equilibrium model designed to assess the potential impacts of China's new venture, considering

> The TPS creates an implicit subsidy for an increase in a covered facility's output, or an implicit tax on a reduction in its output. This is a key difference from cap and trade (C&T).

the effects on emissions, production costs, and incomes over the interval 2020–2035, by sector and province and in the aggregate.[1]

THE TPS

The TPS requires that each covered facility's initial allocation of emissions allowances, plus (minus) any allowances it purchases (sells) on the trading market, be sufficient to justify its emissions during the compliance period. To minimize costs of compliance, covered facilities can utilize three channels: (a) reducing emissions intensity (emissions per unit of output), (b) purchasing or selling allowances, and (c) reducing output supply (which can reduce needed allowance purchases).

The government's allowance allocation to a given covered facility is proportional to the facility's output. If the facility's benchmark emissions-output ratio is β and its output level is q, the facility is allocated $\beta \cdot q$ allowances – just enough allowances needed to authorize its emissions if it achieves an emissions intensity of β. Since the allocation is proportional to output, it is endogenous from the facility's perspective: the facility can influence its allocation through its choice of output. In particular, an additional unit of output earns the facility valuable additional allowances. Consequently, the TPS creates an implicit subsidy for an increase in a covered facility's output, or an implicit tax on a reduction in its output. This is a key difference from cap and trade (C&T), the most frequently used CO_2 emissions trading system in other parts of the world, where a facility's allowance allocation is generally exogenous from the facility's perspective. This difference from C&T has important implications for the TPS's aggregate costs and the distribution of its impacts across sectors.

THE NUMERICAL MODEL

We have developed a model with several distinguishing features that make it especially well suited to evaluate the TPS. The distinguishing features include its general equilibrium framework, which enables it to consider interactions among sectors covered by the TPS as well as between the covered and uncovered sectors; its use of plant-level data, which enables it to account for heterogeneous production technologies within sectors and evaluate the TPS's use of multiple benchmarks within sectors; its multi-period nature, which enables it to capture changes in policy stringency and impacts over time; and its flexibility in terms of the range of future TPS policy designs it can examine, including alternative specifications for the variation and average stringency of benchmarks, the introduction of allowance auctioning, and the possible transition from the TPS to a C&T system. Table 1 displays the model's 31 production sectors.

TABLE 1. **SECTORS**

PHASE ADDED TO THE TPS	SECTORS
PHASE 1	Electricity[a]
PHASE 2	Cement,[b] Aluminum,[c] Iron & steel[d]
PHASE 3	Pulp & paper, Petroleum refining, Raw chemicals, Other nonferrous metals, Other nonmetal products
OTHER SECTORS	Agriculture, General equipment, Mining, Transport equipment, Food, Electronic equipment, Textile, Other manufacturing, Clothing, Water, Log furniture, Construction, Printing & stationery, Transport, Daily chemicals, Services, Metal products, Coal, Gas distribution, Crude oil, Heat, Natural gas

[a] The electricity sector divides into 15 subsectors, distinguishing the following generation technologies: LUSC (1000MW ultra-supercritical), SUSC (600MW ultra-supercritical), LSC (600MW supercritical), SSC (300MW supercritical), LSUB (600MW subcritical), SSUB (300MW subcritical), OTHC (conventional units with installed capacity less than 300MW), LCFB (circulating fluidized bed units with installed capacity greater than or equal to 300MW), SCFB (circulating fluidized bed units with installed capacities less than 300MW), HPG (gas-fired plants, F-class), LPG (gas-fired plants, pressure lower than F-class), Wind power, Solar power, Hydropower, and Nuclear power.

[b] The cement sector divides into 3 subsectors: high-, medium-, and low-efficiency cement production.

[c] The aluminum sector divides into 3 subsectors, including high-, medium-, and low-efficiency aluminum production.

[d] The iron & steel sector divides into 6 subsectors: high-, medium-, and low-efficiency basic oxygen steel production, and high-, medium-, and low-efficiency electric arc furnace steelmaking.

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[1] Detailed documentation of the model's structure and data along with results from a wide range of simulations of the TPS are in Long et al. (2023).

> We employ data from several sources to create a consistent database for inputs, outputs, and emissions. The sources include China's input-output table, the Global Trade Analysis Project database and a plant-level dataset for covered sectors collected by the Ministry of Ecology and Environment (MEE).

We employ data from several sources to create a consistent database for inputs, outputs, and emissions. The sources include China's input-output table; energy balance table; the Global Trade Analysis Project database; and an anonymized plant-level dataset for electricity, cement, aluminum, and iron & steel sectors collected by the Ministry of Ecology and Environment (MEE).

POLICIES CONSIDERED

We perform simulations of policy cases that are of particular interest to China's policymakers as they make important decisions on China's current TPS policy and its future evolution.

The central case reflects the current benchmarks and the ones projected for the next phases of the TPS. Four benchmarks apply to the electricity sector (three for coal-fired and one for gas-fired generators), two apply to the iron & steel sector (one for the basic oxygen process and one for the electric arc furnace process), and one applies to each of the other covered sectors. The tightening rate for the electricity sector is 0.5 percent/year during Phase 1, as announced by the MEE. The annual tightening rate for the electricity sector in Phases 2 and 3 is projected to be 1.5 percent, and the rate for other sectors is 2.5 percent.[2]

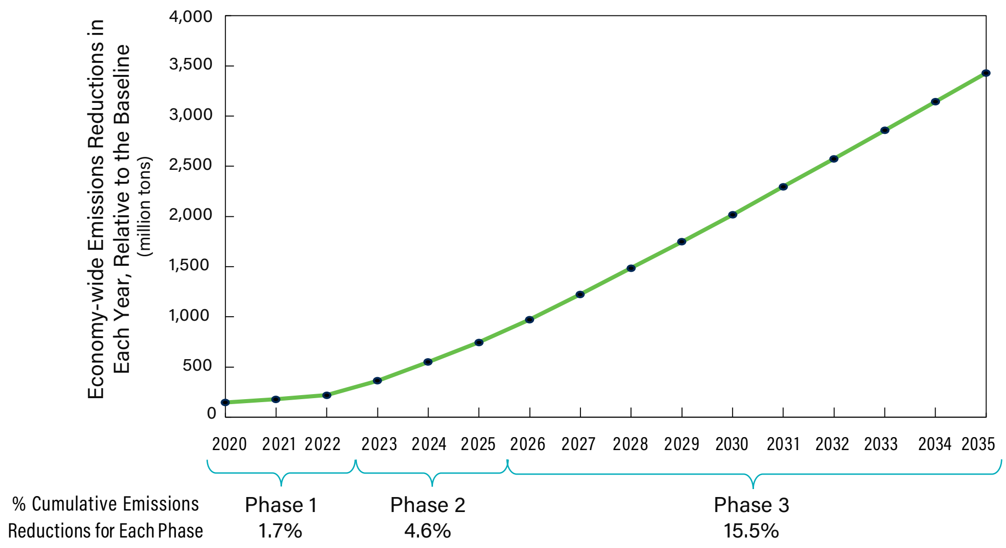
The other policies considered include faster increases over time in the stringency of the benchmarks, the possible transition from the TPS to a C&T system, and the possible introduction of an allowance auction as a supplementary source of allowance supply.

IMPACTS OF THE TPS

Central Case

Figure 1 displays the policy-induced emissions reductions in our central scenario. The reductions relative to the same year of the baseline[3] become progressively larger as the system's coverage expands and benchmarks are tightened in later phases. The cumulative emissions reduction over the interval 2020–2030 is 9.7 billion tons. This is more than half of the cumulative reduction endorsed by the 14th Five-Year Plan as a path toward a peaking of emissions by 2030.[4]

FIGURE 1. **EMISSIONS REDUCTIONS RELATIVE TO THE BASELINE**



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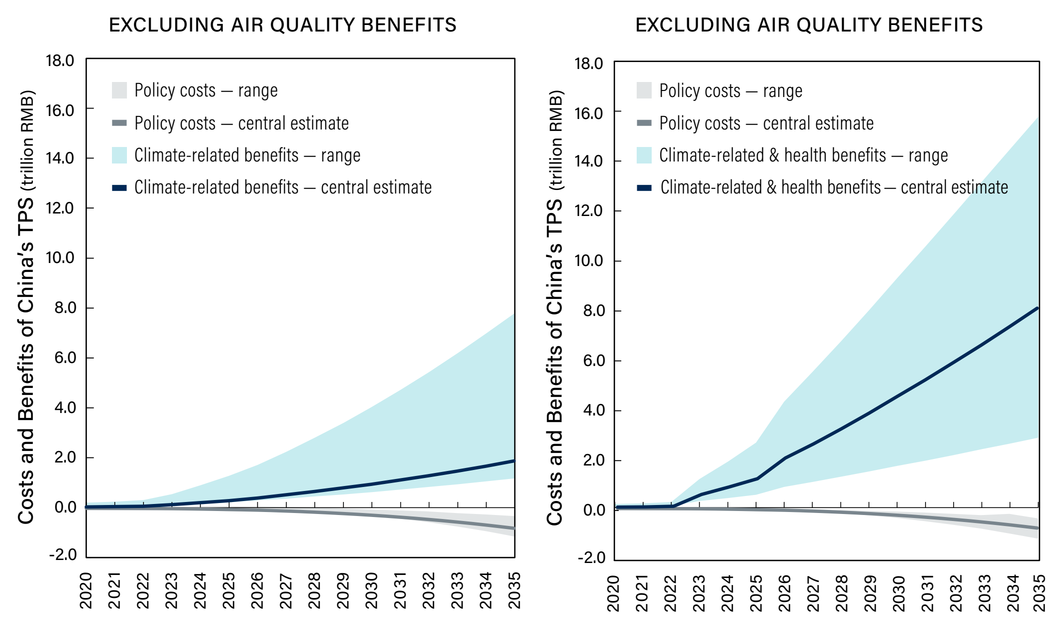
[2] The lower tightening rate for the electricity sector is consistent with the MEE's view that there is less room for future energy-efficiency improvements in this sector than in others.

[3] The baseline represents a scenario without the TPS or any new policy interventions that might occur between 2020 and 2035.

[4] The 14th Five-Year-Plan (FYP) targets an 18% reduction in national emissions intensity, the ratio of total CO_2 emissions to GDP, during the 14th FYP interval (2021–2025). We compare the model's central case cumulative reduction over the interval 2021–2030 with the reduction that occurs in the model if the FYP's goal of an 18% reduction in emissions intensity is achieved over that same interval.

The value of the TPS's climate and air quality benefits is approximately 25 times the TPS's costs.

FIGURE 2. **COSTS AND BENEFITS OF CHINA'S TPS**



Our simulations shed light on the benefits and costs of China's new venture. We estimate the benefits and costs under a wide range of assumptions regarding the parameters that influence abatement costs and the time profile of the "social cost of carbon" (SCC), the external cost from CO_2 emissions. The SCC is a measure of the benefit from reduced emissions of CO_2. Across a wide range of assumptions for the SCC, production parameters, and policy stringency over the interval 2020–2035, the TPS's climate-related benefits are above its economic costs. Figure 2 shows the ranges and the central estimates of TPS's costs and benefits. When only the climate-related benefits (avoided climate damage) are considered, the estimated benefits from the cumulative CO_2 reductions over the interval 2020–2035 are in the range of 8–49 trillion RMB, while the cumulative economic costs range from 2 trillion to 3 trillion RMB. The benefits are 4–23 times the costs. The central estimate of the climate benefit is 12 trillion RMB, more than five times TPS's costs.

Adding benefits from improved air quality to climate-related benefits raises the benefit-cost ratio substantially. The present values of the TPS's climate and air quality benefits are in the range of 19–106 trillion RMB over the interval 2020–2035. The central estimate is 53 trillion RMB, 25 times the central estimate for the TPS's costs.

Sector Impacts

Figure 3 shows the covered sectors' relative contributions to emissions reductions over the interval 2020–2035. The largest reductions are from the electricity sector and the sectors that were added in Phase 2, with the former accounting for 57 percent and the latter accounting for 30 percent of the total.

The impacts on the prices and levels of output of different sectors are displayed in Figure 4. The numbers shown are percentage changes in the weighted-average output price and level of production during the interval 2020–2035, where the weights are based on output levels in the baseline. As expected, The largest emissions reductions are from the electricity sector (57 percent of total) and the sectors added in the next phase (cement, iron & steel and aluminum, 30 percent of total).

FIGURE 3. **COVERED-SECTORS' CUMULATIVE EMISSIONS REDUCTIONS OVER THE INTERVAL 2020-2035**

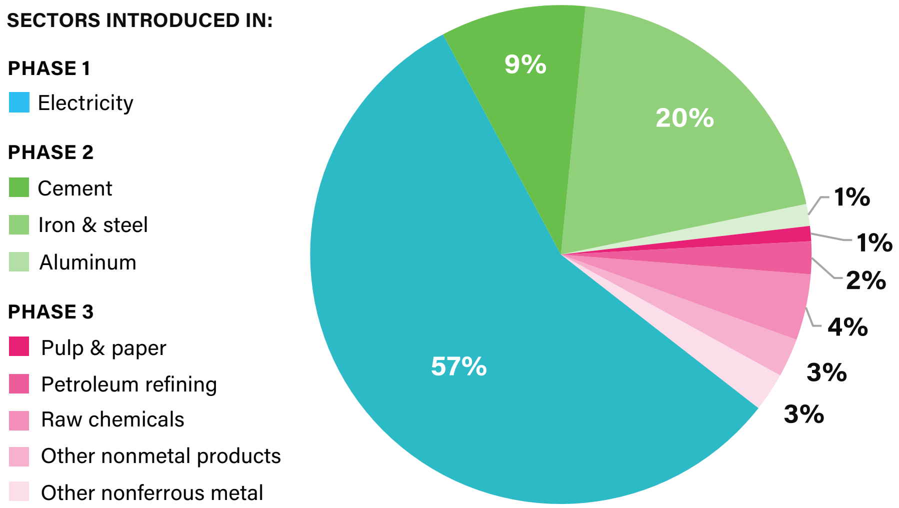
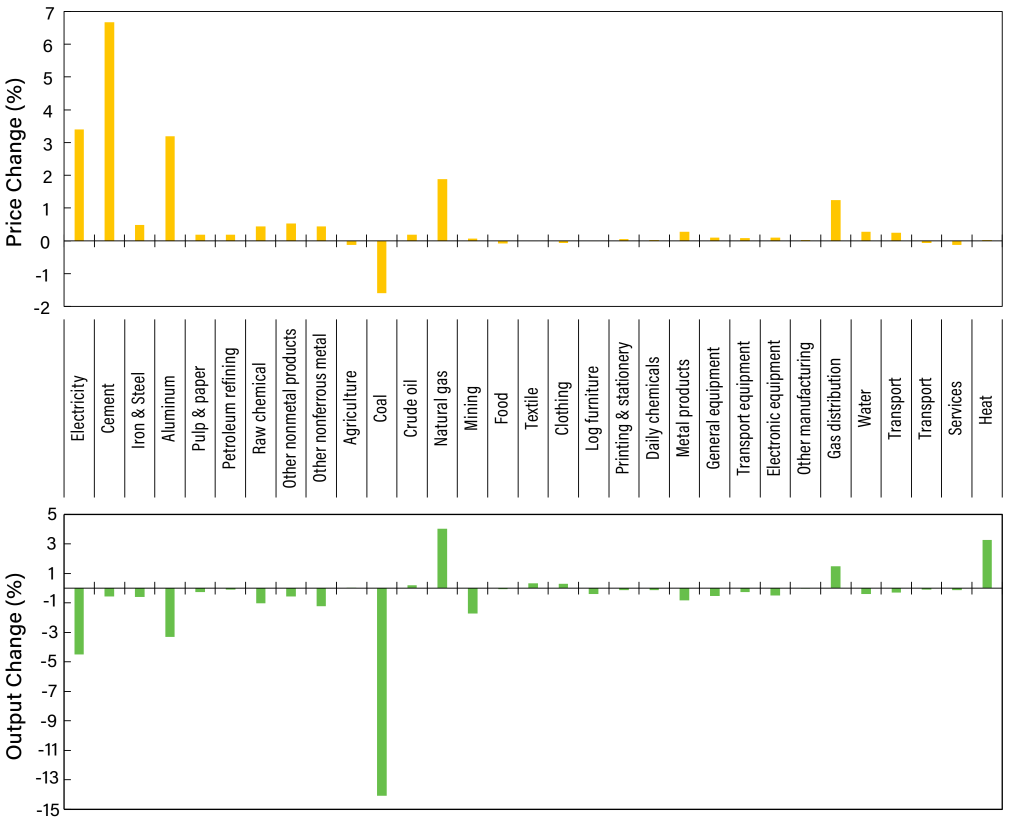


FIGURE 4. **PERCENTAGE CHANGES IN PRICE AND OUTPUT OVER INTERVAL 2020-2035**



Among the uncovered sectors, the coal sector suffers the highest percentage of losses of output over the interval 2020–2035, reflecting a significant reduction in demand for coal by the sectors that the TPS covers.

the covered sectors experience increases in price and reductions in output. This reflects the increased unit cost of production caused by the allowance price and the use of output reduction as a channel for reducing compliance costs.

Among the covered sectors, the electricity, cement, and aluminum sectors on average experience relatively large price increases over the interval 2020–2035, reflecting the larger increased unit cost of production due to their relatively higher baseline emissions intensities (measured by the ratio of emissions to their output value) than other sectors.

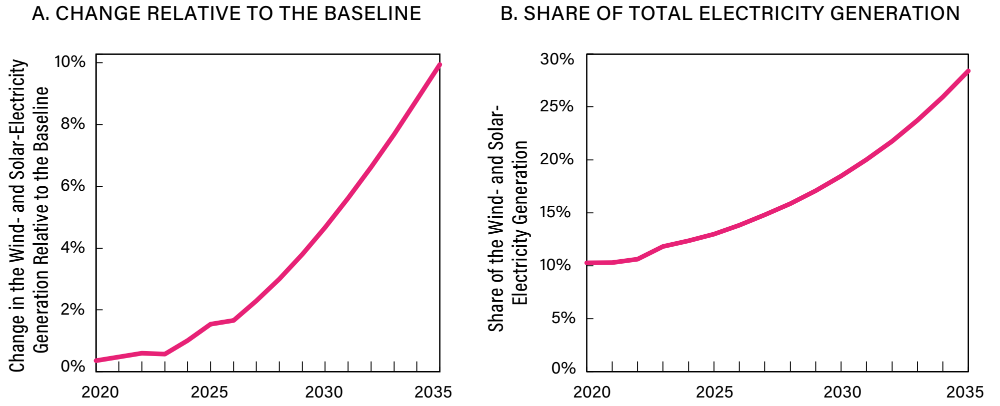
Impacts on output reflect changes in production cost and in demand. The cement sector experiences a relatively small reduction in output over the interval 2020–2035 while also experiencing the largest price increase among the covered sectors. This reflects the relatively inelastic demand for cement. The low elasticity is in part due to the fact that cement is less trade exposed than, for example, the aluminum sector and less vulnerable to imported substitutes.

Among the uncovered sectors, the coal sector suffers the highest percentage of losses of output over the interval 2020–2035, reflecting a significant reduction in demand for coal by the sectors that the TPS covers. In contrast, the natural gas sector experiences large percentage increases in prices and output. This stems from increases in demand for natural gas, which can be used as a substitute for coal in some covered sectors as a way to reduce emissions intensity by fuel substitution. Another factor is that the MEE sets less stringent benchmarks (measured by the difference between the benchmark and the baseline emissions intensity) for gas-fired plants than for coal-fired plants, which contributes to the substitution of natural gas-fired for coal-fired electricity.

Impacts on Renewables

The government hopes that China's climate policies will promote the transition away from fossil fuels and toward renewables-based energy. The TPS encourages the substitution of renewables-based electricity for fossil-based power by raising the relative costs of carbon-intensive fuel inputs. Figures 5a and 5b show the impacts of the TPS on renewables generation, displaying the changes in the level of renewables generation relative to the baseline level (5a) and the changes in the renewables share of electricity

FIGURE 5. **IMPACTS ON THE WIND- AND SOLAR- ELECTRICITY GENERATIONS**


A. CHANGE RELATIVE TO THE BASELINE

B. SHARE OF TOTAL ELECTRICITY GENERATION

The current TPS system involves four benchmarks for the electricity sector. Reducing the number of benchmarks to one reduces costs by 29 percent, as a result of a more efficient allocation of production across generators.

output (5b). Under the TPS, wind- and solar-electricity generation increases by 5 percent relative to the baseline during the period 2020-2035. The TPS's implicit output subsidy mitigates the extent of these changes, as the subsidy mitigates the increase in fossil-based electricity prices and moderates the substitutions toward renewables-based power.

Benchmark Variations

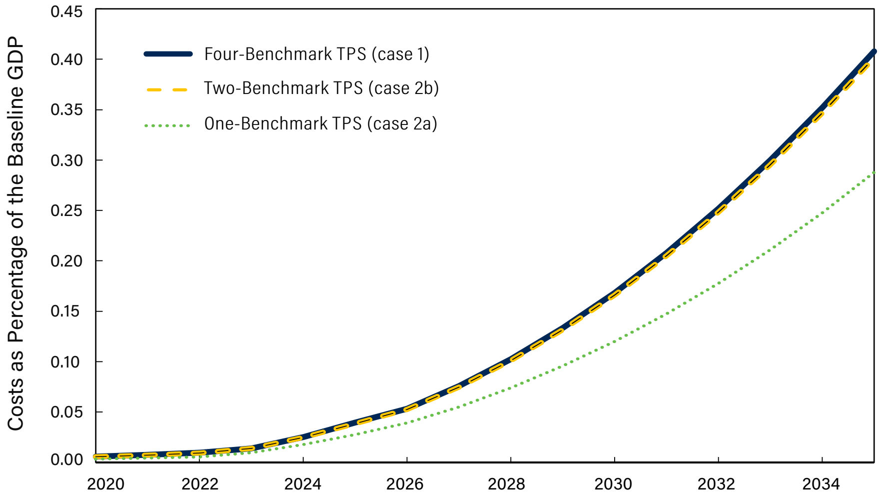
The TPS's cost-effectiveness depends on the variation of benchmarks. Figure 6 displays the economic costs of achieving the same amount of emissions reduction in cases of different variations of electricity sector benchmarks. The current TPS system involves four benchmarks for the electricity sector. Reducing the number of benchmarks to two (while maintaining the same average stringency) reduces costs by 1 percent in 2020-2035. Reducing the number to one reduces costs by 29 percent. Greater uniformity lowers the aggregate cost by reducing the variation in the marginal value of output, which leads to a more efficient allocation of production across generators. Thus, an attraction of greater uniformity of benchmarks is the lower associated cost of meeting given overall abatement targets. Nevertheless, policymakers may wish to have some variation of benchmarks, specifically to customize them in a way that avoids undesirable distributional impacts. The fact that the TPS incorporates variation of benchmarks suggests that these distributional considerations are given some weight.

Alternative Increases in Policy Stringency (Benchmark Tightening Rates)

The government has not yet indicated how the future benchmarks will differ from the current ones, although it is clear that benchmarks will be continually tightened over time. Recognizing the uncertainties, we consider alternative scenarios for the rates at which the benchmarks will be tightened. Figure 7 shows the emissions pathways of these cases. What might appear to be small changes in the rates at which benchmarks are tightened will have a significant impact on emissions by 2035.

Given the importance of China's pledge to

FIGURE 6. **ECONOMIC COSTS UNDER DIFFERENT BENCHMARK VARIATIONS**



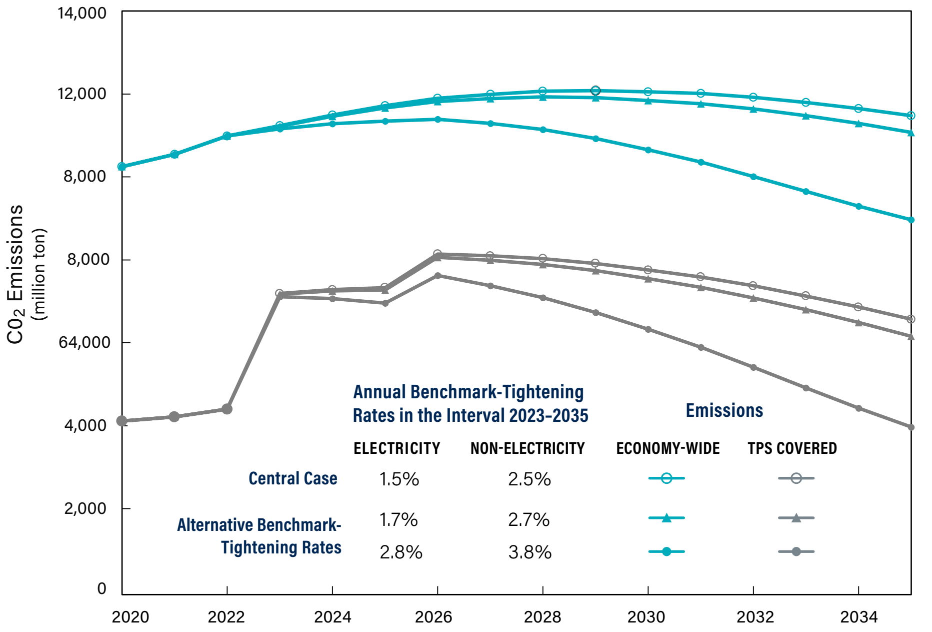
We have applied the model to compare the costs of the TPS with an equivalent C&T system that achieves the same cumulative emissions reductions in the aggregate.

achieve carbon neutrality by 2060, it is useful to consider how the emissions paths in Figure 7 compare with what would be needed over the interval 2020–2035 under an emissions path that leads to net zero. This is challenging because there is no unique pathway that would lead to carbon neutrality by 2060.[5] Nevertheless, it is instructive to compare our central case emissions path over the interval 2020–2035 with the path of He et al. (2020) over that same interval. The He et al. (2020) path leads to net zero emissions in 2060 and is based on a framework that considers China's current conditions and development stage, as well as other policies relevant to medium–to–long-term national plans. Thus, some useful information can be obtained by comparing the He et al. (2020) path with ours over the interval 2020–2035; the cumulative emissions reductions from the alternative stringency cases shown in Figure 7 achieve between 55 percent and 83 percent of the reductions in the He et al. (2020) profile. This is a significant percentage, given that China employs other measures, such as renewable electricity subsidies and the advancement of negative emissions technologies, to reduce CO_2 emissions. China expects the TPS to contribute substantially to meeting its carbon neutrality goal, but it is also counting on other policies to do a fair share of the work.

TPS Costs and the Possible Transition to a C&T System

As noted, China's TPS differs from the most frequently employed CO_2 emissions trading systems in other countries – cap and trade. We have applied the model to compare the costs of the TPS with an equivalent C&T system – specifically, a C&T system that achieves the same cumulative emissions reductions in the aggregate and has (exogenous) allocations of emissions allowances that match the (endogenous) allocations under the TPS in our central case.

FIGURE 7. **EMISSIONS UNDER DIFFERENT BENCHMARK-TIGHTENING RATES, 2020-2035**



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[5] In fact, an infinite number of pathways can achieve net zero by 2060. They will have different time profiles and different cumulative costs because of differences in timing, but all will terminate with the same (net zero) level of emissions.

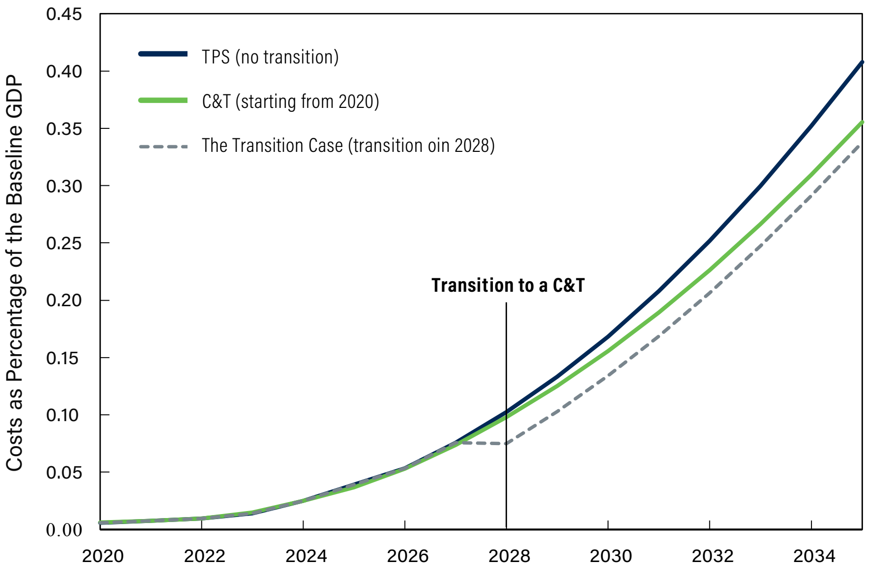
The TPS's costs are close to those of an equally stringent C&T system during the first years of the program, but they rise significantly above the C&T in later years.

As shown in Figure 8, the TPS's costs are close to those of an equally stringent C&T system during the first eight years of the program, but they rise significantly above the C&T in later years, with the difference in costs expanding after the eighth year.

A significant factor underlying this dynamic pattern is the changing magnitude of the impact of the TPS's implicit subsidy to output, which as noted earlier, causes covered facilities to make relatively inefficient use of the output-reduction channel to reduce emissions. Although the TPS's implicit subsidy leads to inefficiently high output relative to C&T, it also has the beneficial effect (in terms of efficiency) of reducing the distortionary effect of preexisting taxes.[6] This impact from the subsidy helps improve the cost-effectiveness of the TPS and offsets what otherwise would be a larger disadvantage relative to C&T in the early years. Other analyses have shown that the efficiency loss from the implicit subsidy is proportional to the product of the benchmark and the allowance price.[7] In later years, the increase in stringency and associated higher allowance prices adds to this efficiency loss. Accordingly, the cost of the TPS rises significantly relative to that of C&T in later years.

The planners are seriously considering a possible transition from the TPS to C&T. We have performed simulations of scenarios where China makes such a transition. Figure 8 shows the outcome when the transition takes place in 2028. That is, the system is a TPS up to 2028 and a C&T system after that: the transition is completed in one year.[8] As in the hypothetical case where C&T is introduced in 2020, when it is introduced in 2028 the C&T cost per ton is again below the cost per ton under the TPS. In fact, the C&T cost per ton is lower in this transition case than if C&T was introduced in 2020. This outcome stems from the TPS's impact on investment prior to the transition year. The TPS's implicit output subsidy results in relatively low prices of new capital goods. This promotes faster investment. The higher associated capital

FIGURE 8. **ECONOMIC COSTS OF THE TPS AND C&T, 2020-2035**



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[6] This "tax-interaction" effect has been examined theoretically and numerically in the prior environmental economics literature. See, for example, Goulder et al. (1999), Parry and Bento (2000), and Parry and Williams (2010).

[7] See Goulder et al. (2023) for a detailed discussion.

[8] In an alternative scenario, we assume the transition is more gradual, starting in 2028 and completed by 2030. This scenario yields similar results with the immediate transition case. Long et al. (2023) present the results of such a gradual transition.

C&T has larger positive effects than TPS on renewable energy because the price of electricity rises more under C&T, giving larger incentives for the wind- and solar-electricity to increase output.

TABLE 2. **SUMMARY OF IMPACTS UNDER DIFFERENT AUCTION REVENUE RECYCLING OPTIONS**

	Present value of cumulative cost (trillion RMB)	**Economic cost per ton** (RMB/ton)	**Wind and solar electricity increase** (percent)
CENTRAL CASE (NO AUCTIONING)	2.07	87	5
AUCTIONING: RECYCLING VIA RENEWABLES OUTPUT SUBSIDIES	1.57	65	38
AUCTIONING: RECYCLING VIA LUMP-SUM TRANSFERS	1.52	63	14
AUCTIONING: RECYCLING VIA MARGINAL INCOME TAX CUTS	1.25	52	14

stock implies a lower rental price of capital, which in turn implies lower future costs of CO_2 abatement in the transition case: covered facilities can switch at a lower cost from fuel inputs to capital. Thus, C&T owes a debt to the TPS for its low costs after the transition: the TPS has led to higher investment prior to the transition, which enabled C&T to inherit a higher capital stock starting in 2028.

Furthermore, in relation to impacts on renewables-based electricity, C&T has larger positive effects than TPS because the price of electricity rises more under C&T, giving larger incentives for the wind- and solar-electricity to increase output. The wind- and solar-generated electricity increases by 13% and 20% under C&T relative to the baseline.

Introducing Auctioning

Policymakers are also contemplating supplying some of the emissions allowances via an auction rather than offering them for free. We consider several scenarios in which an auction complements the TPS system as a source of supply of allowances. We estimate that supplying some allowances under the TPS via an auction can lower the economic costs of achieving given emissions-reduction targets by 24–40 percent relative to the no-auction case, depending on how auction revenues are recycled. Table 2 summarizes these results. Introducing auctioning lowers costs because supplying by auctioning does not involve the TPS's implicit output subsidy and its associated distortions. When the auction revenue is used to finance cuts in preexisting capital and labor tax rates, the costs are reduced further, since lowering the marginal tax rates reduces the economic distortions from such taxes. Using the revenue to finance output subsidies for wind- and solar-generated electricity leads to higher costs because the subsidies introduce new distortions but can significantly increase the output of renewables-based electricity. These results provide support for introducing auctioning as part of China's national emissions trading system.

CONCLUSIONS

China's nationwide emissions trading system is on track to become a major contributor to the nation's efforts to achieve net zero emissions of CO_2 by 2060. Results from our multi-sector, multi-period general equilibrium model indicate that over the interval 2020–2035, the TPS will yield a significant share of the emissions reductions that a plausible path to net zero emissions by 2060 would recommend. Under central values for production parameters and the social cost of carbon, the climate-related benefits from the TPS's CO_2 emissions reductions over the interval

2020–2035 exceed its costs by a factor of five. Taking account of the health benefits from improved local air quality increases the TPS's benefit-cost ratio to 25.

The impacts of the TPS vary significantly across sectors, influencing both the sectors covered by the TPS and those not covered. Relative to the baseline path, the policy causes the output of the coal and electricity sectors to decline by 14 and 4 percent, respectively, while promoting a 4 percent increase in the output of the natural gas sector.

The TPS promotes the transition away from fossil-generated to renewables-based electricity by raising the effective price of using carbon-intensive fuel inputs. Over the interval 2020-2035, it induces a 5 percent increase wind- and solar-electricity generation relative to what would occur in the absence of the policy.

Several significant changes to China's TPS are being contemplated by the central planners, including the transition from the TPS to cap and trade and supplementing the TPS with an auction as a mechanism for supplying emissions allowances. The model's simulation results provide support for these policies, as both can lower the costs of achieving China's emissions-reduction goals.

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