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Original Paper

Climate Change Policy, Emissions Trading Schemes and Carbon Pricing: California and Tokyo

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Abstract

In this paper, we provide up-to-date explicit critical comparisons of two very important and successful regional emissions trading schemes: California and Tokyo. We focus on the contrasts of the different rules and functioning of the carbon credit trading markets. We also compare the carbon leakages and the compliance of the two schemes. We highlight the "negative" carbon leakage and the voluntary compliance associated with the Tokyo- Saitama Prefecture schemes. Finally, we provide a formal model linking some "unique" Japanese labour market practices to the incentives facing the Japanese facilities.

Keywords

Climate Change, California, Tokyo

1. Introduction

From November 6 to November 18, 2022, the 27th Conference of the Parties to the United Nations Framework Convention on Climate Change (COP27) was held in Egypt. According to the United Nations Secretary-General, areas to deal with the existential threat of global warming include environmental integrity and the role of *governments.* Full and rapid decarbonization in this decade is the ultimate test. Furthermore, transition to net-zero should address the needs of *workers* in fossil fuel industries and sectors affected by the renewable energy transition (Note 1).

Given the increased urgency and importance of economic and environmental issues related to climate change, various policies have been proposed and implemented to mitigate the negative externalities associated with greenhouse gas emissions. Among the most discussed policies is "*carbon pricing*", i.e., policies to create more appropriate prices of the use of carbon in the economy. Typical economic policies that aim at lowering greenhouse gas emissions and to establish carbon pricing include explicit

carbon taxes and *Emissions Trading Schemes* (*ETS*), or more commonly known as Cap-and-Trade.

In this paper, we aim to provide up-to-date critical *comparisons* and examinations of two highly important emissions trading schemes (*ETS*). Unlike the bulk of the existing academic literature, this paper will discuss *sub-national* and *regional ETS* that are already in operation. In the economics and international public policy literature, the most widely discussed *ETS* is the trans-national European Union-*ETS* (or *EU-ETS*, see for example, Tanabe, 2022; Colmer, Martin, Muûls, & Wagner, 2018; Commins, Lyons, Schiffbauer, & Tol, 2011; Egenhofer, Alessi, Georgiev, & Fujiwara, 2011; Cooper, 2010; Ellerman & Buchner; 2008, etc.).

As is well known, an emissions trading scheme sets up legal allowances for entities and provides these facilities permissions to emit pollutants such as carbon dioxide and other greenhouse gases. The entities are also allowed to trade in a carbon permit market leading to the setting of the price of carbon. The government or regulatory body sets the cap, i.e., the limits of total quantity of allowable greenhouse gas emissions. The mainly market-based trading of permits or allowances eliminates, at least theoretically, economic inefficiencies compared to a purely command-and-control type climate change policy.

Instead of focusing on a discussion of the *EU-ETS* and how its experiences can be related to the Japanese *ETS*, in this paper, we would like to discuss the *two* most important *sub-national ETS*, that is, the *California-ETS* and the *Tokyo-ETS* (Note 2, Note 3). The experiences of the *California-ETS* are especially relevant for those who are policymakers, educators, and students in the Golden State. Indeed, academics, scholars and researchers at the *University of California* routinely provide insights, support and teaching related to the challenges of climate change. In November 2022, a group of leaders from the *University of California* system actively participated and contributed to COP27 in Egypt (Note 4).

This paper aims to make an academic and public policy *contribution* by *explicitly* comparing and examining the two highly important regional *ETS*, one in *California* and one in *Tokyo*, Japan. In addition, we will provide a parsimonious *formal economic model* connecting the "unique" Japanese labour market practices to the *incentives* facing Japanese employees and company owners during their efforts of decarbonization. We hope and welcome further academic research and international public policy discussions in this *comparative* economic and environmental area. As mentioned earlier, this paper will provide a *formal economic model* of how the climate change policies of Tokyo can interact with the prevailing labour market practices and employment system in Japan (Note 5). Our investigative approach follows earlier work by many important economists, including prominent researchers such as Taylor (2016, 1992), Stiglitz (2016), Tyson (2014, 2015) and Krugman (2022, 1998), etc. The potential *contribution* of this paper is hopefully two-fold: there are relatively *few academic* papers that *explicitly* compare the two most well-known and important *regional* Emissions Trading Schemes, i.e., the *ETS of California* and the *ETS of Tokyo* (Note 6). This paper *adds* to this important *comparative* literature. Second, this paper aims to contribute by providing a simple *formal* Japanese firm model and analytically discusses how carbon pricing can interact with the "unique" employment and labour market features of Japan and to generate interactive results associated with

carbon reduction, carbon leakage, and Japanese firm behaviour.

2. Some Aspects of the *California-ETS*

The *California-ETS* program started in 2003 for electricity generators and large industrial facilities emitting 25,000 metric tons of CO_2 e (carbon dioxide equivalents) each year (Note 7). In 2005, the policy was expanded to include transport fuels and natural gas suppliers (Note 8). By 2021, the *California-ETS* covered about 74 percent of total greenhouse gas emissions (for more details, see California Air Resource Board, 2022a, 2022b; California State Government, 2022a, 2022b; Wang, Carpenter-Gold, Shen, & So, 2022, Sullivan, McIsaac, Robo, & Pandey, 2022, etc.).

As authorized by state law AB 32 (2006), California was required to return to 1990 levels of greenhouse gas emission by 2020. That target was actually achieved by 2016, four years ahead of schedule. In 2016, an updated state law SB 32 required California a target of 40% below 1990s level by 2030. In 2018, an Executive Order required statewide carbon neutrality by 2045 (see e.g., California Air Resource Board 2022a, 2022b; California State Government, 2022a, 2022b; Wang, Carpenter-Gold, Shen, & So, 2022, etc.).

Under AB 32, The California Air Resource Board (CARB) must release an updated Climate Change Scoping Plan at least once every five years. The latest Scoping Plan was released in 2022. For the first time, the 2022 updated Scoping Plan included California's forests, agricultural lands, and wetlands. The decarbonization process would utilize these landscapes for carbon storage. There were additional discussions of extracting and capturing carbon dioxide from facilities as well as from the atmosphere and then safely storing the greenhouse gases.

In March 2022, the State of California signed a Memorandum of Cooperation (MOC) with the Government of Japan to strengthen efforts to combat climate change (State Government of California, 2022b). In the Memorandum of Cooperation, California and Japan agree to promote joint projects on climate change mitigation, including building resilience and reducing short-lived climate pollutants, cleaner transport, and addressing climate change justice and the negative effects on underserved populations. California also welcomed the declaration that by 2050, Japan will aim to reduce greenhouse gas emissions to net-zero (California State Government, 2022b).

California is part of the Western Climate Initiative (WCI). The Initiative provides support to implement greenhouse gas emissions trading programs by various states and provinces in the United States and Canada. There have also been linkages of carbon credit trading markets by different entities. Currently, California is only formally linked in its carbon market trading with the Canadian province of Quebec. The Quebec cap-and-trade program started in 2013 and its scheme has been linked with the Californian system since 2014 (International Carbon Action Partnership, 2022b). Emissions from fuel combustion in the power sector, buildings, transport, and other industries are covered in the program. Like the California program, if the covered entities fail to comply to meet the targets, there will be *legal* consequences, including the possibility of having to pay *fines*. In November 2021, during the COP26 in

Glasgow, Quebec issued a Memorandum of Understanding with California and New Zealand for climate action collaborations.

3. Some Aspects of the *Tokyo-ETS*

The *Tokyo-ETS* is the first regional mandatory emission trading scheme in Japan and the first regional CO_2 emissions trading program in Asia (see, e.g., Asian Development Bank, 2016; Arimura & Matsumoto, 2021; Kurachi, Morishima, Kawata, Shibata, Bunya, & Moteki, 2022; International Carbon Action Partnership, 2022a, etc.). The first phase of the trading scheme was from 2010 to 2014. The emissions trading scheme at the Japanese national level has not yet been introduced (for more details, see Abe & Arimura, 2021, 2022; Arimura & Matsumoto, 2021; Hamamoto, 2021; Kurachi, Morishima, Kawata, Shibata, Bunya, & Moteki, 2022; Sadayuki & Arimura, 2021; International Carbon Action Partnership, 2022a; Asian development Bank, 2016; Poupard, Fetet, & Postic, 2022, etc.). The *Tokyo-ETS* is also the first emissions scheme worldwide to cover the commercial sector. The program started in 2010, and in 2011, a neighboring prefecture, the *Saitama Prefecture* also started its own *regional* emissions trading scheme. The *Tokyo-ETS* is in collaboration with and is formally linked to the *Saitama Prefecture-ETS*. In contrast to the *Tokyo-ETS*, the *California-ETS* and the *Quebec-ETS*, the *Saitama Prefecture-ETS* is *voluntary*. The setting of carbon emission targets is mandatory, but failure to meet the emission targets by facilities in the *Saitama Prefecture-ETS* will *not* have legal or financial consequences. The *Tokyo-ETS* covers both buildings in the service sector as well as industrial plants. The manufacturing sector is responsible for only a small portion of the greenhouse gas emissions in Tokyo. Many large power plants also are not located in Tokyo. The emissions trading scheme in Tokyo is thus designed to mainly cover the commercial and service sectors. Commercial and office facilities accounted for about 80 percent of the included entities. Besides directly reducing emissions, the covered facilities can count as their own emission reductions if they reduce emissions by small and medium-sized entities in Tokyo that do not meet the targets, or establishments outside of Tokyo. Investment in renewable energy can also count as emission reductions. In the Tokyo scheme, the *offset credits* include outside Tokyo credits, renewable energy certificates and small and medium-sized installation credits.

4. Some Comparisons of the *California-ETS* and the *Tokyo-ETS*

The two regional ETS in the United States and in Japan are both considered very *successful* in achieving the objective of mitigating emissions of greenhouse gases. But being situated in *different* economic and public policy environments, they have significant differences in their operations and features as well. In the following, we will attempt to highlight two areas of contrasts and try to distill some general economic and public policy approaches and concepts associated with these comparisons.

4.1 Comparative Examination of the Features and Functioning of the Carbon Credit Markets: California-ETS and the Tokyo-ETS

One area of critical comparative contrast in the *California-ETS* and the *Tokyo-ETS* is the rules and functioning of the tradable market of carbon credits or allowances. In the *California-ETS*, carbon credits are *emission* allowances. Each permit allows the participant to emit a certain amount of greenhouse gas. Specifically, one allowance represents one metric ton of carbon dioxide equivalent emissions (see e.g., Wang, Carpenter-Gold, Shen, & So, 2022, etc.). These emission credits can be traded in the carbon allowance market. Unlike the *California-ETS*, the *Tokyo-ETS* issues credits to those facilities only after they have already reduced their emissions. These emission *reduction credits* can then be traded by the relevant facilities (for more details, see e.g., Abe & Arimura, 2021, 2022, etc.). More than 90% of the regulated facilities reduced their emissions beyond the target set by the Tokyo Metropolitan Government during the first phase of the program. Only about 9% of the facilities complied by acquiring reduction credits (Note 9).

In designing rules in carbon trading, the *Tokyo-ETS* is also very different from the *California-ETS*. The Tokyo Metropolitan Government was concerned that the permit trading under the *Tokyo-ETS* would invite *financial speculations*, leading to deviations and distractions from the original, core focus of the greenhouse gas emission reduction program. So, in addition to using *emission reduction* credits instead of *emission allowances*, in designing the *Tokyo-ETS*, the Tokyo Metropolitan Government has not introduced allowance auctions. Only emission facilities can participate in trading (Note 10).

The *financial* sector so far has not been allowed to be a participant in the *Tokyo-ETS* carbon credit trading (Note 11). Emission credit trading in Tokyo has *not* been active compared to the *California-ETS*. By the end of the second phase (2015 to 2019) of the *Tokyo-ETS*, the number of trades rose but still more than 80 percent of the facilities fulfilled their mandated reductions (for details, see Abe & Arimura, 2021, 2022; Sadayuki & Arimura, 2021, etc.). Carbon credit trading in the *Tokyo-ETS* is bilateral. The market price of permits is not directly observable (see e.g., Abe & Arimura, 2021, 2022, etc.). The Tokyo Metropolitan Government reports each year a weighted average price based on interviews about each transaction. In December 2020, the price of the emission reduction credits was reported to be 540 Japanese yen per ton of carbon dioxide. The design of the emission trading scheme focused on the actual *reductions* of greenhouse gas emissions and has not really focused on the trading or the *financial* and *revenue* aspects. Thus, it is not surprising that the revenue generated by the *Tokyo-ETS* in 2022 is reported to be very small (see e.g., Poupard, Fetet, & Postic, 2022, etc.).

For the *California-ETS*, third party financial institutions are allowed to participate in the carbon credit market. The auction of emission credits is however essentially managed or *regulated*. There is a *price ceiling* as well as a *price floor*. The price ceiling for 2022 is set at US$72.29. The auction price floor for 2022 is set at US$19.70.

From 2021 onward, some allowances will be stored in reserves by the government. Reserves will be released if the auction price reaches 60 percent of the trigger price. One trigger price for the reserve is

$46.05 for each ton of carbon dioxide equivalent. The trigger price will be adjusted by 5% plus inflation each year (Note 12).

In examining the contrasts of the carbon credit markets, we can find some parallels in policy and academic research discussions in other important economics sub-fields, such as in the research area of international finance. For example, in international *finance*, some researchers have pointed out that for some economies, while the current account, which mainly records the transactions in export and import of goods and services, should be open, but the financial or capital account which focuses on trade in assets, including portfolio trade across countries, should be *regulated* or taxed at least under some circumstances (see, e.g. Chari, Stedman, & Lundblad, 2021, 2022, etc.). To some *finance* researchers, volatility of international financial portfolio flows can be detrimental to a domestic economy. Applying this line of thinking to our comparison of trading of carbon permits in California and in Tokyo, California does regulate the carbon trading, including setting a price ceiling and a price floor as well as keeping allowance reserves to stabilize the potentially excessive volatile price of carbon. In the Tokyo case, the original intent was to keep financial institutions out *entirely*. Carbon credit trading is mainly reserved for entities which are covered to reduce greenhouse gas emissions. The core idea of the *Tokyo-ETS* was to only focus on reducing emission of carbon dioxide equivalents and *not* to encourage the transformation of trade in carbon credits into trade of quasi-financial assets. But the latest move in 2022 by the Japanese Ministry of Economy, Trade and Industry (METI) is to try a pilot program at the Tokyo Stock Exchange and to move closer to realize the potential efficiency gains via trading by some financial institutions. Nonetheless, the insights and tools from international *finance* researchers regarding a mix of control and open trading by some qualified financial entities may be applicable to our contrast of carbon credit trading in the *California-ETS* and the continuously evolving *Tokyo-ETS*.

Furthermore, revenue generated by the carbon credit auction in California provides additional *political-economic* support for the climate change program. A portion of the California auction revenue is used to provide subsidies to utility bill payers. Some go into the Greenhouse Gas Reduction Fund (GGRF) that often would ultimately benefit low-income and disadvantaged communities. While there are criticisms of aspects of Environmental Justice not being dealt with satisfactorily in the *California-ETS*, the overall use of the carbon credit auction revenue provides some relief to disadvantaged groups and help mitigate the political-economic pressure from some civic and political organizations who may be even more vocal in criticizing the operation of the Californian climate change mitigation program. This highlights another common insight from public policy implementation and public finance in the economics literature, i.e., some government revenue, appropriately redistributed, can help the continued functioning of well-designed and evolving policy by mitigating some negative impact on the most vulnerable groups. In Table 1, we summarize some of our discussions above.

Table 1. Carbon Credits Trading in the *California-ETS* and the *Tokyo-ETS*

Features of Carbon Credit Trading in Sub-National Emissions Trading Schemes	California Emissions Trading Scheme (California-ETS)	Tokyo Emissions Trading Scheme (Tokyo-ETS)
Financial Institutions	Third Party Financial Institutions Can Participate in Trading	Financial Institutions are Excluded, but Starting September 2022, METI commissioned the Tokyo Stock Exchange to Start a Pilot Trading Scheme, Policies in This Area are Evolving
Price Ceiling and Price Floor	The Government Sets an Explicit Price Ceiling and an Explicit Price Floor	The Tokyo Metropolitan Government Does Not Have Explicit Price Ceiling or Price Floor
Tradable Carbon Credit	Carbon Emission Credit	Carbon Reduction Credit
Auction	Government Holds Auctions for Carbon Allowance Trading	Government Does Not Hold Permit Auction, Most Trade is Bilateral, Permit Trading Has Not Been Active
Government Carbon Credit Reserves	Government Holds Reserves with Trigger Prices That Will Prompt Releases	Government has Some Reserves to Sell in Times of Excessive Price Increases
Carbon Trading Revenue	Used by the Government to Help Utility Bill Payers as well as Investment in Low-Income and Disadvantaged Communities, Overall Using Revenue to Address Environment Justice Issues	Limited Bilateral Trading with Limited Trading Volume, with Small Revenue
Potential Applicable International Finance Approach and Insights to ETS Carbon Credit Trading: the Tokyo Metropolitan Government designed the policy to make sure that carbon credits may not be utilized as financial instruments. It treats the potential financial aspect of carbon trading as risky, in some way like how some researchers in international finance may view unfettered and abrupt international financial and portfolio flows into or out of an economy being destabilizing under some circumstances. The California State Government takes a nuanced view by setting up reserves and price ceiling and price floor, while at the same time allowing the operation of a climate change allowance market. The advantage is that the California government collects significant auction revenue to address a variety of issues, including Environmental Justice concerns. This also is consistent with a version of political-economy or public finance approach highlighted in some economic literature.		

Source: Author's construction

4.2 Comparative Examination of Carbon or Emission Leakages and Linkages: California-ETS and Tokyo-ETS

To prevent greenhouse gas emission-related activities from migrating to other regions that are not covered by the ETS (carbon or emission leakage), policies or regulations are often used to reduce such risks of emission re-location. For example, in the *California-ETS*, free allocation of allowances has been provided to industrial manufacturing to prevent greenhouse gas emitting-production from moving out of state. The extent of aid to different entities was initially decided by detailed studies of differential industrial risk factors. But more recent legislations essentially gave nearly all industries the full assistance leakage factor or consideration. Some researchers argue that these free allowances are too generous (see e.g., Wang, Carpenter-Gold, Shen, & So, 2022, etc.). As an illustration, oil refineries in the California program receive the largest share of industry allowances. But the cost of moving refineries out of state is actually very high and thus carbon leakage is not very likely (Note 13).

However, in the California electricity sector, there may be some evidence of carbon leakage in the form of "resource shuffling". Electricity does not have a fixed locational source for emitting greenhouse gases. The *California-ETS* is a regional program, and the electric grid can be larger than the California state market itself. The energy providers can arguably comply by supplying low-carbon source of electricity to California and use the high greenhouse gas-emitting source to sell outside of the California ETS. This type of "resource shuffling" is currently legally not allowed in California. However, some researchers reported and identified evidence of "resource shuffling" in California (see, e.g. Cullenward, 2014) (Note 14, Note 15).

In contrast to the various findings of *California-ETS* "positive" leakages (i.e., carbon dioxide emissions *increase* outside of the covered emission program even as greenhouse gas emission within the covered area decreases), some scholars have found empirical evidence that for the *Tokyo-ETS*, there is instead *reduced* emission of greenhouse gases in the facilities owned by the same firms *outside* of the regional ETS. In other words, instead of "positive" leakages as found in the *California-ETS*, there is "*negative" leakage* for the *Tokyo-ETS*. So as expected, facilities regulated by the *Tokyo-ETS* reduced their emissions. But facilities unregulated by and outside of the *Tokyo-ETS* and the linked *Saitama Prefecture-ETS* but owned by the same firms also *reduced* their emissions (see e.g. Sadayuki & Arimura, 2021). In addition, even though meeting the emission reduction targets in the *Saitama Prefecture-ETS* is voluntary, entities in the *Saitama Prefecture-ETS* also *reduced* their emissions (see, e.g. Hamamoto, 2021).

Why did facilities outside the Tokyo and Saitama Prefecture schemes reduce their carbon dioxide emissions even though they are not required to? Also why did entities in the voluntary Saitama Prefecture program comply without threats of legal or financial penalties? These *contrasting properties* with respect to the *"negative" leakages and voluntary compliance* will serve as our motivations for providing our formal model in the next section. The idea is that for large Japanese firms, regular employees have greater job security (*quasi-lifetime employment*). There are greater incentives for

business owners to provide in-house retraining of these lifetime-employed workers since they will not leave and work for rival companies. These employees also are much more likely to receive *bonuses* so that they can share in the fruits of a newer, more energy-efficient way of conducting their businesses. Lastly, these firms may also have *enterprise unions* that represent the interests of labour within the same firm, whether they are in the regulated area or outside the covered region. We will elaborate in a more formal manner these potential interpretations of the contrasting characteristics of carbon leakages in the *Tokyo-and Saitama Prefecture-ETS* as compared to the *California-ETS* (Note 16). We summarize some of our discussions above in Table 2.

Table 2. Comparison of Carbon Leakages: *California-ETS*, *Tokyo-ETS* and the Linked *Saitama Prefecture-ETS*

	California-ETS	Tokyo-ETS
Caron Market Linkage with Other ETS	Linked With Quebec-ETS	Linked With Saitama Prefecture-ETS
Carbon Leakage	Concerns about Leakage in California-ETS: In the Past, Variable Risk Assessment Factor applied to Industries. Currently, Uniform Risk Assistance Factor Applied to All Industries	"Negative" Leakage for Large Facilities Outside of Tokyo-ETS and Saitama Prefecture-ETS within the Same Firms
Facilities Outside the ETS Reduce or Increase Their Emissions	Fear of Leakage: Concerns that Facilities Would Move Out of California to Increase Emissions	Facilities Reduce Their Emissions Outside the Tokyo and the Saitama Prefecture-ETS: "Negative" Leakage
Voluntary Compliance	Both the California-ETS and the Quebec-ETS are Mandatory; Non-Compliance Faces Legal and Financial Penalties	The Tokyo-ETS is Mandatory; The Linked Saitama Prefecture-ETS is Voluntary; Non-Compliance Faces No Legal or Financial Penalties, Facilities in the Saitama Prefecture-ETS Voluntarily Reduce Emissions
Resource Shuffling	Past Issues with Resource Shuffling in the California-ETS	No Reports of Resource Shuffling in the Tokyo-ETS or the Saitama Prefecture-ETS

Source: Author's construction

5. A Simple Formal Model of The Interaction of Some Properties of the Tokyo-Saitama Prefecture ETS and "Unique" Features of the Japanese Labour Market

As mentioned earlier and in Table 2, facilities not covered by the *Tokyo-ETS* or the *Saitama Prefecture-ETS* but owned by the same firms in Tokyo generate similar energy efficiency gains even though they are not faced with emission reduction targets. Furthermore, for those in the Tokyo-linked *Saitama Prefecture-ETS*, even though there are no legal or direct financial consequences for not meeting their emission targets, the facilities voluntarily met their CO_2 emission reductions (see, e.g. Hamamoto, 2021; Abe & Arimura, 2021, 2022; Sadayuki & Arimura, 2021; Arimura & Matsumoto, 2021). Taking these somewhat distinctive responses of the *Tokyo-ETS* and *Saitama Prefecture-ETS* together, there seems to be a need to take a Japanese firm modelling approach and examine why there may be *incentives* for the stakeholders of those outside of the *Tokyo-ETS* or those in the voluntary *Saitama Prefecture-ETS* to adapt to a new way to conduct business with higher energy efficiency.

Next, we would like to set up a model of a large Japanese firm with the prevailing Japanese employment practices and argue formally that with such a micro-firm approach, we can show that the incentives to utilize a lower carbon-business model and to achieve better energy efficiency can *benefit* both the employees and the business owners. In other words, the features of the current Japanese employment system *align* well with the properties of the *Tokyo-ETS* and *Saitama Prefecture-ETS* discussed above.

With large Japanese firms, in 2021, about 63% of the employees were regular workers with substantial job protection (quasi-lifetime employment, see e.g., Fung, 2022a, 2022b, etc.). Given this relevant background, we now focus here on two features of the Japanese labour market: first there are biannual *bonuses*, given out each year once in the summer, and once in the winter (see e.g., Fung, 2022a, 1995; Taylor, 2016, 1992). The *bonus*es are given not only to managers, but to all employees, including white-collar as well as blue-collar employees. So, a Japanese regular employee is typically paid a fixed salary plus biannual bonuses that can amount to one-third of the employee's annual income (Fung, 2022a, 2022b; Taylor, 1992; Aoki, 1988; Allen, 1981). In addition, it has been pointed out that the Japanese bonus system has the feature of profit-sharing (Fung, 2022b, 1995; Tyson, 2014, 2015; Taylor, 2016, 1992; Aoki, 1988). A second feature we will focus on in our formal model is Japan's *enterprise union*. Instead of industrial unions, each Japanese large company essentially faces its own company union. The enterprise unions represent the interests of Japanese employees both within the regulated emissions area and outside the covered region. Under the *Tokyo-ETS*, it is reasonable to assume that the emission reduction spurs investment to be made to lower the cost of electricity or to foster more efficient ways for Tokyo business establishments to consume carbon-intensive energy. This would naturally cut carbon dioxide emissions in the regulated Japanese businesses. But in addition to this greenhouse gas emission change, as mentioned earlier, within the same Japanese firm, even the unregulated facilities outside of Tokyo or the Saitama Prefecture schemes also improve their energy efficiency, leading to lower CO_2 emission beyond these emission targets (see e.g., Sadayuki & Arimura,

2021, etc.). One question is then, why did Japanese workers or employees not resist actively or passively in the unregulated facilities outside Tokyo to adjust to the use of these newer, more energy-efficient ways of conducting businesses? In addition, why did facilities in the *Saitama Prefecture-ETS* voluntarily reduce their greenhouse gas emissions?

Here we will provide a microeconomic model to show that indeed both employees and owners of the Japanese businesses can benefit and share the energy efficiency gain even if the new business model is transferred or imported from the regulated facility to the unregulated facility. The "negative" carbon leakage is compatible with the Japanese labour market features of bonuses and enterprise unions. In addition, the same type of firm model incorporating these "unique" Japanese labour market features can also explain why the incentives of adopting and adapting to better energy efficient business models are *aligned* with the interests of both the regular employees and the owners. The research strategy of highlighting properties of Japanese labour market practices in providing explanations of some economic performances can be traced to earlier influential literature such as important work by Taylor (1992, 2016), Tyson (2014, 2015), Stiglitz (2016) and Krugman (2022, 1998), etc. We adopt and adapt this line of thinking by prominent economists to our case of Japanese climate change responses.

To start with, we write down algebraically the objective function of the Japanese enterprise union as L^J:

$$L^J = L^R(w, l) + \lambda\Pi \quad (1)$$

$$L^R = (w-k)l \quad (2)$$

where λ is the *bonus* given to all Japanese regular unionized employees in the form of a share of the Japanese firm's profits Π, w is the wage set by the enterprise union, l is employment and L^R is the conventional union objective without the Japanese-style bonuses.

L^R, the conventional objective of the enterprise union without bonuses, depends on the union wage w and the enterprise union employment l.

More specifically, L^R can be taken as a labour union maximizing its total economic rents. The union wage w is elevated over k, which is the alternative wage that the unionized workers can get elsewhere. In the Japanese labour market context, it can be thought of as the wage of the non-regular or part-time workers. L^R is probably the most direct and popular way to model the objective of a typical labour union. However, in showing our results, we will focus below on the more general objective function given in (1).

For the Japanese business owners, the profit function is given by Π^J:

$$\Pi^J = (1-\lambda)\ \Pi = (1-\lambda)\ (xP(x)-C(x, w, e)) \quad (3)$$

where x is the output or some measure of units of service provided by the Japanese business and P is the inverse demand of the product or service in the unregulated region outside of Tokyo-Saitama Prefecture. We include the example of services because the *Tokyo-ETS* primarily targets greenhouse gas emitters in the service sector, since there is a great concentration of such business activities in Tokyo. We also assume that the Japanese business has some market power so that it faces a downward-sloping demand curve, with $P'(x) < 0$. C is the standard dual cost function. We make all standard assumptions

so that the conventional properties of the cost function, including the Shephard Lemma, will hold. Furthermore, we assume that both C and L^J have continuous second partial derivatives and we can apply symmetry of the second derivatives. We also assume that regular labour and energy are either complements or non-substitutes in production. For carbon-dioxide emitting energy cost, it is represented by a per-unit cost of e. The transfer of more energy efficient way to conduct business to the facility in the unregulated region is represented by a drop of e.

In the formal model, we would want to highlight the theoretical possibility of *gain-sharing* of the improved energy efficiency due to the actual prevailing "unique" Japanese labour market features of *bonuses* and *enterprise unions* (see also Taylor, 2016, 1992; Tyson, 2014, 2015; Stiglitz, 2016; Krugman, 2022, 1998, etc.) We wish to incorporate these characteristics in our economic model of an unregulated business outside of the *Tokyo-ETS and the Saitama Prefecture-ETS*.

For the Japanese enterprise union, it chooses w to maximize L^j:

$$L^j_w=0 \tag{4}$$

$$L^j_{ww} <0 \tag{5}$$

with the subscripts as derivatives and assuming that the second order condition holds.

For the Japanese business outside of the coverage of the *Tokyo-ETS*, we have:

$$\Pi^J_x =0 \tag{6}$$

$$\Pi^J_{xx} <0 \tag{7}$$

assuming the second order condition for profit maximization holds. What is the impact of a decline in e due to the improved business use of energy? If the new, more energy-conserving business model is transferred and adopted by the facility in the unregulated area, then we can evaluate the impact of a decline of e on the Japanese labour interest L^J as well as on the interest of the Japanese firm Π^J (Note 17).

For the impact on L^J, using the first and second order conditions, the envelop theorem and after some algebra, we can show that

$$dL^J/de<0 \tag{8}$$

With a decline in e, the Japanese enterprise union in this hypothetical unregulated firm outside of the Tokyo and Saitama Prefecture schemes can benefit. In other words, the better and more energy efficient way to conduct business imported from the regulated Japanese facility to the unregulated facility can theoretically lead to an improvement of the Japanese employees' interests.

For the impact on the business owners in the unregulated region, we use the Shepherd Lemma, the properties of the dual cost function C, the Japanese enterprise union's objective function L^J and after some algebra, we can show that:

$$d\ \Pi^J/de<0 \tag{9}$$

Thus, the *Tokyo-ETS* "negative" carbon leakage is partly explained by the *compatible incentives* facing both firm owners as well as Japanese employees. In addition, as noted earlier, in a different Japanese regional ETS (Saitama), where the achievement of the emission targets is not mandatory and failure to

meet the cap does not entail financial penalties, still the facilities accomplished their goals of cutting greenhouse gas emissions (see e.g., Hamamoto, 2021, etc.). With the Japanese labour market features of bonuses and enterprise unions, mutual *gain-sharing* can theoretically be realized by adapting to embrace the newer, more energy-efficient business model (for more recent discussions of profit-sharing in economics and businesses, see also Tyson, 2014, 2015, etc.). The mutual-gains property generated by the Japanese bonus system and the enterprise union is consistent with the *Tokyo-ETS* responses of "negative" leakage and the voluntary compliance by facilities in Saitama Prefecture. Of course, there may be other reasons that are consistent with how even unregulated affiliates would improve its energy efficiency and cut its carbon dioxide emissions, but by incorporating the current prevailing characteristics of the Japanese labour market, this parsimonious formal model hopefully provides a plausible theoretical explanation of different properties of carbon leakage and voluntary compliance associated with the Japanese regional ETS.

6. Conclusion

In this paper, we provide critical *comparisons* between two very important and successful sub-national emissions trading schemes (ETS): the *California-ETS* and the *Tokyo-ETS*. Both schemes are formally linked to other significant ETS. The *California-ETS* is linked to the *Quebec-ETS*, while the *Tokyo-ETS* is tied to the *Saitama Prefecture-ETS.* One difference between these ETS and their linkages is that like the *California-ETS* and the *Tokyo-ETS*, the *Quebec-ETS* is also mandatory. But for the *Saitama Prefecture-ETS*, compliance is voluntary.

We focus in this paper *two* major contrasts between the *California-ETS* and the *Tokyo-ETS*. First, even though the carbon credits market in the Californian program is carefully managed, with credit reserves, price ceiling and price floor, there is significant trading of carbon permits. The regular government auctions generate substantial revenues. In contrast, the *Tokyo-ETS* has excluded third party financial institutions from trading in the carbon market, being concerned about financial funds and entities using the climate change market for risky financial speculations. The goal of the Tokyo carbon market is directly focused on greenhouse gas emission reductions. Neither the potential economic efficiency gains from trading nor considerations of auction revenues figure prominently in the *Tokyo-ETS*. The Japanese regional program is however, evolving, with a trial pilot program of carbon trading being conducted at the Tokyo Stock Exchange and sponsored by the Japanese government Ministry of Economy, Trade and Industry (METI).

A second focus of our critical contrast is to highlight some properties and somewhat unexpected responses of the *Tokyo-Saitama Prefecture ETS* as compared to the *California-ETS*: "negative" carbon leakage and voluntary compliance. Under the Californian program, there have been both concerns and observations of carbon leakages (i.e., greenhouse gas emission migrating to locations outside of California), with the consequence of seeing a reduction of carbon dioxide emissions in California, but an increase of emissions outside of California. Under the *Tokyo-* and linked *Saitama Prefecture-ETS*,

there are instead research reports of *"negative" carbon leakage*, i.e., facilities under the same ownerships inside and outside of Tokyo and the Saitama Prefecture actually *both reduce* carbon dioxide emissions. In addition, with the Californian program, there have been strict monitoring and stringent reporting requirements and entities that fail to meet the emission targets are faced with legal and financial penalties. In contrast, for the Saitama Prefecture scheme, meeting the reduction targets is voluntary. There are no legal and financial punishments facing the non-complying facilities in the Saitama program. Yet, there are observations of compliance in the voluntary scheme.

These somewhat unexpected responses serve as motivations for our theoretical work. We thus provide in our paper a parsimonious formal model showing that the "unique" characteristics of the Japanese labour market such as biannual *bonuses*, *enterprise unions* and "quasi-lifetime employment" yield incentives and *gain-sharing* properties that are in *alignment* with the properties of "negative" carbon leakage and voluntary compliances in the Japanese regional schemes.

The potential *contribution* of this paper is *two-fold*: in contrast to the bulk of the literature, we provide some up-to-date *explicit* critical *comparisons* of the two important regional emissions trading schemes: California and Tokyo. Furthermore, unlike the existing literature, we provide a formal approach to link some properties and consequences of the *Tokyo-ETS* and the *Saitama Prefecture-ETS* to the "distinctive" Japanese labour market practices. The research approach adopted in this paper is partly inspired by earlier important analysis by many prominent economists such as Taylor (2016, 1992), Tyson (2014, 2015), Stiglitz (2016), Krugman (2022, 1998) and Aoki (1988), etc.

A general point we would like to make beyond the critical comparisons of the two programs is that regional and perhaps even national emissions trading schemes are *embedded* in specific economic, public policy and legal environments. For these programs to be more effective to reduce greenhouse gas emissions, we may want to at least be mindful of these aspects and incorporate in our analysis and research some of the relevant local conditions and contexts.

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Notes

Note 1. For more details, see United Nations Secretary-General, November 8, 2022, Egypt.

Note 2. A somewhat older international organization report examines a varieties of emissions trading schemes in the Asia-Pacific, but a major focus of that report is on trading schemes linkages. A more recent short policy brief in 2022 presents summary but important indicators for various ETS globally. Unlike this paper, neither the report or policy brief provides explicit, critical comparative examinations of the *California-ETS* and the *Tokyo-ETS*. In these excellent report and policy brief, there is no formal model connecting the Japanese labour market practices with the built-in transitional incentive associated with the decarbonization efforts under the *Tokyo-ETS*. For more details, see Asian Development Bank 2016 and Poupard, Fetet, and Postic 2022. Another 2018 paper compares ETS from various jurisdictions but does not include the Japanese case, see Narassimhan, Gallagher, Koester and Alejo 2018.

Note 3. In the United States, another important regional ETS is the Regional Greenhouse Gas Initiative (RGGI), which is not the focus on this paper. The scheme narrowly focuses on the power sector in comparison to the *California-ETS*. The RGGI is a cooperative, market-based program with participants from the states of Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, Vermont, and Virginia to cap and reduce carbon dioxide emissions from the power sector.

Note 4. For more details, see McMillan, 2022.

Note 5. For more discussions of the characteristics of Japanese labour market and Japanese firm behaviour, see Kotera and Schmittmann, 2022, Hamaguchi, 2022, Fung, 2022a, 2022b, 2019, 2002, 1995, 1992,1989, Aminian, Fung, Garcia-Herrero and Lin 2012, etc.

Note 6. Papers that examine the *California-ETS* alone include California Air Resource Board 2022a, 2022b, California State Government 2022a, 2022b, Sullivan, McIssac, Robo, Pandey, 2022, etc. Some earlier reports and policy briefs that include comparisons of multiple ETS include Poupard, Fetet, and Postic, 2022, Asian Development Bank 2016, Wang, Carpenter-Gold, Shen and So, 2022, etc. As

pointed out earlier, none of these reports provide an explicit, focused comparison of the functioning and features of the *California-ETS* and *Tokyo-ETS*. In particular, none of the existing literature links the design of some characteristics of these regional ETS to policy approaches that have been discussed in economics literature in other economic sub-fields (e.g. financial account vs. current account in international finance, etc.). Furthermore, none of the excellent existing reports and policy briefs provide a formal economic model showing the interactions of domestic Japanese labour market practices with the Tokyo and Saitama Prefecture cap-and-trade program.

Note 7. Some of the discussions of the *California-ETS* are based on work by California Air Resource Board (CARB) 2022a, 2022b, California State Government 2022a, 2022b, Wang, Carpenter-Gold, Shen and So 2022, Sullivan, McIsaac, Robo, Pandey 2022, etc.

Note 8. Marine and aviation fuels, however, are not covered.

Note 9. As mentioned before, some of the discussions of the *Tokyo-ETS* are based on work by Abe and Arimura 2021, 2022, Arimura and Matsumoto 2021, International Carbon Action Partnership 2022a, Sadayuki and Arimura 2021, Dabra-Norris, Daniel, Nozaki, Alonso, Balasundharam, Bellon, Chen, Corvino and Kilpatrick 2021, etc.

Note 10. In general, regulated facilities and other trading account holders trade over the counter and the government does not control carbon prices. However, during times of "excessive" price rises, the Tokyo Metropolitan Government may supply its own credits for stabilizing the market (see, e.g., International Carbon Action Partnership 2022a, etc.).

Note 11. However, the Ministry of Economy, Trade and Industry (METI) started in September 2022, a trial pilot scheme to trade carbon credits on the Tokyo Stock Exchange. The so-called J-Credit scheme may lead to a permanent carbon credit trade in the stock market in Japan in the future, see e.g. Obayashi 2022.

Note 12. Actually, there are two allowance reserves and two trigger prices. To save space, we focus on only one of the reserves. For details, see Sullivan, McIssac, Robo, Pandey 2022, Wang, Carpenter-Gold, Shen and So, 2022, California Air Resources Board 2022a, 2022b, etc.

Note 13. For more detailed discussions and criticisms of the allegation of "excessive" free allowances, see Wang, Carpenter-Gold, Shen and So 2022, etc.

Note 14. For a more updated detailed discussion, see Fowlie and Cullenward, 2018.

Note 15. Researchers also seem to uncover carbon leakage in other regional cap-and-trade programs such as the RGGI. In particular, RGGI may have induced a reduction in coal-fired generation in RGGI states but an *increase* in generation in the RGGI-surrounding regions for example, see. e.g., Fell and Maniloff, 2018.

Note 16. In recent research on Japanese transition to decarbonization and other challenges, various channels are often pointed out. For example, Yagi, Furukawa and Nakajima 2022 highlights that indeed skill formation and education of non-regular Japanese workers would be low in large Japanese firms. But, for regular). lifetime-employed" employees, the within-firm training and human capital

accumulation can be substantial. There can also be mobility of regular workers across different divisions or affiliates within the same firm owned by the same owners. In other words, in thinking about factors that influence resource mobility, lifetime learning and re-training to adapt to decarbonization in Japan, we can distinguish several aspects, within-firm efforts, across firms and across industry factors as well as economy-wide effects. For more discussions of the decarbonization efforts and challenges in Japan, see Kurachi, Morishima, Kawata, Shibata, Bunya and Moteki 2022, etc.

Note 17. For simplicity, we have abstracted from modelling the adjustment costs of adapting to the new, more energy-efficient business model by the facilities in the unregulated area. If the adjustment cost is included, we need to compare the marginal benefit of having a lower energy or electricity cost with the marginal transitional cost of adjustment.