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Electricity regulation in the Chinese national emissions trading scheme (ETS): lessons for carbon leakage and linkage with the EU ETS

Yingying Zeng*, Stefan E. Weishaar†,‡ and Hans H. B. Vedder§

*Department of Law and Economics, Faculty of Law, University of Groningen, Groningen, Netherlands; †MIT Center for Energy and Environmental Policy Research, Massachusetts Institute of Technology, Cambridge, MA, USA; §Department of European and Economic Law, Faculty of Law, University of Groningen, Groningen, Netherlands

ABSTRACT

Carbon leakage is central to the discussion on how to mitigate climate change. The current carbon leakage literature focuses largely on industrial production, and less attention has been given to carbon leakage from the electricity sector (the largest source of carbon emissions in China). Moreover, very few studies have examined in detail electricity regulation in the Chinese national emissions trading system (which leads, for example, to double counting) or addressed its implications for potential linkage between the EU and Chinese emissions trading systems (ETTs). This article seeks to fill this gap by analysing the problem of ‘carbon leakage’ from the electricity sector under the China ETS. Specifically, a Law & Economics approach is applied to scrutinize legal documents on electricity/carbon regulation and examine the economic incentive structures of stakeholders in the inter-/intra-regional electricity markets. Two forms of ‘electricity carbon leakage’ are identified and further supported by legal evidence and practical cases. Moreover, the article assesses the environmental and economic implications for the EU of potential linkage between the world’s two largest ETTs. In response, policy suggestions are proposed to address electricity carbon leakage, differentiating leakage according to its sources.

Key policy insights
- Electricity carbon leakage in China remains a serious issue that has yet to receive sufficient attention.
- Such leakage arises from the current electricity/carbon regulatory framework in China and jeopardizes mitigation efforts.
- With the US retreat on climate efforts, evidence suggests that EU officials are looking to China and expect an expanded carbon market to reinforce EU global climate leadership.
- Given that the Chinese ETS will be twice the size of the EU ETS, a small amount of carbon leakage in China could have significant repercussions. Electricity carbon leakage should thus be considered in any future EU–China linking negotiations.

1. Introduction

As the world’s biggest GHG emitter, China launched the world’s largest carbon emissions trading system (ETS) in December 2017, with the aim of cost-effectively achieving its abatement target (National Development and Reform Commission [NDRC], 2017). The electricity sector has been China’s largest source of CO₂ emissions and is also covered by the Chinese national ETS (hereafter ‘China ETS’) (NDRC, 2016a; NDRC, 2017; State Grid

CONTACT Yingying Zeng y.zeng@rug.nl

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Energy Research Institute and Yingda Media Investment Group, 2014). Therefore, the abatement of the electricity sector remains crucial to domestic mitigation efforts.

China has large spatial disparities between the primary energy resources used for electricity generation and the load centres that dispatch electricity for consumption (Kahrl, Williams, Jianhua, & Junfeng, 2011). Bulk transport of some natural resources (e.g. coal) to the load centre may be costly, whereas other resources (e.g. wind) cannot be easily transferred. The supply and demand mismatch results in large amounts of electricity being transferred from the resource-rich areas to the load centres (China Electricity Council, 2015; Lindner, Liu, Guan, Geng, & Li, 2013). Admittedly, such inter-regional electricity flow may lead to several environmental and economic benefits (Streets, 2003; Wang, 2015). But with a transfer of electricity generation from the regions regulated by the ETS to others without or with fewer carbon constraints, the inter-regional electricity flow in the opposite direction may give rise to the leakage of emissions within the electricity sector (hereafter ‘electricity carbon leakage’). Accordingly, electricity carbon leakage, if any, is likely to undermine the environmental effectiveness of the China ETS.

Meanwhile, a ‘bottom-up approach’ of linking existing ETSs may prove valuable for enabling ‘further international cooperation’ (Tuerk, Mehling, Flachsland, & Sterk, 2009; Weishaar, 2014) and could contribute to meeting the Paris Agreement’s goals. A future linkage between the world’s two largest ETSs (the EU ETS and China ETS), although predicted to be at least several years off, would be a significant step towards global mitigation efforts (European Commission, 2016; Garside, 2016; Macdonald-Smith, 2016). Such a linkage may offer considerable economic, environmental and political benefits to both systems (Zeng, Weishaar, & Couwenberg, 2016), such as reinforcing global climate leadership and gaining first-mover advantage in terms of ETS rule-making/-transferring (de Carbonnel, 2017). In light of the potential gains, both jurisdictions have expressed willingness to link to each other (European Commission, 2010; European Commission, 2016; Garside, 2016; NDRC, 2015a). Altogether, with such political desirability and a long-standing bilateral cooperation on carbon markets (European Commissions, 2016), an EU–China linkage is likely to take place in the future. It bears mentioning, however, that this linkage may not materialize soon owing to different institutional and policy choices between jurisdictions such as different ETS designs and climate governance structures.

However, if such a linkage is to happen, the environmental and economic implications of China’s electricity regulation for its own system (e.g. electricity carbon leakage) and its linking partner remain critical and thus merit further attention in the literature. For instance, double counting of electricity emissions – a striking regulatory feature in the China ETS – prima facie causes environmental concerns. Also, potential electricity carbon leakage in the China ETS appears to give competitive advantages to China’s large electricity users (e.g. industrial sectors) and would thus place different abatement cost burdens on equal entities of both ETSs.

Although ‘carbon leakage’ in the industrial context is widely recognized (see, e.g. Antimiani, Costantini, Martini, Salvatici, & Tommasino, 2013; Juergens, Barreiro-Hurlé, & Vasa, 2013; Kuik & Hofkes, 2010; Martin, Muûls, De Preux, & Wagner, 2014; Monjon & Quirion, 2011; Paroussos, Fragkos, Capros, & Fragkiadakis, 2015; Wang, Teng, Zhou, & Cai, 2017), little attention has been given to the electricity sector in practice or the literature (Weishaar & Madani, 2014). Also, despite the attention China’s electricity regulation has received thus far (see, e.g. Pang & Duan, 2016; Wang & Zhang, 2017; Zeng et al., 2016), few studies discuss electricity regulation (e.g. the inter-regional electricity trade, double counting) in the context of the national ETS in detail (Grubb et al., 2015; Li, 2012; Lin, Gu, Wang, & Liu, 2016; Wang, Yang, & Zhang, 2015; Zhang, 2015). Further, the current literature on ETS linking focuses on mapping linking implications or barriers (see, e.g. Ellis & Tirpak, 2006; Flachsland, Marschinski, & Edenhofener, 2009; Roßnagel, 2009; Stavins & Jaffe, 2007; Tuerk et al., 2009; Weishaar, 2014). A small number of articles have used economic simulation to explore EU–China ETS linkage but have neglected legal complexities (Gavard, Winchester, & Paltsi, 2016; Hübner, Voigt, & Löschel, 2014; Liu & Wei, 2016).

Given the gap in the literature and the need to facilitate the potential linkage, this article addresses the research question of whether and how the inter-provincial/regional electricity regulatory framework under the national ETS will give rise to electricity carbon leakage in the China ETS, and how this would further impact its prospective linked partner (the EU ETS). Particularly, we employ a Law & Economics approach to identify ‘electricity carbon leakage’ that rests upon economic incentive structures and legal details on electricity regulation.
The article is structured as follows. Section 2 introduces the highly regulated intra- and inter-regional electricity markets and ‘double counting’ in the China ETS. Section 3 explains the issue of electricity leakage in the China ETS based on an analysis of the incentive structure of stakeholders. The implications of electricity carbon leakage in China’s ETS for potential linking with the EU ETS are examined in Section 4. Section 5 summarizes the main conclusions and discusses the policy implications.

2. Electricity regulation and double counting in China

Two of the most striking features of electricity regulation in China are introduced in this section, namely the heavy government regulation of China’s electricity market (Section 2.1) and the double counting of electricity emissions in the China ETS (Section 2.2).

2.1. Highly regulated electricity market in China

In China, there is no significant competition in electricity generation, transmission and the retail market. The five state-owned generators account for most of the overall power generation capacity (Polaris power grid, 2015a). Additionally, transmission and distribution are mainly run by two state-owned grid companies, State Grid and Southern Grid (Wu, 2015). In March 2015, the State Council released a new framework that proposed general reforms pushing forward competition in electricity generation and retail (State Council, 2015) in both intra- and inter-regional markets (NDRC, 2015b). Although a comprehensive power sector reform may be on its way, the reality in China suggests that this will not come any time soon (Zhang, 2015).

2.1.1. Mandatory electricity prices in the intra-regional electricity market

Generators face on-grid tariffs set by the government using benchmark pricing for coal-fired, gas-fired and renewable electricity (Kahrl et al., 2011; NDRC, 2014b; Wu, 2015). Additionally, rates for hydropower are set mainly by benchmark pricing along with two other approaches: (1) pricing on a facility-by-facility basis; (2) a receiving-end backward pricing mechanism whereby the on-grid tariff is set in reference to prices in the electricity-receiving region (Polaris power grid, 2015b).

Consumption prices are also set by the government and demonstrate regional differences. Local provinces determine the price ladder by considering regional factors such as availability of natural resources and affordability. Consumers purchase electricity mainly from local grids or electricity-distributing companies (not directly from generators), and pay differently for different categories of end-use electricity (residential, industrial a commercial, or agricultural), time periods, supply voltage and electricity capacity (NDRC, 2013). Further, consumers belonging to the same category of electricity end-use pay the same consumption price within the same regional grid (National People’s Congress, 2015, Article 41), regardless of the geographical location of the electricity generation. In other words, there is no price difference between imported and locally generated electricity.

2.1.2. Strongly regulated inter-regional electricity trade

Most inter-regional electricity transactions are highly regulated to secure a stable supply of electricity and to keep prices within acceptable bounds (State Electricity Regulatory Commission, 2012; Wang, 2015). Specifically, two state-owned grid companies (State Grid and Southern Grid) remain in charge of the inter-regional electricity transactions and dispatch in their respective ‘jurisdictions’ (State Electricity Regulatory Commission, 2003, Article 7). At the beginning of each year, State Grid develops the ‘Annual guidance plan for the inter-regional electricity trade’ alongside local generating companies (State Electricity Regulatory Commission, 2003, Article 20). The Annual Guidance Plan requires the provincial branches to incorporate transactions therein into the ‘Provincial Power Balance Arrangement’ and sign legally binding contracts for purchases/sales. In this way, the Annual Guidance Plan may de facto turn into an inflexible and binding plan.

Further, electricity-pricing mechanisms differ for varied participants among three main categories of electricity sales: (1) ‘point to network’ sales: direct sales of electricity from qualified generators (mainly from the power supply bases) to regional/provincial grid companies; (2) ‘network to network’ sales: transactions between provincial grids; and (3) ‘point to point’ sales: transactions between generators and independent consumers (i.e.
large users that are qualified to directly purchase electricity from generators) (State Electricity Regulatory Commission, 2012).

The first two categories of transactions implement transaction prices that are mainly mandated by the government and, if not mandated, can be set through negotiations between participants with reference to the average on-grid tariff at the sending end and the average purchase price at the receiving end (NDRC, State Electricity Regulatory Commission and National Energy Board, 2009). Prices and volume in ‘point to point’ transactions are determined through negotiations between stakeholders of electricity transactions, and grid companies who charge transmission costs that are mandated by government. Additionally, some inter-regional electricity transactions are conducted on the electricity-trading platform and thus adopt transaction prices through market competition (Li, 2015).

2.2. Double counting of electricity emissions in the China ETS

In the EU, emission allowances are auctioned to electricity generators (Directive 2003/87/EC, Article 10). Accordingly, generators tend to pass the carbon cost to electricity consumers by inflating electricity prices (see, e.g. Bönte, Nielen, Valitov, & Engelmeyer, 2015; Frondel, Schmidt, & Vance, 2012; Jouvet & Solier, 2013; Carbon Point, 2008; Schröder, Traber, & Kemfert, 2013; Sijm, Neuhoff, & Chen, 2006; Woerdman, Couwenberg, & Nentjes et al., 2009). Even though electricity consumers are not required to surrender allowances covering electricity emissions in the EU ETS (European Commission, 2012), the EU ETS inflates the costs of electricity because consumers have to pay higher electricity bills (indirect carbon costs). The electricity consumers are thus incentivized to reduce electricity use in the EU.

In China, by contrast, the carbon costs cannot be passed on from electricity generators to electricity users since the electricity prices are strongly regulated (see above). To incentivize lower electricity use, regulators require both the generators and consumers to surrender allowances for the same electricity (double counting). On the one hand, emissions released from generation and transmission are counted as ‘direct electricity emissions’ at the generators and grids (NDRC, 2013–2015). On the other hand, the same emissions are (double) counted as ‘indirect electricity emissions’ by electricity consumers (NDRC, 2014a, Article 47). Consequently, not only will the generators and grids be incentivized to cut emissions (by adopting, e.g. cleaner generating fuels), but the electricity users are also incentivized to reduce electricity use (Li, 2012; Ou, Xiaoyu, & Zhang, 2011; Zhang, Karplus, Cassisa, & Zhang, 2014; Zhang, Bian, Tan, & Song, 2017; Zhu, Peng, & Wu, 2012).

3. Electricity carbon leakage in China’s ETS: evidence from the regulatory framework of inter-regional electricity trade

This section introduces potential incentive structures for the inter-regional/-provincial electricity trade, resulting in two particular forms of electricity flow that will give rise to ‘electricity carbon leakage’ within the China ETS: the leakage of ‘direct electricity emissions’ at the generators’ side (Section 3.1) and ‘indirect electricity emissions’ at the consumers’ side (Section 3.2).

Allowing for technical and regulatory possibilities, economic drivers (e.g. market characteristics, electricity prices) will ultimately stimulate stakeholders into the most economically efficient investment decisions. A demand for inter-provincial/-regional electricity flow will arise when both electricity purchasers and sellers are incentivized to participate in the inter-regional electricity trade.

On the one hand, grid companies and independent consumers could be incentivized to actively participate in the inter-regional electricity trade as electricity purchasers. Since the government-mandated on-grid tariffs and consumption prices demonstrate regional differences, locally generated electricity may sometimes cost more than imported electricity when the local on-grid tariff exceeds the sum of the selling price (charged by the sending end in the inter-regional sales) and the transmission price (mandated by government). Accordingly, independent electricity consumers and grid companies will be incentivized to import cheaper electricity. Grid companies may benefit more from this, since they profit in the intra-regional electricity trade from the difference between the regulated sales-price and the purchase-price.

On the other hand, certain generators may be incentivized to participate in the inter-regional electricity trade as electricity sellers. For instance, qualified hydropower plants could benefit from a recently introduced pricing
mechanism for hydropower, the ‘receiving-end backward pricing mechanism’ (NDRC, 2014c). Pursuant to this mechanism, the selling price of hydropower generated and sent inter-regionally/-provincially by qualified hydropower plants is the difference between the purchase price (paid by the receiving end) and transmission price (line loss during transmission and distribution included) (NDRC, 2014c). Since the purchase price can be determined through negotiations between the sending and receiving ends (in reference to the average purchase price in the power-receiving area), the qualified hydropower plants could sell the hydropower at a higher price than would otherwise be available in the intra-regional electricity trade (i.e. the local on-grid benchmark tariff) (Polaris power grid, 2015b).

3.1. Inter-provincial leakage of direct electricity emissions

Carbon leakage of direct electricity emissions refers to the electricity emissions spillover when generators move resources to less-regulated ETS regions.

Generators covered by the ETS are legally required to surrender allowances for direct electricity emissions and, potentially, indirect emissions associated with the purchased electricity/heat. Specifically, the direct emissions of generators include combustion and desulphurization emissions that are largely contingent on the generation techniques and fuels adopted. Although uniform measurement, reporting and verification (MRV) guidelines have been adopted by the NDRC, the stringency of coverage and allocation for generators may still differ across different regions (see Table 1). This is because provincial DRCs are legally allowed to adopt expanded coverage (e.g. lower thresholds) or a more stringent allocation than the national standards (granted approval by the NDRC) (NDRC, 2014a, Arts. 7, 12; NDRC, 2016c, Arts. 5, 9).

In practice, the coverage threshold determines whether a firm is covered by the China ETS, which regulates at the firm level. With different coverage thresholds among different regions, similar entities may be covered in one region but not in another. Accordingly, generators can avoid abatement obligations by transferring to another region with a higher coverage threshold. Evidence shows that most of the pilots (Hubei excluded) have already adopted lower coverage thresholds (Table 1). Yet, different coverage thresholds in those pilots demonstrate the potential magnitude of future regional differences, from 3000 tonnes of CO₂ in Shenzhen to 20,000 tonnes of CO₂ in Shanghai/Guangdong (Table 1). It is unlikely that these pilots will simply abandon the previous coverage rules because of their climate change ambitions. More importantly, it has been officially disclosed that a lower national coverage-threshold will be implemented later on, with more sectors (or more entities in the same sector) being covered (Ideacarbon, 2016b).

Despite a nationally uniform allocation method for the power sector (e.g. emissions benchmark Bi, see Table 1), provincial DRCs may be incentivized to apply different adjustment coefficients to the allocation (‘Fp’, see Table 1) for regional economic development and industrial planning considerations (Ideacarbon, 2017; NDRC, 2016b). Such variations may lead to different stringency levels of allocation and thus different allowances allocated for similar covered entities. Accordingly, by shifting generation to less-regulated ETS regions, the relocated generators could receive more allowances and have their abatement costs reduced.

Altogether, potential variations in the ETS rules could place different carbon cost burdens on similar covered generators in different regions. Since the electricity sector is the most sensitive sector in China to the carbon cost signal (Li, Zhang, Wang, & Cai, 2012), generators in the ETS regions may be incentivized to reduce carbon costs simply by shifting resources, without further abatement, to less-regulated ETS regions in three main ways.

The first channel is to transfer the geographical location of generation. In practice, this could be limited since carbon costs may not be the primary concern when it comes to selecting a generation location. Also, relocating generation capacity cannot be easily done for certain types of power plants (e.g. hydropower, wind power), owing to geological requirements or technical difficulty of transferring energy resources. Moreover, regulatory obstacles such as the local protectionism of the government may discourage inter-regional transfer of large taxpayers (e.g. coal-fired plants).

A second way is to transfer the generation resources such as coal and gas. This could also be limited in practice since physically transporting resources in large amounts and over long distances could be costly.

In light of the obstacles to the transfer of generation or resources, the third and most likely channel is through a simple shift in generation output between different provinces/regions. For instance, trans-provincial/-regional
### Table 1. Potential regional differences of the ETS rules in the Chinese electricity sector (Phase I).

<table>
<thead>
<tr>
<th>National rules</th>
<th>Coverage threshold for annual emissions</th>
<th>Allocation</th>
<th>MRV: REEFs adopted for ‘indirect electricity emissions’ (KgCO2/kWh)</th>
</tr>
</thead>
</table>
|                | • 26,000 tonnes (or 10,000 tonnes of standard coal equivalent).  
• Lower threshold allowed provided being approved by NDRC.  
                  | Benchmarking allocation formula (Combined Heat-and-Power (CHP) generation excluded):  
\[ A = \sum_{i=1}^{N} (B_i \times F_l \times Q_i \times F_p) \]  
• Bi: uniform carbon emissions benchmark (for particular category of power generating unit considered) adopted by NDRC.  
• Fp: ‘adjustment coefficient’ adopted by provincial DRCs; potentially demonstrating ‘regional difference’ due to different ‘regional economic development’ and ‘industrial planning’ (see Section 3.1).  
• Varied by 6 regional grids:  
  East China: 0.7035  
  North China: 0.8843  
  Northeast China: 0.7769  
  Central China: 0.5257  
  Northwest China: 0.6671  
  South China: 0.5271 | | |
| Pilots          | Beijing  
• 5000 tonnes (base year: 2009–2012)  
• Most likely remaining below national entry threshold (see Section 3.1). | A: the amount of allowances allocated; N: the amount of generating units.  
F_l: the cooling adjustment coefficient; Q_i: the generation output of the generating unit considered. | 0.8843 |
|                | Tianjin  
• 20,000 tonnes (2009–2012) | | |
|                | Shanghai  
• 20,000 tonnes (2010–2011) | | |
|                | Fujian  
• 5000 tonnes of standard coal (2013–2015) | | |
|                | Guangdong  
• 20,000 tonnes (2011–2012) | | |
|                | Shenzhen  
• 3000 tonnes (2009–2012) | | |
|                | Chongqing  
• 20,000 tonnes (2008–2012) | | |
|                | Hubei  
• 60,000 tonnes of standard coal (2010–2011)  
• Requiring harmonization. | | |


*The latest ‘average regional electricity emissions factors (REEFs)’, issued by NDRC in 2012, are referred (see Section 3.2).*
generating companies can move resources merely by increasing the generation output in less-regulated ETS regions while reducing the output in more-regulated ones without physically transferring generation location or resources. Those generators, ceteris paribus, could have their covered emissions reduced or receive more allowances without substantial abatement.

Consequently, with the leakage of direct electricity emissions to less-regulated ETS regions, more allowances could be rendered available in China’s national ETS despite no actual abatement. Those additional allowances could bring down the carbon price and thus discourage abatement incentives in the system. In the long term, the dynamic environmental effectiveness of the China ETS could also be jeopardized, with carbon leakage embodied in the above-mentioned generation-capacity transfer and a resulting decline of actual abatement in the system.

3.2. Inter-regional leakage of indirect electricity emissions

For electricity consumers falling under the ETS, indirect electricity emissions are calculated by multiplying the amount of purchased electricity with a corresponding regional electricity emissions factor (REEF) that differs across regions (NDRC, 2013–2015). Since indirect emissions are calculated in one regional grid with one uniform REEF, leakage of indirect emissions arises from the demand side on a regional level (not provincial level). Accordingly, different indirect emissions calculations for similar electricity may give rise to leakage, with a flow of electricity from regions with high REEFs to regions with low REEFs. In 2011, approximately 35 billion kWh of electricity was transferred in this direction (China Electricity Council, 2012).

There is still some uncertainty about how REEFs will be determined. The national MRV guideline only stipulates that the REEFs adopted are those issued in the most recent year by the NDRC (REEFs issued by regional grids excluded). Currently there are two main REEFs used in different pilots and one of them is likely to be adopted in the national ETS.

One REEF is the ‘benchmark emissions factors for the regional grids’ (hereafter ‘benchmark REEF’) issued by the NDRC. It was originally designed for Chinese Certified Emission Reduction (CCER) projects development (NDRC, 2015c, para.1) but has been used in practice to calculate indirect emissions associated with electricity consumption (e.g. in the Shenzhen Pilot) (Market Supervision Administration of Shenzhen Municipality, 2012, p. 29; Song, Zhu, Hou, & Wang, 2013; Lv, 2014).

The other one is the ‘average CO2 emissions factors for the regional grids’ (hereafter ‘average REEF’) issued by the National Centre for Climate Change Strategy and International Cooperation (NCSC), a centre affiliated to the NDRC. The average REEF can be used to calculate indirect electricity emissions (NDRC, 2014d) but has so far only been issued after considerable delay (the average REEFs for 2011/2012 were issued only in September 2014).

Average REEF:

\[
EF_{\text{grid},i} = \frac{Em_{\text{grid},i} + \sum_j (EF_{\text{grid},j} \times E_{\text{imp},j,i}) + \sum_k (EF_k \times E_{\text{imp},k,i})}{E_{\text{grid},i} + \sum_j E_{\text{imp},j,i} + \sum_k E_{\text{imp},k,i}}, \tag{1}
\]

\[
Em_{\text{grid},i} = \sum m(FC_m \times NCV_m \times EF_m/1000), \tag{2}
\]

where \(EF_{\text{grid},i}\) and \(EF_{\text{grid},j}\) and \(EF_k\) are the average REEFs for grid \(i\), grid \(j\) and country \(k\). \(E_{\text{grid},i}\) is the annual aggregate generation volume within the geographical scope of regional grid \(i\), whereas \(E_{\text{imp},j,i}\) and \(E_{\text{imp},k,i}\) represent the net imported electricity volume from regional grid \(j\) and the country \(k\). \(Em_{\text{grid},i}\) refers to the combustion emissions from all the fossil fuels (during generation) within grid \(i\) (NDRC, 2014c).

Whichever REEF will be adopted, either can give rise to electricity carbon leakage for different reasons.

The benchmark REEF applies to local regional electricity imports irrespective of their actual carbon content (Li, 2012; NDRC, 2013–2015; Song et al., 2013; Zhang et al., 2014). Consequently, the carbon content of electricity imports into regions with a lower REEF is not fully counted and factual indirect electricity emissions will be under-calculated.

Although the average REEF does include the actual carbon content of the imported electricity (see \(\sum (EF_{\text{grid},j} \times E_{\text{imp},j,i})\), formula 1), indirect emissions for the imported electricity (\(\sum E_{\text{imp},j,i}\)) are still under-counted. This is because, pursuant to national MRV guidelines, both direct and indirect electricity emissions fail to include the
combustion emissions from non-fossil fuels (e.g. biomass fuel such as woody fuels and animal wastes),\(^5\) and indirect emissions further leave out the desulfurization process emissions for coal-fired generators (under-calculation effects) (NDRC, 2013–2015; NDRC, 2014d).

Accordingly, the adoption of the average REEF may cause carbon leakage, when region \(i\) with a lower REEF (\(\text{EF}_{\text{grid},i}\)) imports cheaper-but-dirtier electricity from region \(j\) with a higher REEF. Such imports are cheaper because generators in region \(j\) – with lower carbon costs – would have competitive advantage over generators in region \(i\). Thus, dirtier electricity is generated in grid \(j\) and exported to replace or complement electricity demand in region \(i\) (with cleaner generation). Altogether, with such an electricity flow, further under-calculation effects (for the indirect emissions) – associated with the imported electricity (\(E_{\text{imp},i,j}\)) – will cause carbon leakage.\(^6\)

In the short term, aggregate electricity emissions may increase compared to scenarios without such flow (jeopardizing environmental effectiveness), since dirtier electricity is imported to replace/complement the cleaner local generation. Yet this won’t change the allowances surplus or carbon price because the Annual Plan (for inter-regional transactions, see Section 2.1.2) is oftentimes developed a year ahead; local generators will be notified of the upcoming importation and reduce their output accordingly. When direct electricity emissions decrease, generators will receive fewer allowances owing to the output-based allocation (Table 1). The same applies to generators in the electricity-exporting regions, i.e. increasing electricity emissions and a pro-rata increase of allowances within a certain range.\(^7\) Consequently, the surplus and carbon price remain unchanged, since the supply and demand of allowances in the system have changed to the same extent.

In the long term, the electricity flow to regions with lower REEFs increases the proportion of direct emissions to indirect emissions, since the desulfurization process emissions for coal-fired generators are considered in the measurement of direct emissions but not of their indirect counterpart (see above). Accordingly, the Chinese national ETS – originally covering both upstream generation and downstream consumption in the power sector – may gradually move towards an upstream ETS. More abatement burdens may be shifted to generators, possibly decreasing the political acceptability of the ETS since generators under abatement pressure cannot pass their carbon costs downstream (see Section 2). However, an upstream ETS may bring more direct control and thus meet the environmental objective with a lower level of uncertainty (Kerr & Duscha, 2014). Uncertainty may arise because current electricity prices are highly regulated and the carbon cost signal cannot be passed from the generators to consumers, resulting in generators’ failure to comply. The potential scale effects of abatement at the generators may bring down aggregate abatement costs (efficiency gains). Additionally, transaction costs may be reduced because of the higher emissions per regulated-entity and fewer regulated entities involved (Kerr & Duscha, 2014).

### 4. Linking China’s ETS to the EU ETS: implications of China’ electricity leakage for the EU

As mentioned above, an EU–China ETS linkage appears beneficial and attractive and both jurisdictions have expressed willingness to link. With concerns over the US retreat on climate efforts, EU officials are looking to China and expect ‘an expanded cooperation’ to ‘reinforce a ‘weak’ climate leadership by its own’ (de Carbonnel, 2017). Similarly, China has explicitly expressed the desire for ‘participation in global climate governance in depth’ in the 13th Five-Year-Plan (State Council, 2016), demonstrating a strong interest in gaining global climate leadership. Linking the Chinese national ETS to the world’s first ETS (EU ETS) will serve that goal while China benefits from EU experience. Consequently, building upon the long-standing cooperation on carbon markets,\(^8\) an EU–China linkage is likely to materialise in the future and thus merits further attention.\(^9\)

Building upon the analysis of electricity carbon leakage in the Chinese national ETS in Section 3, this section examines its implications for the EU in the eventuality of a direct and full linkage between both ETSs (i.e. no linking restrictions).\(^10\) Specifically, our analysis adds to the linking literature by addressing the environmental effectiveness, efficiency and competitiveness concerns of China’s electricity regulation, particularly in terms of whether to impede the potential linkage.

First, both types of electricity leakage in the China ETS will certainly undermine the environmental integrity of the linked ETSs but may additionally jeopardize the environmental effectiveness of the EU ETS in different ways. As analysed above, the leakage of direct electricity emissions on the supply side renders more allowances available in the China ETS and brings down the carbon price. *Ceteris paribus*, more allowances will leak from China’s
system into its linking partner. Meanwhile, a lower carbon price in the joint markets will discourage the abatement incentives in the EU ETS, thus jeopardizing environmental effectiveness.

By contrast, leakage of indirect electricity emissions on the demand side will not change the allowances surplus or carbon price in China’s system, since both granted allowances (supply) and covered emissions (demand) inflate to the same extent (see Section 3.1). Accordingly, the environmental effectiveness of the EU ETS will not be directly undermined but may still be compromised, especially in the long term, with the flow of dirtier electricity to regions with lower REEFs. This is because, with such flow and the current electricity/carbon regulation, the China ETS will be granting more allowances to dirtier generators. Meanwhile, there is the danger that the linked ETSs will collectively encourage cheap-but-dirty electricity to replace/complement cleaner electricity, hence discouraging abatement incentives (dynamic environmental effectiveness jeopardized).

Further, electricity carbon leakage in the China ETS may raise competitiveness concerns in the linked systems. Specifically, it may affect the competitive position of independent electricity consumers (large users in the industrial sectors) in China’s system but not of dependent consumers. On the one hand, dependent consumers can only purchase electricity from local grids (or electricity-distributing companies), not directly from generators (see Section 2.1.2). Hence, compared to scenarios without inter-regional flow, dependent consumers pay the same electricity consumption prices (mandated by government) and the same carbon costs for indirect electricity emissions (calculated with the same local REEF). However, since independent consumers are legally allowed to directly purchase electricity from generators in other provinces/regions, they are able to import dirtier electricity at a cheaper price without shouldering higher carbon costs. As a result, competitive distortions may result in large electricity users in the industrial sectors gaining carbon advantages over their competitors in the EU ETS.

Last, one striking source of competitive and efficiency concerns is double counting (the fact that electricity emissions are covered at both generation and consumption side) in the China ETS. The few articles that discuss double counting (Ellis & Tirpak, 2006; Jakob-Gallmann, 2011; Schneider, Kollmuss, & Lazarus, 2015; Sorrell, 2003) have expressed environmental integrity and competitiveness concerns. In the context of linking, indirect emissions of the purchased electricity are covered and measured in the China ETS but not in the EU ETS. Since different coverage and MRV rules between the linked ETSs may lead to competitive distortions and inefficiency (Tuerk et al., 2009; Weishaar, 2014), double counting in this regard may generate certain concerns.

However, further scrutiny may suggest otherwise. Double counting in China’s ETS may actually reduce potential efficiency concerns and competitive distortions between electricity consumers in both systems. This is because, first, electricity consumers under both systems will bear carbon costs in the wake of ‘double counting’: Chinese electricity consumers under the ETS directly pay the carbon cost associated with indirect electricity emissions, whereas electricity consumers in the EU ETS indirectly pay carbon costs embodied by the electricity price increase (see Section 2.2). Furthermore, in the EU ETS, the most electro-intensive sectors may be compensated for the increase in electricity costs resulting from the ETS subject to state aid rules (Directive 2003/87/EC, Article 10a(6)).11 Electricity consumers in China’s ETS may be compensated as well by receiving free allowances associated with indirect electricity emissions (at least in the early stages).

5. Conclusions and policy implications

This article examines a serious issue that has been underrepresented in the literature, namely, electricity carbon leakage. Under current electricity and carbon regulation, such leakage will arise in the China ETS from certain inter-regional electricity flows owing to the way emissions are inventoried in China (double counting) and, as our findings reveal, may endanger climate change mitigation efforts. Admittedly, our findings cannot be quantitative since the details of the China ETS are yet to be fully determined.

Also, we found that electricity carbon leakage concerns the competitiveness of not only the electricity sector but also the industrial sector. In particular, in the Chinese context, large industrial electricity-users – qualified as independent consumers in the inter-regional electricity trade – are legally and practically able to import dirtier electricity at a cheaper price without shouldering correspondingly higher carbon costs. In this regard, they gain carbon advantages over their competitors in the EU or other jurisdictions that impose carbon obligations on the generators.
Further, electricity carbon leakage – a concern that has not yet arisen in the current linking-literature or ETS-linking practices (see, e.g. Ellis & Tirpak, 2006; Flachsland et al., 2009; Tuerk et al., 2009; Weishaar, 2014; or the California-Quebec and EU–Swiss linkage in Görlach, Mehling, & Roberts, 2015; Purdon, Houle, & Lachapelle, 2014; Ranson & Stavins, 2016; Rutherford, 2014) – may add to the uncertainty of linking between the Chinese and EU ETS. In particular, in the eventuality of an EU–China linkage, different forms of electricity carbon leakage in China may compromise the environmental effectiveness of the EU ETS in different ways (Section 4). Since China’s system will be twice the size of the EU ETS, even a small amount of carbon leakage in China could have significant repercussions in the linked systems. Therefore, it remains crucial to include electricity carbon leakage into future EU–China linking negotiations.

In addition, our findings on ‘double counting’ clear up a potential misunderstanding, where double counting has long been perceived negatively as the double claiming or usage of emissions reductions under the UNFCCC (see, e.g. Paris Agreement Article 4.13; Schneider et al., 2015) or in the EU context (see, e.g. rec. 43 in Directive 2009/29/EC; Ellis & Tirpak, 2006; Jakob-Gallmann, 2011; Sorrell, 2003). Our findings show that, contrary to the prima facie perception, China’s double counting actually serves to safeguard environmental effectiveness of the system and further reduce competitive distortions in the joint markets, provided both emissions and abatement are measured to the same extent.

In response to the electricity carbon leakage identified above, specific measures could be taken in the short term but should distinguish leakage of different sources and forms. As analysed above, leakage of direct emissions arises from potentially different stringency of ETS rules, most likely when trans-regional generators move generation resources to less-regulated ETS regions. Since this will be largely done by increasing the generation output in one area while reducing the output in another, it will be difficult to regulate when the government cannot determine whether such a decision is taken specifically to evade their carbon obligations. Still, measures can be taken, e.g. by applying uniform coverage/allocation standards to trans-regional generators, despite local governments’ carbon ambitions or willingness to favour large taxpayers (e.g. generators). When the linkage finally materializes in the future, stringency of ETS rules may be uniformized and such leakage can thus be largely avoided.

Measures to address electricity leakage of indirect emissions largely depend on how the REEF is formed. If the average REEF is to apply (which is most likely), importation effects will be avoided that would otherwise arise from the benchmark REEF and under-calculate the carbon content of the imported dirtier electricity. Yet, further under-calculation effects (electricity leakage) may arise mainly because the current measurement of indirect electricity emissions fails to include combustion emissions from non-fossil fuels and desulfurization process emissions for coal-fired generators. In this case, the magnitude of such leakage can be measured ex post in the future by multiplying the volume of the imported electricity (Eimp\(_{j,i}\)) and the ‘under-calculated emissions’, which largely depend on the specific generation input associated with the imported. Accordingly, to compensate for the under-calculation, specific MRV provisions may be stipulated for inter-regional electricity flow that causes electricity leakage (i.e. when a region with a lower REEF imports dirtier electricity).

Still, such measures associated with indirect emissions should be introduced with a holistic view, e.g. introducing a corresponding adjustment to the calculation of direct emissions of the imported electricity in the regions where it was initially generated. Further, legislation addressing carbon leakage should be fully pre-disclosed to deliver predictable incentive structures and thus predictable environmental/economic impacts. Otherwise, if companies invest in power plants in the less-regulated ETS regions (or outside the ETS), investments that appeared profitable may turn out to be obsolete as a result of subsequent legislation (stranded costs).

Notes

1. ‘Carbon leakage’ commonly refers to a shift of production and thus a transfer of carbon emissions from ‘carbon-constrained’ countries/regions/sectors to others without or with fewer carbon constraints (Directive 2003/87/EC, Article 10a; Antimiani et al., 2013; Wang, Teng, et al., 2017; Weishaar & Madani, 2014).

   Specifically, carbon leakage can be driven via several channels. The one discussed herein is through the ‘shift of production to other countries/regions with fewer carbon constraints’ (‘competitiveness discussion’). A second channel is through the international markets of fossil fuels or other cleaner products (e.g. ethanol). For instance, a decreased demand for fossil fuels – as a result of carbon regulation – could bring down the international prices of fossil fuels, which in turn...
could induce an increased demand for fossil fuels in the less-constrained countries and regions. Additionally, carbon leakage may derive from policy instruments implemented at different levels (e.g. between the federal and state climate efforts). See, e.g., Goulder and Stavins (2011); Zhang (2012).

2. Potential linking challenges that may cast the linkage into uncertainty include, inter alia, differences in the ETS designs (e.g. cap setting), the multi-level carbon governance structure in the EU, the incomplete regulatory infrastructure and thus concerns over the carbon enforcement in China (Görlach et al., 2015; Lo, 2016; Mehling, 2009; Zeng et al., 2016).

Particularly, the multi-level climate governance within the EU adds to the degree of uncertainty over the future linking negotiations. This is mainly because climate change falls into an area of shared competence between the Union and the Member States (Article 4, the Treaty on the Functioning of the European Union), which implies limited legal capability for the EU in terms of EU external climate policy (future EU–China linkage included). Still, given that the EU has generally presented a ‘more unified voice’ in the international climate negotiations (owing to an intended balance between the ‘environmental concerns’ and ‘economic impacts’) (Dreblow, 2013; pp. 20–21; Hart, 2015; Vedder, 2012; p. 495), the governance structure may not pose insurmountable obstacles to linking. But it certainly suggests that the linking negotiations, if any, may not conclude soon.

3. Articles discussing double counting in China largely focus on GHG inventory or discuss the indirect emissions of electricity consumption in the non-electricity sectors (e.g. residential sector). See, e.g., Chen and Zhang (2010); Lin and Sun (2010); Ou et al. (2011); Zhu et al. (2012); Yu, Wei, Guo, and Ding (2014); Zhang et al. (2017).

4. ‘Direct emissions’ are emissions from sources that are owned or controlled by the reporting entity, whereas ‘indirect emissions’ are emissions that are a consequence of the activities of the reporting entity, but occur at sources owned or controlled by another entity. Specifically, ‘direct electricity emissions’ herein refer to emissions associated with a certain amount of electricity from its generation, transmission and distribution, whereas ‘indirect electricity emissions’ are calculated when the same amount of electricity is consumed.

5. Particularly, the waste incineration for power generation has become increasingly common in China, as the government has been pushing waste-to-energy incinerators.

6. The adoption of the ‘benchmark REEF’ would give rise to similar under-calculation effects (carbon leakage) since it does not consider the renewable electricity either.

7. The supply of allowances in the China ETS can only increase to a certain extent owing to the upper-limit of aggregate allowances, despite the ‘intensity-based cap’ adopted in China. See Zeng et al. (2016).

8. See, e.g., the EU–China Partnership on Climate Change, the ‘EU–China emission trading capacity building project’. See NDRC and European Commission (2010); European Council and Council of European Union (2015), para 3, 9(5); European Commissions (2016).

9. Still, it has to be stressed that such a linkage is unlikely to materialise soon for reasons explained earlier in Introduction.

10. For the definition of ‘direct’ or ‘full’ linkage, see Tuerk et al. (2009, p. 343). Specifically, we examine the linking scenarios without any quantitative or qualitative linking restrictions (e.g. quotas or border tax on the imported/exported allowances).

11. Other factors such as differences in Member States’ compensation and electricity mix may further affect their competitive position.

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References


Ideacarbon. (2016a, October 25).


State Council of the People’s Republic of China (State Council). (2015). Several opinions on further deepening the reform of power system (No.9 document).


