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Is Chinese Trade Policy Motivated by Environmental Concerns? An Empirical Analysis

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Abstract

This paper analyses whether China's export VAT rebates and export taxes are driven by environmental concerns. Since China struggles to enforce environmental regulation, export taxes can be used as a second best environmental policy. We use a general equilibrium model to show that the second best export tax increases in a product's pollution intensity. The empirical analysis investigates whether the export tax or the VAT tax (= VAT - VAT rebate) is higher for products which are more pollution intensive along several dimensions. The results indicate that the export tax is set in a way that discourages solid waste intensive exports. The VAT is higher for waste water and energy intensive products as well as natural resources.

Contents

1 Introduction

In recent years, the Chinese government has as launched an ambitious agenda to tackle the country's environmental problems. There are several reasons for this increasing focus on environmental policy. Firstly, the Chinese leadership realized that environmental problems might hamper China's growth in the long run. Secondly, public discontent concerning pollution has been growing (Gang, 2009, p.119). This becomes obvious in mass protests in response to environmental degradation and in increasing participation in environmental NGOs. Gang (2009) argues that addressing environmental issues might be crucial for the government to consolidate its rule (Gang, 2009, p. xxii). Finally, international pressure on China to adopt stricter environmental policies is increasing.

Against this background, China has introduced export taxes and reduced export value-added tax (VAT) rebates for a range of products. According to China's National Development and Reform Commission, the VAT rebate adjustments aim at controlling "exports of energy-intensive, pollution-intensive and resource-intensive products, so as to formulate an import and export structure favorable to promote a cleaner and optimal energy mix" (NDRC, 2007, p. 31). Statements which link trade policy to environmental concerns appeared repeatedly in consecutive years (Wang et al., 2010).

This paper investigates whether, in practice, Chinese trade policy reflects environmental motives. It is not obvious the VAT rebate and export tax adjustments are driven by environmental concerns. Other potential motives include an attempt to manipulate the terms of trade in China's favour, a desire to attract downstream producers to China or lobbying pressure by different industries.

The policy relevance of the motivation behind Chinese export restrictions manifests itself in two WTO dispute settlement cases. The first case concerns the Chinese export restrictions on raw materials and was filed in 2009 (WTO, 2013b). The second case was filed in March 2012 and deals with export restrictions on rare earths (WTO, 2013a). In both cases China is a leading producer of the goods in question which are used as intermediate inputs into high-tech products. The complainants hold that China uses export restriction to manipulate the world market price and to force intermediate producers to move to China where supply of these crucial inputs is stable. China, however, argues, that the export restrictions are necessary to protect China's natural resources and the health of its citizens since the production is highly polluting. Even though China committed to cancelling its export taxes on most products in its Accession Protocol to the WTO, it argues that the export restrictions are justified under Article XX of the GATT. Article XX of the GATT allows an exemption from GATT rules for environmental objectives such as the protection of exhaustible natural resources and health considerations (WTO, 2013c).

It is well-known that local environmental distortions are best internalized through the use of domestic policy instruments such as pollution taxes (see e.g. Copeland, 2011). Copeland (1994), however, shows that a country which fails to implement optimal pollution regulation for a local pollutant can use trade policy as a second-best instrument to reduce pollution. Arguably, the second-best scenario applies to China. The Chinese government attempts to reduce pollution. This is reflected in ambitious targets for environmental protection in recent Chinese Five-Year-Plans. However, the design of the Chinese pollution levy system and difficulties with the enforcement of environmental regulation limit the Chinese government's ability to use pollution levies in order to reduce domestic pollution. Trade policy instruments like export taxes and partial export VAT rebates can thus be used as second-best environmental policy instruments.

The theoretical foundation for our analysis is an extension of Copeland (1994)'s model to a large country which sets trade and environmental policy unilaterally. We solve the model for the second-best export tax. We find that the second-best export tax increases in a product's pollution intensity. The intuition behind this result is simple: The export tax reduces export production of a particular good. As a result, resources are reallocated to sectors which are subject to a lower export tax. If the export tax is largest for the most pollution intensive goods, more resources are allocated to the production of relatively clean goods and the pollution intensity of production declines.

The prediction that the second-best export tax is positively correlated with a product's pollution intensity guides our empirical analysis. We investigate whether the export tax and the difference between the VAT and the export VAT rebate rate (henceforth called VAT tax) are higher for products which are more pollution intensive along several dimensions. The analysis considers pollutants for which the Chinese government specifies emission reduction targets in its Five Year Plans. These include waste water, COD, ammonium nitrogen, soot, SO_2, solid waste and energy use. We use data on Chinese trade policy, pollution intensity and information on industry characteristics spanning the years 2005 to 2009.

Since Chinese officials repeatedly linked trade policy to environmental concerns from 2007 on, we are most interested in the relationship between trade policy variables and pollution intensities for the years 2007 to 2009. The data for the years 2005 and 2006 allow us to test whether there is a stronger link between trade policy variables and pollution intensities as a consequence of the VAT rebate and export tax reforms from 2007 on compared to the situation prior to 2007.

Our empirical results suggest that the the VAT tax is larger for industries with a higher water pollution intensity and energy intensity. This finding is in line with the actions of a regulator who uses partial VAT rebates to reduce exports of water-pollution intensive and energy intensive goods in order to reduce overall water pollution and energy use in China. The VAT tax rate was more responsive to the waste water and energy intensity between 2007 and 2009 than between 2005 to 2006, indicating that the VAT rebate rates were adjusted in a way that hampers exports of waste water and energy intensive products. The energy intensity seems to be more important in the determination of the rebate rate than the water pollution intensity.

There is no evidence that the VAT tax is used to reduce solid waste intensive exports or to reduce production in sectors which recycle a low share of the solid waste. To the contrary, the VAT tax is lower for waste intensive products, thus encouraging the export production of these products.

Our analysis also reveals that the VAT tax is significantly higher for resource products than for the base category, indicating that VAT rebate rates are used to curb exports of natural resources like wood, mineral and metal products as well as precious stones. This is particularly evident for the period from 2007 to 2009.

In addition to our analysis of VAT taxes, we investigate whether the export taxes reflect environmental concerns. The regression results show that the determinants of the export tax differ considerably from the determinants of the VAT tax. As opposed to the VAT tax, the export tax is lower for energy-intensive products and precious stones. However, the export tax is significantly higher for industries which generate more solid waste per unit of output. Yet, the magnitude of the effect is economically small.

Looking at the overall protection generated by both export taxes and partial export VAT rebates reveals that the the Chinese government taxes exports of natural resources more than other products, particularly after 2007. Moreover, we find evidence that the overall export tax discourages waste water, solid waste and energy and energy-intensive production from 2007 onwards.

The paper is structured as follows. Section 2 reviews the relevant literature, followed by information on the policy background for our study in Section 3. In Section 3.1 we argue that environmental problems play a prominent role on the Chinese policy agenda, but that the government struggles to implement and enforce effective domestic pollution taxes. Section 3.2 gives background information on the trade policy reform which motivates our analysis. It explains why partial export VAT rebates are similar to export taxes and gives an overview of the VAT rebate reforms which haven been undertaken in recent years. Section 3.3 provides background information on Chinese export taxes.

Our paper analyses empirically whether the reforms of export taxes and export VAT rebates are driven by an attempt to reduce pollution and energy use. In Section 4 we derive a formula for a second-best export tax which reflects environmental concerns and show that the second-best export tax increases in a product's pollution intensity. This prediction is the basis for our empirical analysis. We investigate whether the export tax and the VAT tax increase in a product's pollution policy. The precise empirical strategy is explained in Section 5. The paper looks at the determinants of the export tax, the VAT tax as well as the structure of protection which imposed by these two variables. Each of these variables is analysed as a function of the pollution intensities and a set of control variables. The choice of control variables is explained in Section 5.2.

Section 6 describes the dataset followed by summary statistics in Section 7. The regression results are presented in Section 8 followed by a sensitivity analysis in Section 9. Section 10 concludes.

2 Related literature

To the best of our knowledge, Wang et al. (2010) provide the only systematic analysis of the environmental aspects behind the Chinese export VAT rebate rate adjustments. Wang et al. (2010) find that the implicit export carbon taxes differ considerably across sectors. The explicit export carbon tax for basic chemicals is 18 US$ per ton of CO_2 emissions. For chemical fibre it is 764 US$.

Yet, the fact that the carbon prices differ across industries does not imply that the VAT rebate reform and the export taxes are not based on environmental concerns. The Chinese government might have aimed at a reduction of pollution emissions other than CO_2 emissions when it implemented the policy. Our paper studies the relationship between Chinese export restrictions and a range of pollutants as well as energy use. It will reveal whether Chinese trade policy reflects concerns about air, water or solid waste pollution and will indicate which pollutant has the largest impact on the respective trade policy instruments.

Since we analyse whether China's trade policy can be considered an second-best environmental policy, this paper is also related to empirical work which explicitly takes the relationship between tariffs and pollution regulation or pollution intensity into consideration. This literature is very sparse. One exception is the paper by Ederington and Minier (2003), which looks at pollution policy as a second-best trade barrier. In contrast to Ederington and Minier (2003), this paper focuses on the case in which the regulator can adjust trade policy but not its environmental policy.

Our paper analyses the determinants of trade policy instruments. The choice of our control variables is guided by the literature on the political economy of protection. Baldwin (1989); Gawande and Krishna (2003); Ethier (2011) provide excellent surveys of that literature. We will refer to the relevant papers for our work in the section that explains the choice of the control variables. Two papers, which analyse trade policy in China, however, are worth describing in detail.

Wang and Xie (2010) provide the only analysis of VAT rebates in China. Their study focuses on the Chinese industry characteristics that determine the structure of VAT rebates in 2008. Wang and Xie (2010) find that industries with a higher export share have a higher rebate, since China supports an export-oriented strategy. The VAT rebate rate is also positively related to the share of national capital. This is interpreted as a sign that state-owned enterprises (SOEs) receive a favourable treatment. Moreover, Wang and Xie (2010) argue that the VAT rebate rates reflect an attempt to reduce adjustment cost and achieve social stability, as reflected by the fact that the rebate rate is higher for less profitable industries, industries with a lower labour productivity and industries with a lower ratio of value added. The results also show that industries with more assets, a large number of firms and a large presence of foreign capital receive higher VAT rebates. Just as in our study, they find that export VAT rebates, export taxes and tariffs are complementary. Industries which receive higher VAT rebates also face lower export taxes and higher protection on the import side.

Chen and Feng (2000) analyse the determinants of Chinese tariffs using data from the Third National Industrial Census of the People's Republic of China. They find that most of the variation in tariffs can be explained by information on industry size. Information on industry profits and and taxes paid by an industry explain the most of the remaining variance in tariffs.

The papers by Chen and Feng (2000) and Wang and Xie (2010) highlight important determinants of Chinese trade policy. Their findings guide the choice of political economy control variables in our study. However, our study differs considerably from Wang and Xie (2010) and Chen and Feng (2000). While we are mostly interested in the relationship between VAT rebates or export taxes and pollution intensities, this aspect is completely neglected in Wang and Xie (2010) and Chen and Feng (2000).

3 Policy background

3.1 Environmental policy in China

In recent years, the Chinese government has launched an ambitious agenda to tackle the country's environmental problems. Firstly, it adopted ambitious targets to reduce pollution and energy consumption in recent Five-Year-Plans (FYPs). Our sample period coincides with the 10th and the 11th FYP. The 10th FYP covers the years 200 to 2005 and foresees the prevention and control of air pollution. It aims at reducing SO_2 emissions by 10 percent by the end of 2005 compared to 2000. Moreover, the 10th FYP specifies that soot emissions should be reduced by 9 percent and dust emissions by 17 percent. The Chinese government also seeks to reduce water pollution. COD discharge and ammonia nitrogen discharge were meant to decline by 10 percent. In addition, the 10th FYP includes a 10 percent reduction target for solid waste generation and aims to increase recycling to 50 percent of the solid waste generated.

The 11th FYP covers the years 2006-2010. Its air pollution target states that SO2 emissions should decline by 10 percent. In terms of water pollution, the 11th FYP foresees are reduction in water consumption per unit of industrial value added by 30 percent. Moreover, COD discharge is meant to decline by 10 percent. For solid waste, the goal is to recycle 60 percent of China's solid waste produced by 2010. A novel feature in the 11th Five-Year Plan is the target to reduce energy consumption per unit of GDP by 20 percent.

Both the 10th and the 11th FYP suggests that the Chinese government aims at reducing air pollution, water pollution, the generation of solid waste was well as energy consumption per unit of GDP. Our analysis will thus investigate whether Chinese export taxes and VAT rebates reflect a second-best attempt of reducing the above-mentioned pollutants.

In addition to ambitious environmental targets, the Chinese government undertook substantial reforms of its administrative structure to give environmental protection a more prominent role in its political hierarchy. For one thing, the Chinese government started to incentivize local leaders to protect the environment by linking the measure for local officials' performance not only to economic growth but also to environmental achievements.

The increasing prominence of environmental issues in the Chinese policy agenda is reflected in its administrative structure. The State Environmental Protection Agency was elevated to the rank of a Ministry in 2008 and received a larger budget and more staff. Moreover, China set up a National Leading Group to Address Energy Saving, Emission Cutting and Climate Change. It is headed by the Premier and has thus got a high rank in the political hierarchy.

3.1.1 The Chinese pollution levy system

Even though China embraced ambitious attempts to protect the environment, the design of the pollution levy system and difficulties with the enforcement of the regulations might hamper its effort to reduce production generated pollution.

China's regulations foresee levies for 29 water pollutants, 22 air pollutants, solid and radioactive waste as well as noise pollution (Wang and Wheeler, 2005, p.117). According to Wang and Wheeler (2005), the levies reflect a range of concerns, including human health considerations, natural resource degradation and economic losses due to pollution.

However, the pollution levies differ considerably from a Pigovian pollution tax. According to Article 18 of China's environmental protection law, pollution charges are levied based on the quantity and concentration of the pollutant, but only if pollution exceeds discharge standards (Dasgupta et al., 1997). If a firm's pollution emissions do not comply with these standards, the firm is required to pay pollution levies, which escalate with the extent to which the emissions do not satisfy the standard.[1]

The firm only pays a levy for one pollutant. The regulator calculates the potential levy for all pollutants emitted by the firm. The highest of these potential levies is the actual levy the polluting firm has to pay. We conclude that there is a marked difference between the Chinese pollution levies and a Pivogian pollution tax.

3.1.2 Responsibility of local and national authorities

The implementation and enforcement of environmental regulation is decentralized to a large extent in China. The national authority (the State Environmental Protection Agency, SEPA) specifies emissions by sector and emission fees by pollutant (Wang and Wheeler, 2003). The implementation of environmental regulation and the collection of levies is in the hands of provincial and municipal authorities (Dasgupta et al., 2001). Given the permission of the State Environmental Protection Agency, local authorities can

[1] In the 1990s, the Chinese government also introduced low levies of 0.05 yuan waste water emissions for which satisfy the standards. Moreover, within-standard levies for SO2 were introduced in 1996(Wang and Wheeler, 2005, p.179).

raise the discharge standards and the pollution fees. This implies that pollution levies vary considerably across regions and across industries.

As a matter of fact, the enforcement of pollution regulations is at the discretion of local authorities. After appropriate inspections, local regulators can reduce the pollution levy or waive fees. Moreover, there is ample anecdotal evidence that local Environmental Protection Bureaus who are responsible for the collection of levies, negotiate the levy payments with firms. If local leaders consider a certain company important for the local economy, Environmental Protection Bureaus are often impeded from collecting the levies (OECD, 2005; Wang and Wheeler, 2003). Dasgupta et al. (1997) show that the strictness of enforcement may vary across plants. The authors argue that regulators have discretion in identifying firms as compliant and determining the effective levy the firms have to pay.

Even if the pollution regulation is enforced and levies are collected, environmental policy can only be effective if it induces producers to reduce their pollution. However, the empirical evidence on the deterrent effect of pollution regulation is mixed.

Wang et al. (2003) use Chinese province level data on water pollution for the year 1987 to 1995 and come to the conclusion that a higher effective pollution levy significantly reduces pollution intensities. Wang and Wheeler (2005) corroborate the finding of a significant deterrent effect of effective pollution levies on SO_2 and COD. Dust emissions, however, are not significantly affected by the pollution levy. The work by Dasgupta et al. (2001) on the other hand finds that effective pollution levies do not deter emissions, but that enforcement (i.e. monitoring) is the crucial element to reduce pollution emissions. Finally, Cole et al. (2008) show that neither formal nor informal regulation have a deterrent effect on industry level emissions. Measures for formal regulation are the number of pollution related prosecutions in a region relative to industry output as well as regional unemployment. Informal regulation is measured by the age structure, the level of education and population density. None of the measures for regulation has a statistically significant effect on industry level emissions.

The substantial leeway that local government have in implementing and enforcing the regulation, the design of the levy system as well as a questionable deterrent effect of the pollution levies make it difficult for the central government to adopt stricter environmental policies. Hence, trade policy might be a second-best option to reduce domestic pollution in China.

3.2 Policy background: Export value-added tax rebates

China has undertaken several adjustments to its value-added tax rebates in recent years. This section provides some policy background on Chinese VAT rebates and explains the effect of changes in export VAT rebates on exports.

Most countries levy value added taxes. It is common practice to exempt exporters from VAT payments and refund the VAT that exporters paid for their intermediate inputs. In China, exporters only get partial VAT rebates. Since the mid 2000s, the Chinese government has adjusted VAT rebate rates on a frequent basis. The Chinese government quotes environmental protection as a main motivation for these adjustments. According to the Communication on China's Policies and Action for Addressing Climate Change[2] these VAT rebate adjustments are geared towards reducing energy intensive and polluting exports and can be considered part of China's climate policy. However, environmental concerns were not the only motive for the VAT rebate rate adjustment. The reforms were also meant to serve China's development strategy and foster the production of high-tech and high-value added exports (Wang et al., 2010).

Partial export VAT rebates have similar effects as export taxes if the export destination levies VATs on its imports (Feldstein and Krugman, 1990). This is due to the double taxation exporters are exposed to under partial VAT rebates. Most countries adopted the destination principle, meaning that the export destination levies a VAT on the imported good and exporters get a full VAT refund in the country of origin. If the VAT in the country of origin is not rebated, then producers face double taxation since they are taxed both at the country of origin and at the export destination. The partial refund is a comparative disadvantage for Chinese producers compared to producers from countries which receive a full refund on the VAT for intermediate inputs. The lower the rebate rate, the higher the double taxation of exporters. Hence, a reduction in the VAT rebate rate has a similar effect as an increase in the export tax.

This theoretical prediction is supported by empirical evidence, which shows that partial export VAT rebates curb exports. Desai and Hines (2005)'s empirical analysis gives tentative support to the notion that partial VAT rebates curb exports. Using a panel dataset which covers 168 countries and spans the years 1950 to 2000, the authors find that exports are 12% lower in countries which use VATs. The reduction in exports due to VATs is larger in low-income countries than in high-income countries. One possible explanation for this phenomenon is that low income countries only give partial VAT rebates. However, Desai and Hines (2005) do not explicitly analyse this hypothesis.

Several studies have analysed the effect of Chinese export tax rebates and export VAT rebates on export performance at a fairly aggregate level (Chao et al., 2001; Chen et al., 2006; Chao et al., 2006). All of these studies find that higher export VAT rebates increase exports. Moreover, Chandra and Long (2013) estimate the effect of a reduction in VAT rebates on exports using firm level data from the Annual Report of Industrial Enterprise Statistics covering the years 2000 to 2006. Their findings suggest a large effect of VAT rebate rates on exports. An increase in the actual VAT rebate rate by one percentage point is estimated to raise exports by 13%.

Since there is ample theoretical and empirical evidence that partial VAT rebates have similar effects as export taxes, this paper will analyse the difference between the VAT and the VAT rebates as if it was an export tax.

[2] Information Office of the State Council of the People's Republic of China (2008)

3.3 Policy background: Export taxes

In its Accession Protocol to the WTO, China agreed to levy export taxes on no more than 84 product lines and the export taxes were not allowed to exceed a certain threshold. This threshold ranges between 20% and 40%, depending on the product.

In practice, China introduced export taxes on far more products since 2007. The first row in Table 1 shows that only 29 products at the HS8 digit level in our sample were subject to an export tax in 2006. In 2009, the government levied export taxes on 235 products in our sample. Some of the export taxes which were introduced since 2007 were introduced as temporary export taxes. However, they have been in place for several years.

Table 1: Products with export taxes

	(1) 2005	(2) 2006	(3) 2007	(4) 2008	(5) 2009
Number of products with export tax > 0	29	39	129	255	235
Average export tax	0.122	0.151	0.339	0.714	0.745
Average export tax | export tax > 0	18.107	17.451	13.113	14.220	15.909

The largest group of products for which the export tax exceed the level allowed under the WTO commitments are iron and steel products. Moreover, China's temporary export taxes exceed the WTO allowance for a range of metal products,[3] for wood products,[4] mineral products,[5] some inorganic chemical products,[6] as well as fertilizers[7]. Ex ante, the introduction of temporary export taxes on minerals and metal products seems to be in line with the Chinese government's goal to reduce exports of resource-intensive products from 2007 on.

4 Second-best export taxes as environmental policy

China seems determined to reduce its emissions but struggles to enforce pollution regulations to internalise the environmental distortion. Under these circumstances, an export tax can be used as a second-best environmental policy instrument.

In this section we derive a formula for the second-best export tax based on an extension of Copeland (1994)'s analysis to the large country case. In the model, a perfectly competitive large open economy produces or consumes $N_g + 1$ goods. Good 0 is the numeraire. Production and consumption of good 0 are denoted by y_0 and c_0. The vectors y and c represent production and consumption of all other N_g goods.

[3]The metal products for which China levies export taxes are in HS categories 72, 73, 74, 75, 79, 80 and 81

[4]Wood products in HS categories 44 an 47

[5]from HS categories 25 to 27

[6]HS category 28

[7]HS category 31

Production of all non-numeraire goods causes domestic pollution z. Pollution reduces the consumer's utility but does not affect the productivity in other sectors. The model considers N_p different pollutants. Firms face pollution taxes s per unit of pollution.

The government levies export taxes for all non-numeraire goods. These export taxes are represented by the vector t. The world market and domestic price vectors for the non-numeraire goods are denoted by p and $q = p - t$. There is no export tax for the numeraire. Hence, both the domestic and the world market price for the numeraire equal 1.

The representative consumer's utility is a function of consumption and of the public bad pollution $u(c_0, c, z)$. We assume that the utility function is well-behaved in the sense that it is continuous, locally unsatiated and strictly convex. The utility can be represented by the expenditure function $E(1, q, z, u)$. The expenditure function is concave and non-decreasing in q and increasing in z and u. By Shephard's lemma, $E_q = \partial E / \partial q'$ is the compensated demand vector. Throughout this section, subscripts denote partial derivatives. $E_z = \partial E / \partial z'$ represents the marginal willingness to pay for a one unit reduction in pollution. In other words, E_z is the marginal damage caused by pollution.

Following Copeland (1994), the production side of the economy is represented by the aggregate revenue or GNP function. Firms maximize their profits, taking the pollution tax s and the prices q as given. The profit maximizing behaviour of the individual firms also maximizes GNP less the pollution tax. Hence, the private sector implicitly solves the problem

$$G(1, q, s, v) = \max_{y,z} \{ y_0 + q'y - s'z \quad s.t. \ (y_0, y, z) \in T(v) \} \tag{4.1}$$

where the prime ($'$) denotes a transpose. v is the endowment of the economy and $T(v)$ is the technology set. The constraint ensures that output is in the technology set. Based on the envelope theorem, $y = G_q = \partial G / \partial q$ and $z = -G_s = -\partial G / \partial s$.

The world in this model consists of China and the rest of the world. China is modelled as a large country. The benevolent Chinese regulator unilaterally chooses the optimal combination of policy instruments in response to local pollution and in order to manipulate the terms of trade.

Our analysis considers unilateral changes in trade and environmental policy. We assume that the rest of the world does not adjust its trade and environmental policy in reaction to changes in Chinese trade and environmental policy. This assumption is not unreasonable if the rest of the world consists of many small countries which do not coordinate their policy.

The goods market equilibrium is characterized by the following equation

$$- E_q(1, q, z, u) + G_q(1, q, s, v) - E^*_p(1, p) + G^*_p(1, p) = 0_N \tag{4.2}$$

where E^* and G^* denote foreign compensated demand and foreign production respectively. Since we abstract from the foreign policy process, foreign production and consumption are functions of the world market price, but not of the Chinese policy variables.

Assuming that the pollution taxes are rebated to the consumer, the equilibrium in the economy is characterized by the following four equations

$$E(1,q,z,u) = G(1,q,s,v) + s'z + t'X \tag{4.3}$$

$$X = G_q(1,q,s,v) - E_q(1,q,z,u) \tag{4.4}$$

$$z = -G_s \tag{4.5}$$

$$-E_q(1,q,z,u) + G_q(1,q,s,v) - E^*_p(1,p) + G^*_p(1,p) = 0_N \tag{4.6}$$

The variable X in Equations 4.3 and 4.4 represents the net export vector which equals output (G_q) minus compensated demand (E_q). Equation 4.5 pins down the equilibrium pollution level in the economy. Equation 4.3 is like a budget constraint for the economy. It states that consumer expenditure equals GNP plus the rebated pollution tax and export tax income. If the economy-wide budget constraint is satisfied, trade is balanced. Equation 4.3 does not allow for a trade deficit or surplus. Equation 4.6 repeats the goods market equilibrium.

We use these equilibrium conditions to solve for the second-best export tax, which is the export tax that yields the highest level of utility u, given that the environmental policy cannot be altered. A change in welfare is measured by $E_u du$.

Totally differentiating Equation 4.3 and using the total differential of Equations 4.4, 4.5 and 4.6 allows us to solve for the second-best export tax as [8]

$$t^{*'} = \underbrace{-M^{*'}(M^*_p)^{-1}}_{\text{Terms of trade}} + \underbrace{(E'_z - s')\frac{\partial z}{\partial q}(X_q - E_{qz}\frac{\partial z}{\partial q})^{-1}}_{\text{Environmental motive}} \tag{4.7}$$

where t^* is the vector of second-best export taxes, $M^* = E^*_p(1,p) - G^*_p(1,p)$ is the vector of foreign imports and M^*_p is the matrix of derivatives of foreign import demand with respect to the world market price p. $\frac{\partial z}{\partial q}$ is a matrix of pollution intensities. The element X_{ij} of the matrix $X_q = G_{qq} - E_{qq}$ captures the change in export supply of good i as the domestic price q_j changes. The matrix X_q is positive semidefinite.[9]

The second-best export tax features a terms of trade motive and an environmental motive. The terms of trade motive captures the incentive to introduce an export tax in order to reduce the supply of the good on the world market. As long as the country is a large supplier on the world market, this drives up the world market price and allows the country to get a higher price for its exports. The terms of trade motive equals the inverse of the foreign elasticity of import demand.

[8]Note that we assume that all income effects attached to the numeraire, i.e. that $E_{qu} = 0$. A step-wise solution for the second-best export tax is available from the author upon request.

[9]With continuous, locally unsatiated and quasiconvex preferences, the matrix E_{qq} is symmetric and negative semidefinite (see e.g. Mas-Colell et al., 1995, p. 70-71). The matrix G_{qq} contains the price derivatives of output and is symmetric and positive semidefinite.

The environmental motive reflects the attempt to reduce pollution through the use of export taxes. The environmental motive is based on the notion that an export tax reduces the production of export goods. If the export tax is largest for the most pollution intensive good, the production of these goods declines more.

To be more precise about this concept, we follow Copeland (1994) and define good i as *pollution intensive in pollutant* k if an increase in the price of good i raises the emissions of pollutant k, i.e. if $dz_k/dq_i > 0$. An increase in the price of good i leads to an expansion of industry i, drawing resources from other industries. If the expanding industry emits more of pollutant k at the margin, than the contracting part of the economy, industry i is pollution intensive with respect to pollutant k.

In what follows we assume that compensated demand for good i, E_{q_i}, is independent of pollution, i.e. $\frac{\partial E_{q_i}}{\partial z_k} = 0$. Moreover, we assume that the matrix X_q is invertible. This implies that X_q is positive definite. If we look at a situation in which all cross-price derivatives of export supply are identical, it is easy to see that the second-best export tax in formula 4.7 increases in a product's pollution intensity as long as the domestic pollution tax does not internalise the environmental distortion, i.e. in the case in which the pollution tax is lower than marginal damage.[10]

The environmental motive is based on the notion that an export tax reduces the production of a good for exportation. If the export tax is largest for the most pollution intensive good, the production of the pollution intensive good declines.[11] The resources that are set free in the polluting sectors are allocated to the production of cleaner goods. This way, the pollution intensity of production in the economy declines.

As production does not only generate one type of pollution, the export tax should target a weighted average of all pollutants k. If the government only levies export taxes based on the pollution intensity of one type of pollutant (e.g. SO_2) then the resources might shift in the production of goods which cause another type of pollution which is even more damaging. Hence, the export tax should be larger the higher the weighted average of all the pollution intensities that are generated during production. This weighted average should take those pollutants into consideration for which the domestic pollution policy cannot internalize the environmental distortion. This is the case if the pollution tax is lower than marginal damage. Hence, we only expect a positive relationship between the export tax and the pollution intensity if the pollution tax is lower than marginal damage.

5 Empirical strategy

5.1 Estimating Equation

In 2007, China's National Development and Reform Commission stated that the adjustments of VAT rebate rates aims at controlling "exports of energy-intensive, pollution-

[10] This is due to the fact that the matrix X_q is positive definite.
[11] Assuming a symmetric response to price changes.

intensive and resource-intensive products, so as to formulate an import and export structure favorable to promote a cleaner and optimal energy mix" (NDRC, 2007, p.31). According to the WTO trade policy report (WTO, 2008, p. 73-74) China claims that not only the VAT rebate rates but also the export taxes are set with environmental goals in mind.

Our empirical analysis tries to reveal whether, in practice, export taxes and export VAT rebates reflect an attempt to protect the environment.If the export taxes are motivated by environmental concerns, or in other words, if the export tax is a secondary pollution policy, then the relationship between the export tax and a product's pollution intensity is described by equation 4.7.

The prediction that the second-best export tax increases in a product's pollution intensity guides our empirical analysis. Based on equation 4.7, the estimating equation is

$$y_{it} = \alpha_0 + \alpha_1 TOT_{it} + \sum_k \beta_k Reg\_gap_{itk} * pol\_int_{itk} + Controls_{it} + \varepsilon_{it} \quad (5.1)$$

where the dependent variable y_{it} is the export tax for product i at time t or its equivalent. As we will explain below, we look at three different dependent variables: the export tax, the VAT tax and the overall export tax, which we will define below. The variable TOT_{it} in Eqution 5.1 is the terms of trade motive to manipulate the VAT tax for good i, Reg_gap_{itk} is the regulatory gap or the difference between marginal damage and the pollution tax for pollutant k at time t, pol_int_{itk} represents the overall pollution intensity of exports with respect to pollutant k and ε_{it} is the idiosyncratic error term.

The VAT tax is defined as

$$VATtax_i = VAT\ rate_i - export\ VAT\ rebate\ rate_i. \quad (5.2)$$

We use the VAT tax as dependent variable, since an analysis of the VAT rebate rate itself is not informative due to differences in the value-added tax across products. It amounts to 17% for most goods and 13% for some agricultural products. A small range of products is not subject to a VAT. A VAT rebate of 5% generates a lower burden for an exporter whose final product is subject to a VAT of 13% rather than 17%. In order to asses the burden of the partial VAT rebate policy on producers, we also need information on VATs. The dependent variable in our regression is, thus, the difference between the VAT and the export VAT rebate for product i.[12] The VAT tax captures the export tax equivalent of partial VAT rebates. Due to the double taxation of exports, a lower VAT rebate rate or a higher VAT tax hamper exports.

In addition to the export tax and the VAT tax, we can look at the overall tax that is levied on exports of a particular product. We add up the export tax and the VAT tax to generate a variable called *Overall export tax*

[12] The VAT rebate rule the applies to most products can be summarized by the following formula (Chan, 2008): *VAT rebate= input VAT - (value of export sale - value of bonded materials)*(VAT rate - rebate rate)*. This implies that the appropriate VAT rate to use is the VAT rate for the export product itself and not the VAT rate that applies to intermediate inputs.

$$Overall\ export\ tax_i = VAT\ tax_i + export\ tax_i. \tag{5.3}$$

Looking at the overall export tax brings us closest to the predictions of the theoretical model. The theoretical model does not distinguish between the actual export tax and the partial VAT rebate. It highlights that the overall export tax should be largest for industries which are most pollution intensive in a particular pollutant if the regulator uses trade policy as a second-best pollution policy. This relationship holds as long as the gap between marginal damage and the pollution tax is positive for the respective pollutant.

Equation 4.7 highlights that the export tax or the VAT tax is a weighted average of the pollution intensities of product i. However, the NDRC's announcement does not tell us which pollutants the Chinese government targets with its policy. In order to gauge which pollutants play a prominent role in China's environmental agenda, we refer to the environmental section of the Chinese Five Year Plan (FYP). The Chinese FYP specifies China's goals and priorities in environmental protection and sets out specific pollution reduction targets for major pollutants. We expect that the set of pollutants K which determine the VAT tax is similar to the set of pollutants for which the government specifies emission reduction targets in the FYP.

The relevant FYPs for our sample period are the 10th FYP for the years 2000 to 2005 and the 11th FYP for 2006 to 2010. According to the FYPs, the Chinese government foresees reductions in waste water, COD, ammonium nitrogen, soot, SO_2 and dust emissions as well energy use per unit of GDP (see Section 3.1). Moreover, China aims at reducing the amount of solid waste generated and at increasing the ratio of solid waste that is recycled. This reveals that the Chinese regulator's objective function puts weight on the above-mentioned pollutants and suggests that our analysis focuses on precisely those pollution indicators. We will investigate the relationship between the VAT tax (or the export tax) and all of the above-mentioned pollution indicators except dust since there are too many missing observations for dust emissions.

When we analyse the relationship between trade policy and pollution intensity of exports, we are interested in the overall pollution generated during all stages of the production process taking place within China. For example the export tax for leather shoes should be based on the overall pollution content of leather shoes. This includes the direct pollution generated during the assembly of leather shoes as well as the indirect pollution generated during the production of leather, but only if the leather is produced within China. In order to obtain the overall pollution content of exports, it is necessary to use input-output analysis. This allows us to capture the pollution embodied in the entire production process. The precise construction of overall pollution intensities is described in Section 6. The overall pollution intensity is measured as the overall pollution generated by an industry relative to the industry's output.

The theoretical model predicts that a higher pollution intensity has a stronger effect on the export tax if the gap between marginal damage and the pollution intensity is larger.

Hence, we have to interact a measure for the pollution intensity with a measure for the gap between marginal damage and the pollution tax.

We measure the regulatory gap or the gap between marginal damage and the pollution intensity as the share of the pollutant not meeting discharge standards.[13] This is based on the notion that the national authority can set discharge standards such that they internalize marginal damage. The enforcement is left to local authorities. As argued in Section 3.1.1, local regulators can waive pollution levies or negotiate the levies with firms. If the local enforcement is lax, firms have few incentives to satisfy discharge standards. Hence, a low ratio of emissions meeting discharge standards means that regulation is ineffective since it does not have a strong deterrent effect on emissions.

However, information on the ratio of a pollutant meeting discharge standards is only available for waste water, soot and SO_2 emission intensities. For the remainder of the pollutants, we do not have any information about the gap between marginal damage and the pollution intensity. However, as mentioned above, the Five-Year-Plans for the years 2000 to 2010 foresee reductions in the emissions of all pollutants in our analysis. The fact that the government intends to reduce emissions and set targets for emission reductions indicates that the emissions are above the social optimum, which is equivalent to a situation in which the pollution tax is too lax.

With the pollution tax not internalizing the distortion to the desired extent, we would expect to see a positive relationship between the pollution intensity and the dependent variable y. In other words, we expect the coefficient β_k in Equation 5.1 to be positive. A coefficient estimate β_k that is negative or not statistically significantly different from zero, would indicate the trade policy instrument that is analysed is not determined by an attempt to reduce emissions of pollutant k.

If all the coefficient estimates β_k are jointly equal to zero, we could infer that the VAT rebate reform is not driven by environmental concerns. We use an F-test to test for this hypothesis.

Our analysis draws on cross-sectional variation. This is in line with the results derived Section 4. Equation 4.7 demonstrates that the second-best export tax is higher for goods which are more pollution intensive at a particular point in time. A comparison of export tax and pollution intensities between goods at a particular moment in time requires a cross-sectional analysis. The panel nature of our dataset would allow us to use fixed effects estimation to control for time-invariant unobserved factors which determine the VAT rebates. However, with fixed effects estimators, the identification comes from the variation within products (or industries) across time. Fixed effects estimation discards the cross sectional variation and is thus not suitable for the purpose of our analysis.

The fact that we have observations for several years is still expedient, since it allows us to verify whether there was a policy change in 2007. As mentioned before, the Chinese government announced that it uses export taxes and export VAT rebates to reduce exports

[13]Note that this measure varies at the industry level.

of energy-intensive and polluting good as well as resources in the year 2007. Similar statements were made in 2008 and 2009 (see e.g. Wang et al., 2010). Hence, we would expect coefficient estimates $\hat{\beta}_k$ for the pollution intensities to be positive in a sample including observation for the years 2007 to 2009.

If the VAT rebates and export tax adjustments from 2007 onwards were motivated by an attempt to reduce emissions of a particular pollutant k, we would expect the magnitude of the coefficient estimate $\hat{\beta}_k$ to increase in sample containing observations for the years 2007 to 2009 compared to a sample containing observations for the years 2005 and 2006. We will thus run two cross-sectional regressions of equation 5.1, one for the sample spanning the years 2005 to 2006 and one for the sample spanning the years 2007 to 2009. Moreover, we will test for a statistically significant difference in the coefficient estimates between the two sample periods. Towards that end, we interact all of the independent variables in our model with a dummy variable that takes the value of 1 for all years after 2007. Let that dummy variable be denoted by D_{2007} and let $\mathbf{X_{it}}$ denote the vector of independent variables. The vector $\mathbf{X_{it}}$ contains the pollution intensities, the resource dummy variables and the control variables. In order to test for statistically significant changes in the coefficient estimates, we estimate the model

$$y_{it} = \alpha_0 + \beta X_{it}' + \gamma(X_{it} * D_{2007})' + \delta_t + \epsilon_{it} \tag{5.4}$$

where β and γ are coefficient vectors and δ_t are year fixed effects. We use data for the entire sample period covering the years 2005 to 2009. A statistically significant coefficient estimate $\hat{\gamma}_l$ indicates that there is a change in the relationship between the explanatory variable X_l and the dependent variable y before 2007 and from 2007 on.

If the coefficient estimate $\hat{\gamma}_k$ for the pollution intensity with respect to pollutant k is statistically significant and positive, this means that an increase in the pollution intensity of a particular pollutant k is associated with a larger increase in the overall export tax after 2007. This would suggest that the export tax or the VAT tax was adjusted to discourage pollution intensive production.

The dependent variable in our model varies at the product level. However, data on pollution intensities are only observed at the industry level. In order to take account of the fact that our main explanatory variable varies at a higher level of aggregation, we cluster the standard errors at the industry level.

The second-best export tax or VAT tax in Equation 5.1 features an environmental component as well as the terms of trade motive. This terms of trade motive depends on the foreign elasticity of import demand and is very difficult to measure. However, the terms of trade motive reflects China's market size on the world market and is thus reflected in China's share in global exports. We use a categorical variable that takes the value of 0 if China's exports relative to global exports are less than 5 percent. In this case, China can be considered a small exporter and the terms of trade motive would be close to zero. This category contains 40 percent of the observations in our sample. Our dummy variable takes the value of 1 if China exports between 5 and 15 percent of global exports. About 30 percent of the observations in our sample fall into this category. If China's share in global exports exceeds 15 percent, the categorical variable takes the value of 2. A higher value of the categorical variable thus reflects a larger terms-of-trade motive. Since the second-best export tax increases in the terms of trade motive, we expect the coefficient estimate α_1 in Equation 5.1 to be positive.

5.2 Control Variables

When we investigate the effect of the pollution intensity (interacted with the regulatory gap) on the export tax or the VAT tax in a cross-sectional analysis, we have to control for all other determinants of the export tax or the VAT tax which are correlated with the pollution intensity or the regulatory gap. This section explains the choice of our control variables.

According to the NDRC, the VAT rebate adjustments are also geared towards reducing exports or resource-intensive products. In order to control for this aspect of policy setting, we introduce dummy variables that take the value of one, if a product is a resource good. We distinguish between four categories of resources: mineral products, wood products, precious stones and metal products. The resource dummy variables are constructed based on the HS classification. The dummy variable *natural mineral* takes the value of one for all products in the HS 2 digit categories 25 to 28. The range of products in these categories includes ores, mineral fuels and oil as well as rare earths. The dummy variable *wood* takes the value of 1 for all wood products, articles of wood and wood charcoal (HS 2 digit code 44). *Stones* is a dummy variable for all products in the HS2 digit category 71. This includes precious metals, precious stones, pearls and jewellery. The dummy variable *metal* takes a value of 1 for all metal products in the HS2 digit categories 72 to 81, including iron and steel, copper, aluminium, lead, zinc, tin and articles thereof. We expect a positive relationship between the VAT tax or the export tax and the resource dummy variables if the trade policy reforms are a substitute for resource conservation.

Our model assumes that the government acts as a welfare maximizer. However, this assumption might be to restrictive in the real world. The literature on the political economy of protection highlights alternative motives that can drive the government's choice of trade policy.

The theories in the literature on the political economy of protection that are most closely related to the notion of a welfare-maximizing regulator in our model are the theories which suggest that the government has social concerns in mind when it sets trade policy. Social considerations might be particularly important in China, since the Chinese government tries to maintain a certain level of social stability. This is reflected in recent attempt to build a "harmonious society" and reduce inequality within the country. One piece of work in the literature that links trade policy to social concerns is the paper by Corden (1974). In Corden (1974), the regulator has a conservative welfare function and grants protection to industries which suffer from adverse economic shocks. This would suggest that protection is larger, and hence the VAT tax or the export tax is lower, in industries in which output growth is lower. Hence, we control for output growth compared to the previous year.

A large literature argues that protection is granted in exchange for political support (e.g. Caves, 1976; Grossman and Helpman, 1994). The most prominent model in this literature is the 'protection for sale' model by Grossman and Helpman (1994), which assumes that industries lobby for protection if they manage to overcome a free-rider problem. Grossman and Helpman (1994)'s model has received considerable attention in the literature that analyses the determinants of trade policy in the U.S. However, none of the measures for lobbying power which are typically used in that literature is available for China. Moreover, it is not obvious that the lobbying models can be applied to China, since lobbying is officially not allowed.

Even thought the Chinese government does not face any elections, we can still assume that it tries to gain popular support for its policies in order to consolidate its power. This is the reason why models like the adding machine model by Caves (1976) apply to China. According to the adding machine model, politicians protect industries which represent the largest number of voters. The model predicts a positive relationship between the number of employees in an industry and protection. In a similar vein, industries with a larger number of firms could receive higher protection. We control for both, the employees and the number of firms in an industry.

An important control variable is the share of state-owned enterprises in an industry, measured as the output value of SOEs relative to the output value in the industry. State-owned enterprises are likely to have links to the government which allow them to lobby for protection. Branstetter and Feenstra (2002) show that the Chinese government gave between four and seven times more weight to SOEs than to consumer welfare in the context of policies that facilitate foreign direct investment. This suggests that SOEs have a significant influence on government decisions which might also be reflected China's trade policy. Hence, it is likely that protection is higher in industries with more state-owned enterprises. We, thus, control for the output share of state owned enterprises in an industry.

In a similar vein, the Chinese government might try to grant foreign firms better treatment in order to enhance the investment climate in China. This would imply that industries with a higher share of foreign output get higher protection. Since foreign firms might use less polluting production technology, it is important to control for the output share of foreign firms. The output share of foreign firms is measured as the output value of foreign firm relative to the overall output value in an industry.

Several authors argue that protection should be higher in industries for which the country does not have does not have a comparative advantage (e.g. Ray, 1981a,b; Trefler, 1993). As a country with an abundant labour supply, China is traditionally associated with a comparative advantage in labour-intensive industries (Yue and Hua, 2002). Hence, we would expect the VAT tax or export tax to be higher in labour-intensive industries. We thus control for labour intensity which is constructed as the number of employees over fixed assets in an industry. If the government protects industries in which it does not have a comparative advantage, the protection could also be expected to be higher in export-intensive industries. The export intensity is measured as the value of exports relative to the output value.

The choice of the VAT rebate rate could also be driven by concerns about government revenue. Evenett et al. (2012) show that the expenses for VAT rebates constitute 8 to 10 percent of final government spending between 2007 and 2010. The theoretical model presented in Section 4 incorporates the revenue generated by the trade policy in the regulator's welfare maximization problem. Hence, there is no need to add a control for the government revenue if we implement Equation 5.1.

If the government is concerned about the effect of the policy on its budget, it might, however, take income taxes from firms into consideration. A higher VAT tax or export tax can be expected to lead to a contraction of the industry and reduce taxes that firms have to pay on their business. Hence, the government might set a lower VAT tax or export tax for industries which pay a higher tax on their principal business.

A complete list of the control variable used in the analysis as well as a variable definition and the expected sign of the coefficient estimates is available in Table 5.2.

6 The dataset

6.1 Trade policy data

Trade policy variables used for the analysis include VAT rebates, export taxes and import tariffs.

For the construction of the dependent variable VAT tax, we use data on VAT and VAT rebate rates at the product level (HS10 digit). The VAT data are from the China Customs homepage and from the Customs Import and Export Tariff of the People's Republic of China.

The VAT rebate data are obtained from the China Customs homepage, from the homepage of the State Administration of Taxation or from the Ministry of Finance. The rebate rates are available at the tariff line level, which is equivalent to the HS10 digit level. The China Customs homepage offers information on VAT rebate rates for all tariff lines for the years 2005 to 2006. From 2006 onwards, we only have information about changes in export VAT rebate rates. The information on rebate rate reforms is used to update the VAT rebate rate schedule for all tariff lines for the years 2007 to 2009. A list of reforms can be found in Table 10 in the Appendix.

However, in 2007 there was an international reclassification of the HS tariff lines. This also affects the Chinese tariff lines. To the best of our knowledge, there is no concordance

Table 2: Variable Definition

Variables	Description	Expected sign
VAT tax	VAT minus export VAT rebate	
Export tax	Defined as ordinary export tax or temporary export tax	
Overall export tax	export tax + VAT tax	
Mineral	Dummy variable that takes the value of 1 if a product is a mineral product and classified in the HS2 digit codes 25 to 27.	+
Wood	Dummy variable that takes the value of 1 if a product is wood product and classified in the HS2 digit code 44.	+
Stones	Dummy variable that takes the value of 1 if a product is wood product and classified in the HS2 digit code 71.	+
Metal	Dummy variable that takes the value of 1 if a product is wood product and classified in the HS2 digit codes 72 to 81.	+
Water Int	Overall waste water intensity (tons/ million yuan output. The output value is deflated using the manufacturing producer price index)	+
COD Int	Overall COD intensity (tons/ million yuan output)	+
Ammonium N. Int	Overall Ammonium Nitrogen Intensity (tons/ million yuan output)	+
Soot Reg_gap*Int	Ratio of soot emissions not meeting discharge standards*Overall soot emissions (tons/million yuan output)	+
SO2 Reg_gap*Int	Ratio of SO2 emissions not meeting discharge standards*Overall SO2 intensity (tons/million yuan output)	+
Waste Int	Overall waste intensity (tons/million yuan output)	+
Recycling Ratio	Overall solid waste utilized/overall solid waste generated	-
Energy Int	Overall energy intensity (tons of SCE/million yuan output)	+
Exp share	Categorical variable, 0 if China's export relative to global exports are less than 5 percent, 1 (2) if China's export share is between 5 and 15 percent (larger than 15 percent)	+
Employees	Employees (in millions)	-
Firm No	Number of firms in the industry (in thousands)	-
Profits	Industry profits (in billion yuan)	-
Δ Output	Output growth compared to the previous year	+
Labour Intensity	Employees/ million Fixed assets in the industry	+
Export Intensity	Exports in an industry/Industry output	+
SOE share	Output share of state-owned enterprises	-
Foreign share	Output share of foreign enterprises	-
Business tax	Taxes and other charges on principal business (billion yuan)	-
Tariff	Applied MFN Tariff	?

table at the 8 or 10 digit level that relates Chinese tariff lines prior to 2007 to tariff lines from 2007 on. Concordance tables only exist at the 6 digit level. Since we cannot link the tariff lines prior and after the reclassification, we only use the VAT rebate rates for tariff lines which were not affected by the reclassification. Since the HS reclassification at the HS6 digit level is undertaken by the World Customs Organization and not by the Chinese government itself, the fact the we do not observe the tariff lines for sectors which were affected by the reclassification should not introduce any systematic bias.

Information on export taxes at the product level (HS10 or HS11) for the years 2005 to 2007 is available on the China Customs homepage. The homepage of the Ministry of Finance provides export tax data at the HS8 digit level for the years 2008 to 2009.

During our sample period there are different kinds of export taxes: ordinary export taxes and a temporary export taxes, which are changed more frequently. The ordinary export tax applies as long as there is no temporary export tax. Our variable export tax is thus defined as the ordinary export tax. If a temporary export tax is implemented, the variable "export tax" takes the value of the temporary export tax.

Data on import tariffs are obtained from the WITS TRAINS database. We use the information on applied most favoured nation (MFN) tariffs. The TRAINS data are available at the HS8 digit level. Prior to 2007, the MFN tariff data are provided in the HS2002 classification. The data for the year 2007 to 2009 are in the new HS2007 classification. As for the rebate rates, we only use information on the tariff lines that are not affected by the reclassification and exist throughout the sample period.

6.2 Environmental data

The China Statistical Yearbook on Environment provides information on water pollution, air pollution and solid waste at the industry level. Data on energy consumption at the industry level are available in the China Statistical Yearbook. The Chinese industry level data distinguish between 40 industry sectors. These sectors include mining, manufacturing as well as production and supply of electricity, gas and water. However, there is no trade in the sectors *Production and Supply of Gas* and *Production and Supply of Water*. Hence, these sectors do not appear in our analysis. A list of industries in our dataset in available in the appendix in Table 10.

While the data provide information on the *level* of pollution in a particular industry, we are interested in pollution *intensities*. To obtain the pollution intensities, we scale emissions by the output value of a sector in a given year. The information for the output value at the industry level is available in the Industry chapter of the China Statistical Yearbook.[14]

As suggested in section 5, it is necessary to work with the pollution embodied in China's exports rather than the pollution generated by each industry sector. The pollution

[14]The industry chapter reports the output value for all state-owned enterprises for non-state-owned industrial enterprises with a revenue of more than 5 mio yuan.

intensity of China's exports can be obtained using input-output analysis.

Input-output analysis makes use of the condition that supply of N goods $X_{[Nx1]}$ equals the demand for those N goods.[15] The demand can be expressed as $A_{[NxN]}X_{[Nx1]} + Y_{[Nx1]}$ where A is the matrix of input coefficients a_{ij}. The input coefficients represent the inputs of commodity i needed to produce commodity j. AX is the amount of goods at are used as intermediate inputs for production and Y is final demand. Supply equals demand if

$$X = AX + Y \tag{6.1}$$

Solving $X = AX + Y$ for X, we get

$$X = (I - A)^{-1}Y \tag{6.2}$$

where $(I - A)^{-1}$ is the Leontief inverse. The element c_{ij} of the Leontief inverse represents the amount of units of input i which is needed for the production of output good j. The Leontief matrix captures both the direct input requirements A and the indirect input requirements $(I - A)^{-1} - A$.

Final demand Y can be decomposed into domestic consumption Y^D, imports Y^M and exports Y^X.

$$Y = Y^D + Y^M + Y^X. \tag{6.3}$$

For the purpose of our analysis, we are interested in the change in domestic output due to a change in exports, which is equivalent to a change in the final demand Y. Expressing the change in output as a function of a change in final demand, we obtain

$$\Delta X = (I - A)^{-1}\Delta Y \tag{6.4}$$

This tells us that a change in exports (or final demand) requires $(I - A)^{-1}$ additional units of domestic output.

We are interested in the additional overall pollution generated as exports increase. To obtain the overall pollution intensities, we make use of an emission matrix $E_{[MxN]}$ whose elements e_{ki} denote emissions of pollutant k caused during production of one unit value of good i. Hence the matrix E is the matrix of emission intensities.

Multiplying equation 6.2 with the matrix of emission intensities, the emissions generated during production are related to the emissions embodied in exports through the following relationship:

$$EX = E(I - A)^{-1}Y \tag{6.5}$$

The matrix $E(I - A)^{-1}$ represents the overall pollution intensity. Its elements tell us how much additional pollution is generated for an additional unit of final demand (which includes exports).

In order to obtain the overall pollution intensity, we need the direct pollution intensity

[15] See e.g. Milner and Xu (2009) for an explanation of input output analysis using Chinese data.

E and the Leontief inverse $(I - A)^{-1}$. The direct pollution intensities in the matrix E are obtained by dividing the pollution emissions of a sector by the value of output. The Leontief inverse can be derived using the Chinese input-output (IO) table. We use the most disaggregated Chinese input-output table which contains 135 sectors ranging from agriculture and manufacturing to services. The disaggregated input-output tables are only produced every 5 years. We use the table for 2007.

Chinese IO tables treat all the imports as final deliveries. Since this is not in line with the real world experience, we follow Milner and Xu (2009) and use the import proportionality assumption.[16] We assume that imports and domestically produced goods within a sector are perfect substitutes and that the same proportion of the sector's output is used as intermediate input irrespective of whether the output is produced domestically or imported. In order to implement the import proportionality assumption we have to use an adjustment matrix. Let q_i be defined as $q_i = \frac{Gross\ Output_i}{Gross\ Output_i + Imports_i}$ where $Gross\ Output_i$ is the gross output of industry i and $Imports_i$ are the imports of industry i. The adjustment matrix D is a diagonal matrix with the values q_i on its diagonal. Using the adjustment matrix, the Leontief inverse is given by $(I - DA)^{-1}$.

The input-output table is slightly more disaggregated than the industry classification in the environmental data. Hence, it is necessary to aggregate the IO table to the industry level for which we have environmental data. Since we do not have data on pollution emissions in the agricultural sectors and service sectors, we aggregate all these sectors into one sector called *Other IO sectors*. The aggregation is undertaken using the basic IO table which specifies the value of output of sector i which is sold to sector j. Once the aggregation is complete, we calculate the input-output coefficients a_{ij}. The input-output coefficients denote the value of input sold from sector i to sector j as a fraction of the total cost of inputs in sector j. The matrix of input coefficients A is used to calculate the Leontief inverse $(I - DA)^{-1}$. The overall emission intensity is then obtained by multiplying the vector of direct emission intensities E with the Leontief inverse $(I - DA)^{-1}$. Since the input-output coefficients in *Other IO sectors* do not correspond to the emission intensities in *Other sectors* in the environmental data, we cannot use the coefficients related to *Other IO sectors*. Hence, we discard the last row and the last column of the Leontief inverse which relate the *Other IO sectors*. Moreover, we delete the pollution intensity of *Other sectors* in the vector of pollution intensities. This has to be taken into account when we interpret the overall pollution intensities (OPIs). The OPI represents the total pollution generated by a final product and all its manufacturing inputs. It does not include the pollution generated by intermediate outputs from agricultural and service sectors.

6.3 Industry level control variables

The information on the number of employees, the number of firms in an industry, output growth compared to the previous year, the output shares of SOEs and foreign firms,

[16] This assumption has also been used by Hummels et al. (2001) and Feenstra and Hanson (1999).

profits, the capital intensity and the income tax is from the industry chapter of the China Statistical Yearbook. The export intensity variable is constructed using data on the trade volume from the BACI trade database. Since the BACI trade data are denoted in US $, we use the average annual exchange rate from the China Statistical Yearbook to obtain the volume of exports in RMB. This export volume is divided by the output value.

6.4 Concordance tables

Our data set contains variables from different data sources at different levels of aggregation.

We aggregate the VAT, VAT rebate and the export tax data to the HS8 digit level and merge it with the tariff line data from the WITS. In order to merge the trade data and the environmental data, we use two concordance tables. The first concordance table links the HS8 digit tariff lines to the sectors in the Chinese Input-Output table for 2007. The concordance table is available in the appendix of the Chinese input output table for 2007. The second concordance table links the relevant sectors from the input-output table to the 40 industry sectors for which we have environmental data. The sectors of the Chinese input-output table approximately follow the Chinese industry classification GB/T4754-2002. Hence, the concordance table is constructed manually based on the subcategories of the description of the Chinese industry classification system.

7 Summary statistics

This section provides summary statistics for all trade policy variables, pollution intensities and the control variables. Table 3 provides means and standard deviations. Table 4 allows us to track the changes in the means of all variables over time.

Trade policy variables

The summary statistics in Table 3 show that the average difference between the VAT and the export VAT rebate (variable *VAT tax*) is 6.2%. The average VAT tax increases from 4.8% in 2004 to 8.4% in 2008 and falls to 6.4% in the aftermath of the economic and financial crisis (see Table 4).

The average export tax is only 0.36 percentage points. This small average export tax is due to the small number of products which are subject to an export tax. The first row in Table 1 shows that only 29 products at the HS8 digit level in our sample were subject to an export tax in 2006. In 2009, the government levied export taxes on 235 products in our sample.

The average export tax increases from 0.15 in 2005 to 0.74 in 2009. This increase in the average export tax is due to an increase in the scope of the export tax. The last row of Table 1 shows that the average export tax for products which are subject to a positive export tax falls from 26.3 in 2004 to 15.9 in 2009.

Table 3: Summary Statistics

	(1)			
	mean	sd	min	max
VAT tax	5.985	4.397	0	17
Export tax	0.363	2.767	0	40
Tariff	9.907	7.106	0	68
Water Int	2091.033	1754.792	139	15793
Water Stand_Rat	0.937	0.040	1	1
COD Int	0.452	0.694	0	7
Ammonium N. Int	0.032	0.036	0	0
Soot Int	0.618	0.425	0	4
Soot Stand_Rat	0.877	0.085	0	1
SO2 Int	1.532	0.817	0	12
SO2 Stand_Rat	0.853	0.081	0	1
Waste Int	145.818	146.706	15	2831
Recycling Ratio	0.608	0.097	0	1
Energy Int	160.224	75.317	14	444
Exp share (v)	0.908	0.847	0	2
Employees	2.909	1.806	0	7
Firm No	14.043	9.703	0	37
Profits	67.371	61.379	-100	460
Δ Output	1.261	0.179	1	4
Labour Intensity	11.970	8.486	1	46
Export Intensity	0.000	0.003	0	0
SOE share	0.212	0.211	0	1
Foreign share	0.292	0.144	0	1
Income tax	13.516	29.240	0	242
Output Value	13926.462	9929.211	80	44728
Observations	24957			

Table 4: Summary Statistics by Year: Mean

	(1) 2005	(2) 2006	(3) 2007	(4) 2008	(5) 2009
VAT tax	4.516	5.012	7.121	8.367	6.415
Export tax	0.122	0.151	0.339	0.714	0.745
Tariff	9.966	9.802	9.924	9.625	9.598
Water Int	2529.445	2113.334	1843.862	1590.979	1359.136
Water Stand_Rat	0.939	0.936	0.930	0.932	0.954
COD Int	0.595	0.470	0.378	0.291	0.240
Ammonium N. Int	0.054	0.033	0.022	0.017	0.014
Soot Int	0.873	0.650	0.486	0.367	0.292
Soot Stand_Rat	0.842	0.862	0.886	0.874	0.919
SO2 Int	1.947	1.653	1.344	1.109	0.920
SO2 Stand_Rat	0.795	0.833	0.853	0.886	0.900
Waste Int	161.718	145.647	138.218	127.951	118.015
Recycling Ratio	0.575	0.592	0.612	0.640	0.678
Energy Int	179.677	163.248	144.175	137.523	126.780
Exp share (v)	0.824	0.901	0.957	0.997	1.015
Employees	2.649	2.807	2.992	3.337	3.320
Firm No	11.494	12.820	14.337	18.079	18.405
Profits	39.081	50.524	80.514	84.852	116.255
Δ Output	1.394	1.266	1.291	1.262	1.091
Labour Intensity	13.746	12.571	11.544	10.312	8.923
Export Intensity	0.000	0.000	0.000	0.000	0.000
SOE share	0.229	0.210	0.198	0.184	0.175
Foreign share	0.303	0.303	0.302	0.289	0.266
Income tax	7.147	8.628	11.553	15.055	33.269
Output Value	9471.007	11883.921	15276.123	19216.244	20755.110
Observations	4165	4173	4176	4165	4122

Table 4 shows that the pollution intensity for all pollutants declines over the sample period. This is due to the fast output growth. In levels, waste water, solid waste increase slightly over the sample period. The average energy use in 2009 is 38 percent above the average energy use in 2005. COD, ammonium nitrogen, soot and SO_2 emissions peak at the beginning of the sample period and decline afterwards.

The average ratio of waste water meeting discharge standards (variable *Water Stand_Rat*) is 0.9. Since firms only pay water pollution levies if the waste water does not satisfy the standards, this means that only 10 percent of the waste water is subject to levies on average. The standard deviation of the ratio of waste water meeting discharge standards is small as there is little variation across time and across sectors. The compliance with the discharge standard regulation is high in all industries. At least 75% of the emissions generated by any industry at any point in time meet the discharge standards. Similarly, an average of 87% of all soot emissions and 85% of all SO_2 emissions satisfy the discharge standards.

The correlation Table 16 in the appendix gives a first impression of the correlation between the VAT tax, the export tax and the pollution intensities. The correlation between the VAT tax (or the export tax) and the pollution intensities should be positive, if the government uses the VAT tax (or the export tax) as a second-best policy instrument to reduce pollution. Table 16 demonstrates that the VAT tax is significantly positively correlated with the waste water intensity, the COD discharge intensity, the solid waste intensity, and the energy intensity.

The correlation coefficient between the export tax and most of the pollution intensities is negative. Only the solid waste intensity and the energy intensity are positively correlated with the export tax. However, the correlation between the export tax and the energy intensity is close to zero. Ex ante, there is little evidence that the Chinese government uses export taxes to reduce pollution.

8 Results

This section presents our empirical findings. Section 8.1 explains our findings for the determinants of the overall export tax. The results for regressions using the export tax and VAT tax as dependent variables are explained in Section 8.3 and Section 8.4 respectively.

8.1 Overall export tax as a dependent variable

Table 5 presents the results for a cross-sectional analysis of model 5.1 with the overall export tax as a dependent variable. Column 1 of Table 5 shows the relationship between the overall export tax and the pollution intensities as well as the control variables for the years 2005 to 2006. The relationship between the pollution intensities and the overall export tax from 2007 on is displayed in column 2 of Table 5. The third column of the

Table 5: Dependent variable: Overall export tax

	(1) 2005-2006	(2) 2007-2009	(2) Difference
Mineral	2.269∗∗∗	7.354∗∗∗	5.086∗∗∗
	(0.671)	(0.933)	(7.14)
Wood	4.092∗∗∗	6.022∗∗∗	1.931∗
	(0.414)	(1.297)	(1.71)
Stones	2.791	3.286∗∗∗	0.495
	(2.060)	(1.114)	(0.24)
Metal	2.850	8.034∗∗∗	5.184∗∗∗
	(2.140)	(2.660)	(3.84)
Water Reg_gap*Int	−0.001	0.013 ∗ ∗	0.013 ∗ ∗
	(0.004)	(0.006)	(2.13)
COD Int	2.015∗∗∗	−1.809	−3.825 ∗ ∗
	(0.521)	(1.499)	(−2.14)
Ammonium N. Int	−2.491	50.052	52.543∗
	(7.934)	(33.183)	((1.87)
Soot Reg_gap*Int	−1.827	−0.746	1.081
	(1.824)	(8.608)	(0.14)
SO2 Reg_gap*Int	0.372	1.176	0.804
	(0.658)	(2.441)	(0.32)
Waste Int	0.007∗∗∗	0.005 ∗ ∗	−0.002
	(0.001)	(0.002)	(−0.96)
Recycling Ratio	9.707∗∗∗	11.372∗∗∗	1.665
	(3.535)	(4.183)	(0.35)
Energy Int	−0.003	0.023∗	0.026∗∗∗
	(0.007)	(0.013)	(3.08)
Exp share (v)	−0.118	−0.427∗	−0.309
	(0.188)	(0.232)	(−1.45)
Employees	−0.039	−0.296	−0.257
	(0.153)	(0.318)	(−0.73)
Firm No	−0.088	−0.125 ∗ ∗	−0.036
	(0.056)	(0.053)	(−0.55)
Profits	0.006	0.001	−0.005
	(0.006)	(0.007)	(−0.81)
Δ Output	3.289∗∗∗	7.472	4.183
	(0.598)	(5.526)	(0.70)
Labour Intensity	0.004	0.035	0.031
	(0.023)	(0.068)	(0.60)
Export Intensity	−35.408 ∗ ∗	44.811	80.219
	(16.774)	(52.130)	(1.33)
SOE share	−4.535 ∗ ∗	−5.339 ∗ ∗	−0.804
	(1.818)	(2.610)	(−0.31)
Foreign share	−1.597	−2.550	−0.953
	(1.444)	(2.857)	(−0.37)
Income tax	0.040	0.011	−0.029
	(0.030)	(0.009)	(−0.96)
N	8297.000	12362.000	
r2	0.331	0.498	

Cluster robust standard errors in parentheses
* p<0.1, ** p<0.05, *** p<0.01

table indicates whether there is a statistically significant difference between the coefficient estimates for the 205-2006 sample and the coefficient estimates for the 2008-2009 model.

Column 1 of Table 5 shows that the overall export tax is not significantly related to the pollution intensity before 2007. However, the statistically significant positive coefficient estimate for Water Reg_gap*Int in Column 2 of Table 5 demonstrates that there is a positive relationship between the overall export tax and the overall waste water intensity (interacted with measure for the regulatory gap) from 2007 onwards. This is in line with our expectations, if the overall export tax is motivated by concerns about waste water discharges from 2007 on. The intuition is as follows: The overall export tax is higher for waste water intensive products, discouraging the export of these products. More resources are thus allocated to the production of less waste water intensive products. This reduces overall waste water discharge in the economy.

The coefficient estimate indicates that the overall export tax increases by 0.013 percentage points as the waste water intensity increases by 1 ton per million yuan output.

In order to asses whether the magnitude of the coefficient estimate is economically meaningful, we calculate the predicted change in the overall export tax that results from an increase in a product's pollution intensity with respect to pollutant k from the 25th percentile to the 75th percentile. This is equivalent to a multiplication of the coefficient estimate for k's pollution intensity with the difference between the 25th and the 75th percentile for k's pollution intensity. The predicted change in the overall export tax is displayed in column 1 of Table 6.

Table 6: Predicted change in the overall export tax

	(1) Before 2007	(2) From 2007 on
Water Reg_gap*Int	-0.098	1.042
COD Int	0.819	-0.439
Ammonium N. Int	-0.073	0.665
Soot Reg_gap*Int	-0.224	-0.028
SO2 Reg_gap*Int	0.082	0.136
Waste Int	0.769	0.415
Recycling Ratio	1.367	1.422
Energy Int	-0.355	1.974
Observations	8297	20659

Change from the 25th percentile to the 75th percentile

Table 6 shows that a jump in the waste water intensity from the 25th to the 75th percentile would only lead to an increase in the overall export tax of 1.042 percentage points from 2007 on. This effect is small considering the large change in the waste water intensity.

The COD intensity is significantly positively related to the overall export tax before 2007, but not from 2007 on. The third column of Table 6 shows that the coefficient estimate is significantly smaller for the period from 2007 on. These findings suggest that the overall export tax discouraged exports of COD intensive products prior to 2007 but not after 2007. The adjustments in the overall export tax could thus lead to an increase in COD emissions.

The results for our baseline regression in Table 5 do not indicate that the overall export tax is set in a way that discourages exports of ammonium nitrogen, soot or SO_2 intensive products neither before not after 2007. The respective coefficient estimates are not statistically significant.

We find that the overall export tax is higher for solid waste intensive products, both before 2007 and from 2007 onwards. The coefficient estimate for Waste Int is smaller for the period from 2007 on, but this difference is not statistically significant. Table 6 shows that an increase in the solid waste intensity from the 25th to the 75th percentile is associated with an increase in the overall export tax by 0.77 and 0.42 before and after 2007 respectively.

There is evidence that the overall export tax is higher for industries which recycle a larger share of their solid waste. This is opposed to our expectations. If the overall export tax was meant to reduce exports of products in industries that recycle only a small share of their production, we would expect a negative relationship: The overall export tax would be higher for industries with a low recycling ratio.

The fact that the coefficient estimates do not reflect an attempt to encourage recycling is not surprising if we look at China's environmental achievements in the 10th FYP. China planned to recycle 50 percent its solid waste. This target was overachieved (State Council of People's Republic of China, 2006). The ratio of solid waste that was recycled reached 56 percent, indicating that domestic instruments might suffice to increase recycling and that the use of trade policy as a second-best policy instrument is not necessary.

The data support the Chinese authorities' claim that the VAT rebate and export tax adjustments aim at reducing energy consumption. The overall export tax is found to be significantly higher for energy-intensive products, thus discouraging export production of those products. Based on our coefficient estimates, the overall export tax is 1.6 percentage points higher for a product with an energy intensity at the 75th percentile than for a product with an energy intensity at the 25th percentile, ceteris paribus (see Table 6). This difference is economically meaningful. Table 6 also shows that differences in the energy intensity can explain more of the difference in the overall export tax than differences in the pollution intensity with respect to any other pollutant k. The Chinese government seems to be most concerned about China's energy consumption when it sets the VAT rebate rates and export taxes.

An F-test demonstrates that the coefficient estimates for water, air and solid waste pollution intensities as well as energy intensity are jointly significant. This indicates that the pollution intensities jointly have an impact on the overall export tax. However, this seems to be driven by concerns about water pollution and energy intensity rather than efforts to reduce solid waste or air pollution.[17]

Moreover, the results support the claim that the export tax and VAT rebate adjustments at meant to contribute to the conservation of China's natural resources. The results in column 1 of Table 5 also demonstrate that the overall export tax is larger for resource products, particularly from 2007 on. In the period from 2007 on, the overall export tax for mineral products is estimated to be 7.4 percentage points higher than the overall export tax for non-mineral products. Exporters of wood products pay an overall export tax that is 6 percentage points larger than the overall export tax on other products. The export tax for stones and metal products exceeds the export tax for other products by 3.3 and 8 percentage points respectively. The difference in the overall export tax for resource products and other products is large. The conservation of resources seems to be an important motive behind China's trade policy especially when we compare the magnitude of the coefficient estimates for the resource dummy variables to the predicted changes in the overall export tax as a consequence of changes in the pollution intensity.

As a large producer on the world market, China could introduce export taxes in order to manipulate the terms of trade in its favour. This would be reflected in a positive coefficient estimate for the variable *Expshare*, which captures the share of Chinese exports in global exports. The findings in Table 5, however, show that the export tax is significantly lower for industries in which China produces a large share of global exports after 2007. Hence, there is no evidence that the overall export tax reflects an attempt to raise the world market price for Chinese exports.

The sign of the coefficient estimates for the control variables is largely in line with our expectations. We find that the overall export tax is significantly lower in industries with a larger number of firms from 2007 on. In addition, the results indicate that industries with a larger output share of state-owned enterprises face a significantly lower overall export tax. The finding indicates that links between the government and SOEs lead to a preferential treatment of industries in which SOEs produce a large proportion of the output value.

Having discussed the results for the overall export tax as a dependent variable, we can now zoom in and analyse the determinants of the export tax and the VAT tax individually. This allows us to see which of the policy instruments is positively correlated with the pollution intensities and which of the policy instruments drives the results.

Before we start our discussion of the results, we investigate the relationship between the two policy variables in more detail.

8.2 Relationship between export tax and export VAT rebate

Our theory suggests that the government uses trade barriers to reduce output in pollution intensive industries (relative to clean industries) and hence reduce overall pollution in the

[17] The F-test for all pollution intensities except the energy intensity also shows that those variables are jointly significant.

economy. However, the theoretical model does not take into consideration, that there are several instruments to tax exports. The government can use either export taxes or partial export VAT rebates to curb exports. Both instruments have very similar effects and jointly determine the overall export tax for a product. It is thus worthwhile investigating the relationship between the two variables more closely.

The VAT rebate rebate rate can be used as an alternative policy instrument if the Chinese government is constrained in the choice of the export tax. As pointed out previously, China committed to eliminate its export taxes for all but 84 HS8 digit products when it joined the WTO. For each of these 84 products, the Accession Protocol list a specific duty rate, which China is not allowed to exceed. This duty rate ranges between 20% and 40%. If the Chinese government has already implemented the maximum export tax allowed under the WTO Accession Protocol but wants to reduce exports further, it can resort to export VAT rebates.

At the same time, it is possible that the government has cancelled the VAT rebate and thus set the maximum VAT tax possible. However, it would like to reduce exports further and thus raises the export tax.

The above-mentioned examples illustrate that the export tax and the VAT tax are related. The choice of the VAT tax depends on the export tax and vice versa.

A look at the data gives us some intuition concerning the policy processes at work in China. The data show that an export tax goes along with the highest possible VAT tax in most cases: The government cancelled VAT rebates for 92 percent of the products on which it levies an export tax.

We get further insights if we distinguish between observations for which the export tax is lower, equal to or higher than the export tax allowed under the WTO Accession Protocol.

The government temporarily reduces the export taxes below the threshold allowed under the WTO accession protocol for some products in our sample. The VAT rebate for 60 percent of those products is positive. This indicates that the government uses the policy instruments simultaneously as long as the commitments under the WTO accession protocol are not binding and the maximum VAT tax has not been reached.

The average rebate rate rate for products for which the export tax is positive and equal to the export tax allowed under the WTO accession protocol is zero. A similar pattern can be observed for products for which the Chinese government introduced temporary export taxes which are higher than the export taxes allowed under the WTO Accession Protocol. The rebate rate is zero for all but 15 product lines in this category. This suggests that the government exploits VAT rebates as a policy instrument before it implements export taxes that could possibly be interpreted as violating its commitments under the WTO Accession Protocol.

On the other hand, a VAT rebate of zero does not immediately imply that the export tax takes a positive value. More than half of the products for which the rebate is zero are not subject to an export tax.

The above description indicates that the governments uses VAT rebates simultaneously for export taxes in all situations in which the export tax is below the WTO allowance. However, it is very likely to set the VAT rebate to zero prior to the introduction of an temporary export tax which exceed the allowance under the WTO commitments.

8.3 Export tax as dependent variable

So far we analysed the relationship between the pollution intensities and the overall export tax, which is the sum of the export tax and the VAT tax. In this section we examine the determinants of the export tax itself.

According to the WTO trade policy report (WTO, 2008, p. 73-74) not only the VAT rebate rates but also the export taxes are motivated by environmental concerns. Thus, we investigate whether the export tax is higher for products which are more pollution intensive.

The export tax is modelled as a function of the pollution intensities, the resource dummies and the control variables (as in equation 5.1).

In addition to the regressors used in the previous paragraph, we use the VAT tax as a control variable in our regression. Both the export tax and the VAT tax are likely to be determined by the same process, i.e. both variables are functions of a product's pollution intensities and political economy considerations. Hence, the VAT tax is correlated with the covariates in the regression of the export tax on the pollution intensities and the political economy variables. Omitting the VAT tax as a regressor would lead to an omitted variables bias unless the export tax is not related to the VAT tax.

As explained in Section 8.2, the data suggest that the Chinese government only implements export taxes that exceed the export tax allowed under the WTO accession protocol once it has exhausted the VAT tax as a policy instrument. This is similar to a situation in which the regulator chooses the VAT tax first and then chooses the export tax. This indicates that the causality runs from the VAT tax to the export tax but not the other way round. Our estimates are therefore unlikely to be biases due to reverse causality.

In addition to the export tax, we include the ad valorem tariff as an independent variable. The tariff might be determined by the same factors as the export tax and related to the export tax. Moreover, protection on the import side might be used as a substitute for protection on the export side and hence the two variables might be related.

The regression results are displayed in Table 7. Column 1 of Table 7 displays the results for a regression using data from 2005 to 2006. Columns 2 of the same table show the results for a sample covering the years after the policy announcement in 2007.

The first four rows show that there is no statistically significant positive relationship between the resource dummy variables and the export tax. To the contrary, the export tax is significantly lower for precious stones from 2007 on. These results do not indicate that the Chinese government uses export taxes to discourage exports of resources.

Table 7: Dependent variable: Export tax

	(1) 2005-2006	(2) 2007-2009	(3) Difference
Mineral	−0.372	0.401	
	(0.260)	(0.551)	
Wood	−1.104 ∗∗	−1.119	
	(0.497)	(0.760)	
Stones	−0.309	−1.005 ∗∗	
	(0.315)	(0.460)	
Metal	1.275	1.649	
	(1.200)	(1.232)	
Water Reg_gap*Int	−0.002	−0.001	
	(0.002)	(0.002)	
COD Int	−0.089	−0.214	
	(0.131)	(0.357)	
Ammonium N. Int	4.740	4.574	
	(4.899)	(15.728)	
Soot Reg_gap*Int	1.328	1.449	
	(1.249)	(3.380)	
SO2 Reg_gap*Int	−0.123	−2.738∗∗∗	***
	(0.353)	(1.027)	
Waste Int	0.003∗∗∗	0.010∗∗∗	***
	(0.001)	(0.001)	
Recycling Ratio	4.293∗∗∗	4.297	
	(1.557)	(2.787)	
Energy Int	−0.007	−0.010	
	(0.004)	(0.006)	
Exp share (v)	−0.041	−0.039	
	(0.061)	(0.099)	
Employees	−0.060	0.350 ∗∗	**
	(0.083)	(0.169)	
Firm No	0.043	−0.062 ∗∗	***
	(0.038)	(0.029)	
Profits	−0.002	0.000	
	(0.004)	(0.003)	
Δ Output	1.494∗∗∗	2.715	
	(0.311)	(1.898)	
Labour Intensity	−0.003	−0.007	
	(0.008)	(0.019)	
Export Intensity	−36.051∗∗∗	−36.947	
	(9.720)	(42.610)	
SOE share	0.980	−0.664	**
	(0.897)	(0.603)	
Foreign share	1.287	−1.216	**
	(0.835)	(1.280)	
Income tax	−0.005	0.000	
	(0.007)	(0.003)	
VAT tax	0.173∗	0.152 ∗∗	
	(0.089)	(0.061)	
Tariff	−0.009	−0.025	
	(0.009)	(0.024)	
N	8262.000	12309.000	
r2	0.154	0.222	

Cluster robust standard errors in parentheses. Column 3 indicates whether there is a statistically significant difference in the coefficient estimates for the 2007-2009 sample compared to the 2005 to 2006 sample. No entry means that there is no statistically significant difference. * p<0.1, ** p<0.05, *** p<0.01

Table 8: Predicted change in the export tax

	(1) Before 2007	(2) From 2007 on
Water Reg_gap*Int	-0.394	-0.107
COD Int	-0.036	-0.052
Ammonium N. Int	0.138	0.061
Soot Reg_gap*Int	0.163	0.055
SO2 Reg_gap*Int	-0.027	-0.316
Waste Int	0.347	0.858
Recycling Ratio	0.604	0.537
Energy Int	-0.708	-0.912
Observations	8262	12309

Change from the 25th percentile to the 75th percentile

However, there is evidence that the export tax is set in a way that discourages solid waste intensive exports. Table 7 shows a statistically significant positive relationship between the solid waste intensity and the export tax throughout the sample period. The relationship between the waste intensity and the export tax is significantly larger after 2007, as can be seen from in the column 3 Table 7, indicating that the introduction of export taxes could be geared towards a reduction in the generation of solid waste. However, even after 2007, the economic effect of a change in the waste water intensity on the export tax is small. Table 8 displays the predicted change in the export tax as the pollution intensities increase from the 25th to the 75th percentile. Such an increase in the solid waste intensity is predicted to raise the export tax by 0.27 percentage points prior to 2007 and by 0.9 percentage points from 2007 on.

The results do not reveal a positive relationship between the export tax and the waste water intensity. The coefficient estimate for the waste water intensity, interacted with the regulatory gap, is statically significant and negative.

Prior to 2007, the export tax is higher for products with a lower recycling ratio. This is opposed to the sign of the coefficient estimate we would expect to see if the government uses export taxes to encourage recycling. The export tax is not significantly related to the recycling ratio from 2007 on. However, the magnitude of the coefficient estimate is similar in both periods.

The energy intensity is not significantly related to export tax between 2005 and 2009 and the coefficient estimate is negative. This does not indicate that the export taxes were adjusted with the aim of reducing the energy intensity of Chinese production.

8.4 Determinants of VAT taxes

8.4.1 Estimation method

Section 8.2 explained how the export tax and the VAT tax are related to each other in the context of our analysis. Since the export tax is correlated with the regressors in our model, we include it as a control variable in order to avoid an omitted variable bias.

However, if we include the export tax as a regressor it is not clear that the causality only runs from the export tax to the VAT tax. As argued above, the choice of the export tax might depend on the VAT tax that has been implemented for a particular product. Moreover, the data show that the Chinese authorities set the maximum VAT tax before they introduce export taxes that might violate China's obligations under the WTO accession protocol. This suggest that the VAT tax affects the choice of the export tax. If that is the case, we need to instrument for the export tax in order to avoid biased estimates due to reverse causality.

We use the maximum export tax allowed under China's WTO Accession Protocol as an instrument for the export tax. In order to a qualify as an instrument, the export tax allowed under the WTO Accession Protocol has to be exogenous to the choice of the VAT tax. This is arguably the case. The WTO Accession Protocol was negotiated at the end of the 1990s and became effective with China's accession to the WTO in 2001.

The export taxes that are actually implemented in China differ from the export taxes negotiated under the WTO accession protocol. The Chinese government is free to set export taxes that are lower than those allowed under the accession protocol and chose to do so in several instances. Moreover, the government introduced temporary export taxes for products for which the WTO Accession Protocol does not foresee any export taxes. However, the actual export tax is positively correlated with the export tax allowed under the accession protocol. The correlation coefficient between the two variables is 0.79.

The VAT tax can only take values between 0 and 17. This means that the data are censored. However, the amount of limit observations with a VAT tax of 0 or 17 is less than 10 percent at each limit. Due to the small number of limit observations, we chose to estimate the model using a pooled OLS regression. The results do not change significantly if we use a Tobit model.

8.4.2 Results

Table 9 shows the results for model 5.1 with the VAT tax as dependent variable.

Prior to the discussion of our results, we assess the quality of our instrument and the necessity of an instrumental variable procedure. It is well known that the small sample bias for the 2SLS estimator is larger if the instruments are weak, or in other words if the correlation between the instruments and the endogenous regressors is low (see e.g. Angrist and Pischke, 2009, p. 205). With one instrument, the F-test for the joint significance of the regressors in the first-stage regression can be used as a test for weak instruments. The F-statistic for the first-stage regression shows that the instruments are jointly highly significant and that 2SLS results do not suffer from problems related to weak instruments for both samples.

Due to the small sample bias of the 2SLS estimator, OLS estimation would be preferable if the export tax was not endogenous. Hence, we test for the endogeneity of the export

Table 9: Dependent variable: VAT tax

	(1) 2005-2006	(2) 2007-2009	(3) Difference
Mineral	2.114***	5.527***	***
	(0.494)	(0.802)	
Wood	4.318***	5.933***	**
	(0.392)	(0.919)	
Stones	2.603	4.055***	
	(1.744)	(0.821)	
Metal	0.514	4.745***	***
	(0.464)	(1.544)	
Water Reg_gap*Int	0.003*	0.012 **	*
	(0.002)	(0.005)	
COD Int	1.588***	−1.457	**
	(0.335)	(1.240)	
Ammonium N. Int	−8.258 **	42.165	*
	(3.899)	(30.493)	
Soot Reg_gap*Int	−3.081 **	−1.756	
	(1.474)	(7.780)	
SO2 Reg_gap*Int	0.457	4.296	
	(0.635)	(2.710)	
Waste Int	0.001	−0.008***	***
	(0.001)	(0.003)	
Recycling Ratio	2.078	4.725	
	(1.881)	(5.563)	
Energy Int	0.006 **	0.030***	**
	(0.003)	(0.009)	
Exp share (v)	−0.004	−0.265	
	(0.138)	(0.203)	
Employees	−0.002	−0.697 **	**
	(0.143)	(0.331)	
Firm No	−0.121***	−0.021	*
	(0.034)	(0.062)	
Profits	0.009 **	0.001	
	(0.004)	(0.006)	
Δ Output	0.469	3.190	
	(0.349)	(3.610)	
Labour Intensity	0.013	0.046	
	(0.021)	(0.070)	
Export Intensity	15.490	68.836	
	(10.853)	(79.278)	
SOE share	−5.550***	−3.602	
	(1.663)	(2.538)	
Foreign share	−3.024 **	−0.445	
	(1.230)	(2.884)	
Income tax	0.052*	0.010	
	(0.027)	(0.006)	
Export tax	0.530 **	0.365***	
	(0.210)	(0.135)	
Tariff	−0.025 **	−0.016	
	(0.012)	(0.022)	
N	8262.000	12309.000	
r2	0.439	0.580	

Cluster robust standard errors in parentheses. Column 3 indicates whether there is a statistically significant difference in the coefficient estimates for the 2007-2009 sample compared to the 2005 to 2006 sample. No entry means that there is no statistically significant difference. * p<0.1, ** p<0.05, *** p<0.01

tax using a test that allows for clustered standard errors.[18] With a p-values of 5 and 6 percent, we reject the null-hypothesis that the export tax is exogenous for both samples and use an instrumental variable estimation as our baseline approach.

The results in Table 9 reveal a statistically significant positive relationship between the VAT tax and the overall waste water intensity (interacted with measure for the regulatory gap) both before 2007 and from 2007 on. The positive coefficient estimate indicates that Chinese authorities discourage exports of waste water intensive products through higher VAT taxes, indicating that the VAT tax is motivated by concerns about waste water emissions. Column 3 of Table 9 shows that the coefficient estimate for waste water intensity is significantly larger for the 2007-2009 sample. This shows that the adjustment in VAT rebate rates discourages waste water intensive exports even further.

Table 10: Predicted change in the VAT tax

	(1) Before 2007	(2) From 2007 on
Water Reg_gap*Int	0.482	0.997
COD Int	0.645	-0.354
Ammonium N. Int	-0.241	0.560
Soot Reg_gap*Int	-0.378	-0.067
SO2 Reg_gap*Int	0.100	0.495
Waste Int	0.133	-0.696
Recycling Ratio	0.292	0.591
Energy Int	0.627	2.645
Observations	8262	12309

Change from the 25th percentile to the 75th percentile

Table 10 displays the predicted change in the VAT tax as the pollution intensities increase from the 25th to the 75th percentile. This allows us to assess the economic meaning of the coefficient estimates. We find that a surge in the waste water intensity from the 25th to the 75th percentile is associated with an increase in the VAT tax by about 1 percentage point for the period 2007 to 2009.

The results in Table 9 also indicate that the VAT tax is set in a way that discourages exports of COD discharge intensive products prior to the reform. However, from 2007 on, there is no statistically significant relationship between the COD intensity and the

[18] The standard procedure to test for regressor endogeneity is the Hausman test. However. the Hausman test assumes that the errors are homoskedastic. Since we use clustered standard errors in our regression, we cannot use the Hausman test. There are two ways of testing for regressor endogenity with clustered standard errors. The user-written command ivreg2 (Baum et al., 2002) provides a test for the endogeneity of regressors that does not require homoskedasticity. The test is based on a C-statisitc and the null-hypothesis is that the regressor is exogenous. With a p-value of 5 percent, we can reject the null-hypothesis that the export tax is exogenous based on this test. Alternatively, we can run a regression of the export tax on the exogenous regressors (i.e. the first-stage regression) and generate the residuals from that regression. In a next step, we run a regression of the VAT tax and all the variables in our model (the pollution intensities, the political economy variables and the export tax) as well as the residual from the first stage regression. The fact that the residuals from that first-stage regression are statistically significant indicates the the export tax is endogenous.

VAT tax. Column 3 of Table 9 shows that the coefficient estimate for the COD intensity is significantly smaller for the 2007-2009 sample indicating that the VAT rebate rate adjustment were not geared towards reducing COD emissions.

Before 2007, the structure of VAT taxes encouraged exports of ammonium nitrogen intensive products, as represented by the statistically significant negative coefficient estimate for the ammonium nitrogen intensity. This changed once the VAT rebate rates were adjusted. From 2007 on, there is not statistically significant relationship between the ammonium nitrogen intensity and the VAT tax. Since the Chinese government put an end to the favourable treatment of ammonium nitrogen intensive products, the VAT rebate adjustments from 2007 on could lead to a reduction in ammonium nitrogen emissions.

A similar pattern prevails for soot intensive products. Soot intensity (interacted with the measure for the regulatory gap) is significantly negatively related to the VAT tax prior to 2007, implying that the structure of the VAT rebates encourages exports of soot intensive products instead of curbing them. From 2007 on, the soot intensity is not significantly related to the VAT tax. This means that the adjustments could lead to a reduction in soot emissions. However, the difference in the coefficient estimates between the two sample periods in not statistically significant.

There is no evidence that the VAT tax aims at reducing SO_2 emission. Even though the coefficient estimates are positive, they are not statistically significant.

The results do not imply that the VAT tax is driven by concerns about the generation of solid waste and recycling either. The coefficient estimate for the solid waste intensity is statistically significant and negative from 2007 on. The recycling ratio is not significantly related to the VAT tax.

The data support the NDRC's claim that the VAT rebates aim at reducing energy consumption. The VAT tax is found to be significantly higher for energy-intensive products, thus discouraging export production of those products. The effect of an increase in energy intensity is significantly larger from 2007 on suggesting that the VAT rebate rate adjustments could aim at reducing the energy intensity of Chines exports. The difference between the coefficient estimates for energy intensity for the 2005-06 and the 2007-09 samples is economically meaningful. Table 10 shows that the VAT tax is predicted to be 2.6 percentage points higher for a product with a pollution intensity at the 75th percentile than for a product with a pollution intensity at the 25th percentile, ceteris paribus. Prior to 2007, a similar change in the energy intensity is associated with a change in the VAT tax of no more than 0.6 percentage points. Table 10 also demonstrates that difference in the energy intensity can explain more of the difference in the VAT tax than differences in the pollution intensity with respect to any pollutant k. The Chinese government seems to be most concerned about China's energy consumption when it sets the VAT rebate rates.

The results in Table 9 also demonstrate that the VAT taxes hamper exports of natural resources. The coefficient estimates for the resource dummies are large and statistically significant, particularly for the period from 2007 on. In the 2007 to 2009, sample the VAT tax for mineral products is estimated to be 5.5 percentage points higher than the VAT tax for non-mineral products. The difference in the average VAT tax between wood exports and other products is even larger and amounts to 5.9 percentage points. On average, exporters of stone and metal products face a VAT tax that is 4.1 and 4.7 percentage point larger than the VAT tax for non-resource products. This gives strong support to the idea that VAT taxes aim at protecting China's natural resources. The difference in the VAT tax between resource and non-resource products is large compared to the predicted increase in the VAT tax associated with an increase in the waste water and energy intensity, respectively.

The sign of the coefficient estimates for the control variables is in line with our expectations. We find that the VAT tax is significantly lower in industries with a larger number of employees from 2007 on. This is in line with Caves (1976)'s argument that larger industries receive more protection. The VAT tax is also lower for industries with a larger number of firms, even though the coefficient estimate is only statistically significant prior to 2007. Higher profits are associated with a larger VAT tax prior to 2007 suggesting that the government grants most protection to the industries which are in need of higher protection.

In addition, the results indicate that industries with a larger output share of state-owned enterprises face a lower VAT tax. The finding indicates that links between the government and SOEs lead to a preferential treatment of industries in which SOEs produce a large proportion of the output value.

The VAT tax is also higher for products with a higher export tax. An increase in the export tax by one percentage point leads to an increase in the VAT tax by 0.47 percentage points. Moreover, protection on the import side seems to be complementary to the VAT tax. A reduction in the tariff increase competition between domestic producers and world market producers. In a similar way, an increase in the VAT tax generates a disadvantage for domestic producers compared to producers in the world markets. The finding that tariffs are lower for products with a higher VAT tax thus indicates that tariffs and VAT taxes are complementary. However, the coefficient estimate is not statistically significant from 2007 on.

8.5 Difference between the determinants of export taxes and VAT taxes

The results suggest that VAT tax and the export tax are driven by different factors, in particular with respect to the resource dummy variables and the environmental variables. While the VAT tax is significantly larger for resource products, the export tax is significantly lower for precious stones after 2007 and not significantly related to any of the other resource dummy variables.

Moreover, we found a statistically significant positive relationship between the VAT tax and energy intensity, indicating that the Chinese government uses VAT taxes in order to curb exports of energy intensive products. The export tax, however, is negatively related to the energy intensity, thus encouraging exports of energy-intensive products. This means that the export tax could potentially offset the effect of the VAT tax.

A similar phenomenon can be observed in the case of solid waste. The VAT tax is lower for solid waste intensive products after 2007. At the same time, the export tax is higher for those products.

The fact that the coefficient estimates for the resource products, waste water, waste and energy intensity have opposite signs in the regression using the VAT tax or the exert tax as dependent variables means that the export tax could potentially offset the effect of the VAT tax and vice versa. In the regression with the overall export tax as dependent variable, however, we found that the effects of both policy instruments do not completely cancel out. From 2007 on, the export tax and the VAT tax jointly discourage exports of resource products as well as waste water, waste and energy intensive products.

9 Sensitivity analysis

9.1 Direct pollution intensities

Our empirical analysis investigates the relationship between trade policy instruments and the overall pollution intensities. However, the calculation of overall pollution intensities is is based on certain assumptions. For one thing, we have to assume that the input-output coefficients are constant over time, since IO tables are only published every five years and there is only one IO table for our sample period. For another thing, Chinese IO tables do not provide any information about imported intermediate inputs. Therefore, we have to make proportionality assumptions.

Due to these shortcomings of Chinese IO tables, several authors suggest to use direct emission intensities rather than overall emission intensities (see e.g. Dean and Lovely, 2010). Hence, we use direct emission intensities rather than overall emission intensities in a robustness check. The results are displayed in Table 11.

In columns 1 and 2 of Table 11, the dependent variable is the export tax. Column of 1 displays the results for a sample including observations spanning the years 2005 to 2006. The results for the 2007-2009 sample are displayed in Column 2.

The sign and significance pattern of the coefficient estimates is similar to the results of the regression using the overall pollution intensities in Table 7. The export tax is significantly positively correlated with solid waste intensity but none of the other pollution intensities.

Column 3 and 4 of Table 11 display the results for a regression using the VAT tax as dependent variable. Again, the coefficient estimates are similar to the ones obtained in a regression using the overall pollution intensities (Table 9). From 2007 on, the VAT tax is significantly larger for resource products and energy-intensive products.

Table 11: Direct emission intensities

	(1) Export tax 05-06	(2) Export tax 07-09	(3) VAT tax 05-06	(4) VAT tax 07-09
Mineral	−0.473	0.231	2.219***	5.334***
	(0.318)	(0.519)	(0.522)	(0.745)
Wood	−1.117 **	−1.333	4.353***	6.783***
	(0.539)	(0.833)	(0.380)	(0.857)
Stones	−0.598*	−0.948*	2.526	3.007***
	(0.352)	(0.518)	(1.737)	(0.764)
Metal	1.123	1.915	0.559	4.026***
	(1.110)	(1.192)	(0.414)	(1.054)
D Water Reg_gap*Int	−0.001	−0.002	−0.000	0.013
	(0.002)	(0.003)	(0.004)	(0.015)
D COD Int	−0.425	0.126	3.153***	−0.508
	(0.292)	(0.745)	(0.792)	(3.642)
D Am Nit Int	9.321	6.437	−12.011 **	43.284
	(8.208)	(25.698)	(5.741)	(47.334)
D Soot Reg_gap*Int	4.443	0.142	−9.892***	5.421
	(3.798)	(8.808)	(2.244)	(15.757)
D SO2 Reg_gap*Int	−1.670	−4.771 **	3.409***	1.095
	(1.717)	(2.231)	(1.086)	(3.941)
D Waste Int	0.003***	0.011***	0.000	−0.007***
	(0.001)	(0.001)	(0.001)	(0.003)
D Recycl. Ratio	−0.072	0.830	−0.438*	−0.314
	(0.239)	(1.254)	(0.246)	(2.276)
D Energy Int	−0.007	−0.006	0.013***	0.049***
	(0.006)	(0.010)	(0.005)	(0.014)
Exp share (v)	−0.048	−0.070	0.020	−0.277
	(0.064)	(0.100)	(0.137)	(0.222)
Employees	0.090	0.395 **	−0.092	−0.791 **
	(0.062)	(0.197)	(0.138)	(0.395)
Firm No	0.003	−0.077 **	−0.090***	0.050
	(0.020)	(0.037)	(0.034)	(0.081)
Profits	−0.006	−0.000	0.007*	−0.006
	(0.006)	(0.003)	(0.004)	(0.006)
Δ Output	1.599***	2.979	−0.075	2.947
	(0.192)	(1.932)	(0.350)	(3.209)
Labour Intensity	−0.009	−0.013	0.010	0.065
	(0.009)	(0.017)	(0.020)	(0.078)
Export Intensity	−31.503***	−32.135	13.088	55.677
	(8.908)	(36.849)	(10.432)	(73.057)
SOE share	0.332	−0.741	−7.552***	−4.425*
	(0.548)	(0.591)	(1.538)	(2.413)
Foreign share	0.576	−1.520	−3.163***	1.107
	(0.592)	(1.254)	(1.007)	(3.077)
Income tax	0.004	0.000	0.071***	0.014 **
	(0.009)	(0.003)	(0.023)	(0.007)
VAT tax	0.178*	0.149 **		
	(0.093)	(0.065)		
Export tax			0.518 **	0.311***
			(0.209)	(0.106)
Tariff	−0.006	−0.022	−0.026 **	−0.015
	(0.008)	(0.024)	(0.012)	(0.022)
N	8262.000	12309.000	8262.000	12309.000
r2	0.147	0.231	0.450	0.589

Cluster robust standard errors in parentheses
* p<0.1, ** p<0.05, *** p<0.01

The coefficient estimate for the wast water intensity is the main difference between the regression using direct emission intensities and the regression using overall emission intensities. Using direct emission intensities, we do not find a statistically significant positive relationship between the overall export tax and the waste water intensity.

While this section presents robustness checks for both the VAT tax and the export tax as dependent variables for both the 2005-2006 and the 2007-2009 samples, the remainder of the sensitivity analysis presents results using the VAT tax as dependent variable in a sample of observations spanning the years 2007 to 2009. In other words, we focus on the time period in which Chinese authorities linked trade policy to environmental motives. The results for the same sample period with the export taxes dependent variable can be found in the appendix in Table 17.

9.1.1 Only manufacturing industries

Our sample so far contains mining industries, manufacturing, recycling as well as production and distribution of electric power. In this section, we restrict our sample to manufacturing industries. There are several reasons for doing so. Firstly, manufacturing industries correspond to significantly more tariff lines than the other sectors on average. Secondly, manufacturing industries might be inherently different from mining and production and distribution of electric power, gas and water. Finally, looking at a sample of manufacturing industries might also facilitate the comparison between findings in our paper and in other papers.

The regression results are presented in Column 1 of Table 12. The results are very similar to those we obtained for the entire sample. The VAT tax is significantly higher for minerals, wood products and precious stones as well as waste water and energy intensive products. The magnitude of the coefficient estimates is similar to the magnitude of the coefficient estimates we obtained in the baseline regression.

9.2 No market power

The theoretical model showed that the second-best export tax is also driven by an incentive to manipulate the world market price of the good which is exported. This terms of trade motive is difficult to measure. In the main analysis we capture the terms of trade motive using a categorical variable for China's share in global exports. However, this measure is not very precise. Moreover, it might be endogenous since the VAT tax or the export tax might reduce China's share in global exports.

As a robustness check, we only look at observations for which China is a small producer in the world market. We know that there is no incentive to set an export tax or a VAT tax in order to manipulate the terms of trade if the industry is small on the world market. The size of a Chinese product in the world market should be reflected in China's share in global exports. Hence, we look at a sample of products for which China exports less than 15 percent of global exports.

Table 12: Sensitivity analysis: Dependent variable VAT tax

	(1) Manufacturing	(2) Small	(3) No Reg_gap
Mineral	5.425***	5.435***	5.802***
	(0.572)	(0.820)	(0.766)
Wood	6.774***	5.938***	5.825***
	(1.199)	(1.021)	(0.962)
Stones	2.404*	4.326***	4.084***
	(1.422)	(0.893)	(0.841)
Metal	2.907	5.084***	4.988***
	(1.833)	(1.579)	(1.641)
Water Reg_gap*Int	0.015***	0.009	
	(0.006)	(0.006)	
Water Int			−0.002
			(0.001)
COD Int	−1.996	−0.411	5.290
	(1.273)	(1.346)	(3.316)
Ammonium N. Int	42.778	64.388**	93.826**
	(26.962)	(31.240)	(41.037)
Soot Reg_gap*Int	−4.521	−0.813	
	(5.795)	(7.872)	
Soot Int			−0.977
			(6.907)
SO2 Reg_gap*Int	9.144***	4.120	
	(2.679)	(2.885)	
SO2 Int			2.414
			(3.060)
Waste Int	−0.003	−0.008**	−0.002
	(0.019)	(0.004)	(0.002)
Recycling Ratio	0.859	6.345	7.137
	(8.860)	(7.446)	(5.674)
Energy Int	0.038***	0.027***	0.016
	(0.013)	(0.009)	(0.012)
Tariff	−0.017	−0.015	−0.017
	(0.028)	(0.023)	(0.022)
Exp share (v)	−0.163		−0.287
	(0.209)		(0.216)
Employees	−0.534*	−0.614	−0.252
	(0.299)	(0.395)	(0.407)
Firm No	−0.039	−0.045	−0.054
	(0.070)	(0.066)	(0.059)
Profits	−0.003	0.001	−0.005
	(0.006)	(0.007)	(0.008)
Δ Output	1.304	3.180	4.068
	(3.047)	(4.012)	(3.605)
Labour Intensity	0.082	0.157	0.052
	(0.065)	(0.110)	(0.072)
Export Intensity	−58.825	195.599***	92.365
	(64.531)	(49.460)	(72.613)
SOE share	−4.374**	−2.620	−5.816**
	(1.990)	(2.993)	(2.491)
Foreign share	1.463	−3.484	−2.527
	(3.741)	(3.416)	(2.828)
Income tax	0.008	0.009	0.018**
	(0.006)	(0.008)	(0.008)
Export tax	0.463***	0.395**	0.298**
	(0.127)	(0.164)	(0.132)
Observations	10806	7935	12372

Cluster robust standard errors in parentheses
* p<0.1, ** p<0.05, *** p<0.01

The results are presented in Column 3 of Table 12. They are similar to the results for the unrestricted sample. One notable difference is the coefficient estimate for the waste water intensity, which positive and but not statistically significant. However, the VAT tax is significantly positively related to ammonium nitrogen intensity.

9.3 No measure for the regulatory gap

In our baseline regression, we interact the waste water intensity, the soot intensity and the SO_2 intensity with the share of emissions meeting discharge standards. The latter variable captures the regulatory gap which corresponds to the difference between marginal damage and the pollution tax in the theoretical model.

In order to investigate whether this measure for the regulatory gap drives our results, we include the waste water, soot and SO_2 intensities without interacting them with the measure for the regulatory gap.

As mentioned above, the Five-Year-Plans foresee a reductions in SO_2 and soot emissions as well as water consumption, indicating that the pollution tax is lower than marginal damage. Moreover, the share of emissions exceeding discharge standards is positive for all industries and all years in the sample. With the pollution tax not internalizing the environmental distortion to the desired extent, we would expect a positive relationship between soot, SO_2 and waste water intensities and the VAT tax.

Including soot and SO_2 intensities without interacting them with a measure for the regulatory gap also allows us to find out whether the absence of a statistically significant positive relationship between the VAT tax and soot or SO_2 intensities was due to a bad measure for the regulatory gap.

The results are displayed in Column 3 of Table 12. We find that the coefficient estimate for the waste water intensity is not statistically significant. However, the VAT tax is significantly larger for products which are ammonium nitrogen intensive.

10 Conclusion

From 2007 on, the Chinese government repeatedly emphasised that it uses export taxes as well as VAT rebates as second best environmental policy instruments. This paper investigates whether, in practice, concerns about pollution drive Chinese trade policy reforms.

Environmental issues are of increasing importance on the Chinese policy agenda. However, the design of the Chinese pollution levy system and the decentralized implementation and enforcement of pollution regulation pose a challenge to internalizing the environmental distortion. Given this constraint on the use of domestic pollution taxes, export taxes can be used as a second-best policy instrument to protect the environment.

Extending Copeland (1994)'s model to the large country case we solve for the second best export tax in a situation in which the regulator cannot adjust trade policy. Under certain assumptions, it is possible to show that the second best export tax increases in a product's pollution intensity. This relationship guides our empirical analysis.

In order to analyse whether Chinese trade policy reflects environmental concerns, this paper investigates whether the export and VAT tax are positively correlated with a product's air, water, solid waste and energy intensity. The analysis is based product-level trade policy data as well as data on Chinese pollution emissions and energy use spanning the years 2005 to 2009.

The results presented in this paper demonstrate that, as a consequence of the trade policy reforms, the VAT tax and the exports tax jointly discourage exports of wastewater intensive, solid waste intensive and energy intensive and products. This lends support to Chinese authorities' claim that exported taxes and VAT rebates are used to reduce energy and pollution intensity of Chinese exports. However, there is no evidence that Chinese trade policy is driven by concerns about air pollution.

Moreover, the export tax and VAT rebates might promote the conservation of natural resources in China. The data suggest that export taxes and the VAT rebates were adjusted in a way that hampers exports of natural resources. From 2007 on, the sum of export tax and VAT tax is significantly larger for mineral products, wood products, precious stones and metals that for non-resource products.

The analysis also reveals that the export tax and the VAT rebate contribute to the overall structure of export taxation in very different ways.

The results demonstrate that China's partial export VAT rebates penalize exports of waste water intensive and energy intensive products. From 2007 to 2009, an increase in the waste water intensity from the 25th to the 75th percentile is estimated to increase the VAT tax by 1 percentage point. According to our estimates, a similar surge in the energy intensity raises the VAT tax by 2.6 percentage points.

The VAT rebates also drive our finding that China discourages exports of natural resources. Throughout the sample period, the VAT tax is several percentage points larger for resource products. In addition, the VAT tax was raised more for mineral, wood and metal products than for the base category from 2007 on.

However, there is no evidence that the VAT rebates aim at reducing COD, soot and solid waste emissions. To the contrary, VAT rebates encourage export production of solid waste intensive products after the VAT rebate rate adjustments in 2007.

The export tax, on the other hand, is higher for solid waste intensive products. This is particularly the case from 2007 on. The introduction of temporary export taxes from 2007 on might thus leads to a reduction in the generation of solid waste. The results do not indicate that the export tax is driven by concerns about water and air pollution or energy consumption.

The fact that export taxes do not reflect attempts to reduce pollution is not surprising if we bear in mind that the Chinese government is restricted in its choice of export taxes due to its commitment under the WTO accession protocol. Hence, there are limits to the extent to which export can be used as a secondary environmental policy.

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Appendix

Table 13: List of sectors

Sectors in the dataset
Mining and Washing of Coal
Extraction of Petroleum and Natural Gas
Mining and Processing of Ferrous Metal Ores
Mining and Processing of Non-Ferrous Metal Ores
Mining and Processing of Nonmetal Ores and Other Ores
Processing of Food from Agricultural Products
Manufacture of Foods
Manufacture of Beverages
Manufacture of Tobacco
Manufacture of Textile
Manufacture of Textile Wearing Apparel, Footware, and Caps
Manufacture of Leather, Fur, Feather and Related Products
Processing of Timber, Manufacture of Wood, Bamboo, Rattan, Palm, and Straw Products
Manufacture of Furniture
Manufacture of Paper and Paper Products
Printing,Reproduction of Recording Media
Manufacture of Articles For Culture, Education and Sport Activity
Processing of Petroleum, Coking, Processing of Nuclear Fuel
Manufacture of Raw Chemical Materials and Chemical Products
Manufacture of Medicines
Manufacture of Chemical Fibers
Manufacture of Rubber
Manufacture of Plastics
Manufacture of Non-metallic Mineral Products
Smelting and Pressing of Ferrous Metals
Smelting and Pressing of Non-ferrous Metals
Manufacture of Metal Products
Manufacture of General Purpose Machinery
Manufacture of Special Purpose Machinery
Manufacture of Transport Equipment
Manufacture of Electrical Machinery and Equipment
Manufacture of Communication Equipment, Computers and Other Electronic Equipment
Manufacture of Measuring Instruments and Machinery for Cultural Activity and Office Work
Manufacture of Artwork and Other Manufacturing Recycling and Disposal of Waste
Production and Distribution of Electric Power and Heat Power

Table 14: Data Source

Variables	**Data Source**
VAT tax	China Customs, State Administration of Taxation, Ministry of Finance (see Table 10 for details)
Export tax	China Customs Homepage
Tariff	WITS TRAINS database
Waste Water Vol	China Statistical Yearbook on Environment
COD Vol	China Statistical Yearbook on Environment
Waste Gas	China Statistical Yearbook on Environment
Soot Emission	China Statistical Yearbook on Environment
Soot Stand_Rat	China Statistical Yearbook on Environment
SO_2 Emission	China Statistical Yearbook on Environment
SO_2 Stand_Rat	China Statistical Yearbook on Environment
Dust Emission	China Statistical Yearbook on Environment
Dust Stand_Rat	China Statistical Yearbook on Environment
Solid Waste	China Statistical Yearbook on Environment
Energy Consumption	China Statistical Yearbook, Energy Chapter
Output Value	China Statistical Yearbook, Industry Chapter
PPI	China Statistical Yearbook, Industry Chapter
Deflated Output	China Statistical Yearbook, Industry Chapter
Firm No	China Statistical Yearbook, Industry Chapter
Employees	China Statistical Yearbook, Industry Chapter
Δ Output	China Statistical Yearbook, Industry Chapter
Labour Intensity	China Statistical Yearbook, Industry Chapter
Export Intensity	China Statistical Yearbook, Industry Chapter
SOE share	China Statistical Yearbook, Industry Chapter
Foreign share	China Statistical Yearbook, Industry Chapter
Income Tax	China Statistical Yearbook, Industry Chapter

Table 15: VAT rebate reforms and data source

Policy reform	**Effective Date**	**Data Source**
Cai Shui (2006) No. 139	15th September 2006	China Customs
Cai Shui (2007) No. 64	15th April 2007	State Administration of Taxation
Cai Shui (2007) No. 90	1st July 2007	State Administration of Taxation
Cai Shui (2007) No. 169	20th December 2007	State Administration of Taxation
Cai Shui (2008) No. 77	13th June 2008	China Customs
Cai Shui (2008) No. 111	1st August 2008	Ministry of Finance
Cai Shui (2008) No. 138	1st November 2008	China Customs
Cai Shui (2008) No. 144	1st December 2008	State Administration of Taxation
Cai Shui (2008) No. 177	1st January 2009	State Administration of Taxation
Cai Shui (2009) No. 14	1st February 2009	State Administration of Taxation
Cai Shui (2009) No. 43	1st April 2009	China Customs
Cai Shui (2009) No. 88	1st June 2009	China Customs

Table 16: Correlation Table VAT tax and Overall Pollution Intensities

	(1)									
	VAT tax	Export tax	Water Int	COD Int	Ammonium N. Int	Soot Int	SO2 Int	Waste Int	Recycling Ratio	Energy Int
VAT tax	1.00									
Export tax	0.29	1.00								
Water Int	0.17	-0.04	1.00							
COD Int	0.21	-0.04	0.93	1.00						
Ammonium N. Int	-0.00	-0.07	0.66	0.56	1.00					
Soot Int	-0.02	-0.06	0.39	0.27	0.41	1.00				
SO2 Int	0.04	-0.03	0.37	0.20	0.38	0.94	1.00			
Waste Int	0.15	0.21	0.04	-0.07	-0.02	0.30	0.45	1.00		
Recycling Ratio	0.20	-0.04	0.22	0.25	0.14	-0.13	-0.25	-0.56	1.00	
Energy Int	0.10	0.01	0.22	0.04	0.34	0.80	0.88	0.46	-0.23	1.00

Table 17: Sensitivity analysis: Dependent variable export tax

	(1) Manufacturing	(2) Small	(3) No Reg_gap
Mineral	−0.078	0.084	0.374
	(0.653)	(0.677)	(0.492)
Wood	−0.069	−1.025	−1.450 ∗ ∗
	(0.985)	(0.803)	(0.690)
Stones	−0.915 ∗ ∗	−0.680	−0.971∗
	(0.431)	(0.641)	(0.527)
Metal	0.930	2.537	2.249
	(0.567)	(1.754)	(1.686)
Water Reg_gap*Int	0.000	−0.003	
	(0.001)	(0.002)	
Water Int			0.001
			(0.000)
COD Int	0.048	0.082	−1.610
	(0.308)	(0.565)	(1.422)
Ammonium N. Int	−11.907	6.947	5.922
	(9.181)	(20.489)	(16.106)
Soot Reg_gap*Int	−0.326	2.078	
	(2.343)	(4.722)	
Soot Int			6.862
			(5.036)
SO2 Reg_gap*Int	−3.870∗∗∗	−2.874 ∗ ∗	
	(0.687)	(1.289)	
SO2 Int			−4.657 ∗ ∗
			(2.197)
Waste Int	0.003	0.012∗∗∗	0.009∗∗∗
	(0.009)	(0.002)	(0.001)
Recycling Ratio	0.822	7.189	−0.570
	(3.955)	(4.662)	(3.062)
Energy Int	0.002	−0.014	−0.002
	(0.004)	(0.008)	(0.009)
Exp share (v)	−0.049		−0.030
	(0.094)		(0.093)
Employees	0.246	0.315	0.341∗
	(0.172)	(0.192)	(0.190)
Firm No	−0.050	−0.033	−0.052∗
	(0.030)	(0.032)	(0.030)
Profits	0.003	−0.001	−0.005
	(0.002)	(0.004)	(0.004)
Δ Output	−0.841	3.976	3.572∗
	(0.772)	(2.469)	(1.873)
Labour Intensity	−0.000	−0.012	−0.024
	(0.015)	(0.041)	(0.019)
Export Intensity	4.877	−81.080	−60.166
	(16.050)	(51.836)	(57.514)
SOE share	0.356	0.003	0.575
	(0.586)	(0.999)	(0.862)
Foreign share	−1.078	0.249	−0.943
	(1.243)	(1.612)	(1.280)
Income tax	−0.004 ∗ ∗	0.001	0.003
	(0.002)	(0.003)	(0.004)
Tariff	−0.010	−0.032	−0.033
	(0.025)	(0.033)	(0.026)
VAT tax	0.141∗	0.163 ∗ ∗	0.158 ∗ ∗
	(0.080)	(0.067)	(0.060)
Observations	10806	7935	12372

Cluster robust standard errors in parentheses
* p<0.1, ** p<0.05, *** p<0.01