Trade policy repercussions: the role of local product space - Evidence from China

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Abstract

Our study shows that the relatively under-studied VAT export rebate system is a major industrial policy of the Chinese authorities to support exports. We use city-specific export-quantity data at the HS6-product level over the 2003-12 period to assess how changes in the VAT export tax have affected China's export performance. We are particularly interested in how the impact of this policy varies within products across cities depending on how well connected the targeted product is to the local productive structure. Our difference-in-difference estimates exploit an eligibility rule disqualifying some export flows from the rebates. Our results suggest that a one percent rise in the VAT export tax leads to a 6.6% relative decrease in eligible export quantities. We then show that the effectiveness of this export tax policy is magnified when it applies to products with denser links with the local productive structure. Hence export benefits from VAT export rebates are greater for cities that have the necessary capabilities and resources to carry out the activities supported by this rebate policy.

Keywords: VAT system, policy evaluation, export tax, export performance, trade elasticity, product relatedness, China.

JEL codes: F10, F14, H20, O25.

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1 Introduction

Over the last decades, China's government has heavy-handedly and openly intervened to promote the country's export performance while in the same time guiding the structural transformation of the economy. China's system of Value Added Tax (VAT) export rebates is considered to be a major instrument of Chinese industrial policy influencing its international competitiveness and has been identified as the most important state measure in terms of international trade covered during the recent crisis (Global Trade Alert, 2010). Contrary to other forms of public intervention such as currency manipulation, multiple subsidies and trade protection, the rather confusing system of tax rebates for exporters has largely been overlooked. This is particularly surprising given that VAT export rebates can be modified easily and directly affect the country's international competitiveness in the short run. Especially in the current context of calls to apply heavier tariffs on Chinese products, it is crucial to be aware of the mechanisms in the hands of the Chinese authorities to mitigate the effects of more protectionist policies of their trading partners.

In this paper, we provide a careful evaluation of China's system of VAT export rebates over a period of 10 years. Moreover, we investigate the spatial heterogeneity in its impact depending on the local industry composition. Notably, we show that export gains are doubled for products with denser links with the local productive structure. Our study hence leads to a better understanding of how the effects of a national trade policy differ across locations and industries and relate to spillovers within the local product space (Hidalgo et al., 2007).

China's VAT policy differs from the standard destination-based VAT system of the OECD countries by not fully refunding the VAT on exports. Instead, exporters may receive VAT rebates that vary across commodities, and range from zero to the full refund of the typical 17% VAT rate. The Chinese VAT system thus imposes a tax on exporters whose goods receive a VAT refund rate lower than the applicable VAT rate.[1] Such incomplete VAT export rebates hence amount to export taxes and are expected to lead to lower exports (Feldstein and Krugman, 1990).[2]

Even though most Chinese exporters face a VAT export tax, the VAT export rebate system has been considered as providing Chinese exporters with an advantage with respect to foreign competitors (Evenett et al., 2012). Two features have been highlighted as evidence that this VAT export rebate system is indeed a systematic form of export management. First, there is tremendous variation across goods in the levels of and changes to the VAT export rebates. Second, no other country amends its VAT export rebates so often. Over the last decade, VAT export rebate rates have been adjusted frequently, both upwards and downwards (WTO, 2010).[3] In particular, since the beginning of the global financial crisis in 2008, China has increased VAT export rebate rates several times. In contrast to many other countries, China's exports resisted rather well during the crisis and more than sextupled between 2002 and 2012, growing two times faster than the world exports over that period.

In our empirical analysis we rely on product-level export data for a panel of 316 Chinese cities over the 2003-2012 period, which covers the worldwide trade crisis of 2008-2010 during which the rebate rates rebounded after years of reduction. We directly link the rebate at a very detailed product level (HS6) to corresponding Chinese exports and study the effect of the policy depending on the local industry structure.

Our main contributions are twofold. First, our study contributes to a better under-

[1] The Value Added Tax (VAT) is an indirect consumption tax: it is paid to the revenue authorities by the seller of the goods, who is the "taxable person", but it is actually borne ultimately by the final consumer. Most countries, including also the EU countries, the US and Japan, leave no residual VAT contained in the export price to avoid double taxation on final consumption: exports are not subject to VAT and VAT exporters have paid on inputs is refundable. In China, incomplete VAT rebates to exporters make it less advantageous to export a product than to sell it domestically. Section 2 will show that the very name of VAT export rebates is misleading as the repercussions of a certain change in the rebate on exporters are not proportional to their value-added.

[2] We hence use the terms of incomplete VAT export rebate and VAT export tax interchangeably.

[3] In total, over the 2002-12 period, 89% of the products at the HS6-product level underwent at least one change in their VAT-refund rate.

standing of the export impact of VAT refund policy in China. So far, only very few other studies have investigated the effectiveness of this major industrial policy. Chen et al. (2006) use aggregate data from 1985 to 2002 and find that VAT export rebates are positively correlated with China's exports, final domestic consumption, and foreign exchange reserves.[4] Chandra and Long (2013) use firm-level panel data for 2004-2006 and find a positive association between firm export volume and the average rebate rate (over exports) in the firm's industry-province pair.[5] We are improving the analysis by using more disaggregated data over a longer period to obtain more detailed and in depth results, covering also the recent crisis. Using a different empirical strategy, we confirm Chandra and Long (2013)'s conclusion of the importance of the VAT export rebate policy for shaping China's exports. Our estimate of -6.6 is however only half the size of theirs. It is closer to that of Garred (2018). Garred (2018) studies the role of China's accession to the World Trade Organisation in 2001 in determining VAT export rebates and shows that there is a negative correlation between the VAT export tax and export value under the system of "ordinary trade" at the product level. His analysis remains however at the industry level, ignoring spatial export patterns, and does not tackle endogeneity issues.

We further add to these studies by showing that the effect on city-level export values goes uniquely via a change in the quantities and that prices, measured as unit values, are unaffected. Our point estimates of the effect of the VAT export tax on export quantities are actually quite similar to the trade elasticity estimates obtained in the recent trade literature (Head and Mayer, 2014). Both our estimates on quantities and prices are fully consistent with a model with heterogeneous firms building on Chaney (2008). In this model, exporters pass VAT export rebate changes through to prices but substantial entry/exit by inferior firms

[4] However, the size of their sample is limited to 18 observations.

[5] The explanatory variable in this study is the average ratio of the value of VAT rebates over exports, calculated over all exporting firms in the same province, 2-digit industry and year. This is instrumented by a proxy for local fiscal conditions.

leads to a compositional change such that there is no change in average prices.

Secondly, we are the first to show how the impact of such a trade policy varies spatially according to the local industrial composition. We find that export gains are all the more important as the product benefiting from an increase in VAT export rebates is densely connected to the local production structure. This result is in line with the finding of product spillovers that arise when locations specialize in closely related industries (Hausmann and Hidalgo, 2011). We find that export benefits from VAT export rebates are greater for localities which have the necessary capabilities and resources to carry out the activities supported by the rebate policy. These results highlight the importance of accounting for regional variations in the industry structure to estimate the local effect of an industrial policy and to help identify the main beneficiaries.

This analysis is motivated by and contributes to a growing literature that finds gains from matching between an activity and the local latent comparative advantage and warns against the inconsistency of industrial policies and the local productive structure (Crozet and Trionfetti, 2013; Lin, 2012; Cai et al., 2011). The production of goods requires capabilities and products that vary considerably in their knowledge requirements (Hausmann and Hidalgo, 2011). The density of a local economy's exports around a particular good measures the potential for subsequently producing this good with a comparative advantage (Hausmann, 2016).[6] Industrial policies are likely to work best when they target these high-potential products. We hence expect the VAT export rebate policy to have a greater effect on activities when there are denser pre-existing links to the local productive knowledge. To test for this heterogeneous effect, we construct a density indicator for each city-product pair which reflects the density of the links between the targeted product and the local product space. It is calculated using bilateral proximities between products that are determined at

[6] Hausmann et al. (2014) find that countries actually diversify to high-density products.

the worldwide level and hence cannot be suspected of endogeneity.[7] This indicator thus captures the intrinsic predisposition of a product in a given Chinese city to benefit from export-promoting policies. Moreover, it allows us to determine the causal effect of the VAT export tax on exports, even if the policy is endogenous. As products vary in terms of their intrinsic density of links to the local productive space structure, interacting this density index with the VAT export tax filters out the impact of the export tax policy.

Our empirical approach builds on efforts to address the problem of omitted variables which has traditionally hindered the evaluation of the impact of trade policies on export performance. It is indeed likely that the timing and scope of changes in the refund rate are correlated with various broader economic variables, such as worldwide economic conditions and product characteristics, as well as other industrial policies which likely affect export performance. Chinese authorities may have simultaneously increased VAT export rebates and implemented other trade-promotion measures. We then risk over-estimating the positive export effects of VAT refunds. Another problem comes from reverse causality: VAT export rebate rates may increase to boost the exports of poorer-performing products or, on the contrary, of those commodities with greater export-growth potential. In both cases we have endogeneity.

We follow a twofold strategy to counter this endogeneity. First, we exploit variations in the expected impact of the VAT export rebates by trade regime, which come from an eligibility rule disqualifying processing trade with supplied materials from the rebates. Second, by interacting the VAT export tax with the city-product specific density variable, we further exploit differences in the impact of the tax on a given product between cities.

Chinese trade occurs through either ordinary or processing forms. Processing trade refers

[7] Products are defined at the 6-digit of the Harmonized System (HS) of trade nomenclature. Proximity between two products is determined based on world co-exporting probabilities which are by construction not related to the particularities of Chinese locations. See Section 4.3 for details.

to operations of firms, most often foreign, which obtain raw materials or intermediate inputs from abroad and, after assembling them in China, re-export the products.[8] The typical VAT export rebate policy is that of "exempt, credit, and refund" (or "refund after collection"), which applies to ordinary trade and processing trade with imported inputs. By contrast, the "no collection and no refund" policy applies to processing trade with supplied inputs. In this type of trade, the firm undertakes processing or assembly work on materials it does not own. Even if the exporter pays VAT on purchases of intermediates, there is no entitlement to any export refund. We thus expect VAT export rebates to only have an effect on eligible export activities (ordinary and processing trade with imported materials).

Export data is disaggregated by city, product and regime type over the 2003-12 period. We isolate the causal effect of the VAT export tax stemming from incomplete VAT export rebates using a difference-in-difference estimate comparing its effect on eligible and non-eligible transactions. The validity of this difference-in-difference estimation crucially depends on proper accounting for differences between the eligible and non-eligible trade regime that could bias our coefficients of interest. We therefore incorporate city-product-regime and city-sector-regime-year dummies that capture also local sector specific export promotion policies.[9] We hence focus on the differential export repercussions of a change in VAT export taxes between eligible and non-eligible transactions by city for a specific product.[10] Our strategy then relies on the fact that China's (endogenous) export policy interventions are product-specific and not product-regime specific. We claim that even though Chinese authorities are concerned with promoting "high value added" trade and "eligible regimes" have higher value

[8] China's processing regime confers substantial benefits on export processors such as the right to import duty-free raw materials, components, and capital equipment used in processing activity (Naughton, 1996).

[9] Sectors are defined following the Chinese 4-digit GB/T industry classification and regroup several products. This is the standard industrial classification used in China and is likely to be of relevance for most national or local industrial policies.

[10] Moreover, we verify that our results remain the same when limiting the sample to processing trade, which allows to ensure a greater comparability between the eligible and non-eligible trade regimes by making our sample more homogenous.

added, the policies used such as subsidies and export rebates are set at the sector or product level and do not vary depending on the export regime. Product-year specific fixed effects capture all factors that affect all exports (both eligible and non-eligible flows) for a given product in a year and control for other nationwide industrial policies that target specific products (such as "high technology products" or "strategic products") and are potentially correlated with the VAT export rebate.

We also need to account for the possibility that the VAT export rebate policy affects the trade form chosen by firms, i.e. a higher VAT export tax for a given product may lead firms to switch from eligible to non-eligible trade. We show that non-eligible exports are indeed unrelated to the VAT export rebate so that our results do not simply reflect firms responding to VAT export tax adjustments by switching between the eligible and non-eligible trade regime. Further, we account for the fact that not all cities export in every year their products in both trade regimes. To make sure that these variations are not driving our results, we provide robustness checks on a sample of city-product pairs that export simultaneously under both regimes.

Our main results rely on a triple-difference specification where we solely exploit variations in the expected impact depending on the density of links between the taxed product and the local productive structure. Here additional product-regime-year fixed effects absorb all sources of differences in level and evolution for a given product between the two trade regimes and ensure that our results are immune to policy endogeneity and a potential switching of the trade regime.

Our results confirm that China's VAT export rebate system is indeed an effective tool for export management. Whereas there is, as expected, no significant effect on non-eligible exports, we find a negative and significant effect of the VAT export tax on eligible exports. The estimation of our difference-in-difference benchmark specification suggests that a one percent rise in the VAT export tax will lead to a 6.6% decline in eligible export quantities with respect to non-eligible trade.

The interaction between the VAT export tax and the city-product density measure shows that the export impact of VAT export taxes is greater for products that have stronger links with other products in the local export basket. Our results therefore suggest that industrial-policy effectiveness is strongly amplified by pre-existing productive knowledge so that the export gains from the national trade policy differ according to the location of exporting firms. This adds to the recent literature cautioning against one-size-fits-all policies that disregard local circumstances (Kali et al., 2013; Lin, 2012). In particular, our findings are in line with existing results that tariff interventions and export promotion policies in China were most successful when targeted at sectors where there was already a latent comparative advantage (Cai et al, 2011; Chen et al. 2017). Our findings highlight however an additional element: whereas the local product density is crucial for domestic exporters, it does not seem to affect foreign owned firms which are generally much less integrated into the local economy.

The remainder of the paper is structured as follows. The next section describes the Chinese VAT export rebate system. Section 3 overviews our empirical specification which derives from the model presented in Appendix E that incorporates export taxation from incomplete VAT export rebates into a standard trade model with firm heterogeneity. Section 4 describes the data and construction of variables. Section 5 discusses the results. The last section concludes.

2 The VAT export rebate system

2.1 The export tax formula

Implemented in 1994 to replace the old industrial and commercial standard tax, the Chinese VAT system differs from that applied in many Western countries, in particular because it is not neutral for exporters (Yan, 2010). In theory, neutral VAT implies a zero rate on exported goods and a full refund of the domestic VAT paid by exporters on their inputs. China started off with a complete rebate in 1994, but the strong rise in exports during the nineties turned into a heavy fiscal burden for the government, so that it quickly lowered the VAT export rebates and fixed different rates across sectors (Chandra and Long, 2013). In practice VAT applies at a standard rate of 17 percent on goods sold on the domestic and foreign market.[11] Export goods are however subject to the VAT export rebate system, which may lead to a reduced VAT rate. These rebates for exported goods vary by commodity and range from zero to the 17% VAT rate.

The Chinese VAT rebate policy on exports is complex and has changed frequently over time.[12] However, the logic has remained fairly stable (Ferrantino et al., 2012). Ordinary trade and processing exports with purchased imported materials fall under the standard rule, which is known as the "exempt-credit-refund" (or "refund after collection") method. According to Circular No.7 (2002), the official formula used to calculate VAT payable is as

[11] A reduced rate of 13 percent applies to basic staples or household necessities such as food, fuel, electricity, books, newspapers and magazines, and agricultural products.

[12] VAT rebates are set by the State Administration of Taxation. Changes are typically announced in a circular jointly edited by the State Administration of Taxation, the Ministry of Finance, the National Development and Reform Commission, the Ministry of Commerce and the General Administration of Customs.

follows:

$$\text{VAT payable} = \underbrace{\sum_k (\text{domestic sales}_k \times \text{VAT rate}_k)}_{\text{output VAT}} - \underbrace{(\sum_{k'} \text{inputs}_{k'} \times \text{VAT rate}_{k'})}_{\text{input VAT}} \\ + \underbrace{\sum_k (\text{Exports}_k - \sum_{k'} \text{BIM}_{k'}) \times (\text{VAT rate}_k - \text{VAT export rebate rate}_k)}_{\text{VAT export tax}} \tag{1}$$

where k denotes products and k' the intermediate inputs used to produce k.

Output VAT is the VAT collected on domestic sales and input VAT is the VAT paid on inputs subject to VAT. The input VAT applies to all inputs, whether domestically-sourced or imported, except the bonded duty-free imported materials (BIM).[13] The tax on exporters whose goods receive a VAT rebate rate lower than the applicable VAT rate is captured by the last interaction term in Equation 1. A higher VAT export rebate lowers the fiscal burden for exporters.[14] For exporters that do not use bonded duty-free inputs, a one percentage-point lower VAT rebate rises their tax payment by one percent of their export value. The change in the fiscal burden is thus not related to the value-added. The very name of the VAT rebate policy on exports is misleading as the bite of a certain shortfall in the rebate does not hurt firms in proportion to the importance of their domestic input purchases.[15]

In contrast to ordinary trade and processing trade with imported material, processing exports with supplied materials are not entitled to any VAT refund (China Tax & Investment Consultants Ltd, 2008). This type of trade falls under the rule of the "tax-exempt" (or "no collection and no refund") method. In this case, even if the exporting company paid VAT

[13] Imports under the bonded status are free from import duties and VAT. This would typically be the case for processing trade activities.

[14] If the VAT payable is negative, the tax bureau will refund it. In fact, the amount of refundable VAT is capped by $\sum_k(\text{Exports}_k$ - $\sum_{k'}\text{BIM}_{k'})$.

[15] There is hence no need to know the share of the domestic value added in exports to assess the quantitative importance of the VAT rebate policy for exports. In our empirical strategy the key explanatory variable is the VAT export tax defined as the difference between the VAT rate and the VAT export rebate rate, in logs as derived from our model in Appendix E.

on purchases on inputs, it is not entitled to any refund. In export processing with supplied materials, the Chinese firm undertakes processing or assembling work on materials it does not own. The property of these materials is retained by a foreign party. The Chinese authorities then consider that there are no imports and no export sales: as such, no VAT on imported inputs is collected and hence no VAT is refunded.

Our empirical approach, detailed in Section 3, exploits the eligibility rule that disqualifies processing trade with supplied materials from the rebates. We measure the impact of the VAT export rebate policy on city-level exports as its differential effect across regime types for a given product-year pair, while accounting for structural differences across product, cities and the two trade regimes via various sets of fixed effects.

2.2 Stylized facts on VAT rebates

Over the 2002-2012 period, only 13% of the products received rebates compensating for the full VAT rate. Incomplete rebates, which are equivalent to export taxation, are hence the rule in China. There are a variety of rationales for these export restrictions including the manipulation of the terms-of-trade (Garred, 2018), stabilization of the domestic demand, food security or value-chain climbing (Bouët and Laborde, 2011). In China, VAT export rebate changes have been carried out frequently to address various economic issues: managing the trade surplus, increasing government revenue or guiding the growth of certain industries to promote structural change.

Figure A-2 depicts the evolution of the average VAT export tax over the 2002-2012 period. The average tax rate increased continuously from 2002, before falling sharply in 2009 in reaction to the international crisis. The upward trend reflects mostly the attempt to reduce the growing financial burden of refunding the rebates for the government as China's trade surplus exploded. It may also reflect China's attempt to offset the effect of the import tax cuts implemented in the context of WTO accession (Garred, 2018). In addition it corresponds to strategic reductions of rebates on products associated with environmental problems or looming trade disputes (Gourdon et al., 2016). Whereas in 2002 the average VAT export tax rate was only 2%, it increased to around 8% in 2008. This rate decreased to around 6% in 2009 as the global economic crisis induced the authorities to raise the VAT export refund rates on thousands of commodities.[16]

The primary logic of VAT export rebate changes relates to the support for sophisticated high-technology products and the limitation of exports of energy intensive and polluting products (Gourdon et al., 2016; Eisenbarth, 2017). Variations in VAT export rebates also appear consistent with mitigation of trade dispute risks (i.e. low rebates apply on rare earths) and food security. The financial crisis in 2008 has however led authorities to engage in an across the board rise in export rebates. Reinforced support to export activities hence applied to a variety of industries in which China had a comparative advantage including low technology products such as textiles and ceramics (Gourdon et al., 2016). There is hence no reason to believe that rebates are disproportionately targeted towards products whose export response is very elastic with respect to rebates so that it drives our findings.

Figure A-3 displays, for each of the 97 HS2 categories, the average and standard deviation of VAT export taxes for 2002, the first year of our sample.[17] This shows that VAT export taxes vary substantially across products, even within a sector.

Figure A-4 reports for each HS2 category the average annual change between 2002 and 2011 in the VAT export tax at the HS6 level, illustrating the magnitude of changes in the VAT rebates over the period. While over our sample period the VAT export tax has overall

[16]The average probability that an adjustment takes place in a given year for a given HS6 product was 34% over this period. This figure was over 60% in both 2004 and between 2007 and 2009.

[17]In our regressions, we define sectors according to the Chinese 4-digit GB/T industry classification. However, since there are more than 400 GB/T sectors, Figures A-3 and A-4 use the broader HS2 classification which has only 97 subgroups. A HS2 category regroups up to 509 HS6 products.

increased, a number of sectors appear with negative average growth rates. The reported standard deviations also highlight the wide range of magnitudes in the change in the VAT rebate across products, which is consistent with the use of VAT export rebates as an industrial policy tool.

3 Empirical specification

Our empirical specification is directly derived from the simple model of international trade with heterogenous firms presented in Appendix E. The dependent variable is the log of the export quantity of HS6 product k in city c under regime R in year t, with R comprising the eligible and non-eligible regime. Our focus on export quantities is motivated by growing evidence on the underreporting of export values by exporters to avoid paying taxes (VAT or processing taxes) based on export value (Ferrantino et al., 2012). Quantities are more easily observable by customs authorities and hence considered less subject to misreporting.[18] Using disaggregated data at the city-level has several advantages. First, it reduces reverse causality concerns since the variation of export flows at the city level is unlikely to affect changes in the nation-wide VAT rebate policy. Second, it allows to control for the spatial heterogeneity in China's economy and to study how it influences the effectiveness of national trade policy.

3.1 Double difference: the effect of VAT export taxes on exports

We first estimate the average impact of a change in the VAT export tax on exports without considering the role of local product density. Our double difference benchmark specification

[18] Fisman and Wei (2004) find prevalent underreporting of the total value imported to China from Hong-Kong but not significant misreporting of total quantities. In Section 5.3, we complement the quantity estimates with results on values and unit values to infer the impact of a VAT export rebate change on the pricing strategy of the exporter.

implemented in Section 5.1 is the following:

$$\ln \text{Export quantity}^R_{ck,t} = \alpha \ \ln \text{VAT export tax}_{k,t-1} \times \text{Eligibility}^R + \lambda X^R_{ck,t-1} + FE_{k,t} + FE^R_{ck} + FE^R_{cs,t} + \epsilon^R_{ck,t} \quad (2)$$

In line with our model, the VAT export tax variable is defined as ln (1+(VAT rate-VAT export rebate)). The dummy *Eligibility*^{R} takes the value one if the export flow is in the eligible trade regime and zero otherwise.

Our key coefficient of interest, α, captures the differential impact of the VAT export tax on eligible exports relative to non-eligible exports. It includes both the effect on the number of firms and on the quantity sold by each firm.[19] The VAT export tax variable is lagged by one year to allow the firms to adjust their production to the generally unanticipated changes in the tax rates.[20]

Our preferred specification includes product-year fixed effects ($FE_{k,t}$). This way we appeal to a differential effect of rebates across regime types for a given product-year pair. Product-year dummies account for all factors that affect product-level exports irrespective of the trade regime in a given year. These include world demand and all product-specific policies which have the same expected impact on eligible and non-eligible exports, such as sector-level subsidies, tariffs imposed by China's trading partners, R&D promotion policies etc., and which are potentially correlated with the VAT rebate (Girma et al., 2009). We are not aware of any other national policy that treats eligible and non-eligible trade flows differently, except for import tariffs which we include explicitly in our regressions. In line

[19]We are unfortunately not able to study in greater details the margins of adjustment since information on the type of processing trade, which is key to our identification strategy, is available at the firm level only until 2006. Our study focuses on the intensive margin of adjustment at the city-product level.

[20]In unreported results available upon request we add the contemporaneous VAT export tax variable in our specification to check whether firms anticipate or respond to policy changes faster than a one-year lag. This variable is not significant and its introduction does not affect the coefficient on the lagged rebate rate term.

with the literature exploring the motivations behind China's industrial and trade policy (Garred, 2018; Eisenbarth, 2017), we believe that the endogenous choice of export tax rates by the authorities is at the product-level and not at the product-regime level.

We account for a city's comparative advantage and export intensity in a given product under a specific regime type with city-product-regime fixed effects, (FE^R_{ck}). The existing literature points to several fundamental differences between the three types of trade (eligible ordinary, eligible processing with imported materials and non-eligible processing with supplied inputs), besides their eligibility to VAT rebates.[21] As these city-product fixed effects vary by regime type, we control for structural differences between eligible and non-eligible regimes and make trade under both trade regimes more comparable.

$FE^R_{cs,t}$ are city-sector-regime-year dummies that capture demand and supply shocks that are common to all products of regime type R in sector s in year t for city c.[22] They control for potential time varying differences across regime types for a specific sector in a given city. This captures, for example, local shocks impacting the two trade types differently, a potentially differential evolution of exporter characteristics across trade regimes or the average of rebate rates for all the products within the same sector.[23] Further, these fixed effects control for all time varying city and sector characteristics such as labor and capital intensity.

Since it is still possible that local export dynamics for a given product vary by trade regime or city, we add a vector of control variables $X^R_{ck,t-1}$, with coefficient vector λ. Therefore, we include the share of exports by foreign firms (Foreign share$^R_{ck,t-1}$) and the share

[21]Several papers highlight the sharp contrast between ordinary and processing regimes notably in terms of their domestic value added, sectoral distribution, production structure, productivity and factor intensity (Kee and Tang, 2016; Dai et al., 2016).

[22]Sectors s are defined following the Chinese GB/T industry classification. Our main sample with 3,346 products at the HS6-level consists of 401 4-digit sectors. The match between Chinese GB/T industry codes and HS codes is taken from Upward et al. (2013). There are a few HS6 for which the GB/T code is not available. In this case we assign missing values with the most common GB/T over coarser HS codes.

[23]In Section 5.4, we further show that our results hold when dropping ordinary trade and limiting the sample to processing trade only, where the structural differences between eligible and non-eligible trade are expected to be much smaller.

of state-owned firms (State share$^R_{ck,t-1}$) defined at the city-product-regime level. These two controls are crucial to account for the time-varying ability of different localities to export different products (under different regimes) as export performance in China varies greatly by firm ownership (Amiti and Freund, 2010).[24] We further include the change in city-level export quantity for products from t-2 to t-1 at the HS6 product-level (Export growth$_{ck,t-1}$) to account for export dynamics at the city-product level.[25]

Finally, $\epsilon^R_{ck,t}$ is the usual error term. All regressions cluster standard errors at the product level to account for serial correlation of the error term within products.

One remaining concern of this baseline difference-in-difference specification comparing VAT export tax repercussions on eligible and non-eligible exports is the possibility that the VAT export tax policy affects the trade form chosen by exporting firms, i.e. higher VAT export tax for a given product may lead firms to switch from eligible to non-eligible trade. While Appendix B provides some suggestive evidence that this is not a major threat to our identification strategy, our triple difference specification detailed in the following subsection addresses this concern directly.

3.2 Triple difference: the role of local product density

In Section 5.2 we estimate a triple difference specification in which we further refine our identification strategy by exploiting variations in the expected impact of the VAT export taxes by product across cities depending on the city-product specific density indicator. For this we adapt Equation 2 to include the triple interaction term between the VAT export tax, the Eligibility dummy and the density of the links between the targeted product and the local product space. This indicator, which will be detailed in Section 4.3, is calculated at

[24]The VAT export rebate policy does not depend on the ownership of the firm but only on the chosen trade regime.

[25]See Appendix D-1 for the construction of these variables.

the city-product level for the year 2000, two years prior to our sample period.

We obtain Equation 3:

$$\begin{aligned}\ln \text{Export quantity}^R_{ck,t} = \beta\ \ln \text{VAT export tax}_{k,t-1} \times \text{Eligibility}^R \times \text{Density}_{ck} \\ + \lambda X^R_{ck,t-1} + FE^R_{k,t} + FE^R_{ck} + FE^R_{cs,t} + \epsilon^R_{ck,t} \qquad (3)\end{aligned}$$

where our main variable of interest is the triple interaction term that identifies the intrinsic predisposition of a product in a given city to benefit from the VAT export tax policy. This triple interaction term does not only vary by product, year and trade regime, but also by location. This allows us to introduce product-regime-year fixed effects, $FE^R_{k,t}$, which account for all time-varying differences across products that vary by regime type and could not be controlled for in our difference-in-difference specification. This hence accounts for possible switches in the trade regime within the same product over time and directly addresses the concern over reverse causality between the VAT export tax and the trade regime.

To correctly identify our coefficient of interest, β, the vector of controls, $X^R_{ck,t-1}$, also includes the interaction between the VAT export tax, local product density and a dummy for Non-eligibility to ensure that we control for the effect of the interaction of the tax with product density for both trade regimes.[26] The product-regime-year fixed effects, $FE^R_{k,t}$, capture the interaction between the VAT export tax and the Eligibility dummy, while the interaction between the Eligibility dummy and local product density is constant over time and thus captured by the city-product-regime fixed effects (FE^R_{ck}).

[26] Alternatively, we can also control for the simple interaction of the VAT export tax and the local product density. This would give us the average effect of the interaction term on both trade regimes while the triple interaction term with Eligibility would capture the additional effect for eligible exports. The choice of the specification does not affect our results.

4 Data and Indicators

4.1 Data on VAT rates and rebates

Our variable of interest is the VAT export tax corresponding to the difference between the VAT rebate and the VAT rate. VAT export rebate rates and VAT rates at the tariff-line level (HS 8-digit or more disaggregated levels) are taken from the Etax yearbooks of Chinese Customs. While VAT export rebates change frequently, the VAT rates have remained constant between 2002 and 2012.[27]

The Chinese 8-digit classification is not consistent over time. To account for these changes which follow the different revisions of the international HS classification in 2002, 2007 and 2012, we aggregate the data to the HS 6-digit level (1996 revision)[28] using the yearly average of these rates.[29] This gives us the VAT rate and VAT export rebate for 5,006 exported HS6 products. Table A-1 presents some descriptive statistics.

4.2 Trade data

The data collected by Chinese Customs include annual export values and quantities by city at the 8-digit product level and separate trade flows according to transaction type and firm ownership.[30] Aggregating the trade flows to the HS6 (1996 revision) level yields a panel of 4,823 products over the 2003-12 period.

We split export flows into two groups depending on whether they are eligible or not

[27]The standard rate of 17 percent applies to roughly 93% of our main sample.

[28]The correspondence tables from UNCTAD can be found at http://unstats.un.org/unsd/trade/conversions/HS Correlation and Conversion tables.htm.

[29]We use the simple average of all tariff lines within a HS6 product and all sub-periods within the year.

[30]Trade flows are also available by destination. However, in our main results, we do not exploit this dimension as the VAT export rebate policy is independent of the destination of the exports. Since the effect of the rebate is not expected to vary according to the chosen destination adding this dimension would simply result in a much greater number of observations and a larger set of fixed effects to include. We rely on the destination of exports only in Table B-1 where we address the potential switching of the trade regime after a change in the VAT export tax.

to VAT refund. Eligible trade includes ordinary trade and processing trade with imported materials (also known as import-and-assembly). The latter refers to "business activities in which the operating enterprise imports materials/parts by paying foreign exchange for their processing, and exports finished processed products for sale abroad" (Manova and Yu, 2016).

Non-eligible trade corresponds to processing trade with supplied materials (also called processing & assembly).[31] It refers to "the type of inward processing in which foreign suppliers provide raw materials, parts or components under a contractual arrangement for the subsequent reexportation of the processed products. Under this type of transaction, the imported inputs and the finished outputs remain property of the foreign supplier" (General Administration of Customs of the People's Republic of China, 2013).

Combining the trade data and the VAT data leaves us with 4,792 HS6 products and 436 cities.[32] As our empirical strategy appeals to heterogeneous policy responses according to the trade regime, we drop products which are not exported under both the eligible and the non-eligible regime, as well as localities that do not export under both trade regimes.[33] We further drop the observations corresponding to the top and bottom 1% of product density to ensure that results are not driven by outliers.

Our final sample includes observations for 316 cities on 3,346 HS6 products (representing 346,986 city-product pairs). The trade included in this sample represents over 80% of China's total exports under these two regimes over the sample period.

[31] The other transaction types in the data include international aid, border trade, contracting projects, customs warehousing trade and logistics goods by customs special control area. These other regimes together cover less than 7% of total exports over the 2003-2012 period. We do not include these flows in our analysis as we have only limited information on how the VAT export rebate policy is applied to them. Column 2 of Table A-2 provides robustness checks to ensure that our results remain when this trade category ("others") are included and regarded as eligible.

[32] China is divided into 4 municipalities (Beijing, Tianjin, Shanghai and Chongqing) and 27 provinces which are further divided into cities which are administrative units encompassing an urban area and adjacent rural counties under its jurisdiction. Our sample includes prefecture and county level cities. Our main results hold if we limit our sample to prefecture-level cities only.

[33] We exclude exports coming from the so-called "bonded zones" and "export processing zones" in which all processing trade is treated as non-eligible for VAT refund.

4.3 Product density at the local level

To evaluate whether the export repercussions from the VAT export tax depend on pre-existing productive capabilities and resources, we use a city-product specific density indicator, as developed by Hidalgo et al. (2007) and Kali et al. (2013), which measures the density of the linkages between product-level export activities and the local product space. We proceed in two steps. First, we determine the relatedness of two given products using international export flows ($\phi_{k,k'}$). Then, using these relatedness measures, we compute a city-product specific variable ($Density_{ck}$) which captures how well the specific product is connected to the main export products of the city.

4.3.1 Construction of revealed comparative advantage and bilateral proximity of products

The degree of proximity $\phi_{k,k'}$ between two products k and k' is calculated based on world co-exporting probabilities. The products that are co-exported with another product in many countries are considered as an outcome-based measure of relatedness. The underlying idea is that co-exporting reflects similar requirements in various dimensions, notably in terms of production factors, technology and local institutions. We compute the probabilities that countries with a revealed comparative advantage (RCA) in one of the goods (k or k') also have a RCA in the other. Revealed comparative advantages are defined using the Balassa's (1965) index. A country is said to export a good with a comparative advantage (RCA=1) when the ratio of the export share of that product in the country's export basket to the analogous worldwide export share is greater than 1. Otherwise the RCA of the product in this country is zero.

Formally, we define Pr($k|k$') as the ratio of the number of countries with a RCA in both k and k' over the number of countries with a RCA in k', and Pr(k'$|k$), the ratio of the number of countries with a RCA in both k and k' over the number of countries with a RCA in k. Proximity between product k and k' is then defined as the minimum of those two pairwise conditional probabilities:

$$\phi_{k,k'} = min[Pr(k \mid k'), Pr(k' \mid k)] \tag{4}$$

This bilateral relatedness $\phi_{k,k'}$ between products k and k' is calculated for 5111 HS6 products, using data for 238 countries in 2000 from the BACI world trade dataset (Gaulier and Zignago, 2010). We use data from 2000, two years prior to our sample period. A few examples of the proximity measure for some particular product pairs help to illustrate how products are related to each other[34]: We compute that digital computers have a proximity value of 0.06 with cotton T-shirts. For the entire sample of countries exporting computers or cotton T-shirts with a RCA, only 6% export the other product with a RCA at the same time. This low value clearly indicates the distinct requirements needed for the export of the two products. On the contrary, computers have relatively high proximity (0.32) to cars, suggesting that the requirements for computer and car export are quite similar.

4.3.2 Construction of product-city density measure

Density for good k in city c (Density$_{ck}$) is calculated as the average of good k's bilateral proximities (ϕ) with the other goods that city c exports with a comparative advantage (RCA$_c$=1):

$$Density_{ck} = \frac{\sum\limits_{k' \in RCA_c=1, k' \neq k} \phi_{k,k'}}{\sum\limits_{k' \neq k} \phi_{k,k'}} \tag{5}$$

This indicator can take values from 0 to 1 and reflects the density of the links between a given product and the local product space. High density values indicate that city c has a comparative advantage in many goods that are closely related to product k and thus that the

[34] Refer to Poncet and de Waldemar (2015) for more descriptive statistics on bilateral proximity of products.

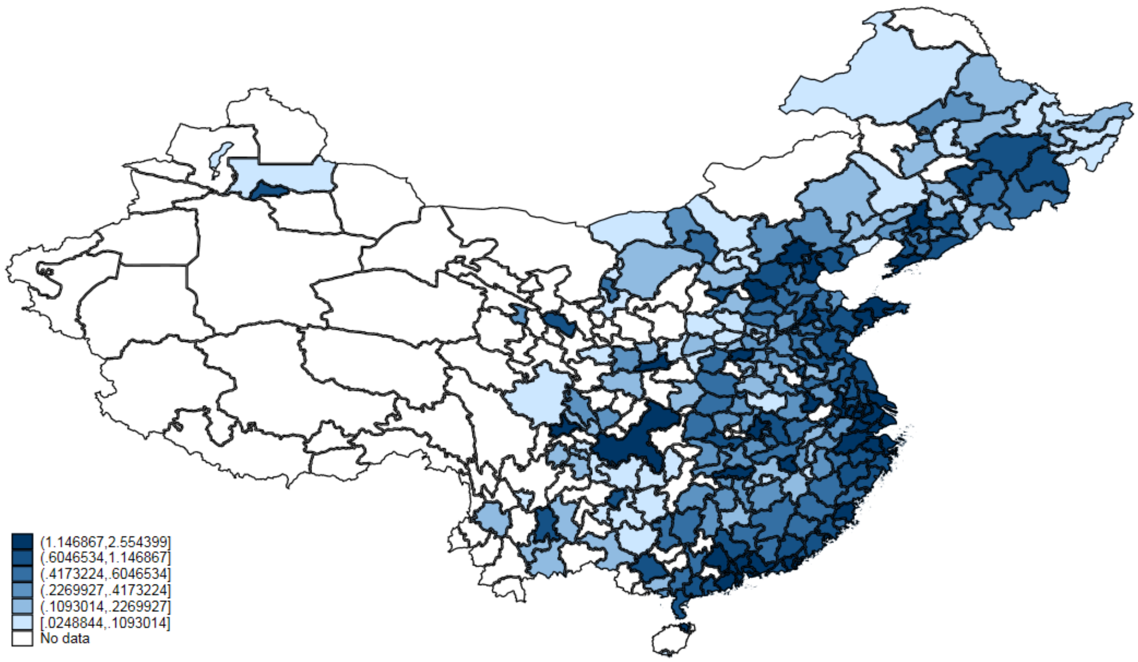
local productive structure is likely to offer the necessary capabilities and resources to allow industrial policies targeting product k to effectively promote exports of k. We expect greater export repercussions of the VAT export rebate policy and more generally of industrial and trade policies for cities with high density of their exports around the product encouraged by the policy. This is because high density confers a pre-disposition to growth thanks to greater ability to find and exploit the required capabilities and resources. Looking at the development of Export Processing Zones (EPZ) in China, Chen et al. (2017) find sizeable export benefits from the opening of an EPZ which are greater for sectors with denser links with the local productive structure. This is in line with density proxying for product spillovers emanating from consistent specialization, such as knowledge externalities and economies of scale and scope spillovers (Kali et al., 2013; Hidalgo et al., 2007; Poncet and de Waldemar, 2015).

RCAs for each Chinese city are computed using data from 2000, two years prior to our sample period, so that it captures pre-existing productive knowledge, abstracting from the reverse causality coming from subsequent export performance. We consider this density indicator as exogenous since bilateral proximities are determined at the worldwide level and hence cannot be suspected of endogeneity. Also, by summing over the products k' and excluding product k, this variable does not incorporate any information on the local export flows for product k.

Figure A-5 displays the distribution of product density for our main sample.[35] The product density measure varies quite substantially across products and cities. To illustrate the resulting spatial variation, the map in Figure 1 shows the average density by city. The three cities with the highest average product density are three of the largest exporters, Shanghai, Beijing and Hangzhou. But a number of inland cities (for example Harbin in the

[35]To make it easier to read the graphs and tables, we have rescaled our density variable from 0 to 1 to 0 to 10.

Figure 1: Average product density by prefecture (2000)



Note: Averages are constructed using product-city specific densities for 2000. Only product-city observations from our main sample are included.

North East) also have relatively high average densities.[36]

5 Results

5.1 Double-difference results: the VAT export tax impact

Before we look at the magnifying role of local product density, Table 1 first presents results on the average effect of the VAT export tax on export quantities (following the specification in Equation 2). The effect of the VAT export tax is identified by comparing its effect on eligible trade flows for a given city-product pair with that on the corresponding non-eligible flows.

[36]In our empirical analysis, the average density by city will be captured by the city fixed effects. The conditional effect of product density on the export repercussions of the VAT export tax is identified by exploiting variations in product density for the same product across cities.

Table 1: The impact of the VAT export tax on export flows

Dependent variable	Ln export quantity (city/product/trade regime/year)				
Trade regime	(1) All	(2) All	(3) Eligible	(4) Non-Eligible	(5) All Benchmark DD
Ln VAT export tax$_{k,t-1}$×Elig.^{R}	-8.743^a	-7.412^a	-7.396^a		-6.625^a
	(0.582)	(0.533)	(0.532)		(1.279)
Ln VAT export tax$_{k,t-1}$×Non Elig.^{R}	-1.211	-0.246		-0.524	
	(1.137)	(1.113)		(1.113)	
Export growth$_{ck,t-1}$		0.156^a	0.158^a	0.110^a	0.156^a
		(0.002)	(0.002)	(0.007)	(0.002)
Foreign export share$^R_{ck,t-1}$		0.409^a	0.399^a	0.504^a	0.396^a
		(0.010)	(0.011)	(0.026)	(0.010)
State export share$^R{}_{ck,t-1}$		0.016^b	0.001	0.251^a	-0.009
		(0.008)	(0.008)	(0.029)	(0.007)
Export growth$_{k,t-1}$		0.112^a	0.114^a	0.099^a	
		(0.011)	(0.012)	(0.030)	
World demand$_{k,t-1}$		2.102^a	2.132^a	1.804^a	
		(0.148)	(0.149)	(0.304)	
Export tax$_{k,t-1}$		-0.014	-0.014	0.010	
		(0.009)	(0.009)	(0.019)	
Import tariffs$_{k,t-1}$×Elig.^{R}		0.003	0.003		0.014
		(0.005)	(0.005)		(0.011)
Import tariffs$_{k,t-1}$×Non Elig.^{R}		0.005		0.007	
		(0.011)		(0.011)	
Fixed effects					
FE$^R_{ck}$	Yes	Yes			Yes
FE$^R_{cs,t}$	Yes	Yes			Yes
FE$_{ck}$			Yes	Yes	
FE$_{cs,t}$			Yes	Yes	
FE$_{kt}$					Yes
Observations	1,890,487	1,890,487	1,713,240	177,247	1,890,487
R^2	0.872	0.875	0.875	0.871	0.884

Heteroskedasticity-robust standard errors clustered at the product level appear in parentheses. ^{a}, ^{b} and ^{c} indicate significance at the 1%, 5% and 10% confidence level respectively. c stands for city, k for the HS6 product level, t for year and R refers to the two eligibility regimes in the VAT-rebate system: the non-eligible processing trade with supplied inputs and the eligible ordinary and processing trade with imported materials. Sectors are defined following the Chinese 4-digit GB/T industry classification and regroup several products.

In columns 1 and 2 we exclude the product-year fixed effects $\mathrm{FE}_{k,t}$ to get an estimate of the repercussions of the VAT export tax on exports for both trade regimes. To obtain the effect of a change in the tax for non-eligible exports, we include the VAT tax interacted with a dummy for non-eligibility.[37] In column 2, we add a variety of product-year specific variables to compensate for the absence of $\mathrm{FE}_{k,t}$. Following the gravity literature, we account for the demand-side determinants of exports by including the world import value, defined at the product level. Further, we add export taxes and import tariffs which are specific to product k.[38]

Since import tariffs apply only to ordinary trade, we allow the coefficient of import tariffs to be different for eligible and non-eligible trade. The latter, which consists uniquely of processing trade, should not be affected by this tariff.[39]

The strong negative and highly significant coefficient of the VAT export tax for eligible exports in columns 1 and 2 show that the export tax stemming from incomplete VAT rebates has negative repercussions for eligible exports. In contrast, and in line with our expectations, the VAT export tax has no significant effect on quantities when exports consist of non-eligible processing with supplied inputs, as indicated by the relatively small and non-significant coefficient of VAT export tax $\times$ Non Eligibility.

Our proxies for world demand and supply side dynamics have all the expected positive and significant impact on our dependent variable. However, other trade policy measures (export tax and import tariffs) fail to be significant. In presence of sector-year dummies

[37] An alternative specification for these first two columns that gives the same results would be to include the product-specific VAT export tax variable and its interaction term with the Eligibility dummy.

[38] Export tax is another fiscal measure affecting Chinese exports, although it applies to far fewer products than VAT export rebates. For a detailed description and the construction of the control variables, see Appendix D-1.

[39] We do not know the corresponding import tariffs on imported inputs for an observed export flow since we do not know which inputs are used in the production of ordinary exports. But we include city-sector-year-regime fixed effects which account for the general level of import tariffs on inputs used by sector s in city c in year t in a way which is specific to each regime type R.

($\mathrm{FE}^{R}_{cs,t}$) this may reflect that there is limited heterogeneity in these rates between products in the same sector.

Columns 3 and 4 restrict the sample to eligible and non-eligible exports respectively. This allows all variables to have a different coefficient according to the eligibility status. Our results confirm that the VAT export tax has a negative and highly significant effect on eligible trade, while the coefficient of the VAT export tax for non-eligible trade is insignificant. This latter result confirms that non-eligible trade is a valid control group for evaluating the export repercussions of the changes in the VAT refunds to exporters. Changes in the VAT export rebate rate hence do not seem to result in a simple nominal relabeling of the trade regime. We thus reject the possibility that the value of trade going up in the eligible regime after the rebate rise is being merely reallocated from the non-eligible regime with total trade remaining the same.

Column 5 reports our double-difference (DD) benchmark results (corresponding to Equation 2). The added product-year fixed effects account for all time-varying product-level factors which are common to both regimes so these variables are dropped.[40]

Our key variable of interest, the interaction term between the VAT export tax and the Eligibility dummy, is highly significant. The coefficient of -6.625 suggests that a one percent increase in the VAT export tax leads to a 6.625% decrease in eligible export quantities relative to non-eligible exports. This effect is economically significant. While the estimate is half that of Chandra and Long (2013), it is about the same size as Garred's (2018).

By using more disaggregated data at the city and product level we obtain a more reasonable impact which is also in line with the estimates of aggregate trade elasticities found in the recent trade literature (Bas et al., 2017; Head and Mayer, 2014) and in our simple

[40]We also have to drop the VAT export tax interacted with the dummy for non-eligible flows, as keeping both interaction terms with the VAT export tax would lead by construction to the presence of multicollinearity with the product-year fixed effects.

model presented in Appendix E. To illustrate, we can solve Equation E-9 of the model for exported quantity assuming following Chaney (2008) that the marginal cost c has a Pareto distribution, bounded between 0 and 1, with a shape parameter $\gamma > \sigma - 1$. In that case, marginal cost is distributed as $P(\tilde{c} < c) = F(c) = c^{\gamma}$ and $dF(c) = f(c) = \gamma c^{\gamma-1}$. This yields an export tax elasticity for the export quantity equal to $(1-\gamma)\frac{\sigma}{\sigma-1}$. The literature proposes estimates of σ for China that average at 6 (Broda and Weinstein, 2006). Following di Giovanni and Levchenko (2013) and considering that $\gamma/(\sigma-1)$ can range between 1 and 2, we obtain a range for the elasticity between -4.8 and -10.8, which is remarkably consistent with our estimate of -6.625.

Table A-2 in Appendix A shows that results hold and magnitudes of VAT export tax coefficients remain highly similar when controlling for even stricter fixed effects at the HS4 product-level instead of the sector-level (column 1) or when including the trade category "others" in the eligible trade (column 2). Results also remain similar when reducing the sample to only city-product combinations ("reduced sample I") that report exports under both types of trade during our sample period (column 3) or using a very strict sample including only city-product observations ("reduced sample II") that report both types of trade in the same year (column 4).[41]

The last column of Table A-2 investigates whether the impact of the policy is stable over our sample period. For this, we split our sample into two periods: 2003-2007 and 2008-2012. The coefficients for these two subperiods are highly similar. There seems to be no disruption in the repercussions of the VAT policy during the crisis, which suggests the massive rise in Chinese VAT export rebates in 2008 helped to maintain the profitability of domestic exporters amid declining world prices, and resulted in greater Chinese export quantity and

[41] In unreported results, we also ensure that results hold for the reduced sample I when observations with zero exports are included and using quantities in levels or ln(1+quantity) as the dependent variable. Due to the high dimensional fixed effects, we cannot provide standard Tobit estimates including zero-value trade flows.

value.

One problem that is potentially still outstanding despite the reassuring results so far relates to misreporting of exports for the purpose of tax evasion. Misreporting can happen either through the underreporting of the export value or through the misclassification of goods within sectors. We undertake three additional steps to ensure that our findings of a negative effect of the VAT tax on export quantity growing with local product density is not merely reflecting some misreporting.

First, we investigate the possibility that firms may declare their product in a different HS6 category when its rebate decreases. Since it is likely to be easier to misclassify within a similar category as the descriptions are quite similar, we construct for every HS6 the simple average of the VAT tax within its sector, excluding the own tax. If misclassification is common, this variable should attract a positive and significant coefficient. When we add this variable to our double-difference benchmark specification, we find a low positive but non-significant effect, while the other estimates are not affected. We thus do not report this result and conclude that by this test at least there is no evidence for systematic misclassification.

Second, in Section 5.4, we will further ensure that our results do not reflect misreporting by excluding ordinary trade and focusing on processing trade only, as stricter controls and enforcement of processing trade at the Chinese border makes processing exporters less likely to underreport than normal exporters (Ferrantino et al., 2012).

Finally, we exploit the fact that if misclassification is more likely between similar products it should not vary across localities depending on the density of the links that the products have with the local industrial structure. In the following section, we interact the VAT export tax with the product-city specific density and include product-year-regime type fixed effects, so as to control for all product-specific incentives (including the VAT export tax) that companies have to misclassify their eligible exports. This should significantly reduce the risk of misclassified products distorting our estimates.

5.2 Triple-difference results: the role of local product density

Table 2 reports the results from our triple-difference specification (Equation 3), where we exploit variations in the expected impact of the VAT export tax depending on the density of links between the taxed product and the local productive structure. This also helps to address endogeneity issues, as we filter out the impact of the export tax policy using the density index which captures the intrinsic predisposition to benefit from export-promoting policies for a given city-product pair.

As in Table 1 we start in column 1 with a simpler specification which excludes the product-year fixed effects. This way, we can see the effect of the VAT export tax for the two trade regimes as well as the conditioning role of the local product density indicator. For non-eligible exports neither the coefficient for the VAT export tax nor its interaction with local product density is significant, suggesting again no link between VAT export rebates and non-eligible export performance. Our key variable of interest, the triple interaction term of the VAT export tax with density and the Eligibility dummy, attracts a negative and highly significant coefficient. This uncovers an important heterogeneity in the effect of the VAT export tax depending on local product density. According to this specification, an increase in density by one standard deviation brings an additional rise of 1.64 percentage points in exports after a one percentage point decrease in the VAT tax.[42] To better illustrate the key role of product density, we compare the export gains from such a VAT export tax reduction for a product at the 10th percentile and a product at the 90th percentile of the within-city distribution of density. We compute that they differ by a factor 1.83. The total beneficial effect would be 9.59 ($4.126 + 2.529 \times 2.16$) for the product at the 90th percentile and but

[42]This number is calculated by multiplying the standard deviation of density (0.65) with our coefficient of -2.53.

only 5.23 (4.126 + 2.529×0.438) at the 10th percentile.

Column 2 reports our baseline triple difference (DDD) estimates. Since our main variable of interest, the triple interaction between the VAT export tax, the Eligibility dummy and the local product density, varies not only by product and year but also by city we can add product-year-regime type fixed effects (FE^{R}_{kt}) which capture all time-varying differences between the two trade regimes for a given product, including the average unconditional effect from the VAT export tax. We hence focus on the magnification of the policy repercussions due to denser links between the taxed good and the local productive structure.

This demanding framework makes it possible to purge the estimated effect of the policy of the last remaining endogeneity problem due to a possible regime change or relabelling in response to a tax change. Therefore, we consider the triple difference (DDD) specification of column 2 as our main specification and will use it to perform various robustness checks in the following sections.

In spite of the strong controls, we still identify a significant negative effect of the interaction term between density and the VAT export tax for eligible trade, which confirms the importance of the VAT export tax. The coefficient of 1.102 indicates that a one standard deviation increase in product density leads to an additional effect of the VAT tax on eligible exports of 0.66 percentage points.

Columns 3 to 5 report results separately for non-eligible and eligible trade. They confirm our findings of a negative effect of the VAT export tax for eligible trade that grows with pre-existing productive knowledge. None of the interactions are significant for non-eligible trade.

We hence interpret our results as evidence that when a city has already an advantage in producing goods that have similar production requirements to product k, raising exports of k in response to an increase in its VAT export rebate is easier because there are

Table 2: Benchmark results on the role of product density

Dependent variable	Ln export quantity (city/product/trade regime/year)					
	(1)	(2)	(3)	(4)	(5)	(6)
Trade flows	All trade flows	Benchmark DDD	Eligible		Non-eligible	
Ln VAT export tax$_{k,t-1}$×Elig.^{R}	-4.126^a		-4.109^a			
	(0.749)		(0.750)			
Ln VAT export tax$_{k,t-1}$×Non Elig.^{R}	-0.984				-1.593	
	(2.447)				(2.408)	
Ln VAT export tax$_{k,t-1}$×Elig.^{R}×Density$_{\mathrm{ck}}$	-2.529^a	-1.102^a	-2.531^a	-1.102^a		
	(0.478)	(0.329)	(0.478)	(0.329)		
Ln VAT export tax$_{k,t-1}$×Non Elig.^{R}×Density$_{\mathrm{ck}}$	0.485	2.649			0.702	2.689
	(1.399)	(1.756)			(1.384)	(1.750)
Export growth$_{ck,t-1}$	0.156^a	0.156^a	0.158^a	0.158^a	0.110^a	0.103^a
	(0.002)	(0.002)	(0.002)	(0.002)	(0.007)	(0.007)
Foreign export share$^R_{ck,t-1}$	0.408^a	0.393^a	0.399^a	0.388^a	0.504^a	0.447^a
	(0.010)	(0.010)	(0.011)	(0.010)	(0.026)	(0.027)
State export share$^R_{ck,t-1}$	0.016^b	-0.016^b	0.001	-0.025^a	0.251^a	0.159^a
	(0.008)	(0.007)	(0.008)	(0.008)	(0.029)	(0.029)
Additional controls$_{k,t-1}$	Yes		Yes		Yes	
FE$^R_{ck}$	Yes	Yes				
FE$^R_{cs,t}$	Yes	Yes				
FE$^R_{kt}$		Yes				
FE$_{ck}$			Yes	Yes	Yes	Yes
FE$_{cs,t}$			Yes	Yes	Yes	Yes
FE$_{kt}$				Yes		Yes
Observations	1,890,487		1,713,240		177,247	
R^2	0.875	0.885	0.875	0.884	0.871	0.892

Heteroskedasticity-robust standard errors clustered at the product level appear in parentheses. ^{a}, ^{b} and ^{c} indicate significance at the 1%, 5% and 10% confidence level respectively. c stands for city, k for the HS6 product level, t for year and R refers to the two eligibility regimes in the VAT-rebate system: the non-eligible processing trade with supplied inputs and the eligible ordinary and processing trade with imported materials. Sectors, indicated by s, are defined following the Chinese 4-digit GB/T industry classification and regroup several products. Additional controls$_{k,t-1}$ include Export growth$_{k,t-1}$, World demand$_{k,t-1}$, Export tax$_{k,t-1}$, Import tariffs$_{k,t-1}$×Eligibility^R and Import tariffs$_{k,t-1}$×Non Eligibility^R.

product spillovers emanating from consistent specialization, such as knowledge externalities, economies of scale and scope spillovers. A national industrial policy such as the VAT export tax can thus have highly differential effects across locations, depending on the structure of the local economy.

In what follows we dig deeper into the underlying mechanism, rule out alternative explanations, discuss the choice of export quantities over export values, and look at the heterogenous impact by type of exports (trade regime and firm ownership). In Appendix C we provide also a battery of robustness checks on the sensitivity of our results with respect to specific products and the construction of our density measure.

5.2.1 Underlying mechanisms and competing explanations

The first two columns of Table 3 investigate in more detail how changes in the VAT export taxes of other products can affect export performance of product k. This allows us to ensure that our results really correspond to the effect on a product's exports of a tax change in the product in question and not more general spillovers. If the related products k' experience an increase in their VAT export tax rates, they will experience a reduction in their exports and, potentially, in their production. This might alleviate some local capacity constraints (e.g. with respect to transport modes or administration) or free resources such as workers with technological know-how which are also relevant for exporting product k. Increased taxation of related products can hence support the export activity of product k by providing it with better access to various types of inputs. To see whether this channel is potentially at play, we construct an indicator capturing the difference of the VAT export tax between product k and the other local products.

More precisely, we weight the bilateral proximity of product k and k' by the difference in the VAT export tax between k and all products k' for which city c has a revealed comparative advantage ($RCA_c = 1$):

$$\text{Average tax difference}_{ck,t-1} = \frac{\sum\limits_{k' \in RCA_c=1, k' \neq k} \phi_{kk'} DIFF\text{tax}_{kk',t-1}}{\sum\limits_{k' \in RCA_c=1, k' \neq k} \phi_{kk'}} \tag{6}$$

where $DIFF\text{tax}_{kk',t-1} = \ln$ VAT export $\text{tax}_{k',t-1}$ - ln VAT export $\text{tax}_{k,t-1}$. In column 1 of Table 3, we add the interaction terms of the average tax difference with the eligibility dummy and the non-eligibility dummy respectively to our triple benchmark specification. We expect a positive and significant effect of the average tax difference for eligible exports if tax changes in different products benefit related products through reallocation of resources. In column 2 we repeat the same exercise but only consider in the sum of Equation 6 products k' that are part of the same sector as product k. We expect also a positive effect here, though smaller if what matters most is the relatedness between products and not the sector affiliation. Both measures for average tax differences attract a positive and significant coefficient suggesting that VAT export taxes of other products also matter. Accounting for these connections and spillovers between related products however do not affect significantly the estimates on our key triple interaction term Ln VAT export $\text{tax}_{k,t-1} \times \text{Eligibility}^R \times \text{Density}_{ck}$.

In the last four columns of Table 3, we add some alternative indicators to ensure that our measured reinforcing effect of local product density on the export impact from the VAT export tax is not simply capturing the conditioning effect of a correlated variable.

In column 3, we add a triple interaction term between the VAT export tax, the trade regime dummy and the number of products exported by the city with a revealed comparative advantage. The product density measures for a given city are likely to be higher the more products are exported with a comparative advantage in the city as the sum in Equation 5 includes more bilateral proximities. Thus we want to make sure that the effect is not driven uniquely by the cities that are exporting a high number of goods with a comparative advan-

Table 3: Robustness checks: alternative explanations

Dependent variable	Ln export quantity (city/product/regime/year)					
	(1)	(2)	(3)	(4)	(5)	(6)
Ln VAT exp. tax$_{k,t-1}$×Elig.^{R}×Density$_{\mathrm{ck}}$	-1.692^a	-1.265^a	-1.648^b	-0.927^b	-1.273^a	-1.285^a
	(0.369)	(0.335)	(0.696)	(0.395)	(0.354)	(0.357)
Av. tax difference$_{ck,t-1}$ ×Elig.^{R}	9.294^a					
	(2.171)					
Av. (within sector) tax difference$_{ck,t-1}$ ×Elig.^{R}		2.374^a				
		(0.740)				
Ln VAT exp. tax$_{k,t-1}$×Elig.^{R}×Ln(# k with RCA)$_{\mathrm{c}}$			0.722			
			(0.808)			
Ln VAT exp. tax$_{k,t-1}$×Elig.^{R}×Competition$_{\mathrm{ck}}$				0.228		
				(0.591)		
Ln VAT exp. tax$_{k,t-1}$×Elig.^{R}×Foreign share$_{\mathrm{ck}}$					1.077	
					(0.846)	
Ln VAT exp. tax$_{k,t-1}$×Elig.^{R}×State share$_{\mathrm{ck}}$						-1.416
						(0.984)
Interactions with Non Eligibility^R	Yes	Yes	Yes	Yes	Yes	Yes
Additional controls$_{ck,t-1}$	Yes	Yes	Yes	Yes	Yes	Yes
FE$^R_{ck}$	Yes	Yes	Yes	Yes	Yes	Yes
FE$^R_{cs,t}$	Yes	Yes	Yes	Yes	Yes	Yes
FE$^R_{kt}$	Yes	Yes	Yes	Yes	Yes	Yes
Observations		1,890,487		1,167,904	1,325,219	1,325,219
R^2	0.885	0.885	0.885	0.885	0.889	0.889

Heteroskedasticity-robust standard errors clustered at the product level appear in parentheses. ^{a}, ^{b} and ^{c} indicate significance at the 1%, 5% and 10% confidence level respectively. c stands for city, k for the HS6 product level, t for year and R refers to the two eligibility regimes in the VAT-rebate system: the non-eligible processing trade with supplied inputs and the eligible ordinary and processing trade with imported materials. Sectors, indicated by s, are defined following the Chinese 4-digit GB/T industry classification and regroup several products. The regressions include the same interaction terms for non-eligible flows as those presented in the table for eligible flows. Additional controls$_{ck,t-1}$ include Export growth$_{ck,t-1}$, Foreign export share$^R_{ck,t-1}$ and State export share$^R_{ck,t-1}$. Competition and shares of foreign and state firms at the city-sector level are computed using China's annual firm-level industrial surveys. See the text for more details.

tage. The added interaction term fails to enter significantly which suggests that our concerns are not grounded.

In column 4 of Table 3, we want to check whether our findings are not driven by the local degree of competition and hence do not solely correspond to Aghion et al.'s (2015) argument that the degree of competition is a key determinant of how an industrial policy affects firm performance. When a product is central in the local product mix, it is also potentially facing a stronger local competition from other exporters of the same or similar goods. We therefore interact the VAT export tax for eligible exports with a measure of the competition intensity in sector s that product k faces in city c.[43] This interaction term is however not significant. Finally, column 5 and column 6 add the interactions with the output share of foreign owned firms and that of state owned firms at the city-product pair level. They are computed from the China's annual firm-level industrial surveys.[44] A greater foreign output share might also reflect a higher level of competition and be correlated with high local product density. On the contrary, a higher share of state owned firms might reduce the level of local competition and slow down the reaction of firms to changes in the VAT export tax. However, also here we see no significant impact and the coefficient of our main variable of interest remains stable.

The findings of Table 3 reinforce our conclusion that products better connected to the local economy have greater export effects as a result of the change in the VAT export rebate. This suggests that the export rebate policy has supported exports all the more as it has been applied where export-enhancing spillovers between products are strong.

5.3 The effect of VAT export taxes on prices

Our empirical approach has so far deliberately relied on export quantities because of two main reasons. First, there are potential measurement problems from the underreporting of export values by firms to avoid paying taxes based on export value. If these practices affect

[43] We use the Lerner Index which measures the importance of markups (the difference between prices and marginal costs) relative to the firm's total value added. We thank Ann Harrison for sharing the stata code used to compute the Lerner index with the data from China's annual firm-level industrial surveys. The index is calculated as an average between 2001 and 2003.

[44] To be consistent with the way the competition index is calculated, these shares are calculated as averages between 2001 and 2003. The restriction to industrial sectors in columns 4 to 6 results in a reduction of the sector-city combinations compared to our main sample.

values and not quantities as suggested by Fisman and Wei (2004), export prices should be underreported. An increase in the VAT export rebate should encourage exporters to cheat less and thus declare a higher price at customs.

Second, it is not clear what is the expected net impact of a change in the VAT export rebate on prices. Our theoretical setting (Appendix E) can provide a clear prediction regarding the VAT export tax elasticity for export quantities but the net effect on prices is ambiguous: the direct negative repercussion of the tax on firm-level export price may be more than compensated by the composition effect related to the exit of less productive firms, those charging high prices. Furthermore, the repercussions of a change in rebates on export prices depend also on the extent to which exporters pass rebates through to prices. Exporters could well absorb the changes in rebates in their margins. Also, considering that unit values are a common proxy for product quality, we could expect a positive effect on unit values when a decrease in the VAT export tax leads to quality improvements. The sign of the overall effect is thus not clear.

Table 4 investigates the impact of VAT export taxes and the conditioning role of local product density on export prices measured by unit values (calculated as the ratio of export value to export quantity) and on export values. Column 1 reports the estimates of our double-difference specification (column 5 of Table 1) using unit values as the dependent variable. Column 2 shows both the unconditional effect of the VAT export tax and the interaction with density. Column 3 presents results of the DDD benchmark specification (column 2 of Table 2) which adds product-regime-year fixed effects. Conditional on our strict controls, we find no significant differential effect of VAT export rebates on unit values for the two trade regimes. Our findings thus suggest that there is no change in average (tax inclusive) prices or in average quality of the exported goods after a change in the VAT export tax. For completeness, we report in columns 4 to 6 the same regressions using export values.

Table 4: Export values and prices

Dependent variable	Ln unit value of exports (city/product/regime/year)			Ln value of exports (city/product/regime/year)		
	(1)	(2)	(3)	(4)	(5)	(6)
Ln VAT export $\text{tax}_{k,t-1}\times\text{Elig.}^R$	0.045	-0.163		-6.569[a]	-4.289[a]	
	(0.481)	(0.242)		(1.204)	(0.683)	
Ln VAT export $\text{tax}_{k,t-1}\times\text{Elig.}^R\times\text{Density}_{ck}$		0.194	0.110		-2.335[a]	-0.992[a]
		(0.167)	(0.136)		(0.440)	(0.309)
Additional $\text{controls}_{ck,t-1}$	Yes	Yes	Yes	Yes	Yes	Yes
Additional $\text{controls}_{k,t-1}$		Yes			Yes	
FE^R_{ck}	Yes	Yes	Yes	Yes	Yes	Yes
$\text{FE}^R_{cs,t}$	Yes	Yes	Yes	Yes	Yes	Yes
FE_{kt}	Yes			Yes		
FE^R_{kt}			Yes			Yes
Observations		1,890,487			1,890,487	
R^2	0.931	0.928	0.932	0.841	0.829	0.843

Heteroskedasticity-robust standard errors clustered at the product level appear in parentheses. [a], [b] and [c] indicate significance at the 1%, 5% and 10% confidence level respectively. c stands for city, k for the HS6 product level, t for year and R refers to the two eligibility regimes in the VAT-rebate system: the non-eligible processing trade with supplied inputs and the eligible ordinary and processing trade with imported materials. Sectors, indicated by s, are defined following the Chinese 4-digit GB/T industry classification and regroup several products. Additional $\text{controls}_{ck,t-1}$ include Export $\text{growth}_{ck,t-1}$, Foreign export $\text{share}^R_{ck,t-1}$, State export $\text{share}^R_{ck,t-1}$, as well as Ln VAT export $\text{tax}_{k,t-1}\times\text{Non Elig.}^R\times\text{Density}_{ck}$ (columns 2, 3, 5 and 6). Additional $\text{controls}_{k,t-1}$ include Export $\text{growth}_{k,t-1}$, World $\text{demand}_{k,t-1}$, Export $\text{tax}_{k,t-1}$, Import $\text{tariffs}_{k,t-1}\times\text{Elig.}$, Import $\text{tariffs}_{k,t-1}\times\text{Non Elig.}$ and Ln VAT export $\text{tax}_{k,t-1}\times\text{Non Elig.}$

The coefficients for all variables of interest are very close to those found for the quantity exported. This confirms that the main effect of a change in VAT export rebates is on the quantity exported.[45]

In the light of our simple model with heterogeneous firms, findings that the elasticities are the same for export values as for export quantities suggest that while exporters pass VAT rebate changes through to prices a substantial entry/exit by inferior firms leads to a compositional change such that there is no change in average prices. Assuming a Pareto distribution in the export value equation (Equation E-10) yields an export tax elasticity for the export value equal to $\frac{\sigma(1-\gamma)-1}{\sigma-1}$. Using again $\sigma = 6$ following Broda and Weinstein

[45]Results on unit values and export values hold when carrying out the same robustness checks as those conducted for export quantity and when the sample is limited to processing trade only.

(2006) and considering as above that $\gamma/(\sigma-1)$ can range between 1 and 2, the range for the export value elasticity is between -5 and -11, almost identical to that for the export quantity elasticity. Under Pareto, the export tax elasticity for the unit value is $\frac{-1}{\sigma-1}$, which equals -0.2 in the case where $\sigma = 6$. The predicted coefficient for export prices is hence much smaller than that for export values or quantities. Our results are rather in line: our estimates on unit values are very small but are not significantly different from zero.

5.4 The role of firm ownership and trade regimes

In this section, we investigate whether the effect of the VAT export tax and the magnification role of local product density vary between processing and ordinary trade flows and the ownership type of exporting firms. Previous findings suggest that the export gains from product density are limited to domestic firms and those engaged in ordinary trade because these firms are more embedded in the local economy (Poncet and de Waldemar, 2015). Our data allow us to distinguish processing and ordinary exports and trade coming from domestically-owned and foreign-owned firms.

Table 5 considers only processing trade, and so excludes ordinary trade. We thus study here the differential effect of the VAT policy between eligible and non-eligible processing trade. Limiting the sample to processing trade also allows to ensure a greater comparability between the two trade regimes by making our sample more homogenous. Ordinary and processing regimes differ in a variety of dimensions that could affect their sensitivity to changes in VAT export rebates. Ordinary exports notably embody more than twice as much domestic value added per USD as do processing exports (Koopman et al., 2012; Kee and Tang, 2016) and are not eligible to duty-free imported material (BIM in Equation 1). Greater duty-free imports means a lower VAT export tax, and lower refunds from any given rise in the VAT export rebate. The focus on processing trade allows us to eliminate this

Table 5: Processing trade only

Dependent variable	Ln export quantity (city/product/regime/year)		
	(1)	(2)	(3)
	Processing exports: eligible versus non eligible		
Ln VAT export tax$_{k,t-1}$×Elig.^{R}	-4.271^a	-0.753	
	(1.389)	(1.938)	
Ln VAT export tax$_{k,t-1}$×Elig.^{R}×Density$_{ck}$		-2.233^b	-0.503
		(1.113)	(1.348)
Additional controls$_{ck,t-1}$	Yes	Yes	Yes
Additional controls$_{k,t-1}$		Yes	
FE$^R_{ck}$	Yes	Yes	Yes
FE$^R_{cs,t}$	Yes	Yes	Yes
FE$_{kt}$	Yes		
FE$^R_{kt}$			Yes
Observations	464,423	464,423	464,423
R^2	0.895	0.882	0.901

Heteroskedasticity-robust standard errors clustered at the product level appear in parentheses. ^{a}, ^{b} and ^{c} indicate significance at the 1%, 5% and 10% confidence level respectively. c stands for city, k for the HS6 product level, t for year and R refers to the two eligibility regimes in the VAT-rebate system: the non-eligible processing trade with supplied inputs and the eligible ordinary and processing trade with imported materials. Sectors, indicated by s, are defined following the Chinese 4-digit GB/T industry classification and regroup several products. Additional controls$_{ck,t-1}$ include Export growth$_{ck,t-1}$, Foreign export share$^R_{ck,t-1}$, State export share$^R_{ck,t-1}$, as well as Ln VAT export tax$_{k,t-1}$×Non Elig^R×Density$_{ck}$ (columns 2 and 3). Additional controls$_{k,t-1}$ include Export growth$_{k,t-1}$, World demand$_{k,t-1}$, Export tax$_{k,t-1}$, Import tariffs$_{k,t-1}$×Elig, Import tariffs$_{k,t-1}$×Non Elig and Ln VAT export tax$_{k,t-1}$×Non Elig.

source of potential bias due to differences in foreign value-added content and other structural differences between ordinary and processing trade regimes. Furthermore as processing receives favorable tariff treatment it is subject to stricter customs controls, hence firms are less likely to misclassify or misreport their exports (Ferrantino et al., 2012).

Results displayed in column 1 confirm that the negative effect of VAT export tax holds, even though the coefficient is slightly lower compared to our full sample (column 5 in Table 1). Column 2 shows both the unconditional effect of the VAT export tax and the enhancing effect of local product density. We find again a negative and significant effect of the triple interaction term, while VAT export tax × Eligibility is not significant. This suggests that the reinforcing effect of density also holds for processing trade. However, column 3 shows that this effect is not robust to the addition of the stricter controls of our benchmark DDD specification (column 2 of Table 2). This could be a consequence of the strongly reduced sample size and the little variation left in the data that can be exploited to identify the effect. Alternatively, it could also signal a reduced role of density for foreign firms which handle the bulk of processing activities in China.

In Table 6 we therefore investigate the difference in the impact of the VAT export tax on foreign-owned and domestically-owned firms separately. We find a strong negative effect of the VAT export tax on eligible trade only for both types of firms (columns 1 and 4). However for foreign firms this average effect does not appear to depend on the local product density, as the interaction term with product density is not significant (columns 2 and 3). In contrast for domestic firms we find a very strong magnifying effect of product density (columns 5 and 6).

This difference between firm types indicates that being less embedded in the local economy makes it more difficult for foreign firms to benefit from common local resources or spillovers that could result from a high local product density. However, the high overall impact of the policy for foreign firms shows that they are also very sensitive to the additional costs created by an increase in the VAT export tax.

Overall, our results are consistent with previous findings that foreign-owned firms and those active in processing benefit less from their local environment and linkages to neighboring firms.

Table 6: Foreign vs domestic firms

Dependent variable	Ln export quantity (city/product/regime/year)					
	(1)	(2)	(3)	(4)	(5)	(6)
	Exports of foreign firms			Exports of domestic firms		
Ln VAT export $\text{tax}_{k,t-1}\times\text{Elig.}^R$	-9.949[a]	-6.726[a]		-3.627[b]	-3.915[a]	
	(1.979)	(1.249)		(1.505)	(0.846)	
Ln VAT export $\text{tax}_{k,t-1}\times\text{Elig}\times\text{Density}_{ck}$		-0.739	0.982		-2.587[a]	-1.434[a]
		(0.695)	(0.641)		(0.523)	(0.352)
Additional $\text{controls}_{ck,t-1}$	Yes	Yes	Yes	Yes	Yes	Yes
Additional $\text{controls}_{k,t-1}$		Yes			Yes	
FE_{ck}^R	Yes	Yes	Yes	Yes	Yes	Yes
FE_{cst}^R	Yes	Yes	Yes	Yes	Yes	Yes
FE_{kt}	Yes			Yes		
FE_{kt}^R			Yes			Yes
Observations		846,583			1,640,575	
R^2	0.874	0.863	0.875	0.879	0.870	0.880

Heteroskedasticity-robust standard errors clustered at the product level appear in parentheses. [a], [b] and [c] indicate significance at the 1%, 5% and 10% confidence level respectively. c stands for city, k for the HS6 product level, t for year and R refers to the two eligibility regimes in the VAT-rebate system: the non-eligible processing trade with supplied inputs and the eligible ordinary and processing trade with imported materials. Sectors, indicated by s, are defined following the Chinese 4-digit GB/T industry classification and regroup several products. Additional $\text{controls}_{ck,t-1}$ include Export $\text{growth}_{ck,t-1}$, Foreign export $\text{share}^R_{ck,t-1}$, State export $\text{share}^R_{ck,t-1}$, as well as Ln VAT export $\text{tax}_{k,t-1}\times\text{Non Elig.}^R\times\text{Density}_{ck}$ (columns 2, 3, 5 and 6). Additional $\text{controls}_{k,t-1}$ include Export $\text{growth}_{k,t-1}$, World $\text{demand}_{k,t-1}$, Export $\text{tax}_{k,t-1}$, Import $\text{tariffs}_{k,t-1}\times$Elig., Import $\text{tariffs}_{k,t-1}\times$Non Elig. and Ln VAT export $\text{tax}_{k,t-1}\times$Non Elig.

6 Conclusion

In this paper, we have provided an empirical investigation of the effectiveness of one of China's major industrial policies, its VAT export rebate system. For this, we have appealed to a product-level database on Chinese exports at the city level to consider how export performance is affected by VAT export rebates and how the effect of this nationwide policy varies across products depending on their connection to the local product space.

To overcome the typical endogeneity problems encountered in policy evaluations, our empirical strategy exploits an eligibility rule that disqualifies processing trade with supplied materials from the rebates. Our estimates rely on export-quantity data for a panel of 316

Chinese cities at the HS6 product-level over the 2003-2012 period, and provide evidence of negative and significant VAT export tax effects on eligible exports. Our baseline estimate suggests that a one percent decline in the VAT export tax leads to a 6.6% increase in eligible trade flows relative to non-eligible trade. Average prices, measured as unit values, remain however unaffected.

We further show how the VAT export tax on a given product has differential effects across locations. For this, we rely on an indicator that measures the density of the links between a product and the local product space. This density measure hence combines information on the intrinsic relatedness of a good with that on the local pattern of specialization. Our results indicate that VAT export taxes are more effective when applied on goods with denser links with the local productive structure. These findings are consistent with the density of links between products giving rise to export-enhancing spillovers. Moreover, we show that this conditional effect of local product density is found only for domestic firms. While exports from foreign owned firms, which are generally less embedded into the local economy, also react strongly to changes in the VAT export tax rate, the magnitude of the impact appears to be independent of the product's connection to the local product space.

Finally, the size of our estimates on the VAT export tax allows us also to better understand the resilience of China's exports during the global recession. VAT export rebates seem to be an effective tool for boosting a country's international competitiveness in difficult times and when exchange rate devaluations are not an option. Our results hence show the key role of trade policy in China's rising advantage in global markets.

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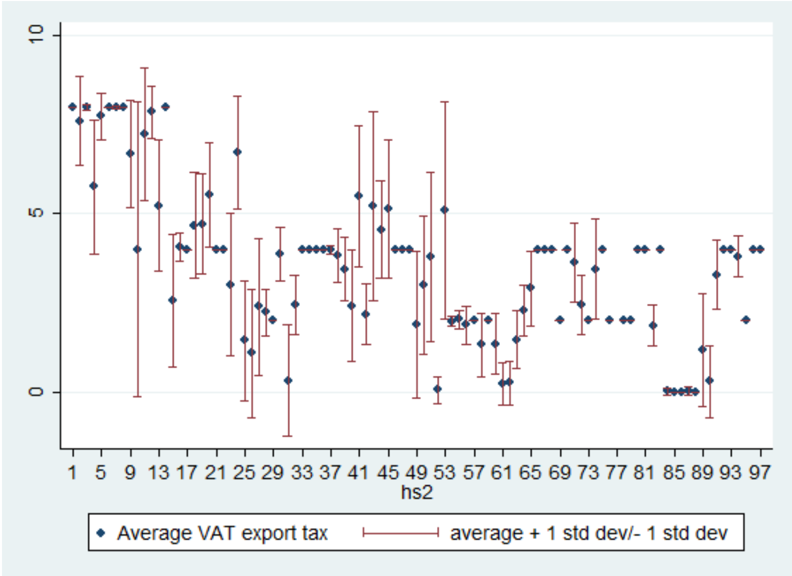
A Additional tables and figures

Figure A-2: Evolution of yearly average VAT export tax 2002-2012

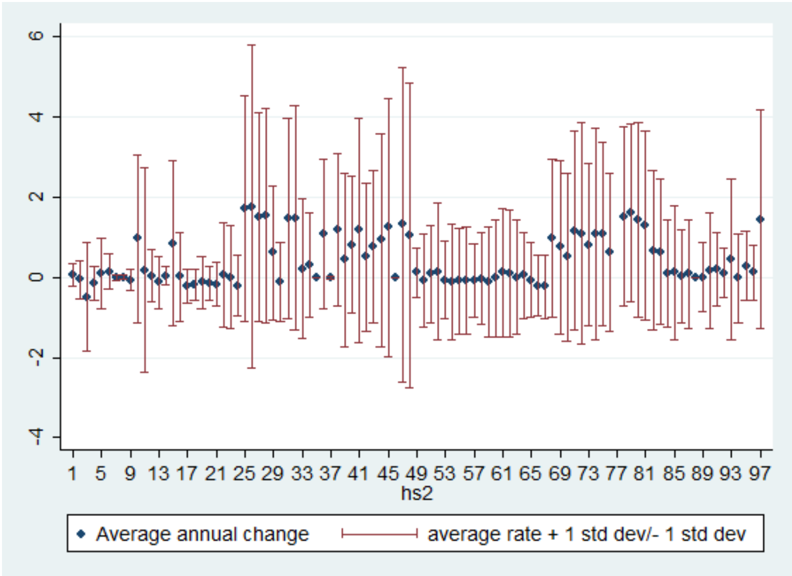
Note: The VAT tax is calculated as the simple average over all products. During our sample period the VAT export tax rates range between 0 and 17%.

Figure A-3: Average VAT export tax and dispersion within each HS2 (2002)



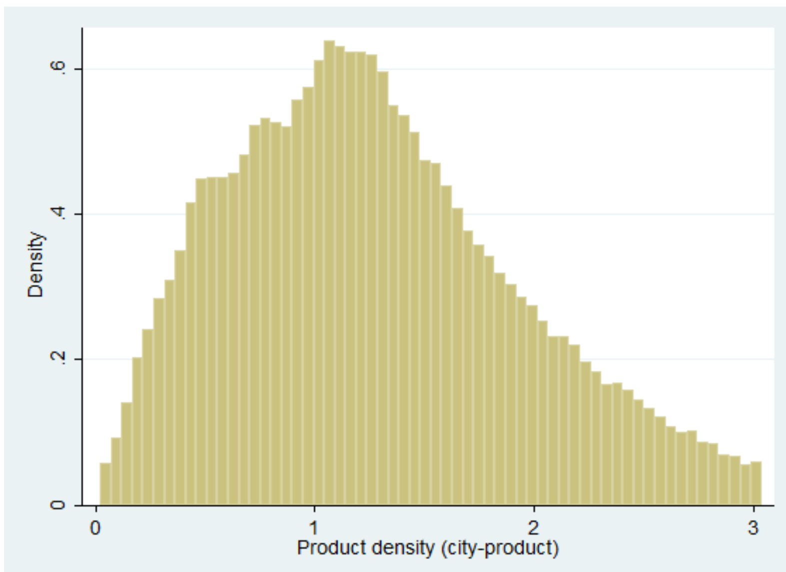
Note: There are in total 97 HS2 categories. Each HS2 category contains between 4 and 509 HS6 products (the median is 29). The VAT export tax rates range between 0 and 17%.

Figure A-4: Average annual change in VAT export tax and dispersion within each HS2 (2002-2011)



Note: There are in total 97 HS2 categories. Each HS2 category contains between 4 and 509 HS6 products (the median is 29). The VAT export tax rates range between 0 and 17%.

Figure A-5: Distribution of product density



Note: Distribution of city-product density (trimming 1%). The scale is modified to be between 0 and 10.

Table A-1: Summary statistics of variables

	Mean	Std. Dev.	Min	Max
ln(exported quantity)$^R_{ck,t}$	9.85	3.66	0.00	24.12
ln(export value)$^R_{ck,t}$	11.62	2.88	0.00	23.96
ln(unit value)$^R_{ck,t}$	1.77	2.42	-10.13	19.97
VAT export tax$_{k,t-1}$ (%)	4.42	3.78	0.00	17.00
VAT rebate$_{k,t-1}$ (%)	12.42	3.93	0.00	17.00
VAT rate$_{k,t-1}$(%)	16.83	0.72	13.00	17.00
World demand$_{k,t-1}$	0.21	0.18	0.00	0.94
Export tax$_{k,t-1}$ (%)	0.08	1.40	0.00	106.25
Import tariffs$_{k,t-1}$ (%)	10.72	6.20	0.00	68.00
Export growth$_{k,t-1}$	0.20	0.33	-2.00	2.00
Export growth$_{ck,t-1}$	0.26	1.20	-2.00	2.00
Foreign export share$^R_{ck,t-1}$ (%)	0.24	0.38	0.00	1.00
State export share$^R_{ck,t-1}$ (%)	0.24	0.37	0.00	1.00
Density$_{ck}$	1.20	0.66	0.02	3.04
Ln(# k with RCA)$_c$	5.96	0.67	1.95	6.98
Competition$_{ck}$	-0.02	1.20	-255.88	4.03
Output share of foreign firms$_{ck}$ (%)	0.33	0.34	-0.00	1.00
Output share of state-owned firms$_{ck}$ (%)	0.29	0.29	-0.00	1.00

Refer to Section 4 and Appendix D-1 for a detailed description of these variables. The statistics are based on the sample in our DD benchmark specification (1,890,487 observations) (last column of Table 1). c stands for city, k for the HS6 product level, t for year and R refers to the two eligibility regimes in the VAT export rebate system: the non-eligible processing trade with supplied inputs and the eligible ordinary and processing trade with imported materials.

Table A-2: Additional results

Dependent variable	$\ln(\text{quantity}^{R}_{ckt})$				
	(1) HS4 controls	(2) including "others"	(3) reduced sample I	(4) reduced sample II	(5) Pre- vs post crisis
Ln VAT export $\text{tax}_{k,t-1} \times \text{Elig.}^{R}$	-6.044^{a}	-6.686^{a}	-5.538^{a}	-4.820^{a}	
	(1.928)	(1.269)	(1.331)	(1.454)	
Ln VAT export $\text{tax}_{k,t-1} \times \text{Elig.}^{R} \times$Dummy 2003-2007					-8.242^{a}
					(1.383)
Ln VAT export $\text{tax}_{k,t-1} \times \text{Elig.}^{R} \times$Dummy 2008-2012					-6.041^{a}
					(1.536)
Additional $\text{controls}^{R}_{ck,t-1}$	Yes	Yes	Yes	Yes	Yes
City-HS4 product-regime-year	Yes				
City-sector-regime-year ($\text{FE}^{R}_{cs,t}$)		Yes	Yes	Yes	Yes
FE_{kt}	Yes	Yes	Yes	Yes	Yes
Observations	1,890,487	1,946,369	498,555	325,426	1,890,487
R^2	0.906	0.885	0.903	0.919	0.884

Heteroskedasticity-robust standard errors clustered at the product level appear in parentheses. ^{a}, ^{b} and ^{c} indicate significance at the 1%, 5% and 10% confidence level respectively. c stands for city, k for the HS6 product level, t for year and R refers to the two eligibility regimes in the VAT-rebate system: the non-eligible processing trade with supplied inputs and the eligible ordinary and processing trade with imported materials. Sectors, indicated by s, are defined following the Chinese 4-digit GB/T industry classification and regroup several products. Reduced sample I only contains the 38,391 city-product pairs that report exports under both types of trade during our sample period. Reduced sample II only includes the 36,753 city-product pairs that report both types of trade in the same year. Additional $\text{controls}^{R}_{ck,t-1}$ include Export $\text{growth}_{ck,t-1}$, Foreign export $\text{share}^{R}_{ck,t-1}$, State export $\text{share}^{R}_{ck,t-1}$ and Import $\text{tariffs}_{k,t-1} \times$Elig.

B Evidence on switching of regime types

The main challenge of our baseline regression concerns the switching of regime types as a consequence of a change in the VAT export rebate rate. In this section, we provide several arguments that the regime choice seems to be independent from changes in the VAT export tax.

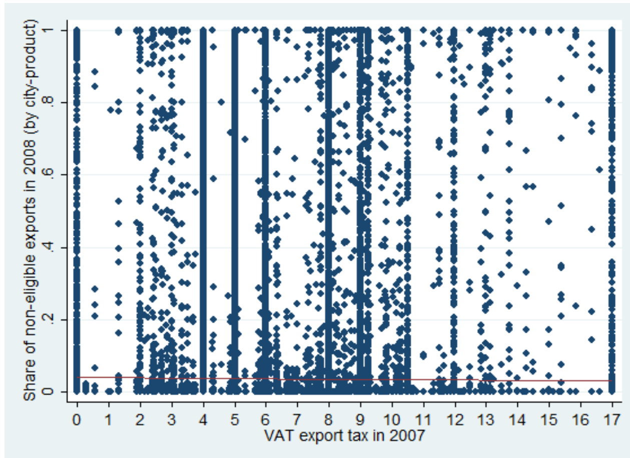
First, we find no evidence that products with high rebates also have a relatively low share of non-eligible exports. Figure B-1 plots the VAT export tax in 2007 against the share of non-eligible exports at the city-level in 2008.[46] It suggests the absence of association between the VAT rebate policy and the chosen trade regime.

Second, Figures B-2 and B-3 report the correlation between the average yearly changes of the VAT export tax and the average annual change in our dependent variable (the logarithm of export quantities) by product, separately for eligible and non-eligible exports.[47] This provides some first suggestive evidence for a statistically significant negative relationship between VAT export taxes and eligible exports. By contrast, the simple correlation between VAT export taxes and non-eligible exports is not significantly different from zero. When we include our many controls and fixed effects in our regressions (Table 1) we also find an insignificant association between the VAT export tax and non-eligible exports. Thus, we conclude that changes in the VAT rebate do not appear to determine the regime in which firms run their operations, which suggests that non-eligible exports are indeed an appropriate control group.

Third, Table B-1 addresses more directly the possibility of firms switching from eligible

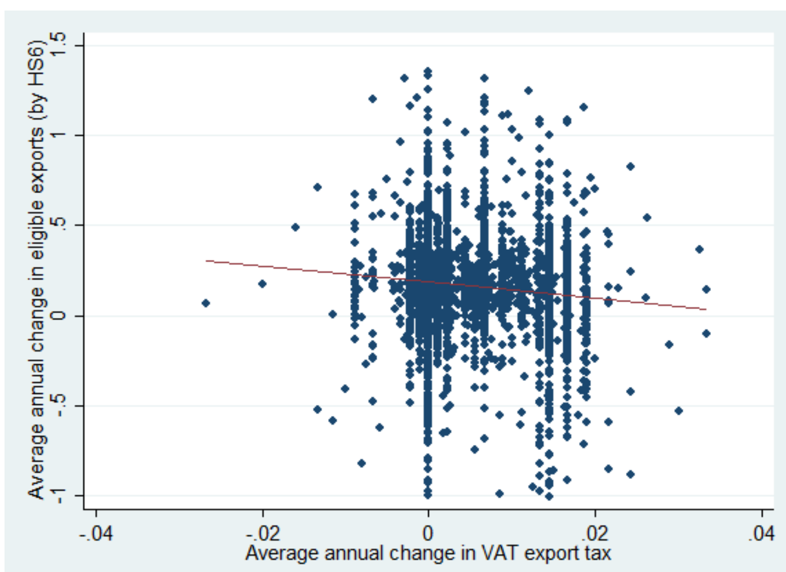
[46] A similar pattern of no correlation is obtained using different years.
[47] Averages are computed over the 2003-12 period.

Figure B-1: VAT-rebate share and share of non-eligible exports (city-product)



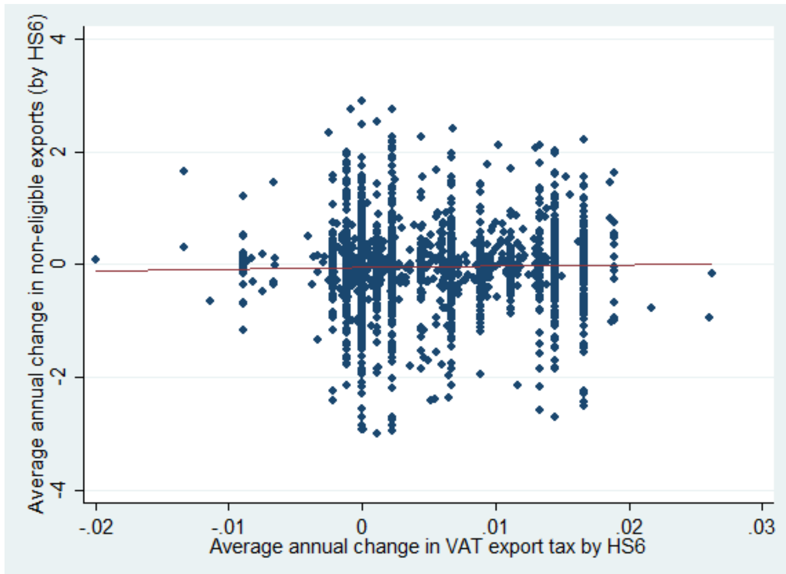
Note: The share of non-eligible exports is the export value share of processing trade with supplied inputs. City-product pairs are those in the main sample. The VAT export tax rates range between 0 and 17%.

Figure B-2: Changes in VAT export tax and eligible exports (by product, 2003-12)



Note: Eligible exports correspond to the export value under ordinary trade and processing trade with imported inputs. The slope is -4.443 with a standard error of 0.559.

Figure B-3: Changes in VAT export tax and non-eligible exports (by product, 2003-12)



Note: Non-eligible exports correspond to the export value under processing trade with supplied inputs. The slope is 2.423 with a standard error of 1.937.

to non-eligible trade after an increase in the VAT export tax. We construct for each city-product-regime triad a time-varying indicator that measures the share of destinations for which a flow appears in regime type R while it disappears for the other regime type. In column 1 we look at the share of destinations that switch from non-eligible to eligible trade. If switching between regimes is common a decrease in the VAT export tax should result in a shift towards the eligible regime. We thus expect a negative coefficient of the VAT export tax. Conversely, in column 2, where we look at the share of destinations which see a switch to non-eligible trade, we expect a positive coefficient since a higher tax makes it less advantageous to export for eligible compared to non-eligible trade.[48] For both types of trade, coefficients are close to zero and we do not find any significant impact of the VAT

[48] We rely here on our double-difference specification, detailed in Section 3.1, which we run separately for the two regime types (and hence do not include the interaction with the Eligibility dummy and product-year fixed effects).

export tax. We are thus confident that firms modifying their regime type is not driving our results in Section 5.

Our results are also consistent with the literature on the specific motives behind the ineligible regime of processing trade with supplied materials in China. Findings are largely unrelated to the VAT rebate system. Manova and Yu (2016) show that the regime type of trade chosen by companies is driven by the importance of financial constraints. Since the ownership of imported intermediates entails high up-front costs, financial constraints restrict firms to processing trade with supplied materials. Fernandes and Tang (2012) show that the choice of form of trade is related to factors that have been suggested by theories of the boundaries of the firm, such as control and hold-up. Their results suggest that control over imported components by international firms is an alternative to asset ownership in alleviating hold-up by export-processing plants. We hence expect the extent of processing trade with supplied materials to depend mostly on the observability of input use or the dominance and power of foreign buyers.[49]

Finally, Brandt and Morrow (2017) investigate another particularity of firms engaged in processing with supplied inputs: their inability to source domestically. As opposed to manufacturers engaged in ordinary trade and processing with imported materials, those in processing trade with supplied inputs are not allowed to buy inputs from China. Their role in China's exports should thus be related to the attraction of Chinese suppliers. The extent of processing trade with supplied inputs should then fall with improvements in the number, diversity, quality or cost advantage of Chinese manufacturers of intermediate inputs and not

[49]It could also depend on the degree of relationship specificity of the physical capital used in production (Nunn and Trefler, 2013).

Table B-1: Regime switching

Dependent variable	Share of destinations$^R_{ck,t}$ that switched regime	
	(1) from eligible to non-eligible	(2) from non-eligible to eligible
Ln VAT export tax$_{k,t-1}$	0.001	0.064
	(0.003)	(0.046)
Export growth$_{ck,t-1}$	-0.001	-0.001
	(0.001)	(0.001)
Foreign export share$^R_{ck,t-1}$	0.001^a	0.020^a
	(0.000)	(0.002)
State export share$^R_{ck,t-1}$	0.001^a	0.016^a
	(0.000)	(0.002)
Export growth$_{k,t-1}$	-0.001	-0.001
	(0.001)	(0.002)
World demand$_{k,t-1}$	0.001	0.001
	(0.001)	(0.011)
Export tax$_{k,t-1}$	0.001^c	0.001
	(0.001)	(0.001)
Import tariffs$_{k,t-1}$	-0.001	-0.001
	(0.001)	(0.001)
Fixed effects	city-product & city-sector-year	
Observations	1,713,240	177,247
R^2	0.272	0.307

Heteroskedasticity-robust standard errors clustered at the product level appear in parentheses. ^{a}, ^{b} and ^{c} indicate significance at the 1%, 5% and 10% confidence level respectively. c stands for city, k for the HS6 product level, t for year and R refers to the two eligibility regimes in the VAT-rebate system: the non-eligible processing trade with supplied inputs and the eligible ordinary and processing trade with imported materials. Sectors, indicated by s, are defined following the Chinese 4-digit GB/T industry classification and regroup several products.

Figure B-4: Share of non-eligible exports over time

Note: The share of non-eligible exports is the export value share of processing trade with supplied inputs.

reflect the ups and downs in the VAT export tax.

To conclude, Figure B-4 shows the share of non-eligible exports between 2000 and 2012. This exhibits a continuous decline over the period, further suggesting the lack of any direct link between the choice of trade regime and the ups and downs in the VAT rebate policy. The downward trend is however consistent with the relaxation of financial constraints over time (in the spirit of Manova and Yu, 2016) and the growing diversity and quality of China's intermediates (as suggested by Brandt and Morrow, 2017).[50]

[50] One could worry that the decline in trade volumes for the ineligible group makes it unlikely that this is a good benchmark relative to which the performance of eligible exports is measured. In total, non-eligible trade represents only about 10% of the observations in our final sample. However Table A-2 shows that our results hold when we limit our sample to the city-product pairs that export simultaneously under both regimes. Furthermore, our results hold when the sample is limited to processing trade only, where close to 40% of the observations represent non-eligible exports (Table 5).

C Robustness checks

C-1 Sensitivity to specific products

This section checks that the triple-difference results from column 4 of Table 2 are robust across various subsamples.[51]

Table C-1: Exports and VAT export taxes: excluding sensitive sectors

Dependent variable	Ln Exported quantity (city/product/regime/year)				
	(1)	(2)	(3)	(4)	(5)
Sample restriction	only manuf	w/o rare earths	w/o energy-int.	w/o high-tech	w/o high-skilled int.
Ln VAT export tax$_{k,t-1}$×Elig.^{R}×Density$_{ck}$	-1.121^a	-1.094^a	-1.076^a	-1.068^a	-1.151^a
	(0.332)	(0.332)	(0.324)	(0.332)	(0.329)
Additional controls$_{ck,t-1}$	Yes	Yes	Yes	Yes	Yes
FE$^R_{ck}$	Yes	Yes	Yes	Yes	Yes
FE$^R_{cgt}$	Yes	Yes	Yes	Yes	Yes
FE$^R_{kt}$	Yes	Yes	Yes	Yes	Yes
Observations	1,850,679	1,888,120	1,872,915	1,773,290	1,852,223
R^2	0.885	0.885	0.885	0.883	0.884

Heteroskedasticity-robust standard errors clustered at the product level appear in parentheses. ^{a}, ^{b} and ^{c} indicate significance at the 1%, 5% and 10% confidence level respectively. c stands for city, k for the HS6 product level, t for year and R refers to the two eligibility regimes in the VAT-rebate system: the non-eligible processing trade with supplied inputs and the eligible ordinary and processing trade with imported materials. Sectors, indicated by s, are defined following the Chinese 4-digit GB/T industry classification and regroup several products. Additional controls$_{ck,t-1}$ include Export growth$_{ck,t-1}$, Foreign export share$^R_{ck,t-1}$, State export share$^R_{ck,t-1}$ and Ln VAT export tax$_{k,t-1}$× Non-Elig.^{R}×Density$_{ck}$.

First, Table C-1 verifies that our estimates do not reflect the specific features of some products which have been targeted by Chinese authorities as either strategic or undesirable. This allows us to address concerns regarding omitted unobserved policies that may be correlated with both VAT rebates and export performance. Our findings of a negative and significant magnification effect of product density remain throughout.

[51]Unreported results on the same checks for our double-difference benchmark specification confirm the findings of Table 1 on the effectiveness of the VAT export tax.

Table C-2: Exports and VAT export taxes: alternative samples

Dependent variable	Ln Exported quantity (city/product/regime/year)		
	(1)	(2)	(3)
Sample restriction	only VAT rate = 17%	no full VAT rebate	no zero VAT rebate
Ln VAT export tax$_{k,t-1}$×Elig.^{R}×Density$_{ck}$	-1.064^a	-1.054^a	-1.317^a
	(0.349)	(0.390)	(0.442)
Additional controls$_{ck,t-1}$	Yes	Yes	Yes
FE$^R_{ck}$	Yes	Yes	Yes
FE$^R_{cgt}$	Yes	Yes	Yes
FE$^R_{kt}$	Yes	Yes	Yes
Observations	1,737,025	1,095,257	1,744,110
R^2	0.886	0.849	0.889

Heteroskedasticity-robust standard errors clustered at the product level appear in parentheses. ^{a}, ^{b} and ^{c} indicate significance at the 1%, 5% and 10% confidence level respectively. c stands for city, k for the HS6 product level, t for year and R refers to the two eligibility regimes in the VAT-rebate system: the non-eligible processing trade with supplied inputs and the eligible ordinary and processing trade with imported materials. Sectors, indicated by s, are defined following the Chinese 4-digit GB/T industry classification and regroup several products. Additional controls$_{ck,t-1}$ include Export growth$_{ck,t-1}$, Foreign export share$^R_{ck,t-1}$, State export share$^R_{ck,t-1}$ and Ln VAT export tax$_{k,t-1}$× Non-Elig.^{R}×Density$_{ck}$.

Column 1 confirms that our estimates do not reflect some particular features of agriculture by limiting the sample to manufacturing products, as agricultural products have indeed been particularly targeted by Chinese authorities concerned by food security in a context of rising prices, notably in 2006-8. In column 2, the few but very strategic rare-earth products are excluded to make sure that they do not drive our results. The same logic is behind the exclusion of energy and carbon-intensive products in column 3 which might be specifically targeted in the attempt to reduce pollution. Column 4 excludes high-tech products as defined by the OECD to ensure that we do not pick up the many unobserved subsidies granted in this sector.[52] Finally, our results also hold when dropping high-skill intensive products (column

[52]High-tech exporters have likely benefited from a variety of policies such as FDI promotion, production and R&D subsidies and access to preferential-tax high-tech zones as part of the Chinese effort to upgrade exports. Findings are robust to alternative classifications by high-tech products, as e.g. defined by Eurostat.

5).[53]

In Table C-2 we make sure that our results are not driven by a specific type of VAT rate or rebate. In column 1 we check that our estimates are not driven by the different VAT rates across products and drop the 165 HS6 products in our sample with the reduced rate of 13% (instead of the basic 17%). In column 2 we exclude products which have enjoyed a full rebate at any time over our sample period, since they may have benefited from other unobserved policies. Column 3 restricts our sample to products that have throughout the whole sample period a positive rebate. Despite the sharp reduction in the number of observations (we drop one third of the products in the second case) the point estimates do not change significantly.

Our main findings remain unchanged in all specifications. We confirm that the effect of the VAT rebate policy is felt stronger when applied to products which have closer links to the local productive structure. Hence, we conclude that our estimated VAT-export tax impact is not simply picking up other aspects of industrial policy or product specific features. Overall, this confirms our claim that changing VAT rebates is an effective policy tool to manage exports in China but that effects vary depending on the density of links between the taxed products and the local productive structure.

C-2 Alternative measures for product density

Table C-3 provides some robustness checks on our product density measure.

Columns 1 and 2 use density measures constructed based on different definitions of revealed comparative advantage of products in a city. Our main product density variable is based on the proximity of product k to all products k' in city c that have a revealed compar-

[53]For details on how we identify the products to drop, see Appendix D-2.

ative advantage which is defined as the ratio of the export share of that product in the city's export basket over the analogous worldwide export share being greater as 1. In column 1 we reduce this threshold to 0.5, which increases the number of products to be considered for the definition of the local productive structure and thus the bilateral proximities included in the density indicator. In column 2, the threshold is increased to 1.5 which reduces the number of products compared to our main indicator.

Table C-3: Robustness checks: alternative measures for product density

Dependent variable	Ln export quantity (city/product/regime/year)		
	(1)	(2)	(3)
Density variable	RCA=1>0.5	RCA=1>1.5	Density 2002
Ln VAT export tax$_{k,t-1}$×Elig.^{R}×Density var.$_{ck}$	-0.688^a	-1.460^a	-1.250^a
	(0.244)	(0.410)	(0.332)
Additional controls$_{ck,t-1}$	Yes	Yes	Yes
FE$^R_{ck}$	Yes	Yes	Yes
FE$^R_{cst}$	Yes	Yes	Yes
FE$^R_{kt}$	Yes	Yes	Yes
Observations	1,890,487	1,890,487	1,890,487
R^2	0.885	0.885	0.885

Heteroskedasticity-robust standard errors clustered at the product level appear in parentheses. ^{a}, ^{b} and ^{c} indicate significance at the 1%, 5% and 10% confidence level respectively. c stands for city, k for the HS6 product level, t for year and R refers to the two eligibility regimes in the VAT-rebate system: the non-eligible processing trade with supplied inputs and the eligible ordinary and processing trade with imported materials. Sectors, indicated by s, are defined following the Chinese 4-digit GB/T industry classification and regroup several products. Additional controls$_{ck,t-1}$ include Export growth$_{ck,t-1}$, Foreign export share$^R_{ck,t-1}$, State export share$^R_{ck,t-1}$ and Ln VAT export tax$_{k,t-1}$× Non-Elig.^{R}×Density var$_{ck}$.

Column 3 uses a density indicator constructed based on the export structure of the city in 2002 instead of 2000. In all cases, the coefficient of the interaction term with the VAT export tax for eligible trade remains negative and significant and changes magnitude in the expected sense.

D Data sources and classifications

D-1 Construction and data sources of control variables

The Customs trade data is used to obtain several of our control variables: Export growth$_{k,t-1}$, Export growth$_{ck,t-1}$, Foreign export share$^{R}_{ck,t-1}$ and State export share$^{R}_{ck,t-1}$.

Export growth$_{k,t-1}$ and Export growth$_{ck,t-1}$ are yearly export growth at the product-level and at the city-product level respectively. These proxies of export dynamics are computed using the mid-point growth rate formula using export values from t-2 and t-1. Foreign export share$^{R}_{ck,t-1}$ and State export share$^{R}_{ck,t-1}$ measure respectively the share of export quantities by foreign and state-owned firms for each product-city-regime combination.

World demand$_{k,t-1}$ is defined as the share of China's exports in world exports for a given product in a given year. This variable is obtained from the BACI world trade dataset.[54]

Export tax information comes from the General Administration of Customs of the People's Republic of China (www.customs.gov.cn) and the Ministry of Finance of the People's Republic of China (www.gss.mof.gov.cn). We calculate annual export taxes at the HS 6-digit level as the simple average over the various lines. This rate includes the special tax (from 2009) when applicable. The number of HS6 products covered by export taxes rose from 20 in 2002 to 252 in 2012.

Data on import tariffs at the HS6 level come from the World Integrated Trade Solution (WITS). We calculate simple averages of MFN tariffs, which measure the average level of nominal tariff protection applied to imports into China.

[54] This dataset is based on COMTRADE data using an original procedure that reconciles the declarations of exporters and importers (Gaulier and Zignago, 2010). BACI uses the 1996 HS 6-digit product nomenclature. It is downloadable from http://www.cepii.fr/anglaisgraph/bdd/baci.htm.

The Lerner index of local competition and the output shares of foreign and state firms used in Table 3 is calculated using firm level data from the Chinese Business Surveys data from 2001 to 2003.

D-2 Different classifications of products

In Section C, we check that our results hold after excluding a number of product categories which have specifically been targeted by the Chinese authorities. Rare-earth products are those listed in the WTO reports (WTO, 2008 and 2010), and products under conflict are a small group of 21 HS6 products of raw materials.[55]

Energy- and emission-intensive products are identified from the European Commission classification which singles out 78 HS6 products as energy- and carbon-emission intensive (Bergmann et al., 2007). High-tech products are defined based on the list established by the OECD of 319 high-tech products (Hatzichronoglou, 1997). The list of high-skilled products comes from the UNCTAD.

[55]Recently the "China Raw Materials dispute" at the WTO highlighted Chinese efforts to restrict its exports of rare-earth products which are key in the production process of many high-value products. China is by far the world's largest producer of the 17 metals known collectively as "rare earths". In the 2000s, Chinese authorities gradually tightened restrictions on these products in an effort to encourage the domestic processing of these metals and secure a better position in the global value chain.

E Theoretical Framework

We present a simple model of international trade with heterogeneous firms to highlight the expressions for the elasticity of the trade volume and price with respect to the export tax resulting from the incomplete VAT rebates. As described above, the non-rebated VAT amounts to an export tax. While it is expected that an export tax lowers the number of exporters and the volume of exports for infra-marginal exports, we need to derive our estimating equation from a formal model of trade to interpret the elasticity we get on the tax for the export quantity and export price.

E-1 Production and consumption

Our model builds on Melitz (2003) and Chaney (2008). We focus on the behavior of exporters using a partial equilibrium. We consider a given industry, characterized by the standard Dixit-Stiglitz assumption of monopolistic competition. There are N firms in this industry, each producing a single differentiated variety.

To produce and sell good k on a foreign market, each firm i incurs a firm-specific marginal cost c_i, a product-specific ad-valorem export tax t_k[56] and a destination-country export fixed cost C_j that is considered to be identical for all firms exporting to country j.

As is usual in the Dixit-Stiglitz monopolistic competition framework, the profit-maximizing price is a constant mark-up over marginal cost:

$$p_k(c_i) = \frac{\sigma}{\sigma - 1} c_i \tag{E-1}$$

[56] It corresponds to the un-rebated VAT. As indicated in Equation 1, the export tax rate implied by the incomplete VAT rebate applies to the export value.

where $\sigma > 1$ is the elasticity of substitution between two varieties of good k.

The price firm i charges for product k with marginal cost c_i to consumers on market j includes also the VAT export tax:[57]

$$p_{kj}(c_i) = \frac{\sigma}{\sigma - 1} c_i \ (1 + t_k) \tag{E-2}$$

Let E_j denote the total expenditure in country j on the relevant industry, and P_j the price index in country j. The final demand for goods in location j is derived from the maximization of the representative consumer's CES utility function. Country j's demand for a given variety i of good k is:

$$m_{kj}(c_i) = p_{kj}(c_i) \ q_{kj}(c_i) = [p_{kj}(c_i)]^{1-\sigma} \frac{E_j}{P_j^{1-\sigma}} \tag{E-3}$$

From these exports, firm i will receive the value net of taxes $\frac{m_{kj}(c_i)}{(1+t_k)}$.

E-2 Export tax, trade volume and price

Using profit-maximizing prices (Equation E-1), we can write the profit for firm i from exporting good k to country j as:

$$\pi_{kj}(c_i) = \frac{m_{kj}(c_i)}{(1 + t_k)} - c_i q_{kj}(c_i) - C_j = \frac{m_{kj}(c_i)}{\sigma(1 + t_k)} - C_j \tag{E-4}$$

Firms decide to export based on their individual profit. Let $\bar{c}_j$ denote the marginal-cost level that ensures that the revenue from exporting to country j just equals the total exporting cost. Substituting Equations E-3 and E-2 in Equation E-4 gives:

$$m_{kj} = [\frac{\sigma}{\sigma - 1} \bar{c}_i \ (1 + t_k)]^{1-\sigma} \frac{E_j}{P_j^{1-\sigma}} = C_j \sigma (1 + t_k) \tag{E-5}$$

[57]For simplicity we abstract from transportation costs.

Hence the marginal-cost threshold value is:

$$\bar{c}_j = \lambda_j \frac{1}{C_j}^{1/(\sigma-1)} \frac{1}{(1+t_k)}^{\frac{\sigma}{\sigma-1}}, \tag{E-6}$$

$$\text{with } \lambda_j = \frac{\sigma-1}{\sigma} E_j^{1/(\sigma-1)} P_j.$$

All firms with marginal cost lower or equal to $\bar{c}_j$[58] will export to j a quantity equal to:

$$q_{kj}(c_i) = [\frac{\sigma}{\sigma-1} c_i \ (1+t_k)]^{-\sigma} \frac{E_j}{P_j^{1-\sigma}} \tag{E-7}$$

Assuming that marginal cost is distributed as $P(\tilde{c} < c) = F(c)$ and $dF(c) = f(c)$, the total number of exporting firms is:

$$N_j = \int_0^{\bar{c}_j} N f(c) dc \tag{E-8}$$

with the marginal-cost threshold $\bar{c}_j$ falling with the export tax (Equation E-6). A drop in $\bar{c}_j$ corresponds to a higher productivity threshold for exporting and hence fewer exporters.

The exported quantity is:

$$Q_j = \int_0^{\bar{c}_j} N q_{kj}(c_i) f(c) dc \tag{E-9}$$

It is straightforward to see that the intensive margin (average quantity per exporting firm in Equation E-7) and the extensive margin (total number of firms in Equation E-8) of the bilateral exported quantity to j, Q_j, are negative functions of the export tax t_k.

Total export value also declines as the export tax rises since it brings a reduction in the number of exporters N and a rise in price p_{kj}:

[58] Note that $\bar{c}_j$ compares to $\bar{c}_j^*$ the classical threshold in Melitz (2003) in the following way: $\bar{c}_j = \bar{c}_j^* \frac{1}{(1+t_k)}^{\frac{\sigma}{\sigma-1}}$.

$$V_j = \int_0^{\bar{c}_j} N m_{kj}(c_i) f(c) dc = \int_0^{\bar{c}_j} N [p_{kj}(c_i)]^{1-\sigma} \frac{E_j}{P_j^{1-\sigma}} f(c) dc \qquad \text{(E-10)}$$

Our expectation is hence a reduction in the export quantity and value following a rise in the export tax stemming from incomplete VAT rebates.

The theoretical prediction regarding average (tax-inclusive) export prices ($\frac{V_j}{Q_j}$) is less clear cut since it concretely depends on the assumptions regarding the distribution of marginal cost $F(c)$. On the one hand, a rise in trade costs results in higher prices (Equation E-2). On the other hand, a rise in the export tax induces a fall in the cut-off $\bar{c}$, which drives some of the less productive firms, those charging high prices, out of export markets. This composition effect induces a reduction in the average unit value of exports that could well more than fully compensate the initial rise in individual prices.

Our empirical analysis hence primarily focuses on export quantities. We nevertheless elaborate in our discussion of the results on whether our estimates (for quantity and price elasticity) are consistent with the use of a Pareto distribution for marginal cost as in Chaney (2008).