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INDUSTRIAL SUBSIDIES AND THEIR IMPACTS ON EXPORTS OF TRADING PARTNERS: THE CHINA CASE

ABSTRACT

This paper explores the impact of Chinese subsidy interventions in the upstream sector on the competitiveness of the downstream sector. In particular, the paper investigates the effect of Chinese subsidies on basic metal products on the export competitiveness of downstream sectors in other major trading countries.

To explore the impact of base metal subsidies interventions on the downstream sector of a trading partner, we exploit both temporal variation in subsidy interventions and in base-metal consumption by the downstream sector. Using panel data for 137 sectors in 40 major trading partners of the Chinese economy, the results reveal that a one-unit increase in Chinese subsidies decreases competitors' exports by an average of 16.6%. This indicates that an increase in one standard deviation of Chinese subsides in the basic metal sector reduces exports in the other major economies by 0.17 percentage point. The findings reveal that the impacts of Chinese subsidies interventions are larger and statistically significant for the exports of developed countries, and metal intensive users in the downstream sectors.

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1. INTRODUCTION

For the past decade, we have observed an increase in government subsidies to domestic firms to increase their competitiveness in the global economy. Since the global financial crisis (GFC), both emerging and developed economies have significantly increased their subsidy support to certain targeted domestic manufacturing industries such as steel, aluminum, semiconductor, automotive, glass and paper (Hoekman 2015). Predominantly, governments justify the subsidies intervention to promote competitiveness of domestic firms and also to increase employment and investment in certain domestic sectors, where there exist high entry and sunk cost for domestic firms (Roberts and Tybout, 1997). In addition, subsidies are given to create high productivity jobs and to promote innovation enhancing investment, which can help domestic firms to move up the regional and global value chain (Hoekman 2015). However, several concerns were raised when subsidies and soft budgets are provided to state-owned enterprises (SOEs) that gives unfair advantages to domestic firms in international markets, as in the case of subsidies to Chinese SOEs that are believed to have distortionary effects on global trade and investment. The United States (US), for example, argues that Chinese subsidies to the steel and aluminum sectors create unfair competitive advantage by distorting global markets and price mechanisms (USTR 2020). Particularly, subsidies tend to intervene in the tradeable intermediate products that engage in a wide range of supply chains, easily propagate and disrupt multiple downstream sectors that are linked through the global value chain (Mattera & Silva 2018). While this anecdotal evidence tends to demonstrate the distortionary effect of China's subsidy policy for key intermediate inputs on global commerce, the causal effect of subsidies on the competitiveness of the downstream sector is not yet explored.

This paper investigates the causal effect of Chinese subsidies to basic metal products on the performance of downstream sectors in other major trading countries. Basic metal products, which include steel, iron, aluminum, copper, nickel, lead, zinc, tin, precious metals (such as silver, gold, and platinum) and other non-ferrous metals and articles thereof, are among the major government support recipients in China. For example, Chinese energy subsidies to the steel sector alone reached approximately $15.7 billion in 2007, registering a 3800 percent increase from year 2000. In the same year, Chinese steel production and export showed 289 percent and 1276 percent growth from their 2000 values, suggesting the potentially significant role of subsidies to Chinese dominance in the steel sector (Haley & Haley 2013). A OECD recent study also documented that government subsidies reached up to $70 billion for the largest 17 global firms operating in the aluminum value chain in the 2013-2017 period, where more than half of the support is provided to Chinese firms (OECD 2019). Similarly, the Chinese government subsidizes other products in the basic metal industry, as this sector supplies key intermediate inputs to many downstream sectors of the domestic and global economy (Blonigen 2015). Using a unique[1] basic metal subsidies interventions data as well as export and input-output data from 2008-2018, we explore the impact of Chinese basic metal subsidies on the export competitiveness of the downstream industries in the other major trading economies.

To do so, we exploit both the temporal variation in subsidies interventions and also in the base-metal consumption of the downstream sector. Following Blonigen (2015), we measure the competitiveness of the downstream sector using the level of export values. Export data value is a relatively good measure of global competitiveness and it is also largely available and consistently measured across countries and industries. Using the World Input-Output Database (WIOD), we identify the input-output linkages between Chinese base metals and the base-metals users of downstream sectors across several countries. Our identification relies on the assumption that changes in Chinese subsidies are exogenous to the exporters in the downstream sectors of the foreign countries. This assumption makes sense given the non-transparent nature and the limited notification history of subsidies interventions in many countries, including China. Moreover, we also assume that the input-output relationship between base metal and the downstream products is exogenous since this is largely determined by the technological requirement of production (Gaiha 1980).

Using a panel data of 137 sectors in 40 major trading countries, our estimated results reveal that a one-unit increase in China's subsidies decreases the total exports of downstream sectors using the basic metal as input in competitor countries by an average of 16.6%.

This indicates that an increase in one standard deviation[2] of Chinese subsides interventions in the basic metal sector reduces exports in the other major economies by 0.17 percent. This is a significant negative effect. Furthermore, the findings reveal that the magnitude of Chinese subsidies are larger and statistically significant for developed countries' exports, and metal-intensive downstream sectors. While the effect of 'liberalizing' subsidies interventions is statistically insignificant, 'harmful' subsidies interventions have large adverse effects on the export competitiveness of these countries.[3] Surprisingly, subsidy interventions that are classified as 'neutral' by the Global Trade Alert database have a relatively larger adverse effect on export competitiveness. Our baseline results remain robust to a set of different sensitivity analyses.

This study builds on the current literature that examines the effect of industrial policy on export performance (Blonigen 2015), production reallocation across countries (Kalouptsidi 2017), labour market effects (Criscuolo et al. 2019), competition (Aghion et al. 2015), and productivity (Rotemberg 2019). Kalouptsidi (2017) provide an empirical framework to detect subsidies in the world shipbuilding industry and quantify their effect on production reallocation across countries, prices, costs as well as consumer surplus. The paper provide strong evidence of Chinese government subsidy intervention in the shipbuilding industry.

1. The subsidy intervention data is extracted from the Global Trade Alert database. To the best of our knowledge, this is the first paper to analyse the effect of Chinese subsidy interventions on the export performance of downstream sectors with this unique data.

2. Standard deviation is usually used to interpret regression results when the explanatory variable is standardized to a mean zero and standard deviation of one. In such cases, a one standard deviation increase in the explanatory variable is equivalent to a unit increase in the standardized version used in the regression, and the effect on the outcome variable being reported is just the marginal effect or elasticity of that standardized explanatory variable. This approach is more appropriate when the explanatory variable has no natural scale or metric.

3. According to GTA evaluation, each intervention is classified in one of the three different groups: harmful, neutral, and liberalizing. Harmful intervention (signaled by red triangle in the GTA database) is an intervention that almost certainly discriminates against foreign trading partners. Neutral intervention (signaled by amber triangle) is an intervention that likely involves discrimination against foreign trading partners. Finally, liberalizing intervention (denoted by green triangle) liberalizes on a non-discriminatory (most favored nation) basis (Evenett, Simon J. & Fritz 2020).

The Chinese subsidies reduced shipyard costs by about 13-20 percent (equivalent to 1.5–4.5 billion U.S. dollars) during 2006 to 2012, which led to extensive reallocation of ship production across countries, with Japan losing significant market share. Similarly, using an exogenous area eligibility criteria change[4] in Europe, Criscuolo et al. (2019) demonstrate that a 10-percentage point rise in investment subsidy increases manufacturing employment by 10 percent in smaller firms. Aghion et al. (2015) also show that Chinese industrial policy (measured by subsidies, tax holidays, loans, and tariffs) that target competitive sectors increase productivity growth of the respective targeted sector. While these recent papers analyse the impact of industrial policy on economic outcomes, they do not consider industrial input-output linkages in their analysis. The input-output linkages are critical to understand the impact of subsidies on the competitiveness of the upstream as well as the downstream sectors. Exploiting input-output linkages, this paper attempts to fill a gap in the subsidies literature by examining the impact of subsidies interventions on global production value-chains in terms of export competitiveness of the downstream sectors.

Our paper is also related to the scant literature on the impact of subsidies interventions in the upstream sector on the competitiveness of the downstream sector. Recently, Liu (2019) explored the effects of industrial subsidies in the presence of cross-sectoral linkages through input-output linkages. He highlighted that market imperfections lead to distortionary effects that propagate to upstream sectors through backward demand linkages, causing these sectors to become significantly less competitive owing to the large market distortions. The findings show that governments should subsidize the upstream sectors (such as firms that are producing metal products, machinery, electronics, petrochemicals, automobiles, and ships) that are more vulnerable to market imperfections. In other words, the government should support those sectors that directly or indirectly supply a disproportionate fraction of output to other sectors with severe market imperfections. The paper also predicts that sectoral subsidy policies might have generated positive aggregate effects in South Korea in the 1970s and industrial activities in China in the 1990s. Blonigen (2015) is the closest paper to this study that considers input-output linkages in the analysis of subsidies interventions' potential effects. Blonigen (2015) analyses the impact of steel subsidies interventions in major steel producing countries on the competitiveness of downstream sectors in the steel subsidy-applying country. However, our paper is different from two perspectives. First, our paper focuses on analysing the effect of Chinese subsidies on the downstream sector of other countries. Second, while Blonigen (2015) focuses on a set of industrial policy interventions on steel (that include export subsidies, production subsidies, government ownership, national or regional cartel arrangements, quotas, price controls, Antidumping and Countervailing Duties (AD/CVD) measures, and import licensing), our paper focuses on just three types of subsidy interventions i.e. harmful, neutral and liberal, as they are the central and contentious issues in the recent US-China trade war. As such, our paper provides valuable insight into the potential effect of Chinese subsidies on the performance of downstream sectors of other countries such as the US.

The rest of the paper is structured as follows. Section 2 provides the background on Chinese metal sector subsidies and the data used in the study. Section 3 describes the empirical strategy. Section 4 presents the results and finally section 5 concludes.

4. Industrial policies generally target firms that are in difficult condition. Hence, the policy interventions are endogenous making regression coefficient unreliable. This paper tackles the identification problem by exploiting a policy experiment (the Regional Selective Assistance (RSA)) that brought exogenous changes to the eligibility criteria governing whether firms in economically disadvantaged areas could receive investment subsidies from a major subsidy program in the United Kingdom. This allows the authors to accurately estimate the impact of the program on employment.

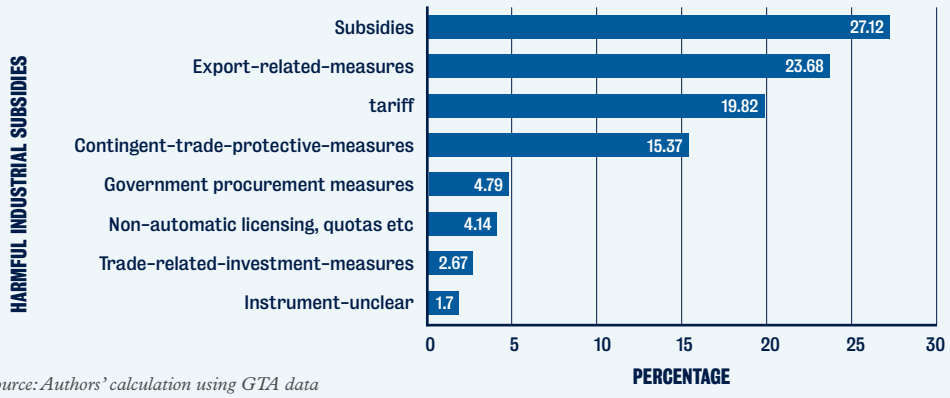
2. BACKGROUND AND DATA

2.1 Background

Many countries provide large subsidies to support a more dynamic industrial and manufacturing sector in the domestic economy. In recent years, Chinese subsidies to state-owned enterprises (SOEs) have helped China to become very competitive in capital-intensive products (such as steel, aluminum, glass, solar panel, auto-parts industry and shipbuilding) that the country has no comparative advantage in since it was a labor-intensive country. Anecdotal evidences suggest that subsidies played a crucial role for China to develop its industries over the course of five years from net importer to one of the largest producers and exporters of capital intensive products, where labor cost has no significant effect (Haley & Haley 2014). In particular, when we consider government discrimination against global trade post-2008, we find that governments tend to favor local firms through different industrial policy instruments. In general, export mercantilism is a persistent feature of government policy responses after the onset of the great financial crisis (Evenett, Simon J 2019).

The Global Trade Alert (GTA) database documents the different policy responses and highlights subsidies interventions as the biggest sources of distortions for global commerce. Figure (1) presents the percentage of the most harmful policy distortions for international trade and investment. Surprisingly, subsidies interventions (that exclude export subsidies) have accounted more than 27% of the policy instruments used to distort global cross-border commerce. The percentage of subsidies policy instruments used in the global market will dramatically increase when we include export subsidies, which are one of the most commonly used policy instruments to discriminate against foreign commercial interests. The figure also demonstrates that the other two major harmful policy instruments are tariffs and contingent trade-protective measures, ranked third and fourth, respectively.

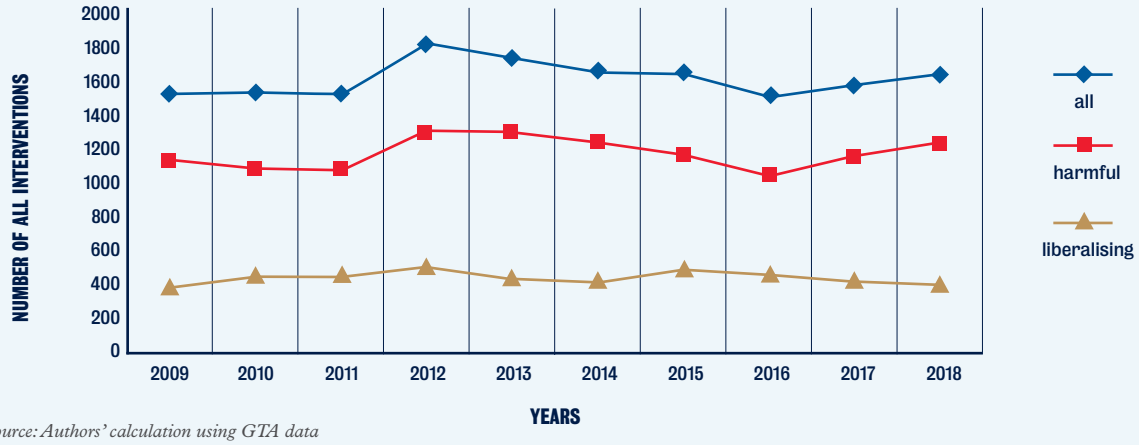
Figure 1: Percentage of harmful industrial policy instruments



Source: Authors' calculation using GTA data

While most countries provide some form of subsidies, there are widespread perceptions that the scale and scope of harmful subsidies interventions is largest in China. Figure (2) presents the number of harmful and liberalizing subsidies interventions by the Chinese government during the 2008-2018 period. According to the GTA, the Chinese government has engaged in more harmful subsidies interventions than liberalizing subsidies intervention in the post-Global Financial Crisis era. The number of harmful subsidies interventions is almost three times larger than the number of liberal subsidies interventions suggesting the unprecedented high number of harmful Chinese subsidies affecting global trade and investment. More importantly, while the number of liberalizing subsidies interventions began declining after 2015, the number of harmful subsidies interventions sharply increased after 2016 in China, implying a move to a potentially more predatory paradigm by the Chinese government.

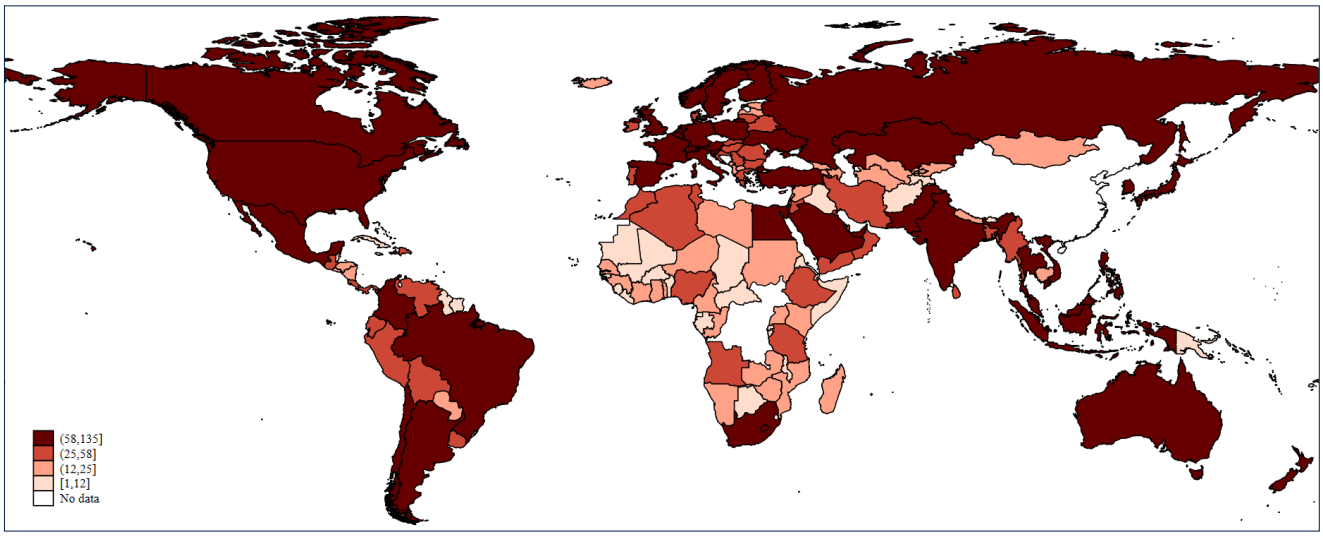
Figure 2: All Chinese harmful and liberalizing subsidies interventions



Source: Authors' calculation using GTA data

The GTA database also provides the number of subsidies interventions that affect the pattern of trade among countries. Hence, the harmful or liberalizing effect of subsidies for a given country directly depends on the degree of trade openness of that country. In Figure 3, we have mapped the potential effects of Chinese harmful subsidies interventions across different countries. As expected, harmful Chinese subsidies have larger adverse effects on more open economies such as the US, Canada, the EU, South East Asia, Australia, and the BRICS countries (i.e. Brazil, Russia, India and South Africa). The effect of harmful interventions is relatively lower in less open economies including sub-Saharan Africa and landlocked least developed countries.

Figure 3: The intensity of the impact of Chinese harmful subsidy interventions across countries from 2009–2019



Source: Authors' calculation using GTA data

Note: Following the global trade alert, the intensity of the effect of subsidy interventions on other countries are measured by the number of Chinese subsidy interventions that will affect each country. When the Chinese government implements a harmful subsidy intervention for the base metal sector, the GTA team records the potential trading partners that will be affected by the intervention based on official trade statistics. On the map, dark red denotes countries that are affected by more than 58 Chinese harmful base metal subsidy interventions from 2009-2019.

Besides the spatial variation, the number of Chinese base metal subsidies interventions also exhibit temporal variation. The Chinese subsidies interventions in this sector were relatively small during the first few years following the financial crisis, however, it is notable that the subsidies increased after 2015. For example, while the State Council of China abolished the export VAT rebate for boron steel and boron-containing steel products in 2014, subsidy interventions substantially increased for several base metal producing firms. Similarly, Lingyuan Iron & Steel Co. Ltd., a state-owned steel manufacturer, announced that it had received a 790 million RMB (roughly 122 million USD) financial grant from the Chinese government on 25 December 2015. The GTA database considers this financial aid discriminatory against foreign commercial interests.

Similarly, on 8 September 2016, the Gansu Chinese local government provided 136 million RMB (27.13 million USD) to the JISCO Hongxing Steel Company. Furthermore, on 25 November 2016, JISCO Hongxing Steel received additional 90.11 million RMB (approximately 13 million USD). According to GTA, this state aid measure is considered as discriminatory for foreign commercial interests. On 6 April 2016, Xinjiang Province authorities of China released three set of discriminatory subsidies policies for Jimsar County aluminum smelters. First, it provided land at low or little cost for aluminum smelter firms for expansion of their operations. Second, eligible firms are able to apply for reductions in the amount of income tax and VAT paid on inputs. Third, firms are also eligible to get several kinds of 'special funds' and 'subsidies' for research or demonstrate a more environmentally friendly production method, amongst other things.

It is important to note that all the three subsidies interventions are discriminatory to foreign commercial interest and hence are considered harmful in terms of market distortions.

More recently (on 15 August 2017), Hongqiao group, the world's largest and state-owned Chinese aluminum smelter, has received $1.02 billion bailouts. Following a joint meeting, China's CITIC, the largest conglomerate in the country, announced that it would be buying USD 806.6 million new shares and provide USD 320 million of convertible bonds. The decision is made after Hongqiao experience a series of difficult years "to adapt its business model to the increasingly stringent environmental requirements from the Chinese government".

2.2 Data

The data for the study was constructed from the following data sources. Output and export may be used to measure the competitiveness of a given sector (country). However, because of data availability issues, and following Blonigen (2015), we have used export value to measure country-sector competitiveness in this study. Export value data is extracted from the UN Comtrade database.[5] Our export data includes 137 sectors at 3-digit Common Product Classifications (CPC) and covers the period between 2008 and 2018. The data includes forestry, fisheries, minerals, food, textiles, petroleum, chemicals, plastics, metals, machinery and equipment. The analysis also covers the export data for 40 major economies. Appendix A presents the list of countries included in this study.

The second key variable in this study is the number of subsidies interventions (NSI). This variable includes the number of harmful, liberalizing and neutral subsidies interventions by the Chinese government in the basic metals sector. This data is collected from the GTA database. The GTA database provides real time government interventions that may potentially affect global commerce. The database contains information about countrywide trade policy interventions that may affect trade in goods and services, foreign direct investment and labor mobility.

In this paper, we focus on Chinese basic metals subsidies interventions that affect global trade in goods only. Overall, China imposed 145 subsidies interventions in all sectors within the 2008-2018 period.

Among the 145 Chinese subsidies interventions, we identify six subsidy types that target the basic metals sector. These subsidies interventions include capital injections and equity stakes including bailouts (1 intervention), financial grants (3 interventions), import incentives (2 interventions), in-kind grant (1 intervention), tax or social insurance relief (2 interventions) and tax-based export incentives (8 interventions).

We also use the global input-output matrix to map 40 countries' basic metals input sourcing from China. The World Input-Output Database (WIOD) provides world Input-Output tables (WIOT) in current prices for 28 European Union (EU) countries and 15 other major countries in the world for the period from 2000 to 2014. In this paper, we match the export of each sector with the WIOT using the two-digit International Standard Industrial Classification (ISIC, revision 4) product classification for the 2008 to 2014 period. The WIOT is not available for the 2015-2018 period. Since our analysis covers 2008-2018, we have used the 2014 WIOT to proxy for the 2015-2018 period. In addition, in the robustness checks[6], we have also used the average of the 2008-2014 world input-output table to proxy the 2015-2018 world input linkage between Chinese basic metals exports and the 137 downstream sectors in the 40 major economies.

Table 1: Summary statistics

Variable	Average	Standard deviation	Minimum	Maximum	Observation
Export value (in log)	11.759	2.855	-6.908	19.328	59413
Metal input share	0.002	0.013	0	0.555	60511
Number of metal subsidies	7.818	5.060	1	17	60511
Number of metal subsidies × metal input share	0.015	0.094	0	3.355	60511

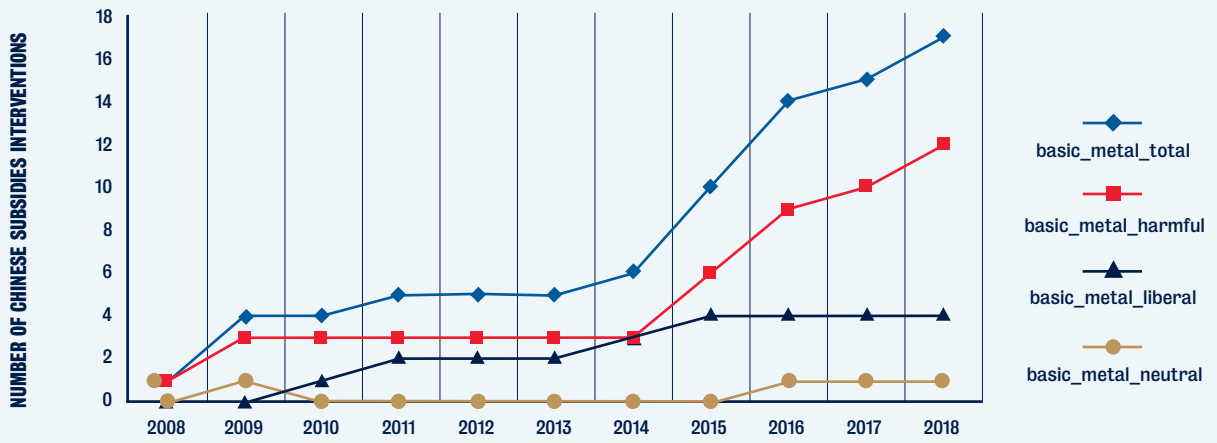
Table (1) shows the summary statistics of our key variables. The base metal input share ranges from zero to 0.55 with an average of 0.002 (or 0.2%) in our sample. The average base metal input percentage is substantially smaller than the share of other inputs as we include a range of different sectors including (1) agriculture, forestry and fishery products, (2) ores and minerals, (3) food, beverage, textile and leather products, (4) other transportable goods (such as wood, paper, chemicals, plastics, glass and furniture) and (5) metal, machinery and equipment. Obviously, agriculture, mineral and food products may likely use smaller amounts of base metals input during production, which can substantially decrease the percentage of average metal inputs share used in production. The table also reveals that the mean presence of base metal subsidies is close to eight for each year suggesting significant Chinese subsidies interventions in the sector.

Figure (4) reports the number of harmful, neutral, liberalizing, and total base metal subsidies interventions by the Chinese government. The figure suggests the number of subsidies interventions in this sector was relatively lower during the 2008-2013 period, however, the number of harmful interventions sharply rises after 2015. Contrarily, the number of Chinese subsidies that have liberalizing effects remain largely lower suggesting a growing protectionism tendency of the regime.

5. The UN Comtrade data is retrieved through the World Bank World Integrated Trade Solutions (WITS) database.

6. Robustness checks are common exercises in empirical economic studies. Such exercises are used to check if the core analysis is robust (insensitive) when the specification of the model is modified. For example, we may check the robustness of the baseline result by excluding outliers, removing some years, reducing the sample size.

Figure 4: Chinese basic metal subsidies interventions



Source: Authors' calculation using GTA data

3. METHODOLOGY

Following Blonigen (2015), we specify our empirical model as follows:

$$E_{ict} = \beta_1 + \beta_2 (NSI_t \times Metal\_Input\_Share_{ict}) + \theta_{ct} + \gamma_{it} + \rho_{ci} + \epsilon_{ict} \ldots\ldots\ldots(1)$$

Where E_{ict} is sector i export in country c and year t. NSI_t is the number of Chinese basic metal subsidies interventions at time t. $Metal\_Input\_Share_{ict}$ is the input share of basic metals (steel, iron, precious metals, aluminum, copper, nickel, lead, zinc and tin) in sector i, country c and time t. We use the global input-output table to identify the input-share of metal in sector t of country c (Blonigen 2015). θ_{ct}, γ_{it} and ρ_{ci} are the exporter-year, sector-year, and exporter-product fixed effects.[7] ϵ_{ict} is the white noise error term. β_1 is the constant term that denotes export when $NSI_t \times Metal\_Input\_Share_{ict}$ and the fixed effects are zero. In general, the constant term can be ignored in the interpretation since the interaction term is non-zero. β_2 is our coefficient of interest and it measures the effect of subsidy intervention on the export of the downstream sectors. We have interpreted the estimated value of β_2 in the result section.

In Eq. (1), NSI_t represents the number of all subsidies interventions in the base metal sector by the Chinese government. We identify the subsidies as harmful, some are liberalizing and others may have potentially neutral effect on the foreign market based on GTA classifications. To investigate the heterogeneous effect of subsidies interventions on export competitiveness, we substitute total subsidies interventions (NSI_t) in Eq. (1) by the total number of harmful interventions, liberalizing interventions, and neutral interventions. For example, to analyze the impact of harmful base metal subsidies interventions, Eq. (1) is re-specified as:

$$E_{ict} = \beta_1 + \beta_2 (HSI_t \times Metal\_Input\_Share_{ict}) + \theta_{ct} + \gamma_{it} + \rho_{ci} + \epsilon_{ict} \ldots\ldots\ldots(2)$$

Where HSI_t is the number of harmful Chinese subsidies interventions in the basic metals sector. Our coefficient of interest in Eq. (1) and Eq. (2) is β_2 and it will have a negative sign if Chinese subsidies interventions in the metal sector have negatively impacted on the export of other countries.

7. A fixed effects model is a statistical model in which the model parameters are fixed or non-random quantities. This is in contrast to random effects models and mixed models in which all or some of the model parameters are considered as random variables.

4. RESULTS

4.1 Baseline Results

Table 2 presents the baseline results. In column (1), we control the sector-year (product-year) fixed effects. In column (2), we control exporter-year fixed effect. Column (3) reports the estimated coefficients when we control both the sector-year and exporter-year fixed effects. Hence, our preferred estimation result is column (3). In all the cases, we have employed robust standard errors clustered at exporter-product level.

Table 2: The effect of Chinese base metals subsidies on exports: Baseline result

	(1)	(2)	(3)
	Dependent Variable: the log of export value		
NSI × Metal_Input_Share	-0.018 (0.056)	-0.117** (0.050)	-0.166** (0.066)
Exporter-Year FE	No	Yes	Yes
Sector-Year FE	Yes	No	Yes
Number of Observations R^2	59413 0.306	59413 0.385	59413 0.714

Note: ***NSI*** *is the number of total subsidies interventions by the Chinese government in each year.* ***Metal_Input_Share*** *is the shares of Chinese 'basic metal' inputs in the production of exportable goods in a particular sector at a given year and country. The 2014 input share of metals to downstream sectors is used as a proxy for the 2015-2018 metal input share. Robust standard errors clustered at the exporter-product level are reported in the parentheses. *, **, *** represent the level of statistical significance at 10%, 5%, and 1%, respectively.*

As column (3) shows, the estimated coefficient of the interaction term is large in magnitude and statistically significant at 5% significance level. The estimate suggests that a one-unit increase in the interaction term decreases exports by about 16.6%, on average. This indicates that an increase in one standard deviation of Chinese subsides interventions in the basic metals sector reduces export in the other major economies by 0.17 percentage.[8] This is a large negative effect for an average downstream sector where its base metal input is only 0.2%. In our preferred specification (column 3), the R^2 illustrates that 71.4 percent of the variation in export is explained by our variable of interest (the interaction of subsidies interventions and the input share of Chinese basic metals in each specific sector of a country) and the year specific fixed effects. We have controlled 1947 fixed effects in the final column. As such, the rich set of fixed effects allows us to capture much of the variation in downstream export value.

4.2 Placebo Test

In the baseline result, we generated our variable of interest by interacting the number of basic metals subsidies interventions by the Chinese basic metals input of a particular sector in a given year. In this section, we conduct a placebo test to detect if our regression is picking up coincidental (placebo) effect other than the effect of Chinese metals subsidies interventions. For the placebo test, we interact the number of all base metals subsidies interventions by sectors that do not use metal inputs, being (1) the input share of Chinese forestry and logging, (2) the input share of Chinese fishing and aquaculture, and (3) the input share of Chinese manufacture textile, wearing apparel and leather products in a particular sector. Intuitively, the false interaction term is not driven by Chinese base metals subsidies. As such, it should not have a significant effect on the downstream sectors of other countries. If the later interaction term has a significant effect (when it should not have), we cannot be assured that the baseline result is not picking up placebo effects.

Table 3: The effect of Chinese base metals subsidies on exports: Placebo test

	(1)	(2)	(3)
	Dependent Variable: the log of export value		
NSI × Forestry_Input_Share	1.105 (1.112)		
NSI × Fishing_Input_Share		-0.313 (0.235)	
NSI × Textile_Input_Share			-0.238 (0.187)
Exporter-Year FE	Yes	Yes	Yes
Sector-Year FE	Yes	Yes	Yes
Number of Observations R^2	59413 0.7146	59413 0.7146	59413 0.7146

8. This is computed as 100 × 5.060 × 0.002 × (-0.166)% = -0.17%. Hence, a one standard deviation (i.e. 5.060) change in the number of Chinese subsidies interventions is associated with a 0.17% decrease in the export value of the down-stream sector where base metal is 0.2% of its input.

Note: ***NSI*** *is the number of total subsidies interventions by the Chinese government in each year.* ***Forestry_Input_Share, Fishing_Input_Share,*** *and* ***Textile_Input_Share*** *are the shares of Chinese 'Forestry and logging', 'Fishing and aquaculture' and 'manufacture textile, wearing apparel and leather products' inputs in the production of exportable goods in a particular sector at a given year and country. The 2014 input share of metal to the downstream sectors is used to create the placebo input-output linkage. Robust standard errors clustered at the exporter-product level are reported in the parentheses. *, **, *** represent the level of statistical significance at 10%, 5%, and 1%, respectively.*

Table 3 presents the placebo effect. In column (1) we control for the interaction of the number of subsidies interventions and the input share of forestry and logging. In column (2) we control for the interaction of the number of subsidies interventions and the input share of fisheries. In addition, we also control for the interaction of the number of subsidies interventions and the input share of textiles products. Across all the columns in Table 3, the placebo term has no significant effect on exports. This indicates there is no evidence that our regression model is picking up a placebo effect on exports in the major global economies.

4.3 Considering lag and long-term effects

The baseline results in Table (2) report the contemporaneous average effect of Chinese subsidies interventions on the export competiveness of the downstream sectors of other economies. However, subsidies interventions may take time to have important effects on the exports of downstream sectors. Hence, in this section, we include 3 period lag interaction variables to examine if the intervention has any lag effects.

Table 4: The effect of Chinese base metals subsidies on exports: Considering lag effects

	(1)	(2)	(3)	(4)
	Dependent Variable: the log of export value			
NSI × Metal_Input_Share, *t*	-0.166** (0.066)			
NSI × Metal_Input_Share, *t-1*		-0.223*** (0.082)		
NSI × Metal_Input_Share, *t-2*			-0.176** (0.083)	
NSI × Metal_Input_Share, *t-3*				-0.058 (0.093)
Exporter-Year FE	Yes	Yes	Yes	Yes
Sector-Year FE	Yes	Yes	Yes	Yes
Number of Observations	59413	54259	48981	43542

Note: ***NSI*** *denotes is the number of all subsidies interventions by the Chinese government in each year.* ***Metal_Input_Share*** *is the shares of Chinese 'basic metal' inputs in the production of exportable goods in a particular sector at a given year and country. The 2014 input share of metal to the downstream sectors is used as a proxy for the 2015-2018 metal input share. Robust standard errors clustered at the exporter-product level are reported in the parentheses. *, **, *** represent the level of statistical significance at 10%, 5%, and 1%, respectively.*

Table (4) provides the estimated results. Column (1) is the baseline result. Columns (2) to (4) contains the estimated coefficient of the first, the second and the third year lags respectively. Interestingly, column (2) shows that a one unit increase in subsidies interventions decreases exports by about 22.3%, on average, suggesting subsidies interventions take time to have important effects on exports. The estimated coefficient in column (3) also shows that the second period lag has a significant negative effect on exports with a relatively smaller magnitude than the first period lag. However, the third period lag has no statistically significant effect on export competitiveness of the downstream sectors. The coefficient estimates in table (4) imply that a one standard deviation increase in Chinese subsidies interventions reduces export competitiveness of the downstream sector by at least 16.9% within the first 2 years. In general, while Chinese subsidies interventions have deleterious contemporaneous effects, the estimated results in table (4) demonstrate that this adverse effect is larger in the following two years. Hence, Chinese subsidies have medium term adverse effects on the export competitiveness of other countries.

4.4 Robustness Checks

We undertake two robustness checks using (a) an alternative input-output proxy for the period 2015-2018 and (b) excluding the basic metal and fabricated products from the derivation of the share of basic metals exports. To construct the interaction term of the baseline result, we used the world input-output table of the Chinese base metal in a given sector. However, the world input-output table in the WIOD database is only available up to 2014. Since our sample period includes 2008-2018, we have used the 2014 input-output table as a proxy for the 2015-2018 period. However, the input-output linkage between Chinese basic metals and the downstream sectors of the other countries may potentially change during the 2015-2018 period from the 2014 level. Hence, our assumption to use the 2014 input-output linkage may be restrictive. To address this concern and to check the robustness of our baseline results, we have calculated the 2008-2014 average input-output linkage and used it as an alternative proxy for the 2015-2018 period.

Table (5) provides estimated results. We control the sector-year fixed effects in column (1), the exporter-year fixed effects in column (2), and all the set of fixed effects in column (3). The preferred specification is given at column (3). Despite the new proxy for the input-output linkage for the 2015-2018 period, Chinese basic metal subsidies interventions have a negative and statistical significant effect on export competitiveness of other countries. Moreover, the magnitude of the interaction term is similar to the baseline results given at table (2).

Table 5: The effect of Chinese subsidy on export: Alternative Input-Output proxy for 2015-2018

	(1)	(2)	(3)
	Dependent Variable: the log of export value		
NSI × Metal_Input_Share	-0.018 (0.039)	-0.090*** (0.034)	-0.112** (0.045)
Exporter-Year FE	No	Yes	Yes
Sector-Year FE	Yes	No	Yes
Number of Observations R^2	59413 0.306	59413 0.385	59413 0.714

Note: ***NSI*** *is the number of total subsidies interventions by the Chinese government in each year.* ***Metal_Input_Share*** *is the shares of Chinese 'basic metal' inputs in the production of exportable goods in a particular sector at a given year and country. For the 2015-2018 average Chinese basic metal subsidies input to the output of each country sectors as a proxy. Robust standard errors clustered at the exporter-product level are reported in the parentheses. *, **, *** represent the level of statistical significance at 10%, 5%, and 1%, respectively.*

Our study focuses on analyzing the impact of Chinese subsidies interventions on the export performance and competitiveness of multiple products in other major countries. Intuitively, it is obvious that Chinese subsidies interventions will have a direct negative effect on the export of base metals in other countries as they directly compete in the world market. Similarly, fabricated metal, which intensively uses base metal products as input, might also negatively affected by Chinese metal subsidies interventions. As such, our baseline results may be mainly driven by the negative effect on base metal and fabricated metal export items, invalidating our assumption that Chinese subsidies in base metal sector are affecting other downstream sectors which source base metal inputs from China. To see the robustness of our results, we have excluded basic metal and fabricated metal export items of all sample countries.

Table (6) reports the estimated results when base and fabricated metals are excluded. Surprisingly, the negative effect of subsidies distortions substantially increases when we exclude the two export items. As column (3) shows, a one unit increase in subsidies interventions in basic metal harms export of the downstream sector by about 30.7% which is significantly larger in magnitude. While Chinese subsidies interventions include both liberalizing and harmful subsidies, our result suggests that subsidy interventions have a negative effect on the export competitiveness of other major global economies.

Table 6: The effect of Chinese subsidy on export: Excluding basic & fabricated metal products

	(1)	(2)	(3)
	Dependent Variable: the log of export value		
NSI × Metal_Input_Share	0.192 (0.128)	-0.167 (0.162)	-0.307* (0.163)
Exporter-Year FE	No	Yes	Yes
Sector-Year FE	Yes	No	Yes
Number of Observations R^2	55098 0.3052	55098 0.3840	55098 0.7122

Note: ***NSI*** *is the number of total subsidies interventions by the Chinese government in each year.* ***Metal_Input_Share*** *is the shares of Chinese 'basic metal' inputs in the production of exportable goods in a particular sector at a given year and country. The 2014 input share of metal to the downstream sectors is used as a proxy for the 2015-2018 metal input share. Robust standard errors clustered at the exporter-product level are reported in the parentheses. *, **, *** represent the level of statistical significance at 10%, 5%, and 1%, respectively.*

4.5 Heterogeneous Effects

The previous results demonstrate the average effect of the interaction of subsidies distortions and the input share of Chinese base metals in the downstream sectors. However, the latter results may mask substantial heterogeneity across different dimensions. In this section, we have analyzed if Chinese subsidies distortions have heterogeneous effects across various subsidies intervention types across countries (developed and developing countries) and also across sectors.

In the baseline result (Table 2), we aggregated the number of all Chinese subsidies interventions. While this allows us to identify the average effect of China's subsidy interventions, it might not reveal the heterogeneous effect of different forms of subsidy interventions. Table (7) illustrates the estimated coefficients of the different types of subsidy interventions. Columns (1), (2) and (3) report the estimated coefficients of harmful, liberalizing and neutral subsidies respectively. As expected, harmful subsidy interventions have a large negative effect on the export competitiveness of other countries. However, subsidies interventions that are classified as neutral by the GTA database have a negative and statistically significant effect on export competitiveness in the downstream sectors. Furthermore, the magnitude of neutral subsidies interventions is substantially larger than both the harmful and the liberal subsidies (columns 1 and 2 of table 7) as well as the estimated coefficient of all subsidies interventions in the baseline result (Table 2). Whereas liberal subsidies interventions have negative effects, the estimated coefficient is not statistically significant[9]. Overall, our results in table (7) reveal that nearly all forms of Chinese subsidies interventions have distortionary negative effects on the export of other countries.

9. When a beneficiary firm's subsidy is removed, it would undercut its price competitiveness both domestically and abroad. Thus, comparing the impact of liberalizing subsidy interventions on domestic and foreign countries would provide insight about the net effect of government support in the base metal sectors to policy makers. This will be one potential direction to explore in our follow up study.

Table 7: The effect of Chinese subsidy on export: Heterogeneous effect

	(1)	(2)	(3)
	Dependent Variable: the log of export value		
NHSI × Metal_Input_Share	-0.243** (0.106)		
NLSI × Metal_Input_Share		-0.459 (0.300)	
NNSI × Metal_Input_Share			-1.055** (0.510)
Exporter-Year FE	Yes	Yes	Yes
Sector-Year FE	Yes	Yes	Yes
Number of Observations	59413	59413	59413

*Note: **NHSI, NLSI** and **NNSI** denotes is the number of harmful, liberalizing, and neutral subsidies interventions by the Chinese government in each year. **Metal_Input_Share** is the shares of Chinese 'basic metal' inputs in the production of exportable goods in a particular sector at a given year and country. The 2014 input share of metal to the downstream sectors is used as a proxy for the 2015-2018 metal input share. Robust standard errors clustered at the exporter-product level are reported in the parentheses. *, **, *** represent the level of statistical significance at 10%, 5%, and 1%, respectively.*

We also explore the impact of subsidy interventions on developing and developed countries. Using the United Nation (UN) classifications, we have eight developing countries (Brazil, India, Indonesia, Korea Republic, Mexico, Russian Federation, Turkey and Romania) and 32 developed economies in our sample. We explore if Chinese subsidies have different impacts on the exports of the two group of countries. Table (8) provides the estimated results of Eq. (1). Columns 1 and 2 report the estimated coefficients for developed countries and developing countries respectively. While both coefficient estimates show negative causal impacts, only the downstream exports of developed economies are significantly affected by Chinese subsidies interventions. Hence, the adverse effects of subsidies on developed economies mainly drive our baseline results (in table 2).

Table 8: The effect of Chinese base metals subsidies on exports: Developing versus developing countries

	(1)	(2)
	Dependent Variable: the log of export value	
	Developed Countries	Developing Countries
NSI × Metal_Input_Share	-0.180*** (0.060)	-0.050 (0.063)
Exporter-Year FE	Yes	Yes
Sector-Year FE	Yes	Yes
Number of Observations R^2	47770 0.306	11643 0.385

*Note: **NSI** is the number of total subsidies interventions by the Chinese government in each year. **Metal_Input_Share** is the shares of Chinese 'basic metal' inputs in the production of exportable goods in a particular sector at a given year and country. The 2014 input share of metal to the downstream sectors is used as a proxy for the 2015-2018 metal input share. Robust standard errors clustered at the exporter-product level are reported in the parentheses. *, **, *** represent the level of statistical significance at 10%, 5%, and 1%, respectively.*

According to the GTA, Chinese subsidies interventions have large effects on some countries, while non-negligible effect on some other countries (see the map on the background section).[10] Hence, the larger effect on highly intensively affected economies may potentially drive our baseline results. To see the heterogeneous effect across intensity of subsidies, we have excluded 11 countries (Bulgaria, Croatia, Cyprus, Estonia, Greece, Hungary, Latvia, Lithuania, Luxembourg, Malta, Portugal, and Slovak Republic) where the intensity of Chinese subsidies interventions impact is lower. Table 9 provides the estimated results when we consider only the most intensively affected countries. Our preferred specification of Eq. (1) (column 3) indicates that a one unit increase in Chinese subsidies interventions reduces exports by around 14.8%, on average. This estimated coefficient is statistically significant (at 5% significance level) with a similar magnitude as the baseline estimate.

10. Countries that are affected by more than 58 Chinese subsidy interventions are considered as highly intensively affected countries. As such, we drop 11 countries (that includes Bulgaria, Croatia, Cyprus, Estonia, Greece, Hungary, Latvia, Lithuania, Luxembourg, Malta, Portugal, Slovak Republic) from the original sample.

Table 9: The effect of Chinese base metals subsidies on exports: Sample of high intensively affected countries

	(1)	(2)	(3)
	Dependent Variable: the log of export value		
NSI × Metal_Input_Share	0.055 (0.049)	-0.144** (0.051)	-0.148** (0.059)
Exporter-Year FE	No	Yes	Yes
Sector-Year FE	Yes	No	Yes
Number of Observations R^2	41847 0.458	41847 0.199	41847 0.664

Note: ***NSI*** *is the number of total subsidies interventions by the Chinese government in each year.* ***Metal_Input_Share*** *is the shares of Chinese 'basic metal' inputs in the production of exportable goods in a particular sector at a given year and country. The 2014 input share of metal to the downstream sectors is used as a proxy for the 2015-2018 metal input share. We classify countries according to the intensity of Chinese subsidy intervention. Robust standard errors clustered at the exporter-product level are reported in the parentheses. *, **, *** represent the level of statistical significance at 10%, 5%, and 1%, respectively.*

We also explored the heterogeneous impact across sectors. The downstream sectors in our study include (1) agriculture, forestry and fishery products, (2) ores and minerals, (3) food, beverage, textiles and leather products, (4) other transportable goods (such as wood, chemicals, plastics, glass and furniture) and (5) metals, machinery and equipment products. Despite including all the five groups of sectors in the analysis, the first three sectors are not the primary users of base metals inputs in the global value chain. Hence, our baseline results may be driven by the export of the latter group of sectors (i.e. transportable goods and metal products). Consequently, we divide our sample into two groups and quantify if subsidy interventions have different effects for the two groups.

Table 10: The effect of Chinese base metals subsidies: Metal intensive users and non-intensive users

	(1)	(2)
	Dependent Variable: the log of export value	
	Non-intensive users	Intensive users
NSI × Metal_Input_Share	1.088 (1.821)	-0.119*** (0.040)
Exporter-Year FE	Yes	Yes
Sector-Year FE	Yes	Yes
Number of Observations R^2	26875 0.647	32538 0.788

Note: ***NSI*** *is the number of all subsidies interventions by the Chinese government in each year.* ***Metal_Input_Share*** *is the shares of Chinese 'basic metal' inputs in the production of exportable goods in a particular sector at a given year and country. The 2014 input share of metal to the downstream sectors is used as a proxy for the 2015-2018 metal input share. Robust standard errors clustered at the exporter level are reported in the parentheses. *, **, *** represent the level of statistical significance at 10%, 5%, and 1%, respectively.*

Table 10 presents the estimated results. Column (1) reports the results for base metals input non-intensive users and column (2) shows the results for base metals input intensive users in the downstream sectors. The estimated results show that Chinese subsidies negatively affect only base metals input intensive user sectors. Interestingly, the estimated coefficient of the interaction term is statistically significant (at 1% significance level) and with a similar effect size as the baseline (in Table 2).

5. CONCLUSIONS

This paper analyzes the impact of Chinese industrial subsidies in the base metals sector on the export competiveness of downstream sectors of 40 developed and developing economies. Using a combination of sectoral exports, metals input shares, and subsidies interventions data, we find that Chinese subsidies interventions have resulted in substantial reductions of the exports of several downstream sectors.

Our results demonstrate that the adverse effects of Chinese industrial subsidies are larger for developed economies and for sectors that intensively use metals inputs. Furthermore, while interventions that liberalize subsidies use do not have a statistically significant effect, both harmful and neutral subsidies have considerable negative effects on export competitiveness. Hence, our results suggest that policy makers in the affected countries may formulate appropriate industrial policies that potentially minimize or eliminate the adverse effects metals subsidies in the downstream sectors of their economies.

Future research may focus on quantifying the impact of the level of subsidy support on the performance of downstream sectors. Using exact subsidy level data (rather than subsidy intervention) will allow to properly quantify the heterogeneous impact of different subsidy types on the performance of downstream sectors in other countries or the domestic economy.

Furthermore, the analysis can be extended to firm level studies to get micro level evidence regarding the role of subsidy on the participation and climbing up of domestic and foreign firms in the GVC ladder.

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APPENDIX

Table A1: List of sample countries

Argentina	Croatia	Ireland	Netherlands	Spain
Australia	Denmark	Italy	Norway	Sweden
Austria	Estonia	Japan	Poland	Switzerland
Belgium	Finland	Latvia	Romania	Thailand
Brazil	France	Lithuania	Russian Federation	Turkey
Bulgaria	Germany	Luxembourg	Singapore	United Kingdom
Cyprus	Greece	Korea Rep.	Slovak Republic	United States
Canada	Hungary	Malaysia	Slovenia	
Chile	India	Malta	South Africa	
China	Indonesia	Mexico		

Note: Our sample includes all the countries the countries that have sector level input-output data in the WIOD. China, Czech Republic and Taiwan have also input-output data in the WIOD. However, we exclude China as we study the effect of China's subsidy. We also excluded Czech Republic and Taiwan because poor export data for the 137 sectors.

Table B1: The effect of Chinese subsidy on export: Heterogeneous effect

	(1)	(2)	(3)
	Dependent Variable: the log of export value		
NHSI × Metal_Input_Share	-0.166** (0.072)		
NHSI × Metal_Input_Share		-0.351* (0.208)	
NHSI × Metal_Input_Share			-0.955** (0.431)
Exporter-Year FE	Yes	Yes	Yes
Sector-Year FE	Yes	Yes	Yes
N	59413	59413	59413

*Note: **NHSI, NLSI** and **NNSI** denotes is the number of harmful, liberalizing, and neutral subsidies interventions by the Chinese government in each year, respectively. **Metal_Input_Share** is the share of Chinese 'basic metal' inputs in the production of exportable goods in a particular sector at a given year and country. For the 2015-2018, we have used the 2008-2014 average Chinese basic metal subsidies input to the output of each country sectors as a proxy. Robust standard errors clustered at the exporter-product level are reported in the parentheses. *, **, *** represent the level of statistical significance at 10%, 5%, and 1%, respectively.*

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