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Trade Implications of China's Subsidies

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Prepared by Lorenzo Rotunno and Michele Ruta*

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JEL Classification Numbers:	F12, F14
Keywords:	China; Domestic subsidies; International trade; Spillovers; Overcapacity
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Trade Implications of China's Subsidies *

Lorenzo Rotunno† Michele Ruta‡

July 22, 2024

Abstract

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I. INTRODUCTION

Governments around the world are increasingly resorting to industrial policy and subsidies to steer their economies. In 2023 alone, there have been 2,500 new industrial policies – of which 71 percent are trade distortive (Evenett and others, 2024). Subsidies are by far the most popular instrument of industrial policy worldwide. Recent examples include the Inflation Reduction Act (IRA) and the Chips and Science Act in the US, the European Green Deal, and the Digital Europe program in the EU, and the so-called Made in China 2025 program in China. Amidst this flurry of new policies, the debate within policy and academic circles about the drawbacks and merits of industrial policy remains lively and with mixed takeaways (Cherif and Hasanov, 2019; IMF, 2024; Juhász, Lane, and Rodrik, 2023). Regardless of the effectiveness of these interventions, in a companion paper we find evidence suggesting that subsidies can have important spillovers through their effects on trade flows (Rotunno and Ruta, 2024).

China's subsidies have multiple goals as identified by the authorities from promoting the green transition to increasing resilience and self-reliance (Qiang, 2024). However, because of the peculiarities of the Chinese economic system and China's rising role in the world economy, China's subsidies have been the target of several complaints and retaliatory measures by its trading partners (Bown, 2023). Specifically, against a backdrop of lackluster domestic demand in recent years, China's subsidies to its manufacturing sector are under close scrutiny because of their potential repercussions on the global markets of subsidized products. To analyze this issue, we empirically investigate the effects of China's subsidies on its trade flows over the period 2009-2022. By assessing the importance of China's subsidies in shaping its exports and imports, we intend to shed light on the implications that China's industrial policy can have for its trading partners.

Our empirical approach builds upon and extends the design used in Rotunno and Ruta (2024). It exploits detailed data on subsidies and other policy instruments from the Global Trade Alert (GTA) database. For our sample period going from 2009 to 2022, these data provide information on the existence of subsidies at the product level implemented by China and other countries. The database, which tracks policy changes based on online sources (official government documents and firms' financial reports), includes in its definition of subsidies to firms both monetary and in-kind transfers (e.g., state aid and preferential access to land and other factors of production), and policies that entail a transfer of risk to the government (e.g., loans and loan guarantees), and losses in government revenues (tax breaks).[1] Importantly though, the database lacks information about the monetary value of subsidies, as well as 'legacy' subsidies introduced before 2009. These two limitations of the data are expected to attenuate our estimates of the impact of subsidies on trade flows. Intuitively, they imply categorizing as non-subsidized some products that actually received subsidies before 2009 and treating all subsidized products in the same way regardless of the size of the subsidy.

A first look at the data suggests that China is the largest user of subsidies measured by the number of policy interventions. By 2022 there were approximately 5,400 subsidy policies introduced since 2009 and in force in China, representing 95 percent of all GTA policies introduced by the country. These subsidies are concentrated in a few industries. Over the period, 20 percent of the sectors received over 50 percent of the subsidies. Importantly, the products and sectors that are targeted vary over time. In the earlier period of our sample, subsidies targeted more traditional industries such as mining of metal, paper and textile, while products such as solar panels, batteries and electric vehicles have been more frequent targets of new subsidies towards the end of the sample (possibly in relation to the Made in China 2025 industrial program), pointing to a shift in strategic sectors in China.

Our empirical analysis aims at assessing the trade effects of China's subsidies. We use variation over time across subsidized and non-subsidized products and industries, and allow the effect of subsidies to differ between China and other countries in the sample. In our empirical specification, we add fixed effects controlling for the influence of time-invariant, product- and country-specific factors, and dummies for the adoption of other GTA policies (e.g., import and export restrictions, local content requirements, government procurement policies). Because of possible endogenous selection into subsidies, other concomitant policy-driven and structural shifts, and retaliatory policies following China's subsidies (which should bias downwards any export effect specific to China), we interpret the estimates as descriptive of the evolution in exports and imports of subsidized products relative to other products after the subsidy.

Our results point to significant effects of China's subsidies on its trade flows. On the export side, exports of subsidized products are 0.9% higher (relative to non-subsidized products) after China's subsidies – an effect that is not statistically different from that found for other

[1] Subsidies as defined in the GTA are 'vertical' policies, since they target only certain products and sectors. While this definition is consistent with the economic concept of subsidies (IMF, OECD, World Bank and WTO, 2022), it may differ from legal interpretations based on WTO law that can be used in the WTO dispute settlement system.

countries.[2] The magnitudes of these direct percent effects are economically meaningful. The export effect on total exports is equivalent to one sixth of the average yearly percent increase in product-level exports. This average effect masks significant heterogeneity across destination markets and sectors. Our estimates suggest that exports of subsidized products from China to other G20 emerging economies (G20 EMs) are 2.1% higher after the subsidy than exports of other products to the same destinations. Furthermore, the export effects of China's subsidies vary considerably across sectors. Within electrical machinery – one of the new 'strategic' sectors – for instance, exports of subsidized products are found to be 7% higher than exports of other products after China's subsidies.

On the import side, China's subsidies are found to depress imports of targeted products relative to imports of non-subsidized products – an effect that is not found for other countries. Across origin countries, the implied effect on imports of subsidized products is stronger for Advanced Economies (AEs) – a 3% and 4.8% decrease in imports of subsidized products from G20 AEs and other AEs, respectively. Electrical machinery and metals are among the sectors where China's subsidies have strong import-substitution effects. Our estimates therefore suggest that China's subsidies have increased the country's share in export markets and reduced its share in import markets of subsidized products.

The effects of China's subsidies are amplified by supply-chain linkages—i.e. the 'indirect' effects of subsidies. We use China's input-output table in 2007 to measure the exposure of downstream sectors to subsidies in upstream industries (through cost shares) and the exposure of upstream sectors to subsidies in downstream industries (through sales shares). As the input-output table provides linkages by industry in China, we aggregate the subsidy and trade data at the industry level. The results reveal strong effects of subsidies propagating from upstream industries. More subsidies given to supplying industries are associated with higher exports in the buying industry. To appreciate the implied magnitudes of our estimates, consider the case of subsidies provided to the steel industry, which is the main supplier of inputs to the automotive industry (10 % of its total costs). The empirical results imply that increasing subsidies to steel by the number observed over 2015-2022 is associated with a 3.5% increase in exports of autos from China. These indirect effects are concentrated on exports to G20 AEs.

The findings on the indirect effects of subsidies are consistent with upstream industries expanding supply and lowering their prices following the deployment of subsidies. This up-

[2] As shown in annex, the China estimates on the export side are similar to the ones for US subsidies, and lower than those for EU subsidies, although the latter impact primarily within-EU trade flows.

stream effect allows industries downstream to become more competitive in export markets. Results from import regressions point to a negative effect of upstream subsidies on imports in downstream sectors. This result suggests that upstream subsidies allow downstream industries to also expand domestically and substitute for imports. Finally, the effects of subsidies given to downstream industries on trade in upstream sectors are statistically significant and with the expected sign (negative on exports of the supplying industry), but weaker than the effects of subsidies upstream — a result that accords well with findings on the US (Navarra, 2023) and South Korea Lane (2022).

As a third step in the analysis, we distinguish between the export price and quantity effects to contribute to the current debate on "overcapacity".[3] The heart of this debate is that, in a situation of slow growth in domestic demand, Chinese subsidies could create a mismatch between domestic demand and supply for certain products, leading to increased supply in world markets which manifests itself in higher export quantities and lower prices.[4] Conceptually, the impact of a subsidy on export quantities and prices is more complex and can be interpreted in different ways. A positive effect on export quantities and a negative effect on export prices are consistent with a subsidy creating excess supply domestically and higher quantities and lower prices in export markets. However, larger export quantities and lower prices can also be the result of subsidized firms realizing efficiency gains and lowering export prices, leading to expansion in foreign markets.[5] Moreover, other combinations of the price and quantity effects are suggestive of different dynamics. For instance, positive export price and quantity effects indicate that subsidies are contributing towards quality upgrading rather than excess supply, while negative export price and quantity effects could be rationalized by trading partners imposing countervailing duties or other trade remedies to offset the trade impact of the subsidies.

[3] We use the term "overcapacity" in this paper as it is commonly used in the public debate (see further below). Note, however, that this definition differs from the standard concept in economics which refers to a situation of excess capacity relative to an efficient benchmark (Cooley, Hansen, and Prescott, 1995; Gilchrist and Williams, 2005; Michaillat and Saez, 2015; Sun, 2023).

[4] In the words of U.S. Secretary of the Treasury Janet Yellen: "Now, we are seeing an increase in business investment in a number of "new" industries targeted by the PRC's industrial policy. That includes electric vehicles, lithium-ion batteries, and solar. China is now simply too large for the rest of the world to absorb this enormous capacity. Actions taken by the PRC today can shift world prices." (U.S. Embassy in China, 2024).

[5] In a recent speech, China's Deputy Finance Minister Liao Min noted about Chinese firms: "Enterprises reduced production costs through technological innovation and improved the affordability of new energy products" (State Council of the People's Republic of China, 2024).

We contribute to this debate by assessing the direction in which China's subsidies over the period of analysis have impacted export prices and quantities of targeted products, controlling for the influence of other factors such as macroeconomic policies and demand and supply shifts for specific products. We find evidence that China's direct subsidies increased export quantities and lowered prices in certain heavy and construction-related industries such as metal products and furniture. For the electrical machinery industry, which includes products at the centre of recent trade controversies such as lithium(-ion) batteries and solar panels, we find evidence suggesting that direct subsidies contributed to quality upgrading (increases in export prices and quantities).[6] We do not find evidence that subsidies reduced significantly export prices for this sector also when we account for the indirect effect of upstream subsidies on downstream exports, at least up to 2022. For autos, we find some evidence that the combination of direct and upstream subsidies has increased export quantities and reduced export prices in world markets. Finally, the point estimates for other industries are consistent with situations where subsidies lead to greater market concentration or inefficiencies (higher prices and lower quantities), or lower prices and quantities – the latter could be explained by the retaliatory policy responses of major trading partners.

This paper relates to the literature on the trade implications of industrial policy and, specifically, on the cross-border spillovers from China's policies. There is a long-standing debate in economics on the potentially distortive effects of industrial policies on trade (Baldwin and Krugman, 1988; Irwin and Pavcnik, 2004; Krueger and Tuncer, 1982). The more recent literature has exploited historical data to identify the effects of industrial policy on trade and economic growth (Harris, Keay, and Lewis, 2015; Juhász, 2018; Lane, 2022).[7] Recent sectoral studies have found evidence that China's policies led to significant reallocation of global market shares in the shipbuilding industry (Kalouptsidi, 2018) and in the lithium-ion battery Barwick and others (2024) industry. Other studies highlight the potential spillovers of China's policies enacted under the country's five-year plans. Cen, Fos, and Jiang (2024) find that China's production and employment expanded in industries targeted by these plans (relative to other industries), while the opposite happened in the same US industries – these negative 'direct' effects on US industries were partly offset by positive effects through supply chain

[6] Note that these results of sector-specific estimations exploit differences in export prices and quantities between subsidized and non-subsidized products *within* a sector. In the case of electrical machinery, batteries and solar panels are examples of HS 6 digit products included in the sector – our estimates do not pinpoint whether these products are driving the quality upgrading finding.

[7] A large literature – which primarily relies on country-specific case studies – deals with the consequences of industrial policies, with a specific focus on subsidies, for competition, productivity, prices, and labor markets (refer to reviews by Juhász, Lane, and Rodrik (2023), Cherif and Hasanov (2019), and Pack and Saggi (2006)).

linkages.[8] These effects of the China's expansion in the world economy linked to industrial policy are reminiscent of the literature on the "China shock" in the 2000s (Autor, Dorn, and Hanson, 2013; Pierce and Schott, 2016). In counterfactual simulations, Ju and others (2024) find that China's industrial policies raised welfare in both China and the US by targeting industries with relatively large external economies of scale. Our results that China's subsidies increase the exports of targeted products and industries are also consistent with firm-level evidence from Girma and others (2009) and Girma, Görg, and Stepanok (2020).

We contribute to this literature in several ways. First, by exploiting comparable data across countries, we are able to put China's experience with subsidies in a cross-country perspective. Second, by elucidating conceptually and empirically the mechanisms that can and cannot lead to effects of subsidies consistent with excess supply, we offer a first contribution to discuss these issues through the lenses of analysis and data.[9] Needless to say, more data and especially sectoral studies would be needed to fully unpack these difficult questions.

The rest of the paper is organized as follows. Section II describes the data used in the analysis and presents some trends in China's use of subsidies. In section III, we explain the empirical strategy and discuss the associated results on the direct and indirect trade effects of China's subsidies. Section IV presents the results on the impact of subsidies on export prices and quantities, and section V concludes by summarizing the main findings and outlining some important avenues for future research on the role of China's subsidies.

II. Data and trends in China's subsidies

Our empirical analysis exploits detailed data on subsidies and other policy instruments from the Global Trade Alert (GTA) database. For our sample period going from 2009 to 2022, these data provide information on the presence of subsidies at the product level implemented by China and other countries. Subsidies are defined as financial transfers from governments

[8]Li and Branstetter (2024) find that listed firms targeted by the MiC 25 plan did not significantly increase their productivity relative to other listed firms.

[9]The notion of excess supply or overcapacity and its implications for global markets is reminiscent of the "vent-for-surplus" hypothesis first introduced by Adam Smith in his *Wealth of Nations* (Smith, 1776). In his words: "When the produce of any particular branch of industry exceeds what the demand of the country requires, the surplus must be sent abroad, and exchanged for something for which there is a demand at home." Almunia and others (2021) find strong evidence for this mechanism in the case of Spain following the Great Recession: firms that faced stronger slumps in their domestic sales expanded exports more. Berman, Berthou, and Héricourt (2015) find instead that positive shocks in foreign demand increases domestic sales of French firms.

to firms that create an advantage to the beneficiaries (IMF, OECD, World Bank and WTO, 2022; UNCTAD, 2019).[10] The data records the dates of announcement, implementation and removal (if any) of each policy, the implementing country, and the set of products (defined at the HS 6-digit level) targeted.[11]

Policies enter the database if they represent "credible changes". We limit our analysis to policies that are deemed to be "trade distortive" – i.e., that discriminate against foreign firms (Evenett and Fritz, 2020). The database, which tracks policy changes based on online sources (official government documents and firms' financial reports), include in its definition of subsidies both monetary and in-kind transfers (e.g., state aid and preferential access to land and other factors of production), and policies that entail a transfer of risk to the government (e.g., loans and loan guarantees), and losses in government revenues (tax breaks). We consider also policies implemented by national financial institutions and subnational governments, which may play an important role in the Chinese context (e.g., through credit given by state-owned financial institutions). While this broad definition of subsidies and their "specific" (or "vertical") nature is consistent with an economic concept adopted by international organizations and the literature (IMF, OECD, World Bank and WTO, 2022; Juhász, Lane, and Rodrik, 2023; UNCTAD, 2019), it may differ from legal interpretations based on WTO law and that can be used in the WTO dispute settlement system.

We use the GTA data to construct dummies (at the product level) and counts (at the industry level) of subsidies and other government policies recorded in the database (e.g., import and export restrictions, technical barriers to trade, local content requirements, and restrictions to investments and other capital flows). Importantly, the database lacks information about the monetary value of subsidies, as well as 'legacy' subsidies introduced before 2009.[12] These limitations are expected to attenuate our empirical results. Ignoring legacy subsidies can lead

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[10]We exclude consumption subsidies and separate out in the empirical analysis the influence of export promotion policies (including export subsidies).

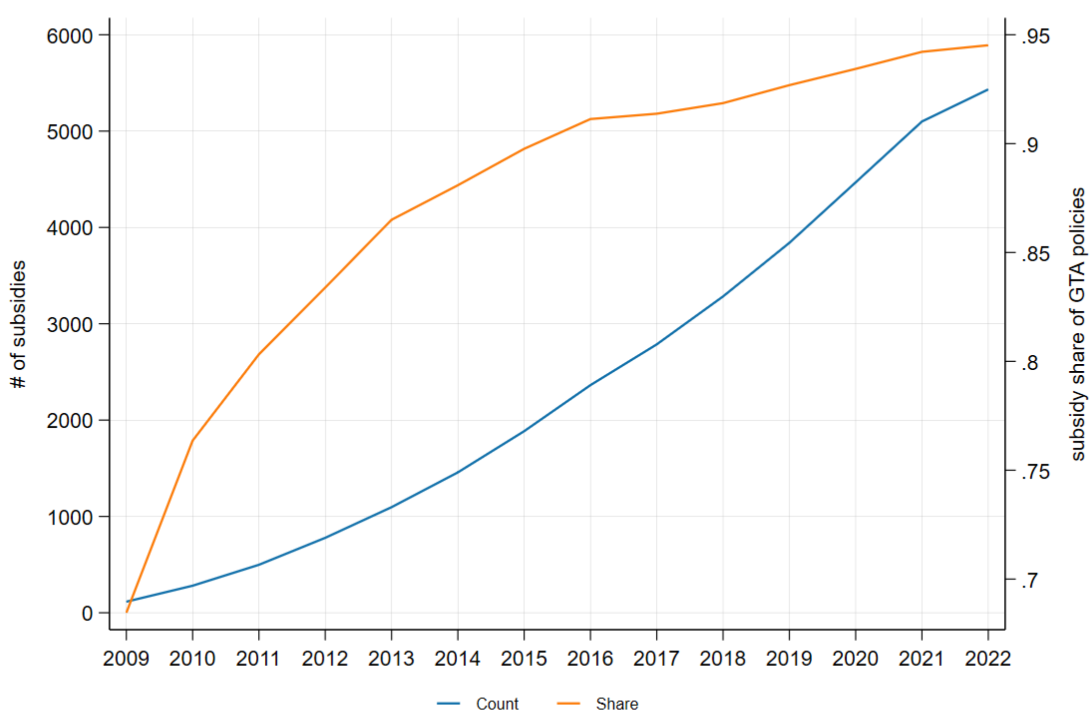
[11]In this section, we consider the year of entry (earliest between announcement and inception) and of removal (if any), as recorded. To better measure the timing of the effects in the econometric analysis (section III), the year of introduction of a policy is the earliest between the announcement and implementation if the date is before July 1st – the following year otherwise. Similarly, the policy is considered in force until the year of removal (if any) if this happens after July 1st – the year before otherwise.

[12]There are different estimates of the monetary importance of China's subsidies. Using different data sources, DiPippo and Kenedy (2022) estimate that different types of public support to industry in China amounted to 1.73% of its GDP in 2019, four times the U.S. support. Using data on large firms, OECD (2023) finds that firms in China received grants, tax breaks, below-market borrowing and equity totalling around 4.5% of their revenues over 2005-2019 period (Frank Bickenbach and Liu, 2024). Using data on the value of subsidies in 2023 from

to wrongly classify products targeted by pre-2009 subsidies as non-subsidized. Furthermore, using dummies and counts for policies means treating all subsidy policies equally, hence missing possible heterogeneity in treatment effects depending on the size of the subsidy.

Figure 1 shows the evolution in the number of subsidy policies implemented by China. By 2022, we count 5,400 subsidy measures introduced since 2009 and in force, which corresponds to two thirds of the total number of subsidy measures by G20 AEs in 2022. Subsidies are by far the most popular industrial policy instrument for China – they represent to 95% of all trade distortive GTA policies implemented by the country over 2009-2022. Almost all (98%) of China's subsidies are classified as monetary transfers from the government to firms (state aid and grants).

Figure 1. China's subsidy over time



Note: Policies announced since 2009 and in force. A policy is a country-policy combination, counted once regardless of the number of products affected.
Source: Global Trade Alert and authors' calculations.

the New Industrial Policy Observatory (Evenett and others, 2024), China's subsidies amount to 0.9% of its GDP (1% in the US and 2.2% in the EU).

The rise in China's subsidies has been concentrated in a few sectors. As Figure 2 Panel (a) portrays, the bulk of subsidies in 2022 target products in the chemicals, machinery, automotive and metals industries.[13] In particular, the top 20 % recipient industries attract almost half of all China's subsidies.

These industries are among the ten key sectors indicated as strategic in the Made in China 2025 (MiC 25) plan launched in 2015.[14] As Panel (b) shows, China's subsidies indeed targeted disproportionately more these sectors than others starting from 2016.[15] By 2022, the number of subsidies in strategic sectors almost quadrupled relative to 2015 – it went from 647 to 2420, while it tripled in other sectors. Although the divergence is most visible since 2019, already over the 2015-2018 period the number of subsidies in key sectors grew by 80% (75% in other sectors).

In Figure 3 we single out the number of subsidies in products that are included in China's strategic industries and that have recently become the subject of trade investigations by the EU and US (e.g., European Commission (2024)). These products – wind turbines, solar panels, lithium-ion batteries and electric vehicles (EVs) – are also indicated as critical in supporting the green transition.[16] China's subsidies have increased after 2015 especially in batteries and solar panels, while the trends for EVs and wind turbines is roughly similar to that in all other products.

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[13]Industries are defined at the ISIC 2-digit level. HS 6-digit products from the HS 2012 classification are matched to ISIC 2-digit rev. 3 industries using correspondences tables from the UN. Note that since define a policy as a country-policy combination, the same policy can span multiple industries.

[14]The ten sectors as listed in the English press release from the Chinese government (China's State Council, 2015) are: new information technology, High-end numerically controlled machine tools and robots, Aerospace equipment, Ocean engineering equipment and high-end vessels, High-end rail transportation equipment, Energy-saving cars and new energy cars, Electrical equipment, Farming machines, New materials, such as polymers, Bio-medicine and high-end medical equipment. These sectors are matched with the following ISIC 2-digit divisions: Medical, precision and optical instruments; Machinery and Equipment, N.E.C.; Electrical machinery; Chemicals and chemical products; Motor vehicles, trailers and semi-trailers; and Other transport equipment.

[15]These patterns are confirmed in firm-level reports of subsidy income. For 2016, Ju and others (2024) find that the value of subsidies as a share of total sales equal on average 0.29% for firms in strategic, MiC 25 sectors, and 0.01% for firms in other industries.

[16] For some of these products the HS 2012 products classification used in GTA is slightly broader than the products themselves. For wind turbines, the HS 6-digit product is 850231, whereas the code for lithium-ion batteries (including batteries for EVs) is 850760. Solar panels are matched with code 854140, which includes also photovoltaic cells not assembled into panels and light emitting diodes (LED). In HS 2012, EVs should be included in code 870390 – vehicles for transporting passengers not elsewhere classified (by exclusion EVs, but also hybrid cars, station wagons and racing cars.

The trends in Figure 3 suggest that in recent years China has oriented its industrial policy towards strategic sectors and products at the frontier of new green technologies. Figure A.1 in the Appendix generalizes this finding, by showing the trends in China's and US subsidies in Advanced Technology Products (ATP, as classified by the US Census Bureau) relative to other products.[17] As depicted in panel (a), the number of CHN subsidies in ATP increased much faster than in other products after 2016, following the same trend of strategic sectors.[18] Panel (b) shows the patterns for the US, as the country has defined a list of "Critical and Emerging Technologies" in 2020, which overlaps with the ATP.[19] US subsidies have also increased more for ATP than for other products, especially since 2020. The relative increase has been however stronger for China's subsidies, highlighting the competitive nature of subsidies to high-tech sectors by the two major economies.

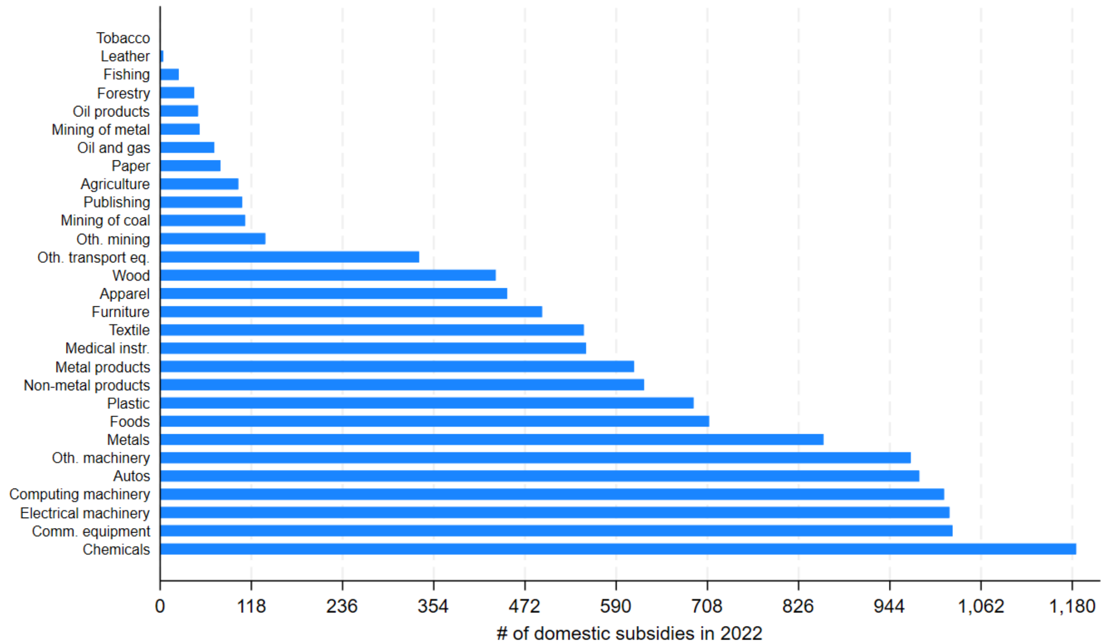
[17]The list of ATP is available here: https://www.census.gov/foreign-trade/reference/codes/atp/index.html. We take the 2012 version as it matches with the HS 2012 classification used in the GTA data.

[18]There is indeed substantial overlap between China's strategic sectors and ATP. All ISIC 2-digit sectors matched with the ten strategic sectors except automotive are represented in ATP. At the product level, 76% of the 2018 ATP are covered in the strategic industries.

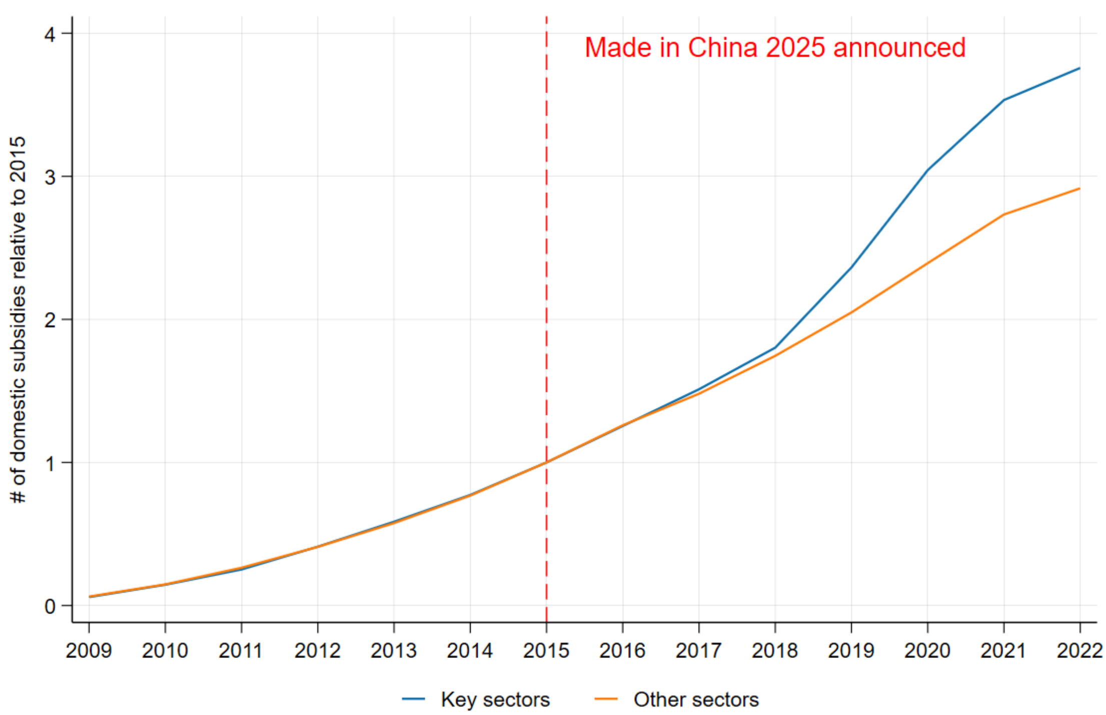
[19]The list does not provide HS product codes, but some of the technologies and products are very close to the HS codes descriptions of the ATP. While the list "should not be interpreted as a priority list for either policy development or funding", it has been introduced to "inform national security-related activities" (US National Sciences and Technology Council, 2024).

Figure 2. China's subsidies by industry and strategic sectors

(a) By ISIC 2-digit industry

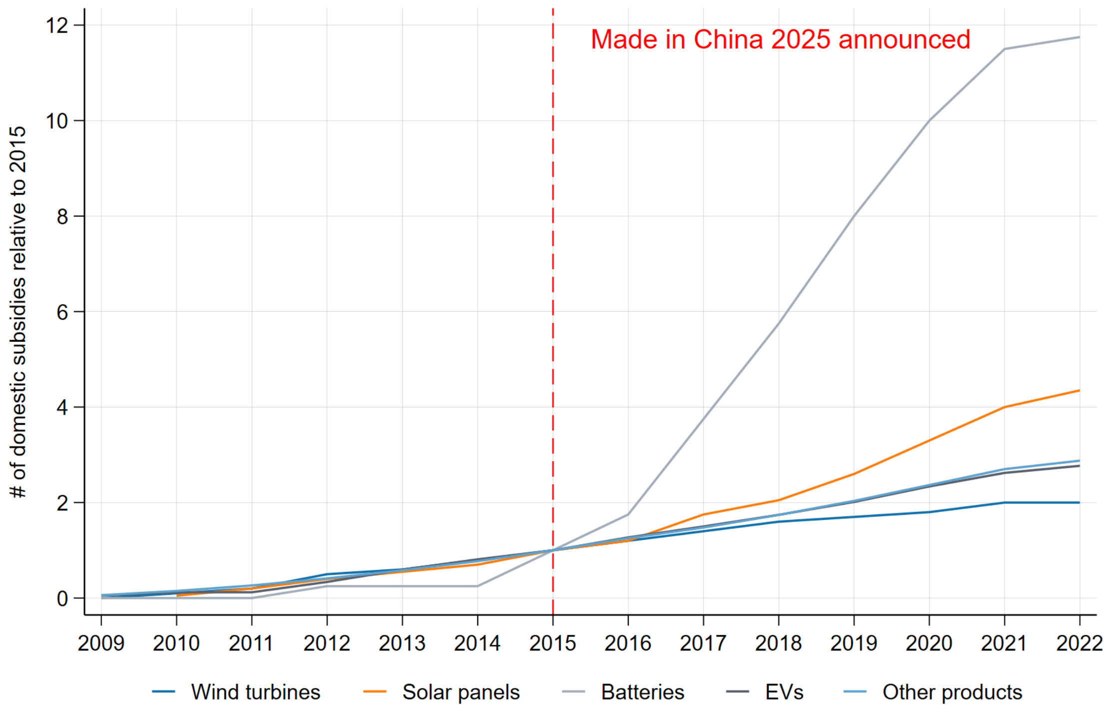


(b) By strategic sectors



Note: Policies announced since 2009 and in force. A policy is a country-policy combination, counted once regardless of the number of products affected. The same policy can be counted in multiple industries. The ISIC 2-digit industries matched with the 10 "key sectors" identified in the MiC 25 plan are: Medical instruments; Other machinery and equipment; Other transport equipment; Chemicals; Electrical machinery and Autos (motor vehicles, trailers and semi-trailers). These industries are somewhat broader than the names of the key sectors in MiC 25.
Source: Global Trade Alert and authors' calculations.

Figure 3. China's subsidies by key product



Note: Policies announced since 2009 and in force in China. A policy is a country-policy combination, counted once regardless of the number of products affected. The same policy can be counted in multiple products. See footnote 16 for the HS 2012 codes matched to each of the products.
Source: Global Trade Alert and authors' calculations.

III. Effects of China's subsidies on its exports and imports

Our empirical analysis investigates the relationship between trade and subsidies, with a focus on China. We combine information on subsidies from the GTA database with product-level data on trade flows from the BACI database of CEPII (Gaulier and Zignago, 2010) to estimate the *direct* effects of China's subsidies on exports and imports of subsidized products relative to other products. To assess *indirect* effects through supply chain linkages, we aggregate the data at the industry level and estimate the effects of China's subsidies given to supplying and buying industries on exports and imports.

A. Direct effects of China's subsidies on product-level trade

Our baseline specification extends the difference-in-difference regression in Rotunno and Ruta (2024) by interacting the subsidy and policy dummies with an indicator for China:

$$\ln\left(X_{ik,t}\right) = \beta_1 S_{ik,t} + \beta_2 S_{ik,t} \times CHN_i + \beta_3 IP_{ik,t} + \beta_4 IP_{ik,t} \times CHN_i + \alpha_{ik} + \alpha_{ik} \times t + \delta_{i,t} + \mu_{k,t} + \varepsilon_{ik,t} \quad (1)$$

The outcome variable X denotes the value of exports or imports of country i in product k ad year t (in logs). We consider totals and flows by group of trading partners: G20 AEs, G20 EMs, other AEs and other EMs (destinations for exports and origins for imports). The main covariate of interest is the dummy S for the existence of subsidies introduced by country i on product k. Our sample includes 150 countries. To identify the effect of subsidies on China's trade while controlling for the influence of subsidies in other countries, we interact the subsidy dummy with an indicator variable, $CHN = 1$ for China's subsidies and trade observations. The sum of the β_1 and β_2 coefficients provides an estimate of how China's subsidies affect exports and imports of subsidized products relative to those of other products, both within and across industries.

The rest of the specification in eq (1) controls for other policies and systematic factors that can obfuscate the relationship between China's trade and subsidies. The IP matrix collects dummies for other GTA policies: import and export restrictions, local content requirements, government procurement restrictions, capital market policies (e.g. restrictions to FDI), technical barriers to trade and other restrictions (intellectual property rights and migration restrictions). We further include country-product fixed effects (α_{ik}), which control for time-invariant determinants of trade (including trade costs) and subsidies, and country-product linear trends. Country-year fixed effects ($\delta_{i,t}$) absorb the influence of macro shocks, including fiscal and monetary policies, as well as any systematic differences in trade or reported subsidies across countries and over time.[20] Product-year fixed effects ($\mu_{k,t}$) capture global shocks to HS 6-digit products, including common non-linear variations in productivity. The inclusion of the product-year fixed effects also implies that the coefficient on the subsidy variables can be interpreted as indicating the effects on export and import shares, conditional on observing positive flows (the fixed effects controls for total exports and imports in a given product, which is the denominator in the market shares).

[20]The country-year fixed effects can absorb also the influence of other interventions such as place-based policies and infrastructure investments that are common across products. However, these policies can have heterogeneous effects across sectors (e.g., through input-output linkages) that can confound the impact of subsidies on trade.

The identification of the effects comes from differences in the trajectories of exports and imports between subsidized and other products around their linear trends. While the variables for other GTA policies and the exhaustive set of fixed effects control for many possible confounders, time-varying shocks specific to subsidized products that correlate with subsidies and trade can invalidate a causal interpretation of the β_1 and β_2 coefficients. For instance, productivity and political economy dynamics that vary across products can influence the allocation of subsidies and correlate with trade performance. The findings of Rotunno and Ruta (2024) underscore this possibility, as they highlight how exports and imports of subsidized products increase relative to the other products before the implementation of the subsidy – a pattern that is most visible in the sample of G20 AEs and is consistent with unobserved political economy forces shaping both subsidy allocation and trade performance. Differential trends in exports and imports between subsidized and non-subsidized products can confound the effect of the subsidy, thus limiting any causal interpretation of our estimates.[21]

A different potential source of bias in our estimates comes from retaliatory policies taken by other countries in response to China's subsidies. By lowering China's exports, these policy reactions can mute the export effect of China's subsidies ($\beta_1 + \beta_2$ in eq (1)). The inclusion of product-year fixed effects in the specification attenuates this concern, since it absorbs the influence of global changes in the number of policies (e.g., as a result of a subsidy war).[22] The fixed effects however do not control for differential policy responses across countries. This factor can be important when estimating the trade effects of China's subsidies. Recent work (Bown, 2023) as well as anecdotal evidence (European Commission, 2024; Office of the United States Trade Representative, 2024) highlight how China is increasingly the target of countervailing and anti-subsidy policies especially by advanced economies. Moreover, the initial wave of US tariffs on China's exports in 2018 targeted disproportionately China's strategic industries (Ju and others, 2024).[23] If effective, these retaliatory policies should curtail any expansion in exports from China to the responding economies following China's subsidies. Because of these potential sources of bias (from endogenous selection into sub-

[21] In additional results available upon request, we confirm that this concern indeed affects our estimates of the China-specific subsidy coefficients. We find significant China-specific effect of subsidies in the years before the subsidy, which rejects the parallel trends assumption. Anticipating the estimates shown below, our baseline results thus suggest that China's subsidies have accelerated trends in exports and imports specific to subsidized products that were already in motion before the intervention.

[22] For instance, the patterns depicted in Figure A.1 in the Appendix are suggestive of tit-for-tat dynamics in subsidies between China and the US, especially in high-tech sectors.

[23] After the first wave of US tariff increases, the average US tariff on Chinese products belonging to the MiC25 industries was 12.07%, against 1.71% in other products.

sidies and from retaliatory actions following China's subsidies), we interpret our estimates as descriptive of the relationship between exports and imports, and subsidies, conditional on other policies and fixed effects.

Table 1 shows the estimates of interest for exports (panel (a)) and imports (panel (b)). Columns (1) and (2) report the estimates for total trade flows. We find that receiving a subsidy increases export values at the product level in China by 0.9% on average. The same but opposite percent effect is found on imports. Both export and import effects are lower in China than in other countries. This difference is most notable on the import side, where subsidies are associated with increased imports for other countries – see Rotunno and Ruta (2024) for an interpretation of this result, which is related to the presence of endogenous selection into subsidies.[24] While small at face value, these percent effects are of economic significance. On the export side, the estimated percent increase in exports of subsidized relative to non-subsidized products in China is equivalent to one sixth of the average yearly percent increase in product-level exports. On the import side, the reduction is more notable, as on average China's imports have grown 3% per year over 2009-2022. Furthermore, the estimated effects apply to a large share of China's trade – China's subsidies cover 77% of the country's exports and 83% of its imports.

The pro-export effect of China's subsidies is driven by exports to other G20 EMs. The estimates in column (5) suggest that China's exports of subsidized products to other G20 EMs are 2.1% higher after the subsidy than those of other products to the same destinations. The coefficients for other destinations are small and not significant, indicating that China's subsidized products do not gain market shares in AEs. A possible explanation of this result is that in those destination markets subsidized Chinese products may face high barriers because of trade remedies such as countervailing duties or other retaliatory policies. On the import side, the estimates reveal strong import substitution effects of China's subsidies across different trading partners. The negative China coefficient is stronger for AEs (implying a 3% and a 4.8% decreases in imports from G20 AEs and other AEs of subsidized products relative other products) than for imports coming from EMs. These results suggest that when targeted by China's subsidies, imports decline while exports increase only when directed to other major emerging economies.

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[24] Table A.1 reports the estimates specific to China's as well as US and EU subsidies. The export effect of China's subsidies is similar to the one of US subsidies, whereas EU subsidies have a stronger percent effect on the exports of subsidized products. The import-substitution influence of China's subsidies stands in contrast with the zero effect of US subsidies and the positive association between EU subsidies and imports.

Table 1. Effects of China's subsidies on trade in targeted products

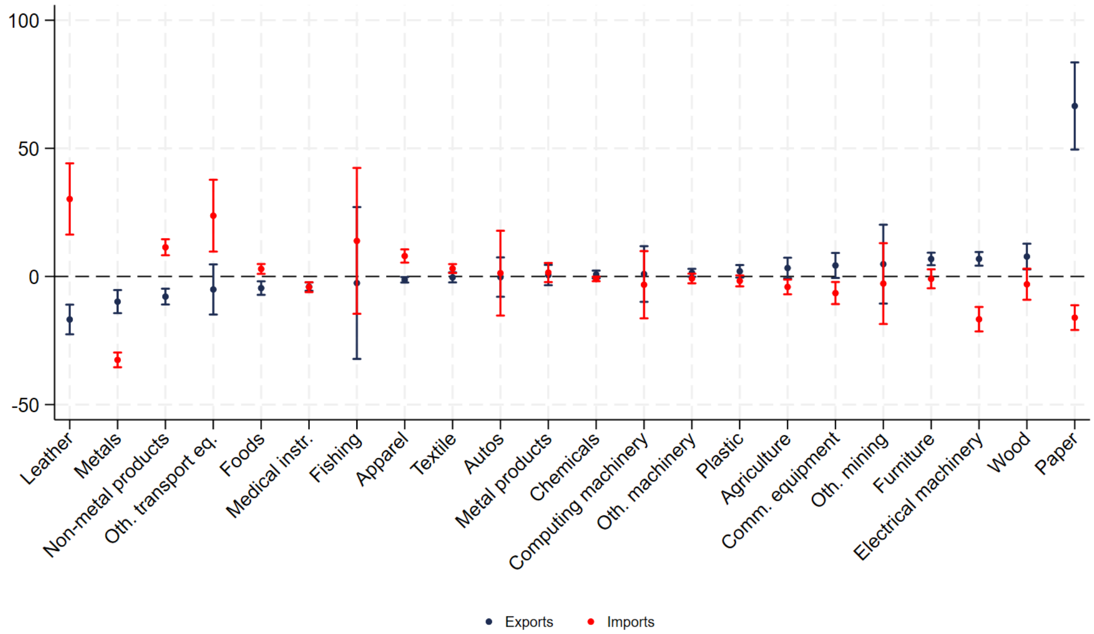
	(1)	(2)	(3)	(4)	(5)	(6)
	Panel (a). Dep. variable: Ln(exports)					
	Total	Total	G20AEs	G20EMs	Oth. AEs	Oth. EMs
Subsidies	0.023***	0.023***	0.021***	-0.005	0.018***	0.004
	(0.006)	(0.006)	(0.008)	(0.009)	(0.007)	(0.007)
Subsidies × CHN	-0.014*	-0.014*	-0.025**	0.026**	-0.009	-0.000
	(0.007)	(0.007)	(0.011)	(0.012)	(0.008)	(0.009)
CHN effect	0.009**	0.009**	-0.004	0.021***	0.009	0.003
	(0.005)	(0.005)	(0.007)	(0.007)	(0.006)	(0.006)
Obs	6783016	6783016	4461509	3854610	4444469	5778983
R^2	0.90	0.90	0.90	0.87	0.90	0.88
	Panel (a). Dep. variable: Ln(imports)					
Subsidies	0.033***	0.034***	0.016**	0.081***	0.023***	0.020**
	(0.006)	(0.006)	(0.007)	(0.012)	(0.006)	(0.009)
Subsidies × CHN	-0.042***	-0.043***	-0.046***	-0.104***	-0.071***	-0.025**
	(0.007)	(0.007)	(0.008)	(0.013)	(0.009)	(0.012)
CHN effect	-0.009**	-0.009**	-0.030***	-0.023***	-0.048***	-0.005
	(0.004)	(0.004)	(0.004)	(0.007)	(0.007)	(0.008)
Obs	9367644	9367644	7617616	7836578	7004814	6916524
R^2	0.92	0.92	0.91	0.88	0.89	0.85

Note: Regressions at the product level. Exports and imports (in logs) are the dependent variables. Columns (2) to (6) include dummies for other GTA policies as well as their interaction with the CHN dummy. All columns include country-product, product-year, country-year fixed effects, and country-product linear trends. Standard errors are two-way clustered by product and country. $*$ significant at 10%; $**$ significant at 5%; $***$ significant at 1%.

The estimates shown in Table 1 conceal significant variation across industries. The China-specific percent effects of subsidies (computed from $\beta_1 + \beta_2$ in eq (1)) by industry (defined at the ISIC 2-digit level) are displayed in Figure 4.[25] While in some industries (including large recipients of subsidies like the auto industry) exports and imports of subsidized products are found to be no different from those of other products, in other industries export and import effects have opposite signs. For instance, in the electrical machinery and furniture industries, subsidies are found to foster exports while reducing imports. The metals industry is an interesting exception – exports and imports of subsidized products in this industry decline relative to those of other products within the industry, possibly indicating that subsidies may promote sales to domestic downstream industries (an issue that is further investigated below).

[25] Because of the log specification, the percent effects equal: $[\exp(\beta_1 + \beta_2) - 1] * 100$.

Figure 4. Effects of subsidies on China's exports and imports by industry (in %)

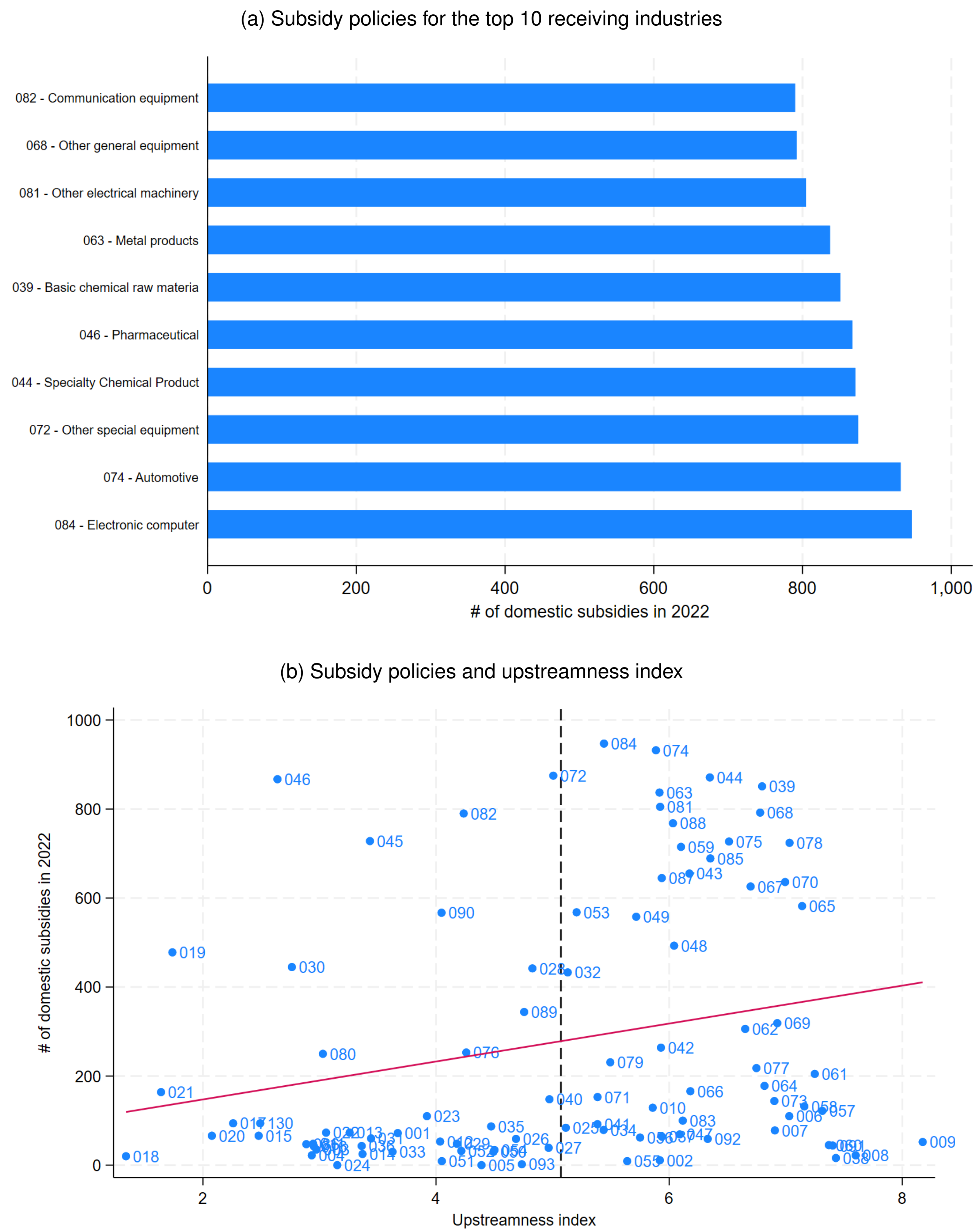


Note: Estimates by ISIC 2-digit industry (mining, fishery and forestry are not reported). Percent effect calculated as $[\exp(\beta_1 + \beta_2) - 1] * 100$ – see the specification in eq (1). Capped bars show 90% confidence intervals. All specifications include dummies for the existence of at least one export subsidy, TBT, import restriction, export restriction, temporary import restriction, local content requirement, government procurement restriction, and other GTA policies. They also include country-product fixed effects, country-product trends, country-year and product-year fixed effects. Standard errors are clustered by country and by product.

B. Export and import effects of China's subsidies through input-output linkages

The empirical specification in eq (1) permits to estimate the export and import responses to the introduction of subsidies by China in a given product. These direct effects miss the influence of subsidies given to other products and industries, which can emerge through input-output linkages. To measure exposure through the supply chain, we use the China's input-output table for 2007 (before the beginning of sample on subsidies in 2009), recording intermediate inputs and final demand purchases for 94 goods (primary and manufacturing) industries. The data suggest that the distribution of China's subsidies depends on the position of the industry along the supply chain. This can be seen in Figure 5 panel (b), which plots the number of China's subsidies against the upstreamness index (Antràs and others, 2012) by industry in 2007. Seven out of the top ten recipients of subsidies up to 2022 (shown in panel (a)) have an upstreamness index above the average.

Figure 5. Subsidy policy and upstreamness by industry



Note: Policies announced since 2009 and in force in China. A policy is counted once regardless of the number of products affected – it can be counted multiple times across industries. The products targeted by subsidies and classified according to the Harmonized System (HS 2012) are matched with the input-output sector using correspondences by Chor, Manova, and Yu (2021) and the United Nations. The upstreamness index is computed as in Antràs and others (2012) and measures the distance of an industry output to its final consumption. The vertical line is at the mean of the upstreamness index. The red line is the linear fit.

To assess how subsidies affect trade flows along the supply chain, we aggregate the trade and subsidy data at the industry level as defined in the China's input-output table and estimate:

$$\begin{aligned}\ln\left(X_{ik,t}\right) = & \beta_{up1}\sum_{j\neq k} cost_{kj}S_{ij,t} + \beta_{up2}\left(\sum_{j\neq k} cost_{kj}S_{ij,t}\right)\times CHN_i + \\ & + \beta_{down1}\sum_{j\neq k} sales_{jk}S_{ij,t} + \beta_{down2}\left(\sum_{j\neq k} sales_{jk}S_{ij,t}\right)\times CHN_i + \\ & + \beta_{own1}S_{ik,t} + \beta_{own2}S_{ik,t}\times CHN_i + \beta_{IP}\Pi_{ik,t} + \alpha_{ik} + \alpha_{ik}\times t + \delta_{i,t} + \mu_{k,t}\varepsilon_{ik,t}\end{aligned} \tag{2}$$

with X being exports or imports at the level of the 94 goods industries included in the 2007 China's input-output table.[26] The trade values are regressed on indexes of exposure of industry k to subsidies given to other industries that are relatively upstream and downstream in the supply chain. Exposure to subsidized industries upstream is measured by each industry j share in the total cost of industry k, $cost_{kj}$ – i.e., how much industry k relies on inputs from other industries. Exposure to subsidized industries downstream is instead captured by each industry j share in the total sales of industry k, $sales_{kj}$ – i.e., how much k provides inputs to other industries.[27] Consistent with the product-level regressions, we include all countries in the sample and allow the effects of subsidies in upstream and downstream industries to vary between China and other countries. The overall effect of China's subsidies given to industries upstream is therefore given by the sum $\beta_{up1}+\beta_{up2}$, while the effect of China's subsidies given to industries downstream is the sum $\beta_{down1}+\beta_{down2}$. Because we apply China's input-output linkages to all countries in the sample, the β_{up1} and β_{down1} coefficients measuring the effects for other countries are likely to be biased towards zero because of measurement error. In a robustness, we check the validity of our findings in a China-only sample.

In our specification, we control for the role of subsidies in the own k industry (also interacted with a China dummy). Because of the aggregation at the industry level, the S variables in eq (2) are counts of subsidy policies in force in a year of each country-industry combination (we take the inverse hyperbolic transform of the counts to include the zeros). While a dummy variable approach would leave us with little variation at the industry level (especially for countries like China with many subsidy policies), using counts is likely to add measurement error, since a higher number of subsidies does not necessarily correspond to a greater

[26]We sum up trade values from the HS 6-digit to the industries in the China input-output table using the correspondence table used in Chor, Manova, and Yu (2021).

[27]The cost and sales share do not sum up to one as total industry costs include labor costs, and total sales include sales to final demand. Lane (2022) and Navarra (2023) adopt similar specifications to estimate the impact of industrial policies and subsidies along the supply chain in South Korea and US, respectively.

intensity of intervention (because of the lack of monetary values).[28] The Π matrix collects the exposure variables (upstream, downstream and own, by themselves and interacted with a China dummy) to counts of other GTA policies (computed in the same way – with the same cost and sales shares – as exposures to subsidies), and the vector β_{IP} includes the associated coefficients. The set of fixed effects used in the estimation mimics the one of the product-level regression: country-industry fixed effects, industry-year fixed effects, country-year fixed effects and country-industry specific trends.

The results of this exercise are reported in Table 2. We show the coefficients on the upstream and downstream exposure variables, their interaction with the China dummy, and the their sum, for exports (panel (a)) and imports (panel (b)), total flows and by group of trading partners. The findings highlight strong trade effects of subsidies given to industries upstream. The pro-export and import-substitution responses to China's subsidies at the product are reinforced by the indirect effects from subsidies given to industries located upstream in the supply chain. The indirect effects are stronger on the export side than on the import side. To gauge the implied magnitude of the estimates, consider the case of two key industries, steel (metals) and automotive, which are linked by a strong input-output relationship – purchases of steel cover 10 % of total costs in the automotive industry. Through back-of-the-envelope calculations, our estimates from column (2), panel (a) suggest that applying the increase in the number of subsidies to steel observed over 2015-2022 would lead to a 3.5% increase in total China's exports in the automotive industry.[29]

This export effect is driven by exports to G20 AEs. The variation in the estimates across trading partners qualifies the evidence from the direct effects. While exports of subsidized products to G20 AEs do not react to subsidies differently from exports of other products, subsidies given to supplying industries appear to increase China's shares in G20 AEs' markets in downstream industries. This pattern could be explained by a situation where retaliatory actions by governments in G20 AEs are more actionable in response to direct subsidies given

[28]Because of this source of measurement error, we rely on the more precise product-level regression to evaluate the 'direct' effect of subsidies on the targeted products.

[29] The simulated effect on China's exports in an industry k (in our case, automotive) equals: $\left(\widehat{\beta}_{up1}+\widehat{\beta}_{up2}\right)\sum_{j\neq k} cost_{kj}\Delta S_{ij}$, where $\widehat{}$ variables indicated estimated coefficients, and ΔS_{ij} is the change in the subsidy variable between the counterfactual and the baseline situation. The baseline is the inverse hyperbolic of the number of subsidies observed in 2015. As counterfactual, we take the (inverse hyperbolic transformed) number of subsidies in 2022 for the steel industries (060 "ferroalloy smelting"; 008 "ferrous metal mining"; 057 "ironmaking"; 063 "metal products"; 059 "steel rolling processing"; 058 "steel making"), leaving the numbers for all other industries unchanged at their 2015 levels. The change in the subsidy variable equals 0.165, which multiplied by the estimated China coefficient in column (2) of Table 2 (0.210) gives 0.035.

by the Chinese government to the exporters, than in response to upstream subsidies that support exports downstream.[30]. The estimates also suggest that subsidies given upstream tend to lower imports in the buying industry (panel (b)), although the effect is weaker than on the export side. These export and import effects are consistent with upstream industries expanding supply and lowering their prices following the deployment of subsidies, hence permitting industries downstream to become more competitive in export markets, which is reflected also in a decrease in imports of products in the same industry.

The effects of subsidies stemming from industries relatively downstream in the supply chain on exports are negative and again pronounced on flows to G20 AEs. The negative response of exports upstream is consistent with a situation where supplying industries re-direct part of their sales from exports to the domestic market to supply the expanding subsidized buying industries.[31] To appreciate the size of the estimated coefficient, we go back to our previous example, but consider this time the effect of subsidies in the automotive industry (the buyer) on the exports of the "steel processing" industry (the supplier).[32] For this supplying industry, automotive takes up 6% of its sales. Our back-of-the-envelope calculations suggest that the 2015-2022 increase in subsidies to automotives is responsible for a 2.6% decline in exports in steel processing.[33] Subsidies given to downstream industries have instead an insignificant effect on imports in the supplying industry.

[30]For instance, U.S. antidumping law allows to sanction "upstream subsidies", defined as subsidies by foreign governments that are given to inputs of the product. The law however requires that the upstream subsidies warrant a "competitive benefit" (defined as price for the input that is lower than the price the exporter would have paid in an arms-length transaction) to the exporter, and that they have a significant effect on the production costs of the exporter (section 771A of the Tariff act 1930). In practice, countervailing duties based on upstream subsidies seem to be rather rare. In the Electronic Subsidies Enforcement Library (accessed on 05/02/2024), out of the 184 final determination documents on China's subsidies since 2007, only 27 contain at least once the words "upstream subsidies" (same for the word "upstream").

[31]Subsidies given to relatively downstream industries could also have a positive effect on the exports of the supplying industry as this expands and realizes greater economies of scale.

[32]In this case, we shock the number of subsidies in one buying industry (automotive), whereas in the previous simulations we changed the number of subsidies given to multiple supplying industries (representing the steel sector). This asymmetry however does translate into a notable difference in the size across the two shocks. The total number of subsidy polices in the steel industries goes from 438 to 1873 between 2015 and 2022, or a 4.23 increase – the average *asinh* (inverse hyperbolic operator) change across steel industries is 1.16. The automotive industry experiences similar changes: the number of subsidies is 4.35 times higher in 2022 than in 2015 – equivalent to a 1.48 *asinh* change.

[33]We follow the same approach described in footnote 29. The simulated effect of downstream subsidies on China's exports in an industry k (in our case, steel processing) equals: $\left(\widehat{\beta}_{down1} + \widehat{\beta}_{down2}\right) \sum_{j \neq k} sales_{jk} \Delta S_{ij}$, where$\widehat{\ }$variables indicated estimated coefficients, and ΔS_{ij} is the change in the subsidy variable between the

Table 2. Effects of China's subsidies on trade flows through input-output linkages

	(1)	(2)	(3)	(4)	(5)	(6)
	Panel (a). Dep. variable: Ln(exports)					
	Total	Total	G20AEs	G20EMs	Oth. AEs	Oth. EMs
Subsidies upstream	-0.030	-0.020	0.036	-0.048	-0.047	-0.007
	(0.023)	(0.022)	(0.033)	(0.044)	(0.032)	(0.021)
Subsidies upstream × CHN	0.279***	0.230***	0.349	0.203	0.165	0.100
	(0.062)	(0.059)	(0.214)	(0.170)	(0.171)	(0.087)
Subsidies downstream	-0.007	-0.004	0.048	0.016	0.065	0.005
	(0.034)	(0.031)	(0.065)	(0.049)	(0.039)	(0.030)
Subsidies downstream × CHN	-0.157	-0.293*	-0.523**	0.220	-0.033	-0.366*
	(0.120)	(0.162)	(0.230)	(0.568)	(0.165)	(0.188)
CHN effect from upstream	0.249***	0.210***	0.385*	0.155	0.118	0.093
	(0.059)	(0.056)	(0.210)	(0.164)	(0.178)	(0.082)
CHN effect from downstream	-0.164*	-0.296**	-0.475***	0.236	0.032	-0.361
	(0.098)	(0.148)	(0.203)	(0.561)	(0.171)	(0.186)
Obs	188039	188039	167976	164209	166656	181575
R^2	0.95	0.95	0.94	0.92	0.94	0.94
	Panel (b). Dep. variable: Ln(imports)					
	Total	Total	G20AEs	G20EMs	Oth. AEs	Oth. EMs
Subsidies upstream	-0.030*	-0.023	0.008	0.024	0.019	-0.014
	(0.015)	(0.016)	(0.017)	(0.044)	(0.021)	(0.022)
Subsidies upstream × CHN	-0.124	-0.110	-0.187**	-0.358*	-0.017	-0.257
	(0.117)	(0.119)	(0.093)	(0.193)	(0.104)	(0.187)
Subsidies downstream	0.023	0.013	-0.020	0.041	-0.023	-0.031
	(0.020)	(0.018)	(0.022)	(0.033)	(0.021)	(0.041)
Subsidies downstream × CHN	-0.145	0.194	-0.019	0.179	-0.114	0.228
	(0.137)	(0.170)	(0.162)	(0.242)	(0.186)	(0.203)
CHN effect from upstream	-0.154	-0.133	-0.180*	-0.334*	0.002	-0.271
	(0.115)	(0.119)	(0.095)	(0.183)	(0.102)	(0.190)
CHN effect from downstream	-0.122	0.207	-0.039	0.220	-0.137	0.197
	(0.138)	(0.171)	(0.163)	(0.233)	(0.185)	(0.196)
Obs	194504	194504	187134	189808	185848	189515
R^2	0.97	0.97	0.97	0.95	0.96	0.94

Note: Regressions at the industry level (94 goods industries as in the 2007 China input-output table). Exports and imports (in logs) are the dependent variables. Columns (2) to (6) include measures of exposure to other GTA policies in industries upstream, downstream and in the own industry as well as their interaction with the CHN dummy. All columns include the count of subsidies in the own industry and its interaction with a China dummy, country-industry, industry-year, country-year fixed effects, and country-industry linear trends. Standard errors are clustered by industry. $*$ significant at 10%; $**$ significant at 5%; $***$ significant at 1%.

IV. Impact of China's subsidies on export prices and quantities

As discussed in the Introduction, policymakers in several advanced economies have recently raised concerns about the global repercussions of China's industrial policy measures such

counterfactual and the baseline situation. The counterfactual change in the subsidy variable for automotive equals 0.09, which multiplied by the estimated China coefficient in column (2) of Table 2 (-0.296) gives -0.026.

as subsidies. The heart of the so-called “overcapacity” debate is that, in a situation of slow growth in domestic demand, Chinese policies could create a mismatch between domestic demand and supply, leading to increased supply in world markets of targeted products which manifests itself in higher export quantities and lower prices. Importantly though, subsidies can lead to complex effects on the export quantities and prices of targeted products. In this section, we aim to provide a better understanding of this issue. First, we introduce a simple framework to think of the impact that subsidies by large economies can have on export quantities and prices.[34] Second, we exploit our empirical approach to assess the role of subsidies in affecting export prices and quantities in the targeted products and industries, controlling for the influence of global and country factors that can shape the demand-supply mismatch such as fiscal and monetary policies.

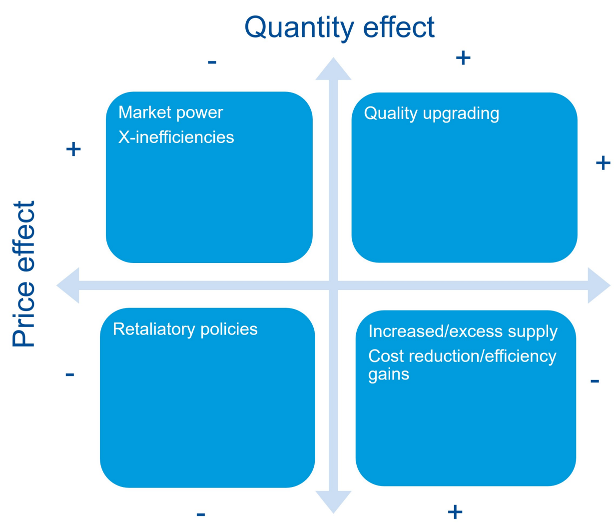
Conceptually, the combinations of export price and quantity responses to subsidies can be related to different market dynamics. The matrix in Figure 6 summarizes the possible effects and provides a tentative list of associated market adjustments. A necessary, although not sufficient, condition for subsidies to aggravate a problem of excess supply in global markets is that they lower export prices and increase export quantities. As argued by US and EU government officials (European Commission, 2023; U.S. Embassy in China, 2024), China’s subsidies can lead to excess supply (given the subdued growth in domestic demand), which spills over into global markets by lowering world prices. However, lower export prices and higher export quantities can also be associated with efficiency gains specific to the subsidized products. In other words, the higher quantity/lower prices quadrant of Figure 6 represents a situation that is *consistent* with increased or excess supply as well as with one of cost reductions.

As illustrated in Figure 6, other export price and quantity responses can emerge. Higher quantities can also be combined with higher prices, which would suggest a situation where subsidies lead to quality upgrading – e.g., by stimulating adoption of better technologies that permit to supply a more sophisticated product. Negative quantity and positive price responses can instead be associated with subsidies raising market concentration (an increase in mark ups) and introducing inefficiencies (an increase in marginal costs). The combination of negative price and quantity effects is less intuitive, but can be explained by trade distortive policies that importing countries can introduce in response to China’s subsidies. While the price received by Chinese exporters may well decrease following China’s subsidies (and it may

[34]The excess supply argument assumes that the country where the domestic mismatch emerges is ‘large’ enough to influence world prices. In the empirical analysis, we use exporter’s (China’s) unit values, which may deviate from product-level world prices.

decrease even further if the retaliatory policy response is adopted by a large country), the consumer price in the importing country can increase as the importing country applies protectionist policies (e.g., temporary trade restrictions and subsidies) that increase the wedge between consumer and exporter prices.

Figure 6. Export price and quantity effects of subsidies



Empirically, we estimate the direct and indirect effects of China's subsidies (specifications in eqs (1) and (2)) on export prices and quantities in the full sample. Quantities are measured in net weight (kg), and export prices at the product level are proxied by a weighted average of bilateral unit values (current USD per kg), with weights equal to the importer share in total exports of the product.[35] By exploiting the more detailed bilateral product-level data and aggregating unit values using destination market shares, we seek to minimize the influence of more volatile and possibly noisier flows to small markets on export prices. Despite this procedure, measurement error in unit values (prices can vary vastly across firms selling the same HS 6-digit product to the same destination) and quantities (because of difference in units of measurement) is likely to affect our estimations. While the fixed effects used in the regressions can attenuate this concern, we take the results of this empirical exercise as purely

[35] In the regressions at the industry level, we further aggregate these unit values using a weighted average by industry, with weights equal to the product share in total industry exports. This aggregation adds further measurement error in the price variable.

illustrative of how granular export price and quantity data can be used to understand the role of supply-side policies in driving different market adjustments.

Table 3 reports the estimates for the direct (columns (1) to (4)) and indirect (columns (5) to (8)) effects of subsidies on export quantities and prices. We find that China's subsidies on average are associated with lower export prices in the targeted products relative to other products (columns (1) and (2)), and in industries more exposed to upstream subsidies (columns (5) and (6)), but the effects are small and not significant. A similar pattern emerges for export quantities: upstream subsidies increase export quantities in the downstream industry, but the coefficients are significant only for upstream subsidies (columns (7) and (8)).[36] On average, the evidence that China's subsidies have lowered export prices and increased quantities – a combination of effects suggestive of subsidies contributing to excess supply or efficiency gains – is weak. This average effect, however, can mask significant differences at the sectoral level, which is what we turn next.

[36]Because of our approach to the measurement of product-level export prices, the signs of the price and quantity effects do not necessarily have to confirm the direction of the effect of China's subsidies on export values (Table 1).

Table 3. Effects of China's subsidies on export prices and quantities

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Direct effects				Indirect effects			
Dep. variable:	Ln(export prices)		Ln(export quantities)		Ln(export prices)		Ln(export quantities)	
Subsidies	-0.004	-0.004	0.021***	0.022***				
	(0.006)	(0.006)	(0.008)	(0.008)				
Subsidies × CHN	-0.001	-0.001	-0.023**	-0.023**				
	(0.007)	(0.007)	(0.009)	(0.009)				
Subsidies upstream					0.053	0.037	-0.044	-0.028
					(0.035)	(0.034)	(0.028)	(0.029)
Subsidies upstream × CHN					-0.127	-0.102	0.404***	0.289***
					(0.169)	(0.149)	(0.101)	(0.098)
Subsidies downstream					0.040	0.038	-0.015	-0.016
					(0.041)	(0.043)	(0.042)	(0.041)
Subsidies downstream × CHN					0.031	0.209	-0.170	-0.391*
					(0.172)	(0.225)	(0.127)	(0.215)
CHN direct effect	-0.005	-0.005	-0.002	-0.002				
	(0.004)	(0.004)	(0.005)	(0.005)				
CHN effect from upstream					-0.074	-0.064	0.360***	0.261***
					(0.167)	(0.143)	(0.099)	(0.097)
CHN effect from downstream					0.071	0.247	-0.185*	-0.407*
					(0.172)	(0.240)	(0.110)	(0.208)
Obs	6710953	6710953	6710953	6710953	186512	186512	186512	186512
R^2	0.80	0.80	0.90	0.90	0.86	0.86	0.94	0.94

Note: Regressions at the product level in columns (1) to (4) and at the industry level in column (5) to (8). Export prices and quantities (in logs) are the dependent variables. Columns (2) and (4) include dummies for other GTA policies and their interactions with a CHN dummy. Columns (6) and (8) include measures of exposure to other GTA policies in industries upstream, downstream and in the own industry as well as their interaction with the CHN dummy. Columns (1) to (4) include country-product, product-year, country-year fixed effects, and country-product linear trends. Standard errors are two-way clustered by country and product in columns (1) to (4). Columns (5) to (8) include the count of subsidies in the own industry and its interaction with a China dummy, country-industry, industry-year, country-year fixed effects, and country-industry linear trends. Standard errors are clustered by industry in columns (5) to (8). ∗ significant at 10%; ∗∗ significant at 5%; ∗ ∗ ∗ significant at 1%.

In Figure 7, we depict the estimated percent effect of China's subsidies on export prices and quantities by industry, exploiting variation across subsidized and non-subsidized products (see Figure 4 for the China effect on export and import values). The quadrants corresponding to different combinations of price and quantity effects can be mapped to the conceptual matrix in Figure 6. Figure A.2 identifies industries where both price and quantity responses are significant, industries where only one coefficient is significant, and industries were none of the two is significant. Figure 7 shows evidence that is consistent with the argument that China's subsidies may have contributed to increased excess supply or efficiency gains in some sectors, but not in others, and that subsidies tend to have a variety of effects on export quantities and prices. The findings indicate that China's direct subsidies have pushed towards greater supply and lower prices in the communication equipment, plastic, chemicals, metal products, wood and furniture industries.[37,38] As shown in Figure 6, the negative export price and positive quantity responses in these industries are consistent with the excess supply view as well as with a situation where subsidies drive down costs and prices in the targeted products, thus leading to an expansion in export supply.

Among the industries that include the ten key sectors identified as strategic, we find evidence consistent with excess supply or efficiency gains induced by direct subsidies only in the chemicals industry. For subsidized products in "Other transport equipment" (e.g., shipbuilding and high-end rail systems) and "Medical and precision instruments" (including robots and high-end medical equipment), the results point to China's subsidies leading to greater market power or inefficiencies (higher prices and lower quantities).[39] The estimates suggest direct positive price and quantity effects of China's subsidies within the electrical equipment industry, indicating the possibility that subsidized firms in this industry have benefited from quality upgrading (e.g., through adoption of better technologies and production processes).[40] For the "automotive" (including EVs) industry, the export price and quantity responses are both negative, whereas they are small and insignificant for the "other machinery and equipment" industry (see Figure A.2). This combination of relatively lower export prices and quantities can be rationalized by the effects of retaliatory tariffs by advanced economies adopted to

[37]The price and quantity response are close to zero for basic metals. For most industries where we observe significant effects (e.g., electrical machinery, communication equipment, plastic), the directions of the price and quantity effects (in Figure 7) are coherent with the sign of the effect on export values (in Figure 4).

[38]Sector-level technological change that can shape productivity and trade dynamics do not affect the industry-level estimates in Figure 7. Moreover, the product-year fixed effects control for global product-specific productivity dynamics. The country-year fixed effects in this regressions by industry also control for any differential adoption of technologies at the industry level across countries (e.g., differential technology shocks in communication equipment between China and other countries). These fixed effects thus attenuate concerns that technological change can obfuscate the effect of subsides on export prices and quantities.

[39]The evidence suggesting that subsidies have contributed to increasing consolidation and market power in the "Other transport equipment" industry is consistent with the second phase of China's subsidies (which overlaps with our sample period) in the shipbuilding industry, which targeted a list of firms and restricted entry (Barwick, Kalouptsidi, and Zahur, 2023). The findings of Wei and others (2023) that a subsidy policy to boost innovation in China led to insignificant productivity gains and welfare losses because bureaucrats failed to consider the quality of patents submitted by applicants remind us that subsidies can create inefficiencies.

[40]Chinese firms are found to increase the quality of their exported goods as a results of an import subsidy program Li, Lu, and Wu (2023) and tariff reductions on imported intermediates following the country's entry into the WTO Fan, Li, and Yeaple (2015). Since export prices are measured as sales-weighted bilateral unit values, their positive response can also be associated with a situation where the subsidy has a relatively larger effect on exports to high-income countries (Fajgelbaum, Grossman, and Helpman, 2011).

counteract (subsidy-led) expansion in China's exports (Bown and Crowley, 2013; Ju and others, 2024).

To further investigate the export price and quantity implications of China's subsidies, we also explore how the indirect effects through input-output linkages vary across industries. Since the variables measuring exposure to subsidies along the supply chain are defined at the industry level (see the specification in equation (2)), estimating China-specific effects by industry as we do for the direct effects in Figure 7 (where the identifying variation is across subsidized and non-subsidized products) is problematic. By industry, the regression in equation (2) would become a country-year panel regression, where the China effect comes only from variation in the China time series (14 observations, from 2009 to 2022).[41] Therefore, we focus on the sectors singled out as strategic (Chemicals; Other transport equipment; Automotive; Electrical Machinery; Medical and precision instruments; and Other machinery and equipment).[42] We extend the specification in equation (2) by interacting the exposure variables (to subsidies in the industry, subsidies upstream and subsidies downstream) with a dummy for the key sectors, one at a time. Because of the additional limitations of this exercise, we take its results as a 'smell test' of whether China's subsidies have contributed to excess supply in strategic sectors through input-output linkages, and report them in Table A.2 in the Appendix.

The estimates reveal significant negative price and positive quantity responses to upstream subsidies in the auto industry. While the direct effects suggested negative price and quantity responses, the indirect effects provide evidence consistent with China's subsidies in upstream industries contributing to cost reduction through cheaper subsidized inputs or excess supply in the auto industry. Consistently with the average indirect effects, the influence from downstream subsidies go in the opposite direction – higher prices and lower quantities. The price effects for the other industries are rather weak. For some of the strategic sectors, like other transport equipment and other machinery and equipment, upstream subsidies expand export quantities, thus countering the negative coefficient found for direct subsidies.

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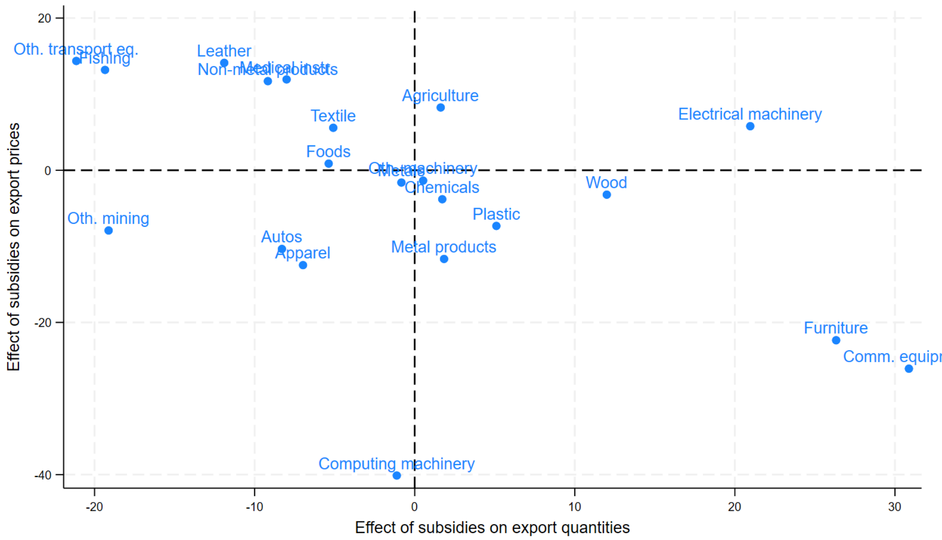
[41] In the specification, we use the 94 goods industries as defined in the China's input-output table. Estimating the regression by the corresponding and slightly more aggregated 23 ISIC 2-digit industries in our sample would not provide significantly more variation in the data.

[42] In the industry classification of the China's input-output table, Chemicals can be found in industries 039, 040, 041, 043, 044, 045, 046, 047; Other transport equipment is matched with industries 066, 073, 075, 076; Automotive is industry 074; Electrical Machinery is in industries 077, 078, 079, 080, 081; Medical and precision instruments are in industries 072, 088; and Other machinery and equipment are in industries 065, 067, 068, 069, 070, 071, 072.

Figure 7. Effects of subsidies on China's export prices and quantities by industry (in %)



Note: Estimates by ISIC 2-digit industry (mining, fishery and forestry are not reported). Sum of the coefficient on a dummy for the existence of at least one subsidy policy and the coefficient on the interaction of the subsidy dummy with a CHN dummy, with export unit values (vertical axis) and export quantities (horizontal axis) as dependent variables. All specifications include dummies for the existence of at least one export subsidy, TBT, import restriction, export restriction, temporary import restriction, local content requirement, government procurement restriction, and other GTA policies. They also include country-product fixed effects, country-product trends, country-year and product-year fixed effects. Standard errors are clustered by country and by product.

V. CONCLUDING REMARKS

This paper investigates the role of China's subsidies in shaping its trade flows between 2009 and 2022. We find evidence that China's subsidies – similarly to other countries' subsidies – result in cross-border spillover effects through trade. Our results suggest that exports in subsidized products and industries in China are higher than other products and industries after the subsidy. The effect on imports is instead negative, suggesting that the policies tend to make targeted industries substitute for imported products. These responses come from the direct exposure to subsidies and from the indirect exposure to subsidies in other industries that are suppliers of inputs (i.e. through input-output linkages). The direct effects of subsidies are most visible for trade with G20 emerging economies, while the indirect effect are most pronounced for trade with G20 advanced economies. Across industries, the impact of subsidies on exports are strongest for electrical machinery and furniture, while for metal products subsidies significantly lower both exports and imports.

The analysis also offers an opportunity to use trade data to provide a contribution to the current debate on China's policy and excess supply (or "overcapacity', as this issue is commonly referred to). When we decompose the price and quantity effects of subsidies, the evidence in the full sample is weak – the effects of China's subsidies on export prices and quantities are not significant. Industry-specific results however reveal important heterogeneity across industries. China's subsidies are found to increase export quantities and lower export prices in certain sectors such as the ones related to construction (e.g., metal products and furniture), but not in others. For instance, the subsidies lead to higher export prices and quantities in electrical machinery. The results thus suggest that Chinese subsidies could have contributed to excess supply in sectors like metal products and furniture, but not in electrical machinery where the subsidies seem to have promoted the industry's quality upgrading – at least up to 2022.

We believe that more research is needed to further our understanding of China's industrial policy and its consequences for international trade and the global economy more generally. On the measurement front, exhaustive information on the monetary value of subsidies and other support policies across different industries (including services) and over time would allow for a more refined assessment of the impacts. Furthermore, firm-level data could be used to identify the effects of government support on firm dynamics in export markets. On the issue of excess supply, a model-based approach would be needed to assess the importance of subsidies relative to other structural and macroeconomic factors that are likely to shape China's demand and supply patterns. More generally, similar approaches could help identify the importance of market and non-market forces as determinants of comparative advantage. Similarly, given the trade spillovers from industrial policy, we believe that more theoretical and empirical work on the interaction of countries' measures would enlighten on the long-term welfare effects of industrial policy.

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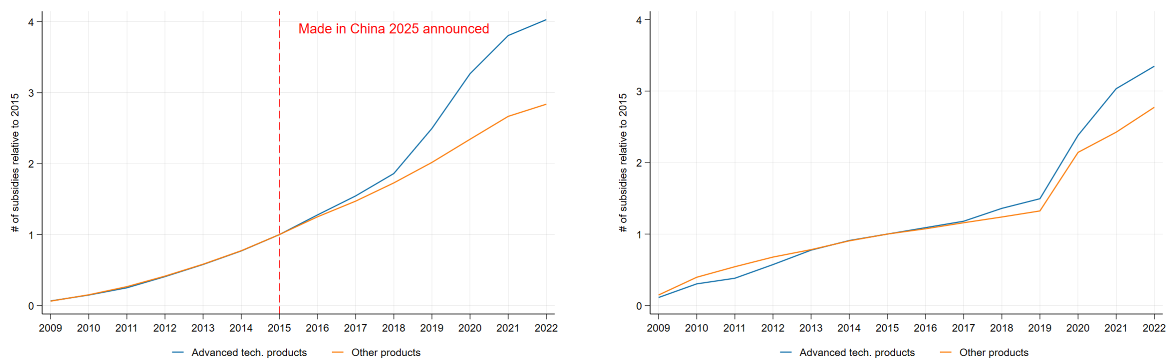
APPENDIX A.

Figure A.1. China's and US subsidies in Advanced Technology Products

(a) China (b) US



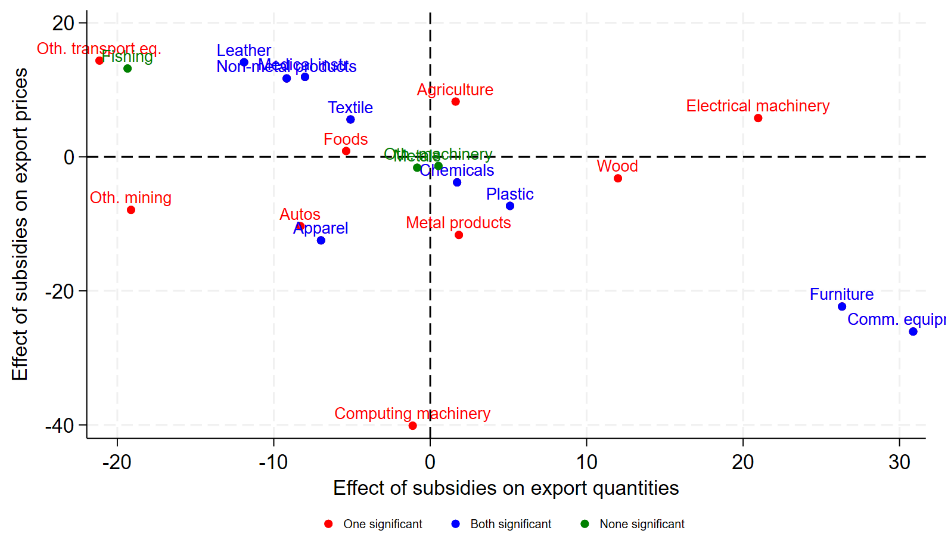
Note: Policies announced since 2009 and in force. A policy is a country-policy combination, counted once regardless of the number of products affected. The same policy can be counted in multiple products. The "Advanced tech. products" are defines as in the list of the US Census bureau (available here: https://www.census.gov/foreign-trade/reference/codes/atp/index.html).
Source: Global Trade Alert and authors' calculations.

Table A.1. Effects of subsidies by China, US and EU on exports and imports

	(1)	(2)	(3)	(4)	(5)	(6)
Dep. variable		Ln(exports)			Ln(imports)	
	CHN	USA	EU	CHN	USA	EU
Subsidies	0.023***	0.023***	0.008	0.033***	0.034***	-0.017*
	(0.006)	(0.006)	(0.010)	(0.006)	(0.006)	(0.010)
Subsidies × country	-0.014*	-0.015**	0.018	-0.042***	-0.033***	0.063***
	(0.007)	(0.006)	(0.012)	(0.007)	(0.007)	(0.012)
Country-specific effect	0.009**	0.008**	0.027***	-0.009**	0.001	0.046***
	(0.005)	(0.004)	(0.007)	(0.004)	(0.003)	(0.006)
Obs	6783016	6783016	6783016	9367644	9367644	9367644
R^2	0.90	0.90	0.90	0.92	0.92	0.92

Note: Regressions at the product level. Exports and imports (in logs) are the dependent variables. All columns include dummies for other GTA policies as well as their interaction with a dummy for CHN (columns (1) and (4)), USA (columns (2) and (5)), and EU (columns (3) and (6)). All columns include country-product, product-year, country-year fixed effects, and country-product linear trends. Standard errors are two-way clustered by product and country. $*$ significant at 10%; $**$ significant at 5%; $***$ significant at 1%.

Figure A.2. Effects of subsidies on China's export prices and quantities by industry (in %) – with statistical significance



Note: Estimates by ISIC 2-digit industry (mining, fishery and forestry are not reported). Sum of the coefficient on a dummy for the existence of at least one subsidy policy and the coefficient on the interaction of the subsidy dummy with a CHN dummy, with export unit values (vertical axis) and export quantities (horizontal axis) as dependent variables. All specifications include dummies for the existence of at least one export subsidy, TBT, import restriction, export restriction, temporary import restriction, local content requirement, government procurement restriction, and other GTA policies. They also include country-product fixed effects, country-product trends, country-year and product-year fixed effects. Standard errors are clustered by country and by product. "One significant" refers to situations where only one direct effect of China's subsidies is significant. "Both significant" means that both direct effect of China's subsidies (on prices and quantities) are significant. "None significant" means that none of the two effects is significant. Statistical significance is at 90% level.

Table A.2. Indirect effects of China's subsidies on export prices and quantities through input-output linkages, by strategic industry

	(1)	(2)	(3)	(4)	(5)	(6)
	Autos	Chemicals	Electrical machinery	Medical instr.	Oth. Machinery	Oth. Transport
			Dep. variable: Ln(export prices)			
Upstream subsidies	0.052	0.055	0.058	0.050	0.053	0.058
	(0.035)	(0.036)	(0.036)	(0.035)	(0.036)	(0.035)
Upstream subsidies × CHN	-0.129	-0.107	-0.118	-0.121	-0.115	-0.124
	(0.171)	(0.162)	(0.167)	(0.169)	(0.167)	(0.167)
Upstream subsidies × CHN × Sect.	-10.317***	-0.210	-1.430	-1.176	-1.342	-4.772*
	(2.798)	(0.672)	(1.189)	(1.134)	(0.914)	(2.832)
Upstream subsidies × Sect.	-0.449***	-0.061	-0.124	0.723***	-0.060	-0.105
	(0.147)	(0.105)	(0.136)	(0.050)	(0.083)	(0.129)
Downstream subsidies	0.039	0.040	0.046	0.040	0.034	0.043
	(0.041)	(0.053)	(0.043)	(0.042)	(0.043)	(0.042)
Downstream subsides × CHN	0.026	0.113	-0.007	0.019	0.016	0.014
	(0.173)	(0.179)	(0.174)	(0.172)	(0.176)	(0.171)
Downstream subsides × CHN × Sect.	37.406***	-0.648	0.848*	16.597***	0.867	12.192
	(10.047)	(0.671)	(0.494)	(1.466)	(0.758)	(8.851)
Downstream subsides × Sect.	0.341	0.013	-0.199*	-0.350***	0.121	-0.573
	(0.453)	(0.068)	(0.105)	(0.063)	(0.076)	(0.379)
CHN effect from upstream in Sect.	-10.394***	-0.262	-1.491	-1.247	-1.405	-4.838*
	(2.748)	(0.676)	(1.203)	(1.196)	(0.915)	(2.836)
CHN effect from downstream in Sect.	37.471***	-0.495	0.887*	16.656***	0.917	12.248
	(10.043)	(0.647)	(0.461)	(1.427)	(0.744)	(8.848)
Obs	186512	186512	186512	186512	186512	186512
R^2	0.86	0.86	0.86	0.86	0.86	0.86
			Dep. variable: Ln(export quantities)			
Upstream subsidies	-0.043	-0.041	-0.045	-0.043	-0.048*	-0.040
	(0.028)	(0.029)	(0.028)	(0.028)	(0.028)	(0.028)
Upstream subsidies × CHN	0.403***	0.409***	0.394***	0.402***	0.403***	0.397***
	(0.102)	(0.104)	(0.098)	(0.101)	(0.100)	(0.101)
Upstream subsidies × CHN × Sect.	3.977**	-0.225	0.387	1.271***	0.712*	2.077***
	(1.535)	(0.213)	(0.424)	(0.475)	(0.414)	(0.565)
Upstream subsidies × Sect.	0.398***	-0.034	0.032	-0.124***	0.196***	-0.285
	(0.141)	(0.066)	(0.043)	(0.044)	(0.064)	(0.223)
Downstream subsidies	-0.014	-0.018	-0.015	-0.015	-0.011	-0.018
	(0.042)	(0.054)	(0.043)	(0.042)	(0.044)	(0.042)
Downstream subsidies × CHN	-0.170	-0.182	-0.169	-0.167	-0.190	-0.159
	(0.127)	(0.140)	(0.131)	(0.127)	(0.131)	(0.128)
Downstream subsidies × CHN × Sect.	-11.083***	0.210	0.176	4.880***	-0.220	-5.294*
	(2.749)	(0.370)	(0.355)	(0.538)	(0.403)	(2.914)
Downstream subsidies × Sect.	-1.461***	0.017	0.003	-0.025	-0.128**	0.382
	(0.405)	(0.058)	(0.085)	(0.068)	(0.060)	(0.417)
CHN effect from upstream in Sect.	4.337***	0.143	0.736*	1.630***	1.066***	2.435***
	(1.510)	(0.223)	(0.434)	(0.510)	(0.411)	(0.569)
CHN effect from downstream in Sect.	-11.267***	0.010	-0.009	4.698***	-0.420	-5.472*
	(2.738)	(0.346)	(0.325)	(0.498)	(0.387)	(2.910)
Obs	186512	186512	186512	186512	186512	186512
R^2	0.94	0.94	0.94	0.94	0.94	0.94

Note: Regressions at the industry level. Export prices and quantities (in logs) are the dependent variables. Specifications include the (inverse hyperbolic sine of the) count of subsidies in the own industry, the weighted sum of subsidies in upstream and in downstream industries. Each of these three variables are interacted with a CHN dummy, with a dummy for the sector indicated as column title, and with both the CHN dummy and the sector dummy. All columns include country-industry, industry-year, country-year fixed effects, and country-industry linear trends. Standard errors are clustered by industry in columns (5) to (8). $*$ significant at 10%; $**$ significant at 5%; $***$ significant at 1%.