The (Un)intended Consequences of Export Restrictions: Evidence from Indonesia

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Abstract

Do voluntary export restrictions promote domestic economic development? While an export ban foregoes export revenue, and may result in a permanent loss of market share, it may also boost local processing industries, thus stimulating local employment and manufacturing growth more generally. We address this question in the context of Indonesia, a major producer of raw materials such as nickel and bauxite, which banned the export of unprocessed ores in 2014. We find that the ban had a positive and statistically significant impact on local employment in nickel-producing districts - not only in sectors like manufacturing and construction but also through spillover effects in the public sector and services. This is rationalized by large investments in processing capacity for nickel ore. In contrast, bauxite extraction collapsed, leading to declines in employment and wages in bauxite-producing regions. Without additional refining capacity, the export ban halted mining activity and had unintended negative consequences for economic growth in these areas.

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1 Introduction

Industrial raw materials such as nickel, bauxite, cobalt and rare earth elements are critical inputs in countless production processes, including renewable energy, lithium batteries, magnets, and other inputs supporting the green transition. Globalisation has allowed advanced economies to source raw materials far and wide, and focus on high value-added segments of global supply chains. In contrast, developing countries often supply the raw materials that provide the basis for economic booms elsewhere, and find it hard to climb the global value chain and thereby escape poverty. To address this imbalance, political leaders around the developing world have established numerous export restrictions on raw materials over the last decade. Frequently, the stated goal of these policies is to promote local processing industries, and thereby boost local employment and manufacturing growth more generally.

In this paper, we provide novel evidence on whether export restrictions on raw materials can indeed promote local employment and downstream industries, thus accelerating structural transformation. We exploit data from Indonesia, a leading raw material producer whose government has targeted manufacturing as the national economy's principal growth engine. In 2014, Indonesia banned the export of raw nickel and bauxite ore, despite having been the world's largest exporter of both minerals in the preceding years which had earned the country substantial export revenue.

We first present descriptive evidence of what followed after the ban: while mineral extraction initially declined due to the suspension of mining activities, Indonesia invested heavily in nickel ore smelting capacity, thereby raising processed ferronickel output from 90,000 to 2,380,000 metric tons between 2013 and 2021. In contrast, the production of alumina (which is made from bauxite) did not increase similarly after 2013, due to a lack of additional smelter capacity. Combining detailed labor market survey data over 2009-2023 with district-level data on mining and downstream processing capacity, we then test whether the export bans promoted labor market outcomes in resource-producing (and resource-processing) districts. Moreover, using detailed plant-level manufacturing census data and resource-specific input-output data, we test whether the export bans promoted domestic manufacturing industries that use specific resources in their production processes.

We find that the ban had a positive and statistically significant impact on local employment - not only in directly affected sectors like manufacturing and construction but also through spillover effects in the public sector and services - in nickel-producing districts. In contrast, the export ban on bauxite thus did not have the intended consequences. Consistent with unchanged processing capacity for bauxite, the collapse in Indonesian bauxite extraction following the export ban had a negative impact on employment and wage levels in bauxite-producing regions of the country. Moreover, we find that the ban had a positive and statistically significant impact on the revenue and employment of plants using nickel, controlling for national and global shocks at a more aggregated industry level, but not of plants using (processed) bauxite. Taken together, our results provide plausibly causal and novel evidence that export restrictions on raw materials must be accompanied by a swift increase in processing capacity to promote local development, while failing to do so implies that foregone mining activity can depress the domestic labor market and economy.

This paper contributes to the literature that analyzes the impact of export restrictions. Previous studies have focused on restrictions that were negotiated under foreign political pressure (Berry, Levinsohn, & Pakes, 1999; Rosendorff, 1996) and trade-partner specific (Konishi, Saggi, & Weber, 1999), and were effectively not voluntary. Moreover, most studies are about restrictions on the trade in final goods as opposed to trade in raw materials (Dei, 1985; Neary, 1987; Takacs, 1978). We add to this literature by examining the effectiveness and unintended consequences of a voluntarily imposed export restriction on raw materials as an industrial policy. To our knowledge, the impact of these types of export restrictions has not been previously studied.

The rest of the paper is structured as follows. Section 2 outlines the conceptual framework. Section 3 provides background on Indonesia and the export restrictions. Section 4 describes the data sources and variables. Section 5 discusses the empirical strategy, Section 6 presents the results, and Section 7 concludes.

2 Conceptual framework

In this section, we consider theoretically how an export ban on raw materials can affect local labor markets and the establishment of a downstream processing industry.

Suppose an export ban is imposed unexpectedly. The first sector to be affected is the mining sector. In the short run, the export ban is equivalent to a reduction in the demand for raw materials, since the sector is unable to export its products to foreign markets, and is instead confined to the domestic processing industry. Furthermore, the domestic processing industry gains market power, which may lower the domestic prices further for raw materials relative to global prices. The decreased demand for raw materials is expected to reduce labor demand in the mining sector, leading to a decline in both sectoral employment and wages.

In the short run, assuming possibilities for migration are limited, the export ban in mining regions should increase the supply of labor to non-mining sectors, raising employment in these sectors. Due to restricted inter-sectoral labor mobility, the increase in employment is anticipated to be more pronounced in sectors requiring fewer specialized skills, such as agriculture or services. This increase in labor supply, ceteris paribus, is likely to put downward pressure on wages within these sectors. The impact will be more pronounced for resources with a smaller (or even non-existent) processing industry.

Eventually, the increased profitability of processing plants, driven by lower input prices for raw materials, may attract investment to the processing sector. However, investors will only invest if the profits from building a smelter, leveraging cheap local raw materials due to export restrictions, exceed the potential profits from building a processing plant elsewhere using non-restricted raw materials sourced from other countries. This may not be the case if raw materials are easily available at equally low costs elsewhere. Additionally, even if a processing plant is established to take advantage of cheap local raw materials, its location depends on several factors, including the availability of labor, proximity to mining sites (to minimize transport costs), and proximity to export ports (to supply the global market).

If the processing industry expands as a result of the export ban, labor demand, and thus employment, will increase in construction (to build smelters) and manufacturing (to operate smelters). Similarly, the demand for raw materials will rise, stimulating labor demand and employment within the mining sector in districts where these raw materials are sourced. Since the national government partly redistributes taxable mining rents to the local governments of producing regions, the public sector may also expand. Assuming higher labor mobility across districts in the long run, some of the increased labor demand in mining and processing sectors may be met through migration. This overall increase in employment is expected to boost aggregate local demand, potentially benefiting sectors not directly related to processing, such as services. However, insofar the total labor supply also increases due to migration, the upward pressure on wages will be dampened.

The growth of the processing industry may also have spillover effects on other districts. Specifically, it could increase the demand for goods supplied by upstream sectors, potentially benefiting non-mining, non-processing districts where these sectors are located. Given that processing is energy-intensive and reliant on coal-fired power, the expansion of the processing industry could increase labor demand—and thus employment and wages—in coal mining districts.

In summary, in the short run, the export ban on raw materials in Indonesia is expected to reduce labor demand and wages in the mining sector, especially when the processing industry is small. Labor will shift to non-mining sectors, particularly those requiring fewer specialized skills like agriculture and services, putting downward pressure on wages. Over time, *if* the processing industry grows, labor demand will increase in construction, manufacturing, and mining sectors in mining and/or processing districts, and potentially spill over into other sectors, such as services or the public sector, although migration may dampen wage increases.

3 Background

The global mining boom between 2003 and 2013 led to a significant surge in Indonesian mineral exports. However, as more and more unprocessed minerals were shipped overseas, mainly to China,[1] policymakers became concerned that the finite resources were being sold at (too) low prices, offering limited benefits to Indonesia (Warburton, 2017). This led to the adoption of Mining Law 4/2009, which introduced a ban in five years on the export of certain minerals in their raw form. To attract investments in this industry, the law required mining companies to refine mineral ores within Indonesia. This would allow Indonesia to climb the global value chain, replacing the production and exports of cheap raw ore with more valuable refined materials.

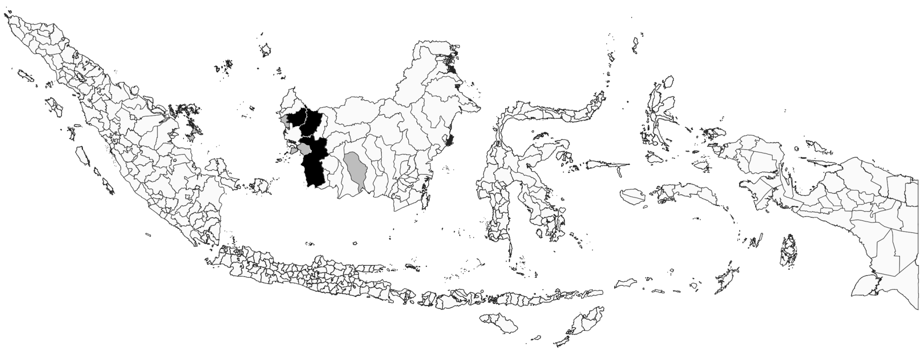
While multiple raw materials were included in the export restrictions, this paper focuses on nickel and bauxite, as they were the most affected. Other minerals subject to a strict ban already met processing thresholds or were exempted from the strict ban. For instance, cop-

[1] See Figure OA7 in the Online Appendix (OA) for an overview of China's role in Indonesia's export market for raw and processed nickel and bauxite in the period 2007-2023.

Figure 1: Geographical dispersion of nickel and bauxite deposits

(a) Nickel

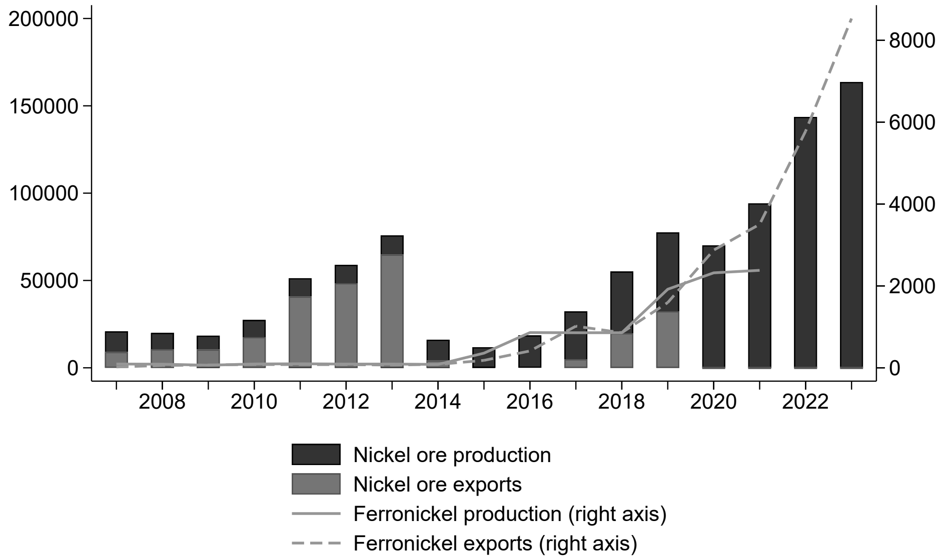
(b) Bauxite



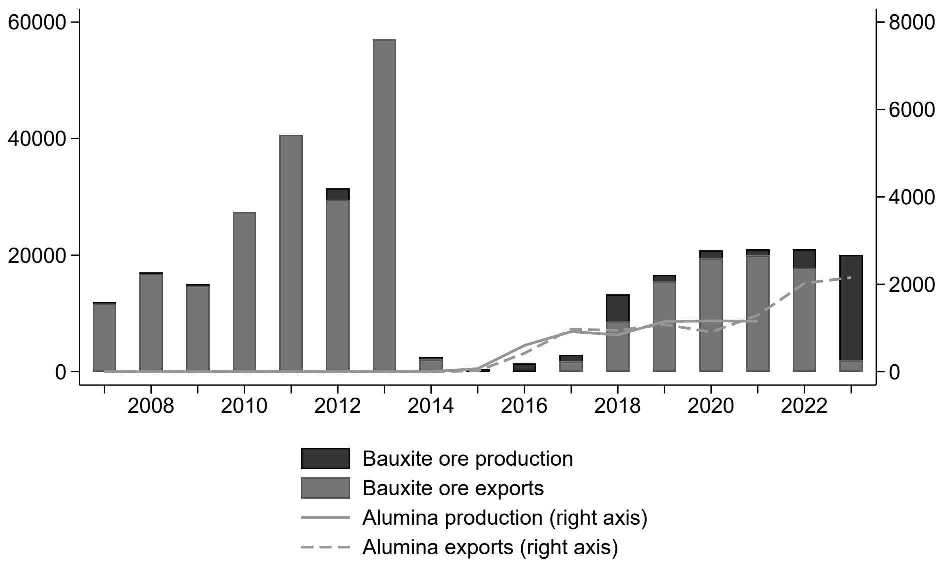
Notes: This figure shows the geographic dispersion of nickel and bauxite across the 497 districts of Indonesia. The unit is the total size of the area covered by licenses for a specific resource as a share of the district's total area, where darker colours correspond to a higher share of licenses. There is no overlap between the two resources.

Figure 2: Production and export of raw and processed nickel and bauxite in Indonesia (2007-2023)

(a) Nickel



(b) Bauxite



Notes: Unit is gross weight in 1000 metric tons. Bars are overlaid: ore production always exceeds ore export. Export figures are based on the following HS-6 codes: nickel ore (260400), ferronickel (720260, which includes nickel pig iron), bauxite ore (260600) and alumina (281820). Alumina is made from bauxite ore; ferronickel is made from nickel ore. Ferronickel and alumina production figures are only available until 2021. The average export value of alumina is also significantly lower at 330 USD per 1000 metric ton, compared to 1,730 USD per 1000 metric ton for ferronickel. Sources: USGS & Comtrade.

per, although economically significant, ultimately only faced an export duty that was later abandoned (Warburton, 2017).[2] Prior to the restrictions, the mining sector was an important employer in nickel- and bauxite-producing districts, especially compared to other areas. These districts were also relatively more reliant on agriculture, with minimal development in manufacturing (see Table A1 in the Appendix). Geographically, nickel and bauxite reserves are located in different regions of Indonesia, with nickel concentrated on Sulawesi and the Maluku Islands, and bauxite on western Kalimantan (see Figure 1).

Despite the announcement, Indonesia's processing capacity for nickel and bauxite remained minimal, as potential investors doubted that the government would forgo high export revenues by imposing a complete ban (Warburton, 2017). Therefore, when the export ban was implemented in 2014, many mining companies lacked access to domestic smelters to purchase their ore, and were forced to close (Pahlevi, Fidelis Sentosa, & Morse, 2024). Indeed, as illustrated in Figure 2, nickel and bauxite ore production fell by 76% and 96%, respectively, in the first year, while the production of processed materials still remained non-existent.

After the export ban, Indonesia's downstream nickel sector developed rapidly. Previously, China had imported over 80% of Indonesia's nickel ore production on average.[3] To retain access to Indonesia's high-grade nickel that is both cheaper and more efficient to process than ore from other countries (UNCTAD, 2017), Chinese companies invested billions in the sector through domestic partnerships (USITC, 2024). This created an oligopsony, allowing the processing sector to pressure domestic miners to sell at low prices (Faridz, 2023). As a result, the number of nickel smelters increased rapidly (see Figure A1) and refined nickel production rose, particularly in the form of nickel pig iron (NPI), which was mainly exported to China for stainless steel production. By 2023, 12 of the 14 nickel smelters were concentrated in six different nickel-mining districts.

In contrast, investments in the downstream bauxite industry remained stagnant. While China had relied on Indonesian bauxite imports prior to 2014, bauxite is more widely available than nickel and Chinese companies quickly adapted to the ban. As Figure OA8 in the Online Appendix shows, Guinea emerged as a dominant supplier to China, offering bauxite of similar quality and price without the same restrictions. With such an alternative readily available, there was little incentive for Chinese companies to invest in the Indonesian processing industry (Pahlevi et al., 2024). As few other investors were willing to pay the significant upfront cost of building a smelter, alumina production remained relatively low from 2014 to 2023. By 2023, only two districts (both of which are bauxite-producing) had operating bauxite smelters.[4]

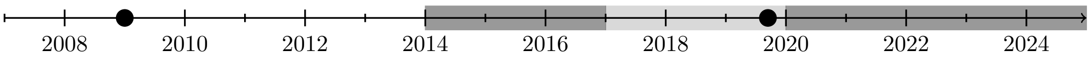
In 2017, Indonesia temporarily relaxed the export ban, allowing unprocessed ore exports if companies were building processing capacity or established a partnership. However, in January 2020, Indonesia reinstated the full ban on nickel exports. A complete ban on bauxite ore exports was implemented in June 2023. Figure 3 gives a full timeline of the Indonesian export

[2]See Section OA1 in the Online Appendix for a detailed description of the export restrictions, production and location of other raw materials.

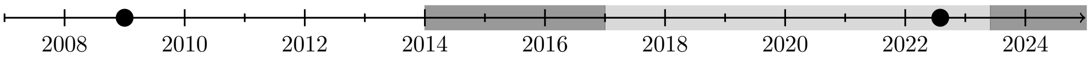
[3]Source: Comtrade, average for 2009-2013. Also see Figure OA8 in the Online Appendix for an overview of Indonesia's role in China's import market for raw and processed nickel and bauxite in the period 2007-2021.

[4]There is no district-level overlap in bauxite and nickel mining, nor is there a district-level overlap in bauxite or nickel smelters, see Table A2 in the Appendix for a full overview.

Figure 3: Timeline of Indonesian export restrictions on nickel and bauxite ore



(a) Nickel



(b) Bauxite

Notes: Announcements are indicated with a black circle. Soft and strict bans are indicated with light and dark shaded bars, respectively. Note that not all events take place at the beginning of the year. For example, the strict nickel ban is reintroduced in June 2023, which means that the dark shaded bar starts between 2023 and 2024.

restrictions on nickel and bauxite.

4 Data

Our primary data sources include information on export restrictions, district-level data on minerals and labor market outcomes, as well as plant-level manufacturing data. Descriptive statistics are provided in Table A3 in the Appendix.

Export restrictions Data on export restrictions comes from the OECD. This dataset lists the various types of export restrictions imposed by the Indonesian government between 2007 and 2023 on various raw materials at the 6-digit HS level. This allows us to construct a chronological dataset for the specific types of export restrictions applied to our two primary resources, nickel and bauxite, as well as other resources.

Mineral resources For data on the production, processing and trade of mineral resources, we draw on various sources. First, we compile a comprehensive database of resource extraction by district. The primary data source is the Direktorat Jenderal Mineral dan Batubara (Minerba), which maintains detailed maps of active resource extraction licenses. To our knowledge, this dataset provides the most comprehensive coverage of mining activity across Indonesia. Nickel licenses were identified in 15 districts, while bauxite licenses were located in 9 districts, out of a total of 497 districts that existed in 2009.[5] To aggregate the data to the district level, we calculate the total area covered by licenses for a specific resource within each 2009 district and then divide by the district's total surface area, as shown in the formula below:

$$r_{rk} = \sum_{l} \left(\frac{R_{rlk}}{Area_k} \right)$$

where R_{lk} represents the area (in square meters) of license l of resource r in district k and $Area_k$ (in square meters) represents the total area in district k.

The Minerba maps only covers current licenses. Therefore, we supplement our analysis with

[5]Due to the changes in district borders in Indonesia, we aggregate data to the 2009 district borders.

data from the Raw Materials Data (RMD) from S&P Global and MinEx Consulting's data on resources discovered by 1990. As shown in Table OA1 in the Online Appendix (OA), these datasets align closely for major deposits. Furthermore, robustness checks in Table A6 demonstrate that the results remain consistent across these alternative data sources and variable definitions.

A key purpose of the export restrictions was to establish more domestic production of valuable refined materials. Therefore, we draw on detailed maps of active and work-in-progress Indonesian smelters by Minerba. This dataset includes information for each smelter on the resource, completion rate, finish year and input and output capacity. We define a smelter as active starting the year its completion rate reaches 100% and thereafter. To aggregate the data to the district level, we compute a resource-specific smelter indicator by summing the output capacities of active smelters of a specific resource in each district-year:

$$p_{rkt} = \sum_{s} P_{rskt}$$

where P_{rskt} denotes the output capacity for a smelter s processing resource r in district k in year t.

The export restrictions implied a drastic change in the volume and composition of Indonesia's nickel, bauxite and coal trade. To examine how these shifts impacted districts heavily involved in mineral trade, we rely on highly detailed data from the the Indonesia's national statistical agency Budan Pusat Statistik (BPS) on mineral trade. This dataset records the value and quantity of exports and imports for each good (6-digit HS level) to/from the respective (air)ports. We combine this with yearly data from Maritime.com, which lists the detailed geographic location of all ports worldwide. By aggregating the data to the district level, we obtain a district-level measure of all out- and inward foreign trade in raw and processed materials and coal for each year:

$$t_{rkt} = \sum_{p} T_{rpkt}$$

where T_{rpkt} denotes the total trade (in 1000 metric tons) of resource r from/to port p in district k in year t.

Labor market To study the effect of export restrictions on the Indonesian local labor market, we draw on the annual labor force survey, Survei Angkatan Kerja Nasional (Sakernas). For the years of our sample period (2009-2023), the August round of this cross-sectional survey is representative at the district-level.[6] The number of respondents ranges from 507,713 in 2012 to 963,172 in 2010. We restrict the sample to the working age population, defined by BPS as individuals older than 15 years. The data provides detailed information on the labor market situation of the respondents, including district of residence, employment status, hours

[6]However, data for 2016 is excluded due to the lack of district-level representation. Our sample includes all 2009 districts, except for certain missing observations: 26 districts are missing in 2009, 6 in 2011, 4 in 2012, 9 in 2013, 6 in 2014, 2 in 2015, and 1 in 2018.

worked, earnings and sector,[7] as well as individual characteristics such as age, gender and education.

We construct a range of district-level indicators to characterize local labor markets using sampling weights. To estimate the number of workers employed in a specific sector for a given district-year, we first calculate the weighted share of individuals employed in that sector within the district-year.[8] This proportion is then multiplied by the district's labor force participation rate — derived from Sakernas data[9] — and the district's most recent population estimates provided by the World Bank.

For earnings, we could simply calculate the average district-level weighted hourly wage within each district-sector-year. However, both the workforce composition and the returns to worker characteristics can change significantly across sectors, districts and years, which could bias simple wage averages. Therefore, we use a measure of the hourly wage premium that adjusts for these differences and changes. Following Dix-Carneiro and Kovak (2017), we estimate, for each year t separately, the wage premium by regressing individual-level hourly wages (in ln) on a set of observable worker characteristics (X_{it}) as well as a set of interactions between industry fixed effects (FE_{jt}) and district fixed effects (FE_{kt}):

$$\ln(W_{ijkt}) = X_{it}\Gamma_t + FE_{jt} \times FE_{kt} + \varepsilon_{ijkt}$$

where our dependent variable W_{ijkt} denotes the hourly nominal wage[10] of individual i, working in one of the eight sectors j in district k at time t. X_{it} denotes a vector of individual worker characteristics, including overall workforce experience (age, age squared), tenure in the current job (in years and its square), and the worker's highest completed level of education.[11] We also include a set of dummy variables regarding the employment status.[12]

The interaction terms between industry (FE_{jt}) and region (FE_{kt}) fixed effects capture the wage premium specific to each district-sector after filtering out the effects of workforce composition (X_{it}) for a given year. Moreover, by estimating the regression for each year separately, we also

[7] The sectors are divided into six different sectors, including agriculture, mining, manufacturing, construction, the public sector and services. See Section OA2 in the Online Appendix for a more detailed description of the sectors in our data.

[8] In accordance with the official World Bank and BPS definitions, the district-sector-year-specific employment rate is calculated as the weighted share of employed respondents older than 15 years (i.e. those who reported their primary activity in the past week as working or having a job within a specific sector, even if temporarily not working) in a given district, sector and year, relative to the total number of employed respondents older than 15 years within that same group.

[9] In accordance with the official World Bank and BPS definitions, the district-specific (core) labor force participation rate is calculated as the weighted share of respondents older than 15 years who are either employed or actively seeking employment in a given district and year, relative to the total number of respondents older than 15 years within that same group.

[10] Sakernas reports monthly earnings in both cash and in-kind. To estimate hourly wages, we follow Bosker, Park, and Roberts (2021) and use the formula: (monthly income/ (365/12)) × (7/hours worked last week). Unless otherwise specified, our analysis uses cash income to calculate monthly income.

[11] We distinguish between four categories of education: (i) did not finish primary school (ii) finished (vocational) junior high school (ii) finished (vocational) senior high school and (iv) completed education beyond (vocational) senior high school, such as university.

[12] Sakernas distinguishes between (i) own-account worker (ii) self-employed assisted by temporary worker/unpaid worker (iii) employer assisted by permanent worker (iv) employee (v) casual employee in agriculture (vi) casual employee not in agriculture (vii) unpaid worker.

account for changes in returns to worker characteristics (Γ_t) over time. The idea is that this set of fixed effects better reflects the *structural* hourly wage within a given sector-district-year than a simple wage average, and this measure therefore serves as our preferred dependent variable when studying the effect of export restrictions on earnings.

Manufacturing plants Apart from the local labor market, we supplement our analysis by studying the effect of export restrictions on manufacturing plants across Indonesia. To do so, we draw on the annual census of manufacturing plants. Between 2007-2019, BPS recorded all Indonesian plants operating with at least 20 employees. For each plant, we know the district in which the plant is located and the five-digit industry (KBLI) code.[13,14] The dataset contains various key performance indicators, such as revenue and employment. Furthermore, ownership data enables us to exclude plants that are partly or fully government-owned, which appear more likely to influence policy or receive financial support. This leaves us with 181,070 plants, which are observed for an average of eight years.

We expect different industries to experience varying impacts from export restrictions on raw materials. To measure resource dependence at the industry level, we rely on input-output tables from the United States Geological Survey (USGS). Due to the lack of such disaggregated data for Indonesia, we use US data, assuming that industries' usage of specific (processed) minerals is comparable between the two countries – at least in a binary sense, which we will follow. The USGS tables, compiled by specialists drawing on a variety of sources, provide end-use data by (3- or 6-digit) NAICS industry codes for various mineral commodities. By cross-checking the reported NAICS codes and sector descriptions with a comprehensive description of each KBLI industry, we establish a concordance table between the USGS data and the 5-digit KBLI codes.[15] This approach enables us to identify the resource dependence by commodity across all 372 five-digit KBLI manufacturing industries. Note that nearly all manufacturing firms (except those in the processing industry) use processed rather than raw minerals in their production processes. For example, no plant outside of the processing industry would use bauxite, but rather alumina or aluminum. However, since both aluminum and alumina originate from bauxite, we will classify these firms as bauxite-dependent, and proceed in the same fashion for other raw materials.

The degree of resource dependence can be calculated in various ways. In our preferred approach,

[13] The KBLI (Klasifikasi Baku Lapangan Usaha Indonesia) classification is based on and closely resembles the ISIC classification.

[14] Unfortunately, district and sector variables are unavailable for plants in the 2015-2021 data. To address this gap, we make the assumption that the five-digit sector classification and district remain consistent for recurring plants from their last observed instance. Non-recurring plants, where sector and district information is unknown, are omitted from the analysis. Additionally, the census occasionally reports two or more districts (2%) and/or industries (10%) over time, potentially due to measurement error. We address this by including the longest continuous reporting period for each plant's district and/or industry.

[15] We cannot use existing concordance tables, such as those mapping NAICS to ISIC and subsequently from ISIC to KBLI, because the USGS table contains supplementary details beyond just the NAICS code. For instance, under the entry 'Batteries', the provided NAICS code is 335 ('Electrical equipment, appliance, and component manufacturing'). However, given the header 'Batteries' and the knowledge that nickel is used in rechargeable (secondary) ones (as indicated by Nickel Institute (2024)), we can instead establish a specific concordance between the entry 'Batteries' and the 5-digit KBLI code 31402 ('Industrial Electric Accumulator (Secondary Battery)').

we define resource input as a dummy variable which takes the value one if an industry uses as input a positive amount of a certain resource. This approach is based on the rationale that even minimal usage of a resource might be crucial for the production process, and thus should not be undervalued compared to industries with higher consumption. Moreover, this binary approach is less sensitive to differences in input usage intensity across the United States and Indonesia within a given industry.

5 Empirical framework

The export restrictions may have had a significant impact on the local labor market in districts where these resources can be found. Therefore, the first part of this paper focuses on the district-level labor market effects of the export restrictions. More specifically, we estimate the following difference-in-difference (DID) specification for the sample period 2009-2023:

$$Y_{kt} = \beta_1 Nickel_k \times ER_t + \beta_2 Bauxite_k \times ER_t + X_{kt}\Gamma + FE_k + FE_t + \varepsilon_{kt} \tag{1}$$

where Y_{kt} is outcome variable Y in district k at time t. $Nickel_k$ and $Bauxite_k$ are dummy variables which take the value one if in district k at least one deposit of nickel or bauxite, respectively, can be found. ER_t is a dummy variable for an export restriction active in year t.[16] X_{kt} represents a vector of time-varying district characteristics included as controls for other factors that may affect the outcome variable. In our preferred specification, this includes the interaction term for a district's share of copper licenses and the export restriction, as copper is the only other economically significant mineral in Indonesia.[17] We also include various fixed effects, including district fixed effects FE_k and year fixed effects FE_t. Standard errors are clustered at the district level. β_1 and β_2 capture the impact of export restrictions on districts where nickel and bauxite ore are extracted, respectively.

Our empirical strategy relies on two key assumptions. First, we assume that nickel and bauxite districts followed a similar economic trajectory to the control group before the export ban. In Figure 4 (see Online Appendix), we show that prior to the export ban, total employment shows parallel trends across districts with nickel and/or bauxite mining and those without, which supports the parallel trends assumption required for causal identification in DID. Moreover, our results remain robust when including island $\times$ year fixed effects, which allows us to compare districts on the same island where unobserved factors are likely more comparable (see Table A5).

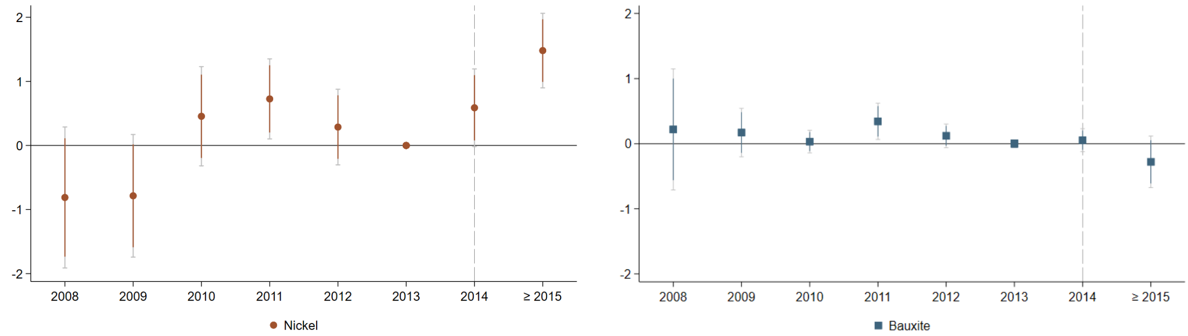
The second identification assumption is that, conditional on our controls, there are no time-varying district-level factors which are simultaneously correlated with both the timing of the export restriction and local labor market outcomes. This assumption would be violated if a district's labor market would have had time to adjust in anticipation of the policy. However, while announced five years earlier, the 2014 implementation of the export ban was unexpected. Not only were downstream industries not yet developed to absorb increased domestic produc-

[16] In the main analysis, we do not distinguish between export bans and softer export restrictions (see Section 3).

[17] See Section OA1 in the Online Appendix for a detailed description of the export restrictions, production and location of other raw materials.

Figure 4: Pre-ban trends of total employment

(a) Nickel (b) Bauxite



Notes: The results are based on the following specification: $Y_{kt} = \sum \alpha_t Nickel_{kt} + \sum \gamma_t Bauxite_{kt} + X_{kt}\Gamma + FE_k + FE_t + \varepsilon_{kt}$, where Y_{kt} is the log number of people who are employed. $Resource_{kt}$ is a continuous variable which measures the total size of the nickel or bauxite licenses, respectively, as a share of the district's surface area, in district k. X_{kt} is a vector of control variables, including the copper share. We also include district fixed effects FE_k year fixed effects FE_t. Standard errors are clustered at the district level. The dots represent point estimates, and the blue (grey) lines correspond to 95% (90%) confidence intervals. The year 2013 serves as the reference year.

tion (see Section 3), the London Metal Exchange saw a sharp, sustained rise in nickel prices immediately after the ban indicating not even the market had anticipated the policy (Lim, Kim, & Park, 2021).

6 Export restrictions and local labor market

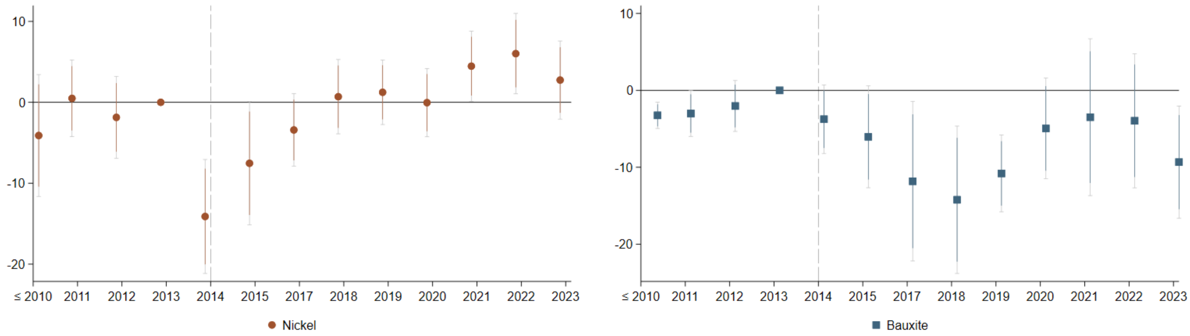
6.1 Main findings

Export restrictions and mining employment The first sector affected by the export ban was the mining sector, as bauxite production dropped by 96% and nickel production by 76% between 2013 and 2014. While nickel production rebounded to 2013 levels by 2019, bauxite production remained over 60% until 2023. Figure 5 shows the dynamic effects of the export ban on the number of employed people (in ln) in the mining sector in nickel- and bauxite-producing districts. The year 2013 and non-nickel and non-bauxite districts are used as references. As hypothesized in Section 2, the direct effect of the export restrictions was an immediate and strong reduction in mining employment in 2014. In nickel-producing districts, however, mining employment recovered quickly, consistent with a recovery in nickel ore production due to increased processing capacity. Bauxite-producing districts, on the other hand, experienced a prolonged downturn in mining employment with only a brief recovery between 2020 and 2022 when export restrictions were more relaxed and production had somewhat stabilized. However, mining employment decreased again when the export ban on bauxite was reinstated in 2023.

Sectoral decomposition We now turn to the broader impact of the export ban on employment. Column (1) of Table 1 shows the effect of export restrictions on the (log) number of employed people within districts where mineral deposits are located. In nickel-intensive districts, the export restrictions are associated with a substantial overall increase in employment,

Figure 5: Timing of effects on mining employment (2009-2023)

(a) Nickel (b) Bauxite



Notes: The results are derived from the following specification: $Y_{kt} = \sum \alpha_t Nickel_{kt} + \sum \gamma_t Bauxite_{kt} + X_{kt}\Gamma + FE_k + FE_t + \varepsilon_{kt}$, where Y_{kt} is the log number of people who are employed in the mining sector. $Resource_{kt}$ is a continuous variable which measures the area of the nickel or bauxite licenses, respectively, as a share of the district's surface area, in district k. X_{kt} is a vector of control variables, including the interaction term of the copper share with the export restriction. We also include district fixed effects FE_k year fixed effects FE_t. Standard errors are clustered at the district level. The dots represent point estimates, and the blue (grey) lines correspond to 95% (90%) confidence intervals. The year 2013 serves as the reference year.

Table 1: Export restrictions and sectoral employment

dependent var	ln employment						
	(1) aggregate	(2) agriculture	(3) mining	(4) manu-facturing	(5) construc-tion	(6) public	(7) services
nickel share × ER	0.923^{**}	-0.321	0.852	4.959^{*}	2.319^{**}	1.836^{**}	2.388^{***}
	(0.388)	(0.693)	(2.171)	(2.627)	(0.959)	(0.834)	(0.693)
bauxite share × ER	-0.998^{***}	-0.069	-5.303^{*}	1.900	2.106^{*}	-1.019	0.598
	(0.134)	(0.282)	(3.090)	(2.352)	(1.237)	(1.292)	(0.984)
N	6902	6897	6080	6745	6777	6882	6866

Notes: In this table we study how export restrictions on raw materials impact sectoral employment in districts where these resource deposits are located. The sample period is 2009-2023. 'ln employment' is the log number of people who are employed in a specific sector. 'resource share' is a continuous variable which measures the total area of the nickel or bauxite licenses, respectively, as a share of the district's surface area, in district k. 'ER' is a dummy variable which takes the value one if there is an export restriction active for this specific resource in year t. All columns include a full set of control variables, including interaction terms of the copper share with the export restriction, as well as year fixed effects and district fixed effects. Standard errors are clustered at the district level and shown in parentheses. $^{***}p < 0.01, ^{**}p < 0.05, ^{*}p < 0.1$.

while the ban is associated with a decrease in employment in bauxite-producing districts. The point estimates suggest that, in nickel districts, a one standard deviation increase in the share of the district covered by a nickel license (3.96%) implies a 3.72% increase in the total district employment. By contrast, in bauxite districts, a one standard deviation larger increase in the share of the district covered by a bauxite license (4.74%) is associated with a 4.84% decrease in the total district employment. Together, the results suggest that - conditional on the successful development of a processing industry - the effect of export restrictions can raise employment within treated districts, similar to economic shocks in the form of mining booms (Aragón & Rud, 2013), but the reverse may happen if the processing industry cannot be developed.

This aggregate employment impact in column (1) is further broken down in columns (2)-(7) of Table 1 across six sectors: agriculture, mining, manufacturing, construction, public sector, and services. In nickel districts, the manufacturing, construction, public sector, and services saw an increase in the number of employed workers after the export ban, while agriculture and mining employment remained unaffected. However, as discussed in Section 2, labor market outcomes may vary between the short run and the long run.

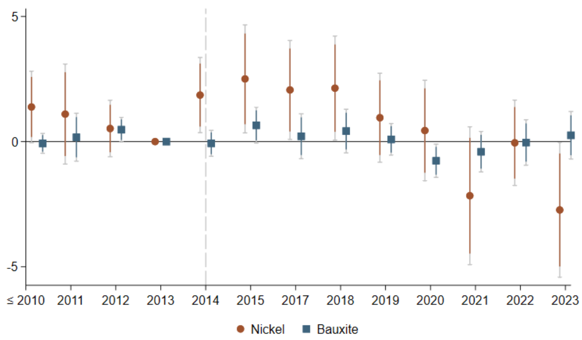
To distinguish between these effects, Figure 6 presents event studies comparing employment outcomes across six sectors in nickel-producing districts to the control group. Although our yearly estimates sometimes lack significance due to lower power, several interesting insights still emerge. First, immediately following the export ban, agricultural employment rises, particularly in nickel districts, supporting the hypothesis that agriculture serves as a fallback for displaced workers. Indeed, although we lack the sample size to formally test sector-level shifts, existing individual-level data on sector switching from the Sakernas survey suggest that in nickel-producing districts, 18% of 2013 mining workers entered non-employment (i.e., unemployment and exit from labor force), and 77% of 2013 transitioned to other sectors in 2014 (up from 59% in 2009–13), with half moving to agriculture and around one fifth to both construction and manufacturing. In bauxite-producing districts, 15% entered non-employment, and 86% switched sectors in 2014 (up from 57% in 2009–13), with half entering agriculture and one fifth moving to low-skilled services.[18]

As the processing industry expands in nickel districts, manufacturing employment rises, likely reflecting increased labor demand in processing plants. This pattern is absent in bauxite districts, consistent with the lack of a processing sector there. The public sector in nickel districts also grows post-ban, whereas in bauxite districts, it declines—possibly due to the close link between taxable mining rents and ore production. Similarly, employment in services gradually increases in nickel districts, likely driven by higher aggregate demand and spillovers into non-extractive industries, aligning with previous research on resource development spillovers (Allcott & Keniston, 2018). While services employment also shows some growth in bauxite districts, the effects are generally weaker and often statistically insignificant. A notable exception to the stronger employment trends in nickel districts is the construction sector. In bauxite districts,

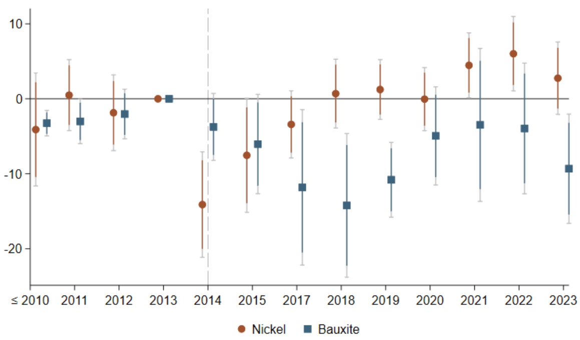
[18] Over the entire sample period, in nickel districts, 53% of mining workers switched jobs post-ban (compared to 53% pre-ban), 14% entered unemployment (compared to 16% pre-ban) and 21% exited the labor force (compared to 11% pre-ban). In bauxite districts, 68% of mining workers switched jobs post-ban (compared to 59% pre-ban), 18% entered unemployment (compared to 11% pre-ban) and 14% exited the labor force (compared to 20% pre-ban).

Figure 6: Event study of the impact of export restrictions on employment (2009-2023)

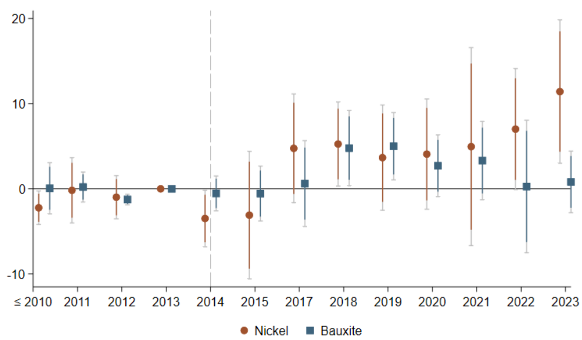
(a) Agricultural sector



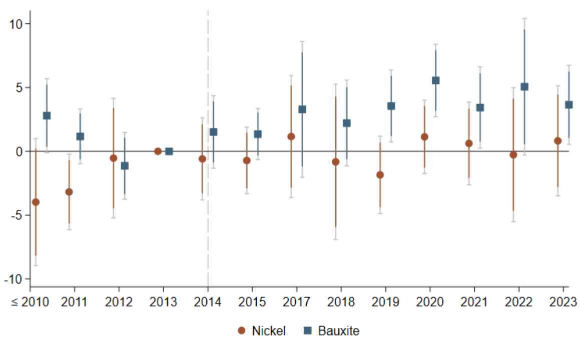
(b) Mining sector



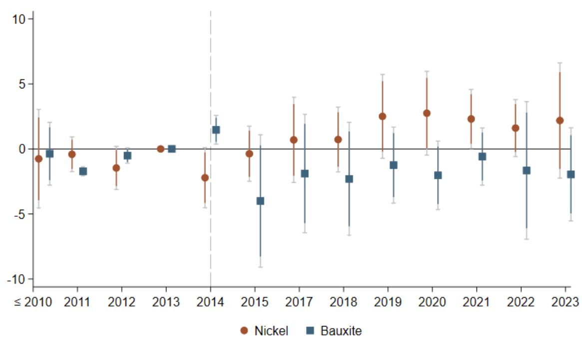
(c) Manufacturing sector



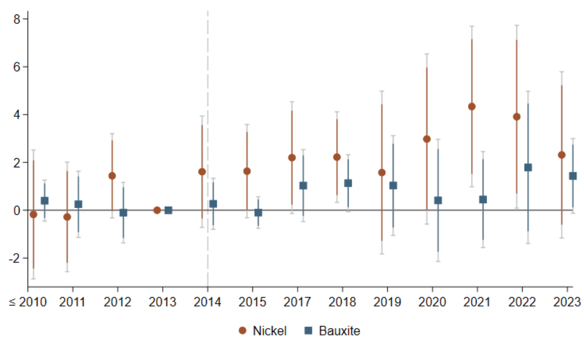
(d) Construction sector



(e) Public sector

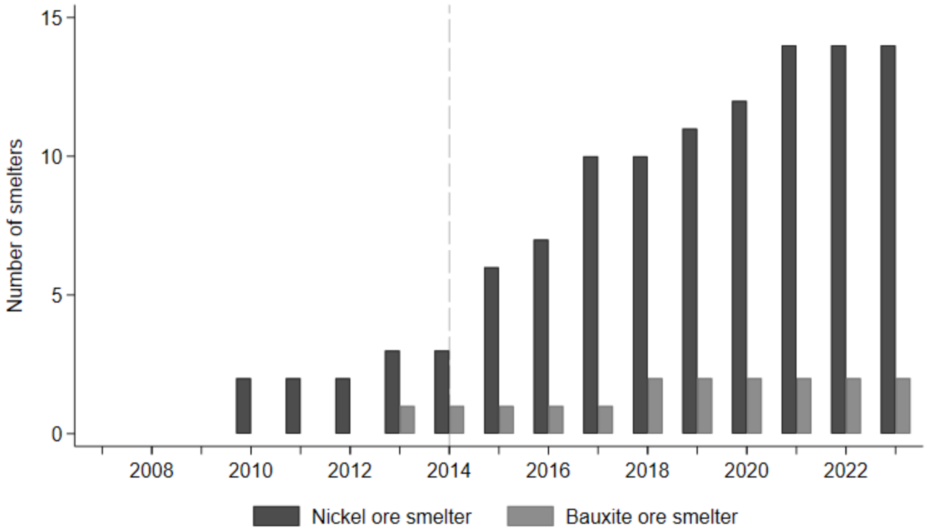


(f) Service sector



Notes: The results are based on the following specification: $Y_{kt} = \sum \alpha_t Nickel_{kt} + \sum \gamma_t Bauxite_{kt} + X_{kt}\Gamma + FE_k + FE_t + \varepsilon_{kt}$, where Y_{kt} is the log number of people who are employed in a specific sector. $Resource_{kt}$ is a continuous variable which measures the total size of the nickel or bauxite licenses, respectively, as a share of the district's surface area, in district k. X_{kt} is a vector of control variables, including the copper share. We also include district fixed effects FE_k year fixed effects FE_t. Standard errors are clustered at the district level. The dots represent point estimates, and the blue (grey) lines correspond to 95% (90%) confidence intervals. The year 2013 serves as the reference year.

Figure 7: Development of processing industry (2007-2023)



Notes: Source: Minerba.

construction employment rises in later years, likely due to the development of bauxite smelters ahead of the second export ban.[19]

Development of downstream industry We continue by attempting to distinguish the effect of export restrictions in general from the specific effects of the processing industry.[20] As discussed in Section 3, the export ban had a heterogeneous effect for nickel and bauxite. Due to to the non-substitutabilty of Indonesian nickel in the Chinese industry, significant investments in the nickel processing sector were made after the ban took effect. Indeed, Figure 7 shows that the number of nickel smelters increased substantially after the export ban, while the establishment of a bauxite processing industry lagged behind.

Panel A of Table 2 compares districts with nickel mining but no processing at any time (nine districts) to a control group of districts without nickel mining or smelters.[21] The results are largely similar to Table 1, with a positive effects on aggregate employment, as well as a positive impact on the number of employed workers in the public sector, and services, indicating that the benefits of the export ban extend beyond the direct impact of smelter establishment. However, the effect on construction and manufacturing has disappeared, consistent with the idea that these sectors are most directly linked to the processing industry itself. It is worth underlining that this does not imply that nickel processing is unimportant for our findings. In fact, the bauxite results underscore that the presence of a processing industry *is* crucial for an export

[19] As of 2023, nine bauxite smelters were under construction. Source: Minerba.

[20] Here, we opt to focus on nickel processing, since only one bauxite smelter was completed post-ban, giving us insufficient variation for empirical analysis.

[21] Several factors complicate our analysis. Table A2 in the Appendix shows that out of eight smelter districts, two are outside nickel-mining districts (Java), while two additional nickel districts had processing industries before the ban. This creates six sets of treatments based on three factors: (i) presence of nickel mining, (ii) existence of processing before the ban, and (iii) establishment of processing after the ban. However, the small sample size of each of these groups complicates a reliable estimation of separate treatment effects.

Table 2: Role of processing industry

Panel A							
sample	nickel districts which never get a nickel smelter						
dependent var	ln employment						
	(1) aggregate	(2) agriculture	(3) mining	(4) manu-facturing	(5) construc-tion	(6) public	(7) services
nickel share × ER	0.965***	0.053	-1.179	4.260	2.271	2.263**	1.715***
	(0.212)	(0.704)	(2.354)	(3.410)	(1.403)	(1.033)	(0.484)
bauxite share × ER	-0.538***	0.389	-4.946	2.252	2.507**	-0.581	1.026
	(0.103)	(0.248)	(3.101)	(2.339)	(1.223)	(1.309)	(0.975)
N	6762	6757	5940	6605	6637	6742	6726

Panel B							
sample	nickel districts which ever get a nickel smelter						
dependent var	ln employment						
	(1) aggregate	(2) agriculture	(3) mining	(4) manu-facturing	(5) construc-tion	(6) public	(7) services
# nickel smelters	0.048**	-0.049	0.255***	0.475***	0.151***	0.044*	0.096**
	(0.020)	(0.031)	(0.032)	(0.110)	(0.051)	(0.025)	(0.044)
nickel share × ER	-1.030***	-0.917	-3.400	-5.115***	-1.551	-0.683	0.819
	(0.382)	(0.601)	(3.759)	(1.881)	(1.103)	(1.482)	(0.649)
bauxite share × ER	-0.985***	-0.069	-5.257*	1.980	2.160*	-0.984	0.622
	(0.134)	(0.282)	(3.090)	(2.351)	(1.235)	(1.292)	(0.984)
N	6706	6701	5900	6549	6581	6686	6670

Notes: In this table we study how export restrictions on raw materials impact the sectors in districts where these resource deposits and smelters are located. The sample period is 2009-2023. This table excludes two districts with smelters but no mining and two additional districts with smelters before the export ban. In Panel A, we compare districts with nickel mining but no processing at any time (nine districts) to a control group of districts without nickel mining or smelters. In Panel B, we focus on districts with both mining and a post-ban processing industry (four districts) to a control group of districts without nickel mining or smelters. 'ln employment' is the log number of people who are employed in a specific sector. 'resource share' is a continuous variable which measures the total area of the nickel or bauxite licenses, respectively, as a share of the district's surface area, in district k. 'ER' is a dummy variable which takes the value one if there is an export restriction active for this specific resource in year t. '# nickel smelters' is a continuous variable which measures the number of nickel smelters in a specific district. All columns include a full set of control variables, including interaction terms of the copper share with the export restriction, as well as year fixed effects and district fixed effects. Standard errors are clustered at the district level and shown in parentheses. $^{***}p < 0.01,^{**} p < 0.05,^{*} p < 0.1$.

Table 3: Upstream impact in coal districts

dependent var	ln employment						
	(1) aggregate	(2) agri-culture	(3) mining	(4) manu-facturing	(5) construc-tion	(6) public	(7) services
coal share × ER	0.241	-0.114	2.566***	1.757**	0.335	1.055***	1.022***
	(0.161)	(0.324)	(0.690)	(0.707)	(0.524)	(0.388)	(0.281)
nickel share × ER	0.829***	-0.649	0.775	5.404**	2.357**	1.785**	2.501***
	(0.210)	(0.519)	(2.282)	(2.724)	(0.927)	(0.831)	(0.659)
bauxite share × ER	-0.522***	0.383	-4.748	2.344	2.516**	-0.504	1.088
	(0.103)	(0.249)	(3.098)	(2.338)	(1.224)	(1.309)	(0.974)
N	6902	6897	6080	6745	6777	6882	6866

Notes: In this table we study how export restrictions on raw materials impact sectoral employment in districts where these resource deposits and coal deposits - a key input for the downstream processing industry - are located. The sample period is 2009-2023. 'ln employment' is the log number of people who are employed in a specific sector. 'resource share' is a continuous variable which measures the total area of the nickel or bauxite licenses, respectively, as a share of the district's surface area, in district k. 'ER' is a dummy variable which takes the value one if there is an export restriction active for nickel and bauxite in year t. All columns include a full set of control variables, including interaction terms of the copper share with the export restriction, as well as year fixed effects and district fixed effects. Standard errors are clustered at the district level and shown in parentheses. $^{***}p < 0.01, ^{**} p < 0.05, ^{*} p < 0.1$.

ban generating a positive impact on the local labor market. Rather, the results highlight that the (indirect) effects of a successfully developed industry are not confined to processing districts themselves.

Panel B of Table 2 focuses on districts with both mining and a post-ban processing industry (four districts), again using non-mining, non-smelting districts as the control group. We focus on the effect when an (additional) nickel smelter becomes operational in a nickel mining district - although we do realize that smelter placement may be endogenous and the results should be interpreted with caution. We find that the number of smelters have a positive impact on overall employment, as well as on aggregate, public sector and services employment. As may be expected, the largest effects can be observed in sectors most closely linked to the processing industry - mining, manufacturing and construction employment. The event studies for the two sets of samples can be found in Figure OA9 (see Online Appendix). All in all, the results show that while the intensity of the processing industry is positively correlated with a number of labor market outcomes, the positive effects (and the indirect ones in particular) are not solely confined to processing districts.

Impact on upstream industry The effects of export restrictions may extend beyond mineral-producing districts. Smelting raw ore is highly energy-intensive and many smelters rely on coal-fired power plants for their operations. As a result, power plant capacity in nickel-producing districts surged from 295 MW in 2014 to 6,090 MW in 2023 (see Table OA3 in the Online Appendix).[22] This expansion has increased demand for coal from Indonesia, the world's largest exporter of thermal coal (International Energy Agency, 2021). Between 2013 and 2021, Indone-

[22] All coal power plants are located in nickel-producing districts *with* a a nickel smelter. In bauxite-producing districts, power plant capacity remained at 0 MW.

Table 4: Export restrictions and employment status

dependent var	ln population	empl share	unempl share	NLF share
	(1)	(2)	(3)	(4)
nickel share × ER	1.079***	-0.118	-0.036	0.154
	(0.389)	(0.142)	(0.036)	(0.142)
bauxite share × ER	-0.446***	-0.480***	0.042	0.438***
	(0.137)	(0.142)	(0.035)	(0.114)
N	6902	6902	6902	6902

Notes: In this table we study how export restrictions on raw materials impact the sectors in districts where these resource deposits are located. 'ln population' is the log number of the working age population (15+) in district k. 'empl share' is the share of the working age population that is employed. 'unempl share' is the share of the working age population that is unemployed (i.e., those who are unemployed but are still actively searching for work). 'NLF share' is the share of the working age population that are is not in the labor force (i.e., those who are unemployed and not actively searching for work). 'resource share' is a continuous variable which measures the total area of the nickel or bauxite licenses, respectively, as a share of the district's surface area, in district k. 'ER' is a dummy variable which takes the value one if there is an export restriction active for this specific resource in year t. All columns include a full set of control variables, including interaction terms of the copper share with the export restriction, as well as year fixed effects and district fixed effects. Standard errors are clustered at the district level and shown in parentheses. $^{***}p < 0.01,^{**} p < 0.05,^{*} p < 0.1$.

sian coal production rose from 487,000 to 614,000 thousand metric tons, with non-exported coal tripling over the same period (see Figure OA5 in the Online Appendix). Table 3 examines the impact of export restrictions on employment in coal-producing districts. While aggregate employment remains unchanged, the results confirm a significant increase in mining employment compared to districts that do not produce coal; a one standard deviation increase in the share of a district covered by a coal license (5.12%) corresponds to a 14% increase in total district mining employment. Moreover, other sectors, such as construction, the public sector, and services, also experienced notable employment gains. These findings highlight the broader spillover effects of the export ban on upstream coal-producing regions - even beyond these district's mining sector.[23]

6.2 Extensions

Employment status Where do the workers driving sectoral employment changes come from? The export ban can trigger various labor market adjustments, including geographic mobility across districts, and/or shifts in employment, unemployment, or labor force participation within districts. Table 4 examines these channels. Column (1) focuses on worker reallocation across districts, and shows a significant increase in population in nickel-producing districts following the export ban but no corresponding mobility response in bauxite-producing areas. Columns (2)–(4) present the effect on the employment, unemployment, and non-employment share of the working age population. These categories are mutually exclusive, so shifts in one category must be offset by changes in others (see also Autor, Dorn, and Hanson (2013)).

In nickel-producing districts, a one standard deviation increase in the share of nickel licenses is associated with a 5.25% increase in the population, while we find no significant effects on the employment-to-population ratio (column (2)). This suggests that observed sectoral employment

[23]The event studies for coal districts can be found in Figure OA10 (see Online Appendix).

Table 5: Export restrictions and sectoral wage

dependent var	ln hourly wage premium						
	(1) aggregate	(2) agriculture	(3) mining	(4) manu-facturing	(5) construc-tion	(6) public	(7) services
nickel share × ER	-0.610	-1.161	0.240	-0.088	-1.794	1.620**	-1.123**
	(0.923)	(1.096)	(1.244)	(1.299)	(1.195)	(0.668)	(0.524)
bauxite share × ER	-1.135**	-1.448**	-1.332	-0.515	-0.157	-0.272	-0.810**
	(0.565)	(0.626)	(1.582)	(1.077)	(0.307)	(0.610)	(0.400)
N	6902	6897	6080	6745	6777	6882	6866

Notes: In this table we study how export restrictions on raw materials impact the sectors in districts where these resource deposits are located. The sample period is 2009-2023. 'ln hourly wage premium' 'ln hourly wage premium' is the log sectoral-district wage premium, calculated as described in the Data section. 'resource share' is a continuous variable which measures the total area of the nickel or bauxite licenses, respectively, as a share of the district's surface area, in district k. 'ER' is a dummy variable which takes the value one if there is an export restriction active for this specific resource in year t. All columns include a full set of control variables, including interaction terms of the copper share with the export restriction, as well as year fixed effects and district fixed effects. Standard errors are clustered at the district level and shown in parentheses. $^{***}p < 0.01, ^{**}p < 0.05, ^{*}p < 0.1$.

effects in nickel districts are primarily driven by geographic and inter-sectoral mobility rather than changes along non-employment margins. In bauxite-producing districts, we find no strong evidence of population decline following the mining sector's collapse. Instead, the employment-to-population ratio falls by 2.24%, largely due to labor force withdrawal, and about one-tenth of the decline attributable to rising unemployment.

Wages Table 5 examines the impact of the export ban on wage levels, using the district-sector-year specific (log) hourly wage premium as the dependent variable to account for compositional differences (see Section 4). Since this measure applies only to the employed, and Table 4 shows that the ban affected employment in nickel- and bauxite-producing districts, any findings must be interpreted with caution. Still, Table 5 finds a significant decline in the aggregate hourly wage premium in bauxite-producing districts, particularly in agriculture. This aligns with previous findings that displaced workers turned to agriculture as a short-term fallback, driving wages down. Despite the large employment gains, we find no statistically significant effect on wages in nickel-producing districts. This is likely due to the population influx in nickel districts, as shown in Table 4, putting a downward pressure on wages.[24]

Spillovers to port districts The export ban implied a drastic change in the volume and composition of Indonesia's trade. Before the export ban, over 80% of nickel and bauxite ores were exported. The ban sharply reduced both these exports, but ferronickel production and exports (primarily to China) surged. 58% of ferronickel exports were transported from ports in districts that had previously exported raw nickel ore (see Table OA3 in the Online Appendix).[25] Moreover, the non-exported amount of coal tripled between 2013 and 2021, which suggests - combined with the 2000% increase in coal power plants in nickel districts - that coal trade also

[24] The event studies for coal districts can be found in Figure OA11 (see Online Appendix).

[25] Four of the eight nickel-exporting districts pre-ban now export ferronickel, whereas only two of seven bauxite-exporting districts transitioned to alumina exports by 2023.

changed substantially after the export ban. While direct domestic shipping data is limited, coal-specific infrastructure investments in traditional coal export ports make it likely they also handle domestic coal shipments to nickel-producing regions. Table A4 (see Appendix) examines the labor market effects of the export ban in these traditional export districts and shows that, after controlling for mining locations, both former nickel-exporting and coal-exporting districts saw modest employment gains following the export restrictions.

6.3 Robustness

The estimated effects of the export restrictions on employment are robust to a variety of alternative specifications and robustness checks.

Fixed effects and controls Column (1) of Table A5 (see Appendix) replicates the aggregate employment effects from the baseline specification (see Table 1) and aggregate wage effects from Table 5. In column (2), we include island × year fixed effects. In column (3), we add a linear district-specific time trend. Column (4) includes a full set of control variables for other export restricted resources (see Section OA1 in the Online Appendix). In column (5), we report two-way clustering standard errors by district and year following Feyrer, Mansur, and Sacerdote (2017). The results for employment are highly robust to these different specifications.

Resource definition In the baseline specification, we use recent data from Indonesia's Ministry of Energy and Mineral Resources (Minerba) to define resource intensity as the share of a district's area covered by mining licenses. Table A6 examines the robustness of this definition and data source. Column (1) replicates the baseline specification. In columns (2) and (3), we use the same Minerba dataset but redefine resources. Column (2) measures the absolute area covered by licenses (in 1,000 hectares), while column (3) employs a dummy. In columns (4) and (5), we rely on the RMD/MinEx dataset, applying a dummy approach in column (4) and incorporating the deposit size (in 1,000 megatons) in column (5). Again, the results for employment are highly robust to these different specifications.

Varying control groups The baseline specification includes all Indonesian districts, which differ significantly in development levels and mining importance. To address this, Table A7 modifies the control group, ensuring comparisons among more similar districts. Column (2) restricts the sample to districts with an above-median mining employment share in 2013. Column (3) includes only districts holding a mining license, based on the Minerba dataset. Column (4) excludes Java and Sumatra, the country's more economically developed islands. Across these alternative samples, the employment results remain highly robust.

7 Beyond local labor: Impact on manufacturing plants

7.1 Methodology

Beyond the effects on the local labor market predominantly in Kalimantan and Sulawesi, we also examine the effect of export restrictions on all manufacturing plants that use exported-restricted raw materials (typically in processed form) as inputs. Therefore, we estimate the following DiD specification:

$$Y_{ijgt} = \gamma_1 Nickel_j \times ER_t + \gamma_2 Bauxite_j \times ER_t + X_{ijt}\Gamma + FE_i + FE_{gt} + \varepsilon_{kt} \tag{2}$$

where Y_{ijgt} is outcome variable Y of manufacturing plant i in 5-digit KBLI industry j in 2-digit KBLI industry g in year t. $Nickel_j$ and $Bauxite_j$ are dummy variables which take the value one if industry j uses as input a positive amount of nickel or bauxite (either directly, or processed to ferronickel, alumina or aluminum). ER_t is a dummy variable for an export restriction active in year t. X_{ijt} is a vector of time-varying plant characteristics which are included as controls for other factors that may affect the outcome variable. This vector includes interaction terms for a plant's other inputs (e.g. gold, copper etc.) with the export restriction. We also include various fixed effects, including plant fixed effects FE_i (which nest district fixed effects and 5-digit KBLI j fixed effects) and 2-digit industry-year fixed effects FE_{gt}. These fixed effects control for example for changes in world mineral prices or global industry-year specific shocks. Standard errors are clustered at the 3-digit KBLI industry level. γ_1 and γ_2 capture the impact of being downstream to the nickel and bauxite industry, respectively, in times where these materials are export-restricted in their raw form.

This empirical strategy rests on a number of assumptions. First, we assume that there are no time-varying *industry-level* variables (over and above the 2-digit KBLI sector level)[26] that are correlated both with the imposition of upstream export restrictions and the performance of downstream manufacturing plants. In other words, we assume that conditional on belonging to a certain two-digit industry, upstream export restrictions form an exogenous shock (of varying degree) to downstream industries within that two-digit industry.

This first assumption would fail to hold if policymakers were targeting very specific sectors with the imposition of trade restrictions. Industry-level lobbying would give rise to related concerns. We address these concerns in various ways. First and foremost, it should be noted that the Indonesian government was specifically focused on the development of a value-enhancing *processing* industry. In contrast, our dataset predominantly includes plants further downstream (e.g., construction companies, car manufacturers), who were not the primary target of the policy intervention and whose interests are less directly tied to the export restrictions. Moreover, Warburton (2018) argues that even for plants directly affected by the export restrictions (such as mining companies and smelters), "layered and fragmentated ownership structures at the local level made business interest aggregation and collective action hugely challenging".

The second identification assumption is that there are no time-varying *plant-level* variables that are correlated both with the imposition of upstream export restrictions and the performance of downstream manufacturing plants. Again, lobbying could be a concern. However, our baseline sample already excludes all firms with government ownership whose political ties arguably make it easier to access and influence policymakers.

[26] Since the independent variable draws upon 5-digit KBLI industry-year variation, we include 2-digit KBLI industry-year fixed effects to control for the general developments of the broader industry. We opt not to include 3-digit or 4-digit KBLI industry-year fixed effects, as this would eliminate too much of the variation between plants

Table 6: Export restrictions and manufacturing plants

dependent variable	ln output	ln employment
	(1)	(2)
nickel input × ER	0.164***	0.0655**
	(0.0466)	(0.0271)
bauxite input × ER	-0.0699	0.0226
	(0.0556)	(0.0393)
N	181,070	181,070

Notes: In this table we study how export restrictions on raw materials impact the performance of manufacturing plants that use these export-restricted raw materials (in processed form) as inputs. The sample period is 2007-2019. 'ln output' is the total value of goods sold (in log) and 'ln employment' is the total number of employed people (in log). 'resource input' is a dummy variable which takes the value one if the plant's industry uses a positive input of nickel or bauxite, respectively. 'ER' is a dummy variable which takes the value one if there is an export restriction active for this specific resource in year t. All specifications include a full set of control variables, including interaction terms of a plant's use of other materials with the export restriction, as well as year fixed effects and 2-digit-year fixed effects. Standard errors are clustered at the 3-digit KBLI industry level and shown in parentheses. $^{***}p < 0.01, ^{**}p < 0.05, ^{*}p < 0.1$.

7.2 Results

So far, we have focused on the effects of the export ban on the local labor market in the districts where mining, processing or trade of the raw materials took place. However, the significant increase in processed materials may have had important repercussions beyond the local setting. In Table 6, we zoom in on the manufacturing sector across Indonesia and examine the effect of the export ban on all plants that use export-restricted raw materials (typically in processed form) as inputs. The idea is that the (absence of) an increase in domestically produced refined materials may have affected manufacturing firms across Indonesia, e.g., due to different input prices as a result of changes in transportation costs.[27]

Table 6 reports the main results on the impact of the bauxite and nickel export restrictions on manufacturing performance. In column (1), the dependent variable is log output, which we define as the log of the total value of goods sold. In column (2), the dependent variable is log employment. The results show a positive and statistically significant coefficient on the nickel dummy for both outcome variables, indicating that after the export restrictions take effect, plants that use nickel improve their performance relative to non-nickel plants. This result is consistent with the idea that the export restriction on raw nickel positively affected processed nickel-using plants through a rise in the domestic supply of processed nickel, potentially also at lower prices. Contrary to nickel, we do not observe any significant effect for industries that are downstream to bauxite. This is consistent with the lack of an increase in processing capacity for this mineral.

[27] The amount of non-exported domestically processed nickel increased from 22,819 in 2013 to 325,305 metric tons in 2019.

8 Conclusion

In this paper we asked whether voluntary export restrictions promote domestic economic development. We did so by investigating the impact of Indonesia's 2014 ban on the export of unprocessed ores, focusing on its major raw materials: nickel and bauxite. The data reveal a positive and statistically significant impact on local employment in nickel-producing districts - not only in sectors like manufacturing and construction but also through spillover effects in the public sector and services. In contrast, the export ban on bauxite thus did not have the intended consequences. The collapse in Indonesian bauxite extraction following the export ban had a negative impact on employment and wage levels in bauxite-producing regions of the country, which is consistent with a lack of corresponding investments in bauxite smelters. Moreover, we find that the ban had a positive and statistically significant impact on the revenue and employment of plants using nickel, controlling for national and global shocks at a more aggregated industry level, but not of plants using (processed) bauxite. Taken together, our findings suggest that the benefits of export restrictions are contingent on the development of domestic processing infrastructure, which promote local labor market outcomes.

Our results offer valuable insights for other resource-rich developing countries contemplating similar export restrictions. Malaysia, for instance, plans to ban exports of rare earth raw materials in a similar bid to boost the high-value domestic processing industry. As a concrete example, the disappointing performance of bauxite producing regions, coupled with Indonesia's overestimation of Chinese investment in aluminum smelters, underscores the need for strategic planning in processing capacity when introducing export restrictions on raw materials.

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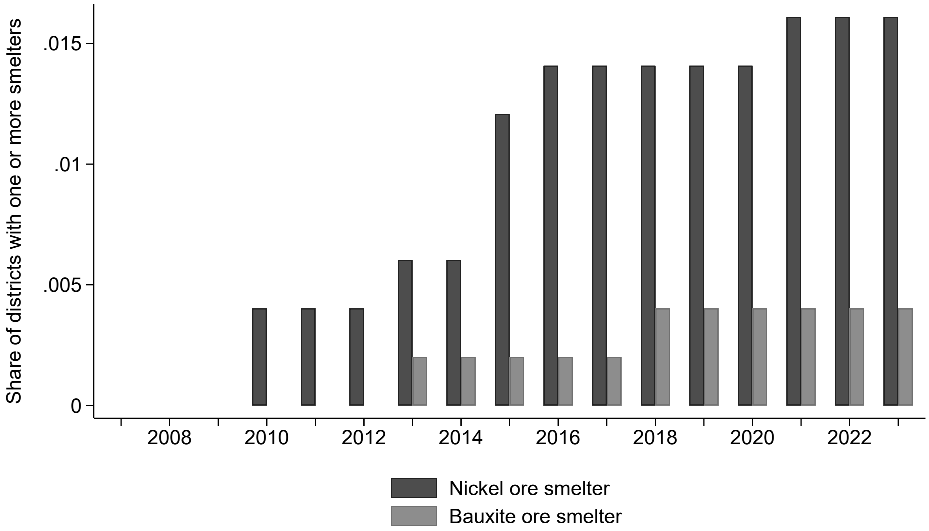
Appendix

Figure A1: Development of processing industry (2007-2023)



Notes: Source: Minerba.

Table A1: Employment share by sector

	nickel districts (N = 15)		bauxite districts (N = 9)		other districts (N = 473)	
	mean	sd	mean	sd	mean	sd
pre-ER						
agriculture	0.603	0.119	0.503	0.234	0.462	0.250
mining	0.041	0.036	0.031	0.023	0.020	0.041
manufacturing	0.044	0.028	0.047	0.025	0.084	0.081
construction	0.040	0.020	0.061	0.034	0.049	0.029
services	0.172	0.065	0.258	0.154	0.289	0.165
public	0.097	0.031	0.096	0.047	0.092	0.052
post-ER						
agriculture	0.441	0.108	0.421	0.211	0.378	0.224
mining	0.041	0.031	0.021	0.012	0.018	0.034
manufacturing	0.093	0.062	0.071	0.035	0.099	0.074
construction	0.056	0.019	0.068	0.026	0.057	0.026
services	0.234	0.057	0.307	0.131	0.334	0.157
public	0.132	0.043	0.107	0.049	0.109	0.053

Notes: This table presents sectoral employment shares for bauxite, mining, and other districts. 'pre-ER' refers to 2009-13, while 'post-ER' refers to 2014-23.

Table A2: Overlap of districts with mining and smelters (pre-ban and post-ban)

	nickel districts		bauxite districts		other districts	
	pre-ER	post-ER	pre-ER	post-ER	pre-ER	post-ER
nickel						
smelter districts	2	6	0	0	1	2
no smelter districts	13	9	0	0	481	480
bauxite						
smelter districts	0	0	1	2	0	0
no smelter districts	0	0	8	7	488	488

Notes: This table illustrates the district-level overlap of nickel and bauxite mining and smelters before and after the export ban. Resource districts are defined as those with at least one active mining license, smelter districts are defined as having at least one smelter of the respective raw material. Pre-ER refers to 2009-13, while post-ER refers to 2014-23.

Table A3: Descriptive statistics

	N	mean	sd	min	max
plant-level data					
ln output	181,070	16.033	2.205	8 .161	25.274
ln employment	181,070	4.209	1.206	1.609	10.936
nickel input	181,070	0.079	0.269	0.000	1.000
bauxite input	181,070	0.102	0.303	0.000	1.000
other input	181,070	0.264	0.342	0.000	1.000
district-level data					
ln employment	6,902	12.237	1.018	8.989	15.176
ln hourly wage premium	6,881	0.010	0.271	-1.223	1.452
ln hours worked	6,902	3.659	0.131	2.766	4.031
nickel share	6,902	0.001	0.009	0.000	0.098
bauxite share	6,902	0.001	0.008	0.000	0.109
coal share	6,902	0.006	0.025	0.000	0.208
nickel smelter	6,902	0.010	0.100	0.000	1.000
bauxite smelter	6,902	0.002	0.048	0.000	1.000
nickel port	6,902	0.016	0.125	0.000	1.000
bauxite port	6,902	0.014	0.118	0.000	1.000
coal port	6,902	0.057	0.231	0.000	1.000

Table A4: Spillovers to port districts

dependent var	ln employment						
	(1) aggregate	(2) agri-culture	(3) mining	(4) manu-facturing	(5) construc-tion	(6) public	(7) services
ni port × ER	0.088***	-0.109	0.209	0.273*	-0.006	-0.081**	0.032
	(0.026)	(0.068)	(0.213)	(0.155)	(0.101)	(0.037)	(0.045)
ba port × ER	-0.006	-0.043	-0.448***	-0.078	-0.305***	-0.076	-0.132***
	(0.015)	(0.079)	(0.151)	(0.066)	(0.047)	(0.064)	(0.051)
coal port × ER	0.048**	0.056	-0.057	-0.115	-0.182***	-0.074*	0.023
	(0.019)	(0.054)	(0.091)	(0.078)	(0.042)	(0.041)	(0.036)
ni share × ER	0.689**	-0.017	0.211	4.030	2.016**	2.056**	2.316***
	(0.350)	(0.563)	(1.955)	(2.769)	(0.937)	(0.805)	(0.639)
ba share × ER	-0.465***	0.553	-3.144*	2.622	3.529***	-0.273	1.596**
	(0.098)	(0.395)	(1.892)	(2.276)	(0.886)	(1.454)	(0.711)
coal share × ER	0.170	-0.227	2.623***	1.990***	0.606	1.166***	0.985***
	(0.148)	(0.342)	(0.689)	(0.670)	(0.529)	(0.387)	(0.270)
N	6902	6897	6080	6745	6777	6882	6866

Notes: In this table we study how export restrictions on raw materials impact the sectors in districts where these resource deposits and ports with resource trade are located are located. The sample period is 2009-2023. ‘ln employment’ is the log number of people who are employed in the respective sector. ‘resource share’ is a continuous variable which measures the total size of the nickel (‘ni’) or bauxite (‘ba’) licenses, respectively, as a share of the district’s surface area, in district k. ‘resource port’ is a dummy variable which takes the value one if there is at least one port which exported the specific resource in 2014 (see Table OA3 in the Online Appendix). ‘ER’ is a dummy variable which takes the value one if there is an export restriction active for nickel and bauxite in year t. All columns include a full set of control variables, including interaction terms of the copper share with the export restriction, as well as year fixed effects and district fixed effects. Standard errors are clustered at the district level and shown in parentheses. $^{***}p < 0.01,^{**} p < 0.05,^{*} p < 0.1$.

Table A5: Robustness: Fixed effects and controls

Panel A					
dependent variable	ln employment				
specification	(1) baseline	(2) island × year FE	(3) district-specific trends	(4) all ER controls	(5) two-way clustering
nickel share × ER	0.923^{**}	0.777^{***}	0.704^{***}	0.859^{***}	0.887^{***}
	(0.388)	(0.242)	(0.218)	(0.204)	(0.252)
bauxite share × ER	-0.540^{***}	-0.843^{***}	-0.595^{***}	-3.802^{***}	-0.540^{***}
	(0.103)	(0.188)	(0.106)	(1.254)	(0.152)
N	6902	6902	6902	6902	6902

Panel B					
dependent variable	ln hourly wage premium				
specification	(1) baseline	(2) island × year FE	(3) district-specific trends	(4) all ER controls	(5) two-way clustering
nickel share × ER	-0.610	-0.117	-0.824	-0.483	-0.479
	(0.923)	(0.776)	(0.955)	(0.927)	(0.916)
bauxite share × ER	-0.998^{***}	-0.454	-1.117^{*}	-0.724	-1.009
	(0.134)	(0.602)	(0.569)	(2.752)	(0.604)
N	6881	6881	6881	6881	6881

Notes: In this table we study how export restrictions on raw materials impact the districts where these resource deposits are located. The sample period is 2009-2023. 'ln employment' is the log number of people who are employed in a specific sector and 'ln hourly wage premium' is the log sectoral-regional wage premium, as described in the Data section. 'resource share' is a continuous variable which measures the total size of the nickel or bauxite, licenses, respectively, as a share of the district's surface area, in district k. 'ER' is a dummy variable which takes the value one if there is an export restriction active for this specific resource in year t. In column 2, we include island × year fixed effects. In column 3, we include a linear district-specific time trend. In column 4, we include a full set of control variables for other export restricted resources. In column 5, we include two-way clustering standard errors by district and year. All columns include a full set of control variables, including interaction terms of copper resources with the export restriction, as well as year fixed effects and district fixed effects. Standard errors are clustered at the district level and shown in parentheses. $^{***}p < 0.01, ^{**}p < 0.05, ^{*}p < 0.1$.

Table A6: Robustness: Resource definitions

Panel A					
dependent variable	ln employment				
	(1)	(2)	(3)	(4)	(5)
definition (resource)	share (Minerba)	area (Minerba)	dummy (Minerba)	dummy (RMD/MinEx)	size (RMD/MinEx)
nickel × ER	0.923^{**}	0.617^{**}	0.050^{***}	0.043^{***}	0.206^{**}
	(0.224)	(0.311)	(0.016)	(0.016)	(0.080)
bauxite × ER	-0.998^{***}	-0.249^{***}	-0.039^{***}	-0.053^{***}	-0.162^{***}
	(0.103)	(0.039)	(0.012)	(0.009)	(0.048)
N	6902	6902	6902	6902	6902

Panel B					
dependent variable	ln hourly wage premium				
	(1)	(2)	(3)	(4)	(5)
definition (resource)	share (Minerba)	area (Minerba)	dummy (Minerba)	dummy (RMD/MinEx)	size (RMD/MinEx)
nickel × ER	-0.610	-0.428	-0.049	-0.011	0.216
	(0.388)	(0.666)	(0.036)	(0.049)	(0.162)
bauxite × ER	-1.135^{*}	-0.259	-0.013	-0.107^{*}	-0.548^{***}
	(0.134)	(0.247)	(0.035)	(0.035)	(0.177)
N	6881	6881	6881	6881	6881

Notes: In this table we study how export restrictions on raw materials impact the districts where these resource deposits are located. The sample period is 2009-2023. 'ln employment' is the log number of people who are employed in a specific sector and 'ln hourly wage premium' is the log sectoral-regional wage premium, as described in the Data section. 'resource' measures the intensity of nickel or bauxite resources within a specific district k, where the definition differs per column. 'ER' is a dummy variable which takes the value one if there is an export restriction active for this specific resource in year t. In column 1-3, we use Minerba data. In column 2, we measure the absolute area covered by licenses (in 1,000 hectares). In column 3, we measure resource intensity with a dummy. In columns 4-5, we use RMD/MinEx data. In column 4, we measure resource intensity with a dummy. In column 5, we measure resource intensity with the total deposit size (in 1,000 megatons). All columns include a full set of control variables, including interaction terms of copper resources with the export restriction, as well as year fixed effects and district fixed effects. Standard errors are clustered at the district level and shown in parentheses. $^{***}p < 0.01, ^{**}p < 0.05, ^{*}p < 0.1$.

Table A7: Robustness: Varying control groups

Panel A				
dependent variable	ln employment			
sample	(1) baseline	(2) > 50p mining employment	(3) any mining licenses	(4) no Java & Sumatra
nickel share × ER	0.923**	0.730***	0.981***	0.615***
	(0.388)	(0.215)	(0.237)	(0.204)
bauxite share × ER	-0.998***	-0.639***	-0.477***	-0.722***
	(0.134)	(0.114)	(0.104)	(0.116)
N	6902	4253	4587	4675

Panel B				
dependent variable	ln hourly wage premium			
sample	(1) baseline	(2) > 50p mining employment	(3) any mining licenses	(4) no Java & Sumatra
nickel share × ER	-0.610	-0.090	-0.440	0.204
	(0.923)	(0.911)	(0.921)	(0.900)
bauxite share × ER	-1.135**	-0.782	-1.021*	-0.589
	(0.565)	(0.573)	(0.569)	(0.576)
N	6881	4253	4587	4675

Notes: In this table we study how export restrictions on raw materials impact the districts where these resource deposits are located. The sample period is 2009-2023. 'ln employment' is the log number of people who are employed in a specific sector and 'ln hourly wage premium' is the log sectoral-regional wage premium, as described in the Data section. 'resource share' is a continuous variable which measures the total size of the nickel or bauxite, licenses, respectively, as a share of the district's surface area, in district k. 'ER' is a dummy variable which takes the value one if there is an export restriction active for this specific resource in year t. In column (2), we restrict the sample to districts with an above-median mining employment share in 2013. In column (3), we restrict the sample to districts holding a mining license, based on the Minerba dataset. In column (4), we restrict the sample to non-Java and non-Sumatra districts. All columns include a full set of control variables, including interaction terms of copper resources with the export restriction, as well as year fixed effects and district fixed effects. Standard errors are clustered at the district level and shown in parentheses. $^{***}p < 0.01, ^{**}p < 0.05, ^{*}p < 0.1$.

The (Un)intended Consequences of Export Restrictions: Evidence from Indonesia

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ONLINE APPENDIX

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OA1 Background

In 2009, a full ban on the export of raw materials was announced. However, by 2014, the policy was revised to introduce a two-tier system. Minerals were split into two categories. *Category 1* comprised copper, iron, lead, zinc, and manganese, while *Category 2* included nickel, bauxite, tin, gold, silver, chromium, zirconium and antinomy. The revised regulation permitted the export of lower-grade ores from Category 1 minerals but upheld a strict ban on unprocessed Category 2 minerals, which were required to be fully refined domestically to meet minimum refinement standards. Among Category 2 minerals, the ban had the most pronounced impact on nickel and bauxite, as tin, gold, silver, and chromium had already undergone sufficient processing domestically to meet the requirements (Warburton, 2018). A full overview of all export restrictions on raw materials can be found below:[1]

Category 1

Copper. From 2014 onwards, the export of low-grade copper concentrate ($<$15% Cu, vs. initially 99% Cu) was prohibited. High-grade copper concentrate ($\geq$ 15% Cu) was exempted from this ban initially for three years, with the exemption later extended to 2023. The exemption came with conditions, including the requirement to develop processing capacity and the imposition of a progressive export duty starting at 25% and increasing to 60% after three years. The export tax was abandoned in 2017.

Iron. From 2014 onwards, the export of low-grade iron concentrate ($<$51-62% Fe, depending on the mineral, vs. initially 80-88% Fe) was prohibited. High-grade iron concentrate was exempted from this ban initially for three years, with the exemption later extended to 2023. The exemption came with conditions, including the requirement to develop processing capacity.

Manganese. From 2014 onwards, the export of low-grade manganese concentrate ($<$49% Mn, vs. initially 60/98/99% Mn) was prohibited. High-grade manganese concentrate was exempted from this ban initially for three years, with the exemption later extended to 2023.

Lead and zinc. From 2014 onwards, the export of low-grade lead and zinc concentrate ($<$51-52% Zn vs. initially 99.85% Zn and $<$56-57% Pb vs. initially 90% Pb) was prohibited. High-grade lead and zinc concentrate was exempted from this ban initially for three years, with the exemption later extended to 2023.

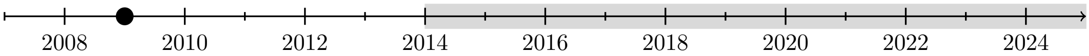
Category 2

Nickel. From 2014 onwards, the export of all unrefined nickel was prohibited. From 2017-2020, export of some unrefined nickel ($<$1.7% Ni) was allowed, subject to arrangements with domestic smelters. From January 2020 onwards, any export of unrefined nickel has been banned.

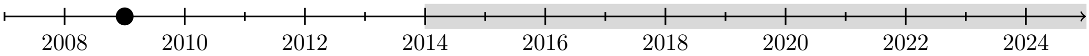
Bauxite. From 2014 onwards, the export of all unrefined bauxite was prohibited. From 2017-2020, export of some unrefined bauxite ($<$42.3% Al_2O_3) was allowed, subject to arrangements

[1] Sources: PWC reports (Mining in Indonesia, Investment and Taxation Guide) in 2014-2023 & OECD.

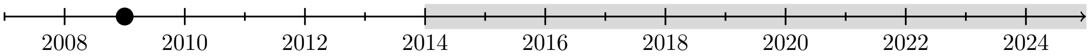
Figure OA1: Timeline of all Indonesian export restrictions on raw materials



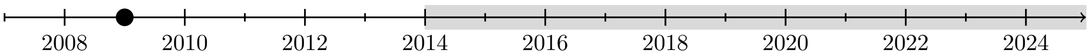
(a) Copper



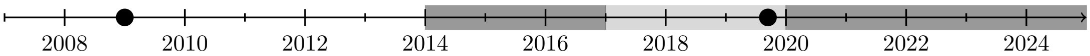
(b) Iron



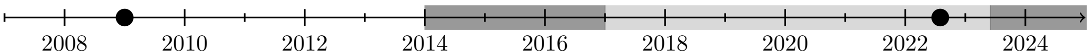
(c) Manganese



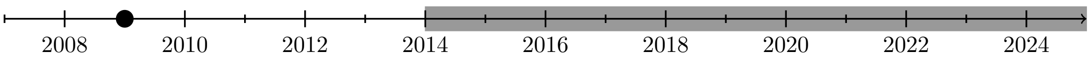
(d) Lead and zinc



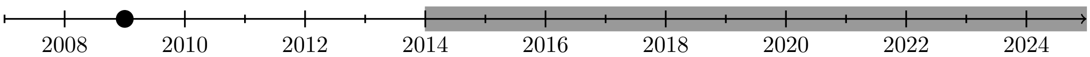
(e) Nickel



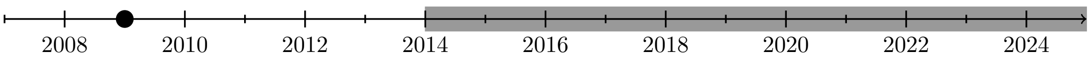
(f) Bauxite



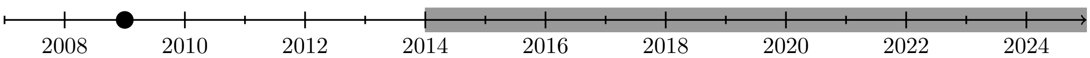
(g) Tin



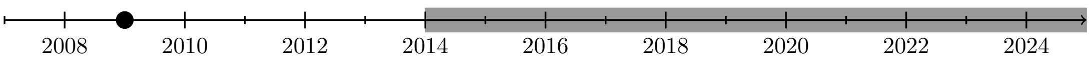
(h) Gold



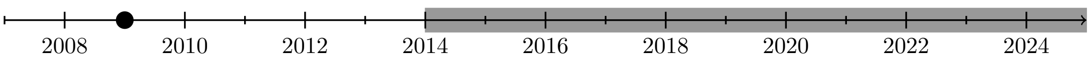
(i) Silver



(j) Chromium



(k) Zirconium



(l) Antimony

Notes: Announcements are indicated with a black circle. Soft and strict bans are indicated with light and dark shaded bars, respectively.

with domestic smelters. From June 2023 onwards, any export of unrefined bauxite has been banned.

Tin. From 2014 onwards, the export of all unrefined tin (<99.9% Sn) was prohibited.

Gold. From 2014 onwards, the export of all unrefined gold (<99% Au) was prohibited.

Silver. From 2014 onwards, the export of all unrefined silver (<99% Ag) was prohibited.

Chromium. From 2014 onwards, the export of all unrefined chromium (<99% Cr) was prohibited. Moreover, from 2019 onwards, the export of all chromite ore (<40% Cr_2O_3) was prohibited

Zirconium. From 2014 onwards, the export of all unrefined zirconium (<95% Zr and/or 95% Hf) was prohibited.

Antimony. From 2014 onwards, the export of all unrefined antimony (<99% Sb) was prohibited.

Figure OA2: Geographical dispersion of export prohibited raw materials and coal

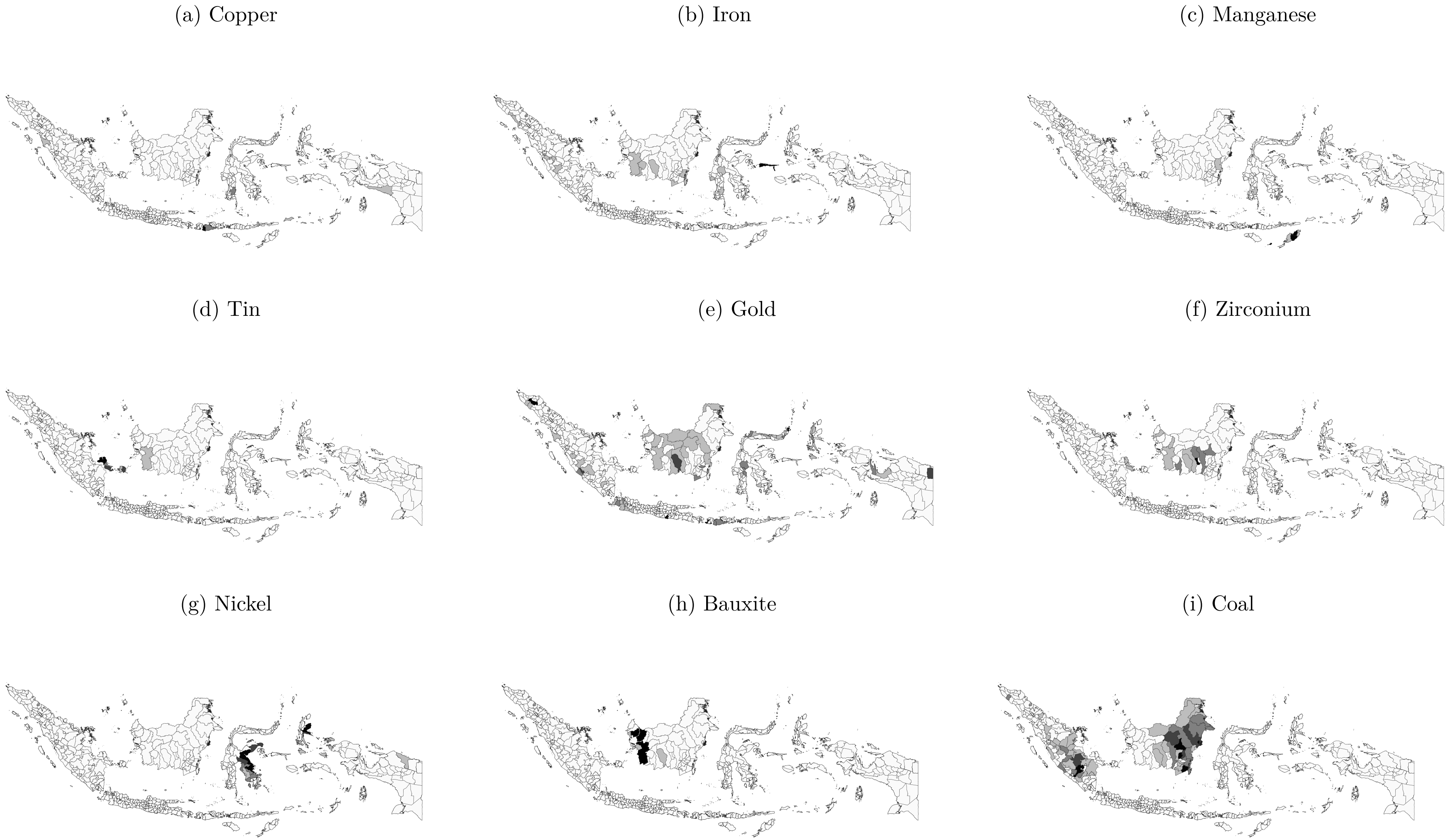


Figure OA3: Export of other export prohibited raw materials

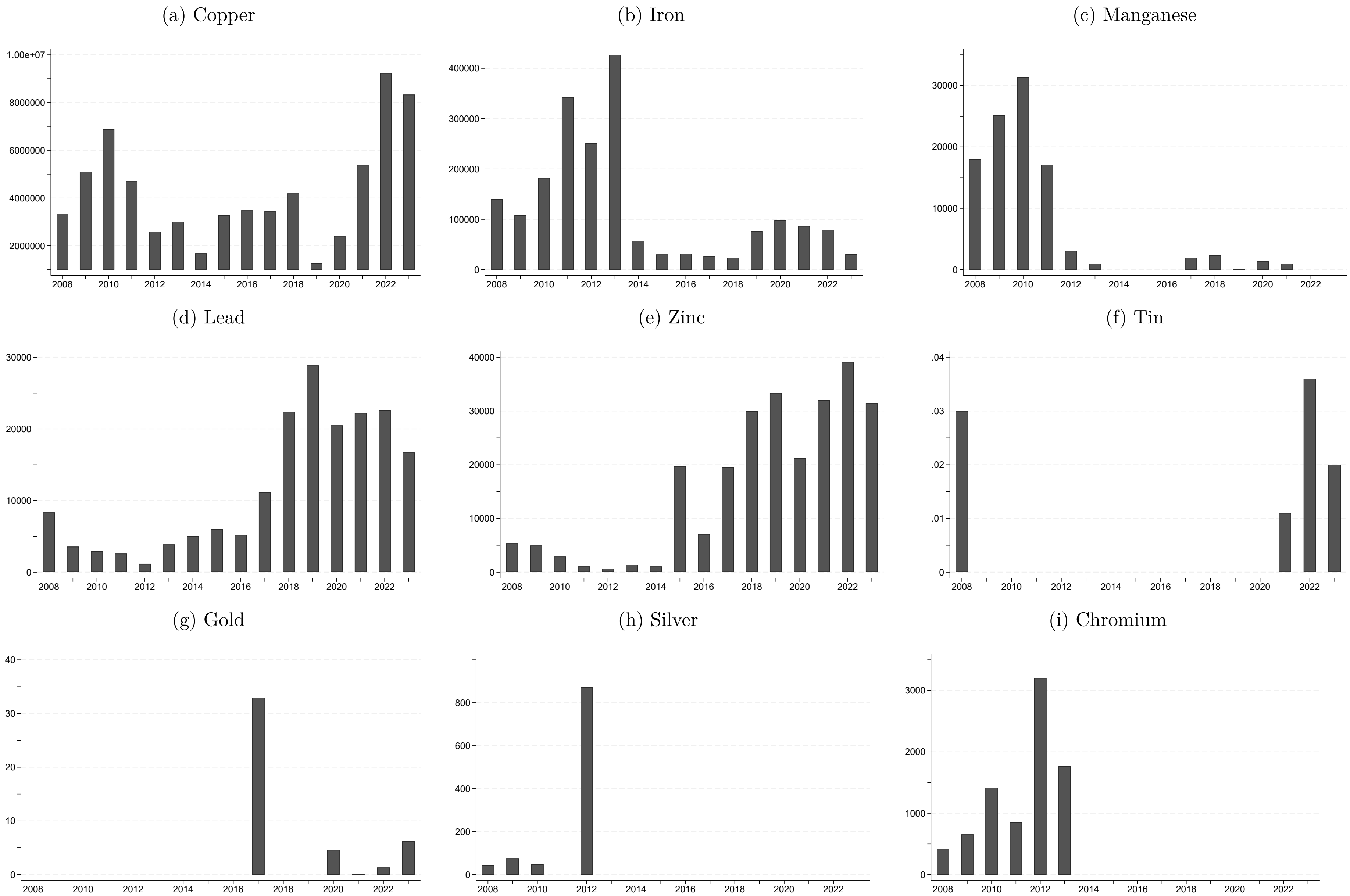
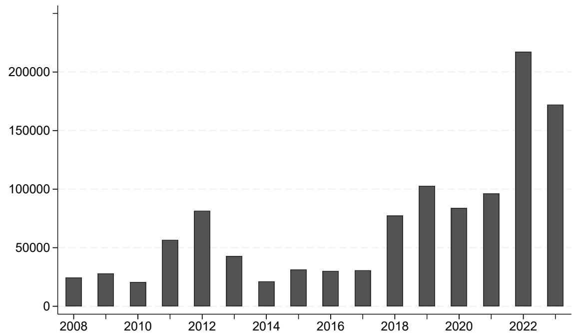
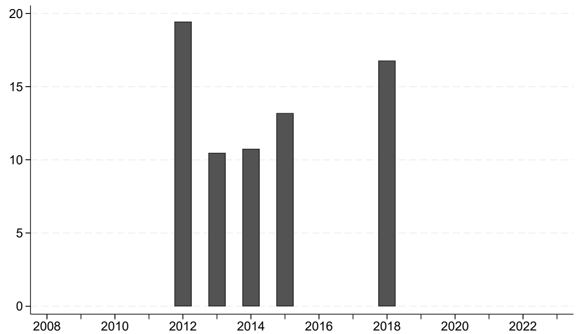


Figure OA3 (cont.): Export of other export prohibited raw materials

(j) Zirconium

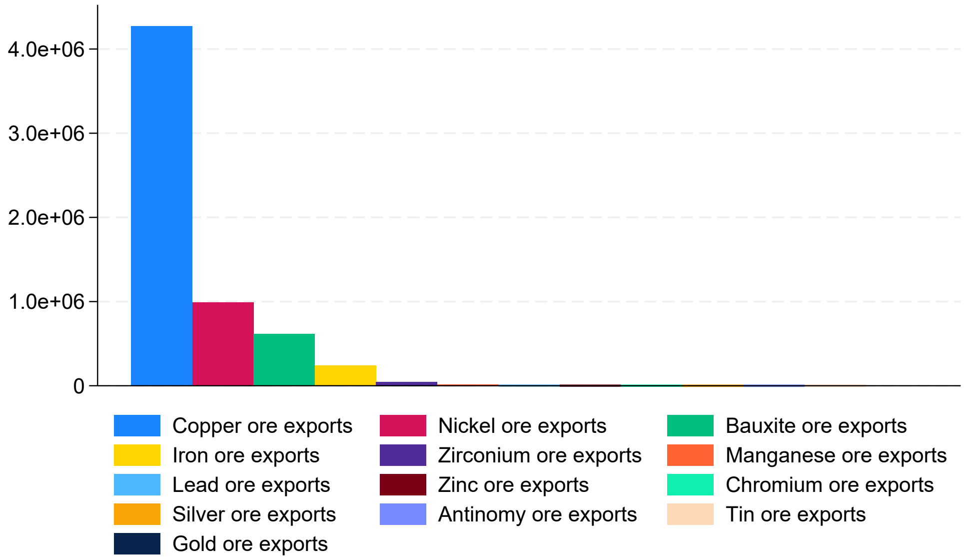


(k) Antinomy



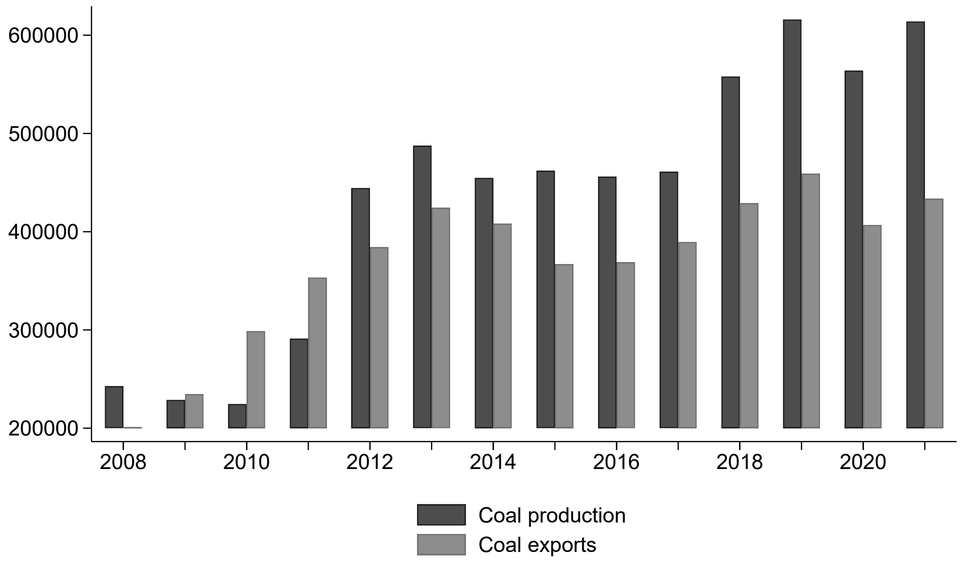
Notes: Unit is gross weight in 1000 metric tons. Export data comes from Comtrade and is based on the following HS-6 codes: copper (260300), iron (260111 & 260112), manganese (260200), lead (260700), zinc (260800), tin (260900), gold (261690), silver (261610), chromium (261000), zirconium (261510) and antinomy (261710).

Figure OA4: Mean export value of raw materials in Indonesia (2007-2013)



Notes: The unit is average export revenue (in thousands of US dollars) for the period 2007–2013. Export data comes from Comtrade and is based on the following HS-6 codes: copper (260300), iron (260111 & 260112), manganese (260200), lead (260700), zinc (260800), tin (260900), gold (261690), silver (261610), chromium (261000), zirconium (261510) and antinomy (261710).

Figure OA5: Production and export of coal in Indonesia (2008-2021)



Notes: Unit is gross weight in 1000 metric tons. Export figures are based on the following HS-6 codes: 270111, 270112, 270119, 270210 & 270220. Sources: USGS & Comtrade.

Figure OA6: Development of power plants (2007-2023)

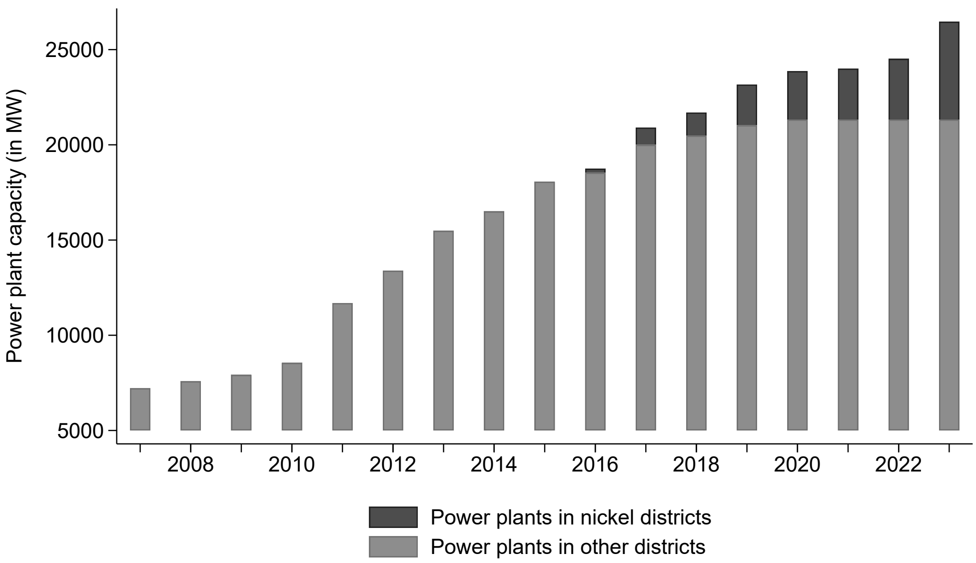
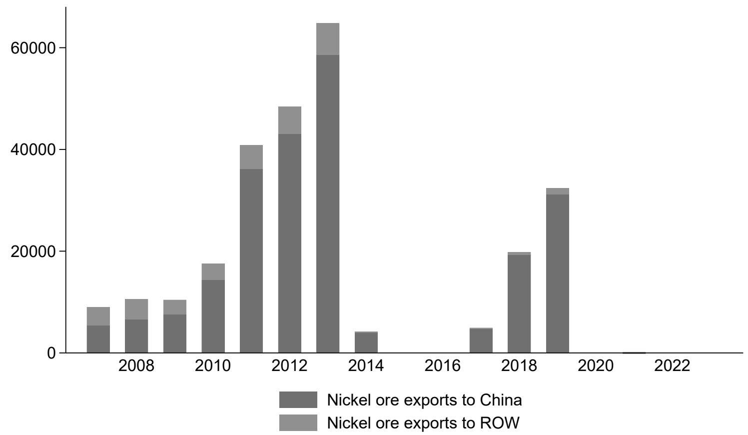
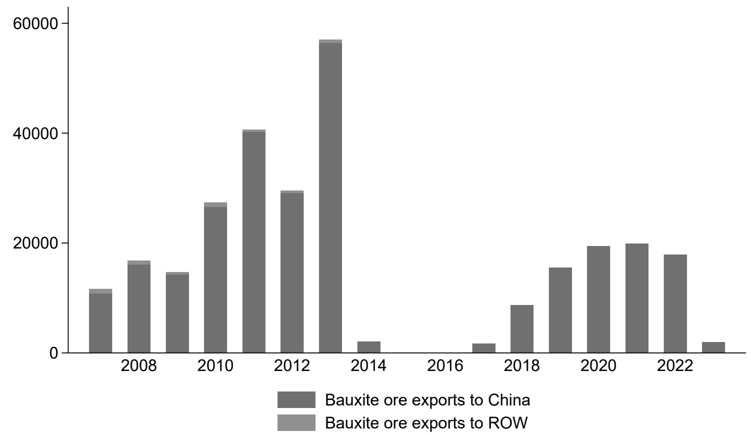


Figure OA7: Export of raw and processed nickel and bauxite from Indonesia to China (2007-2023)

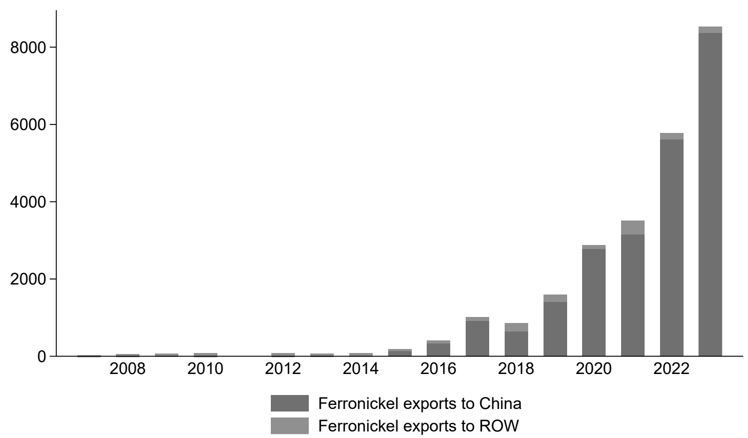
(a) Nickel ore



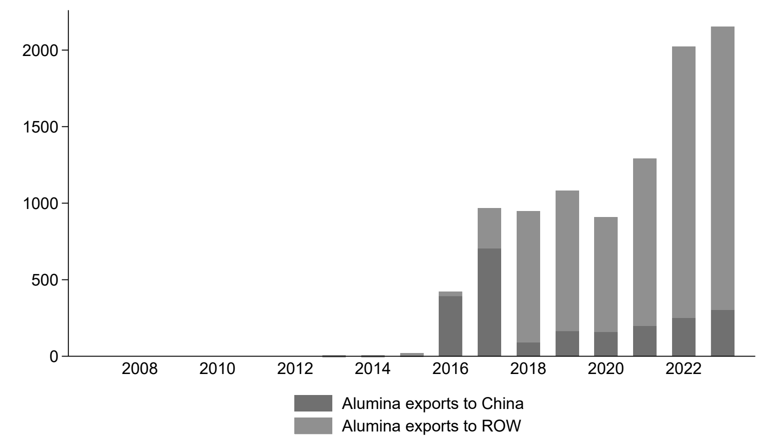
(b) Bauxite ore



(c) Ferronickel

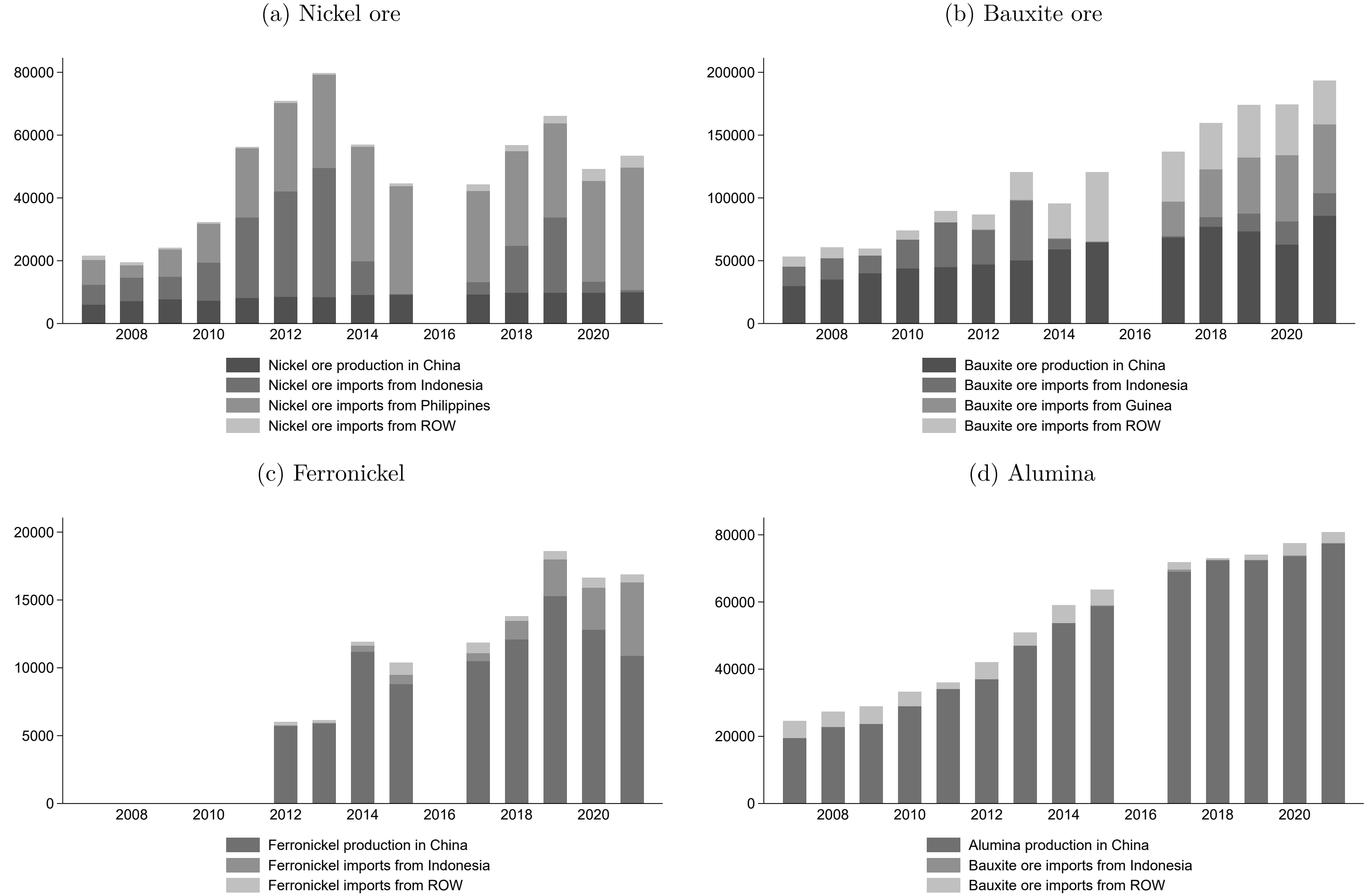


(d) Alumina



Notes: Unit is gross weight in 1000 metric tons. Export data comes from Comtrade and is based on the following HS-6 codes: nickel ore (260400), ferronickel (720260, including nickel pig iron), bauxite ore (260600) and alumina (281820). Alumina is made from bauxite ore; ferronickel is made from nickel ore. Production data comes from USGS and is only available up to 2021.

Figure OA8: Production and import of raw and processed nickel and bauxite in China (2007-2021)



Notes: Unit is gross weight in 1000 metric tons. Import data comes from Comtrade and is based on the following HS-6 codes: nickel ore (260400), ferronickel (720260, including nickel pig iron), bauxite ore (260600) and alumina (281820). Alumina is made from bauxite ore; ferronickel is made from nickel ore. Production data comes from USGS and is only available up to 2021. Ferronickel data is only available from 2012 onwards. Moreover, due to missing export data for 2016, this year is excluded from the figures.

OA2 Data

Licenses Minerba provides two types of datasets for mining licenses: WIUP ("Wilayah Izin Usaha Pertambangan", which translates to Mining Business License Area) and IUP ("Izin Usaha Pertambangan", which translates to Mining Business License). WIUP refers to the geographical area allocated for mining exploration and production, essentially the spatial zone within which a mining company can operate. However, it does not grant permission for specific mining activities yet. In contrast, IUP is the business license that permits a company to perform mining activities within a designated WIUP area, such as exploration, exploitation (mining), and resource production. To capture resources within a district in the widest sense, we focus on WIUP areas with "operasi produksi" (production operation) licenses.

As a robustness test, we draw on two other datasets: the Raw Materials Data (RMD) from S&P Global and MinEx Consulting (MinEx) data on resources discovered by 1990. Table OA1 confirms that there is a significant overlap between these datasets and the Minerba dataset - particularly for the bigger deposits.

Sectors For the years 2007–2015, detailed sector data is available at the three-digit KBLI level. However, from 2015–2022, only aggregated data across 17 categories is provided. We harmonize this information by grouping it into seven distinct categories, as shown in Table OA2. We do not show results for the utility sector, as this sector is a combination of the private and public sector, which makes the results difficult to interpret.

Table OA1: Correspondence between deposits, licenses and smelters

		deposits		licenses		smelters	
resource	district	#	size	#	share	#	capacity
nickel	3525	0	0	0	0	1	10
	3604	0	0	0	0	1	24
	7202	0	0	22	0.060	0	0
	7203	2	189	79	0.098	3	899
	7325	1	234	12	0.041	1	80
	7401	0	0	1	0.007	0	0
	7403	0	0	17	0.038	1	1
	7404	2	34	8	0.011	1	90
	7405	0	0	11	0.023	0	0
	7406	0	0	7	0.025	0	0
	7408	0	0	11	0.038	0	0
	7410	3	215	42	0.096	0	0
	8202	2	368	10	0.053	2	420
	8204	1	75	6	0.011	4	521
	8206	2	77	19	0.082	0	0
	9108	2	290	1	0.005	0	0
	9403	1	0	0	0	0	0
	9419	0	0	1	0.006	0	0
bauxite	2101	0	0	1	0.002	0	0
	2104	0	0	2	0.019	0	0
	2172	0	0	1	0.003	0	0
	6103	3	337	10	0.110	0	0
	6104	0	0	1	0.011	0	0
	6105	2	259	18	0.110	1	300
	6106	4	57	25	0.101	1	1000
	6111	0	0	1	0.001	0	0
	6202	0	0	8	0.007	0	0

Notes: Deposits data comes from two datasets: the Raw Materials Data (RMD) and the MinEx Consulting (MinEx). # refers to the number of deposits with ore resources. Size refers to the ore resources in thousand tons. This data is incomplete, which explains why some districts have a deposit, but no corresponding figure for size. Licenses data comes from Minerba. # refers to the number of licenses for a specific resource. Share refers to the share of the license area relative to the district's surface area. Smelters data comes from Minerba. # refers to the number of smelters. Capacity refers to the output capacity of a smelter in 1000 metric tons in 2023.

Table OA2: Classification of sectors into categories

Sector	Category
A1 Agriculture, Forestry & Fisheries	agriculture
B2 Mining and Quarrying	mining
C3 Manufacturing	manufacturing
D4 Electricity, Gas, Steam/Hot Water & Cold Air Supply	utility
E5 Water Treatment, Wastewater Treatment, Treatment and Recovery	utility
F6 Construction	construction
G7 Wholesale & Retail Trade; Automobile Repair & Maintenance	services
H8 Transportation & Warehousing	services
I9 Accommodation & Food & Beverage Provision	services
J10 Information & Communication	services
K11 Financial & Insurance Activities	services
L12 Real Estate	services
M,N13 Professional & Corporate Services	services
O14 Government Administration, Defense & Social Security Waj	public
P15 Education	public
Q16 Human Health & Social Activities	services
R,S,T,U17 Other Services	services

Notes: Division of sectors into categories. High-skilled services (J10, K11, L12, M, N13, and Q16—those with an average education level of at least junior high school) account for only 2.8% of total pre-export restrictions employment in non-nickel and non-bauxite districts, compared to (on average) 1.8% in nickel and bauxite districts. Consequently, we combine both low-skilled and high-skilled sectors into a single category labeled 'services'.

OA3 Descriptives

Table OA3: Spatial distribution of production and trade of coal, raw and processed materials

		coal		raw materials				processed materials			
		power plants		licenses		export		smelters		export	
resource	district	2014	2023	#	share	2014	2023	#	capacity	2014	2023
nickel	3175	0	0	0	0	0	0	0	0	0	80
	3525	0	0	0	0	0	0	1	10	0	0
	3578	0	0	0	0	0	0	0	0	7	103
	3604	295	780	0	0	0	0	1	24	0	0
	7202	0	0	22	0.060	0	0	0	0	0	0
	7203	0	3785	79	0.098	1153	0	3	899	0	2260
	7325	0	0	12	0.041	0	0	1	80	0	0
	7371	0	0	0	0	0	0	0	0	0	277
	7401	0	0	1	0.007	0	0	0	0	0	0
	7403	0	530	17	0.038	0	0	1	1000	0	0
	7404	0	60	8	0.011	326	0	1	90	77	5
	7405	0	0	11	0.023	0	0	0	0	0	0
	7406	0	0	7	0.025	0	0	0	0	0	0
	7408	0	0	11	0.038	0	0	0	0	0	0
	7410	0	0	42	0.096	0	0	0	0	0	0
	7471	0	0	0	0	1430	0	0	0	0	1716
	7472	0	0	0	0	469	0	0	0	0	0
	8171	0	0	0	0	35	0	0	0	0	0
	8202	0	760	10	0.053	0	0	2	420	0	3061
	8204	0	0	6	0.011	258	0	4	521	0	1020
	8206	0	0	19	0.082	0	0	0	0	0	0
	8271	0	0	0	0	387	0	0	0	0	11
	9108	0	0	1	0.005	0	0	0	0	0	0
	9171	0	0	0	0	103	0	0	0	0	0
	9419	0	0	1	0.006	0	0	0	0	0	0
bauxite	2101	0	0	1	0.002	75	0	0	0	0	0
	2102	0	0	0	0	563	0	0	0	0	0
	2104	0	0	2	0.019	116	0	0	0	0	0
	2172	0	0	1	0.003	140	0	0	0	0	0
	6103	0	0	10	0.110	0	0	0	0	0	0
	6104	0	0	1	0.011	0	0	0	0	0	0
	6105	0	0	18	0.110	0	0	1	300	0	0
	6106	0	0	25	0.101	247	575	1	1000	0	2119
	6111	0	0	1	0.001	0	0	0	0	0	0
	6112	0	0	0	0	0	46	0	0	0	0
	6171	0	0	0	0	227	1300	0	0	0	30
	6202	0	0	8	0.007	595	0	0	0	0	0

Notes: Coal data comes from the Global Energy Monitor and refers to the capacity of power plants in MW. It is included only when corresponding figures exist in other columns. Raw materials refers to nickel and bauxite ore. Licenses data comes from Minerba. # refers to the number of licenses for a specific resource. Share refers to the share of the license area relative to the district's surface area. Processed materials refers to ferronickel (for nickel) and alumina (for bauxite). Smelter data comes from Minerba. # refers to the number of smelters in 2023. Capacity refers to the output capacity of a smelter in 1,000 metric tons in 2023. Export data comes from BPS and refers to the district-level export of materials in 2014 and 2023 in 1000 metric tons.

Table OA4: Overlap of districts with other export prohibited raw materials

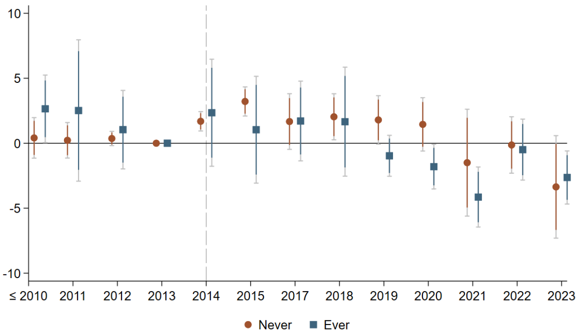
	ba	cu	au	fe	pb	mn	ni	sn	zn	zr
bauxite (ba)	9	0	3	2	0	0	0	2	0	3
copper (cu)	0	10	5	1	0	2	0	0	0	0
gold (au)	3	5	59	7	0	3	2	1	1	7
iron (fe)	2	1	7	23	1	1	0	1	0	3
lead (pb)	0	0	0	1	4	0	0	1	0	1
manganese (mn)	0	2	3	1	0	13	1	0	0	0
nickel (ni)	0	0	2	0	0	1	15	0	0	0
tin (sn)	2	0	1	1	1	0	0	9	0	6
zinc (zn)	0	0	1	0	0	0	0	0	1	0
zirconium (zr)	3	0	7	3	1	0	0	6	0	19

Notes: This table illustrates the district-level overlap of mineral licenses. Resource districts are defined as those with at least one active mining license.

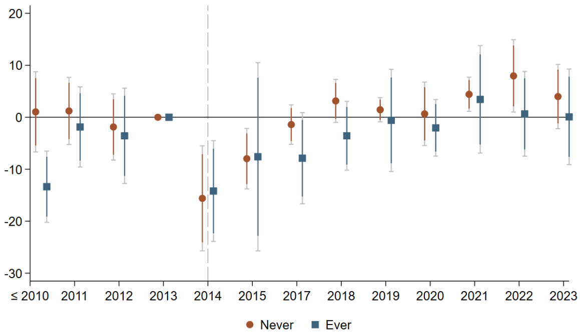
OA4 Results

Figure OA9: Event study of the impact of nickel export restrictions on employment in never-smelter and ever-smelter districts (2009-2023)

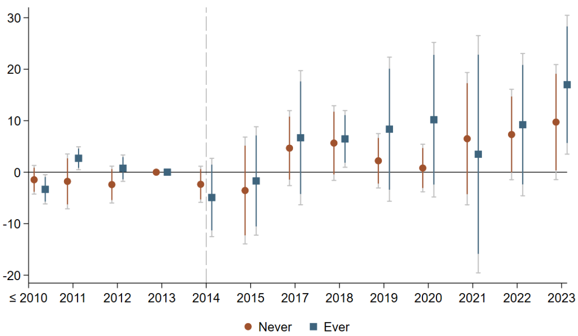
(a) Agricultural sector



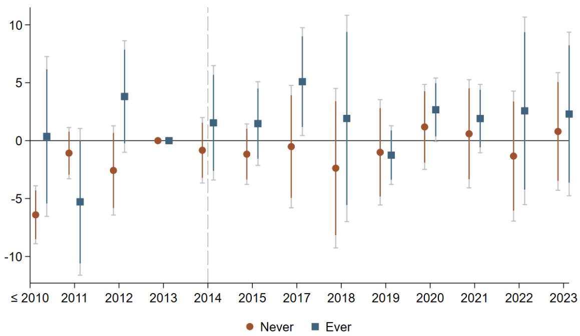
(b) Mining sector



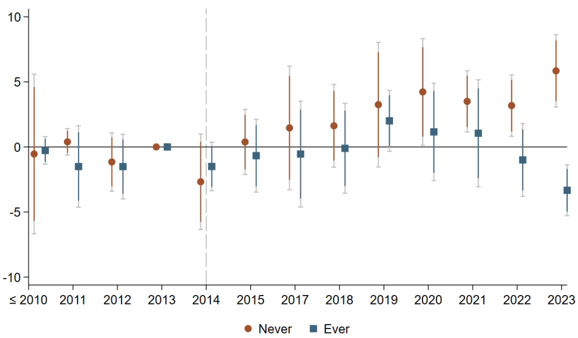
(c) Manufacturing sector



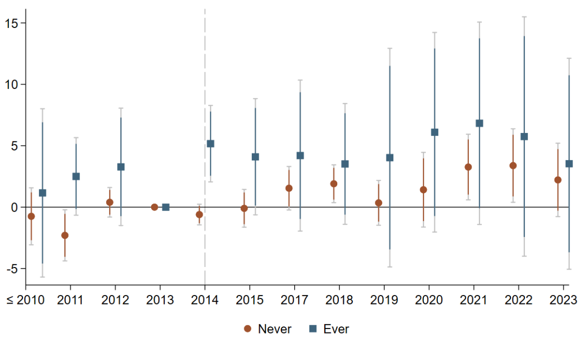
(d) Construction sector



(e) Public sector



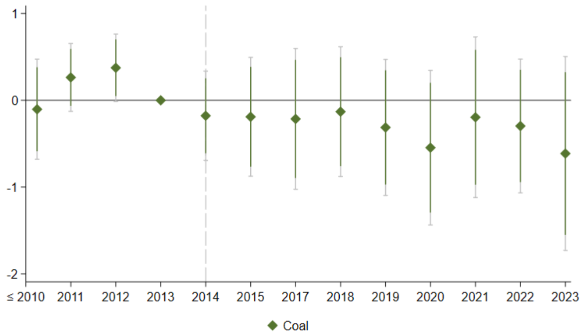
(f) Service sector



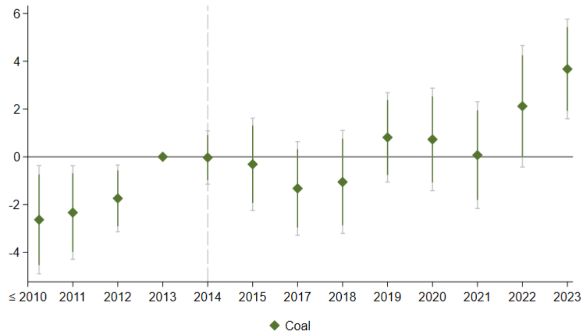
Notes: The results are based on the following specification: $Y_{kt} = \sum \alpha_t Nickel_{kt} + X_{kt}\Gamma + FE_k + FE_t + \varepsilon_{kt}$, where Y_{kt} is the log number of people who are employed in a specific sector. This specification excludes two districts with smelters but no mining and two additional districts with smelters before the export ban. In 'never', we compare districts with nickel mining but no processing at any time (nine districts) to a control group of districts without nickel mining or smelters. In 'ever', we focus on districts with both mining and a post-ban processing industry (four districts) to a control group of districts without nickel mining or smelters. $Resource_{kt}$ is a continuous variable which measures the total size of the nickel licenses as a share of the district's surface area, in district k. X_{kt} is a vector of control variables, including the copper and bauxite share. We also include district fixed effects FE_k year fixed effects FE_t. Standard errors are clustered at the district level. The dots represent point estimates, and the blue (grey) lines correspond to 95% (90%) confidence intervals. The year 2013 serves as the reference year.

Figure OA10: Event study of the impact of coal export restrictions on employment (2009-2023)

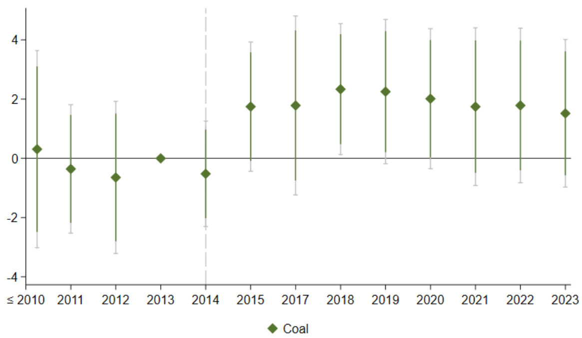
(a) Agricultural sector



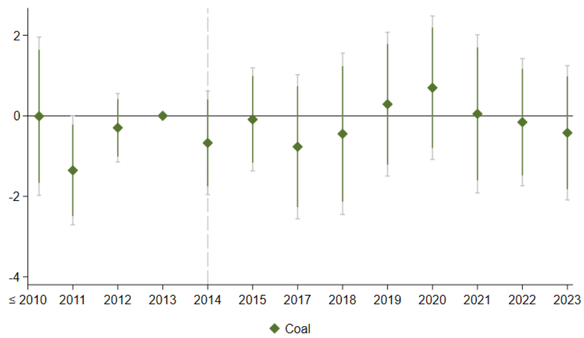
(b) Mining sector



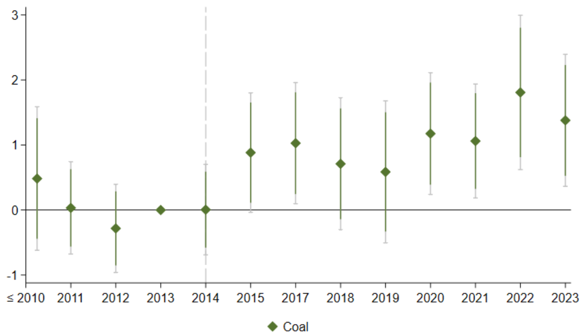
(c) Manufacturing sector



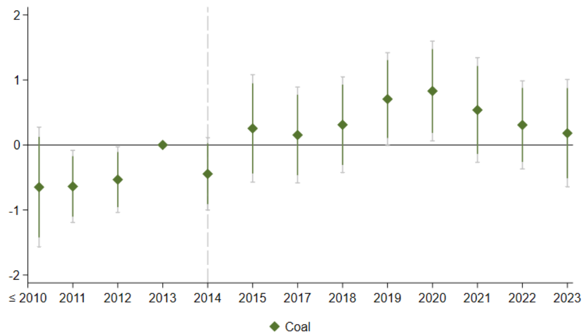
(d) Construction sector



(e) Public sector



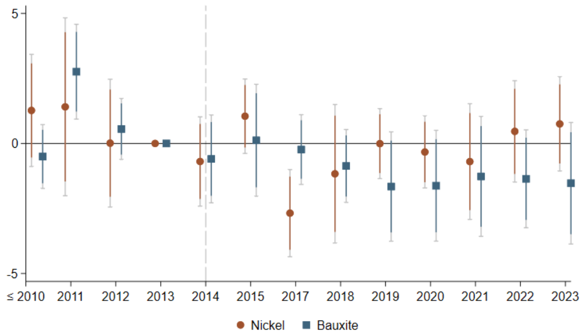
(f) Service sector



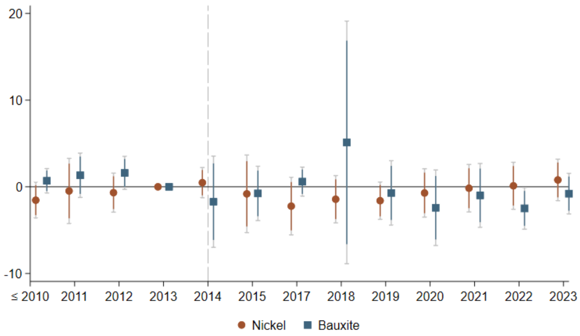
Notes: The results are based on the following specification: $Y_{kt} = \sum \alpha_t Coal_{kt} + X_{kt}\Gamma + FE_k + FE_t + \varepsilon_{kt}$, where Y_{kt} is the log number of people who are employed in a specific sector. $Coal_{kt}$ is a continuous variable which measures the total size of the coal licenses, respectively, as a share of the district's surface area, in district k. X_{kt} is a vector of control variables, including the copper, nickel and bauxite. We also include district fixed effects FE_k year fixed effects FE_t. Standard errors are clustered at the district level. The dots represent point estimates, and the blue (grey) lines correspond to 95% (90%) confidence intervals. The year 2013 serves as the reference year.

Figure OA11: Event study of the impact of export restrictions on hourly wage premium (2009-2023)

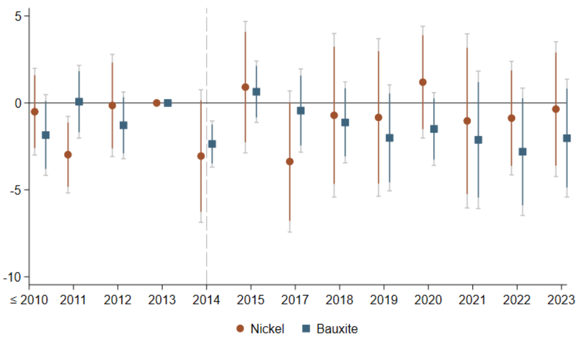
(a) Agricultural sector



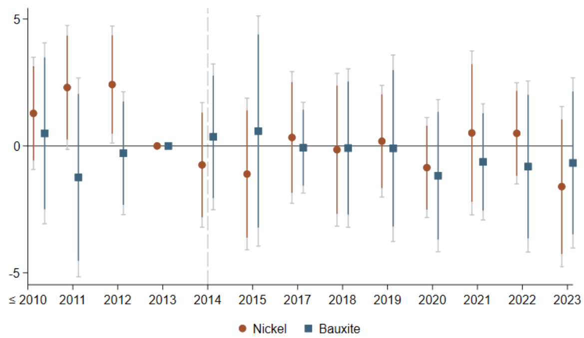
(b) Mining sector



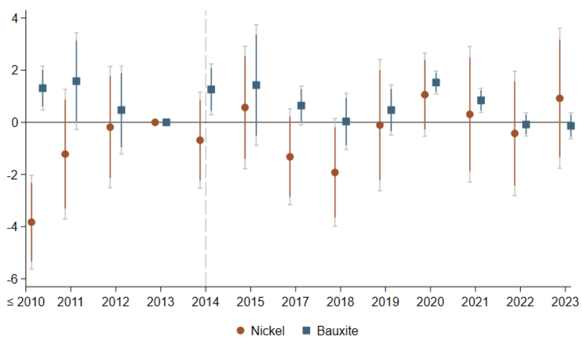
(c) Manufacturing sector



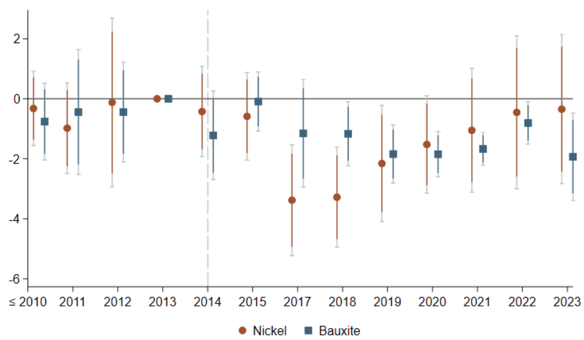
(d) Construction sector



(e) Public sector



(f) Service sector



Notes: The results are based on the following specification: $Y_{kt} = \sum \alpha_t Nickel_{kt} + \sum \gamma_t Bauxite_{kt} + X_{kt}\Gamma + FE_k + FE_t + \varepsilon_{kt}$, where Y_{kt} is the log hourly wage premium in the respective sector. $Resource_{kt}$ is a continuous variable which measures the total size of the nickel or bauxite licenses, respectively, as a share of the district's surface area, in district k. X_{kt} is a vector of control variables, including the copper share. We also include district fixed effects FE_k year fixed effects FE_t. Standard errors are clustered at the district level. The dots represent point estimates, and the blue (grey) lines correspond to 95% (90%) confidence intervals. The year 2013 serves as the reference year.

References

Warburton, E. (2018). *Our resources, our rules: A political economy of resource nationalism in Indonesia.* Ithaca, New York: Cornell University Press.