To what extent did global price shocks and downstreaming policy jointly explain Indonesia's nickel export boom?

1. Introduction

In March 2022, nickel prices surged to historic levels due to rising uncertainty from the Russo-Ukrainian War and a suspected short squeeze (Clarke 2022), while the rise of Electric Vehicles bolstered demand (Figure1) (Sappor 2022). Amidst the volatility, Indonesia quickly rose to become the world's largest exporter of nickel (Figure2) . Even after prices began their tumble in late 2022 (Sappor 2022), Indonesian exports continued increasing, which seemingly contradicts predictions of the Standard Trade Model (STM) (Figure2); in fact, Indonesia currently produces 54.8% of the world's nickel, up from 24% before the price surge (Sparks 2025). *Why did Indonesian nickel exports increase disproportionately during the price surge and how did it maintain this growth despite falling global prices?*

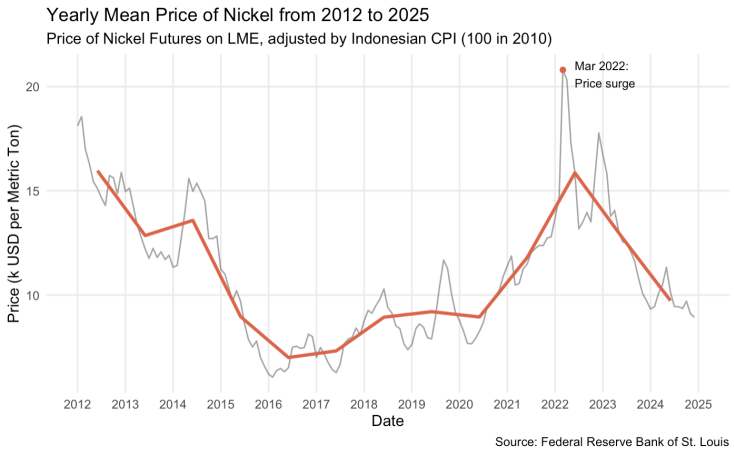


Figure1: Yearly Mean Price of Nickel from 2012-2025 (1000USD per metric ton)

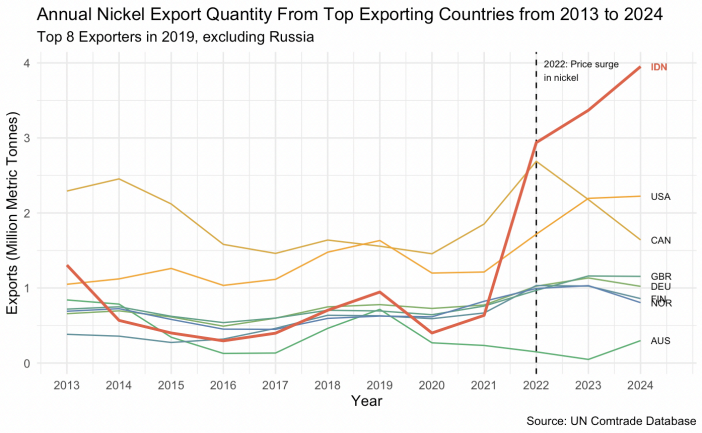


Figure2: Nickel Exports of Top Exporting Countries from 2013-2024 (metric tonnes)

In sum, we argue that the initial price surge and Indonesia's downstreaming policies jointly drove the early increase in nickel exports. As prices later declined, downstreaming continued to expand Indonesia's production capacity, generating nickel-biased growth. This expansion was strong enough that its positive effect on export volumes outweighed the negative effect of falling world prices.

We use the STM model, analysing how Indonesian nickel exports change in the Period 1 price surge and Period 2 price decline, with price and nickel export-biased growth mechanisms operating in each period. Then, we estimate the contributions of the mechanism to Indonesian export growth using Fixed Effects Regression.

2. Literature Review

2.1 Price changes on export quantity

Commodity prices can be highly volatile and shaped by inventories, storage, and market power, which may disconnect the link between prices and quantities (Deaton and Laroque 1992b; Benguria et al. 2018). However, a strand of the literature argues that the Standard Trade Model (STM) remains a useful framework for analysing commodity price changes, because predictable production and export responses are induced. Boakye et al. (2022) proves empirically that commodity price rises significantly boost real

output, private capital investment and exports in resource-dependent economies due to higher output values and profit margins. Crucially, nickel meets the STM assumptions of factor input substitutability as production involves flexible stages—adjustable extraction intensity, energy-driven smelting, and scalable chemical leaching (Henriksson and Wårell 2009).

Although Indonesia is a major nickel producer, global nickel prices are driven primarily by global inventory dynamics and demand shocks rather than supply (Deaton and Laroque, 1992), allowing us to treat prices as exogenous to Indonesia's supply decisions.

2.2. Impacts of Indonesian Downstreaming Policies

Recent empirical papers on Indonesia's nickel industry document a profound structural shift driven by downstreaming policies fully implemented in 2020 (Guberman et al. 2024). The policy successfully halted raw ore exports and diverted FDI investment into more capital-intensive downstream processes (Guberman, Schreiber and Perry 2024). Indeed, operational smelters tripled from 13 in 2020 to 44 in 2023 (Figure3).

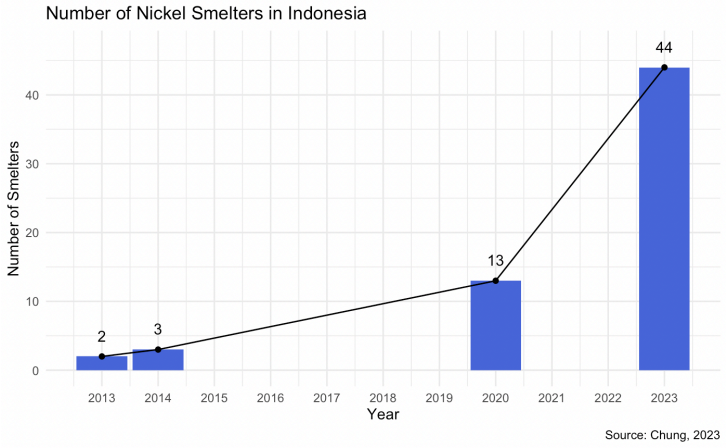


Figure3: Number of nickel smelters in Indonesia (Chung 2023)[1]

This triggered a massive surge in the production of processed minerals such as ferronickel and stainless steel. Thus, we interpret this as an increase in the supply of nickel capital factor of production, a "forced capital accumulation" (Camba 2021), in line with Heckscher-Ohlin logic. Similarly, Harrigan and Zakrajsek (1996) models this type of increased capital stock as a sector-biased production possibility frontier shift that increases export.

Notably, this further suggests STM's analytical suitability; the rapid establishment of smelters created "capacity inventory" for Indonesia, classifying it as a "buffer regime" substitutes factors (e.g. labour) across sectors when price increases (Deaton and Laroque 1992a), fulfilling a key STM assumption.

Existing studies document Indonesia's downstreaming policies (Guberman et al. 2024) and the effects of commodity price shocks on resource-exporting economies (Boakye et al. 2022), but the two mechanisms are analysed separately. No paper integrates global price movements and biased growth within a unified Standard Trade Model framework, nor quantifies their relative contributions to Indonesia's nickel export boom. Our paper addresses this gap by modelling both channels simultaneously and providing empirical estimates of their effects.

3. Theoretical Justification

We use the STM model to analyse how Indonesian nickel exports change from nickel export-biased growth, during Period 1 price surge, and Period 2 price decrease. Within each period, both price and nickel export-biased growth mechanisms operate.

3.1. Period 1: Price Surge

[1] Data on the number of nickel smelters was available only for limited years.

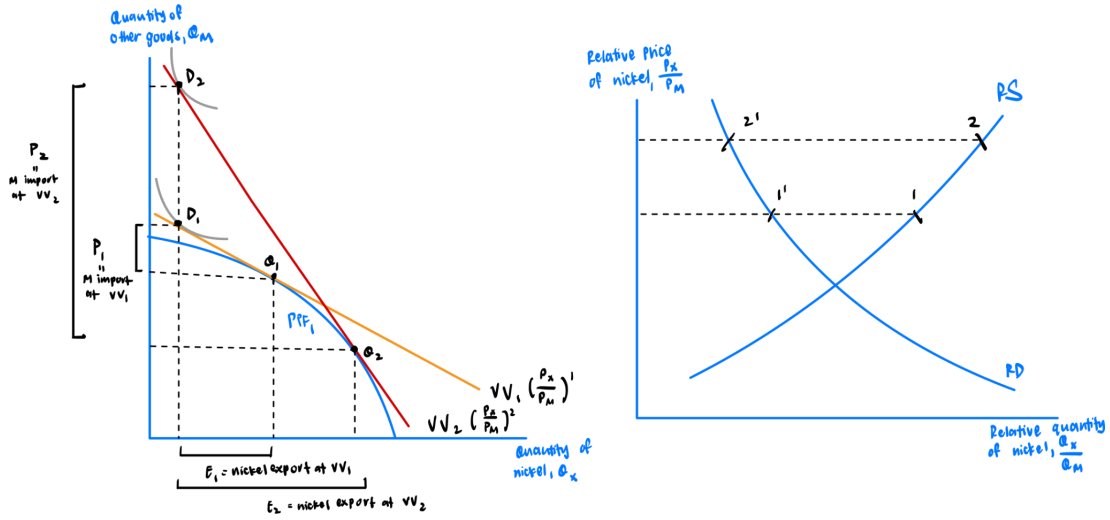
Assume there are two countries, proxied as Indonesia (IND) and the rest of the world (ROW), producing two goods, nickel (X) and other goods (M), both requiring two inputs (labour (L) and capital (K)). Assume country production possibility frontier (PPF) is curved and smooth—because there is more than one factor input and producers can substitute one input for another—and determines country-level relative supply (RS) functions.

Indonesia chooses X (Q_x) and M (Q_M) quantities to maximise output value given prices P_X and P_M, choosing the highest possible isovalue line (VV_1, slope = $-\frac{P_X}{P_M}$).

Effect A: Price Surge Increases Exports

Indonesia produces at point Q_1 (GraphA) initially, where PPF_1 is tangent to the highest possible isovalue line; relative nickel price $(\frac{P_X}{P_M})^1$ equals PPF_1 slope (nickel production opportunity cost). Trade-off in production equals trade-off according to market prices. Consumption is at point D_1 initially on the isovalue line passing through Q_1—representing budget constraints—tangent to the highest possible indifference curve, maximising utility.

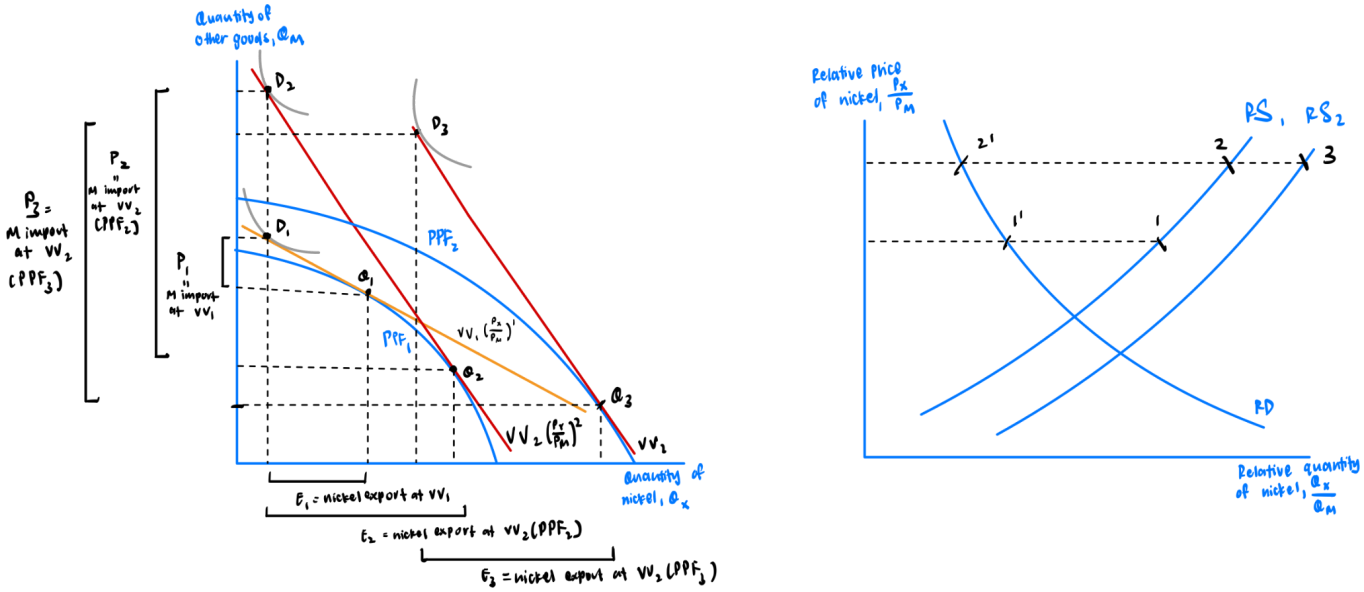
Nickel price surge leads to *relative* nickel price surge $[(\frac{P_X}{P_M})^1 \rightarrow (\frac{P_X}{P_M})^2]$ *ceteris paribus*, causing a steeper isovalue line ($VV_1 \rightarrow VV_2$). X consumption remains while M increases ($D_1 \rightarrow D_2$) due to substitution and income effects, decreasing RD (1' → 2'). X production increases while M decreases ($Q_1 \rightarrow Q_2$), increasing RS (1 → 2). Gap between RD and RS increases (2-2' > 1-1'), increasing nickel exports ($E_1 \rightarrow E_2$).



GraphA: Standard Trade Model — effect of price increase on RD, RS and export in nickel in Indonesia

Effect B: Downstreaming Policy Increases Exports

We argue Indonesia alone experienced export-biased growth. Downstreaming policies increased the number of Indonesian smelters (Figure3), increasing nickel sector-specific capital stock. At a given relative price, relative factor prices remain unchanged under continued output diversification, thus capital-labor ratios within each sector $(\frac{L_X}{K_X}, \frac{L_M}{K_M})$ remain constant. To utilise the additional capital the economy must expand capital-intensive $(\frac{L_X}{K_X} < \frac{L_M}{K_M})$ nickel sector (Rybczynski theorem), generating nickel-biased growth, shifting PPF out ($PPF_1 \rightarrow PPF_2$, GraphB) disproportionately towards nickel per Heckscher-Ohlin (Harrigan and Zakrajsek, 1996). Nickel output increases ($Q_2 \rightarrow Q_3$). RS curve shifts outwards towards nickel ($RS_1 \rightarrow RS_2$), increasing RS further (2 → 3), with a bigger shift in exports (3-2' (Indonesia) > 2-2' (other countries) > 1-1' (initial)). RD remained constant, assuming constant relative prices to isolate this effect.



GraphB: Increase in output of nickel due to export-biased growth and price surge

Effect A and B: Price Surge and Downstreaming Policy

The increase in exports due to price surge in Indonesia was more than ROW, because Indonesia alone experienced nickel-biased growth (PPF shifting out).

3.2. Period 2: Price Decrease

Effect A: Price decrease dampen exports increase

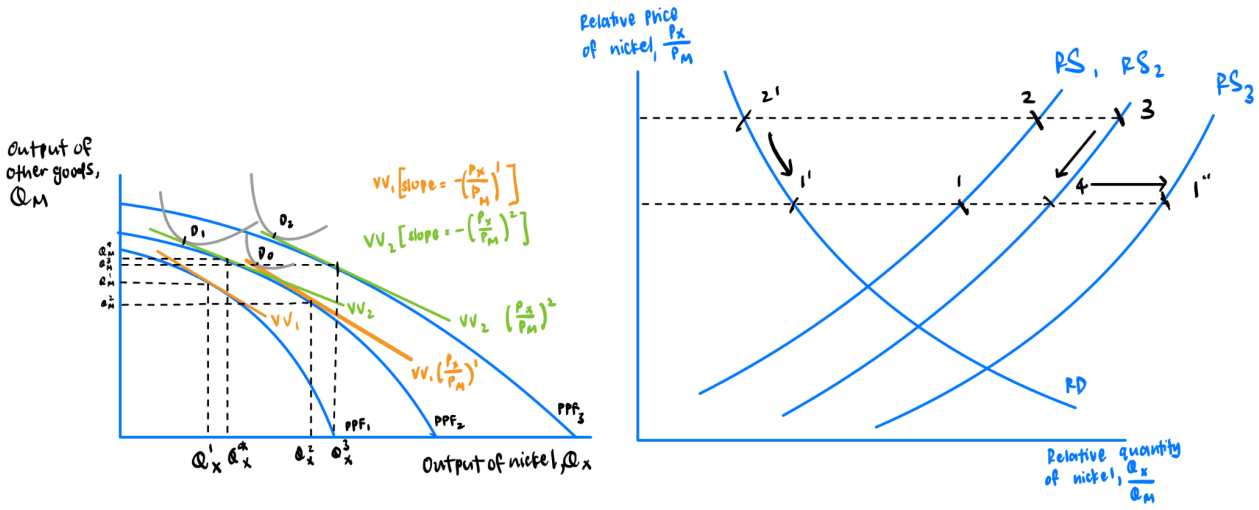
STM logic predicts that when relative nickel price decreases $[(\frac{P_X}{P_M})^1 \rightarrow (\frac{P_X}{P_M})^2]$, leading to a flatter isovalue line $(VV_1 \rightarrow VV_2)$ on GraphC PPF_2, inducing movement along PPF_2 where production of X decreases ($Q_X^2 \rightarrow Q_X^*$) and M increases ($Q_M^2 \rightarrow Q_M^*$). This decreases RS (3 → 4), gap between RS-RD ((2'-3) → (1'-4)) and thus exports. X consumption decreases while M increases ($D_0 \rightarrow D_1$), but RD still increases (2' → 1') as the substitution effect dampens the income effect.

Effect B: Downstreaming policy increases exports

As downstreaming persists with accelerated growth in smelters (Figure3), PPF continues to shift outwards in a nickel-biased direction ($PPF_2 \rightarrow PPF_3$). Nickel output quantity increase ($Q_X^* \rightarrow Q_X^3$), due to the same Rybczynski logic, shifting RS out ($RS_2 \rightarrow RS_3$), increasing RS (4 → 1''). RD-RS gap increases ((1'-4) → (1'-1'')), increasing exports.

Combined Effect A & B: Downstreaming offsets price decline effects

Because the PPF shift was sufficiently large, the export-biased growth effect dominates the contraction generated by the price decline. The economy thus moves from $Q_X^2 \rightarrow Q_X^* \rightarrow Q_X^3$; exports still increase overall ((2'-3) → (1'-1'')) from period 1 to 2, with falling prices partially dampening expansion. Other countries did not have the export-boosting effect from biased growth, thus when price declined, exports decreased.



GraphC: GraphB: Increase in output of nickel due to export-biased growth even during price decline

4. Empirical Analysis

4.1 Fixed Effects Model

We obtained yearly export volumes of raw nickel (HS2604) and nickel products (HS75) of all countries from the UN Comtrade Database and monthly prices of nickel futures listed on the London Metal

Exchange (LME) from the Federal Reserve Bank of St. Louis, which we summarised into yearly prices and adjusted with Indonesian CPI levels from the World Bank.

To show the significance of downstreaming policies in Indonesia, we estimate the following Fixed Effects model, using other countries which did not implement such policies as a counterfactual:

$$\Delta ln(Q_{i,t}) = \beta_0 + \beta_1 \Delta ln(P_t) + \beta_2 \Delta ln(P_t) \times Indo_i + \beta_3 DS_t \times Indo_i + \beta_4 \Delta ln(P_t) \times DS_t \times Indo_i + \ldots + \alpha_i$$ [2] [3]

Coefficient	Interpretation
$\beta_1 + \beta_2$	Co-movement between price and Indonesian export quantity[4] (Effect A)
β_3	Increase in the growth rate of Indonesian exports associated with its downstreaming policies (Effect B)
β_4	Possible change in the co-movement pattern between price and Indonesian exports.

Description of Variables found in Appendix A

Table1: Interpretation of Regression Coefficients

We hypothesise that price effects ($\beta_1 + \beta_2$) and the impact of downstreaming policies (β_3) should be statistically significant and both positive to support our theoretical model and explain differences between Indonesian and ROW nickel exports trajectory.

[2] "..." represents lower order terms in the interaction.
[3] See Appendix A for variable descriptions.
[4] We take price to be exogenous to quantities exported by individual producers including Indonesia. We aggregate the relationships between price and quantity exported for the rest of the world.

4.2 Results

We obtained the following estimates:

Coefficient	Variable	Estimates
β_1	$\Delta ln(P_t)$	-0.6788* (0.3411)
β_2	$\Delta ln(P_t) \times Indo_i$	0.8019* (0.3411)
β_3	$DS_t \times Indo_i$	0.3093*** (0.0812)
β_4	$\Delta ln(P_t) \times DS_t \times Indo_i$	-0.2866 (0.5751)
-	DS_t	-0.0527 (0.0812)
-	$\Delta ln(P_t) \times DS_t$	0.9764 (0.5751)
	S.E.: Clustered	by: CountryCode

Results are robust to excluding the Philippines, which announced downstreaming policies in 2025, and Canada, which implemented green regulations that likely significantly affected output. It is also robust to the addition of a COVID dummy which = 1 in 2020.

Table2: results from Fixed Effects Regression

The results align with our theory. The co-movement between price and Indonesian export quantity is positive ($\beta_1 + \beta_2 = 0.1231$), with each estimate being significant; increased prices increase exports. The relationship between price and quantity did not change significantly in the presence of downstreaming policies for Indonesia or the rest of the world, suggesting effects A and B are additive rather than interactive. At the same time, downstreaming is significantly correlated with increased growth rate of exports in Indonesia in particular ($\beta_3 = 0.3093$***).

5. Conclusion

Our results find that Indonesian downstreaming policies contributed significantly to the high growth of its export quantity compared to other countries, counteracting pressures from falling prices to reduce quantity. Future research can relax the STM's price-taking assumption. Because Indonesia is now a dominant supplier of nickel, its output growth may itself influence world prices. A more complete framework—such as a general-equilibrium or large-country trade model—would allow endogenous P_X/P_M responses to Indonesian production shocks. The empirical model is also descriptive rather than causal because of unaccounted-for endogeneity. Given more time and more detailed data, we can build a carefully matched counterfactual or implement stronger robustness checks such as synthetic controls, richer downstreaming measures, and pre-trend tests.

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Appendix A: Description of Variables for Regression

Variable	Description
$\Delta ln(Q_{i,t})$	Change in nickel export quantity from the previous year. Export quantities obtained by dividing export value by price.
$\Delta ln(P_t)$	Change in real nickel price from the previous year.
DS_t	Indicator for Indonesia's capital boom and is 1 after 2020[5].
$Indo_i$	Indicator which is 1 only for Indonesia[6].
α_i	Country fixed effects.

[5] Downstreaming policies from 2020 onwards were especially effective in promoting capital formation (Figure 4).
[6] Indonesia is the only country which heavily implemented downstreaming policies in this period. Russia was excluded from the regression.