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TRADE OPENNESS, FOREIGN INVESTMENT, AND INFLATION AS PREDICTORS OF MANUFACTURING PERFORMANCE ACROSS DIVERSE GLOBAL ECONOMIES

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Abstract:

This analysis examines whether trade openness, foreign investment, and inflation explain manufacturing's relative economic contribution across global economies. Using World Bank annual panel data for 168 economies spanning 2010 through 2023, we estimate a linear model with economy and year effects and standard errors clustered by economy across 2,208 observations. Trade openness has a positive coefficient of 0.01644, foreign investment a negative coefficient of −0.00185, and inflation a positive coefficient of 0.00410; all baseline 95 percent confidence intervals include zero. Coefficients express percentage point associations with manufacturing's GDP share. The predictors jointly explain 1.95 percent of variation remaining after fixed effects. Restricting coverage to a balanced panel preserves the imprecise trade and investment associations but increases the inflation coefficient to 0.04591, with a confidence interval excluding zero. Excluding two flagged source records leaves baseline estimates virtually unchanged. These findings qualify aggregate interpretations of international integration by showing sensitivity to temporal coverage. Industrial assessments should distinguish national exposure indicators from manufacturing outcomes and disclose how sample restrictions affect comparative evidence.

Key Words: Manufacturing Share; Trade Openness; Foreign Direct Investment; Inflation; Panel Data Analysis.

1. Introduction:

Greater international integration does not necessarily translate into a larger manufacturing contribution to the domestic economy. Trade and foreign investment can expand market access and production opportunities, yet their implications depend on how economic activity develops across sectors. The World Bank, 2020, identifies participation in global value chains as a potential route to development while emphasizing the conditions required to realize its benefits. For industrial policy, the empirical question is therefore whether greater macroeconomic exposure accompanies an increase in manufacturing's relative economic weight. This distinction matters when governments evaluate industrial progress through national trade and investment ratios that encompass activities beyond manufacturing. The structural transformation literature provides competing reasons to expect manufacturing shares to expand or contract. Rodrik, 2016, documents declining industrialization opportunities across many economies, with substantial differences in their exposure to deindustrialization. Haraguchi et al., 2017, find that manufacturing retains an important developmental role and emphasize the international redistribution of manufacturing activity. These contributions address distinct aspects of industrial change: the opportunities available to individual economies and manufacturing's continuing importance for development. Together, they motivate examining the macroeconomic conditions associated with manufacturing share without assuming a common industrial trajectory across economies.

Trade openness can support manufacturing through access to foreign demand and intermediate inputs. Goldberg et al., 2010, show that access to imported inputs contributed to product expansion among Indian manufacturers. Uy et al., 2013, demonstrate the importance of international trade in explaining structural change in South Korea. However, these findings do not establish that a higher aggregate trade ratio consistently accompanies a larger manufacturing share across economies. Total trade combines imports and exports of goods and services. It can increase alongside manufacturing expansion, greater reliance on imported manufactures, or growth in other internationally traded activities. The expected association consequently depends on the composition of trade and the relative performance of manufacturing. Foreign investment introduces a related distinction between international financing and domestic productive contribution. Alfaro et al., 2010, explain how domestic financial conditions influence the production linkages through which foreign investment can support growth. Havranek and Irsova, 2011, identify positive average productivity spillovers to domestic suppliers while documenting variation across empirical settings. These findings establish plausible benefits from productive relationships involving foreign enterprises, but aggregate inward investment does not identify their sectoral allocation or strength. Investment directed toward services or resource extraction can increase national inflows without expanding manufacturing's GDP share. An aggregate investment association must therefore be interpreted separately from evidence concerning supplier productivity or technology transfer.

Inflation adds a domestic price dimension to these international exposures. Changes in consumer prices can accompany shifts in purchasing power and production conditions, but their association with manufacturing share need not match their association with aggregate growth. Kremer et al., 2013, find that inflation relationships differ across economic settings and inflation regimes. Their evidence cautions against imposing a uniform interpretation on annual inflation rates. Manufacturing share is a relative outcome: it depends on manufacturing value added compared with total GDP. A positive association with that share cannot, by itself, establish an improvement in manufacturing productivity or absolute output. The reviewed evidence does not establish whether aggregate trade openness, inward investment, and inflation exhibit consistent conditional associations with manufacturing's GDP share when evaluated jointly across a broad international panel. The closest contributions examine different outcomes, including product expansion, supplier productivity, aggregate growth, and national structural transformation. This

analysis addresses the connection between those arguments and an observed sectoral share. Its contribution combines a common specification for the three macroeconomic exposures with explicit assessment of how temporal coverage changes their estimated relationships. This approach qualifies the interpretation of aggregate indicators without treating them as direct measurements of productive integration.

This study aims to assess how trade openness, foreign investment net inflows, and consumer price inflation are associated with manufacturing value added as a percentage of GDP. The central research question asks whether these relationships remain distinguishable after accounting for persistent economy differences and common annual influences. The specific objectives are to estimate each conditional association, assess their joint explanatory contribution, and examine sensitivity to temporal coverage and identified source irregularities. The framework uses three observed predictors and one observed outcome, with no constructed index or interaction term. The empirical analysis uses an unbalanced panel of 2,208 annual observations across 168 economies from 2010 through 2023. All four indicators come from the World Bank's World Development Indicators. Ordinary least squares estimation includes economy and year effects, with standard errors clustered by economy. This design evaluates variation over time within economies after common annual influences are absorbed. A balanced coverage comparison and a separate source zero exclusion assess specific sample sensitivities. The estimates describe conditional associations rather than identified causal effects.

The completed analysis finds a positive trade coefficient, a negative investment coefficient, and a positive inflation coefficient, with all baseline 95 percent confidence intervals including zero. Together, the predictors explain 1.95 percent of the variation remaining after economy and year effects. Trade and investment estimates change little across the sample checks, whereas the inflation estimate changes substantially under balanced coverage. These findings contribute a bounded empirical result: aggregate macroeconomic exposures provide limited additional explanation of manufacturing share under the implemented specification, and coverage choices materially affect the inflation relationship. For international industrial assessment, the practical implication is to distinguish national exposure indicators from manufacturing outcomes and to examine the population represented before transferring estimated relationships across settings.

2. Theory, Conceptual Framework and Research Question Development:

Manufacturing performance depends on how economies combine access to international markets, foreign capital, and domestic price stability. Structural transformation theory explains these relationships through the allocation of resources across activities with different productive capacities. McMillan et al., 2014, demonstrate that productivity improvements within sectors and resource movements between sectors make distinct contributions to aggregate performance. This analysis examines manufacturing value added as a percentage of GDP, which captures manufacturing's relative economic contribution rather than productivity or absolute output growth. The framework treats trade openness, foreign direct investment, and inflation as three observed dimensions of macroeconomic conditions. They enter the analysis separately because market integration, capital inflows, and price changes represent different economic processes. Their associations with manufacturing's GDP share depend on whether manufacturing expands faster than other sectors. Rodrik, 2016, documents divergent industrialization trajectories across economies, indicating that international integration does not generate a uniform manufacturing outcome. This theoretical ambiguity motivates research questions that allow positive, negative, or statistically indistinguishable associations.

Trade openness measures exports plus imports of goods and services relative to GDP. Greater trade exposure can expand market access and increase the availability of intermediate inputs. Manufacturers may consequently introduce products, reduce production costs, or operate at greater scale. These mechanisms support a positive theoretical association between openness and manufacturing's economic contribution when domestic producers can exploit international demand and imported inputs. Goldberg et al., 2010, provide evidence from Indian manufacturing that access to imported intermediate inputs supported domestic product expansion. Their findings establish a plausible production mechanism, but they do not demonstrate that aggregate trade openness necessarily increases manufacturing's GDP share across economies. The measure used here combines exports and imports across all sectors and therefore captures overall trade exposure rather than manufacturing participation alone. Competing pressures arise when imports displace domestic production or trade expansion concentrates in commodities and services. Manufacturing output can increase while its GDP share declines if other activities grow faster. This analysis therefore examines the net association between observed openness and manufacturing share without imposing a common directional prediction.

RQ1. How is trade openness associated with manufacturing value added as a percentage of GDP, conditional on foreign investment, inflation, and economy and year effects?

Foreign direct investment differs from trade openness because it involves international ownership and financing relationships rather than the exchange of goods and services. Foreign investment can expand productive capacity and connect domestic suppliers to multinational production. These relationships may increase demand for local inputs and create incentives for suppliers to improve production practices. Alfaro et al., 2010, develop a model in which domestic financial conditions determine how effectively local firms respond to demand generated by foreign enterprises. Their analysis explains why foreign capital does not automatically produce domestic productive gains. Financial capacity constitutes a theoretical boundary condition here, rather than an additional measured variable in the framework. Havranek and Irsova, 2011, identify positive average productivity spillovers to domestic suppliers while documenting variation across empirical settings. Such evidence supports the plausibility of production linkages, but the available investment indicator measures aggregate net inflows rather than investment specifically directed toward manufacturing. Inflows into services or resource extraction can expand other sectors without increasing manufacturing's relative contribution. The relevant empirical question therefore concerns the association between aggregate investment exposure and manufacturing share.

RQ2. How are foreign direct investment net inflows as a percentage of GDP associated with manufacturing value added as a percentage of GDP, conditional on trade openness, inflation, and economy and year effects?

Inflation introduces a domestic constraint on production decisions. Rising consumer prices can coincide with higher operating costs, reduced household purchasing power, and difficulties maintaining working capital. Manufacturers may respond by adjusting prices, reducing production, or delaying investment. These mechanisms suggest that inflation can weaken

manufacturing activity, although annual consumer price inflation does not directly measure producer costs or uncertainty. Bittencourt, 2012, reports evidence linking inflation to weaker economic growth in Latin American economies that experienced substantial monetary instability. This evidence supports concern about the productive consequences of inflation, but aggregate growth and manufacturing's GDP share are different outcomes. Manufacturing's share depends on how inflation and associated economic adjustments affect manufacturing relative to other activities. Kremer et al., 2013, find that the association between inflation and economic growth varies across inflation regimes and economy groups. Their results caution against interpreting all inflation increases as economically equivalent. This analysis retains annual consumer price inflation as the observed predictor and examines its conditional association with manufacturing share without assuming that findings about aggregate growth establish the direction of a sectoral share relationship.

RQ3. How is annual consumer price inflation associated with manufacturing value added as a percentage of GDP, conditional on trade openness, foreign investment, and economy and year effects?

The conceptual framework links three observed predictors to one observed outcome. Trade openness represents international market exposure, foreign investment represents inward capital participation, and inflation represents domestic price change. Manufacturing performance is operationalized exclusively as manufacturing value added relative to GDP. Macroeconomic conditions serve as an organizing concept rather than a latent variable or composite index. Each relationship represents a conditional association assessed while accounting for persistent economy differences and common annual influences. The research questions concern these measurable relationships; the theoretical mechanisms explain their plausibility without being treated as independently established empirical channels.

3. Data:

This section establishes data provenance, documents sample selection, and defines the observed measures supporting the analytical framework. It reports verified coverage, cleaning decisions, descriptive statistics, and the estimation procedures applied to the supplied data.

3.1 Data Sources, Population, and Sample Construction:

This analysis uses four annual series from the World Bank's World Development Indicators, accessed through the public API under source identifier 2. World Bank, 2013, documents the indicator system and its international reporting framework. The operative data version is the supplied workbook, which preserves the extraction date, database update date, indicator identifiers, and retrieval URLs in its Study and Sources worksheets. These dates describe the data vintage rather than the observation period. The series carry a Creative Commons Attribution 4.0 licence. The unit of analysis is the economy year. The analytical window covers 2010 through 2023, inclusive, at annual frequency. Trade openness, foreign investment, and manufacturing value added are published percentages of GDP. They describe annual flows or production rather than asset stocks. This distinction follows the national accounting framework explained by Lequiller and Blades, 2014, and the investment flow definitions documented by the International Monetary Fund, 2014. Trade includes goods and services, consistent with the coverage distinction explained by the United Nations, 2017. Inflation measures annual consumer price change, following the conceptual definition discussed by the International Monetary Fund, 2020.

The target population comprises economies worldwide for which manufacturing activity and the three macroeconomic measures are substantively relevant. The accessible frame contains 217 World Bank economies and territories, excluding regional and income aggregates. Applying the analytical window produces 3,038 possible observations. Selection includes every available eligible record rather than a randomly drawn sample. The sectoral outcome concerns manufacturing, while the explanatory indicators describe the wider economy. Table 1 documents sequential exclusions. Missingness across variables overlaps, so each exclusion count represents additional losses after the preceding rule. Complete records provide 2,210 observations across 170 economies. Two economies with only one complete observation, Micronesia and Suriname, are excluded from estimation because they provide no variation over time after economy effects are absorbed. The baseline therefore contains 2,208 observations across 168 economies. These estimator eligibility rules were documented during the audit rather than through a registered analysis plan.

Table 1: Sample construction

Stage	Economies Retained	Observations Retained	Additional Observations Excluded	Rule
Eligible analytical frame	217	3,038	0	Annual observations from 2010 through 2023
Trade availability restriction	190	2,549	489	Exclude missing trade openness
Foreign investment availability restriction	183	2,401	148	Exclude additional records missing foreign investment
Inflation availability restriction	174	2,264	137	Exclude additional records missing inflation
Complete analytical records	170	2,210	54	Exclude additional records missing manufacturing share
Baseline estimation sample	168	2,208	2	Exclude economies with one complete observation
Balanced coverage sensitivity sample	140	1,960	248	Retain economies observed in all 14 years
Source zero sensitivity sample	167	2,206	2	Exclude simultaneous zero trade and manufacturing records

The baseline panel is unbalanced, with between two and 14 observations per economy and a median of 14. Complete records cover every analytical year, ranging from 150 observations in 2023 to 162 in both 2014 and 2015. The balanced sensitivity sample contains 140 economies observed throughout the window.

3.2 Data Integration, Cleaning, and Quality Assurance:

The four indicators are aligned using the World Bank economy identifier and observation year. Economy attributes attach through the economy identifier. The audit found no duplicate economy and year keys, conflicting duplicated records, or expansion beyond the expected analytical grid. Reconstructing complete records from the Source panel worksheet reproduced the supplied Analysis data worksheet exactly within the analytical window. All measures retain their published annual frequency, units, and precision. No currency conversion, additional deflation, temporal aggregation, interpolation, or imputation was applied. Records are matched by their published year without imposing an additional fiscal calendar adjustment. The data represent revised historical observations rather than information available in real time at each observation date. Table 2 distinguishes variable availability from joint sample eligibility. Missing source entries remain unavailable values rather than zeros. The workbook does not identify the reason for every missing entry, so the analysis does not classify them as structurally inapplicable.

Table 2: Indicator availability in the analytical frame

Indicator	Economies With Observed Values	Observed Records	Missing Records	Missing Share, Percent
Trade openness	190	2,549	489	16.10
Foreign investment net inflows	203	2,738	300	9.87
Consumer price inflation	193	2,596	442	14.55
Manufacturing value added share	200	2,695	343	11.29

Complete record selection excludes 828 observations, representing 27.25 percent of the frame. Hughes et al., 2019, explain that the validity of this approach depends on the missingness process rather than the proportion missing alone. Little and Rubin, 2019, likewise distinguish observed completeness from assumptions about selection. This analysis therefore reports observed differences between retained and excluded records rather than assuming that missingness is random. Among excluded records with an observed manufacturing share, the mean is 9.08 percent, compared with 11.83 percent among complete records. Observed foreign investment averages 21.21 percent of GDP among excluded records and 5.55 percent among complete records. These differences show that selection changes the observed composition of the sample. Missingness summaries by economy and year accompany the replication materials, following the transparency principles discussed by Lee et al., 2021. No imputation model was constructed; as van Buuren, 2018, explains, imputation requires explicit modeling assumptions rather than mechanical filling of gaps.

Numerical checks identified no infinite observed values, negative trade shares, manufacturing shares outside zero to 100 percent, or inflation rates below minus 100 percent. Trade shares above 100 percent and negative investment or inflation values were retained because their definitions permit such observations. No percentile trimming or winsorization was applied. This treatment distinguishes extreme observations from demonstrated recording errors, consistent with Aguinis et al., 2013. Two Venezuelan records, corresponding to 2010 and 2011, contain simultaneous zeros for trade openness and manufacturing share. The baseline preserves these supplied values. An exploratory sensitivity calculation excludes them without overwriting the source records. This check was introduced after the initial source preserving estimation and is documented separately from the baseline selection rules.

3.3 Variable Measurement, Construction, and Validation:

Manufacturing performance is operationalized as manufacturing value added relative to GDP. Rodrik, 2016, motivates attention to manufacturing's relative economic contribution within structural transformation. Accordingly, this measure represents sectoral weight rather than labour productivity, employment, or absolute production growth. Trade openness measures total exports plus imports relative to GDP. It captures aggregate international exposure rather than access to particular manufacturing inputs. This distinction matters because Goldberg et al., 2010, identify an input access mechanism using detailed manufacturing information that is not directly observed in the aggregate trade indicator.

Foreign investment measures net inward investment flows relative to GDP. It does not identify manufacturing investment, domestic supplier relationships, or technology transfer. Alfaro et al., 2010, explain why domestic financial conditions influence productive linkages, while Havranek and Irsova, 2011, document variation in supplier spillovers. These contributions inform the interpretation of the aggregate indicator without treating those mechanisms as measured variables. Inflation measures annual consumer price change. It does not measure inflation uncertainty or changes in manufacturing input prices. Kremer et al., 2013, demonstrate that inflation relationships can differ across economic settings and inflation regimes. The available annual rate is therefore interpreted as an observed macroeconomic exposure rather than a direct measure of instability or a universally directional effect.

Table 3: Variable dictionary

Variable or Indicator	Analytical Role	Definition and Construction	Source and Identifier	Unit and Frequency	Transformation and Direction	Missing Value Rule	Coverage and Limitation
Manufacturing value added share	Outcome	Manufacturing value added divided by GDP, multiplied by 100; supplied directly	World Bank WDI	Percent of GDP; annual	Published level; higher values indicate greater manufacturing weight	Exclude incomplete records	2,695 observed frame records; does not measure productivity
Trade openness	Predictor	Exports plus imports of goods and services divided by GDP, multiplied by 100; supplied directly	World Bank WDI	Percent of GDP; annual	Published level; higher values indicate greater trade exposure	Exclude incomplete records	2,549 observed frame records; includes activities beyond manufacturing

Variable or Indicator	Analytical Role	Definition and Construction	Source and Identifier	Unit and Frequency	Transformation and Direction	Missing Value Rule	Coverage and Limitation
Foreign investment net inflows	Predictor	Net inward direct investment flows divided by GDP, multiplied by 100; supplied directly	World Bank WDI	Percent of GDP; annual	Published level; negative values retained	Exclude incomplete records	2,738 observed frame records; aggregate flows rather than manufacturing investment
Consumer price inflation	Predictor	Published annual percentage change in consumer prices	World Bank WDI	Annual percent change	Published rate; negative values indicate deflation	Exclude incomplete records	2,596 observed frame records; household prices rather than producer costs

The three predictors remain separate observed measures. Macroeconomic conditions is an organizing concept rather than a constructed index. No normalization, weighting, aggregation, interaction, or latent variable estimation was applied. Zero and negative values remain on their published scales. Table 4 reports descriptive statistics for the baseline estimation sample. Standard deviations use the sample denominator. The statistics describe pooled observations, so economies with longer observed coverage contribute more records.

Table 4: Descriptive statistics for the baseline sample

Variable	Valid Observations	Mean	Standard Deviation	Median	Minimum	Maximum
Manufacturing value added share	2,208	11.83	6.09	11.28	0.00	37.10
Trade openness	2,208	91.49	57.74	78.25	0.00	442.62
Foreign investment net inflows	2,208	5.55	26.28	2.62	−376.06	452.22
Consumer price inflation	2,208	5.33	15.38	3.13	−12.56	557.20

Validation consists of identifier checks, numerical range checks, reconciliation between source and analytical worksheets, and preservation of published definitions. These procedures establish internal consistency without claiming independent verification of the underlying national statistics. A one unit change in a published percentage represents one percentage point, not a one percent proportional increase.

3.4 Analytical Framework, Identification, and Reproducibility:

The analysis is associational. Its estimands are the conditional linear relationships between manufacturing share and the three contemporaneous macroeconomic measures after accounting for economy and year effects. Equation 1 defines the implemented baseline specification.

$$M_{it} = \alpha_i + \lambda_t + \beta_1 T_{it} + \beta_2 F_{it} + \beta_3 P_{it} + \varepsilon_{it}$$

Here, M_{it} denotes manufacturing value added as a percentage of GDP in economy i and year t; T_{it} denotes trade openness; F_{it} denotes foreign investment net inflows as a percentage of GDP; and P_{it} denotes consumer price inflation. The terms α_i and λ_t represent economy and year effects. The coefficients β_1, β_2, and β_3 summarize conditional associations, while ε_{it} denotes the residual. Ordinary least squares estimation includes economy and year indicators and uses variation over time within economies after common annual influences are absorbed. The design matrix has full column rank, with 184 estimated parameters. An independent residualization calculation reproduces the three slope estimates to within 0.0000000001. Fixed effects do not establish causal identification: Imai and Kim, 2021, demonstrate the importance of the additive modeling assumptions underlying these specifications.

Standard errors are clustered across 168 economies, using a finite sample correction and a student reference distribution with 167 degrees of freedom. This permits heteroskedasticity and dependence over time within economies, following Cameron and Miller, 2015. It does not accommodate every form of dependence between economies, a distinction emphasized by Cameron et al., 2011. Estimation assigns equal weight to retained observations rather than weighting by GDP or population. The resulting coefficients describe the observed panel rather than the contribution of large economies to global production. This distinction follows the weighting considerations discussed by Solon et al., 2015. Because inclusion depends on data availability, inferential uncertainty does not establish representativeness of excluded economies, consistent with the distinction between sampling and design uncertainty developed by Abadie et al., 2020.

The balanced coverage calculation reestimates Equation 1 using 1,960 observations from 140 economies. It examines sensitivity to unequal temporal coverage. The separate zero value calculation uses 2,206 observations from 167 economies. Both are exploratory checks, and their sample differences are retained in the audit rather than presented as comparisons on an identical sample. No additional observations are lost through lags, differencing, or additional controls. The interpretation remains bounded by contemporaneous measurement, possible reverse relationships, omitted changing conditions, and the shared GDP denominator of three indicators. Definitions, annual matching, and measurement scales remain consistent across all specifications. The replication package preserves the original workbook, construction code, source checksum, sample exclusions, coverage summaries, descriptive statistics, and estimation outputs.

4. Methods:

4.1 Research Design and Measurement Alignment:

This analysis uses an observational panel design to estimate conditional associations between macroeconomic conditions and manufacturing value added as a percentage of GDP. The unit of analysis is the economy year, covering annual observations from 2010 through 2023. The estimands are the linear associations of trade openness, foreign investment net inflows, and consumer price inflation with manufacturing share, conditional on the other predictors and economy and year effects. Economy effects absorb persistent differences between economies, while year effects absorb annual influences shared across the panel. Estimation consequently uses variation over time within economies after these additive influences are removed. This adjustment supports international comparison without establishing causal identification. As Imai and Kim, 2021, explain, the interpretation of fixed effects models depends on their modeling assumptions. The estimated relationships remain conditional associations because the design does not isolate externally assigned changes in the predictors.

The sample construction rules appear in Table 1, and the measurement definitions appear in Table 3. The baseline contains 2,208 observations across 168 economies. Economies with only one complete observation are excluded because they provide no variation over time after economy effects are absorbed. The panel remains unbalanced, and inference concerns the observed analytical sample rather than a probability sample of all economies. All measures retain their published scales. Trade openness, investment inflows, and manufacturing value added are expressed as percentages of GDP, while inflation is an annual percentage change. The predictors enter separately and contemporaneously. A coefficient therefore represents the percentage point difference in manufacturing share associated with a one percentage point difference in the corresponding predictor, holding the other model terms constant.

4.2 Model Specification, Estimation, and Inference:

Equation 1 specifies the implemented additive model. Manufacturing share is regressed on the three contemporaneous predictors, economy effects, and year effects. The specification estimates a common slope for each predictor across the retained economies. It includes no additional covariates, transformations, or constructed interactions. Ordinary least squares estimation uses an intercept, three predictor columns, 167 economy indicators, and 13-year indicators. One category from each indicator set is omitted to identify the model. The resulting baseline design matrix contains 184 parameters and has full column rank. Each observation receives equal weight. Consequently, economies with longer observed histories contribute more observations; the estimates are not weighted by population or economic size. This distinction follows the weighting considerations discussed by Solon et al., 2015. The covariance estimator clusters residual contributions by economy and applies a finite sample correction:

$$\widehat{\mathrm{Var}}_{\mathrm{CR1}} = \frac{\mathrm{G}}{\mathrm{G}-1}\frac{\mathrm{N}-1}{\mathrm{N}-\mathrm{K}}[\mathrm{X}'\mathrm{X}]^{-1}\left[\sum_{\mathrm{g}=1}^{\mathrm{G}} \mathrm{X}_{\mathrm{g}}'\,\hat{\mathrm{u}}_{\mathrm{g}}\hat{\mathrm{u}}_{\mathrm{g}}'\mathrm{X}_{\mathrm{g}}\right][\mathrm{X}'\mathrm{X}]^{-1}$$

Here, X denotes the complete design matrix, X_{g} denotes its rows for economy g, and $\hat{\mathrm{u}}_{\mathrm{g}}$ denotes the corresponding estimated residual vector. G is the number of economy clusters, N is the number of observations, and K is the number of estimated parameters, including the intercept and indicator coefficients. In the baseline, these quantities equal 168, 2,208, and 184, respectively. Equation 2 permits heteroskedasticity and dependence over time within economies, following Cameron and Miller, 2015. Its inferential justification requires sufficiently independent residual contributions across economies; economy clustering does not address every form of international dependence. Individual probability values are two sided. Confidence intervals use a 95 percent coverage level and a student reference distribution with $\mathrm{G}-1$ degrees of freedom. The joint restriction that the three predictor coefficients equal zero is evaluated using their clustered covariance submatrix. The quadratic Wald statistic is divided by three and compared with an F distribution having three numerator degrees of freedom and $\mathrm{G}-1$ denominator degrees of freedom. Statistical uncertainty is interpreted alongside coefficient magnitude and confidence intervals. Implementation uses Python 3.12.14, NumPy 2.3.5, pandas 2.2.3, and SciPy 1.17.0. Coefficients are obtained through NumPy's least squares routine with its default numerical rank threshold. SciPy supplies the Student and F distribution calculations. The procedures are deterministic and require no random seed.

4.3 Analytical Sequence and Diagnostic Procedures:

Processing begins by restricting the supplied source panel to the analytical window and checking economy and year identifiers. Duplicate keys trigger an error rather than automatic aggregation. Complete records are reconstructed from the source worksheet and compared with the supplied analytical worksheet using relative and absolute tolerances of 10^{-13}. Records missing any outcome or predictor are excluded before estimation. No missing values are replaced with zero, interpolated, or imputed. Variable specific missingness, sequential sample losses, and annual coverage are documented in Tables 1 and 2. This procedure preserves observed measurements but does not establish that selection is ignorable. Hughes et al., 2019, distinguish the validity of complete record analysis from the amount of missing data alone. Observed characteristics of retained and excluded records are therefore compared without assuming random missingness.

Numerical screening checks for infinite observed values, negative trade shares, manufacturing shares outside zero to 100 percent, and inflation below minus 100 percent. Negative investment flows, negative inflation, and trade shares above 100 percent remain admissible under their definitions. Published values are preserved without percentile trimming or winsorization. This treatment distinguishes unusual observations from established recording errors, consistent with Aguinis et al., 2013. Estimation is followed by three diagnostic calculations. First, numerical rank is checked against the number of design columns. Second, both the outcome and predictors are residualized against the intercept and economy and year indicators. Regressing the residualized outcome on the residualized predictors provides an independent computational check of the three slope estimates. Agreement is assessed using a relative tolerance of 10^{-9} and an absolute tolerance of 10^{-10}

Third, collinearity among the focal predictors is evaluated after fixed effects are removed. For each residualized predictor, the variance inflation factor equals its sum of squares divided by the residual sum of squares from regression on the other two residualized predictors. This calculation assesses predictor overlap within the variation used for estimation. Incremental explanatory contribution is calculated as one minus the ratio of the full model residual sum of squares to the residual sum of squares from the economy and year effects specification alone. It measures the additional fit provided by the three predictors after fixed effects are absorbed. Descriptive summaries use observed counts, arithmetic means, medians, sample standard deviations, and observed minima and maxima.

4.4 Sensitivity Analysis, Interpretive Limits, and Reproducibility:

Two exploratory sample restrictions assess distinct threats to interpretation. The balanced coverage analysis retains economies with complete observations in all 14 analytical years, yielding 1,960 observations across 140 economies. It applies the same specification, measurement scales, weighting convention, and covariance calculation as the baseline. This comparison evaluates sensitivity to unequal temporal coverage while recognizing that the restriction changes the economies represented. The source zero sensitivity analysis excludes records containing simultaneous zero trade and manufacturing shares. Economy coverage is then checked again, and economies with fewer than two remaining observations are excluded. The resulting sample contains

2,206 observations across 167 economies. This calculation examines the influence of the identified records without overwriting their source values. Neither sensitivity analysis was preregistered. The source zero check was introduced after the initial baseline estimation. Both are reported as exploratory, and comparisons consider changes in direction, magnitude, and uncertainty rather than continued statistical significance alone. This distinction follows the transparency principles discussed by Nosek et al., 2018.

The specifications remain associational. Persistent economy differences and common annual influences are controlled additively, but changing omitted conditions, reverse relationships, measurement error, and dependence between economies can affect interpretation. Shared GDP denominators also limit the extent to which the estimated relationships distinguish sectoral expansion from changes elsewhere in the economy. The replication materials preserve the original workbook, its SHA256 checksum, the executable analysis script, software requirements, sample construction records, coverage summaries, and estimation outputs. The script reproduces coefficients, clustered uncertainty estimates, confidence intervals, joint tests, collinearity diagnostics, and incremental model fit. The methodological contribution is the transparent alignment of established procedures with the research questions and available measurements.

5. Findings:

This analysis evaluates how trade openness, foreign investment, and inflation relate to manufacturing's share of GDP. The findings distinguish estimated direction and magnitude from statistical precision. Sample sensitivity and model diagnostics establish the limits of the empirical conclusions. The baseline contains 2,208 annual observations from 168 economies spanning 2010 through 2023. Selection begins with 3,038 possible observations across 217 economies. Missing indicators exclude 828 records, and removing two economies with only one complete observation excludes another two records. The retained panel contains between two and 14 observations per economy, with a median of 14. Manufacturing value added averages 11.83 percent of GDP, with a median of 11.28 percent and a standard deviation of 6.09 percentage points. Mean trade openness reaches 91.49 percent of GDP. Foreign investment averages 5.55 percent of GDP, compared with a median of 2.62 percent, while inflation averages 5.33 percent against a median of 3.13 percent. These differences indicate asymmetric distributions, particularly for investment and inflation. Manufacturing share captures relative sectoral weight rather than productivity or absolute production growth, a distinction relevant to the industrialization patterns documented by Rodrik, 2016. Table 5 presents the baseline estimates from ordinary least squares with economy and year effects. Each coefficient represents the change in manufacturing share, measured in percentage points, associated with a one percentage point increase in the corresponding predictor, conditional on the other predictors and fixed effects. Confidence intervals and probability values use standard errors clustered by economy. This inference accommodates dependence over time within economies, following Cameron and Miller, 2015.

Table 5: Conditional associations with manufacturing value added share

Predictor	Coefficient	Clustered Standard Error	Lower 95 Percent Confidence Bound	Upper 95 Percent Confidence Bound	p Value
Trade openness	0.01644	0.00945	−0.00221	0.03509	0.0837
Foreign investment net inflows	−0.00185	0.00267	−0.00712	0.00342	0.4884
Consumer price inflation	0.00410	0.00391	−0.00362	0.01183	0.2958

Source: Computed estimates using 2,208 observations across 168 economies. All predictors are contemporaneous. Confidence intervals use a student reference distribution with 167 degrees of freedom. The outcome is manufacturing value added as a percentage of GDP.

For RQ1, trade openness has a positive estimated association with manufacturing share. A ten-percentage point increase in openness corresponds to an estimated increase of 0.164 percentage points in manufacturing share. The corresponding 95 percent confidence interval extends from a decrease of 0.022 percentage points to an increase of 0.351 percentage points. The estimate therefore remains compatible with a negligible negative association as well as a positive association. Its direction is consistent with potential production gains from international integration, but the aggregate indicator does not identify the imported input mechanism examined by Goldberg et al., 2010.

For RQ2, foreign investment has a negative point estimate with limited precision. A ten-percentage point increase in net inflows relative to GDP corresponds to an estimated decline of 0.0185 percentage points in manufacturing share. The 95 percent confidence interval spans −0.0712 to 0.0342 percentage points. This interval does not establish a consistent direction. Because the investment indicator covers the entire economy, the result cannot be interpreted as evidence against manufacturing productivity spillovers. Havranek and Irsova, 2011, examine supplier productivity relationships that differ from the aggregate sectoral share relationship estimated here.

For RQ3, inflation has a positive baseline point estimate, but its confidence interval includes zero. A ten-percentage point increase in inflation corresponds to an estimated increase of 0.0410 percentage points in manufacturing share, with a 95 percent confidence interval from −0.0362 to 0.1183 percentage points. This estimate does not demonstrate that inflation improves manufacturing performance. The outcome measures manufacturing's contribution relative to other activities, while Kremer et al., 2013, examine inflation relationships with aggregate economic growth. Differences in outcomes prevent a direct interpretation of these findings as confirming or contradicting their growth results.

The three predictors jointly explain 1.95 percent of the variation remaining after economy and year effects are absorbed. The joint Wald test produces an F statistic of 1.557, with three numerator degrees of freedom and 167 denominator degrees of freedom, yielding p = 0.2017. The evidence therefore does not reject the joint restriction that all three slope coefficients equal zero. This result indicates limited evidence of joint explanatory contribution under the implemented specification, rather than proof that macroeconomic conditions are unrelated to manufacturing outcomes. Numerical diagnostics identify no exact collinearity in the estimated design matrix. After removing economy and year effects, variance inflation factors range from 1.002 to 1.003 across the three predictors. Overlap among these residualized predictors therefore provides little indication of inflated coefficient uncertainty. Independent residualization reproduces the slope estimates within 0.0000000001, confirming numerical agreement between equivalent estimation procedures. These checks establish computational consistency rather than causal

validity. Table 6 assesses sensitivity to temporal coverage and the two records containing simultaneous zero trade and manufacturing shares. The balanced panel contains 1,960 observations across 140 economies. The zero exclusion sample contains 2,206 observations across 167 economies. Both checks are exploratory, and their differences from the baseline reflect changes in sample composition.

Table 6: Sensitivity of estimated associations to sample restrictions

Sample Restriction	Predictor	Coefficient	Lower 95 Percent Confidence Bound	Upper 95 Percent Confidence Bound	p Value
Balanced coverage	Trade openness	0.01858	−0.00238	0.03953	0.0818
Balanced coverage	Foreign investment net inflows	−0.00167	−0.00689	0.00354	0.5268
Balanced coverage	Consumer price inflation	0.04591	0.00264	0.08919	0.0377
Exclusion of simultaneous source zeros	Trade openness	0.01644	−0.00221	0.03508	0.0837
Exclusion of simultaneous source zeros	Foreign investment net inflows	−0.00185	−0.00712	0.00341	0.4883
Exclusion of simultaneous source zeros	Consumer price inflation	0.00410	−0.00362	0.01182	0.2957

Trade and investment estimates change little across these restrictions. The trade coefficient remains positive, while the investment coefficient remains negative; their 95 percent confidence intervals continue to include zero. Excluding the simultaneous source zeros also leaves the inflation estimate virtually unchanged. Those two records therefore do not materially explain the baseline associations. Inflation is substantially more sensitive to balanced coverage. Its coefficient increases from 0.00410 to 0.04591, and the balanced panel confidence interval excludes zero. A ten-percentage point inflation increase corresponds to an estimated manufacturing share increase of 0.459 percentage points in that sample, with a 95 percent confidence interval from 0.026 to 0.892 percentage points. However, the balanced panel has mean inflation of 4.47 percent, compared with 12.10 percent among the 248 observations omitted by the coverage restriction. Maximum inflation also falls from 557.20 percent in the baseline to 72.31 percent in the balanced panel. The changed estimate therefore accompanies a substantial change in observed inflation exposure and cannot establish a general positive relationship across the full sample. The research questions yield differentiated conclusions. Trade openness has a positive but imprecisely estimated association with manufacturing share. Foreign investment has a small negative point estimate without a statistically distinguishable direction. Inflation has an uncertain baseline association that changes materially under balanced coverage. Together, the findings support a bounded conclusion: the observed macroeconomic indicators provide limited additional explanatory contribution beyond economy and year effects, while temporal coverage materially affects the estimated inflation relationship.

6. Discussion:

Manufacturing's economic weight cannot be inferred reliably from aggregate openness alone. Table 5 shows limited precision around the three macroeconomic associations estimated through Equation 1, while their joint contribution explains only 1.95 percent of the variation remaining after economy and year effects. This finding qualifies the use of national trade, investment, and inflation indicators as explanations of changes in manufacturing share. Haraguchi et al., 2017, examine manufacturing's continuing importance for development, while Duarte and Restuccia, 2010, connect structural transformation to sectoral productivity differences. The present estimates address a narrower relationship: whether aggregate macroeconomic exposures accompany changes in manufacturing's relative contribution. The empirical contribution lies in establishing the limited explanatory contribution of these indicators within a common international specification, without interpreting uncertain coefficients as evidence that manufacturing lacks developmental importance. The investment result sharpens the distinction between international exposure and productive integration. In Table 5, the aggregate investment coefficient is close to zero and its confidence interval permits either direction. Equation 1 therefore provides little basis for treating total inward investment as a consistent indicator of expanding manufacturing share. Cadestin et al., 2018, demonstrate the importance of distinguishing multinational activities across industries and linking investment information with production and trade relationships. Antràs, 2020, similarly emphasizes the organization of production across global value chains. These contributions clarify why the aggregate investment measure and manufacturing outcome need not move together uniformly. This analysis contributes a measurement boundary to the conceptual framework: national investment inflows describe exposure, while their estimated association with manufacturing share does not establish the productive relationships emphasized in international production theory.

Temporal coverage materially changes the interpretation of inflation. Table 6 shows that the inflation coefficient increases from approximately 0.004 in the baseline to 0.046 in the balanced panel, where its confidence interval excludes zero. However, the coverage restriction also changes the observed inflation distribution: omitted observations have substantially higher mean inflation than retained observations. The comparison therefore establishes sensitivity to the economies and periods represented, rather than a general industrial benefit from inflation. Manufacturing share measures performance relative to the rest of the economy, so a positive coefficient does not demonstrate stronger productivity or absolute production growth. The contribution is to show that complete temporal coverage changes the empirical population supporting the inflation relationship. International comparisons based on balanced panels consequently require attention to which economic conditions disappear when incomplete histories are excluded. The diagnostic evidence locates the principal interpretive challenges more precisely. Variance inflation factors near one indicate little overlap among the predictors after economy and year effects are removed. Meanwhile, excluding the simultaneous zero trade and manufacturing records produces virtually unchanged estimates in Table 6. Limited precision in Table 5 therefore cannot be attributed readily to overlap among these predictors or those two source records. Coverage sensitivity remains more consequential for interpreting inflation than the specific source anomaly examined. This

distinction improves the evidentiary basis for evaluating global panel results: numerical consistency and resistance to a particular data irregularity do not establish stability across population definitions. Retaining the exploratory status of the sensitivity calculations also preserves the distinction between evidence generated by an analysis and evidence used to assess an earlier expectation, consistent with Nosek et al., 2018.

The international contribution concerns the conditions under which evidence can travel across empirical settings. Uy et al., 2013, quantify the importance of trade for structural change in South Korea using a model designed around sectoral production and international exchange. The imprecise global trade association in Table 5 addresses a different estimand and does not establish that the same production relationships operate uniformly across economies. Read together, Equation 1 and Tables 5 and 6 redirect comparison toward matched outcomes, exposure measures, and coverage rules. Decision makers should therefore assess manufacturing outcomes separately from national trade and investment ratios, and examine sample composition before interpreting inflation coefficients as industrial evidence. The broader theoretical implication is that aggregate integration measures require careful interpretation when explaining relative sectoral change. The evidence supports greater attention to measurement and population boundaries when translating international industrialization arguments into empirical claims.

7. Conclusion and Implications:

Global integration offers industrial opportunities, but aggregate exposure alone provides an uncertain guide to domestic industrial progress. Considered jointly, the three macroeconomic dimensions provide limited additional explanation once persistent national differences and common annual influences are accounted for. Their estimated relationships also depend on which economies maintain complete observation histories. This analysis contributes an international empirical insight by distinguishing relatively stable associations from a relationship that changes materially with temporal coverage. The theoretical contribution qualifies the translation of integration arguments into aggregate industrial expectations: plausible productive pathways do not establish a uniform relationship with relative sectoral expansion. Decision makers should therefore distinguish external exposure from demonstrated domestic productive outcomes when evaluating strategic performance. Managers can strengthen investment appraisal by matching national indicators with evidence relevant to their industries and operations. Policymakers should assess industrial programmes using transparent outcome definitions and disclose how eligibility rules affect comparative evidence. Operationally, maintaining consistent reporting histories and documenting source irregularities can improve the credibility of monitoring systems. These practices support more defensible resource allocation without treating uncertain associations as policy effects. Their broader social value lies in strengthening accountability for public interventions intended to support productive employment and livelihoods across diverse economic settings.

The observational design creates opportunities for stronger identification and more detailed measurement. Future research should combine sector specific investment and production accounts with measures of output volumes and employment, allowing relative economic weight to be distinguished from productive expansion. Alternative coverage rules and explicit models of missingness could assess the transferability of the observed relationships. Institutional comparisons could investigate whether financial capacity or production linkages condition these associations. Designs based on clearly identified policy changes could then examine causal pathways. These extensions would deepen the empirical contribution while testing its applicability across different economic structures and reporting environments.

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