

Financial Liberalization and Investment-Specific Technological Change (ISTC)

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Abstract

This paper studies how capital-account liberalization reallocates activity across manufacturing industries that differ in investment-specific technological change (ISTC). Using UNIDO industry data and a local-projection difference-in-differences design with clean controls, I find that liberalization is followed by a stronger cumulative value-added response in high-ISTC industries in countries with stronger institutions, while the corresponding differential is absent or reversed in weaker institutional environments. The pattern appears under both the Chinn–Ito measure of statutory capital-account openness and a de facto External Wealth of Nations measure, and it is robust to controlling directly for trade liberalization. Institutional heterogeneity is strongest for broad governance and court-enforcement measures and is not reproduced systematically by de jure creditor-rights indices. I interpret these facts through a multi-sector overlapping-generations model in which entrepreneurs borrow against a pledgeable fraction of installed capital. A quantitative exercise uses the actual 22-industry ISTC distribution and, without targeting the LP-DiD estimates, produces medium-run cross-industry slopes comparable in magnitude to those estimated for stronger-institution countries. Removing the collateral cap still leaves a positive ISTC slope, showing that collateral constraints modify, rather than fully account for the cross-sector response. As sectors graduate from binding constraints, the incremental collateral contribution fades. Differential capital deepening generates the positive slope, while equilibrium relative-price adjustment offsets part of it.

Keywords: financial liberalization; investment-specific technological change; institutions; pledgeability; local projections; structural change.

JEL codes: E22, F36, O16, O33.

1 Introduction

Capital-account liberalization changes the terms on which domestic firms obtain external finance, but its aggregate growth effects vary widely across episodes. This paper asks whether part of that heterogeneity reflects systematic differences across industries. The starting point is that industries differ substantially in the rate at which improvements are embodied in new capital goods. If access

to finance determines how quickly firms can replace and upgrade capital, a reduction in the cost of external funds should matter more in industries where the quality of new capital improves rapidly.

The empirical analysis combines UNIDO manufacturing data with industry measures of investment-specific technological change (ISTC) and country-level measures of financial openness and institutional quality. The central specification is a local-projection difference-in-differences design with clean controls. The coefficient of interest captures whether industries with higher ISTC respond more strongly to a liberalization episode, and the response is estimated separately across stronger and weaker institutional environments.

The empirical results reveal substantial institutional heterogeneity. Under the Chinn–Ito treatment, the medium-run response becomes increasingly steep in ISTC among countries with stronger governance institutions, while no comparable positive gradient appears in the weaker-institution sample. The magnitude is economically substantial: at the five-year horizon, moving from the bottom to the top of the observed ISTC range is associated with roughly a 17 percent larger cumulative value-added response to liberalization in the strong-WGI sample. The same institutional ordering appears when liberalization is measured by de facto external financial integration from the External Wealth of Nations data. The pattern is also stronger for broad governance and enforcement measures than for statutory creditor-rights, strength-of-legal-rights, or credit-information indices.

The institutional measures are not interpreted as direct measures of pledgeability. WGI captures the broader governance environment, while the sign-reversed Djankov et al. Formality measure captures features of legal enforcement procedures more closely related to the model mechanism. They are used to distinguish relatively stronger from weaker enforcement environments, not to assign countries numerical values of the model’s pledgeability parameter.¹

To interpret these findings, we develop a multi-sector overlapping-generations model in which households save through competitive banks and entrepreneurs use internal funds and borrowing to finance sector-specific investment. Financial liberalization lowers the cost of external borrowing, while institutions affect the amount of installed capital value that can support enforceable repayment. Because industries differ in ISTC, cheaper finance generates heterogeneous investment responses across sectors. When collateral constraints bind, greater pledgeability allows firms to expand financing and strengthens the response to liberalization.

The model distinguishes between a relaxation of a binding collateral constraint and the eventual disappearance of the constraint. As pledgeability rises, the collateral limit expands and initially allows constrained firms to respond more strongly to cheaper finance. A firm can, however, become unconstrained before the collateral limit becomes infinite: once its desired financing falls below the limit, further increases in pledgeability no longer relax its actual borrowing constraint. We call this transition *graduation*. In the quantitative model, high-ISTC sectors tend to graduate earlier, so institutional amplification first strengthens and then declines as more sectors become unconstrained.

The quantitative exercise uses the 22 manufacturing industries in the empirical sample and

¹I use the published Djankov et al. Formalism Index with its sign reversed, so higher values denote less procedural formalism. The index records procedural features of legal adjudication and is not a recovery rate or a pledgeable fraction.

their observed ISTC values; the LP-DiD coefficients are not calibration targets. The model produces medium-run cross-industry slopes comparable in magnitude to those estimated in stronger-institution countries. Institutional amplification is largest at intermediate pledgeability: tight collateral constraints initially suppress the heterogeneous response to cheaper finance, while the collateral contribution declines as sectors become unconstrained. A counterfactual without the collateral cap (NoCap) retains a positive ISTC slope, showing that collateral constraints are not the only source of heterogeneous sectoral responses. Differential capital deepening generates the positive value-added response, while equilibrium relative-price adjustment partly offsets it.

1.1 Relation to the literature

The paper is related first to the literature on investment-specific technological change. Greenwood et al. (1997) show that technological progress embodied in new capital goods is quantitatively important for long-run growth, and Cummins and Violante (2002) provide a detailed measurement of investment-specific technical change using the quality-adjusted relative price of equipment. More recent work has emphasized that embodied technological progress is not neutral across activities: industries use different capital bundles and therefore face different rates of improvement in the effective quality of new capital (Samaniego and Sun, 2020; Jones and Liu, 2024). I take this cross-industry heterogeneity as given and ask a different question: whether access to finance determines how strongly industries can take advantage of improvements embodied in new capital. The empirical design therefore uses continuous industry ISTC as an exposure measure rather than attempting to infer technology adoption from post-reform outcomes.

A second literature studies the interaction between financial frictions, institutions, and sectoral allocation. Models of limited enforcement and collateral constraints generate persistent differences in investment and productivity because entrepreneurs cannot always finance the scale they would choose in frictionless markets. The quantitative counterfactuals in Buera et al. (2011) and Buera and Shin (2017) provide precedent for removing or reallocating a financial friction to isolate its contribution. Ilyina and Samaniego (2012) provide a close multi-industry precedent for confronting a finance–technology interaction generated by a quantitative model with an empirical counterpart. The mechanism here is narrower: institutions enter through effective pledgeability of installed capital, while sectoral heterogeneity comes from ISTC. Following this quantitative tradition, I use counterfactuals to isolate the collateral mechanism and compare model-generated industry responses with their empirical counterpart.

A third literature studies the real effects of financial liberalization using firm and industry data. Aggregate growth estimates following capital-account opening are often heterogeneous, which motivates looking for margins along which treatment effects differ. Levchenko et al. (2009) show that financial liberalization has heterogeneous industry effects related to financial dependence, while Larrain (2015) and Varela (2017) document firm-level changes in financing, investment, and reallocation around liberalization episodes. Bau and Matray (2023) provide recent evidence on capital-market integration and misallocation. My empirical contribution is to use an industry

characteristic tied directly to the productivity of newly installed capital and to show that the post-liberalization ISTC gradient is concentrated in stronger institutional environments.

Finally, the empirical design is related to the recent literature on staggered treatment and dynamic difference-in-differences. With repeated policy changes, already-treated or soon-to-be-treated observations can contaminate comparison groups when treatment effects are heterogeneous over time (de Chaisemartin and D’Haultfœuille, 2020; Goodman-Bacon, 2021). I use a local-projection DiD design with clean controls in the spirit of Dube et al. (2025). The event construction and emphasis on full dynamic response paths are close to Cugat and Manera (2024), who study technology diffusion around capital-flow liberalization, while Ahn et al. (2024) provides a recent example of organizing heterogeneous cross-border technology responses through dynamic LP-DiD figures rather than selected-horizon summaries. The model here is not estimated by matching these reduced-form coefficients. The empirical analysis establishes the sectoral and institutional pattern; the quantitative section reports the corresponding model-generated cross-industry slope and counterfactuals that isolate the collateral mechanism.

The rest of the paper proceeds as follows. Section 2 describes the data, identification strategy, and empirical results. Section 3 presents the model and analytical results. Section 4 reports the quantitative comparative statics. Section 6 concludes.

2 Empirical Evidence

The empirical analysis asks whether the response to capital-account liberalization differs systematically across manufacturing industries according to the pace of investment-specific technological change, and whether that cross-industry response depends on the institutional environment. I first describe the outcome and the industry ISTC measure, then the liberalization episodes and clean-control design, and finally the institutional heterogeneity and trade-liberalization checks.

2.1 Data and sectoral ISTC

The unit of observation is a country–industry–year. Manufacturing outcomes come from UNIDO INDSTAT2. The underlying panel covers 139 countries and ISIC Rev. 3 manufacturing industries 15–36 over 1963–2021. The estimation sample is smaller because financial-openness measures, institutional variables, lagged outcomes, and forward outcomes are not observed for every country-year. The final empirical and quantitative exercises use the same 22 manufacturing industries.

The outcome is log value added. UNIDO reports value added at producers’ prices. I deflate nominal value added using the World Bank country-year GDP deflator, take logs, and winsorize the resulting variable at the 1st and 99th percentiles. Because the deflator is common across industries within a country-year, the country-by-year fixed effects absorb this common component, while industry-relative price movements remain in the measured outcome. The empirical variable should therefore be interpreted as GDP-deflator-adjusted value added at producers’ prices rather than as a pure physical-output index. Appendix A gives the exact transformation and accounting identity.

Investment-specific technological change (ISTC) measures the rate at which technological improvements are embodied in new capital goods. The underlying idea differs from disembodied productivity growth: an industry has high ISTC when the equipment and capital goods it uses improve rapidly in quality over time. The industry measures originate in Cummins and Violante (2002), who use quality-adjusted equipment prices together with industry capital-use information to construct differences in embodied technological progress across industries. In the regressions, $ISTC_i$ is a continuous, time-invariant industry characteristic. A larger value means that new investment embodies faster technological improvement.

Table 1 reports the 22-industry support used in the empirical analysis. The values span roughly 3.19 to 5.15. Machinery and several equipment-intensive industries lie toward the upper end of the distribution, while rubber and plastics, paper, and basic or fabricated metals lie toward the lower end. The empirical specification uses these continuous values rather than dividing industries into high- and low-ISTC groups.

Table 1: Sectoral investment-specific technological change

ISIC	Industry	ISTC	ISIC	Industry	ISTC
15	Food products and beverages	3.94	26	Other non-metallic minerals	4.68
16	Tobacco products	3.98	27	Basic metals	3.44
17	Textiles	3.91	28	Fabricated metal products	3.42
18	Wearing apparel	4.37	29	Machinery and equipment n.e.c.	5.15
19	Leather and footwear	4.02	30	Office and computing machinery	4.31
20	Wood products	3.93	31	Electrical machinery	4.31
21	Paper and paper products	3.25	32	Radio and communication equipment	4.31
22	Printing and publishing	4.41	33	Medical and precision instruments	4.46
23	Coke and refined petroleum	3.95	34	Motor vehicles	3.85
24	Chemicals and chemical products	4.64	35	Other transport equipment	3.85
25	Rubber and plastics	3.19	36	Furniture and manufacturing n.e.c.	3.65

Notes: Values are the 22-industry ISTC of the ISIC Rev.3 used in the analysis, rounded to two decimals. The underlying industry ISTC profile is based on Cummins and Violante (2002). The unrounded values are used in estimation and in the 22-sector quantitative exercise.

2.2 Financial-liberalization episodes

The headline treatment uses the Chinn–Ito capital-account openness index (Chinn and Ito, 2008). Let $Open_{ct}$ denote the underlying openness measure and let p_{95} denote the pooled-panel 95th percentile of its nonmissing annual first differences. A liberalization episode is

$$Lib_{ct} = \mathbf{1}\{\Delta Open_{ct} \geq p_{95}\}. \quad (1)$$

The threshold is computed on the country-industry construction panel, so p_{95} is a pooled-panel threshold rather than a country-specific percentile.² The Chinn–Ito analysis contains 175 liberalization episodes over 1970–2018. Since the treatment is an event rather than a permanent absorbing

²Because openness is measured at the country-year level, the same country-year change is repeated across available industry rows in the construction panel. The replication files document the exact construction and the resulting cutoff.

state, a country can contribute more than one episode when sufficiently separated large changes satisfy the clean-control restrictions below.

As the main robustness treatment, I use de facto external financial integration from the External Wealth of Nations data (Lane and Milesi-Ferretti, 2007). The EWN measure is gross external assets plus liabilities relative to GDP, with episodes defined analogously from unusually large positive annual changes. The two measures capture different objects: Chinn–Ito records statutory capital-account openness, whereas EWN captures realized international balance-sheet integration. Their event dates and country coverage therefore need not coincide.

2.3 LP-DiD specification and clean controls

Let y_{cit} denote log real value added in industry i , country c , and year t . For each post-event horizon $h \in \{0, 1, \dots, 10\}$, I estimate

$$\Delta_h y_{cit} = \beta_h (\text{Lib}_{ct} \times \text{ISTC}_i) + \sum_{j=1}^3 \rho_{j,h} y_{ci,t-j} + \boldsymbol{\eta}'_h \mathbf{x}_{cit} + \lambda_{ct}^h + \gamma_{it}^h + u_{cit,h}, \quad (2)$$

where

$$\Delta_h y_{cit} = y_{ci,t+h} - y_{ci,t-1} \quad \text{and} \quad \mathbf{x}_{cit} = \begin{pmatrix} y_{ci,t-4} - y_{ci,t-6} \\ \text{Share}_{ci,t-1} \end{pmatrix}.$$

Thus the first three lags of the outcome enter explicitly, while $\mathbf{x}_{cit}$ contains the additional pre-determined controls used in the baseline specification: the longer-run pre-event change in value added and lagged industry share. The specification includes country-by-year fixed effects λ_{ct}^h and industry-by-year fixed effects γ_{it}^h and is estimated without observation weights. Standard errors are two-way clustered by country and year. Country-year fixed effects absorb the liberalization main effect and country-specific macroeconomic shocks at the base date; industry-year fixed effects absorb the time-invariant ISTC main effect and common industry-specific shocks. The coefficient β_h therefore measures how the cumulative response to a liberalization episode varies with continuous industry ISTC.

The comparison sample follows the clean-control logic used for repeated treatment. Define the eligible treated and control country-years as

$$\begin{aligned} (c, t) \in \mathcal{T} &\iff \text{Lib}_{ct} = 1 \quad \text{and} \quad \text{Lib}_{c\tau} = 0 \quad \forall \tau \in [t-5, t-1], \\ (c, t) \in \mathcal{C} &\iff \text{Lib}_{c\tau} = 0 \quad \forall \tau \in [t-5, t+10]. \end{aligned} \quad (3)$$

Thus a treated observation cannot have been treated during the preceding five years, while a control observation must remain untreated from five years before the base date through ten years after it. This restriction prevents already-treated or soon-to-be-treated country-years from serving as clean comparisons. The forward clean window is fixed at ten years in the baseline sample; horizon-specific regression support still declines with h because longer-horizon outcomes and the required lagged variables are progressively unavailable. For graphical diagnostics I also report pre-event coefficients

for $h \in \{-5, -4, -3, -2\}$, with $h = -1$ normalized to zero. Because the dependent variables at $h = -3$ and $h = -2$ are exact linear combinations of the included first three outcome lags, those two coefficients are mechanically zero and should not be interpreted as pre-trend tests. The informative pre-event checks are therefore the earlier horizons.

Institutional heterogeneity is first presented by estimating equation (2) separately above and below the cross-country median of the institutional measure. For inference on the strong-minus-weak difference, I also estimate a pooled specification on the union of the two subgroup samples, allowing the treatment slope and control coefficients to differ by institutional group. A linear combination of the two treatment slopes gives the difference and its two-way clustered standard error.³

2.4 Headline institutional heterogeneity: WGI

Figure 1 reports the main empirical result. The left column uses Chinn–Ito liberalization episodes and the right column uses EWN episodes. Within each treatment definition, the upper panel reports countries above the WGI median and the lower panel countries below it. The lower bars are horizon-specific regression observations, not counts of distinct liberalization episodes.

The Chinn–Ito paths separate gradually after liberalization. At five years, the coefficient is 0.081 (SE 0.032) in the stronger-institution sample and -0.062 (SE 0.039) in the weaker-institution sample. The direct pooled difference is 0.143 (SE 0.051; $p = 0.007$). Since the observed ISTC support spans almost two units, the coefficient in the strong-institution sample corresponds to a sizable difference in cumulative value-added responses between industries near the top and bottom of the ISTC distribution. The informative earlier pre-event estimates are small relative to the medium-run divergence; as noted above, the $h = -3$ and $h = -2$ coefficients are mechanically zero because of the included outcome lags.

The EWN estimates show the same institutional ordering, although their magnitudes differ from Chinn–Ito. At five years the strong-side coefficient is 0.028 (SE 0.042) and the weak-side coefficient is -0.048 (SE 0.040); the strong-side response becomes more pronounced at longer horizons. It shows that the institutional asymmetry is also visible when liberalization is measured by realized external-balance-sheet integration rather than statutory openness.

2.5 Formality and effective enforcement

The WGI result alone does not identify which aspect of institutions matters. The six WGI components are highly correlated, and a broad governance index can proxy for many features of the business environment. I therefore use the Djankov et al. court Formalism measure as a narrower enforcement-oriented exercise. The published index rises with procedural formalism; throughout the paper I reverse its sign so that larger values indicate less formalism and, in that limited sense, more effective legal procedure.

³The pooled step is important because the two subgroup estimators share calendar-year clusters. The final inference therefore uses the covariance from the pooled two-way-clustered variance matrix rather than the earlier zero-covariance approximation.



Figure 1: Dynamic LP-DiD estimates by WGI institutional quality. The figure plots the coefficient on liberalization interacted with continuous industry ISTC over event time, separately for countries above and below the WGI median. The left column uses Chinn–Ito episodes and the right column uses External Wealth of Nations episodes. Shading reports the 95 percent confidence intervals. Lower bars report horizon-specific regression observations.

Figure 2 repeats the dynamic LP-DiD exercise under this split. Under Chinn–Ito, the direct strong-minus-weak difference is 0.121 (SE 0.066) at five years and becomes larger and more precisely estimated later in the medium run; at seven years the difference is about 0.20. The difference persists across the medium-run horizons rather than being concentrated at a single year.

Formality is useful for interpretation because it is closer to the enforcement margin in the model than a broad WGI composite. It is not, however, a direct measure of pledgeability. The index records procedural features of legal adjudication rather than the present value of recoverable collateral. I therefore use WGI and Formality to order institutional environments, not to map observed scores into numerical values of the model parameter θ .⁴

The broader WGI evidence is also not an artifact of one component. Rule of Law, Control of Corruption, Political Stability, and several other WGI dimensions produce positive medium-run strong-minus-weak differences. Because these components are strongly correlated, I do not attempt to rank them or assign a structural interpretation to one particular WGI sub-index. The complete

⁴The project contains court-duration and de jure legal-rights measures, but not a secured-creditor recovery object whose units line up with the model pledgeability parameter.



Figure 2: Dynamic LP-DiD estimates by legal Formality. Countries are split at the median of the sign-reversed Djankov et al. Formalism index, so larger values denote less procedural formalism. The left column uses Chinn-Ito episodes and the right column uses External Wealth of Nations episodes. Lower bars report horizon-specific regression observations.

dynamic and numerical results are reported in the appendix.

2.6 De jure creditor institutions

The next question is whether the WGI/Formality pattern is simply a reflection of stronger creditor protection on the books. Figure 3 reports the full strong-minus-weak paths for creditor rights, the World Bank Strength of Legal Rights index, and the Depth of Credit Information index. Each panel plots the direct pooled strong-minus-weak coefficient and its 95 percent confidence interval.

The de jure measures do not reproduce the systematic positive medium-run differential seen for WGI and Formality. At five years, the direct differential is -0.055 (SE 0.081) for creditor rights, 0.067 (SE 0.087) for Strength of Legal Rights, and -0.015 (SE 0.061) for Depth of Credit Information. None is statistically distinguishable from zero at conventional levels, and the paths are unstable in sign or imprecise at longer horizons. These estimates do not support the same systematic institutional amplification seen for WGI and Formality, although their imprecision does not imply a zero effect. Rather, these statutory measures do not display the same systematic institutional amplification as WGI and Formality.

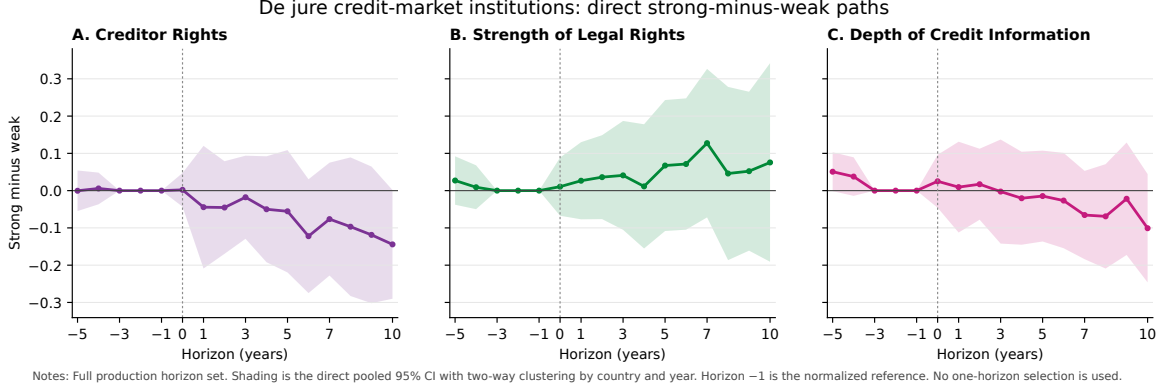


Figure 3: Institutional heterogeneity under de jure credit-market measures. Each panel reports the direct strong-minus-weak difference in the Chinn–Ito LP-DiD coefficient on liberalization interacted with ISTC. Shading is the 95 percent confidence interval from the pooled specification with two-way clustering by country and year. Horizon -1 is normalized to zero.

2.7 Trade liberalization as an alternative explanation

Capital-account reform often occurs as part of a broader reform package, making trade liberalization an immediate alternative explanation. High-ISTC industries may use imported capital goods and intermediate inputs intensively, so contemporaneous trade opening could generate a similar sectoral pattern. I address this concern first by comparing reform dates and then by including trade reforms directly in the capital-account LP-DiD.

Exact-year overlap is limited. Of the 175 Chinn–Ito episodes, only six (3.4 percent) occur in the same calendar year as a Wacziarg–Welch trade opening and four (2.3 percent) coincide with a large tariff-reduction episode. Table 2 also reports the wider ± 5 -year overlap: 37 Chinn–Ito episodes lie within five years of a Wacziarg–Welch opening and 31 lie within five years of a large tariff reduction. The wide-window figures are deliberately conservative because Wacziarg–Welch records a single permanent opening date, so a later capital-account episode can lie near that date without representing the same policy event.

Table 2: Timing overlap between capital-account and trade liberalization

Trade-reform measure	Exact year	Within ± 5 years
Wacziarg–Welch opening	6 (3.4%)	37 (21.1%)
Large tariff reduction	4 (2.3%)	31 (17.7%)

Notes: Entries are counts of Chinn–Ito liberalization episodes, with shares of the 175 episodes in parentheses. “Exact year” requires the trade and capital-account episodes to occur in the same calendar year. The ± 5 -year column is a deliberately wider timing diagnostic. The table is descriptive and does not by itself establish orthogonality of capital-account and trade reforms.

More directly, I re-estimate the exact headline strong-WGI Chinn–Ito specification after adding Wacziarg–Welch and tariff-liberalization interactions with ISTC. The trade-event lookup matches every observation in the headline panel, so adding these controls does not change the estimation sample. Panel A of Figure 4 therefore reproduces the strong-WGI Chinn–Ito path in Figure 1; Panels B and C differ only by the added trade interactions.

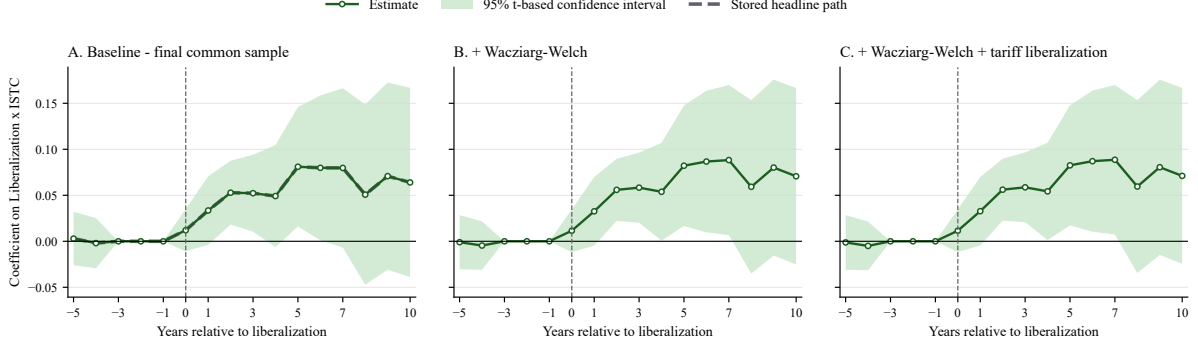
The three paths are strikingly similar. At five years, the coefficient is 0.081 in the headline baseline, 0.082 after adding Wacziarg–Welch, and 0.083 after adding both Wacziarg–Welch and tariff liberalization. Across post-event horizons, adding Wacziarg–Welch changes the target coefficient by at most 0.0093, and adding the tariff interaction on top changes it by at most 0.0004. The trade interactions themselves are not uniformly zero, so this stability should not be read as evidence that trade reforms have no sectoral effects. Rather, controlling for contemporaneous trade liberalization does not explain away the capital-account $\times$ ISTC response.

As a further check, I replace capital-account liberalization with Wacziarg–Welch trade opening and run the same LP-DiD design. The standalone trade estimates are substantially noisier and do not exhibit a stable strong-institution advantage. The trade-treated sample is also much smaller—41 in-panel Wacziarg–Welch events compared with 175 Chinn–Ito episodes—so I interpret this as an absence of a detectable analogue in the available trade sample rather than evidence of a structural zero. The sharper identification result is the stability of the headline capital-account coefficient after controlling directly for contemporaneous trade reforms.

2.8 Additional robustness and interpretation

The appendix collects the remaining empirical exercises. It reports the direct pooled WGI and Formality differences over the full horizon, the individual WGI components and International Property Rights Index, alternative institutional thresholds and continuous interactions, and the standalone trade-liberalization estimates. Exact coefficient tables are kept there as numerical supplements to the main dynamic figures.

The empirical evidence leaves a specific set of facts for the model to rationalize. Capital-account liberalization is followed by a steeper ISTC gradient in stronger institutional environments; the ordering appears under both a broad WGI measure and the more enforcement-oriented Formality measure; and it is not reproduced systematically by narrower de jure credit-market indices. Direct trade controls leave the capital-account result essentially unchanged. None of these facts identifies a cardinal level of pledgeability. They motivate a model in which effective enforceability changes the extent to which industries can exploit technological improvements embodied in new capital.



Notes: Strong-institution (above-median WGI) sample and fixed CCS_10 control window. Intervals use the reghdfe residual degrees of freedom. $h = -1$ is normalized; the dashed vertical line marks reform. At $h = -2$ and -3 , the preserved lag controls span the dependent variable, so those coefficients are mechanically zero.

Figure 4: Capital-account ISTC response with trade-liberalization controls. Panel A reproduces the headline strong-WGI Chinn–Ito specification using the same fixed clean-control window as Figure 1. Panel B adds Wacziarg–Welch opening $\times$ ISTC, and Panel C additionally adds tariff liberalization $\times$ ISTC. The estimation sample is unchanged across panels. Shading gives 95 percent confidence intervals using the finite-sample t reference distribution implied by the two-way country/year clustered estimator. Horizon -1 is normalized to zero.

3 Model

3.1 Households

Time is discrete. A mass n_t of agents is born each period and lives for two periods. Population evolves according to $n_{t+1} = (1 + \nu)n_t$. Preferences are

$$U_t = u(c_t^y) + \beta \mathbb{E}_t[u(c_{t+1}^o)], \quad u(c) = \frac{c^{1-\gamma} - 1}{1 - \gamma}. \quad (4)$$

Young agents work inelastically, earn wage income w_t , consume, and save s_t through competitive banks,

$$c_t^y + s_t = w_t. \quad (5)$$

When old, agents operate entrepreneurial projects and consume entrepreneurial profits plus the lump-sum transfer τ_{t+1} rebated by the financial sector,

$$c_{t+1}^o = \sum_i \Pi_{i,t+1} + \tau_{t+1}. \quad (6)$$

Let $R_{i,t+1}^E \equiv \partial \Pi_{i,t+1} / \partial s_{it}$ denote the marginal old-age payoff generated by one additional unit of youth saving when the entrepreneur operates in sector i . Because sector choice is probabilistic, the saving Euler equation weights these returns by the endogenous entrepreneur shares $\omega_{i,t+1}$:

$$u'(c_t^y) = \beta \mathbb{E}_t \left[\sum_i \omega_{i,t+1} R_{i,t+1}^E \right] u'(c_{t+1}^o). \quad (7)$$

This Euler equation links household saving directly to the sectoral financing problem below. The quantitative implementation solves the saving choice jointly with sectoral investment, prices, and

entrepreneur allocation.

3.2 Intermediate production and embodied technological change

There are I intermediate industries. A firm in sector i produces

$$y_{it} = A_t k_{it}^\alpha n_{it}^{1-\alpha}, \quad (8)$$

where α is the production capital share. Investment-specific technological change enters through q_{it} : one unit of the investment good purchases q_{it} units of effective capital services. Sectoral ISTC follows

$$q_{it} = q_{i0}(1 + g_i)^t, \quad (9)$$

with g_i varying across industries. Capital evolves as

$$k_{i,t+1} = (1 - \delta)k_{it} + q_{it}(R_t^d s_{it} + \ell_{it}). \quad (10)$$

Given next-period capital, the entrepreneur chooses labor to maximize operating surplus,

$$\Xi_{i,t+1}(k_{i,t+1}) = \max_{n_{i,t+1}} \left\{ p_{i,t+1} A_{t+1} k_{i,t+1}^\alpha n_{i,t+1}^{1-\alpha} - w_{t+1} n_{i,t+1} \right\}. \quad (11)$$

The labor first-order condition is

$$n_{i,t+1}^* = \left(\frac{(1 - \alpha) p_{i,t+1} A_{t+1}}{w_{t+1}} \right)^{1/\alpha} k_{i,t+1}. \quad (12)$$

Substitution makes the operating value linear in installed capital,

$$\Xi_{i,t+1}(k_{i,t+1}) = \Gamma_{i,t+1} k_{i,t+1}, \quad \Gamma_{i,t+1} = \alpha p_{i,t+1}^{1/\alpha} A_{t+1}^{1/\alpha} \left(\frac{1 - \alpha}{w_{t+1}} \right)^{(1-\alpha)/\alpha}. \quad (13)$$

Thus equilibrium prices and wages enter the entrepreneur's investment return through $\Gamma_{i,t+1}$.

3.3 Financial liberalization and pledgeability

Entrepreneurs finance investment with internal funds and borrowing. Borrowing carries the gross rate

$$R_t^b = R^* + \mu_t, \quad (14)$$

where μ_t is a capital-control wedge. Financial liberalization is an unanticipated permanent decline in μ_t .

Borrowing is limited by enforceability. Let $\theta_t \in (0, 1]$ denote effective pledgeability. The collateral condition is

$$R_t^b \ell_{it} \leq \theta_t q_{it} (R_t^d s_{it} + \ell_{it}). \quad (15)$$

Define

$$\phi_{it} \equiv \frac{\theta_t q_{it}}{R_t^b}. \quad (16)$$

The role of θ is deliberately narrow: it is the enforceable share of installed capital value that can support promised repayment. This is why the empirical Formality measure is useful as a proxy for the ordering of enforcement environments, while it would be inappropriate to equate the numerical Formality score with θ itself.

For the regime distinction it is useful to define internal funds $e_{it} \equiv R_t^d s_{it}$ and a financing multiple

$$m_{it} \equiv \frac{e_{it} + \ell_{it}}{e_{it}} = 1 + \frac{\ell_{it}}{e_{it}}. \quad (17)$$

This notation is distinct from the production capital share α .⁵ Substituting $\ell_{it} = (m_{it} - 1)e_{it}$ into equation (15) gives

$$m_{it}(1 - \phi_{it}) \leq 1. \quad (18)$$

When $\phi_{it} < 1$, pledgeability therefore implies the finite cap

$$m_{it}^{\text{cap}} = \frac{1}{1 - \phi_{it}}. \quad (19)$$

Let m_{it}^* denote the financing scale implied by the unconstrained investment first-order condition. Three regimes are then distinct:

$$\begin{aligned} \text{constrained: } \phi_{it} < 1, \quad m_{it}^* &> m_{it}^{\text{cap}}, \\ \text{graduated: } \phi_{it} < 1, \quad m_{it}^* &\leq m_{it}^{\text{cap}}, \\ \text{saturated: } \phi_{it} &\geq 1. \end{aligned}$$

Thus $\phi < 1$ means that the collateral condition supplies a finite cap; it does not imply that the cap binds at the optimum. Likewise, $\phi \geq 1$ is sufficient for slackness but is not the only slack regime.⁶

3.4 Investment choice

On the binding branch, borrowing is set at the cap and next-period capital is

$$\ell_{it} = \frac{\phi_{it}}{1 - \phi_{it}} e_{it}, \quad k_{i,t+1} = (1 - \delta)k_{it} + \frac{R_t^d s_{it} q_{it}}{1 - \phi_{it}}. \quad (20)$$

When the collateral cap is slack—either because the sector has graduated or because it is literally saturated—investment satisfies the unconstrained condition

$$\Gamma_{i,t+1} q_{it} + (1 - \delta) \frac{q_{it}}{q_{i,t+1}} = R_t^b + q_{it} \psi(\iota_{it} - \delta), \quad (21)$$

⁵The multiple has a simple leverage interpretation: $m = 1$ means no borrowing, $m = 2$ means external borrowing equals internal funds, and in general $\ell/e = m - 1$.

⁶At the knife-edge equality $m^* = m^{\text{cap}}$, the collateral multiplier is zero. I classify this case as graduated.

where

$$\iota_{it} \equiv \frac{q_{it}(R_t^d s_{it} + \ell_{it})}{k_{it}}, \quad \Phi(\iota_{it}) = \frac{\psi}{2}(\iota_{it} - \delta)^2. \quad (22)$$

The unconstrained investment rate is therefore

$$\iota_{it}^* = \delta + \frac{\Gamma_{i,t+1} - R_t^b/q_{it} + (1 - \delta)/q_{i,t+1}}{\psi}, \quad (23)$$

and the desired financing multiple is

$$m_{it}^* = \frac{\iota_{it}^* k_{it}}{q_{it} e_{it}}. \quad (24)$$

Equation (19) and the last expression make the economic binding test transparent: the cap matters only when desired investment lies above it.

Given saving and borrowing choices, old-age entrepreneurial profit net of debt repayment and adjustment costs is

$$\Pi_{i,t+1} = \Gamma_{i,t+1} k_{i,t+1} - R_t^b \ell_{it} - \Phi(\iota_{it}) k_{it} - \frac{1 - \delta}{q_{it}} k_{it} + \frac{1 - \delta}{q_{i,t+1}} k_{i,t+1}. \quad (25)$$

The last two terms value the undepreciated capital carried into and out of the one-period entrepreneurial project in investment-good units. The marginal return entering the household Euler equation is therefore

$$R_{i,t+1}^E \equiv \frac{\partial \Pi_{i,t+1}}{\partial s_{it}}. \quad (26)$$

Proposition 1 (Collateral amplification under a binding constraint). *Suppose $\phi_{it} < 1$ and $m_{it}^* > m_{it}^{\text{cap}}$, so that the collateral cap actually binds. Holding current internal funds and the local equilibrium objects fixed, a reduction in the capital-control wedge raises next-period capital. Within the binding region, the response is stronger in sectors with higher q_{it} and under higher pledgeability:*

$$\frac{\partial k_{i,t+1}}{\partial \mu_t} < 0, \quad \frac{\partial^2 k_{i,t+1}}{\partial \mu_t \partial q_{it}} < 0, \quad \frac{\partial^2 k_{i,t+1}}{\partial \mu_t \partial \theta_t} < 0. \quad (27)$$

The proof, given in Appendix D.3, uses the binding expression (20). The proposition is local to the active set: $\phi < 1$ alone is not sufficient.

Corollary 1 (Collateral channel after graduation). *Suppose the collateral cap is slack at the entrepreneur's optimum and remains slack under the marginal changes considered. Conditional on prices, returns, and state variables, θ_t does not enter the unconstrained investment rule. Hence the direct collateral component of the response to liberalization vanishes after graduation. This result applies both to a graduated sector with $\phi_{it} < 1$ and to a literally saturated sector with $\phi_{it} \geq 1$.*

The qualification is local: in general equilibrium, changing θ can still affect a graduated sector indirectly through wages, prices, saving, or the behavior of other sectors.

Lemma 1 (Marginal value of internal funds in the slack regime). *When the collateral cap is slack, internal and external funds are marginal substitutes at market rates. The marginal value of one unit*

of saving carried into entrepreneurship is

$$R_{i,t+1}^E = R_t^b R_t^d. \quad (28)$$

Remark 1 (ISTC heterogeneity remains after graduation). *Graduation removes the sector's direct θ -dependent collateral channel, not all heterogeneity. From equation (23),*

$$\frac{\partial \nu_{it}^*}{\partial \mu_t} = -\frac{1}{\psi q_{it}}. \quad (29)$$

Thus sectoral ISTC can continue to shape the response to liberalization even when collateral is slack.

3.5 Sector choice, final demand, and prices

The entrepreneur share allocated to sector i evolves according to a smoothed multinomial-logit rule. Let ω_{it} denote this entrepreneur share, distinct from the financing multiple m_{it} . With intensity λ and inertia parameter ρ_ω ,

$$\omega_{i,t+1} = (1 - \rho_\omega)\omega_{it} + \rho_\omega \frac{\exp\{\lambda \mathbb{E}_t[\Pi_{i,t+1}^e]\}}{\sum_j \exp\{\lambda \mathbb{E}_t[\Pi_{j,t+1}^e]\}}, \quad (30)$$

where $\Pi_{i,t+1}^e$ is the expected entrepreneurial payoff index associated with sector i , constructed from the profit object in equation (25). This rule allows profitability differences to move entrepreneur shares gradually rather than reallocating the entire cohort on impact. In the baseline calibration, changes in entrepreneur shares are small relative to the capital and price responses.

A competitive final-good producer aggregates intermediates using

$$Y_t = \left(\sum_i \zeta_i y_{it}^{(\epsilon-1)/\epsilon} \right)^{\epsilon/(\epsilon-1)}, \quad \sum_i \zeta_i = 1. \quad (31)$$

Demand for intermediate i is

$$y_{it} = \zeta_i^\epsilon \left(\frac{p_{it}}{p_t} \right)^{-\epsilon} Y_t, \quad (32)$$

with the final-good price index normalized to one. Nominal sectoral value added therefore satisfies

$$\frac{p_{it} y_{it}}{p_{jt} y_{jt}} = \left(\frac{\zeta_i}{\zeta_j} \right)^\epsilon \left(\frac{p_{it}}{p_{jt}} \right)^{1-\epsilon}. \quad (33)$$

When $\epsilon > 1$, a larger relative-price decline raises a sector's nominal value-added share. This relative-price margin is relevant to the empirical outcome because the data are deflated by a common country-year GDP deflator rather than by industry-specific price indices.

3.6 Graduation and diminishing institutional amplification

The distinction between a finite collateral cap and an actually binding cap implies that institutional amplification can begin to attenuate before literal saturation.

Proposition 2 (Graduation before collateral saturation). *Suppose the unconstrained desired financing multiple m_{it}^* is finite and exceeds one. For $\phi_{it} < 1$, define the graduation threshold*

$$\phi_{it}^G \equiv 1 - \frac{1}{m_{it}^*}. \quad (34)$$

Then $0 < \phi_{it}^G < 1$, and the collateral cap is slack whenever

$$\phi_{it} \geq \phi_{it}^G \iff m_{it}^* \leq m_{it}^{\text{cap}}. \quad (35)$$

Hence a sector can become unconstrained before literal collateral saturation, $\phi_{it} = 1$.

The threshold ϕ_{it}^G is a local regime condition rather than a fixed structural cutoff in θ : in general equilibrium, m_{it}^* moves with prices, wages, capital, and internal funds. Proposition 2 therefore establishes the possibility of attenuation before saturation, while the quantitative model determines the sectoral ordering of graduation and the location of the peak in the cross-industry response.

Higher q_i mechanically raises ϕ_i and expands the collateral cap more rapidly. It also changes desired investment and equilibrium prices, so the statement that high-ISTC sectors graduate first is not imposed as a theorem. It is a quantitative implication of the parameterized model, documented in Section 4.

3.7 Equilibrium and external balance

Labor-market clearing requires

$$\sum_i n_{it} = n_t. \quad (36)$$

With C_t denoting aggregate household consumption and I_t aggregate installed investment, the final-good resource constraint is

$$Y_t = C_t + I_t + NX_t. \quad (37)$$

Competitive banks intermediate household deposits and domestic entrepreneurial borrowing and hold the residual net foreign asset position B_t :

$$\sum_i n_t \ell_{it} + B_t = n_t s_t. \quad (38)$$

In the small-open-economy baseline, the world rate pins down the deposit return, $R_t^d = R^*$. The spread generated by the capital-control wedge is rebated to households,

$$\tau_{t+1} = (R_t^b - R^*) \sum_i n_t \ell_{it}, \quad (39)$$

and net foreign assets evolve according to

$$B_{t+1} = R^* B_t + N X_t. \quad (40)$$

A recursive competitive equilibrium consists of household saving and consumption, entrepreneur borrowing and investment, entrepreneur shares, intermediate labor demands and prices, the wage, bank positions and transfers, and the external asset path such that household and firm problems are solved, the collateral active set is respected, the CES final-good conditions hold, and equations (36)–(40) clear markets. Appendix E collects these conditions in compact form and Appendix F.1 describes the numerical transition solution.

4 Quantitative Comparative Statics

4.1 Quantitative design and parameterization

The numerical exercise is a comparative-static calculation across effective pledgeability environments, not an estimation of θ or a cardinal interpretation of an institutional index. The baseline uses the actual 22 manufacturing industries in the empirical sample, their continuous observed ISTC values, and equal model weights. The same piecewise-linear ISTC-to- g_i mapping is used throughout. I evaluate the predetermined grid $\theta = .05, .0625, \dots, .65$. No empirical LP-DiD coefficient is used to choose θ , the sector grid, or any model parameter.⁷

The model is annual and is simulated from a common pre-reform path. At the reform date the borrowing wedge falls permanently from $\mu = .07$ to zero, while the counterfactual leaves it unchanged. Table 3 reports the remaining parameters. The CES elasticity $\epsilon = 3.75$ follows the manufacturing value used by Ilyina and Samaniego (2012). The adjustment-cost coefficient $\psi = .30$ is an auxiliary benchmark; .15 and .60 are robustness values rather than a confidence interval. Appendix F.1 describes the transition solution and active-set diagnostics.

For each sector and horizon, define the reform-minus-counterfactual log value-added response

$$r_{i,h}(\theta) = [\ln \text{VA}_{i,T+h}^R - \ln \text{VA}_{i,T}^R] - [\ln \text{VA}_{i,T+h}^U - \ln \text{VA}_{i,T}^U], \quad (41)$$

where R denotes the liberalization path and U the no-reform path. The model ISTC gradient $\beta_h^M(\theta)$ is the equal-weight OLS slope from projecting the 22 sector responses $r_{i,h}(\theta)$ on the actual sectoral ISTC values.⁸ It is not the empirical LP-DiD estimator applied to a simulated panel and is not used as a calibration target.

⁷The grid is a numerical comparative-statics domain, not an empirical confidence region. Graduation and saturation thresholds are therefore numerical grid brackets rather than estimated institutional cutoffs.

⁸The empirical $\hat{\beta}_h$ is a residualized coefficient from an unbalanced country–industry–year LP-DiD with fixed effects and controls. The model slope is therefore an economic analogue of the cross-industry gradient, not an algebraically identical estimator.

Table 3: Baseline quantitative parameterization

Parameter	Value	Role / source
α	0.35	capital share
β	0.96	discount factor
γ	2.00	CRRA
δ	0.08	depreciation
ϵ	3.75	CES elasticity; Ilyina and Samaniego (2012)
R^*	1.02	world gross rate
μ	$0.07 \rightarrow 0$	capital-control wedge
ψ	0.30	adjustment-cost benchmark
λ	0.30	entrepreneur-choice intensity
ρ_ω	0.60	entrepreneur-allocation inertia
q_0	0.60	common initial quality level
I	22	actual empirical industries
ζ_i	1/22	equal CES weights
θ	0.05–0.65	comparative-static pledgeability grid

Notes: No empirical LP-DiD coefficient enters the parameterization. The $\psi = .15$ and .60 cases are broad sensitivity values, not a confidence interval.

4.2 Model-generated and empirical ISTC slopes

Figure 5 compares the empirical strong- and weak-WGI paths with two fixed model pledgeability environments. The strong-institution panel reports the model path at $\theta = .4125$, the model-defined five-year peak and the point at which all sectors have graduated at the five-year horizon. The weak-institution panel reports $\theta = .05$, the lower endpoint of the maintained grid and a tight-pledgeability benchmark. The two model benchmarks are defined by the model’s regime structure: $\theta = .4125$ is the five-year peak, where all sectors have graduated, while $\theta = .05$ represents tight pledgeability. No cardinal mapping from WGI to θ is imposed. The empirical and model objects have a related economic interpretation—a steeper response among higher-ISTC industries—but they are not identical estimators.

For stronger-WGI countries, the $\theta = .4125$ model path reproduces the gradual buildup of the response and is comparable in magnitude to the medium-run empirical estimates. The empirical coefficients are not used as calibration targets. For weaker-WGI counterparts, the tight-pledgeability path remains close to zero over the displayed horizons. This captures the attenuation of the ISTC response but not the negative empirical point estimates at several early and middle horizons. Horizon zero is excluded because the model reform-minus-no-reform response at the reform state is mechanically zero, whereas the empirical $h = 0$ outcome is $y_t - y_{t-1}$ and need not be zero. For this reason, $h = 0$ is omitted.

4.3 Pledgeability, graduation, and the collateral mechanism

Figure 6 combines the five-year pledgeability profile with the active financing regimes. Panel (a) compares the full model with a no-collateral-cap (NoCap) counterfactual that removes only the

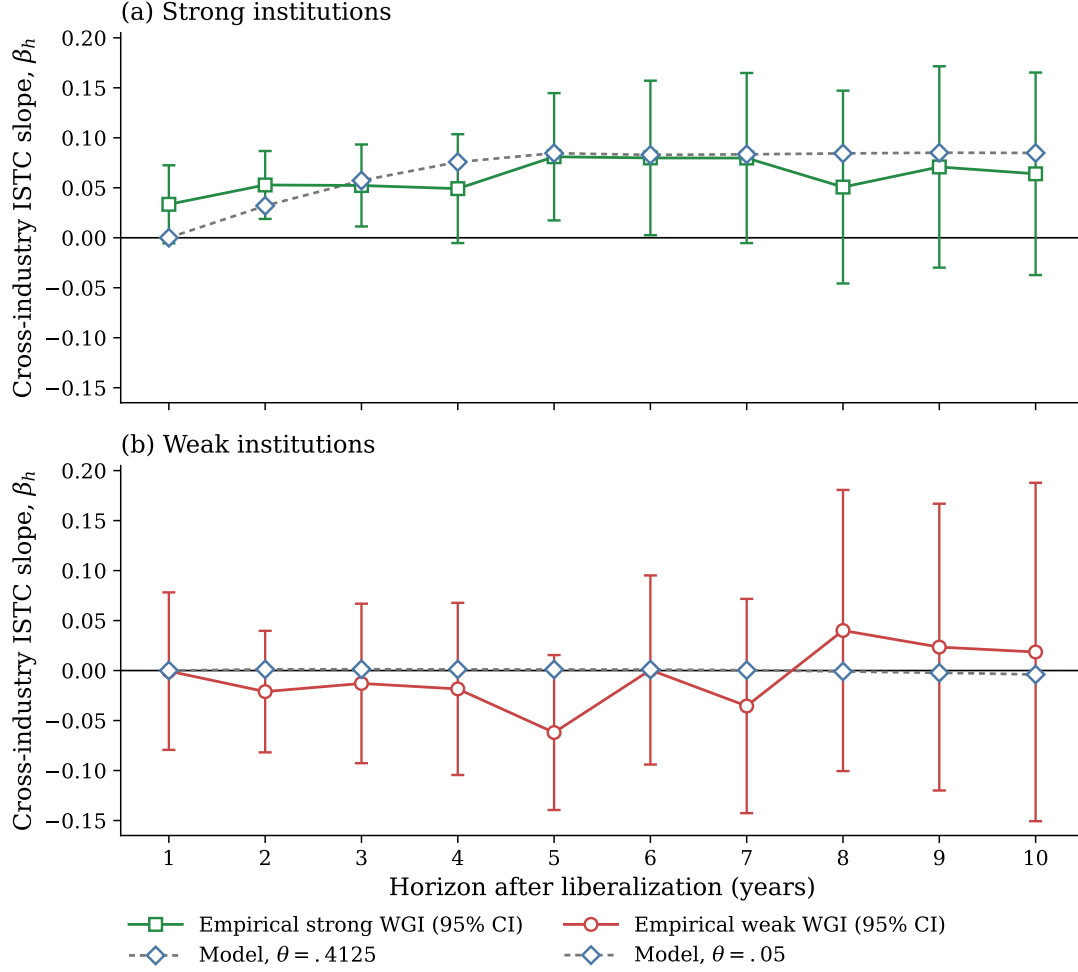


Figure 5: Empirical and model cross-industry ISTC-response slopes. Empirical markers report the baseline LP-DiD estimates with 95 percent confidence intervals for countries above and below the WGI median. The model line in Panel (a) uses $\theta = .4125$, the five-year peak, where all sectors have graduated; the model line in Panel (b) uses the tight-pledgeability benchmark $\theta = .05$. These model values are illustrative comparative-static environments and are not estimated mappings from WGI groups into θ .

collateral borrowing cap and leaves the remaining environment unchanged. Panel (b) reports each industry's active regime, sorting industries by ISTC from low to high. This sector-level panel makes the graduation ordering visible directly rather than repeating aggregate regime shares.

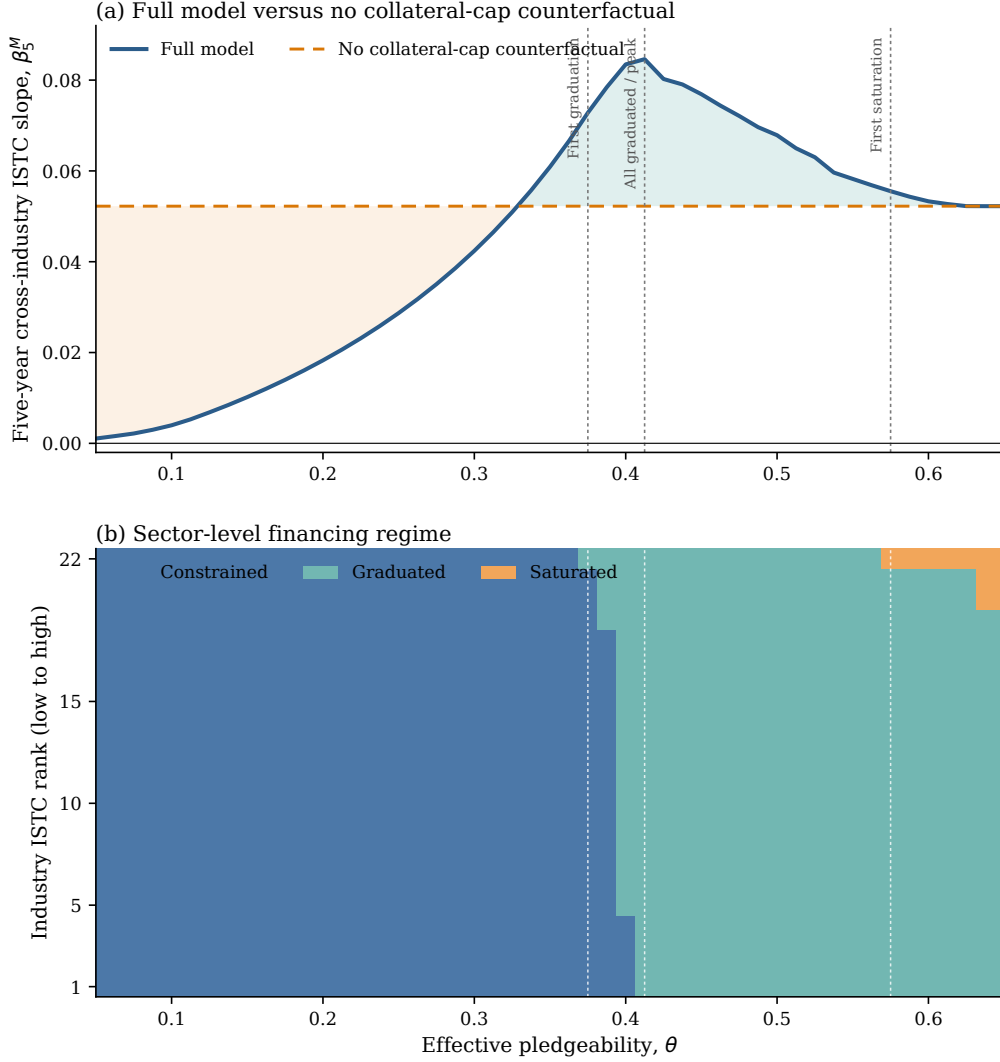


Figure 6: Pledgeability, the collateral mechanism, and financing regimes. Panel (a) reports the full-model five-year cross-industry ISTC slope and the θ -invariant no-collateral-cap counterfactual. Panel (b) reports the sector-level active regime, with industries ordered by ISTC from low to high; high-ISTC industries graduate first in the baseline quantitative transition. The horizontal axis is a comparative-static parameter, not a cardinal mapping from WGI or Formality.

At low pledgeability, tight collateral caps suppress the heterogeneous response to cheaper finance. At $\theta = .05$, the full-model slope is $\beta_5^{\text{Full}} = .001060$, compared with $\beta_5^{\text{NoCap}} = .052234$ in the NoCap economy. This negative Full-minus-NoCap difference means that tight collateral caps mute an underlying cross-industry ISTC response.

Over the intermediate region, higher pledgeability expands collateral-supported financing and the full-model gradient rises above the NoCap benchmark. Graduation begins at $\theta = .375$, and Panel (b) shows that the highest-ISTC industries are the first to exit the constrained regime. The full-model grid maximum is $\beta_5^{\text{Full}} = .084608$ at $\theta = .4125$, while $\beta_5^{\text{NoCap}} = .052234$. The difference, $.032374$, is the additional five-year cross-industry ISTC slope generated by the collateral/pledgeability

mechanism relative to the NoCap counterfactual. It is a within-model counterfactual, not a share of an empirical effect.

At higher pledgeability, graduation spreads and the direct collateral contribution falls. First literal saturation occurs only around $\theta = .575$. By $\theta = .65$, β_5^{Full} and β_5^{NoCap} are both approximately .05223. The downturn is therefore associated with the disappearance of actual binding through graduation; literal saturation is not required. Economically, once sectors are already largely unconstrained on the collateral margin, liberalization no longer receives much additional amplification from relaxing that margin. It still generates a positive differential response through the unconstrained investment rule, which is why the NoCap slope remains positive. Collateral constraints are therefore not the only source of heterogeneous sectoral responses. Pledgeability determines whether the collateral mechanism suppresses or amplifies that response, and its contribution disappears as sectors become unconstrained.

At $\theta = .4125$, all industries are classified as graduated at the reported five-year state even though the full-model gradient remains above NoCap. Graduation is a contemporaneous active-set condition. It does not erase capital stocks and equilibrium objects accumulated earlier in the transition, when collateral constraints affected financing. Appendix F reports the dynamic collateral increment.

4.4 Capital and equilibrium-price channels

In the model, sectoral log value added can be written, up to common terms, as a capital component plus a relative-price component. The exact cross-sector accounting identity is

$$\beta_h^{VA} = \beta_h^K + \frac{1}{\alpha} \beta_h^p. \quad (42)$$

Here α is the production capital share. The factor $1/\alpha$ follows from optimal labor adjustment under Cobb–Douglas production, so the plotted relative-price series is already the scaled contribution $(1/\alpha)\beta_h^p$. Figure 7 reports the identity at the five-year horizon.

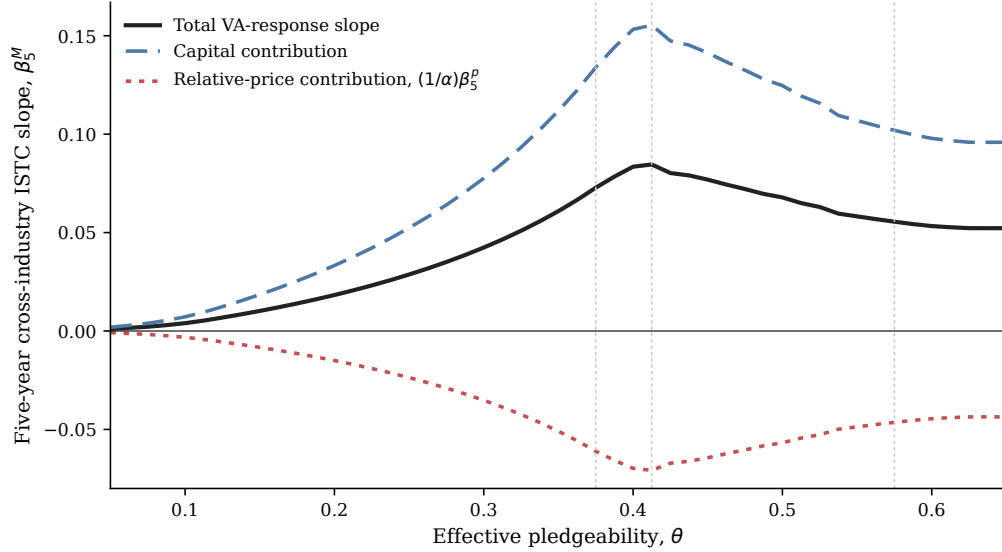


Figure 7: Capital and relative-price contributions to the five-year cross-industry ISTC slope. The relative-price line is the already-scaled contribution $(1/\alpha)\beta_5^P$, so the capital and price contributions sum to the total value-added response slope.

At $\theta = .4125$ and $h = 5$, the total cross-industry slope is .084608, the capital contribution is +.155365, and the relative-price contribution is $-.070757$. Differential capital deepening generates the positive cross-industry slope, while general-equilibrium relative-price adjustment offsets a substantial part of it. The price term is relevant for comparison with the empirical outcome because country-year GDP deflation removes a common country price component but leaves industry-relative price movements in producer-price value added. The entrepreneur-allocation response is quantitatively small and is reported separately in the appendix; it is not a third additive term in this identity.

4.5 Scope and robustness

The $\psi = .15$ and $.60$ sensitivity cases leave the qualitative mechanism intact even though quantitative magnitudes move substantially. The one-year response is small because capital is predetermined. Collateral amplification is primarily a transition mechanism and attenuates at longer horizons. Exact graduation, peak, and saturation thresholds are numerical features of the baseline parameterization rather than estimated institutional cutoffs. Detailed horizon and parameter sensitivity is reported in Appendix F.

5 Discussion

The model accounts for one central feature of the data. Stronger institutional environments exhibit positive medium-run ISTC slopes after capital-account liberalization, and the intermediate-pledgeability model path generates a response of similar magnitude without targeting the empirical coefficients. Effective pledgeability supplies an amplification mechanism: at low θ tight caps suppress

the heterogeneous response to cheaper finance, at intermediate θ expanding caps amplify it, and graduation eventually generates diminishing institutional amplification.

The model is less successful on the weak-institution side. The tight-pledgeability benchmark generates attenuation toward zero but not the negative weak-WGI point estimates observed at several early and medium horizons. Imported capital goods or intermediate inputs, FDI and technology transfer, and broader technology-adoption or organizational changes may contribute to the empirical difference. The trade-control results do not eliminate these possibilities: capital-account liberalization itself may facilitate such channels.

The NoCap counterfactual sharpens the mechanism interpretation. Removing the collateral cap leaves a positive ISTC gradient, so collateral is not the only source of heterogeneous sectoral responses. Instead, pledgeability determines whether the underlying response is suppressed or amplified. As sectors graduate, the incremental collateral contribution fades even before literal saturation. Capital deepening supplies the positive value-added gradient, while equilibrium relative-price movements partly offset it.

The exercise does not estimate θ . WGI and Formality distinguish relatively stronger from weaker institutional environments, but their numerical values are not mapped into the model's pledgeability parameter. The quantitative results should therefore be interpreted as comparative statics rather than country-specific estimates.

6 Conclusion

This paper shows that financial liberalization is followed by a stronger medium-run response of high-ISTC manufacturing industries in stronger institutional environments. The ordering appears under both *de jure* and *de facto* measures of financial liberalization and is more closely associated with broad governance and effective legal enforcement than with statutory creditor-rights indices.

The theory identifies effective pledgeability as an amplification mechanism. When collateral caps bind, liberalization expands investment more in high-ISTC sectors. Sectors can nevertheless graduate once desired financing falls below the finite cap, well before literal saturation. Sequential graduation therefore produces diminishing institutional amplification.

Using the actual 22-industry sector's ISTC values, the quantitative model produces medium-run slopes comparable in magnitude to the strong-WGI estimates without targeting those coefficients. The NoCap counterfactual leaves a positive slope, so collateral amplifies or suppresses underlying ISTC heterogeneity rather than creating it. Its incremental contribution is largest at intermediate pledgeability and fades after graduation. Capital deepening is positive, relative prices offset it, and the model generally does not reproduce the negative weak-institution point estimates.

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A Data Construction and Additional Empirical Detail

A.1 Source files, unit of observation, and sample construction

The empirical panel is organized at the country–industry–year level. Manufacturing outcomes come from UNIDO INDSTAT2. The estimation file retains ISIC Rev. 3 manufacturing industries 15–36, yielding the same 22 industries used in the empirical and quantitative analyses. The raw source contains substantially more countries than appear in any one regression. A country enters a given horizon only when the outcome, the required lags and controls, the relevant treatment series, the institutional split variable, and the clean-control indicators are all observed.

The regression is consequently unbalanced by construction. This matters for two reasons. First, the number of observations declines with the horizon as forward outcomes become unavailable. Second, the same industry need not receive the same implicit weight at every horizon because the baseline estimator is unweighted at the observation level. These facts are another reason not to describe the 22-point model slope as an exact algebraic reduction of the empirical coefficient.

Table 4: Selected sample counts in the empirical analysis

Treatment / sample	Countries at $h = 5$	Observations at $h = 5$	Comment
Chinn–Ito, full sample	68	18,005	Headline treatment
Chinn–Ito, strong WGI	32	11,334	Above-median WGI
Chinn–Ito, weak WGI	36	6,616	Below-median WGI
External Wealth of Nations, full sample	69	28,492	De facto integration treat- ment

Notes: Counts are reported for the five-year horizon. The strong and weak subsamples need not sum exactly to the full-sample observation count in every alternative treatment because institutional and treatment coverage differ. Horizon-specific missingness changes these counts away from $h = 5$.

A.2 UNIDO value added and deflation

The raw UNIDO field is value added at producers’ prices. The data pipeline reshapes the long-form table into a country-year-industry panel and constructs

$$\text{VA}_{ict}^{\text{real}} = \frac{\text{VA}_{ict}^{\text{nominal}}}{D_{ct}/100}, \quad (43)$$

where D_{ct} is the World Bank GDP deflator (NY.GDP.DEFL.ZS). The deflator varies only at the country-year level. Log value added is then winsorized at the 1st and 99th percentiles. This construction explains why the model’s relative-price term remains conceptually relevant even though the empirical variable is labeled real value added.

Writing $\text{VA}_{ict}^{\text{nominal}} = P_{ict}^{VA} Q_{ict}^{VA}$ gives

$$\ln \text{VA}_{ict}^{\text{real}} = \ln Q_{ict}^{VA} + \ln P_{ict}^{VA} - \ln(D_{ct}/100). \quad (44)$$

For a fixed regression horizon, the change in the common GDP deflator is the same for all industries observed in the same country and base year and is absorbed by the country-year fixed effect. A country-specific industry relative-price movement is not. The winsorization step means that this exact additive identity is mechanically censored for observations moved to a tail cutoff; for the rest of the sample it is an accounting identity. The empirical outcome should therefore be understood as GDP-deflator-adjusted producer-price value added, not as an industry-specific physical quantity index.

A.3 ISTC support and model mapping

The empirical sample contains 22 ISIC Rev. 3 manufacturing industries. The observed ISTC support spans roughly 3.19 to 5.15 and contains repeated values. The final quantitative model uses each observed industry separately with weight $1/22$. Sectoral ISTC is mapped into model growth rates through the piecewise-linear knots

$$(3.19, 0.015), \quad (3.68, 0.0177), \quad (4.17, 0.0205), \quad (4.66, 0.0232), \quad (5.15, 0.026).$$

No model fit criterion is used to choose the number or placement of sectors.

The mapping from the empirical ISTC measure to model g_i is a quantitative normalization, not an additional empirical estimate. It preserves the observed ordering of the 22 manufacturing industries and maps their empirical ISTC support into the model technology process used in the quantitative exercise.

A.4 Liberalization episodes

The empirical treatment is a large positive annual change in an underlying measure of financial openness. Chinn–Ito is the headline de jure measure and External Wealth of Nations is the de facto robustness measure. The episode indicator is non-absorbing: separate large changes in the same country may enter as separate events if they meet the clean-control restrictions. This differs from a one-time stock-market-liberalization date and is one reason the clean-control construction is important.

The event threshold is the pooled-panel 95th percentile of nonmissing annual first differences in the baseline empirical implementation. Because the treatment is an event rather than a permanent absorbing state, the clean-control restrictions are applied around every eligible episode rather than only around a country’s first liberalization.

A.5 Institutional variables and the interpretation of enforcement

The WGI composite is formed from the six Worldwide Governance Indicators and is used for the headline above/below-median split. Individual WGI components are then considered separately. Formality is based on Djankov et al. (2003); we reversed the sign so that a larger value corresponds

to less procedural formalism. Throughout the appendix, larger Formality values therefore denote less procedural formalism.

The empirical exercises distinguish these effective-institution measures from three de jure credit-market indices. The latter are informative about legal provisions but do not reproduce the same institutional moderation. This distinction supports an enforcement interpretation of θ but does not identify its level. A direct cardinal mapping would require an object such as the present value of enforceable secured-creditor proceeds relative to installed collateral value. No such measure is available in the current panel.⁹

A.6 Clean controls and timing

The empirical dependent variable at horizon h is $y_{ci,t+h} - y_{ci,t-1}$. Treated country-years are required to be free of liberalization episodes over the five preceding years. Controls must satisfy the same backward-clean condition and remain free of treatment through the ten-year forward window used in the baseline implementation. The control restriction is stronger than simply requiring $\text{Lib}_{ct} = 0$ in the base year. It prevents a control observation from being recently treated or imminently treated within the range over which the post-event outcomes are measured.

Missing forward outcomes and lagged controls make the estimation sample horizon-specific. The model response uses reform-minus-counterfactual changes from the shock date. Because the reform and no-reform paths share the same pre-shock history, using $T - 1$ rather than T as the common baseline does not change the reform-minus-counterfactual difference in the deterministic model. This cancellation is convenient for interpretation, but it does not make the model statistic the same estimator as the LP-DiD coefficient.

A.7 Exact baseline regression and weighting

For the WGI group g and horizon h , the baseline regression can be written as

$$\begin{aligned} \Delta_h \ln \text{VA}_{cit} = & \beta_{g,h}(\text{Lib}_{ct} \times \text{ISTC}_i) + \rho_1 \ln \text{VA}_{ci,t-1} + \rho_2 \ln \text{VA}_{ci,t-2} + \rho_3 \ln \text{VA}_{ci,t-3} \\ & + \rho_4(\ln \text{VA}_{ci,t-4} - \ln \text{VA}_{ci,t-6}) + \kappa \text{Share}_{ci,t-1} + \lambda_{ct} + \gamma_{it} + u_{cit,h}. \end{aligned} \quad (45)$$

The point estimates are unweighted. Inference is two-way clustered by country and year. There is no country-industry fixed effect in this specification. The fixed effects λ_{ct} and γ_{it} absorb the treatment main effect, the time-invariant ISTC main effect, aggregate country shocks, and global industry-by-year shocks.

⁹Even an observed cents-on-the-dollar recovery rate would not equal θ without aligning the denominator, enforcement costs, delays, priority, and collateral-value recovery with the model's installed-capital object.

B Additional Empirical Results

B.1 Direct institutional-difference inference

The main text presents WGI and Formality as separate strong/weak paths because that display makes the economic asymmetry easy to see. Formal inference on the difference uses a pooled regression. For each institutional measure and horizon, the pooled specification reproduces the two subgroup point estimates and computes the difference with the covariance implied by the two-way clustered variance matrix.

Table 5: Direct strong-minus-weak inference at the five-year horizon

Measure	Weak	Strong	Difference	Direct SE
WGI composite	-0.0620	0.0810	0.1430	0.0509
Formality	-0.0841	0.0374	0.1214	0.0660
Rule of Law	-0.0604	0.0669	0.1273	0.0598
Creditor Rights	0.0397	-0.0157	-0.0554	0.0809
Strength of Legal Rights	0.0112	0.0785	0.0673	0.0874
Depth of Credit Information	0.0264	0.0118	-0.0146	0.0606

Notes: Chinn–Ito treatment. Direct standard errors come from the pooled group-interacted regression with two-way clustering by country and year.

B.2 Strong and weak coefficients by institutional measure

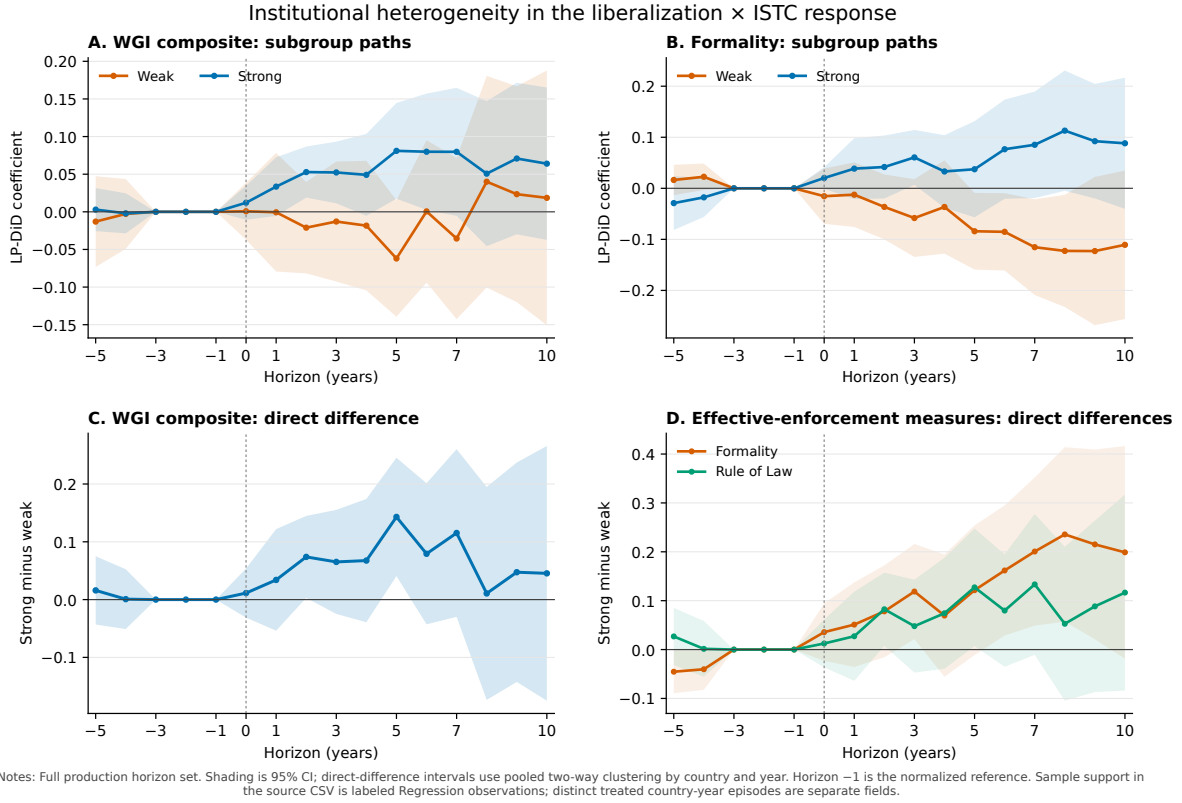


Figure 8: Institutional heterogeneity in the liberalization–ISTC response. Panels A and B show the LP-DiD coefficients for the strong- and weak-institution subsamples using the WGI composite and Formality, respectively. Panel C reports the strong-minus-weak difference for WGI, and Panel D reports the corresponding differences for Formality and Rule of Law. Shaded areas denote 95 percent confidence intervals. The strong-minus-weak coefficients in Panels C and D are estimated directly from regressions pooling the two institutional groups, with standard errors clustered by country and year.

Table 6: Strong and weak subsample coefficients by institutional measure

Measure	Strong subsample				Weak subsample				n_s/n_w
	$h = 3$	$h = 5$	$h = 7$	$h = 9$	$h = 3$	$h = 5$	$h = 7$	$h = 9$	
Rule of Law	.042* (.023)	.067** (.032)	.079** (.040)	.084* (.046)	-.006 (.040)	-.060 (.047)	-.054 (.055)	-.004 (.067)	39/40
Government Effectiveness	.025 (.025)	.053 (.037)	.070* (.042)	.065 (.048)	.017 (.039)	-.026 (.033)	-.027 (.046)	.046 (.057)	39/40
Regulatory Quality	.037* (.021)	.057* (.031)	.072* (.040)	.077* (.047)	.022 (.045)	-.021 (.048)	-.024 (.057)	.025 (.072)	39/40
Control of Corruption	.046** (.020)	.075** (.032)	.077* (.041)	.070 (.048)	.006 (.042)	-.052 (.041)	-.031 (.054)	.037 (.069)	39/40
Political Stability	.045** (.021)	.087*** (.029)	.104*** (.039)	.101** (.046)	.023 (.044)	-.044 (.047)	-.039 (.053)	.002 (.063)	40/39
Voice and Accountability	.037* (.019)	.064** (.030)	.067 (.041)	.070 (.048)	.009 (.058)	-.033 (.062)	-.007 (.082)	.038 (.094)	40/39
Property Rights (IPRI)	.050** (.022)	.067** (.032)	.071* (.043)	.064 (.049)	.027 (.054)	-.019 (.044)	.025 (.078)	.052 (.094)	61/61
Formality (sign reversed)	.061** (.027)	.037 (.047)	.085 (.052)	.092* (.056)	-.058 (.038)	-.084** (.038)	-.115** (.047)	-.123* (.073)	52/53
Creditor Rights	-.005 (.038)	-.016 (.057)	-.010 (.042)	-.038 (.059)	.013 (.036)	.040 (.052)	.066 (.056)	.081 (.061)	16/32
Strength of Legal Rights	.061 (.059)	.078 (.080)	.142* (.083)	.102 (.089)	.021 (.031)	.011 (.030)	.015 (.042)	.050 (.050)	33/44
Depth of Credit Information	.032 (.063)	.012 (.054)	-.017 (.046)	.041 (.066)	.034 (.026)	.026 (.033)	.048 (.041)	.063 (.046)	17/60

Notes: Each entry is the LP-DiD coefficient on $\text{Lib} \times \text{ISTC}$ after splitting at the median of the listed institutional measure. Standard errors are in parentheses. n_s/n_w denotes country counts above and below the relevant median. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

The side-by-side presentation is useful because a positive strong-minus-weak differential can in principle come from several configurations. For the broad institutional measures, the recurring pattern is a positive strong-side coefficient together with a weak-side coefficient near zero or negative. The direct creditor-rights measures do not show the same configuration.

B.3 Correlation among institutional measures

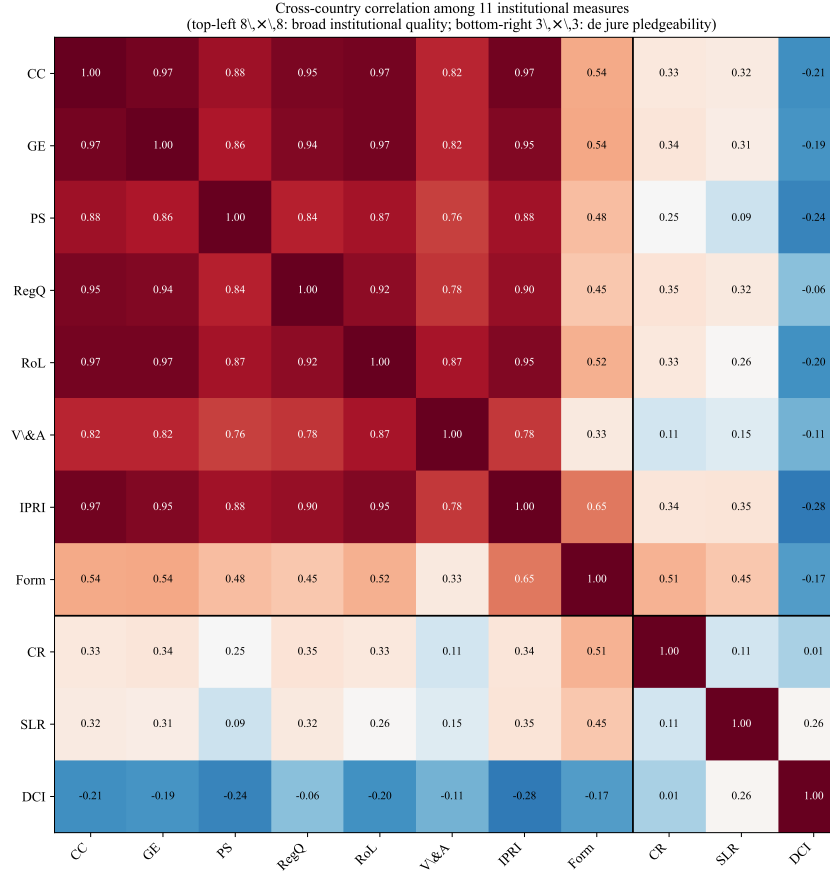


Figure 9: Cross-country correlation among institutional measures. WGI components form a tightly correlated block. Formality is less tightly correlated with WGI but remains positively related to the broad-quality cluster. The three de jure credit-market measures are substantially less aligned with the WGI block.

C Trade Liberalization Robustness

A possible alternative explanation is that capital-account reforms proxy for contemporaneous trade reforms. I therefore construct Wacziarg–Welch trade-opening dates and large tariff-reduction episodes, include them as controls in the capital-account LP-DiD, and estimate standalone trade-treatment specifications.

The overlap is limited in the exact event year. Of 175 Chinn–Ito episodes in the empirical analysis window, only six (3.4 percent) occur in exactly the same calendar year as a Wacziarg–Welch opening and four (2.3 percent) coincide exactly with a large tariff-reduction episode. The wider ± 5 window is a conservative diagnostic: 37 episodes fall within five years of a Wacziarg–Welch opening and 31 within five years of a large tariff reduction. Because the Wacziarg–Welch variable records one permanent opening date per country, later financial episodes can mechanically lie nearby.

Table 7: Capital-account and trade-liberalization episode overlap

Trade measure	Chinn–Ito episodes within ± 5 years	Fraction
Wacziarg–Welch opening	37	21.1%
Large tariff reduction	31	17.7%

Notes: Percentages use the 175 Chinn–Ito episodes in the LP-DiD analysis window and apply the same ± 5 -year timing metric across measures. Exact-year coincidences are six (3.4 percent) for Wacziarg–Welch openings and four (2.3 percent) for large tariff reductions. The table is a timing diagnostic; it does not by itself establish orthogonality of capital-account and trade reforms.

Table 8: Headline-aligned capital-account ISTC coefficient with trade-liberalization controls

Horizon	Baseline	+ Wacziarg–Welch	+ Wacziarg–Welch + tariff
1	.0335 (.0183)	.0326 (.0183)	.0327 (.0183)
3	.0523 (.0205)	.0583 (.0187)	.0587 (.0186)
5	.0810 (.0318)	.0822 (.0321)	.0825 (.0320)
7	.0797 (.0424)	.0883 (.0400)	.0886 (.0398)
10	.0640 (.0504)	.0707 (.0470)	.0711 (.0468)

Notes: Standard errors are in parentheses. All three columns use the exact headline strong-WGI Chinn–Ito sample and fixed clean-control window. The trade merge drops no headline observations; the five-year sample contains 11,334 observations in every column. Inference in the accompanying dynamic figure uses the finite-sample t reference distribution from the two-way country/year clustered estimator rather than normal-approximation significance stars.

The capital-account coefficient is preserved or modestly enlarged after the trade controls are included. At $h = 5$, for example, the point estimate changes from .0810 to .0822 and .0825. Across the full post-event path, the largest change relative to the baseline is below .01.

Neither standalone trade treatment generates a stable strong-minus-weak ISTC pattern. Because the trade-treated samples are smaller and tariff coverage begins late, these results are best interpreted as an absence of detectable evidence for an analogous trade channel, not as a precise zero restriction. The stronger evidence is the stability of the capital-account coefficient after directly controlling for trade episodes.

Table 9: Standalone trade-liberalization LP-DiD

h	Wacziarg–Welch		Tariff drop	
	Strong	Weak	Strong	Weak
1	.040 (.034)	-.064 (.078)	-.007 (.017)	-.038 (.045)
3	-.049 (.074)	.060 (.037)	-.050 (.042)	-.094 (.047)
5	-.044 (.044)	.026 (.051)	-.053 (.043)	-.044 (.058)
7	-.078 (.073)	.043 (.077)	-.072 (.069)	-.016 (.048)
10	-.084 (.119)	.007 (.076)	-.075 (.084)	.120 (.074)

Notes: The capital-account treatment is replaced by the indicated trade-liberalization episode. Strong and weak groups use the WGI median; the remainder of the LP-DiD specification is unchanged. Standard errors are in parentheses; significance markers are omitted because this auxiliary table is reported for pattern comparison rather than inference.

D Theory Derivations and Proofs

D.1 Collateral algebra and financing scale

Let $e_{it} = R_t^d s_{it}$ denote internal funds and define the financing multiple

$$m_{it} = \frac{e_{it} + \ell_{it}}{e_{it}}.$$

Then $\ell_{it} = (m_{it} - 1)e_{it}$. The collateral inequality is

$$R_t^b \ell_{it} \leq \theta_t q_{it} (e_{it} + \ell_{it}).$$

Substitution and division by positive internal funds yield

$$R_t^b (m_{it} - 1) \leq \theta_t q_{it} m_{it}.$$

With $\phi_{it} = \theta_t q_{it} / R_t^b$,

$$m_{it} (1 - \phi_{it}) \leq 1.$$

If $\phi_{it} < 1$, the collateral condition therefore imposes the finite upper bound

$$m_{it} \leq m_{it}^{\text{cap}} = \frac{1}{1 - \phi_{it}}.$$

If $\phi_{it} \geq 1$, the left-hand side is nonpositive or zero for every $m_{it} \geq 1$ after moving terms to one side, so the collateral inequality no longer supplies a finite upper bound. This is the literal saturation case.

The existence of a finite cap is distinct from actual binding. Let m_{it}^* be the financing scale chosen from the unconstrained investment problem. For $\phi_{it} < 1$, the realized scale is

$$m_{it} = \min\{m_{it}^*, m_{it}^{\text{cap}}\}.$$

The multiplier on the collateral constraint is positive only when $m_{it}^* > m_{it}^{\text{cap}}$. At equality, the entrepreneur sits at the cap with a zero multiplier; the quantitative classification treats this knife edge as graduated.

D.2 Unconstrained investment condition and the binding test

The adjustment cost is expressed per unit of existing capital,

$$AC_{it} = \frac{\psi}{2}(\iota_{it} - \delta)^2 k_{it}, \quad \iota_{it} = \frac{q_{it}(e_{it} + \ell_{it})}{k_{it}}.$$

Taking next-period prices and the marginal value of installed capital as given, the slack first-order condition is

$$\Gamma_{i,t+1} q_{it} + (1 - \delta) \frac{q_{it}}{q_{i,t+1}} - R_t^b - q_{it} \psi(\iota_{it} - \delta) = 0.$$

Solving gives equation (23). At the finite collateral cap, define

$$\iota_{it}^{\text{cap}} = \frac{m_{it}^{\text{cap}} q_{it} e_{it}}{k_{it}}.$$

The cap is actually binding when the unconstrained marginal return evaluated at the cap remains positive:

$$\Gamma_{i,t+1} q_{it} + (1 - \delta) \frac{q_{it}}{q_{i,t+1}} - q_{it} \psi(\iota_{it}^{\text{cap}} - \delta) - R_t^b > 0. \quad (46)$$

Equation (46) is equivalent to $\iota_{it}^* > \iota_{it}^{\text{cap}}$ and hence to $m_{it}^* > m_{it}^{\text{cap}}$. It is the economic binding condition used by the diagnostic implementation; $\phi < 1$ by itself is only the finite-cap condition.

D.3 Proof of Proposition 1

On the actually binding branch,

$$k_{i,t+1} = (1 - \delta)k_{it} + q_{it} e_{it} \frac{R_t^b}{R_t^b - \theta_t q_{it}},$$

where $e_{it} = R_t^d s_{it}$ and $R_t^b = R^* + \mu_t$. Holding e_{it} and local equilibrium objects fixed,

$$\frac{\partial k_{i,t+1}}{\partial \mu_t} = - \frac{e_{it} \theta_t q_{it}^2}{(R_t^b - \theta_t q_{it})^2} < 0.$$

Differentiating with respect to q_{it} ,

$$\frac{\partial^2 k_{i,t+1}}{\partial \mu_t \partial q_{it}} = - \frac{2e_{it} \theta_t q_{it} R_t^b}{(R_t^b - \theta_t q_{it})^3} < 0.$$

Differentiating with respect to θ_t ,

$$\frac{\partial^2 k_{i,t+1}}{\partial \mu_t \partial \theta_t} = -\frac{e_{it} q_{it}^2 (R_t^b + \theta_t q_{it})}{(R_t^b - \theta_t q_{it})^3} < 0.$$

These derivatives are valid while the cap remains binding. Crossing into the graduated region changes the active set, which is precisely why the global θ comparative statics need not remain monotone.

D.4 Proof of Proposition 2

For $\phi < 1$, the finite collateral cap is $m^{\text{cap}} = 1/(1 - \phi)$. The entrepreneur is graduated when $m^* \leq m^{\text{cap}}$. For any finite $m^* > 1$, define $\phi^G = 1 - 1/m^*$. Then $0 < \phi^G < 1$, and

$$m^* \leq \frac{1}{1 - \phi} \iff \phi \geq 1 - \frac{1}{m^*} = \phi^G.$$

Thus the cap can be slack while $\phi < 1$, proving that graduation can occur strictly before literal saturation at $\phi = 1$.

An equivalent multiplier condition can be written using the unconstrained FOC evaluated at the constrained investment rate ι^{cap} :

$$\Gamma_{i,t+1} q_{it} + (1 - \delta) \frac{q_{it}}{q_{i,t+1}} - q_{it} \psi(\iota_{it}^{\text{cap}} - \delta) - R_t^b > 0.$$

The cap binds when this margin is positive; equality is the graduation boundary.

D.5 Proof of Lemma 1

Let $e_{it} = R_t^d s_{it}$ denote internal funds and let $x_{it} = e_{it} + \ell_{it}$ denote total financing. In the slack regime, write entrepreneurial profit, holding the inherited state fixed, as

$$\Pi_{i,t+1} = V_{it}(x_{it}) - R_t^b \ell_{it} = V_{it}(x_{it}) - R_t^b (x_{it} - e_{it}),$$

where $V_{it}(x)$ collects the operating return, adjustment cost, and continuation value generated by total investment financing x . The unconstrained optimum satisfies $V'_{it}(x_{it}^*) = R_t^b$. By the envelope theorem,

$$\frac{\partial \Pi_{i,t+1}^*}{\partial e_{it}} = R_t^b.$$

Since $\partial e_{it} / \partial s_{it} = R_t^d$,

$$R_{i,t+1}^E = \frac{\partial \Pi_{i,t+1}^*}{\partial s_{it}} = R_t^d R_t^b.$$

The argument requires only a zero collateral multiplier, so it applies to both graduated and literally saturated sectors.

D.6 Relative prices and value added

CES demand implies

$$y_i = \zeta_i^\epsilon p_i^{-\epsilon} Y$$

under the unit final-good price normalization. Hence

$$p_i y_i = \zeta_i^\epsilon p_i^{1-\epsilon} Y.$$

For any sectors i, j ,

$$\frac{p_i y_i}{p_j y_j} = \left(\frac{\zeta_i}{\zeta_j} \right)^\epsilon \left(\frac{p_i}{p_j} \right)^{1-\epsilon}.$$

When $\epsilon > 1$, a sector whose relative price falls more experiences a larger increase in nominal value added relative to other sectors, holding the final aggregate fixed. In the empirical data, common GDP deflation removes aggregate country inflation but leaves these relative industry valuations in the outcome.

For the numerical decomposition, the Cobb–Douglas labor condition implies

$$y_{it} = k_{it} A_t^{1/\alpha} \left(\frac{(1-\alpha)p_{it}}{w_t} \right)^{(1-\alpha)/\alpha}.$$

Multiplying by p_{it} and taking logs,

$$\ln(p_{it} y_{it}) = \ln k_{it} + \frac{1}{\alpha} \ln p_{it} + C_t,$$

where C_t is common across industries at a date. A cross-industry slope of reform-minus-counterfactual responses therefore satisfies the accounting identity

$$\beta_h^{VA} = \beta_h^K + \frac{1}{\alpha} \beta_h^p.$$

The entrepreneur-allocation statistic reported in the numerical appendix is not a third additive term in this identity; it is a separate diagnostic for whether changes in ω_{it} are quantitatively large.

E Equilibrium Conditions

Given the exogenous sequences $\{A_t, n_t, \{q_{it}\}_i, R^*, \mu_t, \theta_t\}_{t \geq 0}$ and initial states, a recursive competitive equilibrium is a sequence of household choices, sectoral allocations, prices, financing decisions, entrepreneur shares, bank positions, and net foreign assets satisfying the following conditions.

Households. Young households satisfy

$$c_t^y + s_t = w_t, \tag{47}$$

and optimal saving obeys

$$u'(c_t^y) = \beta \mathbb{E}_t \left[\sum_i \omega_{i,t+1} R_{i,t+1}^E \right] u'(c_{t+1}^o). \quad (48)$$

The deposit return is pinned down by the world rate,

$$R_t^d = R^*. \quad (49)$$

Production and financing. For each sector i , production and capital accumulation satisfy

$$y_{it} = A_t k_{it}^\alpha n_{it}^{1-\alpha}, \quad (50)$$

$$k_{i,t+1} = (1 - \delta)k_{it} + q_{it}(R_t^d s_{it} + \ell_{it}). \quad (51)$$

Borrowing satisfies

$$R_t^b \ell_{it} \leq \theta_t q_{it}(R_t^d s_{it} + \ell_{it}), \quad R_t^b = R^* + \mu_t. \quad (52)$$

Let m_{it}^* denote desired financing under the unconstrained investment condition and $m_{it}^{\text{cap}} = 1/(1 - \phi_{it})$ when $\phi_{it} < 1$, with $\phi_{it} = \theta_t q_{it}/R_t^b$. The realized financing multiple satisfies the active-set rule

$$m_{it} = \begin{cases} \min\{m_{it}^*, m_{it}^{\text{cap}}\}, & \phi_{it} < 1, \\ m_{it}^*, & \phi_{it} \geq 1, \end{cases} \quad (53)$$

subject to the no-borrowing lower bound $m_{it} \geq 1$. On the slack branch, m_{it}^* is implied by

$$\Gamma_{i,t+1} q_{it} + (1 - \delta) \frac{q_{it}}{q_{i,t+1}} = R_t^b + q_{it} \psi(\ell_{it} - \delta). \quad (54)$$

Entrepreneur allocation and final demand. Entrepreneur shares evolve according to

$$\omega_{i,t+1} = (1 - \rho_\omega) \omega_{it} + \rho_\omega \frac{\exp\{\lambda \mathbb{E}_t[\Pi_{i,t+1}^e]\}}{\sum_j \exp\{\lambda \mathbb{E}_t[\Pi_{j,t+1}^e]\}}, \quad \sum_i \omega_{it} = 1. \quad (55)$$

The final-good producer satisfies

$$Y_t = \left(\sum_i \zeta_i y_{it}^{(\epsilon-1)/\epsilon} \right)^{\epsilon/(\epsilon-1)}, \quad (56)$$

$$y_{it} = \zeta_i^\epsilon p_{it}^{-\epsilon} Y_t, \quad (57)$$

$$1 = \left(\sum_i \zeta_i^\epsilon p_{it}^{1-\epsilon} \right)^{1/(1-\epsilon)}, \quad (58)$$

where the last equation is the final-good price normalization.

Market clearing and external balance. Labor and goods markets clear according to

$$\sum_i n_{it} = n_t, \quad (59)$$

$$Y_t = C_t + I_t + NX_t. \quad (60)$$

Competitive banks satisfy

$$\sum_i n_t \ell_{it} + B_t = n_t s_t, \quad (61)$$

and the borrowing wedge is rebated lump-sum,

$$\tau_{t+1} = (R_t^b - R^*) \sum_i n_t \ell_{it}. \quad (62)$$

Net foreign assets evolve as

$$B_{t+1} = R^* B_t + NX_t. \quad (63)$$

Together with the profit definition and labor-demand condition in Section 3, these equations determine the equilibrium transition, including the endogenous collateral active set.

F Quantitative Implementation and Robustness

F.1 Numerical design and solution protocol

The quantitative exercise uses annual periods, $T = 40$, and a reform after the fifteenth simulated period. The no-reform and reform economies share the same history up to the shock. The reform permanently lowers the borrowing wedge from 0.07 to zero. For each θ and ψ cell, the transition is solved for the full 22-sector economy and the full annual transition path is stored; selected robustness diagnostics are reported at $h \in \{1, 3, 5, 7, 10\}$.

The entrepreneur block is solved with an active-set logic. The solution algorithm computes the collateral cap and unconstrained financing choice separately and determines the active regime from the converged binding condition.

All 147 cells in the final 3×49 (ψ, θ) grid converge and all 22 sectors are retained in every cell. Post-processing verifies that sector weights sum to one, regime shares sum to one, and the value-added decomposition identity holds to numerical precision.

F.2 Parameter choices and what disciplines them

Table 10 distinguishes externally anchored parameters from auxiliary numerical choices; sensitivity to the latter is reported below.

The adjustment-cost coefficient deserves particular caution because numerical magnitudes are sensitive to it. The baseline $\psi = .30$ is retained as a transparent auxiliary benchmark rather than presented as a structural estimate. Annual manufacturing studies use a variety of convex-cost

Table 10: Quantitative parameters: interpretation and discipline

Parameter	Baseline	Status	Comment
α	.35	conventional	Manufacturing capital share.
β	.96	conventional	Annual discounting.
γ	2	conventional	CRRA curvature.
δ	.08	conventional	Annual depreciation.
ϵ	3.75	literature anchor	Manufacturing elasticity used by Ilyina and Samaniego (2012).
R^*	1.02	normalization	Annual world gross rate.
μ	$.07 \rightarrow 0$	experiment	Pre/post borrowing wedge defining liberalization.
ψ	.30	auxiliary benchmark	Broad robustness at .15 and .60.
λ	.30	auxiliary	Entrepreneur-choice sensitivity.
ρ_ω	.60	auxiliary	Inertia in entrepreneur allocation.
q_0	.60	normalization	Common initial quality level.
g_i	ISTC mapping	data ordered	Piecewise-linear mapping from observed sector ISTC.
θ	.05–.65	comparative statics	Not calibrated to WGI, Formality, or LP-DiD coefficients.

normalizations and often combine quadratic costs with fixed or irreversible adjustment costs. The wide $\{.15, .30, .60\}$ exercise is therefore best read as sensitivity, not as a confidence interval.

F.3 Summary of baseline dynamics

Table 11: Peak model ISTC slope by horizon, baseline $\psi = .30$

Horizon	Grid location of maximum	Maximum β_h^M
1	.4750	.00007
3	.4625	.07178
5	.4125	.08461
7	.4125	.08347
10	.4375	.08516

Notes: Maxima are descriptive grid summaries, not estimated values of θ . The one-year gradient is economically negligible because the relevant capital stock is predetermined by model timing.

Table 12: Five-year adjustment-cost sensitivity

ψ	Peak θ	Peak β_5^M	Graduated share at peak	Saturated share at peak
.15	.4750	.10535	100.0%	0.0%
.30	.4125	.08461	100.0%	0.0%
.60	.3875	.05146	81.8%	0.0%

The peak varies by roughly a factor of two across these values. The robust result is the intermediate region of institutional amplification followed by attenuation before literal saturation. For $\psi = .15$ the high- θ region is flatter and mildly irregular; for $\psi = .60$ the downturn is sharper and low- θ five-year gradients can be slightly negative.

F.4 Dynamic collateral contribution

Define the collateral contribution at horizon h as the within-model difference

$$\Delta_h^{\text{coll}}(\theta) = \beta_h^{\text{Full}}(\theta) - \beta_h^{\text{NoCap}}. \quad (64)$$

Figure 10 shows that this contribution is strongest in the medium-run transition and fades at longer horizons. Negative values at low pledgeability indicate that tight caps suppress the heterogeneous response present in the NoCap economy; they should not be interpreted as negative collateral finance. The one-year contribution is approximately zero by model timing and is omitted for readability.

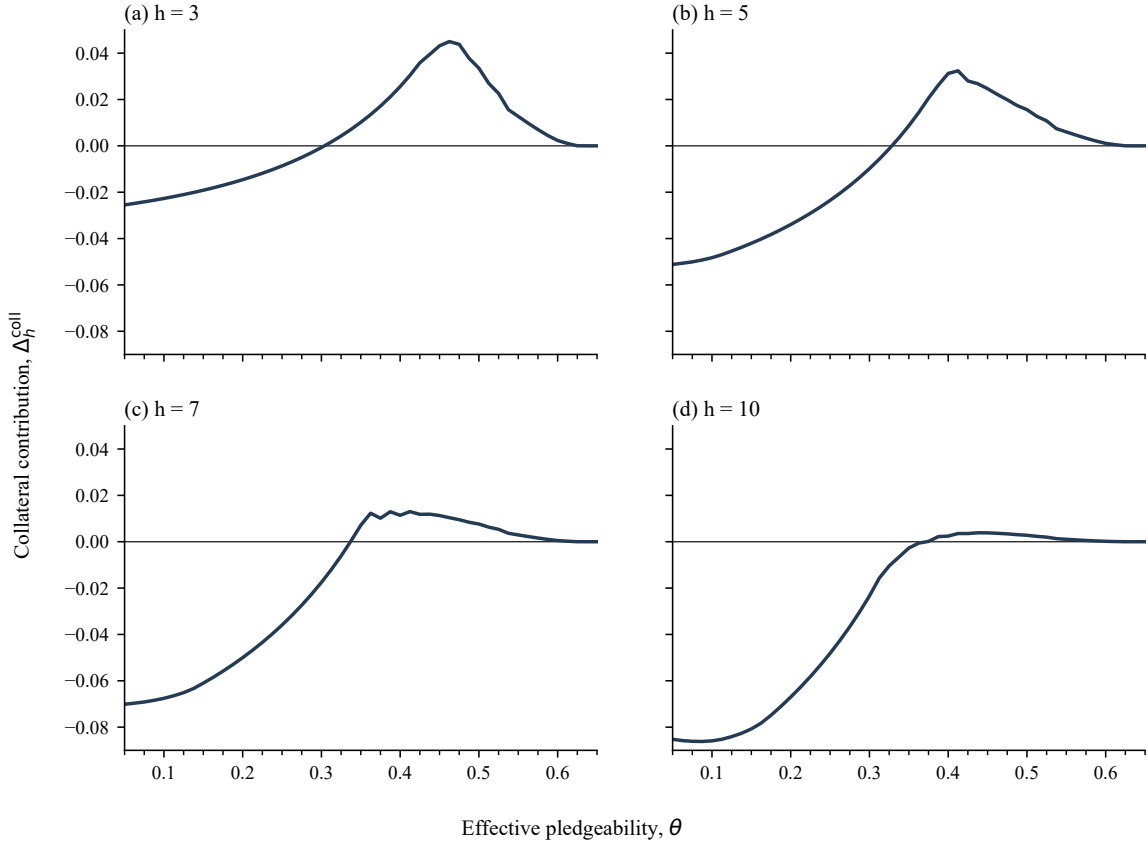


Figure 10: Dynamic collateral contribution to the model ISTC slope. Each panel reports $\Delta_h^{\text{coll}}(\theta) = \beta_h^{\text{Full}}(\theta) - \beta_h^{\text{NoCap}}$ for $h \in \{3, 5, 7, 10\}$. The one-year contribution is approximately zero and is omitted for readability.

F.5 Dynamic θ profiles and ψ sensitivity

At $h = 5$, the grid maxima are $(\theta, \beta_5^M) = (0.475, 0.105)$ for $\psi = 0.15$, $(0.4125, 0.0846)$ for $\psi = 0.30$, and $(0.3875, 0.0515)$ for $\psi = 0.60$. The interior amplification region is robust, while its magnitude and peak location vary with ψ .

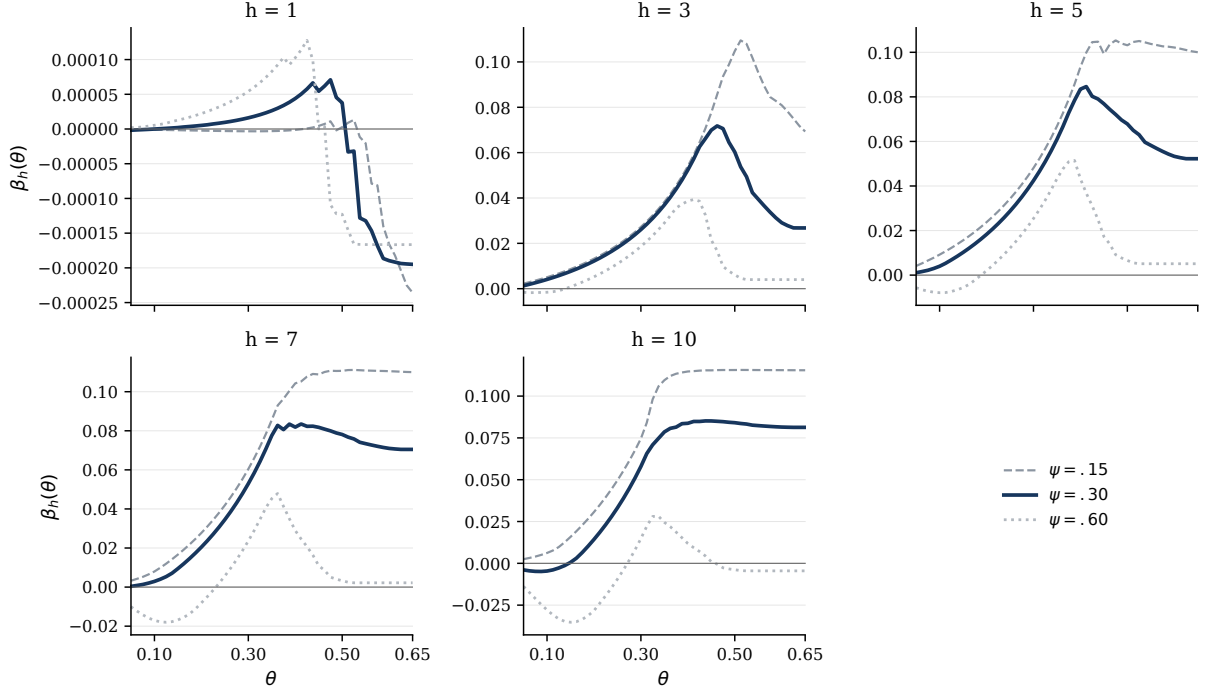


Figure 11: Model ISTC slope across horizons and adjustment-cost sensitivity. The one-year panel is on a much smaller numerical scale because current capital is predetermined.

F.6 Sector-level responses and regimes

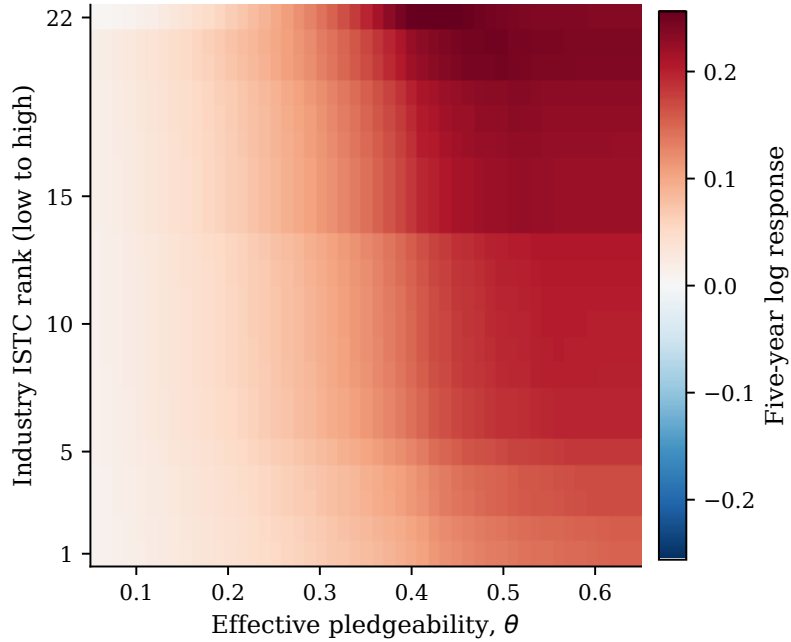


Figure 12: Sector-level five-year reform-minus-counterfactual log value-added responses at baseline $\psi = 0.30$. Industries are sorted by ISTC from low to high. Main Figure 6(b) reports the corresponding financing regime for each industry.

The heatmap shows the industry-level responses underlying the cross-sector slope. The largest cross-industry slope occurs over the same intermediate pledgeability range in which main Figure 6(b) shows sequential graduation.

F.7 Graduation and saturation thresholds

At the baseline five-year horizon, the highest-ISTC industry graduates in the interval $(0.3625, 0.375]$. Industries with ISTC roughly 4.46–4.68 graduate by about 0.3875, the middle of the distribution by about 0.40, and the lowest-ISTC industries by 0.4125. Literal saturation begins only for the maximum-ISTC industry in $(0.5625, 0.575]$; two additional high-ISTC industries saturate around 0.6375. These are grid brackets rather than continuous parameter estimates.

Table 13: Baseline five-year regime transitions

Event	θ bracket / point	Interpretation
All 22 sectors constrained	through .3625	Every finite collateral cap is active.
First graduation	$(.3625, .3750]$	Highest-ISTC sector becomes slack with $\phi < 1$.
Most high-ISTC sectors graduated	by .3875–.4000	Graduation frontier moves down the ISTC ranking.
All sectors graduated	.4125	Coincides with the baseline grid maximum of β_5^M .
First literal saturation	$(.5625, .5750]$	Highest-ISTC sector reaches $\phi \geq 1$.
Three sectors saturated	by .65	Remaining sectors are graduated rather than constrained.