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Did the Uruguay Round Spark Innovation? Evidence from Developing Countries Using Patent Data

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Abstract. This paper investigates the long-term effects of trade liberalization on innovation in developing economies during the Great Liberalization period (1980–1992). Using a two-way fixed effects model and the Sachs et al. (1995) classification, several innovation proxies are analyzed, including patents, industrial applications, R&D expenditure, and labor productivity. By separately examining patents filed by residents and non-residents, genuine domestic innovation responses are distinguished from the formal registration effects induced by the contemporaneous TRIPS Agreement. The results demonstrate that trade liberalization significantly increases innovation outcomes, with robust patterns for total patents and industrial applications, more mixed evidence for R&D expenditure and labor productivity, and dynamic effects persisting for up to 30 years. Foreign competition, measured through foreign direct investment (FDI), emerges as a key transmission channel, stimulating technological advancements and industrial applications. Policymakers should consider the long-term benefits of trade openness, despite short-term adjustment costs, while fostering absorptive capacity to maximize knowledge spillovers.

Keywords: Trade Liberalization, Innovation, Patents, Foreign Direct Investment, Productivity

¿Impulsó la Ronda Uruguay la innovación? Evidencia de países en desarrollo a partir de datos de patentes

Resumen. Este artículo investiga los efectos de largo plazo de la liberalización comercial sobre la innovación en economías en desarrollo durante el período de la Gran Liberalización (1980–1992). Empleando un modelo de efectos fijos de dos vías y la clasificación de Sachs et al. (1995), se analizan diversas variables proxy de la innovación, entre ellas el número de patentes, las solicitudes de diseños industriales, el gasto en investigación y desarrollo, y la productividad laboral. Al examinar por separado las patentes solicitadas por residentes y no residentes, se distinguen las respuestas genuinas de innovación doméstica de los efectos de registro formal inducidos por el contemporáneo Acuerdo sobre los ADPIC (TRIPS). Los resultados muestran que la liberalización comercial incrementa significativamente los indicadores de innovación, con patrones robustos para el total de patentes y las solicitudes de diseños industriales, evidencia más mixta para el gasto en I+D y la productividad laboral, y efectos dinámicos que persisten hasta 30 años después de su implementación. La competencia extranjera, medida a través de la inversión extranjera directa (IED), emerge como un canal de transmisión clave que estimula los avances tecnológicos y las aplicaciones industriales. Los hacedores de política deberían considerar los beneficios de largo plazo de la apertura comercial, a pesar de los costos de ajuste de corto plazo, fomentando al mismo tiempo la capacidad de absorción para maximizar los spillovers de conocimiento.

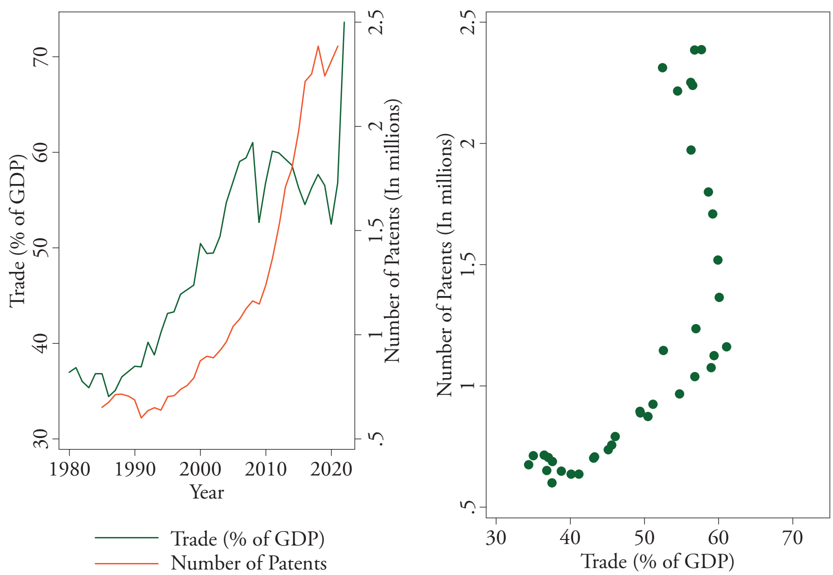
Palabras clave: liberalización comercial, innovación, patentes, inversión extranjera directa, productividad.

1. Introduction

Between 1986 and 1994, the General Agreement on Tariffs and Trade (GATT) underwent a profound transformation during the Uruguay Round, a period often referred to as The Great Liberalization. This era marked the adoption of policies promoting trade and financial integration, coupled with efforts to harmonize regulatory frameworks—including open trade policies, legal systems, tax structures, and institutional agreements. These reforms, aimed particularly at developing countries, later became synonymous with the Washington Consensus.

This paper investigates whether the trade liberalization measures implemented during this period influenced innovation in countries that embraced these open trade policies compared to those that did not. Specifically, trade openness, measured as Trade (%GDP), is positively associated with innovation, proxied by the number of patents, as illustrated in Figure 1.

Figure 1
Trade (%GDP) vs Number of Patents



Source: World Bank

To explore this relationship, a two-way fixed effects model is employed, leveraging the Sachs et al. (1995) database to classify countries into those that liberalized trade and those that did not. While this database has been influential, it is not without its limitations, as highlighted by Rodríguez and

Rodrik (2000). Their critique questioned the robustness of earlier findings that linked trade liberalization to economic growth, pointing out weaknesses in econometric methods and data, as also noted by Edwards (1998). Subsequent studies, such as Estevadeordal and Taylor (2013), improved upon earlier analyses by incorporating better data, advanced econometric techniques, and clearer theoretical frameworks, yielding more plausible benefits from tariff reductions. However, even these estimates are not beyond scrutiny, as highlighted by Hoyos (2021).

This paper adopts a methodology inspired by Clarke and Tapia-Schythe (2021), enabling a classification of countries based on their trade liberalization status and an examination of parallel pre-liberalization trends. Innovation is measured through proxies such as resident and non-resident patents, trademarks, and industrial applications filed in intellectual property offices. Trade liberalization is proxied by weighted average tariff rates, with key periods of analysis spanning 1992–1999, 2000, and 2001–2004, reflecting the timing of most liberalization processes as recommended by Coelli et al. (2022).

The findings of this study align with prior research by Coelli et al. (2022), Aghion et al. (2005), Teshima (2009), Gorodnichenko et al. (2010), and Iacovone (2012). Whereas Coelli et al. (2022) employed firm-level patent data to identify innovation responses to tariff reductions, this paper provides a complementary country-level analysis: The cost of aggregation is the loss of within-firm variation, but the gain is broader cross-country coverage of developing economies and a longer post-treatment horizon. By examining multiple dependent variables as proxies for innovation, and by separately tracking patents filed by residents and non-residents—a distinction that helps separate genuine domestic innovation from the formal-registration response induced by the contemporaneous TRIPS Agreement—this paper extends the literature by demonstrating the long-term persistence of trade liberalization effects, which last up to 30 years from their implementation. In addition, evidence points to a potential transmission channel: foreign corporations entering liberalized economies and fostering innovation through competition. This mechanism aligns with findings by Liu and Wang (2021) and Fons-Rosen et al. (2017).

The remainder of the paper is organized as follows: Section 2 outlines the methodology and describes the database used. Section 3 introduces the theoretical framework. Section 4 provides a literature review. Section 5 presents the results and robustness checks, while Section 6 concludes with key insights and implications.

2. Methodology and Databases

There are several variables that can measure innovation, as highlighted by Shu and Steinwender (2019). These measures can be classified into two main types. First, direct measures include the number of patents, as discussed by Bloom et al. (2015), Coelli et al. (2022), and Autor et al. (2020). Other direct measures include industrial applications, trademark applications, scientific articles, and R&D investment, as noted by Autor et al. (2020) and Xu and Gong (2017). Second, indirect measures include labor productivity, as examined by Trefler (2004), Dunne et al. (2010), and Chen and Steinwender (2021).

In this paper, the number of patents, $Patents_{i,j}$, issued in country i in year j, serves as the primary innovation indicator. For robustness checks, other innovation indicators are also utilized. Since both residents and non-residents contribute to patent production, three dependent variables are defined: resident patents, non-resident patents, and total patents. These variables are available for the period 1980–2021.

Sachs et al. (1995) classified a country as having a closed trade policy if it meets at least one of the following criteria:

1. Nontariff barriers covering 40% or more of trade.
2. Average tariff rates of 40% or greater.
3. A black-market exchange rate depreciated by 20% or more relative to the official exchange rate.
4. A socialist economic system.
5. A state monopoly on major exports.

Using these criteria, a dichotomous variable $Trade_{i,j}$ is constructed, which takes the value of 1 if country i in year j does not meet any of these criteria simultaneously, and 0 otherwise. The variable is therefore strictly dichotomous and defined at the country–year level, switching from 0 to 1 in the first calendar year in which all five Sachs et al. (1995) criteria for openness are simultaneously satisfied; no cumulative or threshold-based criterion is imposed across years.

The control variables included in the analysis are:

- Real GDP per capita ($RGDPper_{i,t-1}$): Measured as real GDP at chained PPPs divided by population from the previous period, serving as a proxy for economic conditions.
- Annual hours worked per worker ($avh_{i,j}$): Representing labor conditions.
- Stock of capital at current PPPs ($ck_{i,j}$): Serving as a proxy for capital conditions.

- Economic growth ($growth_{i,j}$): Measuring annual economic growth.

The main model is a two-way fixed effects model, or differen-ce-in-differences (DiD), specified as:

$$\text{Patents}_{i,j} = \alpha + \theta_j + \sum_{j=2}^{J} \beta_j \text{Trade}_{i,j}^{\text{Lag}} + \sum_{k=2}^{K} \beta_k \text{Trade}_{i,j}^{\text{Lead}} + \text{Controls}_{i,j} + \nu_{i,t} \quad (1)$$

where $\text{Patents}_{i,j}$ is the natural logarithm of the number of patents (total, resident, or non-resident) in country i in year j; θ_j denotes time fixed effects; $\text{Trade}^{\text{Lag}}$ and $\text{Trade}^{\text{Lead}}$ are lags and leads of trade liberalization; $\text{Controls}_{i,j}$ is a vector of control variables ($\text{RGDPper}_{i,t-1}$, $avh_{i,j}$, $ck_{i,j}$, $growth_{i,j}$); and $\nu_{i,t}$ is the error term.

The lags and leads are defined as follows:

$$\text{Trade}_{i,j}^{\text{Lag}(J)} = 1[t \leq \text{Trade}_i - J] \quad (2)$$

$$\text{Trade}_{i,j}^{\text{Lag}(j)} = 1[t = \text{Trade}_i - j] \text{ for } j \in \{1, ..., J-1\} \quad (3)$$

$$\text{Trade}_{i,j}^{\text{Lead}(k)} = 1[t = \text{Trade}_i + k] \text{ for } k \in \{1, ..., K-1\} \quad (4)$$

$$\text{Trade}_{i,j}^{\text{Lead}(k)} = 1[t \geq \text{Trade}_i + K] \quad (5)$$

These indicators capture the number of periods away from the trade liberalization year. Countries that remain closed throughout the period serve as the counterfactual, under the assumption of parallel trends between treated and control countries prior to liberalization.

Equation 1 can be restated for simplicity as:

$$\text{Patents}_{i,j} = \alpha + \theta_j + \beta_1 \text{PostTrade}_{i,j} + \beta \text{Controls}_{i,j} + \nu_{i,t} \quad (6)$$

where $\text{PostTrade}_{i,j} = 1[t \geq \text{Trade}_i]$. However, as Clarke and Tapia-Schythe (2021) pointed out, this specification does not allow for the observation of differential trends between treated and control groups post-reform. For visualizing effects, Equation 1 is used; Equation 6 is employed to present aggregate results in tables.

Table 1 provides summary statistics for the main variables, separately for open and closed trade-policy countries.

Table 1
Summary Statistics

	Open			Closed		
Variable	**Obs**	**Mean**	**Std. Dev.**	**Obs**	**Mean**	**Std. Dev.**
Log Patents	690	6.54	1.84	942	5.90	2.29
Log Industrial App.	484	6.16	1.71	424	6.18	2.30
Log GDP per Capita	732	9.06	0.65	1006	8.36	0.95
Log Population	732	2.69	1.31	1056	3.11	1.60
Log Avg Hours	423	7.59	0.10	329	7.64	0.10
Log Capital Stock	671	–4.82	1.43	831	–5.15	1.93
Economic Growth	691	0.03	0.03	1009	0.03	0.08

Note: Summary statistics for the main variables used in the regressions. Countries are classified as open or closed in line with Sachs et al. (1995). All variables except economic growth are expressed in logarithms.

Data Sources. The empirical analysis combines six harmonized sources at the country–year level. Patent counts (resident, non-resident, and total), industrial design applications, and trademark applications come from the World Intellectual Property Organization (WIPO) IP Statistics Data Center. Counts of scientific articles come from the World Bank's World Development Indicators (WDI), which itself draws on Scopus. Research and development expenditure as a share of GDP, foreign direct investment as a share of GDP, and total trade as a share of GDP are also taken from WDI. Weighted and simple-average effective tariff rates come from the World Bank's World Integrated Trade Solution (WITS), drawing on UNCTAD's TRAINS database. Macroeconomic controls—real GDP per capita at chained PPPs, average annual hours worked per worker, capital stock at current PPPs, and real GDP growth—come from Penn World Tables version 10.01 (Feenstra, Inklaar, and Timmer, 2015). The Sachs et al. (1995) openness indicator is taken in its original form for the years 1980–1992. Beyond 1992, countries that liberalized within the original Sachs et al. (1995) window are coded as remaining open, consistent with the assumption that liberalization is an absorbing state during the sample period; this convention coincides with the extension of Wacziarg and Welch (2008). Innovation counts and tariff series are linearly interpolated within country to fill short gaps, following the convention adopted in Coelli et al. (2022).

Sample. The Sachs et al. (1995) classification covers 110 economies. Of these, 35 countries transitioned from closed to open trade regimes between 1980 and 1992 and constitute the treated group; 41 countries remained closed throughout the Sachs window and serve as the control group; 34 economies—largely OECD members and a small number of Asian economies that were already open in 1980—are excluded from the difference-in-differences estimation, since they do not provide useful pre-treatment variation in the openness indicator. The full lists of treated and control countries, together with the year of transition for each treated country, are reported in Appendix A. The estimation sample is restricted to country–year observations for which the dependent variable, the openness indicator (or the tariff measure in the continuous specifications), and at least the core controls (real GDP per capita, growth, and capital stock) are jointly available; the resulting effective sample sizes are reported in each table.

Liberalization measures. Two complementary proxies for trade liberalization are used throughout the paper. The dichotomous Sachs et al. (1995) indicator captures the broad, regime-level transition to an open trade policy and is well suited for the event-study design, which exploits the calendar year of the regime change. The continuous tariff measures—levels and first differences of weighted-average effective tariff rates—capture the gradual, intensive-margin component of liberalization that the Sachs indicator necessarily abstracts from, and they reduce concerns that variation in the dichotomous indicator is being driven by black-market exchange-rate criteria rather than by trade policy itself. The two measures are therefore presented as complements rather than substitutes: The dichotomous indicator identifies dynamic patterns around the regime change, while the tariff measures discipline the magnitude of the response to actual policy variables.

Methodological note. The two-way fixed effects specification with leads and lags follows Clarke and Tapia-Schythe (2021). Recent contributions—Sun and Abraham (2021), Callaway and Sant'Anna (2021), Goodman-Bacon (2021), and de Chaisemartin and D'Haultfoeuille (2020)—have documented that aggregate TWFE estimates can be biased in settings with staggered treatment timing and heterogeneous effects across cohorts; the implications of this literature for the present design are discussed explicitly in Section 5.3.

3. Theoretical Model and Extensions

3.1 Basic Model

The theoretical foundation begins with a simplified framework, based on Coelli et al. (2022), to explain the relationship between trade liberalization and innovation. Assume a country i trades with a partner x, importing goods subject to a tariff $\tau_{ix} \geq 0$. The productivity of country i, denoted by z_i, depends on its knowledge stock K_i, which is endogenously determined.

Under a constant elasticity of substitution (CES) framework, the demand for a product in country x is:

$$D_{ix} = A_{ix} P_{ix}^{-\sigma} \quad (7)$$

where A_{ix} is an exogenous demand shifter, P_{ix} is the price of the imported product, and $\sigma > 1$ is the elasticity of substitution.

The price under monopolistic competition is:

$$P_{ix} = \left(\frac{\sigma}{\sigma - 1}\right)\frac{\tau_{ix}\omega_i}{z_i} \quad (8)$$

where ω_i is the wage in country i. Substituting into the profit function, profits from exports to country x are:

$$\pi_{ix} = \left(\frac{z_i}{\tau_{ix}}\right)^{\sigma - 1} B_x \quad (9)$$

where

$$B_x = \frac{1}{\sigma}\left(\frac{\sigma - 1}{\sigma}\right)^{\sigma - 1} A_{ix}$$

aggregates demand and structural factors.

Country i maximizes net benefits by choosing its knowledge stock K_i:

$$\max_{K_i} \ \pi_{ix} - c(K_i) \quad (10)$$

where $c(K_i)$ is the cost of maintaining the knowledge stock. Assuming z_i depends linearly on K_i, the first-order condition yields:

$$K_i = k(\tau_{ix}^{1-\sigma} B_x)^{\frac{1}{k - (\sigma - 1)}} \quad (11)$$

where k > 0. As Equation 11 shows, reductions in tariffs ($\tau_{ix} \downarrow$) increase K_i, enhancing innovation and productivity.

3.2 Extended Model

To capture the broader dynamics of trade liberalization, the basic model is extended to incorporate dynamic productivity feedback, sectoral heterogeneity, and foreign direct investment (FDI). The sectoral parameters introduced below—innovation efficiency, absorptive capacity, competitive pressure elasticity, and sectoral weights—are not estimated empirically in the present paper, since the panel is aggregated at the country–year level.

The extension is intended as a theoretical motivation that connects the reduced-form aggregate evidence in Section 5 to the firm- and sector-level mechanisms documented in the literature, and it identifies an explicit agenda for future work using sectorally disaggregated WIPO data.

3.2.1 Dynamic Productivity Feedback

For a sector s in country i, productivity at time t + 1 is:

$$z_i^s(t+1) = z_i^s(t) + \gamma_s \cdot K_i^s + \nu_s \cdot S_i^s \qquad (12)$$

where γ_s is innovation efficiency, K^s_i is the sectoral knowledge stock, and S^s_i represents FDI spillovers:

$$S_i^s = \varphi_s \cdot \mathrm{FDI}_i^s \cdot \theta_s \qquad (13)$$

where φ_s measures absorptive capacity, FDI^s_i is foreign investment, and θ_s captures competitive pressure.

3.2.2 Sectoral Aggregation

Aggregate innovation I_i across all sectors is:

$$I_i = \sum_s \beta_s \cdot K_i^s \qquad (14)$$

where β_s denotes the weight of each sector. Sectors with higher absorptive capacity (φ_s) and stronger FDI spillovers contribute disproportionately to I_i.

3.2.3 Equilibrium in the Extended Model

The equilibrium for each sector s is:

$$K_i^s = k_s(\tau_{ix}^{1-\sigma} B_x^s)^{\frac{1}{k_s - (\sigma - 1)}} \qquad (15)$$

Aggregating across sectors results in:

$$K_i = \sum_s \beta_s \cdot k_s(\tau_{ix}^{1-\sigma} B_x^s)^{\frac{1}{k_s - (\sigma - 1)}} \qquad (16)$$

As Equation 15 shows, tariff reductions ($\tau_{ix} \downarrow$) drive increases in K^s_i and K_i, amplifying innovation through three key mechanisms:

- Increased competition enhances firm-level innovation.
- FDI inflows provide knowledge spillovers.
- Dynamic feedback reinforces long-term productivity growth.

4. Empirical Context and Related Literature

The relationship between trade liberalization, productivity, and innovation has long been debated. Early studies from the 1990s, such as Dollar (1992), Sachs et al. (1995), and Frankel and Romer (1999), suggested a positive correlation between trade openness and economic growth. However, Rodríguez and Rodrik (2000) challenged these findings, arguing that endogeneity concerns and weak econometric designs limit their reliability, echoing similar critiques by Edwards (1998).

Subsequent research, such as Estevadeordal and Taylor (2013), addressed these limitations using improved datasets and methods. They found that tariff reductions had plausible benefits consistent with theoretical predictions. However, Hoyos (2021) noted lingering limitations in his estimates, highlighting ongoing debates in the literature.

The evidence linking trade liberalization and productivity is more robust, particularly in Latin America and Asia. The Great Liberalization of the 1980s and 1990s introduced new foreign firms, intensifying domestic competition and enhancing productivity. For example, studies have documented these effects in Chile (Pavcnik, 2002), Brazil (Muendler, 2004; Schor, 2004), Colombia (Fernandes, 2007), Mexico (Teshima, 2009), and Indonesia (Amiti and Konings, 2007).

Although productivity and innovation are distinct concepts, they are closely related. Productivity reflects efficiency improvements, while innovation drives changes in efficiency, as demonstrated by Shu and Steinwender (2019).

Studying the link between trade liberalization and innovation is crucial because innovation is a fundamental driver of economic growth (Romer, 1990; Jones, 2005) and productivity gains (Hall, 2011; Syverson, 2011). Moreover, trade-induced competition fosters innovation as firms are compelled to reduce costs and improve quality to remain competitive (Gilbert, 2006; Cohen, 2010). This aligns with Schumpeter (1942), who argued that competition erodes rents, incentivizing firms to innovate.

Empirical studies provide robust evidence across diverse contexts: India (Goldberg et al., 2010), Norway (Bøler et al., 2015), China (Bas & Strauss-Kahn, 2015), Egypt (Atkin et al., 2017), the United States and Canada (Schmitz, 2005), and globally (Coelli et al., 2022). This discussion highlights how reduced tariffs stimulate innovation through increased competition, knowledge spillovers, and productivity gains.

5. Results

Table 2 presents the results from the two-way fixed effects (TWFE) estimation. The findings reveal that trade liberalization has a significant and positive effect on patent production, with patents increasing by 3% to 4% in liberalizing countries.

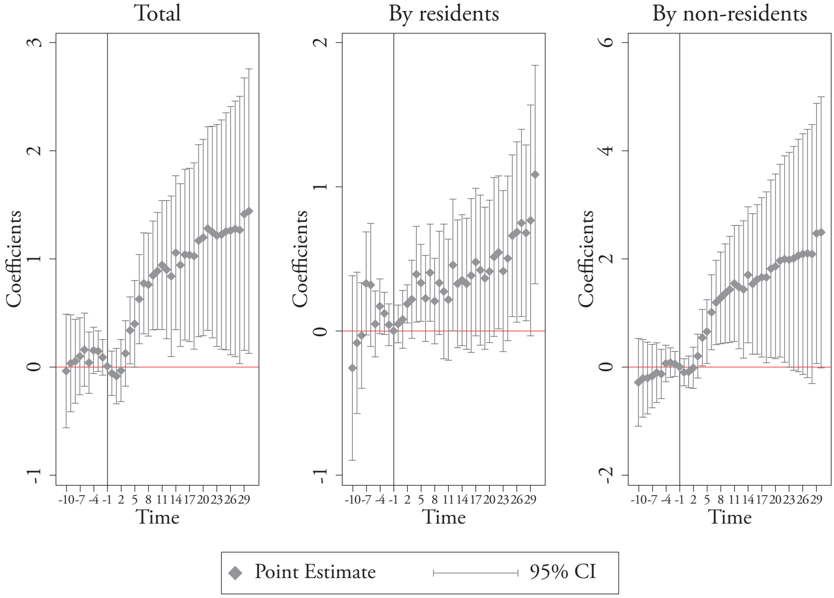
Table 2
Trade Liberalization and Patents: TWFE Estimates

Variables	**Total Patents**	**Patents by Residents**	**Patents by Non-Residents**
PostTrade(i,j)	0.033***	0.041	0.040*
	(3.72)	(1.81)	(2.70)
Control Variables	Yes	Yes	Yes
Country Fixed Effects	Yes	Yes	Yes
Time Fixed Effects	Yes	Yes	Yes
N	420	420	420
Adj. R^2	0.583	0.270	0.358

Note: t-statistics in parentheses. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. Coefficients from Equation 6. Column (1) uses Total Patents as the dependent variable; Columns (2) and (3) use Patents by Residents and Non-Residents, respectively. All dependent variables in natural logarithm. Standard errors clustered by country.

Figure 2 illustrates the dynamic effects by plotting leads and lags relative to the treatment period. Pre-treatment coefficients are statistically insignificant and close to zero, which provides suggestive—though not conclusive—evidence in favor of the parallel trends assumption. Post-treatment coefficients display a clear upward trajectory, with 95% confidence intervals confirming robustness across many post-liberalization years.

Figure 2
Trade Liberalization Shock on Patents



To further investigate these effects, the relationship is examined using tariffs as an alternative proxy for trade liberalization:

$$\text{Patents}_{i,j} = \alpha + \theta_j + \beta_1 \text{Tariff}_{i,j} + \beta \text{Controls}_{i,j} + \nu_{i,t} \quad (17)$$

where β_1 captures the effect of tariff rates on innovation. To account for potential serial correlation, the difference in tariff rates, ΔTariff_i, is used as suggested by Coelli et al. (2022), calculated as averages over 1992–1999, 2000, and 2001–2004:

$$\Delta\text{Patents}_i = \alpha + \beta_1 \Delta\text{Tariff}_i + \beta \text{Controls}_i + \nu_{i,t} \quad (18)$$

Table 3 presents the results. A 1% tariff increase reduces total patent production by residents and non-residents by 2.9% and 6%, respectively, corroborating the results presented in Table 2. To interpret the magnitude, a 1 percentage point tariff reduction is associated with a 3% increase in patent applications, equivalent to an additional 30 patents annually for a typical country with 1,000 patents.

Table 3
Trade Liberalization Effects on Patents Using Tariff Rates

Variables	Total Patents	Patents by Residents	Patents by Non-Residents
Tariff	−0.032**	−0.029*	−0.060***
	(−3.10)	(−2.10)	(−4.71)
ΔTariff	−0.033**	−0.039*	−0.029**
	(−3.27)	(−2.39)	(−2.65)
Control Variables	Yes	Yes	Yes
Country Fixed Effects	Yes	No	Yes
Time Fixed Effects	Yes	No	Yes
N	1,444	1,444	1,444
Adj. R^2	0.299	0.403	0.177

Note: t-statistics in parentheses. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. Coefficients from Equations 17 and 18. Column (1) uses Total Patents; Columns (2) and (3) use Patents by Residents and Non-Residents, respectively. All dependent variables in natural logarithm.

5.1 Robustness Checks

While patents serve as the primary proxy, their heterogeneous quality (Nagaoka et al., 2010) motivates the use of additional direct and indirect innovation proxies: industrial design applications, R&D expenditure (% GDP), and labor productivity.

Industrial Applications. Table 4 presents results using industrial design applications as the dependent variable. The coefficient on $PostTrade_{(i,j)}$ is positive and significant for total and non-resident applications, with total industrial applications increasing by approximately 4.3% after trade liberalization. Higher tariffs exhibit a significant negative effect, particularly for non-resident applications.

Table 4
Trade Liberalization Effects on Industrial Applications

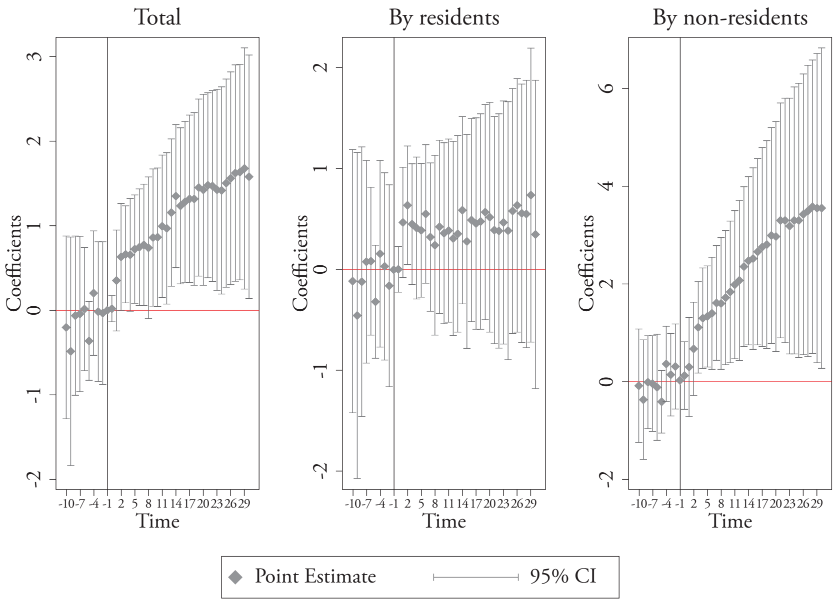
Variables	Total Industrial App.	Resident App.	Non-Resident App.
PostTrade	0.0426**	0.0367	0.0456***
	(3.70)	(1.65)	(5.95)
Tariff	−0.0184	−0.0117	−0.0399**
	(−1.90)	(−1.33)	(−3.16)
ΔTariff	−0.0392*	−0.0479*	−0.0438*
	(−2.11)	(−2.24)	(−2.70)

Variables	Total Industrial App.	Resident App.	Non-Resident App.
Control Variables	Yes	Yes	Yes
Country Fixed Effects	Yes	Yes	No
Time Fixed Effects	Yes	Yes	No
N	347	424	102
Adj. R^2	0.519	0.543	0.146

Note: t-statistics in parentheses. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. All dependent variables in natural logarithm.

Figure 3 further visualizes the dynamic effects. Pre-treatment coefficients remain close to zero, offering suggestive though not conclusive evidence consistent with the parallel trends assumption. Post-liberalization coefficients show a clear upward trajectory for total and non-resident applications, with persistent effects extending up to 30 years.

Figure 3
Trade Liberalization Shock on Industrial Applications



R&D Expenditure. Table 5 shows that a 1% increase in tariff rates reduces R&D expenditure by approximately 2% to 2.4%, with effects statistically significant and robust across specifications.

Table 5
Trade Liberalization Effects on R&D Expenditure

	Tariff		**ΔTariff**	
Variables	**(1)**	**(2)**	**(3)**	**(4)**
Tariff	–0.0202*	–0.012	–	–
	(–2.59)	(–1.07)		
ΔTariff	–	–	–0.0244**	–0.0238**
			(–3.26)	(–3.16)
Control Variables	Yes	Yes	Yes	Yes
Country Fixed Effects	No	Yes	No	No
Time Fixed Effects	No	Yes	No	No
N	817	817	51	51
Adj. R^2	0.067	0.072	0.206	0.180

Note: t-statistics in parentheses. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. Dependent variable is R&D Expenditure (% GDP) in natural logarithm. Standard errors clustered by country.

Labor Productivity. Table 6 shows that trade liberalization positively influences labor productivity. The coefficient on $PostTrade_{(i,j)}$ indicates a 2% productivity increase after liberalization. Higher tariffs are associated with reduced productivity across all specifications.

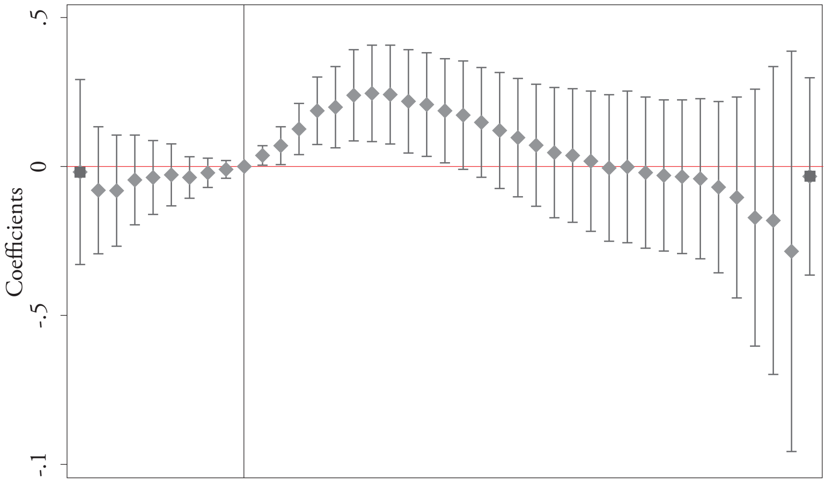
Table 6
Trade Liberalization Effects on Labor Productivity

Variables	**(1)**	**(2)**	**(3)**
PostTrade	0.020***	–	–
	(3.13)		
Tariff	–	–0.007*	–
		(–1.95)	
ΔTariff	–	–	–0.0129*
			(–2.13)
Control Variables	Yes	Yes	Yes
Country Fixed Effects	Yes	Yes	No
Time Fixed Effects	Yes	Yes	No
N	422	543	43
Adj. R^2	0.577	0.830	0.074

Note: t-statistics in parentheses. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. Dependent variable is labor productivity (GDP divided by employment), in natural logarithm. Standard errors clustered by country.

Figure 4 illustrates the dynamic effects on labor productivity. A significant positive effect is confirmed in the decade following liberalization, but coefficients gradually diminish over time, suggesting productivity gains may not persist indefinitely.

Figure 4
Trade Liberalization Shock on Labor Productivity



Trademark Applications. Table 7 reports results for trademark applications and academic papers (data available for 2004–2021 only, precluding event study estimation). A 1% tariff increase reduces trademark applications and academic paper publications by 2.6% to 3.6%.

Table 7
Trade Liberalization Effects on Trademark Applications and Academic Papers

Variables	Total Trademark	Residents	Non-Residents	Academic Papers
Tariff	−0.0271*	−0.0264*	−0.0356*	−0.0317**
	(−2.46)	(−2.48)	(−2.31)	(−2.72)
Control Var.	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes
N	644	644	644	919
Adj. R^2	0.433	0.528	0.199	0.661

Note: t-statistics in parentheses. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. Dependent variables are trademark applications and academic paper counts, both in natural logarithm.

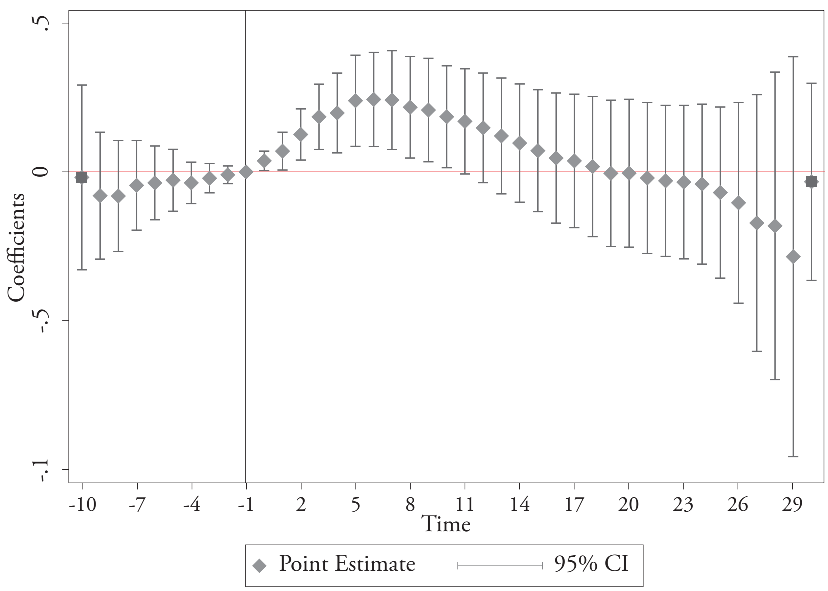
Overall, the robustness checks confirm that trade liberalization fosters innovation through multiple channels. Positive effects are evident in direct measures (industrial applications, R&D expenditure) and the indirect proxy (labor productivity), underscoring the significance of trade openness in stimulating innovative activity across economies.

5.2 Schumpeterian vs. Escape–Competition Effects

The literature highlights two primary effects of competition on innovation: (i) the Schumpeterian effect, which predicts that increased competition reduces the rents a firm could capture from innovating; and (ii) the escape-competition effect (Shu & Steinwender, 2019), which predicts that competition increases incentives to innovate by reducing rents for firms that do not innovate. A more comprehensive model of the latter can be found in Fieler and Harrison (2023).

Empirically, the relationship remains ambiguous. Aghion et al. (2005) posited an inverted-U shape: an optimal level of competitor entry promotes innovation, but additional competition beyond this point discourages it. The Great Liberalization prompted significant foreign firm entry into emerging markets, intensifying competition with domestic firms, as illustrated in Figure 5.

Figure 5
Foreign Direct Investment and The Great Liberalization



To analyze the role of competition, FDI is used as a proxy for competitor entry, consistent with Fons-Rosen et al. (2017), Javorcik (2008), Zhang et al. (2010), and Liu and Wang (2021). A dichotomous variable COMP(i,j) is constructed, equal to 1 if FDI falls between the maximum and third quartile, and 0 if between the minimum and first quartile, representing high competition entry in country i during period j.

The estimation specification is:

$$\text{Innovation}_{i,j} = \alpha + \theta_j + \beta_1 \text{Event}_{i,j} + \beta_2 \text{COMP}_{i,j} + \beta_3 (\text{Event} \times \text{COMP})_{i,j} + \beta \text{Controls}_{i,j} + \nu_{i,t} \qquad (19)$$

where $\text{Innovation}_{(i,j)}$ is the vector of innovation proxies ($\text{Patents}_{(i,j)}$, $\text{IndustrialDesign}_{(i,j)}$, $\text{R\&D}_{(i,j)}$, $\text{Labor}_{(i,j)}$), and β_3 captures whether high foreign competition entry amplifies innovation gains.

Table 8 confirms that FDI positively affects innovation. Coefficients on patents and industrial applications are positive and significant, while results for labor productivity and R&D are mixed.

Table 8
Trade Liberalization and the Competition Channel

Variable	Patents	Industrial	Labor Prod.	R&D
FDI(i,j)	0.0057***	0.0009***	0.0002	0.0005*
	(10.04)	(4.17)	(1.88)	(2.57)
Event(i,j)	0.0378*	0.0455*	0.0284**	−0.0000
	(2.69)	(2.38)	(3.34)	(−0.00)
COMP(i,j)	−0.1623	−0.4413	−0.0769	−0.0202
	(−1.03)	(−1.78)	(−1.30)	(−0.22)
Event × COMP(i,j)	0.0332*	0.0277**	−0.0062	0.0127
	(2.48)	(3.79)	(−1.04)	(1.78)
N	664	522	670	416
Adj. R^2	0.284	0.664	0.765	0.339
Control Variables	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes

Note: t-statistics in parentheses. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. Dependent variables are patents, industrial applications, labor productivity, and R&D expenditure (% GDP), all in natural logarithm.

The competition channel has a stronger impact on patents and industrial applications than on labor productivity and R&D, consistent with the finding that trade liberalization primarily drives non-resident patent applications. The escape–competition effect appears to dominate: Firms innovate to remain competitive as foreign firms enter, stimulating new technologies and industrial designs. Effects on labor productivity and R&D are less robust, indicating that the competition channel primarily fosters technological advancements rather than immediate productivity gains.

5.3 Limitations

There are several limitations of the empirical strategy and the underlying data that should be acknowledged.

Measurement of liberalization. The Sachs et al. (1995) classification combines tariff barriers, non-tariff barriers, the black-market exchange rate premium, the presence of state monopolies on major exports, and the broad characterization of the economic system. As Rodríguez and Rodrik (2000) stressed, the black-market premium criterion in particular reflects general macroeconomic conditions and capital account distortions that are not synonymous with trade policy itself, so part of the variation in the openness indicator is driven by macroeconomic mismanagement rather than by tariff or non-tariff reform. The continuous tariff specifications in Tables 3–7 and the difference-in-tariffs specifications partially address this concern by isolating the price-based component of liberalization, but they cannot fully separate trade policy from contemporaneous macroeconomic stabilization.

Staggered treatment and TWFE bias. Treatment timing in the sample is markedly staggered: 35 countries liberalized across 13 different years between 1980 and 1992. Recent econometric work—Goodman-Bacon (2021), Callaway and Sant'Anna (2021), Sun and Abraham (2021), and de Chaisemartin and D'Haultfoeuille (2020)—shows that two-way fixed effects estimators applied to such designs can yield aggregate ATT estimates that are biased due to negatively weighted comparisons between already treated and newly treated units. The event–study coefficients in Figures 2–4 are less vulnerable to this critique to the extent that they recover cohort-averaged dynamic effects, but the aggregate post-treatment coefficients in Tables 2–8 should be interpreted as a weighted average that may not coincide with a clean average treatment effect on the treated coefficients. Re-estimating the main specifications using cohort-robust estimators is a natural extension for future work.

FDI as a proxy for foreign competition. The FDI variable used in Section 5.2 captures both a direct competition margin (foreign firms entering and competing for the domestic market) and a knowledge transfer margin (foreign firms introducing technology, managerial practices, and supplier linkages, as documented by Javorcik, 2004, and Fons-Rosen et al., 2017). The empirical specifications in Table 8 do not separate these two channels, so the coefficient on the FDI×Event interaction should be interpreted as a reduced-form effect that combines both forces. Disentangling them would require either firm-level data on horizontal versus vertical FDI, or sector-level information on the technological content of foreign affiliates—both beyond the scope of the present panel.

Patent counts as an innovation proxy. As Nagaoka et al. (2010) have shown, patent counts are a noisy proxy for innovation. Their quality is highly heterogeneous, propensity to patent varies systematically with sector and firm size, and changes in legal environment—most notably, the TRIPS Agreement adopted as part of the Uruguay Round—mechanically affect filing behavior regardless of the underlying innovative activity. The separation of resident and non-resident filings used throughout the paper partially addresses this concern, but a complete decomposition would require citation-weighted patent quality measures and disaggregation by technological field, which are not available for the full developing country sample over the 1980–2021 horizon.

Aggregation. The analysis is conducted at the country–year level, which precludes a granular examination of within-firm or within-sector adjustment. Aggregation is unavoidable given the breadth of cross-country coverage targeted by this paper, but it implies that the estimated effects are reduced-form averages over a heterogeneous population of firms and industries. Future research using firm-level patent data harmonized with WIPO sectoral classifications would complement the country-level evidence presented here.

6. Conclusion

The Great Liberalization marked a transformative period in which many developing countries opened up their economies commercially and financially. While the impact of this process on economic growth remains debated, as noted by Hoyos (2021), its effects on innovation are consistently found to be positive. This paper builds on the foundational classification by Sachs et al. (1995) to assess the long-term effects of trade liberalization on patent counts, industrial applications, R&D expenditure, and labor productivity, extending the analysis to trademark applications and scholarly articles following the methodology of Coelli et al. (2022).

The findings reveal significant and persistent increases in innovation metrics, with effects lasting up to 30 years post-implementation. The evidence is, however, heterogeneous across outcomes. The most robust effects appear for total patent counts and industrial design applications—both statistically significant and stable across alternative specifications, control sets, and proxies for liberalization (post-treatment indicator and tariff levels and changes). Results for R&D expenditure as a share of GDP and for labor productivity are more mixed: signs are consistently in the expected direction but coefficients lose significance in some specifications, and event-study dynamics for labor productivity attenuate in the long run (Tables 5 and 6, Figure 4). The differential pattern between resident and non-resident patents is also informative: Non-resident filings respond strongly and persistently to liberalization, consistent with the entry of foreign filers facilitated by both reduced trade barriers and the contemporaneous TRIPS Agreement, while resident filings respond more modestly, consistent with a slower domestic capacity-building margin. A likely transmission mechanism is the entry of foreign competition, which stimulates new patents and industrial applications in liberalizing economies. These results underscore the long-term benefits of trade openness, even as it imposes short-term competitive pressures on domestic firms.

Policymakers should weigh these trade-offs carefully. The present findings align with Coelli et al. (2022), who demonstrated the role of trade liberalization in fostering innovation through competition and technological upgrades. This study also diverges from Aghion et al. (2005), who observed limited innovation responses in low-tech sectors, by highlighting substantial gains driven by FDI knowledge spillovers—a divergence that may reflect the growing importance of absorptive capacity in developing economies.

A key limitation is the reliance on aggregate data, which precludes a granular examination of firm-level dynamics. Future research should use firm-level datasets to uncover how different types of firms and industries respond to trade liberalization, furthering our understanding of how global economic integration shapes the innovation landscape in developing countries.

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Appendix A. Sample Composition

The sample is built on the Sachs et al. (1995) classification of trade openness, which assigns each country–year observation to either an open or a closed regime according to the criteria described in Section 2. Country names below follow the World Bank's World Development Indicators convention. Country–year coverage of the openness indicator runs from 1980 to 1992; for the years after 1992, countries that liberalized within the original Sachs et al. window are coded as remaining open, consistent with Wacziarg and Welch (2008).

A.1. Treated countries (35) and year of liberalization

Ecuador (1980), Sri Lanka (1980), Morocco (1985), Bolivia (1986), Colombia (1986), The Gambia (1986), Ghana (1986), Israel (1986), Costa Rica (1987), Guinea (1987), Guinea-Bissau (1987), Mexico (1987), New Zealand (1987), Uganda (1988), Guatemala (1989), Guyana (1989), Philippines (1989), Tunisia (1989), Benin (1990), El Salvador (1990), Jamaica (1990), Paraguay (1990), Turkey (1990), Venezuela (1990), Argentina (1991), Brazil (1991), Hungary (1991), Mali (1991), Poland (1991), Uruguay (1991), Honduras (1992), Nepal (1992), Nicaragua (1992), Peru (1992), South Africa (1992).

A.2. Control countries (41): closed throughout the Sachs window

Algeria, Angola, Bangladesh, Burkina Faso, Burundi, Cameroon, Central African Republic, Chad, China, Republic of Congo, Côte d'Ivoire, Dominican Republic, Arab Republic of Egypt, Ethiopia, Gabon, Haiti, India, Islamic Republic of Iran, Iraq, Kenya, Madagascar, Malawi, Mauritania, Mozambique, Myanmar, Niger, Nigeria, Pakistan, Papua New Guinea, Rwanda, Senegal, Sierra Leone, Somalia, Syrian Arab Republic, Tanzania, Togo, Trinidad and Tobago, Yugoslavia, Zaire, Zambia, Zimbabwe.

A.3. Always-open countries (34): excluded from the difference-in-differences estimation

Australia, Austria, Barbados, Belgium, Botswana, Canada, Chile, Cyprus, Denmark, Finland, France, Germany, Greece, Hong Kong SAR (China), Indonesia, Ireland, Italy, Japan, Jordan, Republic of Korea, Malaysia, Mauritius, Netherlands, Norway, Portugal, Singapore, Spain, Sweden, Switzerland, Taiwan, Thailand, United Kingdom, United States, Republic of Yemen. These economies were already classified as open in 1980 and therefore do not provide pre-treatment variation in the openness indicator; they are excluded from the main panel but included in robustness checks that use continuous tariff measures.