Capital Misallocation and Economic Development in a Dynamic Open Economy *

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Abstract

Some countries, such as Canada, Italy, and Mexico, have experienced a higher growth rate of capital per worker but a lower growth rate for GDP per worker compared to the United States. This paper explains these two facts through the lens of a dynamic multisector open economy model where capital flows across countries. In the model, firms face sector-specific distortions on capital and intermediate inputs that influence the actual rate of return on capital and the aggregate total factor productivity (TFP). We calibrate the model to Mexico for the period 2000-2014 and show that changes in sectoral distortions and productivities reduced the actual rate of return on capital, triggering capital accumulation and a reduction in TFP. The results show that aggregate output decreased by 7.3% and aggregate capital increased by 10.6%. From 33 sectors (out of 48) that suffered productivity losses, approximately 50% accumulated more capital. Furthermore, the capital-intensive sectors explain 82% of the capital-output ratio increase.

Keywords: Misallocation, Open Economy Growth Models, Capital Accumulation, Technology Adoption, Mexico. *JEL Codes*: F12,F43,O10,O19,O41,O47,O54.

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1 Introduction

During the 1990s, macroeconomic policy recommendations known as the "Washington Consensus" became widespread. Those recommendations prescribed market-oriented policies such as fiscal discipline, trade liberalization, and privatization, primarily spurring reforms to promote growth (Rodrik, 2006; Estevadeordal and Taylor, 2013). The following decades experienced improvements in many dimensions, for instance, the frequencies of extreme inflation, black market premiums, and extremely low trade shares (Easterly, 2019). However, some countries that have deployed these recommendations have shown sluggish growth in output per worker after the 1990s. Indeed, one intriguing fact is that countries such as Canada, Italy, and Mexico have presented a higher growth rate of capital per worker but a lower growth rate for GDP per worker compared to the United States.[1]

This article aims to reconcile these two facts in a dynamic open economy model. In the model, there are multiple sectors with different capital intensities, and firms employ capital and tradeable intermediate varieties facing wedges over the purchase of their inputs along the lines of Hsieh and Klenow (2009) and Meza et al. (2019). However, our model is dynamic, and we allow for international trade and international capital flows. Along the balanced growth path (BGP), the world economy grows at the exogenous technology adoption rate given by the growth rate of the mass of varieties produced in each country. We follow Basco and Mestieri (2019) and assume that countries are heterogeneous in aggregate productivity, and the mass of varieties produced by each country is increasing and concave in this aggregate productivity. Finally, following Acemoglu and Ventura (2002), in our model the number of varieties grows at an exogenous rate.

In the model, capital accumulation and exogenous technology adoption affect growth. The former is related to the market incentives summarized in the real rate of return on capital, while the latter is induced by an exogenous increase in the measure of domestically produced traded varieties. International trade allows countries to be exposed to the expansion of the world's technological frontier and to learn from it. This technology adoption process ultimately increases the number of tradable varieties that are internally produced, constituting the long-term growth mechanism. Thus, complementary to the misallocation literature,[2] we analyze how capital allocation across sectors could affect growth in a dynamic open economy.

We assume that an open economy is in a BGP in the initial and final periods and analyze the transition dynamics of capital allocation between these two periods. In the BGP the main macroeconomic variables (like output, capital, consumption, etc) grow at the same rate for all countries, which is a function of the growth rate of frontier knowledge and the elasticity of substitution among intermediate varieties. Capital and intermediate input distortions can affect the transitional dynamics between steady states. Since we allow for sectoral distortions by inputs, the rental rate of capital can differ across countries, distorting the investment rate along the transition to a balanced growth path. Thus, our model embeds the theoretical framework hypothesized by Kehoe and Ruhl (2010) and

[1] In Section 2 we discuss in more detail these stylized facts.

[2] Hopenhayn (2014) and Restuccia and Rogerson (2017) provide comprehensive surveys on the topic.

Kehoe and Meza (2011).

We use Mexican sectoral data from the World Input-Output Database and the Socio-Economic Accounts (Timmer et al., 2015) to calibrate the model in 2000 and 2014.[3] The model reproduces well statics related to the share of exports, sectoral output participation into GDP, capital-output ratio, and the real internal rate of return. We show that our calibrated distortions are related to changes in tariffs and differences in sectoral credit allocation over time. According to the results, more productive sectors had a fall in trade distortions on average, but those highly productive sectors observed an increase in capital distortions between 2000 and 2014. Indeed, although tariffs have declined and barriers to international trade have been significantly reduced with some success in Mexico (Caliendo and Parro, 2014), our results show that this drop in international trade barriers has not been accompanied by significant reductions in capital distortions nor sufficiently rapid technology adoption. Our model highlights how all these mechanisms interact to explain the relative stagnation of Mexico and the rapid increase in the capital-output ratio.

After the 1990s, the Mexican economy showed a catch-up in aggregate capital per worker relative to the U.S. economy but sluggish growth in output per worker.[4] We generate this pattern without targeting GDP and capital levels in calibration. According to the results, aggregate output decreased by 7.3%, and capital increased by 10.6%. The results are driven mainly by capital distortions and suggest that capital was misallocated over time. Between 2000 and 2014, 33 out of 48 sectors suffered productivity losses, in which approximately 50% of those sectors accumulated more capital. Regarding sectors that faced increased productivity, 10 out of 15 had a reduction in their capital participation in the aggregate capital. Furthermore, heterogeneity across sectors in capital intensity is important to explain the results. Indeed, high capital intensity sectors explain 82% of the capital-output ratio increase, in our model.

Our paper contributes to several branches of literature, mainly the one on misallocation (Restuccia and Rogerson, 2008; Hsieh and Klenow, 2009, 2014). In line with this literature, the model presented here assumes theoretical exogenous wedges as primitives, which are backed out from the data, and assesses the impact of such wedges on aggregate outcomes. This branch of the literature has been termed the "indirect approach".[5] This article contributes to this literature by analyzing the dynamic effects of static sectoral distortions on aggregate outcomes.

Closer in spirit are two main papers, Jovanovic (2014) and Bento and Restuccia (2017), that are worth mentioning. Jovanovic (2014) focuses on frictions in the labor market that arise when young and old workers need to be matched and there is uncertainty about the skill of the young agent. Bento and Restuccia (2017) extend the basic factor misallocation model to allow for entry investment and life-cycle productivity investment, implying an

[3] Mexico is a prominent example of implementing the macro reforms recommended by the Washington Consensus. Still, it has yet to succeed in terms of economic growth response. For a discussion about the macro reforms in Mexico recommended by the Washington Consensus, see, for example, Algazi (2020).

[4] These facts are also observed in some developed economies, such as Canada and Italy, and underdeveloped countries, such as Belize and the Central African Republic.

[5] See also Restuccia and Urrutia (2001) for distortions or barriers to capital accumulation and relative prices of aggregate investment.

endogenous distribution of productivities. Our paper complements these two other papers by considering an open economy model and focusing on the effect of static distortions on capital and intermediate inputs and the dynamics of aggregate outcomes. Furthermore, we calibrate our model to the Mexican economy and compute the transitional dynamics between the two BGPs.

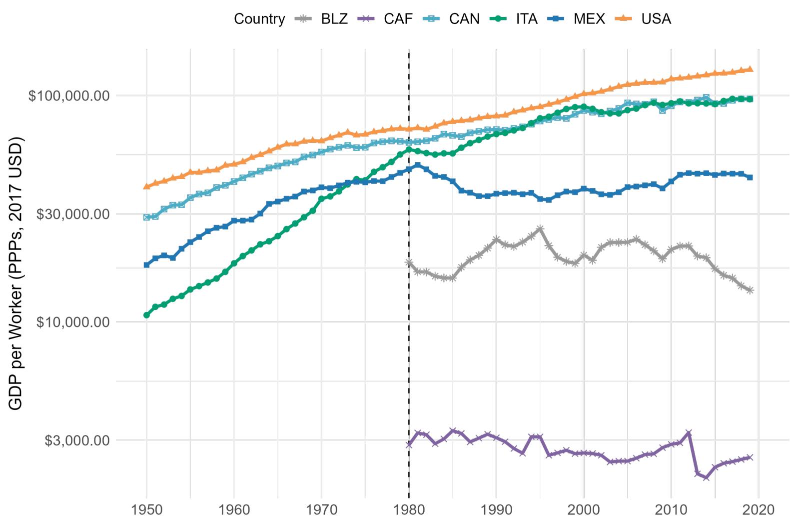
There is also a set of papers that focuses on specific sources of resource misallocation (Pratap and Urrutia, 2012; Midrigan and Xu, 2014; Moll, 2014; Gopinath et al., 2017; Buera and Shin, 2017), in particular, the effect of financial frictions and credit conditions. Pratap and Urrutia (2012), for example, explores the role of financial frictions in exacerbating the misallocation of resources in Mexican economy, after an unexpected shock to interest rates. Gopinath et al. (2017) study the effect of financial frictions on the misallocation of resources across firms and over time. They first show that the dispersion of the return to capital in Spanish firms increased between 1999 and 2012 and relate this to financial frictions. In their model, a reduction in the real interest rate channels investment towards firms with higher net worth but probably with lower productivity, thus inducing a reduction in TFP. Lastly, Jones (2011) shows how the input-output structure of the economy can amplify the effects of shocks in the TFP. Our paper complements these papers and considers trade in intermediate varieties and capital flows across countries. Although we take a broader approach by considering the effect of sectoral distortions on capital and intermediate tradeable varieties, we show that our measure of capital distortions is partly attributed to credit frictions.

This paper is also related to the literature on the growth effects of trade (Ventura, 1997; Acemoglu and Ventura, 2002; Sposi et al., 2021). Sposi et al. (2021) study the implications of trade integration in a two-country model with Ricardian and Heckscher-Ohlin comparative advantage forces and capital accumulation. Our model is closer to Acemoglu and Ventura (2002) that shows how trade can generate a steady-state world equilibrium to an otherwise diverging set of AK economies. Although our framework is related, we depart from them by including intermediate varieties in a multiple-sector framework and allow for international capital flows. Our framework is also related to Ravikumar et al. (2019) as we analyse capital accumulation in a dynamic open economy. Ravikumar et al. (2019) focus on the effect of trade liberalizations on capital accumulation, while our focus is showing how distortions on inputs can affect capital accumulation and growth.

Finally, this paper is related to the literature on the lack of growth in the Mexican economy (Arias et al., 2010; Hanson, 2010; Kehoe and Ruhl, 2010; Kehoe and Meza, 2011; Meza et al., 2019). Although the literature mostly provides descriptive analyses of the Mexican situation, we build a theory for the sectoral capital allocation that could induce stagnation. Meza et al. (2019) focus on the 2003-2012 period and show, in a static model, how better access to credit and lower interest rates contributed to the recovery from the 2008-2009 recession. We contribute to studying the transition between two BGPs in a dynamic open economy.

The rest of the paper is organized as follows. Section 2 describes the evidence of

Figure 1: Real GDP per worker for selected countries



Note: The data is from the Penn World Tables 10.1. Real GDP per worker is constructed as Output-Side real GDP at chained PPPs (2017 US$) divided by the number of persons engaged.

faster capital accumulation relative to the U.S. and relative stagnation. Then, it provides evidence for the mechanism in our model and empirical evidence for the misallocation of capital in Mexico. Section 3 presents the open economy growth model with sectoral distortions. Section 4 presents the calibration strategy. Section 5 analyzes the main results and the counterfactuals. Finally, Section 6 concludes.

2 Empirical Facts

This section explores the evolution over time of some developed and developing economies. Figure 1 shows the real GDP per worker in Canada, Italy, Mexico, Belize, the Central African Republic, and the United States, measured in purchasing power parity (PPP) from the Penn World Tables 10.1 (Feenstra et al., 2015). This figure shows that until the 1980s there was a process of convergence where Canada, Italy, and Mexico grew faster than the United States. Between 1950 and 1980, Canada, Italy, and Mexico GDP per worker grew at an average rate of 2.60%, 5.81%, and 3.35%, respectively, whereas the average growth in the United States was around 2.0% per year. Table 1 shows the average growth rates for the GDP per worker by country and for the 1950-1980, 1980-2000, and post-2000 periods.[6]

Since the sovereign debt crisis in the early 1980s, Mexico has suffered a considerable slowdown. From 1980 to 1995, the GDP per worker growth rate shrank at an average rate of 1.94% per year, whereas U.S. growth kept pace at 1.54% per year. Although growth resumed from 1995 to 2017, it continued at a moderate pace, especially for the post-2000s period, where the average growth rate was 0.65% per year compared to 1.3%

[6] Fernández-Villaverde et al. (2023) measure GDP per worker using the World Development Indicators (WDI) data, in particular, they measure it as GDP in national constant prices. We also compute the growth rates of GDP per worker using this data and find no qualitative differences. Table A.10 in Appendix A shows the growth rates of GDP per worker by periods using the WDI data.

Table 1: Average Growth Rate of GDP per Worker by Country

	Canada	Italy	Mexico	United States
1950-1980	2.60	5.81	3.35	1.99
1980-2000	1.65	2.23	-0.92	1.82
Post-2000	0.69	0.42	0.65	1.31

Note: All numbers are in percent. Growth rates are computed as the average annual growth rate of GDP per worker over the indicated period. Data are from the Penn World Table 10.1.

for the United States. For Italy, the numbers are not as striking as for Mexico, but there was a significant slowdown from the pre-1980s period. Italy grew at an average rate of 5.81% per year before the 1980s, and then the average growth rate decreased to 0.42% per year in the post-2000s period. Between 1980 and 2000, Canada witnessed an average growth of 1.65%, very close to the U.S. growth rate of around 1.82%. But in the post-2000s period, the Canadian as well as the Italian and Mexican economies started to experience stagnation, as shown in Figure 1. The GDP per worker grew in Canada at 0.69%, similar to Italy and Mexico, while the United States grew at 1.31%. Even developing countries such as Belize and the Central African Republic showed relative stagnation compared to the United States in the past decades.[7]

Figure 2 shows real GDP and capital per worker normalized to 1 in 2000 for the same countries as before. For all countries shown in Figure 2, the GDP per worker has diverged from that of the United States since 2000. For instance, real GDP per worker in Belize has been shrinking at an average rate of -1.13% while in the Central African Republic the growth rate has been very moderate at 0.3% between 2000 and 2019, respectively. However, when we examine capital per worker, both Belize and the Central African Republic have experienced a faster growth rate than the United States.[8] Moreover, between 2000 and 2019, every country in Figure 2 (except the United States) has experienced a higher growth rate of capital per worker than GDP per worker, and these growth rates have outpaced those of the United States as well.[9]

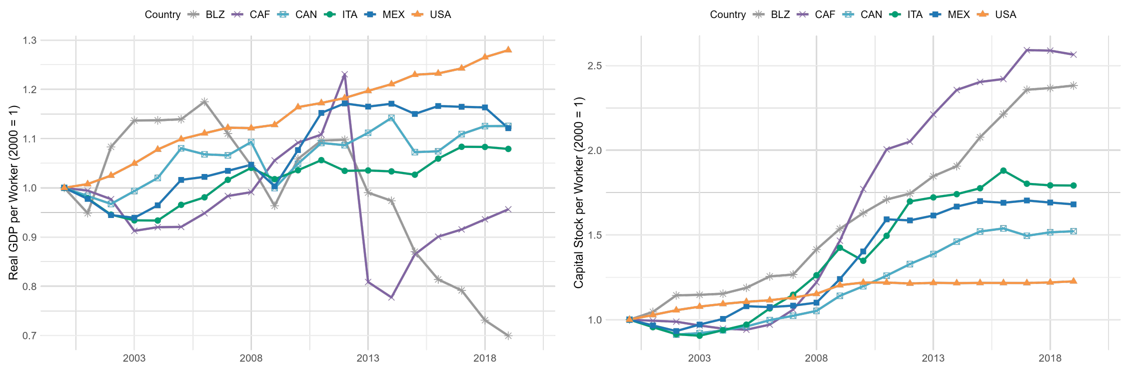
During the 1980s and 1990s, the macroeconomic literature prescribed policy measures to tackle the lack of growth in some economies. The policy prescriptions included opening the economy to international trade and foreign direct investment (FDI), control of public spending, and monetary policy restricting inflation and privatization. Although aggregate capital increased in some countries, the lack of GDP growth response to these policy reforms led to widespread doubts about the value of such reforms (see Easterly, 2019, for example).

[7]Fernández-Villaverde et al. (2023) show that comparing the economic performance of countries based on GDP per capita misses a crucial factor of developed economies like population aging. We abstract from population aging, so we focus on GDP per worker.

[8]The average growth rate of capital per worker for Belize and the Central African Republic was 4.82% and 4.99%, respectively, between 2000 and 2019. The average growth rate of capital per worker for the United States was 1.12% in the same period. See Table B.11 for the growth rates of GDP per worker and capital per worker for Belize, Central African Republic, Canada, Italy, Mexico, and the United States in the period from 2000 to 2019.

[9]Although here we focus on a specific set of countries, faster capital per worker growth compared to GDP per worker is prevalent across many countries. See Appendix B for further explanation.

Figure 2: Cross Country Real GDP and Capital per Worker Relative to 2000



(a) Real GDP per Worker (b) Capital per Worker

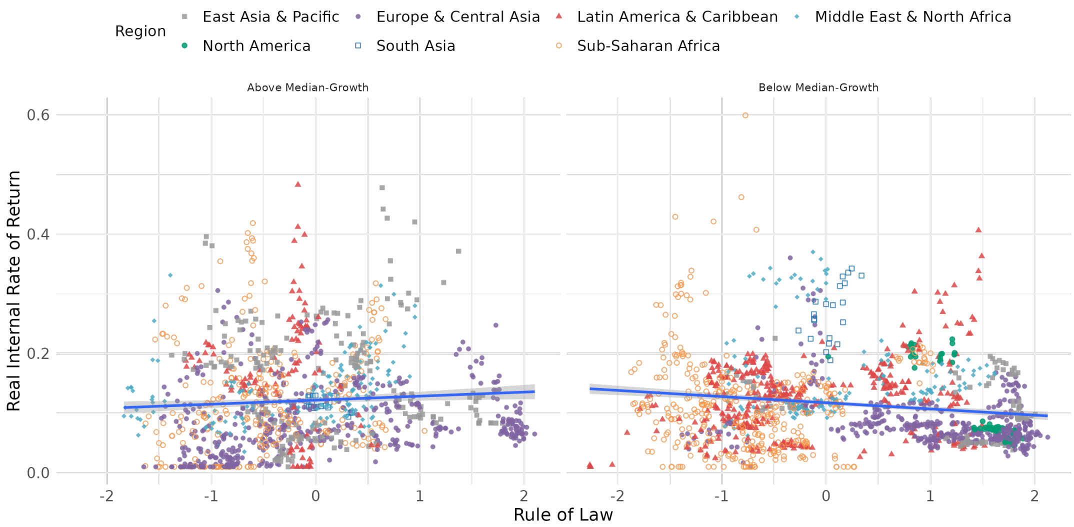
Note: The data is from the Penn World Tables 10.1. Real GDP per worker is constructed as real GDP at chained PPPs (2017 US$) divided by the number of persons engaged. Capital per worker is constructed as the capital stock at constant 2017 US$ divided by the number of persons engaged. The data is normalized to 1 in 2000.

Potential explanations for the stagnation have centered on policies and institutions that may generate perverse incentives and distort allocative decisions, causing aggregate productivity to decline. Possible explanations are inefficient financial systems, lack of contract enforcement, and rigidities in the labor market as noted by Kehoe and Ruhl (2010). For example, one major consequence of an inefficient financial market is failing to channel enough investment to high-return productive sectors while low-return sectors continue to receive too much investment, generating capital misallocation in the economy (as in Gopinath et al., 2017).

In light of these misallocation arguments for the stagnation of some economies, we build a general equilibrium growth model that considers the impacts of heterogeneous capital allocations among productive sectors on economic growth. The key prediction of the model is that along the balanced growth path, in which all countries grow at the same rate, the profile of sectoral distortions in the economy determines the equilibrium internal rate of return on capital. Moreover, countries with fewer overall distortions will face a lower rate of return in the long run after capital adjustments and, consequently, will have higher output per worker. Figure 3 depicts the real internal rate of return for all countries in the Penn World Table 10.1 for the years 1995-2020 against the Worldwide Governance Indicator of "Rule of Law" calculated by the World Bank,[10] as a proxy for misallocation. We chose this indicator because it reflects the type of institutions and policies that may distort decision-making. Countries with below-median GDP per worker growth rate in the period show a negative relationship between the real internal rate of return and the index of rule of law, suggesting that the model prediction might find empirical support.

[10] These indicators are constructed based on several survey sources that reflect the views of the citizens, entrepreneurs, and pundits in public, private, and nongovernmental organizations regarding governance issues. We focus on the Rule of Law aggregate indicator that includes individual indicators. The World Bank defines the Rule of Law aggregate indicator as: *"Rule of Law captures perceptions of the extent to which agents have confidence in and abide by the rules of society, and in particular, the quality of contract enforcement, property rights, the police, and the courts, as well as the likelihood of crime and violence"*.

Figure 3: Cross Country Real Internal Rate of Return and Misallocation (by real GDP per worker growth rate)



Note: The data on the real internal rate of return is from the Penn World Tables 10.1 (Feenstra et al., 2015) while the data for the Rule of Law indicator is from the Worldwide Governance Indicator from the World Bank.

In addition, the relationship among high-growth countries is slightly positive, which is in line with the model's predictions.[11]

We calibrate the model to Mexican economy which is an interesting case since it experienced an impressive convergence growth up to the early 1980s and then stagnated. For example, in terms of foreign policy Mexico joined the General Agreement on Trade and Tariffs in 1986 and reinforced its commitment with an open and competitive market by signing the North America Free Trade Agreement (NAFTA) in 1994 (Hanson, 2010) and joined the World Trade Organization on January 1, 1995. In fact, the participation of trade in goods and services in total GDP for the Mexican economy increased by 20 percentage points in the 1994–95 period, after joining NAFTA (Kehoe and Ruhl, 2010). As a consequence of all the reforming efforts put in place through almost 15 years, Mexico joined the Organization for Economic Cooperation and Development (OECD) in 1994 –an organization formed primarily by rich countries (Hanson, 2010). Nevertheless, growth remained sluggish thereafter.[12]

An explanation for the disparity between capital per worker convergence and GDP per worker divergence could be attributed to the misallocation of capital. We use data from the

[11] Appendix C provides additional evidence for the relationship between the real internal rate of return and this misallocation measure.

[12] By the end of 1994, Mexico experienced a profound financial crisis called the Mexican Peso crisis. According to Griffith-Jones (1998), the cause of this crisis is composed of a variety of factors such as a rapid financial liberalization, a large scale of the current account deficit, short-term capital inflows, a high proportion of private and public debt financed by non-resident short-term funds, among others. Between 1994 and 1995, the real exchange rate depreciated more than 55 percent, according to Pratap and Urrutia (2012). Simultaneously, the interest rate increased to almost 50% from around 7% in 1994. In 1996, the interest rate started to fall slowly, and only at the beginning of 2000 did the interest rate and exchange rate return to 1990 levels. For more details about the Mexican economy see Kehoe and Meza (2011), Estevadeordal and Taylor (2013), and Algazi (2020).

Table 2: Panel Regression — Capital Misallocation in Mexico

	(1)	(2)	(3)
Sector-to-Total Capital Ratio	-0.508***	-0.217*	-0.430***
	(0.153)	(0.113)	(0.118)
Intermediate Goods per Worker		0.254**	0.045
		(0.090)	(0.089)
Capital per Worker			0.335***
			(0.071)
Num.Obs.	742	728	728
R2	0.297	0.557	0.627

Note: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Newey-West standard errors are in parentheses. All regressions include sector and year fixed effects. The dependent variable is the growth rate of value added per worker. Sector-to-Total Capital Ratio denotes the growth rate of sectoral capital to aggregate capital. Intermediate Goods per worker denotes the growth rate of intermediate goods per worker. Capital per worker denotes the growth rate of capital per worker.

World Input-Output Database Release 2016 (Timmer et al., 2015) and empirically evaluate if there is a negative relationship between the share of sectoral capital into aggregate capital and the growth rate of value added per worker for Mexico. In particular, we regress for the period available (2000-2014) the yearly growth rate of value added per worker on the share of sectoral capital in aggregate capital, intermediate goods per worker, and capital per worker, including sector and year fixed effects. In this way, we can assess the relationship between the growth rate of sectoral value added and the share of capital in that sector controlling for constant sector specific factors (such as the output elasticity with respect to capital) and aggregate time trends that control for aggregate phenomena such as structural change.

Table 2 shows the panel regression results. The coefficient of the share of capital in the sector is negative and statistically significant in all specifications. These results indicate that sectors with increased capital participation have lower growth rates of value added per worker, which suggests that capital was misallocated over time in Mexico.[13]

3 Model

This section outlines our open economy growth model. Time is continuous and there is a continuum of countries $n \in [0, N]$ with productivity θ_n. Each country n has a representative agent that supplies labor and capital inelastically to domestic firms, purchases consumption goods from domestic firms, and can lend or borrow money in international markets, trading one-period bonds. There is no population growth, and we normalize labor supply to one. There are multiple sectors and a final consumption good that is an aggregate of sectoral production. There is perfect competition in each sector, and producers face sector-specific distortions over capital and intermediate inputs comprised of

[13]Table F.15 in Appendix F contains the same regression for Canada where we find the coefficient of interest to remain negative and statistically significant after controlling for capital per worker and intermediate goods per worker.

tradeable intermediate varieties. A mass N of world varieties is indexed by $\nu \in [0, N]$, where each country produces a subset of varieties $\mathcal{V}_n$ with measure μ_n. Thus, the total number of varieties is given by

$$\int_0^N \mu_n dn = N. \tag{1}$$

We follow Basco and Mestieri (2019) and assume that the mass μ_n of world varieties is determined by country's productivity so that $\mu_n = f(\theta_n)$, where $f'(\theta_n) \geq 0$ and $f''(\theta_n) \leq 0$, that is, the measure of varieties produced by a country is increasing and concave in its productivity. As in Acemoglu and Ventura (2002), the number of countries and varieties grow at an exogenous rate λ, i.e., $\dot{N}/N = \dot{\mu}_n/\mu_n = \lambda$.

3.1 Firms

3.1.1 Final goods

In each country n, there is a perfectly competitive final good market that uses products from S sectors as inputs ($S \in \mathbb{N}$). The production function is described by

$$Y_n(t) = \prod_{s=1}^{S} y_{sn}(t)^{\omega_s}, \tag{2}$$

where $\sum_{s=1}^{S} \omega_s = 1$ and sells it domestically at price p_n^Y. The final good price satisfies

$$p_n^Y(t) = \prod_{s=1}^{S} \left(\frac{p_{sn}^y(t)}{\omega_s} \right)^{\omega_s}, \tag{3}$$

where $p_{sn}^y(t)$ is the price of the sectoral good $y_{sn}(t)$.

3.1.2 Sectoral goods

In each sector $s \in \{1, \ldots, S\}$, a representative firm produces sectoral output y_{sn} using capital k_{sn} and intermediate inputs X_{sn} according to the Cobb-Douglas technology

$$y_{sn}(t) = z_{sn} k_{sn}(t)^{\alpha_s} X_{sn}(t)^{1-\alpha_s}, \tag{4}$$

where

$$X_{sn}(t) = \left(\int_0^N x_{sn}(\nu, t)^{\frac{\varepsilon-1}{\varepsilon}} d\nu \right)^{\frac{\varepsilon}{\varepsilon-1}}$$

and the productivity (z_{sn}) and the capital share (α_s) are sector specific. The intermediate input composite X_{sn} is a Constant Elasticity of Substitution (CES) aggregator of tradable varieties, where $x_{sn}(\nu, t)$ denotes the demand for variety ν by sector s in country n, and ε denotes the elasticity of substitution across varieties. Note that the firm potentially uses varieties from all countries to produce sectoral output, so X_{sn} aggregates varieties in the interval $[0, N]$. The representative firm in each sector maximizes

$$\Pi_{sn}(t) = p^y_{sn}(t) y_{sn}(t) - \tau^k_{sn} r_n(t) k_{sn}(t) - \tau^x_{sn} \int_0^N p(\nu, t) x_{sn}(\nu, t) d\nu,$$

subject to (4) where r_n denotes the capital rental rate, and τ^k_{sn} and τ^x_{sn} denote distortions affecting capital and intermediate goods prices, respectively.[14] Since varieties are internationally traded, the price of varieties is given by $p(\nu, t)$.

Perfect competition implies that the price of the sectoral good is given by the cost of the input bundle to produce one unit of sectoral output, that is

$$p^y_{sn}(t) = c_s(r_n(t), P(t)) \equiv \frac{(\tau^k_{sn} r_n(t))^{\alpha_s} (\tau^x_{sn} P(t))^{1-\alpha_s}}{z_{sn} \alpha_s^{\alpha_s} (1 - \alpha_s)^{1-\alpha_s}}, \tag{5}$$

which is a function of the static distortions τ^k_{sn} and τ^x_{sn}, the price of capital $r_n(t)$ and the ideal price index $P(t)$ given by

$$P(t) = \left(\int_0^N p(\nu, t)^{1-\varepsilon} d\nu \right)^{\frac{1}{1-\varepsilon}}. \tag{6}$$

3.1.3 Intermediate Varieties

Intermediate varieties are produced with a linear technology in labor given by $x_n(\nu, t) = \theta_n(t) \ell_n(\nu)$, where $\ell_n(\nu)$ denotes the labor used to produce variety ν in country n. Note that $\theta_n(t)$ changes over time since the measure of varieties produced by each country grows exogenously at rate λ. Producers maximize profits in a perfectly competitive environment. Since each country produces a measure of varieties $\mu_n(t)$ and the marginal cost is the same across varieties, the price of all varieties produced by country n is given by $p(\nu, t) = p_n(t) = w_n(t)/\theta_n(t)$ for all $\nu \in \mu_n$, where w_n denotes the wage rate in country n.

3.2 Households

The representative household in country n supplies labor and capital inelastically and has preferences over consumption given by

$$\int_0^\infty e^{-\rho t} \log(C_n(t)) dt, \tag{7}$$

where $C_n(t)$ denotes consumption at time t and ρ is the discount factor. The household can lend or borrow in international markets by trading bonds. Let the net foreign asset position of country n be denoted by $\mathbb{M}_n(t)$ and the flow constraint by

$$\dot{\mathbb{M}}_n(t) = R(t) \mathbb{M}_n(t) - B_n(t), \tag{8}$$

[14] As intermediate goods are tradeable, trade distortions and intermediate goods distortions are used interchangeably in the text to refer to τ^x_{sn}.

where $R(t)$ is the interest rate on bonds and $B_n(t)$ denotes the net borrowing of country n. Note that if $\mathbb{M}_n(t) > 0$ then country n is a net lender and if $\mathbb{M}_n(t) < 0$ then country n is a net borrower. Thus, the household's budget constraint is given by

$$C_n(t) + \dot{K}_n(t) + \delta K_n(t) - B_n(t) = \tilde{r}_n(t) K_n(t) + \tilde{w}_n(t), \tag{9}$$

where $\tilde{r}_n(t) = r_n(t)/p_n^Y(t)$ and $\tilde{w}_n(t) = w_n(t)/p_n^Y(t)$, $K_n(t)$ denotes the capital stock and δ denotes the depreciation rate of capital. And the no-Ponzi game condition for the representative household in country n is

$$\lim_{t\to\infty} \mathbb{M}_n(t) \exp\left(-\int_0^t R(s)ds\right) = 0. \tag{10}$$

The household maximizes (7) subject to (8), (9) and (10). Note further that the world's capital market clearing condition implies that the amount borrowed and lent in international markets equalizes, that is

$$\int_0^N B_n(t)dn = 0 \tag{11}$$

must be satisfied at all t. The first-order conditions of the household's problem imply that the consumption Euler equation is given by

$$\frac{\dot{C}_n(t)}{C_n(t)} = \frac{r_n(t)}{p_n^Y(t)} - \delta - \rho, \tag{12}$$

and that the interest rate on bonds and the actual net return on capital satisfy

$$R(t) = \frac{r_n(t)}{p_n^Y(t)} - \delta. \tag{13}$$

The Euler equation (12) depends on what we label the actual rate of return given by the rental rate of capital divided by the national final good price index. In this model, we denote the numeraire as the ideal price index (normalized to $P(t) = 1$ for all t) defined in equation (6), which is the price index of the tradeable intermediate varieties bundle. Equation (13) simply relates the interest rate on bonds to the national actual rate of return on capital which, in equilibrium, must be equal. Following Schmitt-Grohé and Uribe (2003), we assume that the interest rate on bonds faced by domestic agents $R(t)$ is increasing in the aggregate level of foreign debt, specifically

$$R(t) = R^* + p(\mathbb{M}_n(t)), \tag{14}$$

where $p(\mathbb{M}_n(t))$ is assumed to be decreasing. It denotes the premium on foreign debt and R^* denotes the world interest rate. This assumption is motivated by the fact that countries with higher levels of foreign debt tend to face higher interest rates on their debt.[15]

[15] See for example Aguiar and Gopinath (2007) for a calibrated model using this assumption.

3.3 International trade

Intermediate varieties are internationally traded while sectoral production goods are not. Additionally, our model incorporates a capital flow wherein agents can borrow from or lend to other countries. Total exports are defined as

$$TX_n(t) = \int_{\nu \in \mu_n} p(\nu, t) x_n(\nu, t) d\nu,$$

which means total exports of country n are given by the world's demand for variety ν produced by country n times the price of that variety $p(\nu, t)$ aggregating across the measure of varieties μ_n produced by country n.

We define similarly total imports of country n as

$$TI_n(t) \equiv \int_0^N \sum_{s=1}^{S} \int_{\nu \in \mu_{n'}} p(\nu, t) x_{sn}(\nu, t) d\nu dn'$$

which are determined by the demand from each sector s in country n of each variety ν produced in each country n' of the world, $x_{sn}(\nu, t)$, times the price of each variety ν. The aggregation is first across the measure of varieties $\mu_{n'}$ produced by each country n', aggregating across all sectors, and then across all countries n' in the world.

3.4 Equilibrium

Definition 1. *Given the productivities* $\{\theta_n(t)\}_{t \geq 0}$, $\{z_{sn}\}_{s=1}^{S}$ *and the distortions* $\{\tau_{sn}^k, \tau_{sn}^x\}_{s=1}^{S}$, *a competitive equilibrium consists of a vector of prices* $\{p_n^Y(t), p_{sn}^y(t), p(\nu, t), w_n(t), r_n(t)\}_{t \geq 0}$ *and quantities* $\{\{y_{sn}(t), k_{sn}(t), x_{sn}(\nu, t)\}_{s=1}^{S}, Y_n(t), \ell_n(\nu), C_n(t), B_n(t), K_n(t)\}_{t \geq 0}$ *for each country n such that given* $R(t)$*:*

1. *The representative household maximizes (7) subject to (8), (9) and (10), and chooses* $\{C_n(t), B_n(t), K_n(t)\}_{t \geq 0}$.

2. *The final good firm maximizes profits subject to (2) choosing* $y_{sn}(t)$ *and the final good price satisfies (3).*

3. *Firms producing the sectoral good maximize profits subject to (4) choosing* $k_{sn}(t)$ *and* $x_{sn}(\nu, t)$*. The price of the sectoral good satisfies (5).*

4. *Intermediate good firm maximizes profits subject to the linear technology in labor and the price of each variety* $\nu \in \mu_n$ *is given by* $p(\nu, t) = w_n(t)/\theta_n(t)$.

5. $r_n(t)$ *is given by (12).*

6. *Market clears in all markets (Final goods, Sectoral goods, Intermediate varieties, Capital, Labor, and International market).*

3.5 Aggregation and Balanced Growth Path

In this section, we show that static sectoral distortions on the factor prices affect total factor productivity and capital accumulation, and we prove that our economy admits a balanced growth path (BGP).[16] Proposition 1 shows that aggregate output can be expressed as a function of an aggregate TFP term, the capital, the internal rate of return, and the price index. Furthermore, it establishes that both aggregate TFP and the actual rate of return are functions of the static distortions.

Proposition 1. *Define aggregate sectoral distortions as* $\tilde{\tau}_{sn} \equiv (\tau_{sn}^k)^{\alpha_s} (\tau_{sn}^x)^{1-\alpha_s}$ *and* $\tilde{\alpha}_s \equiv \alpha_s^{\alpha_s}(1-\alpha_s)^{1-\alpha_s}$*. In the competitive equilibrium, the economy's aggregate production function can be obtained as*

$$Y_n = \mathcal{A}_n \left(\frac{r_n}{P}\right)^{1-\sum_s \omega_s \alpha_s} K_n, \tag{15}$$

where

$$\mathcal{A}_n \equiv \left(\sum_{s=1}^{S} \frac{\alpha_s \omega_s}{\tau_{sn}^k}\right)^{-1} \prod_{s=1}^{S} \left(\frac{\tilde{\alpha}_s z_{sn} \omega_s}{\tilde{\tau}_{sn}}\right)^{\omega_s}, \tag{16}$$

and K_n *denotes the aggregate capital stock in country* n*, i.e.* $\sum_{s \in S} k_{sn}$*.*

Furthermore, the actual rate of return on capital is given by

$$\frac{r_n}{p_n^Y} = \mathcal{B}_n \left(\frac{r_n}{P}\right)^{1-\sum_s \omega_s \alpha_s}, \tag{17}$$

where

$$\mathcal{B}_n \equiv \prod_{s=1}^{S} \left(\frac{\tilde{\alpha}_s z_{sn} \omega_s}{\tilde{\tau}_{sn}}\right)^{\omega_s},$$

which implies that static distortions affect capital accumulation and total factor productivity.

Proof. Proof is in Appendix D.1. □

Proposition 1 shows that the distortion term $\mathcal{B}_n$ directly affects the actual rate of return and, then, the level of capital in the economy. Furthermore, the aggregate production (equation (15)) depends on the TFP term $\mathcal{A}_n$, which is a combination of sectoral productivity and wedges. The average wedges do not affect $\mathcal{A}_n$, but higher dispersion decreases this term.[17] To see that, suppose an increase in all distortions by a factor of $\chi > 1$. This increase in the average distortion would have no impact on $\mathcal{A}_n$, although the actual rate of return would be affected through $\mathcal{B}_n$. Thus, a reform that decreases the average wedge but increases dispersion can increase the level of capital and, at the same time, decrease the TFP. If the TFP effect dominates, it could reduce overall GDP.

The extent to which either capital or intermediate inputs distortions affect $\mathcal{B}_n$ depends on the sectoral output elasticity with respect to capital or intermediate inputs. In particular, input intensity matters for how changes in distortions affect $\mathcal{B}$. Indeed, it can be shown that

$$\frac{\partial \log(\mathcal{B}_n)}{\partial \log(\tau_{sn}^k)} = -\alpha_s \omega_s \quad \text{and} \quad \frac{\partial \log(\mathcal{B}_n)}{\partial \log(\tau_{sn}^x)} = -(1-\alpha_s)\omega_s. \tag{18}$$

[16] We will omit the time index (t) in this section to simplify the notation.

[17] See Appendix D.2 for a formal proof.

Furthermore, the effect of changes in distortions on aggregate TFP ($\mathcal{A}_n$) is given by

$$\frac{\partial \log(\mathcal{A}_n)}{\partial \log(\tau^k_{sn})} = -\alpha_s \omega_s \left(1 - \frac{1}{\tau^k_{sn}} \sum_{s' \in S} \frac{\alpha_{s'}\omega_{s'}}{\tau^k_{s'n}}\right) \quad \text{and} \quad \frac{\partial \log(\mathcal{A}_n)}{\partial \log(\tau^x_{sn})} = -(1-\alpha_s)\omega_s. \tag{19}$$

The last equation shows that the effect on aggregate TFP from changes in capital distortions depends on the current level of capital distortions. In particular, as $\tau^k_{sn} \to \infty$, the effect of reducing the capital distortions converges to $\alpha_s \omega_s$. However, if the sector already has low capital distortions (i.e., $\tau^k_{sn} \to 1$), then the effect of reducing them is smaller. In contrast, the effect of intermediate input distortions τ^x_{sn} on aggregate TFP is constant and equal to that of $\mathcal{B}_n$.

Proposition 2. *Consider the above described economy. The participation of a country in world trade is a function of its productivity and the measure of varieties produced in that country. In particular, the share of country n in world exports is given by*

$$\frac{\int_{\nu \in \mu_n} p(\nu)x(\nu)d\nu}{PX^W} = \frac{\mu_n^{\frac{1}{\varepsilon}} \theta_n^{\frac{\varepsilon-1}{\varepsilon}}}{\int_0^N \mu_{n'}^{\frac{1}{\varepsilon}} \theta_{n'}^{\frac{\varepsilon-1}{\varepsilon}} dn'}. \tag{20}$$

Proof. Proof is in Appendix D.3. □

The above proposition shows that export participation in world trade is increasing in country n's productivity and the measure of varieties produced in that country. Furthermore, since the measure of varieties is an increasing function of θ_n, more productive countries tend to export more conditional on the measure of varieties they produce.

Proposition 3 shows that the economy admits a balanced growth path where all variables grow at constant rates. It is not immediate that a balanced growth path would exist since, for example, the Euler equation for consumption depends on the actual rate of return that is a function of national distortions (through p^Y_n). This implies that the reference price for investment in each country (associated to the traded goods produced) depends on the distortions τ^k_{sn} and τ^x_{sn}. Therefore, different countries that face the same interest rate r_n would have different actual rates of return on capital r_n/p^Y_n.

Proposition 3. *Consider the above described economy and assume $\mu_n = \kappa\theta_n$, where $\kappa \in \mathbb{R}_+$. The long-run growth rate of aggregate output, aggregate capital, aggregate consumption, aggregate demand for intermediate inputs, wages, net fixed asset position, and total world exports along the balanced growth path is given by*

$$\frac{\dot{Y}_n}{Y_n} = \frac{\dot{K}_n}{K_n} = \frac{\dot{C}_n}{C_n} = \frac{\dot{\bar{X}}_n}{\bar{X}_n} = \frac{\dot{w}_n}{w_n} = \frac{\dot{\mathbb{M}}_n}{\mathbb{M}_n} = \frac{\dot{X}^W}{X^W} = \frac{\varepsilon}{\varepsilon - 1}\lambda.$$

Furthermore, the rental rate of capital r_n remains constant along the balanced growth path.

Proof. Proof is in Appendix D.4. □

Thus, Proposition 3 shows that the long-run growth rate of the economy depends on the growth rate of the technological frontier (i.e. λ) and the elasticity of substitution across varieties (i.e. ε). In Acemoglu and Ventura (2002) the elasticity ε determines the extent to which changes in relative income in a given country affect its terms of trade, which, in turn, is related to the rate of return to capital. Thus, in their world of AK economies, a higher level of ε would imply a higher output growth rate needed to bring down the rate of return to capital through terms of trade and to ensure a common steady-state growth rate for the world economy. In contrast, in our model, the elasticity of substitution determines the degree of trade between countries and, as a result, the extent of technology adoption. In this sense, higher values of ε mean that all countries' varieties are highly substitutable and there is less need for trade and less opportunity for technology adoption coming from international trade interactions. In the limit, when $\varepsilon \to \infty$, the growth rate converges to λ, the growth rate of the technological frontier.

It is important to note that in Proposition 3, the balanced growth path growth rate of aggregate output or aggregate capital does not depend on the static distortions. However, it affects the rate of return on capital not only in the transition but also in the long run. In particular, according to Proposition 1, a change in sectoral distortions will affect capital accumulation and GDP during the transition through the actual rate of return and the aggregate TFP. Then, we can compare the transition from one initial steady state to another where sectoral productivities and distortions change and quantify the effects of each type of distortion and sectoral productivities. These issues are examined in Section 5.

4 Data and Calibration

In this section, we explain the calibration procedure, which is carried out in two stages. First, we define a set of parameters calibrated either directly from the data or the literature, which we call external calibration. Then, the second set of parameters is endogenously calibrated considering the general equilibrium structure in our model.

We calibrate the BGP in the initial and final periods for the Mexican economy[18] corresponding to the years 2000 and 2014.[19] The main data used is the World Input-Output Database Release 2016 (Timmer et al., 2015), which provides a panel of 43 countries and a "rest of the world" additional country from 2000 to 2014 disaggregated into 56 sectors.[20] In particular, we use the Socio-Economic Accounts that provide industry-level data on employment, capital stock, gross output, and value-added for each country and have an industry classification consistent with the World Input-Output Tables.

The first set of parameters $\{\delta, \varepsilon, \lambda\}$ is externally calibrated. We set the annual depreciation rate $\delta = 0.05$ as is standard in the literature. We calibrate the elasticity of substitution across varieties ε to 2 as in Ravikumar et al. (2019), and we set λ to match the average growth rate of GDP per worker of the United States between 2000 and 2014, which is 1.3%, and this implies $\lambda = 0.0066$. Note that the elasticity of substitution across

[18] In Appendix F we also calibrate our model for Canada.

[19] We focus on this period to avoid the effects of the Mexican Peso crisis in 1994.

[20] We aggregate this information to 48 industries because of missing information in several industries. Appendix E explains in detail how we aggregate these sectors.

varieties ε does not affect the BGP rate of return on capital.

We calibrate the exponents of the final good aggregator (2), ω_s, to the average share of each sector s over aggregate gross output in the United States, that is,

$$\omega_s = \frac{1}{T}\sum_{t=1}^{T} \frac{\text{gross output}_{st}^{\text{U.S.}}}{\sum_{s'} \text{gross output}_{s't}^{\text{U.S.}}},$$

where T is the number of years of available data ($T = 14$).

To determine sectoral distortions in 2000, we use equation (23) and follow a standard approach in literature (Hsieh and Klenow, 2009; Meza et al., 2019). First, we calibrate α_s using the factor shares from the corresponding sector s for the U.S. as the benchmark for an economy without distortions. In particular, we calibrate α_s as the average of capital compensation over gross output for each sector s. Then, the distortions are given by

$$\tau_{sn}^{k} = \frac{\alpha_s}{\frac{\text{capital compensation}_{sn}}{\text{gross output}_{sn}}} \quad \text{and} \quad \tau_{sn}^{x} = \frac{1-\alpha_s}{\left(1 - \frac{\text{capital compensation}_{sn}}{\text{gross output}_{sn}}\right)}.$$

The productivity that determines the mass of varieties (θ_n), the sectoral productivities (z_{sn}), and the discount factor (ρ) remain to be calibrated. We first let $z_{sn} \equiv \bar{z}_n \tilde{z}_{sn}$ where $\bar{z}_n$ is a common component across sectors and $\tilde{z}_{sn}$ is a specific component normalized such that $\sum_{s\in S} \tilde{z}_{sn} = S$ (i.e. the average of $\tilde{z}_{sn}$ is 1). This normalization captures the sector productivity in the steady state relative to the average productivity across sectors in that steady state. We denote $\mathbf{m}_d$ as the vector of moments obtained from the data and $\mathbf{m}(\boldsymbol{\Theta})$ the vector of moments implied by the model, where $\boldsymbol{\Theta} = \{\bar{z}_n, \tilde{z}_{sn}, \theta_n, \rho\}$, and we solve the following problem

$$\boldsymbol{\Theta}^* = \arg\min_{\boldsymbol{\Theta}} \left(\mathbf{m}_d - \mathbf{m}(\boldsymbol{\Theta})\right)' \mathbf{W} \left(\mathbf{m}_d - \mathbf{m}(\boldsymbol{\Theta})\right),$$

where $\mathbf{W}$ is a diagonal matrix of weights with diagonal elements given by $1/m_{di}^2$ where m_{di} is the i-th element of $\mathbf{m}_d$.

We assume that the economy was in a steady state in 2000 and use as a target (i) the internal rate of return, (ii) the share of exports over world exports, (iii) the capital-output ratio, and (iv) the relative sectoral output.

Proposition 3 implies that all growing variables grow at a constant growth rate given by $g \equiv \lambda\varepsilon/(\varepsilon - 1)$. To find the steady state we divide all growing variables by $\exp\{gt\}$. Since we have international capital flows that could generate trade imbalances, we follow Ravikumar et al. (2019) and assume that the current account is balanced on the initial steady state. Then, we choose the net foreign position $\mathbb{M}_n$ such that net exports are equal to those observed in 2000. From equations (12), (13), and (17), we can pin down the interest rate as

$$r_n = \left(\frac{\rho + g + \delta}{\mathcal{B}_n}\right)^{\frac{1}{1-\sum_{s\in S}\omega_s\alpha_s}},$$

the output to-capital ratio as

$$\frac{Y_n}{K_n} = \mathcal{A}_n r_n^{1-\sum_{s\in S}\omega_s\alpha_s},$$

and the share of exports of country n as

$$\frac{TX_n}{PX^W} = \frac{\theta_n}{N},$$

where we normalize N to be 1000. Although all parameters are identified from all moments, these moments are closely related to $\{\bar{z_n}, \rho, \theta_n\}$ while $\tilde{z}_{sn}$ are identified from the relative sectoral outputs and the normalization $\sum_{s\in S}\tilde{z}_{sn} = S$. From the final goods's first order condition (see equation (21)) and the cost function (equation (5)), we can write the relative sectoral output as

$$\frac{y_{sn}}{y_{1n}} = \frac{\omega_s}{\omega_1}\frac{(\tau_{sn}^k r_n)^{\alpha_s}(\tau_{sn}^x)^{1-\alpha_s}}{z_{sn}\alpha_s^{\alpha_s}(1-\alpha_s)^{1-\alpha_s}}\frac{z_{n1}\alpha_1^{\alpha_1}(1-\alpha_1)^{1-\alpha_1}}{(\tau_{1n}^k r_n)^{\alpha_1}(\tau_{1n}^x)^{1-\alpha_1}}.$$

For the year 2014 we need to calibrate the set of parameters $\{\bar{z}_n, \tilde{z}_{sn}, \theta_n, \tau_{sn}^k, \tau_{sn}^x\}$ while keeping all other parameters as in the year 2000. For the parameters that remain to be calibrated, we follow the same strategy as for 2000.

Table 3: Aggregate Calibrated Parameters

Definition	Parameter	Value (2000)	Value (2014)
Panel A: Externally Calibrated			
Depreciation Rate	δ	0.050	0.050
Elasticity of Substitution	ε	2.000	2.000
Tech. Frontier Growth Rate	λ	0.007	0.007
Panel B: Internally Calibrated			
Average Sectoral Productivity	$\bar{z}$	59.149	49.954
Productivity in Varieties	θ_n	29.122	21.896
Discount Factor	ρ	0.034	0.034

Table 3 summarizes the calibrated parameters.[21] Table 4 shows the differences between the moments in the data and those implied by the model. The model matches all targeted moments correctly. The capital-output ratio in 2014 is not matched exactly because our calibration needs to match both the capital income shares and the capital output ratio. However, since ρ is calibrated in the year 2000 and fixed for 2014, there is less scope for adjustment in the capital-output ratio. However, as observed in the data, our model predicts an increase in the capital-output ratio between 2000 and 2014.[22]

Regarding the sectoral moments, Figures 4a and 4b show the relative sectoral output

[21] See Table G.18 in Appendix for the sectoral distortions and productivities change between 2000 and 2014 and the values of α_s and ω_s.

[22] Our calibration is based on the steady-state condition that investment must be equal to depreciation. If instead we took investment from the data, the model would predict a capital-output ratio of 4.4, which implies a 6.9% percentage deviation from the data.

implied by the model versus the data in 2000 and 2014, respectively. The model can match precisely these moments. The sectoral capital compensation and intermediate inputs shares are matched exactly. Overall, the model does a good job of matching the targeted features of the Mexican economy.

Table 4: Model Fit

Target	Data	Model
Exports Share (2000)	0.029	0.029
Capital-Output Ratio (2000)	2.891	2.891
Internal Rate of Return (2000)	0.149	0.149
Exports Share (2014)	0.022	0.022
Capital-Output Ratio (2014)	4.117	3.449
Internal Rate of Return (2014)	0.131	0.131
Relative Sectoral Output	See Figures 4a and 4b	
Capital Income Share	See Figures 4c and 4d	
Intermediate Inputs Share	See Figures 4e and 4f	

Note: The table shows the value of each moment in the data and the model for the benchmark calibration.

According to the literature that studies the macroeconomic effects of misallocation of resources, there is a positive correlation between sectoral productivity and sectoral distortions.[23] Since in our model there are two sources of sectoral distortions (capital and intermediate inputs), we define a composite measure of distortions given by

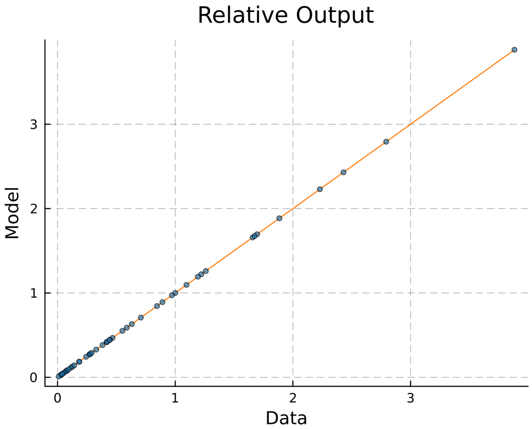
$$\tilde{\tau}_{sn} = \left(\tau^k_{sn}\right)^{\alpha_s} \left(\tau^x_{sn}\right)^{1-\alpha_s},$$

which depends on the elasticity of sectoral output to capital (α_s). In our calibration, the correlation between the composite distortions ($\tilde{\tau}_{sn}$) and the sectoral productivities are 0.48 in 2000 and 0.47 in 2014, suggesting that more productive sectors also face larger overall distortions.

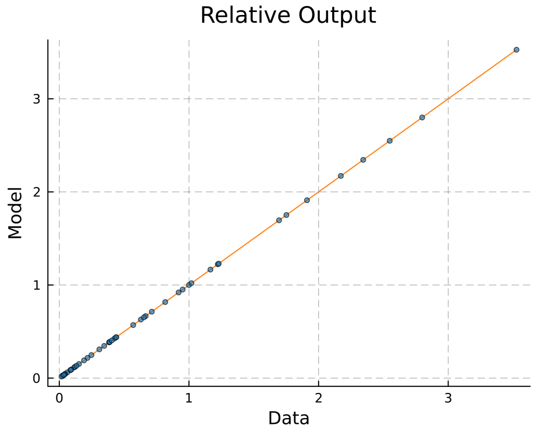
Panel 5a shows a negative correlation between the initial level and the changes in sectoral productivity, which suggests that the initially least productive sectors faced larger increases in productivity. Panel 5b shows no correlation between the change in sectoral distortions and the initial level of productivity. Panels 5c and 5d show how changes in capital and trade distortions, respectively, relate to the initial level of sectoral productivities. We find a positive correlation between the change in capital distortions and the initial level of productivity while this correlation is negative for trade distortions. This suggests that sectors with higher initial productivities faced larger increases in capital distortions but larger decreases in trade distortions. Caliendo and Parro (2014) show that tariffs declined significantly in Mexico, however, our results highlight that this reduction in trade barriers has not been followed by an average decrease in capital distortions.

[23]For instance, Restuccia and Rogerson (2008) considers the case of correlated idiosyncratic distortions when assessing the static effects of changes in the distortions, and Bento and Restuccia (2017) highlights the dynamic effects of changes in the empirically observed correlation between productivities and distortions on the productivity distribution.

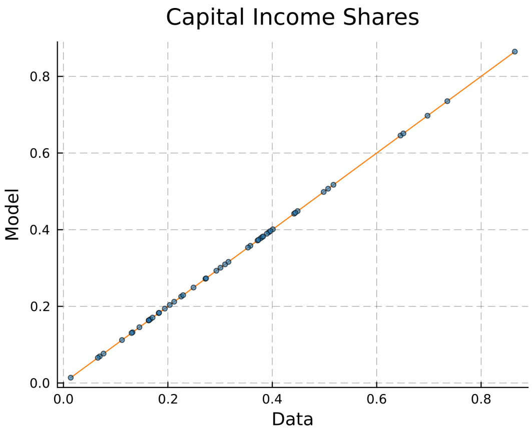
Figure 4: Model versus Data



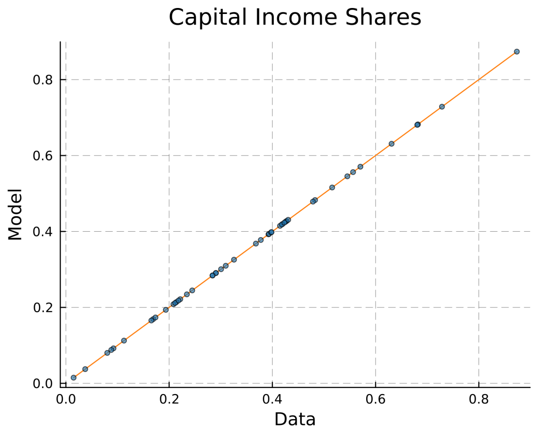
(a) 2000



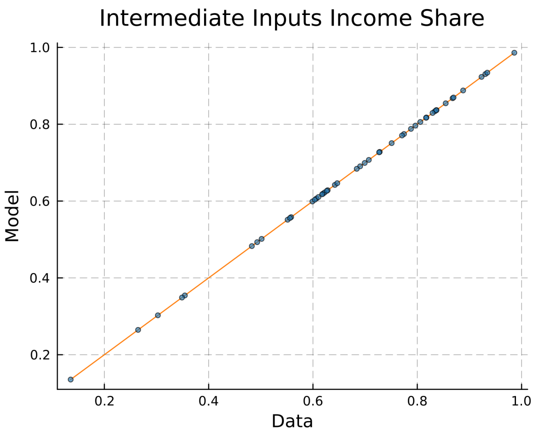
(b) 2014



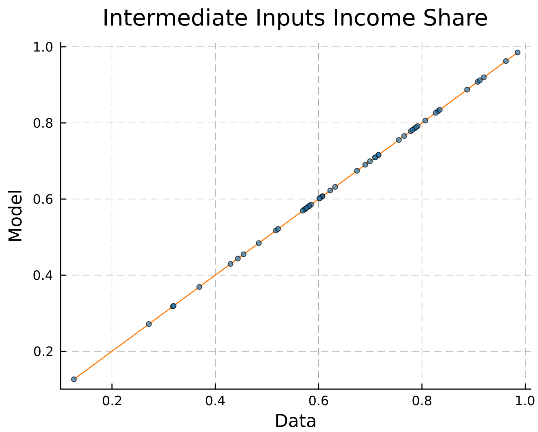
(c) 2000



(d) 2014

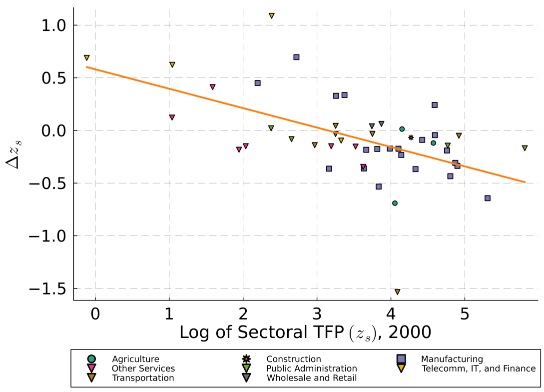


(e) 2000

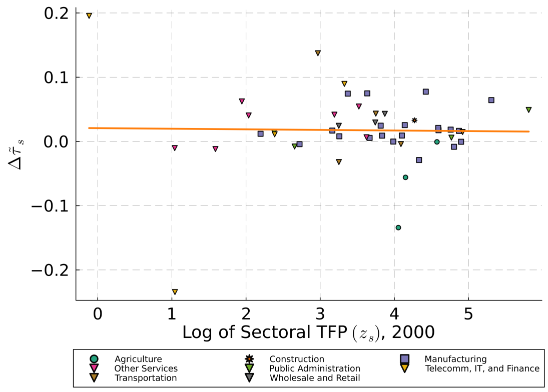


(f) 2014

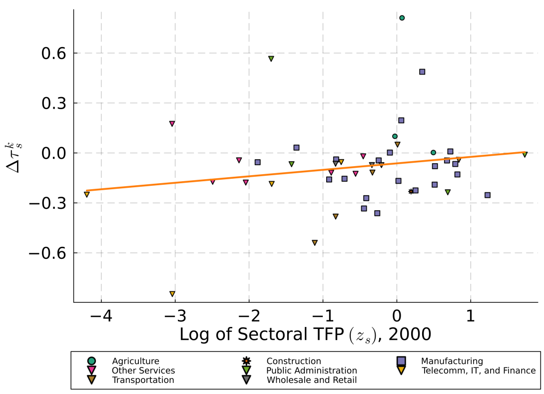
Figure 5: Productivities and Distortions



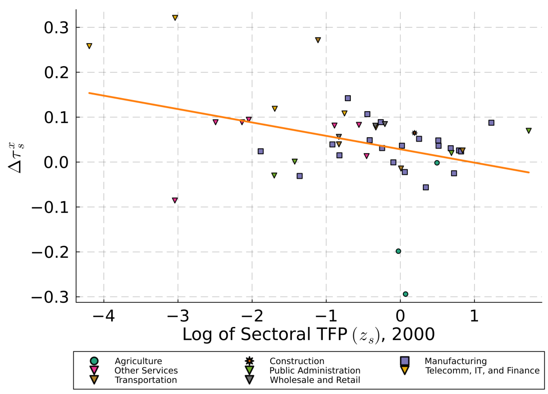
(a) Changes in Productivities



(b) Changes in Distortions



(c) Productivities and Capital Distortions



(d) Productivities and Trade Distortions

Table 5: Tariffs and Distortions

	(1)	(2)	(3)
Change in Trade Distortions	1.721***	1.531***	1.356***
	(0.460)	(0.461)	(0.487)
Tariff Type (MFN = 1)	18.319***	18.319***	18.319***
	(4.088)	(3.988)	(3.977)
Initial Productivity		0.083*	0.080*
		(0.047)	(0.047)
Initial Trade Distortions			14.082
			(12.823)
Num.Obs.	44	44	44
R2	0.454	0.493	0.508

Note: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Observations weighted by the share of imports in the year 2000. Heteroskedasticity robust standard errors are in parentheses. The dependent variable is the growth rate of the average sectoral tariff between 2000 and 2014. The average tariff is a weighted mean of tariffs from all countries where the weights are the imports from those countries. The variable Change in Trade Distortions is defined as the growth rate of the distortions between 2000 and 2014. Tariff Type is a dummy variable equal to 1 if the tariff is for the most favourable nation. Initial Productivity and Initial Trade Distortions are the values of sectoral productivities and trade distortions for the year 2000.

4.1 External Validation

We now focus on how our calibrated distortions relate to other measures not used in the calibration procedure. First, we use tariff data from the United Nations Statistical Division-Trade Analysis and Information System (UNCTAD-TRAINS) to compare with the trade distortion. Then, we follow the approach of Meza et al. (2019) and look at how capital distortions relate to credit constraints.

We use two measures of tariffs as reported by TRAINS, effective and most-favoured nation (MFN) for each country.[24] During the period considered, tariffs were reduced across all sectors.[25] To gauge whether our measure of distortions for intermediate inputs (τ^x_{sn}) is related to tariffs, we regress the change in tariffs between 2000 and 2014 on the change in trade distortions between 2000 and 2014, controlling for the type of tariff (MFN or effective).[26] Table 5 shows the results of the regressions. We find that the change in distortions is positively correlated with the change in tariffs, which suggests that our measure of distortions is capturing relevant information contained in the tariffs data even when we control for initial productivity and initial trade distortions.

Regarding the capital distortions, we use data from the Global Credit Project (Müller and Verner, 2023) that provides data on credit for 188 countries from 1910 to 2014. In

[24]Members of the World Trade Organization (WTO) cannot discriminate between trading partners. MFN tariffs capture this concept. When there are bilateral or multilateral trade agreements, the countries are exempt from this rule, which is why effective tariff rates differ.

[25]Figure G.8 in Appendix G shows the evolution of the weighted average of both tariffs weighted by imports share for Mexico by sector.

[26]We focus on the relative change in tariffs across sectors and how that compares to the relative change in the distortions across the two steady states.

the case of Mexico, the data is disaggregated into six sectors.[27] Meza et al. (2019) show that a measure of aggregate distortions in a similar setting to ours can be mapped to a model with financial frictions. In this model, the tightness of the borrowing constraint is governed by a parameter ξ_{sn} that controls the credit conditions and by an industry-specific interest rate ι_{sn}. In their setting, they can compute ι_{sn} directly from the data and calibrate ξ_{sn} as

$$\xi_{sn} = (1 + \iota_{sn}) \left(\frac{\text{short term credit}_{sn}}{\text{gross output}_{sn}} \right).$$

We do not have the available data to compute the industry-specific interest rate. Instead, we use the data from Müller and Verner (2023) and compute

$$\tilde{\xi}_{sn} \equiv \frac{\xi_{sn}}{1 + \iota_{sn}} = \frac{\text{short term credit}_{sn}}{\text{gross output}_{sn}},$$

and relate that measure to our measure of distortions. If ξ_{sn} is large, the sector faces good credit conditions and can access credit easily. When ξ_{sn} is close to zero, the sector has no access to credit. Thus, we should expect a negative relationship between our measure of capital distortions τ^k_{sn} and the measure of credit constraints $\tilde{\xi}_{sn}$.

We aggregate distortions to the available sectors in the Müller and Verner (2023) data by recomputing the distortions as in our calibration aggregating capital income and sectoral output for the United States (to compute α_s) and Mexico. Furthermore, we compute our distortions for all years from 2000 to 2014. Table 6 estimates the relationship between our calibrated distortions on capital and the credit share on output by regressing the distortion on the measure of credit constraints with sector and year fixed effects. Columns 2 and 3 control for the share in total output and the trade distortions. The coefficient of the credit share on output is always negative and statistically significant, which suggests that our measure of capital distortions is capturing relevant information related to credit constraints even after adding controls and sector and year fixed effects.

5 Results

This section describes the main results of the paper. The primary goal of this section is to measure capital allocation across sectors over time and understand its impact on aggregate GDP. We first present the benchmark calibration results for the long-run equilibrium and the transition starting from the initial BGP toward the final BGP equilibrium where sectoral productivities and distortions vary simultaneously. Next, we explore a set of counterfactuals to understand the role of sectoral distortions and sectoral productivities in capital allocation across sectors and the aggregate GDP.

[27]The sectors are Agriculture, forestry, and fishing (A); Manufacturing, mining, and quarrying (BC); Real estate and construction (FL); Retail and wholesale trade, accommodation, and food services (GI); Transport and communication (HJ); and Other sectors (Z).

Table 6: Panel Regression — Capital Distortions and Credit Allocation

	(1)	(2)	(3)
Credit Share on Output	-0.018***	-0.016***	-0.016***
	(0.005)	(0.004)	(0.004)
Share in Total Output		-0.027*	-0.027*
		(0.015)	(0.014)
Trade Distortions (τ_s^x)			0.005
			(0.199)
Num.Obs.	90	90	90
R2	0.979	0.981	0.981
FE: Sector	X	X	X
FE: Year	X	X	X

Note: * p < 0.1, ** p < 0.05, *** p < 0.01. Newey-West standard errors are in parentheses. All regressions include industry and year fixed effects. In all regressions the dependent variable is the capital distortions (τ_s^k). Credit Share on Output is the ratio of short term credit on sectoral gross output. Share in Total Output is defined as the share of sectoral output over total gross output. Trade Distortions are the yearly distortions on trade (τ_s^x).

5.1 Long-run Effects

The first result compares the aggregate endogenous variables in the BGP equilibrium calibrated for the Mexican economy in 2000 and 2014. The final BGP takes into account the long-run effects of changes in the profile of distortions and productivities. Table 7 summarizes these results.

Table 7: Benchmark Steady States

	Benchmark BGP Relative to 2000	
	2000	2014
Output	1.000	0.927
Capital	1.000	1.106
Consumption	1.000	0.887
Capital-Output Ratio	2.891	3.449
Output Price (p^Y)	1.000	0.878
Internal Rate of Return	0.149	0.131
Import Share (%)	2.912	2.189
$\mathcal{A}$	1.000	0.925
$\mathcal{B}$	1.000	1.104

Note: Output, capital, consumption, output price, $\mathcal{A}$, and $\mathcal{B}$ are relative to their values in 2000. The rest of values are in levels.

Table 7 shows the normalized values of the main variables in the year 2000 and their relative change in 2014. First, there is a reduction in output and an increase in capital and consumption, as observed in the data. Subsequently, the capital-output ratio increases from 2.9 to 3.5 and the output price falls approximately 12%.[28] The internal rate of return is reduced from 0.15 to 0.13, and the import share decreases from 2.9% to 2.2%. So, after

[28] We show in Appendix H that this fall aligns with data.

sectoral distortions and productivities change, output is reduced by 7.3% and the capital-output ratio increases by 10.6%. However, note that $\mathcal{A}$ is reduced and $\mathcal{B}$ has increased, suggesting that overall efficiency has worsened. The reduction in output can be explained by an increase in the variance of composite distortions that reduces $\mathcal{A}$ (see Proposition 4), a fall in country-wide productivity θ_n, and the effect of the internal rate of return. In fact, using equations (15) and (17) we can show that

$$Y_n = \frac{\mathcal{A}_n}{\mathcal{B}_n} \frac{r_n}{p_n^Y} K_n.$$

Since the actual rate of return must not change along the BGP (see equation (12)) and the ratio $\mathcal{A}_n/\mathcal{B}_n$ fell, the increase in capital cannot offset the aggregate effect of a reduction in output. The fall in the internal rate of return can explain the capital increase. From equation (17), an increase in $\mathcal{B}_n$ translates into a reduction of r_n which triggers an increase in the demand for capital from equation (23), which triggers capital accumulation. However, from equation (23), the change in the sectoral demand for capital will not be homogeneous across sectors.

To address the degree of capital misallocation across sectors, we compare the change in sectoral capital between 2000 and 2014 with the initial level of sectoral productivity. Figure 6 shows this relationship. We can see that the correlation is negative which means that those sectors with lower levels of productivity increased their sectoral capital the most, which is a major symptom of misallocation and is in line with the estimates in Table 2. Furthermore, between 2000 and 2014, 33 out of 48 sectors suffered productivity losses, in which approximately 50% of those sectors accumulated more capital. Regarding sectors that faced increased productivity, 10 out of 15 had a reduction in their capital participation in the aggregate capital.

5.2 Transition Dynamics

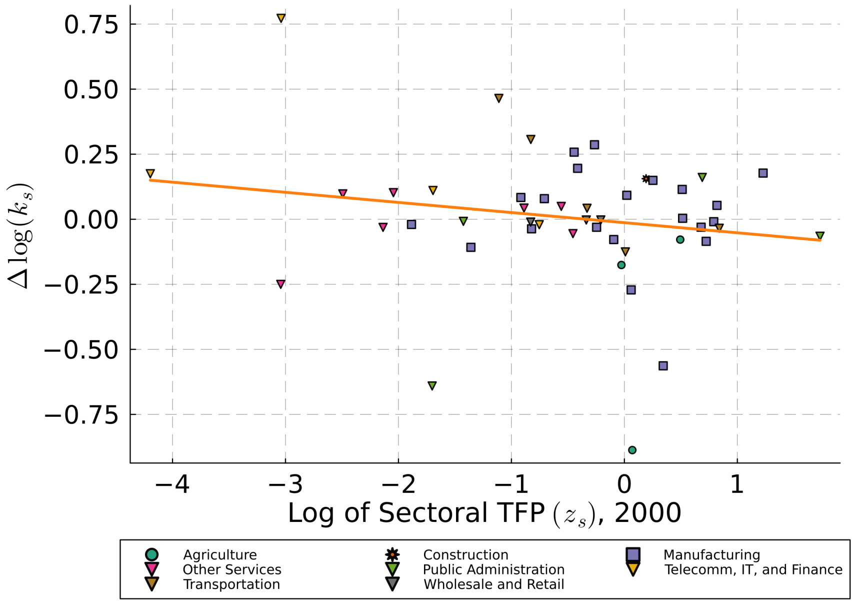
Now we turn to the transitional dynamics from one steady state to another. We assume the economy starts in the initial steady state in the year 2000 and receives an unexpected shock that changes sectoral productivities and distortions together with the production of varieties productivity θ_n. To compute the transition path, we assume that function $p(\mathbb{M}_n(t))$ in equation (14) takes the form

$$p(\mathbb{M}_n(t)) = \psi \left(\exp\left\{ \frac{\mathbb{M}_n}{\mathbb{M}_n(t)} - 1 \right\} - 1 \right)$$

where $\mathbb{M}_n$ denotes the final steady state of $\mathbb{M}_n(t)$. We calibrate $\psi = 0.001$ as in Schmitt-Grohé and Uribe (2003) and Aguiar and Gopinath (2007).[29] To compute the transition path, we use the relaxation algorithm developed by Trimborn et al. (2008). Figure 7 shows the transition from one steady state to another for capital, consumption, output, and actual rate of return r_n/p_n^Y. Note that consumption drops in the first period and then increases but stays below the initial value, while capital increases since the first period.

[29] Our results are not significantly affected by the value of this parameter.

Figure 6: Capital Accumulation Across Sectors



Regarding output, the initial decline is approximately 14%, but it converges to the final steady state where output falls by approximately 7.3%. Note that this recovery is due to the capital increase, not to an overall efficiency gain in the economy. The dynamics of the internal rate of return are not monotonic. It falls on impact but increases right after falling monotonically to the new steady state value.

Note that, along the BGP, the actual rate of return must remain constant. Indeed, from equation (12), in the BGP it must be that

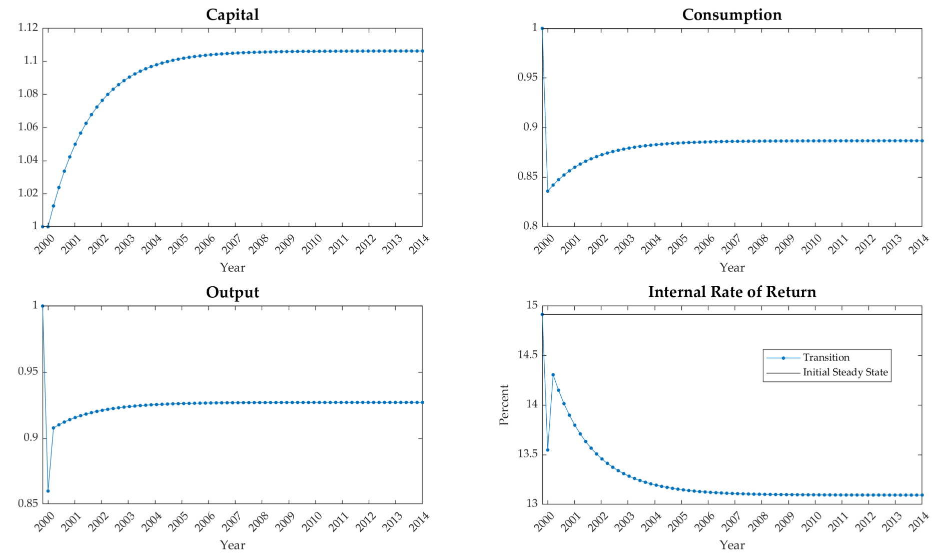
$$\frac{r_n}{p_n^Y} = \frac{\varepsilon}{\varepsilon - 1}\lambda + \rho + \delta,$$

which does not change across BGPs. However, during the transition, r_n/p_n^Y can adjust. It first increases through $\mathcal{B}_n$, but it returns to its steady state value through the effect of the internal rate of return that declines over time. This increase in both the actual rate of return and capital accumulation explains why output partially recovers along the transition. However, since the economy did not experience an overall efficiency gain, the final steady state of output is below the initial steady state.

5.3 Counterfactuals

In this section, we perform four counterfactuals, where we change all parameters from the initial steady state (2000) to the final one (2014), except the parameter labelled in each of the columns in Table 8. For example, in the first counterfactual (column labelled Trade Distortions), we set all parameters to their 2014 values except for the trade distortions (τ_{sn}^x) that remain at the values of the year 2000. Table 8 shows in the second and third columns the benchmark steady states in 2000 and 2014, respectively, and in the following

Figure 7: Benchmark Transition



columns each of the counterfactuals.

Table 8: Counterfactual Steady States

	Benchmark		Counterfactual BGP Relative to 2000			
	2000	2014	Trade Distortions	Capital Distortions	All Distortions	Productivities
Output	1.000	0.927	0.920	0.842	0.836	0.834
Capital	1.000	1.106	1.098	0.842	0.836	0.995
Consumption	1.000	0.887	0.941	0.786	0.836	0.798
Capital-Output Ratio	2.891	3.449	3.449	2.891	2.891	3.449
Output Price (p^Y)	1.000	0.878	0.817	0.966	0.900	0.976
Internal Rate of Return	0.149	0.131	0.122	0.144	0.134	0.146
Import Share (%)	2.912	2.189	2.189	2.189	2.189	2.189
$\mathcal{A}$	1.000	0.925	0.977	1.027	1.084	0.854
$\mathcal{B}$	1.000	1.104	1.166	1.027	1.084	1.019

Note: Output, capital, consumption, output price, $\mathcal{A}$, and $\mathcal{B}$ are relative to their values in 2000. The rest of values are in levels.

From the first counterfactual, it is clear that the trade distortions cannot explain the fall in GDP and nor the aggregate capital increase. Indeed, according to the first counterfactual in Table 8, if the trade distortion had not changed between 2000 and 2014, the aggregate GDP would have fallen, and capital would have increased approximately the same amount as in the benchmark. Thus, it means the main channel for the increase in the capital-output ratio and a decline in GDP at the same time is not the trade distortions. The capital-output ratio does not change compared to the final steady state because trade distortions do not affect the $\mathcal{A}_n$ and $\mathcal{B}_n$ ratio.

In the second counterfactual, when capital distortions are held constant to the initial BGP, the effect on $\mathcal{A}_n$ and $\mathcal{B}_n$ is symmetric, which accounts for the concurrent decrease in GDP and capital. This means that the change in capital distortions has generated an asymmetric effect on GDP and capital which is in line with equations (18) and (19).

When both distortions are fixed to the initial BGP values, we find a symmetric decline in capital and GDP, albeit larger than in the capital distortions counterfactual. Indeed, the aggregate TFP increased in the counterfactual, suggesting that the economy lost efficiency due to the more distorted environment in the final benchmark. Another way to see this is by means of the last counterfactual, where we kept the sectoral productivities constant. In that case, we can see that the change in distortions generates a reduction in aggregate TFP ($\mathcal{A}_n$) and an increase in $\mathcal{B}_n$, which triggers an increase in the capital-output ratio. In fact, $\mathcal{A}_n$ falls more in this counterfactual than in the benchmark scenario which implies that sectoral productivities improved but this cannot offset the effect of sectoral distortions on inputs. Overall, these counterfactuals show that each element in our model alone cannot explain the increase in the capital and the reduction in output simultaneously.

5.4 Heterogeneity in Capital Intensity

In this section, we investigate heterogeneity in capital intensity across sectors. The rationale is that those sectors that are more intensive in capital, would be hurt more by the capital distortions, while those sectors more intensive in intermediate inputs would be mostly affected by the trade distortions. We divide the 48 sectors into high and low capital intensity depending on whether α_s is larger than the median α_s. We perform two additional counterfactuals to see how heterogeneity in capital intensity affects our results. In the first one, we only keep capital and intermediate inputs distortions constant for those low capital intensity sectors. In the second one, we keep constant at the 2000 levels only the distortions for the high-intensity sectors. Table 9 shows the results of these counterfactuals.

Table 9: Heterogeneity in Capital Intensity

	Benchmark		Counterfactuals Relative to 2000		
	2000	2014	All Distortions	Low Capital Intensity	High Capital Intensity
Output	1.000	0.927	0.836	0.928	0.834
Capital	1.000	1.106	0.836	1.074	0.864
Consumption	1.000	0.887	0.836	0.895	0.828
Capital-Output Ratio	2.891	3.449	2.891	3.348	2.992
Output Price (p^Y)	1.000	0.878	0.900	0.864	0.914
Internal Rate of Return	0.149	0.131	0.134	0.129	0.136
Import Share (%)	2.912	2.189	2.189	2.189	2.189
$\mathcal{A}$	1.000	0.925	1.084	0.965	1.035
$\mathcal{B}$	1.000	1.104	1.084	1.117	1.071

Note: Output, capital, consumption, output price, $\mathcal{A}$, and $\mathcal{B}$ are relative to their values in 2000. The rest of values are in levels.

Table 9 shows that the high capital-intensity sectors drive most of the changes between 2000 and 2014. In fact, when distortions are kept constant at the 2000 level for high capital-intensity sectors, output and capital fall 26.6% and 23.6%, respectively, which are big falls compared to the final steady state. The internal rate of return increases due to the decrease in $\mathcal{B}_n$ (compared to 2014), generating a more substantial reduction in aggregate capital that was not compensated by the rise in the aggregate TFP ($\mathcal{A}_n$). The low capital intensity sectors could explain only a tiny part of the increase in aggregate capital — an increase of 7.4% versus 10.6% in the 2014 benchmark. These counterfactuals suggest that the increase in the capital-output ratio is mostly driven by high capital-intensity sectors. Overall, high capital intensity sectors explain 82% of the capital-output ratio increase.

6 Conclusions

In this paper, we document that capital per worker has increased substantially more than GDP per worker for a set of countries and that GDP per worker has grown at a slower rate than in the United States. The model is calibrated to Mexico, but we document that this fact is prevalent in Canada, Italy, Belize, and the Central African Republic, among others.

We build a dynamic general equilibrium model that can account for this fact. In our model, we consider an open multi-sectoral economy that uses capital and tradeable intermediate inputs to produce goods, where firms face static sectoral distortions that affect the prices of capital and intermediate goods. The economy grows through capital accumulation (from household savings or international capital flows), exogenous technology adoption from international trade in intermediate varieties, and economy-wide productivity in exports. We show that these distortions in prices affect the actual rate of return and aggregate output differently. Thus, changes in distortions can trigger different effects on output and capital during the transition. However, along the balanced growth path, the economy's growth rate is not affected by these distortions.

We calibrate our model to Mexico for 2000 and 2014. Along the transition, there is a short-run drop in output of 14% that in the long-run becomes a drop of 7.3% and an increase in capital of 10.6% consistent with the rise in the capital-output ratio and the reduction in output observed in the data. We analyze several counterfactual scenarios and show that the change in capital distortions induces an asymmetric effect on GDP and capital accumulation. Capital accumulates at a faster rate than technology adoption due to changes in capital distortions, which induces an increase in the capital-output ratio.

According to the results, 33 out of 48 sectors experienced a reduction in productivity and approximately 50% of these sectors accumulated more capital. This suggests a substantial degree of misallocation in the economy. Furthermore, sectoral productivity improvements in the other sectors were not sufficient to offset the negative effects of sectoral distortions on aggregate productivity.

We also explore how heterogeneity in capital intensity across sectors interacts with capital and intermediate input distortions. Highly capital-intensive sectors drive most of the capital accumulation and, thus, the increase in the capital-output ratio. Thus, these sectors helped to offset part of the reduction in GDP through capital accumulation.

The results suggest that Mexico has undergone some improvements in allocative efficiency but has yet to catch up with the technological frontier. These improvements were not enough to offset the effects of sectoral distortions on aggregate productivity and the actual rate of return. Although capital was accumulated at a faster rate than technology adoption, it was not enough to offset the reduction in aggregate productivity.

Altogether, the results warn that policies that incentive capital accumulation in some specific sectors might backfire in terms of their effect on economic growth. Heterogeneity in the cost of capital across industries might be an important source of misallocation if sectoral productivity increases do not accompany it.

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A Alternative Figures of GDP Growth

Pinkovskiy and Sala-i Martin (2016) suggest that the World Development Indicators perform well in estimating the unobserved income from nighttime lights. We show in Table A.10 the growth rates of GDP per worker for the same countries as in Table 1 using the World Development Indicators. GDP per worker is computed as the ratio of real GDP in national constant prices divided by the working-age population between 15 and 64 years old, like in Fernández-Villaverde et al. (2023). In all cases, the GDP per worker growth rate has decelerated, and for Italy and Mexico, it even became negative in the post-2000 period. Still, the U.S. GDP per worker growth rate is higher than for other countries.

Table A.10: Average Growth Rate of GDP per Worker by Country

	Canada	Italy	Mexico	United States
1960-1980	2.64	4.24	3.33	1.99
1980-2000	1.59	1.78	0.06	2.28
Post-2000	0.75	-0.17	-0.61	1.00

Note: All numbers are in percent. Growth rates are computed as the average annual growth rate of GDP per worker over the indicated period. Data are from the World Development Indicators.

B Capital Accumulation and Economic Growth

Table B.11 presents the growth rates of GDP per worker and capital per worker for Belize, Central African Republic, Canada, Italy, Mexico, and the United States in the period from 2000 to 2019

Table B.11: Average Growth Rate of GDP and Capital per Worker

	BLZ	CAF	CAN	ITA	MEX	USA
GDP per worker	-1.13	0.30	0.85	0.42	0.80	1.38
Capital per worker	4.82	4.99	1.90	2.97	2.53	1.12

Note: All numbers are in percent. Growth rates are computed as the average annual growth rate of GDP per worker and capital per worker for the 2000-2019 period. Data are from the Penn World Table 10.1.

Faster capital per worker growth compared to GDP per worker is prevalent across many countries. For example, considering only countries with faster capital per worker growth than the United States but lower GDP per worker growth after 2000, there were 28 countries where capital per worker grew faster than GDP per worker. Of these, 13 countries experienced GDP growth rates per worker below 1% per year and capital per worker growth rates faster than 1.2% per year. Table B.12 shows the average growth rates of capital and GDP per worker for these countries.

We regress a dummy variable equal to 1 if the growth rate of capital per worker was larger than the growth rate of GDP per worker in that country and year on a dummy that takes value 1 if the growth rate of GDP per worker was negative. We find a positive association between two variables even after controlling for the log of GDP per worker, the internal rate of return, capital per worker, and population after including country and year fixed effects. Table B.13 shows the results of these estimations. This suggests that crises tend to increase the prevalence of this phenomenon, although they are not the sole determinant.

Table B.12: Countries with Faster Capital than GDP per Worker Accumulation

Country	GDP per Worker	Capital per Worker
Germany	1.40	2.73
Niger	1.37	1.97
France	1.37	4.76
Mexico	1.35	3.32
Iceland	1.35	1.50
United Kingdom	1.29	4.45
Taiwan	1.22	4.74
Canada	1.21	2.25
Cameroon	1.19	1.89
Cyprus	1.14	3.65
Madagascar	1.09	1.53
Greece	1.02	4.23
New Zealand	0.94	2.65
Finland	0.85	2.56
Grenada	0.72	7.01
Luxembourg	0.67	2.32
Mauritius	0.65	3.70
Belize	0.61	4.89
Bahamas	0.37	8.86
Italy	0.27	3.75
Gambia	0.23	2.66
Eswatini	0.20	3.56
Central African Republic	-1.03	6.07
Aruba	-1.23	1.99
Cayman Islands	-2.00	1.56
Barbados	-3.55	9.38
Dominica	-6.05	4.90
Anguilla	-6.47	4.15
Saint Kitts and Nevis	-12.44	11.99

Note: All numbers are in percent. Growth rates are computed as the average annual growth rate of GDP per worker and capital per worker for the 2000-2014 period. Data are from the Penn World Table 10.1.

Table B.13: Panel Regression — Crises, Capital Accumulation, and Growth

	(1)	(2)	(3)	(4)	(5)
Crisis Dummy	0.332***	0.329***	0.325***	0.326***	0.325***
	(0.018)	(0.018)	(0.020)	(0.020)	(0.020)
log(Real GDP per Worker)		-0.047	-0.017	-0.080	-0.082
		(0.034)	(0.040)	(0.049)	(0.049)
Internal Rate of Return			-0.914***	-0.614*	-0.612*
			(0.283)	(0.318)	(0.317)
log(Capital per Worker)				0.116**	0.120**
				(0.049)	(0.049)
log(Population)					0.113
					(0.108)
Num.Obs.	3523	3523	2740	2740	2740
R2	0.237	0.237	0.253	0.255	0.255
FE: Country	X	X	X	X	X
FE: Year	X	X	X	X	X

Note: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Newey-West standard errors are in parentheses. The dependent variable is a dummy that takes value 1 if the growth rate of capital per worker in that country and year was larger than the growth rate of GDP per worker in the same country and year. Crisis Dummy takes value 1 if the growth rate of GDP per worker was negative. All regressions include country and year fixed effects.

Table C.14: Panel Regression — Internal Rate of Return and Misallocation

	(1)	(2)
Rule of Law Index	0.008**	-0.008*
	(0.004)	(0.004)
Below Median Growth × Rule of Law Index	-0.013**	-0.009*
	(0.005)	(0.004)
Real GDP per Worker		0.001***
		(0.000)
Num.Obs.	2809	2809
R2	0.121	0.157
FE: Region	X	X
FE: Year	X	X

Note: * p < 0.1, ** p < 0.05, *** p < 0.01. Newey-West standard errors are in parentheses. All regressions include region and year fixed effects. In all regressions the dependent variable is the internal rate of return. Rule of Law Index is the index of rule of law from the World Bank. Below Median Growth is a dummy variable that takes value 1 if the median growth rate over the whole sample period for that country was below the global median over the whole sample.

C Misallocation and the Internal Rate of Return

Table C.14 provides additional evidence for the relationship between the real internal rate of return and the misallocation measure. The table shows the estimates of a panel regression for the internal rate of return regressed on the rule of law index interacted with a dummy that takes value 1 if the median GDP per worker growth rate is below the sample median and 0 otherwise and also controls for transition effects using GDP per worker. Furthermore, we include year and region-fixed effects. The results show that the coefficient of the interaction term is negative and statistically significant, which suggests that poorer economic performance and lower institutional quality are associated with higher rates of return. When we control for real GDP per worker, the coefficient of the interaction term is still negative and statistically significant but smaller in size.

D Equilibrium and Proofs

D.1 Proof of Proposition 1

The final good producer solves the problem

$$\max_{y_{sn}} \quad p_n^Y Y_n - \sum_{s=1}^{S} p_{sn}^y y_{sn}$$

subject to (2). The first order conditions of this problem imply that the demand for sectoral good y_{sn} is given by

$$y_{sn} = \omega_s \frac{p_n^Y Y_n}{p_{sn}^y}. \tag{21}$$

Using the demand for sectoral goods from the final good problem (21) and substituting inside the expression for the price (5), the sectoral output share is given by

$$\frac{y_{sn}}{Y_n} = \omega_s \frac{r^{\sum_{s'} \omega_{s'} \alpha_{s'}} P^{1-\sum_{s'} \omega_{s'} \alpha_{s'}}}{r^{\alpha_s} P^{1-\alpha_s}} \prod_{s'=1}^{S} \frac{\left[\left(\tau^k_{s'n}\right)^{\alpha_{s'}} \left(\tau^x_{s'n}\right)^{1-\alpha_{s'}} \right]^{\omega_{s'}}}{\left(\tau^k_{sn}\right)^{\alpha_s} \left(\tau^x_{sn}\right)^{1-\alpha_s}} \frac{z_{sn}\tilde{\alpha}_s}{\left[\omega_{s'} z_{s'n} \tilde{\alpha}_{s'}\right]^{\omega_{s'}}} \tag{22}$$

where $\tilde{\alpha}_s \equiv \alpha_s^{\alpha_s}(1-\alpha_s)^{1-\alpha_s}$.

Profit maximization in the sectoral production of final goods yields factor demands

$$k_{sn} = \alpha_s \frac{p^y_{sn} y_{sn}}{\tau^k_{sn} r_n} \qquad X_{sn} = (1-\alpha_s) \frac{p^y_{sn} y_{sn}}{\tau^x_{sn} P} \tag{23}$$

where the demand for a single variety ν is given by

$$x_{sn}(\nu) = X_{sn} \left(\frac{p(\nu)}{P} \right)^{-\varepsilon}. \tag{24}$$

Using (5) and (22) we can obtain total sectoral demand for capital as

$$k_{sn} = \frac{\alpha_s \omega_s Y_n}{\tau^k_{sn} r} r^{\sum_{s'} \omega_{s'} \alpha_{s'}} P^{1-\sum_{s'} \omega_{s'} \alpha_{s'}} \prod_{s'=1}^{S} \left(\frac{\tilde{\tau}_{s'n}}{\omega_{s'} z_{s'n} \tilde{\alpha}_{s'}} \right)^{\omega_{s'}},$$

where $\tilde{\tau}_{sn} = \left(\tau^k_{sn}\right)^{\alpha_s} \left(\tau^x_{sn}\right)^{1-\alpha_s}$. Aggregating across sectors and solving for Y_n yields (15). Using (5) and (3) we get that the *actual rental rate* of capital given by r_n/p^Y_n is given by (17). This completes the proof of Proposition 1.

D.2 Variance of distortions and Aggregate TFP

Proposition 4. *Define $\bar{\tau}^k$ and $\bar{\tau}^x$ as the average capital and intermediate inputs distortions, respectively. To consider an increase in the variance, suppose we move from a situation where all distortions are equal to the average to a situation where there are S^- sectors with distortions below the average and S^+ sectors with distortions above the average so that $S = S^- + S^+$. In the first situation, the variance is zero, in the second one, it is positive. Then*

1. *Given τ^k_s, a sufficient condition for the increase in the variance of τ^x_s to have a negative effect on $\mathcal{A}$ is*
$$\bar{\tau}^x < \prod_{s \in S^-} (\tau^x_s)^{\tilde{\omega}_s} \prod_{s \in S^+} (\tau^x_s)^{\tilde{\omega}_s},$$
where $\tilde{\omega}_s \equiv \omega_s(1-\alpha_s)/(\sum_{s\in S} \omega_s(1-\alpha_s))$.

2. *Given τ^x_s, a sufficient condition for the increase in the variance of τ^k_s to have a negative effect on $\mathcal{A}$ is*
$$\prod_{s \in S^+} \left(\frac{\bar{\tau}^k}{\tau^k_s}\right)^{\hat{\omega}_s} \prod_{s \in S^-} \left(\frac{\bar{\tau}^k}{\tau^k_s}\right)^{\hat{\omega}_s} < \left(\sum_{s \in S^+} \hat{\omega}_s \frac{\bar{\tau}^k}{\tau^k_s} + \sum_{s \in S^-} \hat{\omega}_s \frac{\bar{\tau}^k}{\tau^k_s} \right)^{\frac{1}{\sum_{s=1}^{S} \omega_s \alpha_s}},$$
where $\hat{\omega}_s \equiv \omega_s \alpha_s/(\sum_{s\in S} \omega_s \alpha_s)$.

These conditions imply that for the variance of distortions to have a negative effect on $\mathcal{A}$, those sectors that experience an increase in their distortions need to have a sufficiently large weight on aggregate output (through ω_s) and need to rely sufficiently on each input (through α_s).

Proof. First, consider a sufficient condition for the increase in the variance of τ_s^x for a given distribution of τ_s^k. Assume that we start with the following distribution of τ_s^x where the variance is zero: $\mathbb{D}_0 = \{\tau_s^x \in \mathbb{R}_+ : \tau_s^x = \bar{\tau}^x \text{ for all } s \in S\}$. Suppose that we move for a new distribution $\mathbb{D}_+$ with a positive variance where there are S^- sectors with distortions below the average and S^+ sectors with distortions above the average such that $S = S^- + S^+$. Then we can define $\mathbb{D}_+$ as:

$$\mathbb{D}_+ = \mathbb{S}^- \cup \mathbb{S}^+,$$

where

$$\mathbb{S}^- = \{\tau_s^x \in \mathbb{R}_+ : \tau_s^x < \bar{\tau}^x \text{ for all } s \in S^-\}$$

and

$$\mathbb{S}^+ = \{\tau_s^x \in \mathbb{R}_+ : \bar{\tau}^x < \tau_s^x \text{ for all } s \in S^+\}.$$

Assume that aggregate TFP (16) related to $\mathbb{D}_0$ and $\mathbb{D}_+$ distributions are given by $\mathcal{A}_0$ and $\mathcal{A}_+$, respectively. Then, taking log differences of aggregate TFP (16) under these two distributions, we get

$$\Delta \log(\mathcal{A}) = \log(\mathcal{A}_+) - \log(\mathcal{A}_0) = \sum_{s=1}^{S} \omega_s (1-\alpha_s) \left[\log(\bar{\tau}^x) - \log(\tau_s^x)\right],$$

then

$$\Delta \log(\mathcal{A}) = \sum_{s \in S^-} \omega_s (1-\alpha_s) \left[\log(\bar{\tau}^x) - \log(\tau_s^x)\right] + \sum_{s \in S^+} \omega_s (1-\alpha_s) \left[\log(\bar{\tau}^x) - \log(\tau_s^x)\right].$$

Dividing both sides by $\sum_{s\in S^-} \omega_s(1-\alpha_s) + \sum_{s \in S^+} \omega_s (1-\alpha_s)$, we get

$$\frac{\Delta \log(\mathcal{A})}{\sum_{s\in S^-} \omega_s(1-\alpha_s) + \sum_{s \in S^+} \omega_s (1-\alpha_s)} = \sum_{s \in S^-} \frac{\omega_s(1-\alpha_s)}{\sum_{s\in S^-} \omega_s(1-\alpha_s) + \sum_{s \in S^+} \omega_s (1-\alpha_s)} \left[\log(\bar{\tau}^x) - \log(\tau_s^x)\right] + \sum_{s \in S^+} \frac{\omega_s(1-\alpha_s)}{\sum_{s\in S^-} \omega_s(1-\alpha_s) + \sum_{s \in S^+} \omega_s (1-\alpha_s)} \left[\log(\bar{\tau}^x) - \log(\tau_s^x)\right]$$

and note that $\log(\bar{\tau}^x) - \log(\tau_s^x)$ is positive for all $s \in S^-$ and negative for all $s \in S^+$.

Let $\tilde{\omega}_s \equiv \omega_s(1-\alpha_s)/(\sum_{s\in S}\omega_s(1-\alpha_s))$, then, for $\Delta\log(\mathcal{A})<0$ we need

$$\bar{\tau}^x < \prod_{s\in S^-}(\tau_s^x)^{\tilde{\omega}_s}\prod_{s\in S^+}(\tau_s^x)^{\tilde{\omega}_s}. \tag{25}$$

Equation (25) shows that the sectors that experience an increase in τ_s^x have a sufficiently large weight in aggregate output (through ω_s) and the sectoral output is sufficiently intensive in intermediate goods.

Now we consider the case of an increase in the variance of τ_s^k for a given distribution of τ_s^x. As for the previous case, consider two distributions of τ_s^k analogous to $\mathbb{D}_0$ and $\mathbb{D}_+$. Then, taking log differences of aggregate TFP (16) under these two distributions, we get

$$\Delta\log(\mathcal{A}) = \log(\mathcal{A}_+) - \log(\mathcal{A}_0) = \underbrace{\sum_{s=1}^{S}\omega_s\alpha_s\left[\log(\bar{\tau}^k)-\log(\tau_s^k)\right]}_{(1)} + \underbrace{\log\left(\sum_{s=1}^{S}\frac{\omega_s\alpha_s}{\bar{\tau}^k}\right)-\log\left(\sum_{s=1}^{S}\frac{\omega_s\alpha_s}{\tau_s^k}\right)}_{(2)},$$

where the first term is analogous to the previous case with distortions on intermediate inputs. Dividing both sides by $\sum_{s=1}^{S}\omega_s\alpha_s$, we get

$$\frac{\Delta\log(\mathcal{A})}{\sum_{s=1}^{S}\omega_s\alpha_s} = \sum_{s\in S^+}\hat{\omega}_s\left[\log\left(\frac{\bar{\tau}^k}{\tau_s^k}\right)\right] + \sum_{s\in S^-}\hat{\omega}_s\left[\log\left(\frac{\bar{\tau}^k}{\tau_s^k}\right)\right] + \frac{1}{\sum_{s=1}^{S}\omega_s\alpha_s}\left[\log\left(\sum_{s=1}^{S}\omega_s\alpha_s\right)-\log\left(\sum_{s=1}^{S}\frac{\omega_s\alpha_s\bar{\tau}^k}{\tau_s^k}\right)\right],$$

where $\hat{\omega}_s \equiv \frac{\omega_s\alpha_s}{\sum_s\omega_s\alpha_s}$.

For the previous expression to be negative, we need that

$$\sum_{s\in S^+}\hat{\omega}_s\left[\log\left(\frac{\bar{\tau}^k}{\tau_s^k}\right)\right] + \sum_{s\in S^-}\hat{\omega}_s\left[\log\left(\frac{\bar{\tau}^k}{\tau_s^k}\right)\right] < \frac{1}{\sum_{s=1}^{S}\omega_s\alpha_s}\left[\log\left(\sum_{s=1}^{S}\frac{\omega_s\alpha_s\bar{\tau}^k}{\tau_s^k}\right)-\log\left(\sum_{s=1}^{S}\omega_s\alpha_s\right)\right]$$

which is equivalent to

$$\sum_{s\in S^+}\hat{\omega}_s\left[\log\left(\frac{\bar{\tau}^k}{\tau_s^k}\right)\right] + \sum_{s\in S^-}\hat{\omega}_s\left[\log\left(\frac{\bar{\tau}^k}{\tau_s^k}\right)\right] < \frac{1}{\sum_{s=1}^{S}\omega_s\alpha_s}\left[\log\left(\sum_{s=1}^{S}\hat{\omega}_s\frac{\bar{\tau}^k}{\tau_s^k}\right)\right]$$

and exponentiating both sides, we get

$$\prod_{s\in S^+}\left(\frac{\bar{\tau}^k}{\tau_s^k}\right)^{\hat{\omega}_s}\prod_{s\in S^-}\left(\frac{\bar{\tau}^k}{\tau_s^k}\right)^{\hat{\omega}_s} < \left(\sum_{s\in S^+}\hat{\omega}_s\frac{\bar{\tau}^k}{\tau_s^k}+\sum_{s\in S^-}\hat{\omega}_s\frac{\bar{\tau}^k}{\tau_s^k}\right)^{\frac{1}{\sum_{s=1}^S \omega_s\alpha_s}} \tag{26}$$

which holds as long as τ_s^k for $s \in S^+$ is sufficiently large relative to τ_s^k for $s \in S^-$.

□

D.3 Proof of Proposition 2

To get the world demand for varieties, first note that the total value of exports from country n must be equal to the world demand for the varieties produced in that country. We can express that as the accounting identity

$$\int_{\nu\in\mu_n} p(\nu)x_n(\nu)d\nu = \int_0^N \sum_{s=1}^S \int_{\nu\in\mu_n} p(\nu)x_{sn'}(\nu)d\nu dn'.$$

In previous expression $p(\nu)$ corresponds to the price of varieties produced in country n, i.e. $p(\nu) = p_n$ and that on the right-hand side the outer integral is across all countries n' that demand varieties from n. Substituting (24) and simplifying

$$\int_{\nu\in\mu_n} p(\nu)x_n(\nu)d\nu = \left(\int_0^N \bar{X}_{n'}dn'\right)P^{\varepsilon}\mu_n p_n^{1-\varepsilon},$$

where $\bar{X}_n \equiv \sum_{s=1}^S X_{sn}$, and we can denote the world demand for varieties as $X^W \equiv \int_0^N \bar{X}_{n'}dn'$. Substituting on the left-hand side the production function for intermediate varieties and noting that $\int_{\nu\in\mu_n}\ell_n(\nu)d\nu = 1$ we can express the price of varieties in country n as

$$p_n = \left(\frac{\mu_n}{\theta_n}X^W\right)^{\frac{1}{\varepsilon}}P. \tag{27}$$

Replacing (27) into (6) and noting that

$$P = \left(\int_0^N p(\nu)^{1-\varepsilon}d\nu\right)^{\frac{1}{1-\varepsilon}} = \left(\int_0^N \mu_n p_n^{1-\varepsilon}dn\right)^{\frac{1}{1-\varepsilon}}$$
$$= P(X^W)^{\frac{1}{\varepsilon}}\left(\int_0^N \mu_n^{\frac{1}{\varepsilon}}\theta_n^{\frac{\varepsilon-1}{\varepsilon}}dn\right)^{\frac{1}{1-\varepsilon}},$$

we can express the world demand for varieties (X^W) as a function of productivities weighted by the measure of varieties produced in each country.

$$X^W = \left(\int_0^N \mu_n^{\frac{1}{\varepsilon}}\theta_n^{\frac{\varepsilon-1}{\varepsilon}}dn\right)^{\frac{\varepsilon}{\varepsilon-1}}. \tag{28}$$

To get total exports of country n as a function of productivities, we can start from the definition of total exports and manipulate it as follows

$$\begin{aligned}\int_{\nu\in\mu_n} p(\nu)x(\nu)d\nu &= \int_{\nu\in\mu_n} p(\nu)\theta_n\ell_n(\nu)d\nu \\ &= p_n\theta_n \int_{\nu\in\mu_n} \ell_n(\nu)d\nu = p_n\theta_n \\ &= \mu_n^{\frac{1}{\varepsilon}}\theta_n^{\frac{\varepsilon-1}{\varepsilon}} P(X^W)^{\frac{1}{\varepsilon}}.\end{aligned}$$

The first equality substitutes the production function for varieties; the second equality notes that the price of varieties produced by country n is the same across all varieties and that total labor in country n is normalized to 1. Last equality uses (27) and simplifies. Expressing the total exports as a ratio of world trade using (28) we get equation (20).

D.4 Proof of Proposition 3

Using the Euler equation (12) and (13) it is easy to verify that

$$\frac{C_n(t)}{C_{n'}(t)} = \frac{C_n(0)}{C_{n'}(0)}$$

Using the budget constraint (9), equation (13), and the international market clearing condition for assets we can show that

$$\dot{K}(t) = R(t)K(t) - C(t) + \tilde{w}(t), \tag{29}$$

where $C(t) \equiv \int_0^N C_n(t)dn$, $K(t) \equiv \int_0^N K_n(t)dn$, and $\tilde{w}(t) \equiv \int_0^N \tilde{w}_n(t)dn$ where $\tilde{w}_n(t)$ is defined as $w_n(t)/p_n^y(t)$.[30] Similarly, integrating across countries the Euler equation (12) and considering equation (13) it is immediate to get

$$\frac{\dot{C}(t)}{C(t)} = R(t) - \rho, \tag{30}$$

which implies that the aggregate world equilibrium dynamics are characterized by a system of equations similar to the standard neoclassical growth model.

Using the Euler equation (12) and the expression for the actual rate of return (17) we can find that

$$r_n = \left(\frac{g_{cn} + \delta + \rho}{\mathcal{B}}\right)^{\frac{1}{1-\sum_s \omega_s\alpha_s}},$$

where the price index is normalized to one for all countries ($P = 1$), and $g_{cn} \equiv \dot{C}_n(t)/C_n(t)$ denotes the growth rate of consumption.

Aggregating the demand for varieties across sectors using (23), it can be shown that

$$\bar{X}_n = Y_n \left(\frac{r_n}{P}\right)^{\sum_s \omega_s\alpha_s} \mathcal{C}_n,$$

where $\mathcal{C}_n \equiv \left[\sum_{s=1}^S (\omega_s(1-\alpha_s))/\tau_{sn}^x\right]\left[\prod_{s=1}^S \left(\frac{\tilde{\tau}_{sn}}{\omega_s z_{sn}}\right)^{\omega_s}\right]$ which is constant. Using $P = 1$

[30] Note that $\dot{K}(t) = \int_0^N \dot{K}_n(t)dn$ is a result of Leibniz's rule for differentiation under the integral sign.

and log differentiating with respect to time, we get that

$$\frac{\dot{\bar{X}}_n}{\bar{X}_n} = \frac{\dot{Y}_n}{Y_n},$$

so that the demand for varieties grows at the same rate as aggregate output. Using (15), we can show that the growth rate of aggregate output and aggregate capital are equal. This implies

$$\frac{\dot{\bar{X}}_n}{\bar{X}_n} = \frac{\dot{Y}_n}{Y_n} = \frac{\dot{K}_n}{K_n}.$$

Assume, for simplicity, that $\mu_n = \kappa\theta_n$ where $\kappa \in \mathbb{R}_+$ so that more productive countries produce a larger share of varieties. Furthermore, from (1) we can show

$$\int_0^N \theta_n dn = N$$

and using this in the definition of the world-demand for varieties (28) we can express total world demand as

$$X^W = \left(\int_0^N \theta_n dn\right)^{\frac{\varepsilon}{\varepsilon-1}}.$$

Log-differentiating last equation we get that total world demand for varieties grows at the rate

$$\frac{\dot{X}^W}{X^W} = \frac{\varepsilon}{\varepsilon - 1}\lambda.$$

Recall that total exports (TX_n) of country n can be expressed as

$$\int_{\nu\in\mu_n} p(\nu)x(\nu)d\nu = \mu_n^{\frac{1}{\varepsilon}}\theta_n^{\frac{\varepsilon-1}{\varepsilon}} P(X^W)^{\frac{1}{\varepsilon}}.$$

Thus, we can find that the growth rate of total exports is given by

$$\frac{\dot{TX}_n}{TX_n} = \frac{\varepsilon}{\varepsilon - 1}\lambda.$$

To obtain total imports of country n, we can define them as

$$TI_n \equiv \int_0^N \sum_{s=1}^S \int_{\nu\in\mu_{n'}} p(\nu)x_{sn}(\nu)d\nu dn'$$

and using the demand for a single variety (24) we get

$$p(\nu)x_{sn}(\nu) = X_{sn}P^\varepsilon p(\nu)^{1-\varepsilon} = X_{sn}P^\varepsilon p(\nu)^{1-\varepsilon}.$$

Now remember that $p(\nu) = p_n$ for all $\nu \in \mu_n$, then

$$\begin{aligned} TI_n &= \int_0^N \sum_{s=1}^S \int_{\nu \in \mu_{n'}} X_{sn} P^{\varepsilon} p_{n'}^{1-\varepsilon} d\nu dn' \\ &= \int_0^N \sum_{s=1}^S X_{sn} P^{\varepsilon} p_{n'}^{1-\varepsilon} \int_{\nu \in \mu_{n'}} d\nu dn' \\ &= \bar{X}_n P^{\varepsilon} \int_0^N \mu_{n'} p_{n'}^{1-\varepsilon} dn', \end{aligned}$$

where $\bar{X}_n = \sum_{s=1}^S X_{sn}$. Finally, we can substitute (27) in previous expression to get

$$TI_n = \bar{X}_n P (X^W)^{\frac{1-\varepsilon}{\varepsilon}} \left[\int_0^N \mu_n^{\frac{1}{\varepsilon}} \theta_n^{\frac{\varepsilon-1}{\varepsilon}} dn \right].$$

Let NX_n be the net exports defined as

$$NX_n = TX_n - TI_n = \mu_n^{\frac{1}{\varepsilon}} \theta_n^{\frac{\varepsilon-1}{\varepsilon}} P (X^W)^{\frac{1}{\varepsilon}} - \bar{X}_n P (X^W)^{\frac{1-\varepsilon}{\varepsilon}} \left[\int_0^N \mu_n^{\frac{1}{\varepsilon}} \theta_n^{\frac{\varepsilon-1}{\varepsilon}} dn \right].$$

We can show that

$$\begin{aligned} TI_n &= \bar{X}_n P (X^W)^{\frac{1-\varepsilon}{\varepsilon}} \left[\int_0^N \mu_n^{\frac{1}{\varepsilon}} \theta_n^{\frac{\varepsilon-1}{\varepsilon}} dn \right] \\ &= \bar{X}_n \kappa^{\frac{1}{\varepsilon}} \left(\int_0^N \theta_n dn \right) (X^W)^{\frac{1-\varepsilon}{\varepsilon}} \\ &= \bar{X}_n \kappa^{\frac{1}{\varepsilon}} N (X^W)^{\frac{1-\varepsilon}{\varepsilon}}, \end{aligned}$$

which log-differentiating implies

$$\frac{\dot{TI}_n}{TI_n} = \frac{\dot{\bar{X}}_n}{\bar{X}_n}.$$

Taking the law of motion for the net assets position (8) we can denote g_M as the growth rate of the net fixed assets position. Thus

$$g_M = R(t) + \frac{NX_n(t)}{M_n(t)},$$

where we have substituted the accounting identity $B_n(t) = -NX_n(t)$. Along the BGP, it must be that $\dot{g_M} = 0$. Thus, differentiating with respect to time the previous equation, we get

$$g_M = \frac{\dot{NX}_n(t)}{NX_n(t)}.$$

Let $\psi \equiv TX_n(t)/NX_n(t)$ and use the definition of $NX_n(t)$ to show

$$\frac{\dot{NX}_n(t)}{NX_n(t)} = g_M = \psi \frac{\dot{TX}_n(t)}{TX_n(t)} + (1-\psi) \frac{\dot{TI}_n(t)}{TI_n(t)}.$$

Given that $\dot{g_M} = \partial(\dot{TX}_n(t)/TX_n(t))/\partial t = \partial(\dot{TI}_n(t)/TI_n(t))/\partial t = 0$, and differentiating with respect to time the previous equation we can show

$$\dot{\psi}(g - g_I) = 0,$$

where $g = \frac{\epsilon}{\epsilon - 1}\lambda$ and $g_I = \dot{TI}_n(t)/TI_n(t)$. We can compute $\dot{\psi}$ from its definition and get $\dot{\psi} \equiv \psi(g - g_M)$. Replacing $\dot{\psi}$ in the equation above

$$\psi(g - g_M)(g - g_I) = 0.$$

Thus, if there are positive exports (i.e. $\psi \neq 0$), either $g = g_M$ or $g = g_I$. Suppose $g = g_M$, then

$$g_M = \psi g + (1 - \psi)g_I \Rightarrow g_I = g_M = g.$$

If, instead, $g = g_I$, by the same equation as before, we get $g = g_I = g_M$. Thus, we have shown that

$$\frac{\dot{Y}_n}{Y_n} = \frac{\dot{K}_n}{K_n} = \frac{\dot{\bar{X}}_n}{\bar{X}_n} = \frac{\dot{X}^W}{X^W} = \frac{\dot{M}_n(t)}{M_n(t)} = \frac{\dot{TI}_n(t)}{TI_n(t)} = \frac{\dot{TX}_n(t)}{TX_n(t)} = \frac{\varepsilon}{\varepsilon - 1}\lambda.$$

Using (27), the definition for μ_n, the normalization for P, and the growth rate of X^W, we can show $\dot{p}_n/p_n = \lambda/(\varepsilon - 1)$ which implies that $\dot{w}_n/w_n - \dot{\theta}_n/\theta_n = \lambda/(\varepsilon - 1)$. By (5), $\dot{p}_n^y/p_n^y = 0$. Thus, the growth rate of $\tilde{w}_n(t)$ is the same as the growth rate of $w_n(t)$. Then,

$$\frac{\dot{\tilde{w}}_n(t)}{\tilde{w}_n(t)} = \frac{\varepsilon}{\varepsilon - 1}\lambda,$$

which implies

$$\frac{\dot{\tilde{w}}(t)}{\tilde{w}(t)} = \frac{\dot{\tilde{w}}_n(t)}{\tilde{w}_n(t)} = \frac{\varepsilon}{\varepsilon - 1}\lambda.$$

We have shown that aggregate world dynamics are characterized by (29) and (30). Then,

$$\dot{K}_n = \frac{\varepsilon}{\varepsilon - 1}\lambda K_n$$

and using the definition of $K(t)$ it is immediate that

$$\frac{\dot{K}(t)}{K(t)} = \frac{\dot{\tilde{w}}(t)}{\tilde{w}(t)} = \frac{\varepsilon}{\varepsilon - 1}\lambda.$$

Now, remember that from the world resource constraint (29) we have that

$$\frac{C(t)}{K(t)} = R(t) + \frac{\tilde{w}(t)}{K(t)} - \frac{\dot{K}(t)}{K(t)}.$$

Note that $\tilde{w}(t)/K(t)$ is a constant, $R(t)$ is the international rental rate, which is constant along the BGP, and the growth rate of the world stock of capital is also constant. Then, the ratio $C(t)/K(t)$ must remain constant. Thus, the growth rate of aggregate world consumption is the same as that of the aggregate world stock of capital. By the Euler equation, $g_c \equiv \dot{C}_n(t)/C_n(t)$ is the same across countries, which means

$$\int_0^N \dot{C}_n(t)dn = g_c \int_0^N C_n(t)dn \Rightarrow g_c = \frac{\varepsilon}{\varepsilon - 1}\lambda.$$

In sum,

$$\frac{\dot{Y}_n}{Y_n} = \frac{\dot{K}_n}{K_n} = \frac{\dot{\bar{X}}_n}{\bar{X}_n} = \frac{\dot{X}^W}{X^W} = \frac{\dot{C}_n}{C_n} = \frac{\dot{w}_n}{w_n} = \frac{\varepsilon}{\varepsilon - 1}\lambda.$$

Furthermore, $r(t)$ remains constant along the balanced growth path.

E Data

In this Section, we describe the aggregation process and the sectors utilized in more detail. Table G.18 shows the change in distortions and productivities by sector. To aggregate nominal quantities, we sum them. To aggregate real quantities, we employ a Törnqvist index. In particular, if real gross output in sector s is an aggregation of industries $j \in S(s)$ where $S(s)$ denotes only the industries in S that we aggregate to s, then, real gross output Y_{st} is computed as

$$Y_{st+1} = Y_{st} \exp\left\{ \sum_{j \in S(s)} v(P_{jt}Y_{jt}) \log\left(\frac{Y_{jt+1}}{Y_{jt}}\right) \right\}$$

where $v(P_{jt}Y_{jt})$ is defined as

$$v(P_{jt}Y_{jt}) = \frac{1}{2}\left(\frac{P_{jt}Y_{jt}}{\sum_{i \in S(s)} P_{it}Y_{it}} + \frac{P_{jt+1}Y_{jt+1}}{\sum_{i \in S(s)} P_{it+1}Y_{it+1}}\right),$$

that is, the real gross output of aggregate sector s is constructed by adding up growth rates of real gross output of each subindustry, which are weighted by their nominal share. Note that nominal and real gross output will be the same for a base year.

F Calibration to Canada

In this section, we calibrate our model to Canada.[31] Table F.15 shows the same regression as for Mexico in Table 2, where we regress the growth rate of value added per worker on the share of sectoral capital over total capital controlling for intermediate goods per worker and capital per worker. The coefficient is significant once we control for the intermediate goods per worker and the aggregate capital per worker. This suggests that in the case of Canada, there is still some degree of capital misallocation once we control for the aggregate inputs use.

Furthermore, we calibrate our model to Canada following the same strategy as we did for Mexico in Section 4, targeting the same moments. Table F.16 shows the model's fit to the data's moments. The model matches the moments very well, although it cannot match

[31] Canada is also an interesting example of macroeconomic reforms but sluggish economic growth. See for example Conesa and Pujolas (2019).

Table F.15: Panel Regression — Capital Misallocation in Canada

	(1)	(2)	(3)
Sector-to-Total Capital Ratio	-0.006	0.179*	-0.259**
	(0.112)	(0.092)	(0.103)
Intermediate Goods per Worker		0.443***	0.143*
		(0.074)	(0.070)
Capital per Worker			0.443***
			(0.091)
Num.Obs.	714	714	714
R2	0.141	0.414	0.497

Note: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Newey-West standard errors are in parentheses. All regressions include sector and year fixed effects. The dependent variable is the growth rate of value added per worker. Sector-to-Total Capital Ratio denotes the growth rate of sectoral capital to aggregate capital. Intermediate Goods per worker denotes the growth rate of intermediate goods per worker. Capital per worker denotes the growth rate of capital per worker.

the capital-output ratios exactly. However, it generates an increase in the capital-output ratio, matching the internal rate of return in both steady states. Table F.17 shows the change from the steady state in 2000 to the steady state in 2014. The model generates an increase in the capital-output ratio and a reduction in output.

Table F.16: Model Fit Canada

Target	Data	Model
Exports Share (2000)	0.051	0.051
Capital-Output Ratio (2000)	3.340	3.042
Internal Rate of Return (2000)	0.075	0.075
Exports Share (2014)	0.034	0.034
Capital-Output Ratio (2014)	4.271	3.224
Internal Rate of Return (2014)	0.057	0.057

Note: The table shows the value of each moment in the data and the model for the benchmark calibration.

Table F.17: Benchmark Steady States Canada

	Benchmark BGP Relative to 2000	
	2000	2014
Output	1.000	0.858
Capital	1.000	0.909
Consumption	1.000	0.859
Capital-Output Ratio	3.042	3.224
Output Price (p^Y)	1.000	0.767
Internal Rate of Return	0.075	0.057
Import Share (%)	5.099	3.351
$\mathcal{A}$	1.000	1.155
$\mathcal{B}$	1.000	1.224

G Tariffs, Distortions, and Productivities

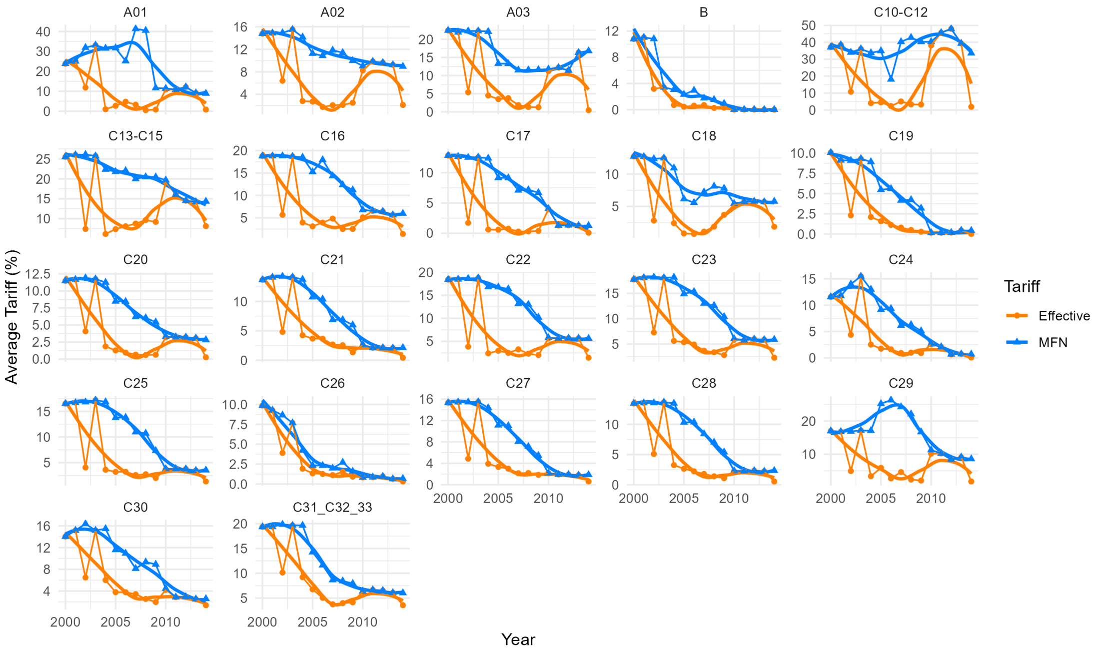

Figure G.8: Average Tariffs

Table G.18: Change in Distortions and Productivities

			Changes Relative to 2000		
	ω_s	α_s	τ^k_{sn}	τ^x_{sn}	z_{sn}
Agriculture & Hunting	0.012	0.233	0.888	1.003	0.998
Timber Harvesting	0.001	0.215	0.501	1.105	0.820
Fishery Industry	0.001	0.215	1.014	2.251	0.745
Resource Extraction	0.017	0.489	0.648	1.009	0.975
Food Production	0.030	0.162	0.957	0.924	1.037
Textile Manufacturing	0.004	0.068	0.526	0.776	1.092
Wood Crafting	0.004	0.072	0.697	0.716	1.113
Paper Making	0.007	0.143	0.839	0.696	1.093
Printing Services	0.004	0.113	0.696	0.853	1.040
Petroleum Refining	0.021	0.219	0.792	1.216	0.978
Chemical Production	0.018	0.291	0.693	0.798	1.053
Pharmaceutical Manufacturing	0.008	0.291	0.587	0.956	1.032
Rubber & Plastics	0.008	0.133	0.841	0.846	1.037
Non-Metallic Materials	0.004	0.163	0.827	0.956	1.031
Metal Production	0.009	0.103	0.735	0.936	1.026
Metal Fabrication	0.012	0.135	0.832	0.762	1.050
Tech Manufacturing	0.017	0.246	0.914	1.628	0.945
Electrical Equipment	0.005	0.158	0.714	0.879	1.024
Machinery Production	0.013	0.130	1.389	0.962	1.015
Vehicle Manufacturing	0.020	0.114	1.273	0.827	1.049
Other Transport Manufacturing	0.009	0.151	1.569	0.946	1.024
Furniture Production	0.010	0.157	0.842	1.002	0.999
Energy Supply Services	0.016	0.424	2.006	1.033	0.969
Water Management	0.003	0.228	1.400	0.857	1.153
Construction Industry	0.046	0.108	0.935	0.793	1.067
Vehicle Trade & Repair	0.013	0.262	0.966	0.937	1.058
Wholesale Trade	0.048	0.334	1.040	0.930	1.084
Retail Trade	0.043	0.264	1.064	0.930	1.088
Ground Transportation	0.016	0.167	0.951	0.960	1.026
Waterway Transport	0.002	0.165	0.870	0.583	1.312
Aviation Industry	0.006	0.170	1.045	0.682	1.040
Logistics Support	0.005	0.172	0.967	0.889	1.080
Mail & Delivery	0.004	0.160	0.216	1.051	0.986
Hospitality Industry	0.028	0.199	0.708	0.980	1.013
Publishing Sector	0.012	0.289	1.130	1.191	0.918
Entertainment Industry	0.010	0.383	1.509	0.841	1.093

Continued

Table G.18 — Continued

			Changes Relative to 2000		
	ω_s	α_s	τ^k_{sn}	τ^x_{sn}	z_{sn}
Telecom Services	0.022	0.353	2.968	0.830	1.126
IT Services	0.015	0.123	1.992	0.778	1.295
Financial Services	0.165	0.475	1.865	0.428	1.379
Professional Services	0.034	0.114	0.908	0.947	1.114
Engineering Services	0.015	0.198	0.861	0.837	1.099
Research & Development	0.007	0.198	0.861	0.888	1.085
Ad & Market Research	0.010	0.198	0.833	0.957	1.093
Admin Services	0.033	0.256	0.845	0.990	1.072
Govt & Defense	0.116	0.129	0.921	0.935	1.001
Educational Services	0.009	0.055	0.866	0.789	1.020
Health & Social	0.062	0.075	1.021	1.760	0.970
Miscellaneous Services	0.025	0.136	0.858	0.882	1.086

H Relative Prices

In our model, the price index p^Y denotes both the price of output and the price of investment in a given country relative to the rest of the world. Our model generates a decline from the steady state in 2000 to the steady state in 2014 of 12.2%. To see how close to the data this prediction is, we use data from the Penn World Table 10.1 (Feenstra et al., 2015) on the price of output and the price of investment and we compute the price of output and investment in Mexico relative to that of the United States. Figure H.9 plots the evolution of both relative prices and the one predicted by the model p^Y. We find that the implied decline in our model is between the decline in the data for the relative price of output and the relative price of investment. It is important to highlight that this is not targeted in the calibration.

Figure H.9: Decline in Relative Prices