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# THE TARIFF TAX CUT: TARIFFS AS REVENUE

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## ABSTRACT

We evaluate the aggregate effects of a change in tariffs on the US and world economies when tariff revenue is used to enact fiscal reform. Our model combines a standard international model of fiscal policy with taxes and a dynamic model of trade participation and tariffs that allows for uncertainty and transitions. We consider effects of permanent and temporary tariffs–with and without retaliation–when tariff revenue is used to reduce taxes on capital or labor or to subsidize investment. Compared to a lump sum redistribution, using tariff revenue for these reforms always boosts economic activity. Key to our analysis is the effect of trade dynamics on import substitution, such that tariff revenue after an increase in tariffs is higher in the short run than in the long run. When increasing the tariff by 20 percentage points, the revenue raised is largest when tariffs are temporary, unilateral, and used to subsidize investment, increasing by about 2 percent of GDP. This case also yields a large temporary increase in the trade balance. We find the welfare-maximizing unilateral tariff is close to 18 percent when tariff revenue is used to subsidize investment compared to 0 percent under a lump sum redistribution. We also find cutting capital taxes does not generate as much growth as introducing an investment subsidy since tariffs raise the price of investment substantially.

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# 1 Introduction

Many countries rely on tariff revenue to support fiscal objectives. In the US, tariffs were the main source of federal revenue until the introduction of the income tax in 1913, which was accompanied by a cut in the import tariff from about 40 percent to 25 percent. In an August 2024 campaign rally, Presidential Candidate Trump proposed implementing an import tariff of 20 percent to raise revenue to offset other taxes.[1] And on April 2, 2025, the US administration introduced new import tariffs that they claimed would increase the US import-weighted tariff to 41 percent. Again, the administration linked the tariff revenue to tax reform. Here, we study the effect of using tariff revenue for fiscal reform in a multi-country dynamic general equilibrium model. We argue that in the presence of other distortionary taxes, which are linked to tariff revenue through the government budget constraint, the welfare-maximizing unilateral or multilateral tariff is much higher than when one ignores these fiscal interactions. The welfare-maximizing tariff depends on the dynamics of tariff revenue and the tariff Laffer curve.

Our finding that a country, and the world as a whole, may increase welfare by raising tariffs to generate revenue rather than relying solely on distortionary capital and labor taxes is consistent with the theory of the second best (Lipsey and Lancaster, 1956). Our main contribution is in our quantitative evaluation of the tradeoff between tariff revenue and other taxes in a dynamic general equilibrium model that nests the key features used in tax analysis (Auerbach and Kotlikoff, 1987; Mendoza and Tesar, 1998; House and Shapiro, 2006; Trabandt and Uhlig, 2011) and dynamic trade analysis (Alessandria and Choi, 2014b; Alessandria et al., 2021; Mix, 2023). Our framework allows us to trace out the transition from all types of reforms under consideration both before and after they are implemented. For our baseline case, we find that a permanent unilateral increase in the US import tariff to 18 percent from 4 percent maximizes welfare if that revenue is directed to subsidize investment in physical capital. In contrast, if the tariff revenue is just rebated lump sum, as is typically assumed in trade analyses with tariffs, then we find it is unilaterally optimal to lower tariffs or even subsidize imports. These stark differences imply that the estimates of the benefits (or costs) of increasing tariffs ignoring fiscal tradeoffs will be underestimated (exaggerated) in a framework with only lump sum reimbursement of tariff revenues. Moreover, we find the welfare-maximizing unilateral tariff is largely invariant to the features of the economy that takes it away from an efficient allocation provided the tariff revenue is used to offset some other tax. The welfare-maximizing tariff depends on the dynamics of tariff revenue, which is mostly determined by long-run import substitution. Owing to the dynamics of this substitution, the tariff that maximizes the present-value of revenue is about one-half of the tariff that maximizes short-run revenue.

To study the fiscal interactions between tariffs and other taxes, we extend the dynamic heterogeneous firm trade model to include the key features used in fiscal policy analysis. The model without the fiscal adjustments has been shown to improve upon static models of trade in capturing the dynamics of trade behavior and cross-sectional effects of widespread trade liberalizations (Alessandria and Choi, 2014b; Alessandria and

[1] See Trump (2024).

Mix, 2021; Mix, 2023). Our fiscal extension introduces domestic taxes so that, as is typical of fiscal analysis, we have optimizing agents making savings, investment, and labor supply decisions subject to taxes on capital and labor income. Agents save by accumulating physical capital, shares in domestic producers, and a non-contingent bond traded internationally. As is typical of trade models, these domestic producers are monopolists in an intermediate variety, earning a flow of profits. Following Hopenhayn (1992) and Atkeson and Kehoe (2005), these domestic producers are created with an upfront investment and then subject to idiosyncratic shocks. The idiosyncratic shocks lead some firms to make investments in market access to export their products. The structure of fixed export costs makes exporting a dynamic decision in the spirit of Baldwin and Krugman (1989); Das et al. (2007); Alessandria and Choi (2014b); Ruhl and Willis (2017); Alessandria et al. (2021). The decision to export is strongly influenced by current and expected future tariffs. Importantly, these features imply that capital income combines the returns from physical capital and the profits of intermediate good producers, which are returns to investment in firm creation and export market access. Additionally, the dynamic nature of the export decision implies that the substitution away from imports and toward domestically produced goods induced by a tariff change depends on the horizon and persistence of the policy as well as the accompanying fiscal adjustment.

The production structure of the model is developed to capture the range of inputs producers use and the importance of imported goods in materials, consumption, and investment. Specifically, producers' inputs include other intermediates, physical capital, and labor. Their output is then sold either to other intermediate good producers or to households and firms for investment and consumption. To capture the importance of foreign inputs in the production of the three types of goods, we allow the shipping costs to depend on the use of the intermediates. Modeling materials in production is common in trade models but unusual in fiscal policy analysis. Owing to the roundabout structure and taxes on imports, the model thus features double marginalization as in Lerner (1934). Additionally, the model captures the high use of foreign intermediates in investment, which implies that tariffs will increase the price of investment more than consumption.

We consider four ways to use tariff tax revenue. We let tariff revenue: 1) be rebated lump sum 2) reduce the labor income tax, 3) reduce the capital income tax, or 4) be used to subsidize investment in physical capital. While the first three policies are natural, we believe there are several reasons to consider this last policy. First, owing to the sources of capital income, firm profits and rents on capital, this last case relates most closely to fiscal policy work that argues for low capital taxes to stimulate capital accumulation. Second, because of the high import share of capital goods, an increase in the tariff will raise the price of investment, deterring capital accumulation. But the investment subsidy will more than offset this effect. To the extent that these policies are aimed at boosting the capital stock, this is a more effective approach than cutting the capital income tax. And finally, along the transition this type of subsidy generates the strongest output response since it encourages investment, whereas the capital income tax is mainly a windfall for capital owners. We find it is always better to use tariff tax revenue to cut some other distortion rather than rebate it lump sum and the welfare differences can be large.

Given our focus on using tariff revenue for tax reform, we begin by focusing on permanent policies of the magnitude being discussed. As one would expect, the largest gains to the US come from unilateral policies that are not met with retaliation. We also find that welfare calculations understate the long-run changes in the economy as is common in models with capital accumulation and trade dynamics (Alessandria and Choi, 2014b; Ravikumar et al., 2019; Mix, 2023). For instance, we find that a unilateral increase in import tariffs of 20 percent will boost US welfare by nearly 1.5 percent when paired with an investment subsidy funded by both existing and new tariff revenue. But the same policy will boost steady state consumption by 3.55 percent and the capital stock by over 20 percent. Clearly, evaluating these policies based on their impact on the steady state will not accurately reflect the aggregate effects of these reforms. Importantly, we find large differences in the effects of the reforms on the economy that offset other taxes. For a range of policies under consideration, global and unilateral, welfare is always higher with a fiscal adjustment, and can be as much as 2.5 percentage points higher.

We also use our framework to study the transition to these reforms, including the period in advance of the reform. Specifically, to best capture the current economic and political environment around the reform, we start our economy prior to the onset of the reform. We assume agents expect an uncertain tariff change in 2025Q2 that becomes certain with the election of President Trump. As detailed in Alessandria and Mix (2021), the anticipation of higher tariffs leads the economy to expand as households stock up on investment goods and work more. This effect is strongest if a global trade war is expected. If agents don't expect full retaliation from foreign countries, we also see a widening US trade deficit and an appreciation of the real exchange rate. The observed widening of the trade deficit at the end of 2024 and the start of 2025 appears consistent with this view.

We also use our framework to study a temporary tariff increase with and without fiscal reforms. We find that temporary tariffs can be quite recessionary unless they are paired with tax cuts. If the tariffs and tax cuts are temporary, it would be best to introduce a labor tax cut or an investment subsidy to offset the effects of the tariffs on aggregate economic activity.

We conclude with a consideration of the welfare-maximizing permanent change in tariff under the investment subsidy and lump sum rebate. We do not consider a full tax reform, only the limited interaction between tariffs through the investment subsidy from the government budget constraint. In the unilateral case, we find that increasing tariffs by about 14 percent to 18 percent maximizes welfare without retaliation. Abstracting from these fiscal interactions, would lead one to go to unilateral free trade or even subsidize imports. We show these differences are related to starting with distortionary taxes, elastic labor supply, and roundabout production structure. When we shut these margins down, the welfare-maximizing unilateral tariff with revenue rebated lump sum approaches that from our baseline case with the tariff-funded investment subsidy. Importantly, the welfare-maximizing tariff with distortions that is used for tax relief is largely invariant to these aspects of the model. Additionally, in the presence of other tax distortions it is never optimal to reduce tariffs to zero.

The dynamics of tariff revenue are central to our analysis. These dynamics are largely determined by the trade elasticity—the change in trade from a change in tariffs—and the change in tariffs. The revenue that can be raised by tariffs depends on the path of substitution between imports and domestic goods (or across sources with and without tariffs) and the demand for final goods produced intensively with imported goods. There is much disagreement about the magnitude of substitution across horizons. Recent papers by Alessandria et al. (2025a,c) on US-China imports and trade policy over a long horizon, find a trade elasticity of about 3 in the first year that rises to twelve or more over a longer horizon. More closely related is evidence from the recent US China trade war, Hoang and Mix (2023) and Alessandria et al. (2025d) find a trade elasticity of about 3 on impact, which has almost doubled five years later. They argue that this substitution has been slowed by the possible reversal of the tariffs leading firms to slowly exit the export market. Our model contains a short-run elasticity of about 3.75 that rises to about 7 from a permanent tariff change. We show that abstracting from the margins leading to these adjustments would overstate revenue gains and lead to very different transition dynamics.

In line with these trade dynamics, our model implies that tariffs raise more revenue initially than in the long run as domestic households substitute away from imported goods. The speed of this adjustment is affected by the expected persistence of the tariff. When tariffs are perceived as permanent, revenue falls more quickly, as exporting firms in the tariffed country exit the market, causing prices to rise and trade to adjust quickly. By contrast, when tariffs are perceived as temporary, these same firms are more hesitant to leave the market, keeping prices lower and slowing the trade adjustment. Thus, tariff revenue falls more slowly.

Our paper relates to several papers that study international dimensions of trade or fiscal policy. For instance, Lashkaripour (2021) studies these effects in a multi-sector static trade model with endogenous labor. Goulder et al. (1983) provide an early analysis of the importance of incorporating international interactions in the evaluation of domestic tax policy. Mendoza and Tesar (1998) study the role of tax reform in a two country neoclassical growth model with a single good. Mendoza and Tesar (2005) build on this framework to study the determination of taxation with commitment. Quadrini and Ríos-Rull (2024) study tax reform in the open economy without commitment and with intangible capital investment. Relatedly, Spencer (2021) studies corporate tax reform of multinationals in multi-country models of firm dynamics and capital accumulation. Our paper also relates to a closed economy literature on fiscal reforms that builds on Auerbach and Kotlikoff (1987); Prescott (2004). Closest in spirit is the work by Trabandt and Uhlig (2011) in the consideration of tax reforms. Our paper also relates to a large literature on the theory of the second best (Lipsey and Lancaster, 1956; Bhagwati and Ramaswami, 1963). Boadway et al. (1973) studies tariff and commodity tax determination when lump sum taxes are not available. Corden (1984) reviews numerous papers that discuss the use of tariff for revenue purposes. Our paper contributes to this vast literature with a model that incorporates trade dynamics and with a focus on the tradeoff between tariffs and other taxes within that framework.

Our paper also relates to a large trade literature—summarized by Caliendo and Parro (2022)—on optimal tariffs without retaliation. These analyses generally focus on analytical solutions in static general equilibrium models of trade, often with rich heterogeneity across sectors or goods. A contribution of our paper is extending this analysis quantitatively in the presence of macro and trade dynamics, other distortionary taxes, and with using tariff revenue for fiscal reforms other than lump sum redistribution. Several papers have shown that including macro and trade dynamics in a trade model leads to very different aggregate outcomes (Ravikumar et al., 2019; Reyes-Heroles, 2016; Alessandria and Choi, 2014b; Mix, 2023). Alessandria and Mix (2021) show that a dynamic trade model is more consistent with aggregate behavior across countries in anticipation of and after widespread tariff changes during GATT rounds.

In section 2 we describe some salient features of tariffs, tariff revenue, and trade over a long-horizon for the US and more narrowly in the past ten years. A key finding here is that imports fall in response to tariffs and that this adjustment is larger over longer horizons. In section 3 we describe the model and its calibration, including fiscal policies. In section 4 we discuss the effects of various trade policy and alternative fiscal adjustments on welfare and the transition of the economy. In section 5 we consider a range of sensitivity related to the trade elasticity and country asymmetries. In Section 6 we estimate the optimal unilateral and global tariffs for the lump sum case and our case with using tariffs to subsidize investment. We use different variations of the model to isolate the source of our findings. We also study the amount of revenue that can be raised with tariffs at various horizons. Section 7 concludes.

## 2 Evidence on Gradual Trade Response

We start our analysis with some perspective on the relationship between tariffs, trade, and tariff revenue. We emphasize that the revenue raised from tariffs by the US has been less than 0.5 percent of GDP for the last century. We also find that revenue has been non-monotonic in tariffs as there are periods when tariff cuts increased revenue owing to subsequent increases in trade and there are periods where tariff increases have temporarily raised substantial revenue. These dynamics are consistent with tariff changes leading to delayed substitution in trade flows. We recover some measures of this substitution using US tariff changes on China in the past 50 years and changes in the growth in imports from all sources over a longer span.

Tariff revenue as a share of GDP, $TRY$, depends on the level of tariffs, $\tau$, and the effect of tariffs on imports, $M$ and GDP, Y. That is,

$$TRY_t \equiv \frac{TR_t}{Y_t} = (\tau_t - 1)\frac{M_t}{Y_t}.$$

To get some sense of how tariffs determine tariff revenue and trade, we begin with a high level overview of the dynamics of tariffs, tariff revenue, and trade since 1929 in the United States.[2] In Figure 1a we plot the fall in the tariff rate, measured as customs duties as a share of imports of goods. This tariff series understates the changes in tariffs as it puts less weight on goods with high tariffs. It also ignores the effect of non-tariff

[2]For a more concrete discussion of US tariffs see Irwin (1998).

barriers such as quotas, voluntary export restraints, or other quantitative restrictions. For instance, the US had an import embargo on China from 1951 to 1971 and then very high tariffs until 1980 that is not accounted for in this measure. Tariffs rose with the Smoot-Hawley tariffs in 1931 from about 13 percent to 19 percent of imports and then drifted down to 6 percent at the end of the war. Aside from a modest increase in the tariff rate in the mid 1950s, largely owing to the conversion of several quantitative restrictions into tariffs, tariff rates continued to fall from further GATT rounds and free trade agreements and were close to 1.5% of imports through 2017. After the onset of the tariff increases in 2018, the tariff rate rose to 3.1 percent in 2021 but has now fallen back to 2.5 percent through 2024. The recent reduction in tariffs reflects substitution away from high tariff Chinese imports to other imports or domestic production.

With the high tariffs in the late 1920s and early 1930s, tariff revenue accounted for a high share of federal revenue. But the share fell sharply with the large rise in federal revenue in the 1930s through World War 2. By 1954, tariff revenue fell to just one percent of federal revenue. From 1954 to 1989 the growth in imports outpaced the decline in tariffs and tariff revenue tripled to about three percent of federal revenue before stabilizing at about 2 percent in the early 2000s. With the tariff increases of the first Trump administration and extension under the Biden administration, tariffs rose to as much as 3.7 percent of revenue but have now fallen back to 2.7 percent through the end of 2024.

The high share of tariff revenue in the federal budget in the 1920s and 1930s reflects high tariffs and low taxation. In Figure 1b we plot tariff and federal revenue as a share of GDP and find that tariff revenue was about 0.45 percent of GDP in the 1930s when federal revenue was only three to five percent of GDP. Historically, tariff revenue has remained less than 0.5 percent of GDP.

The increase in tariffs in the early 1930s coincided with a drop in the trade share of GDP (measured in real terms as the ratio of the average of exports and imports to GDP) from about 4 percent to 3 percent. Since the end of World War 2, trade has grown steadily along with the decline in tariffs reaching about 14 percent of GDP.

The amount of revenue raised by a tariff depends on the substitution away from high tariff sources and the horizon of that substitution. As we have seen tariff revenue actually rose even as the tariff rate fell through the mid 1980s. Likewise, the increase in tariffs in 2018 raised revenue temporarily, but revenue fell as households and firms substituted away from tariffed Chinese products. There are short-run increases in revenue in 1971q4 when President Nixon institutes an import surcharge that is lifted in four months. Likewise tariffs increase in 1975 owing to an import fee on oil imposed by President Ford.

## 2.1 Import substitution from tariffs

To isolate the substitution induced by tariffs we consider the dynamics of tariffs and imports from China and all the rest of the world. Trade with China allows us to explore substitution at the product level. The aggregate data allows us to focus on substitution between imports and domestic production. Both approaches show a one year import response to tariffs that is between 3 and 4 while a long-run response is

considerably higher, perhaps as high as 20 times the tariff change.

### 2.1.1 Dynamics of Substitution US Imports from China

We now study the dynamics of tariffs, trade, and tariff revenue from China. We first focus on the period since 2015 and then we move to a long-term analysis that includes the two main trade liberalizations on China: the 1971 lifting of the trade embargo and the granting of most favored nation tariffs in 1980. Our analysis allows us to trace out the dynamics of substitution.

Focusing on the recent period, from 2015 to the 2024, we collect monthly disaggregate trade flows at the 10-digit Harmonized-System Level by source country from the Census. Figure 1c plots the path of the trade-weighted tariff for all US imports and separately for China and the rest of the world (ROW). We also plot the median tariff for China and the ROW. The median tariff on imports from China rises from about 3 percent to 25 percent, while the trade weighted tariff from China rises to about 12 percent. The median and trade-weighted tariffs from the ROW are fairly stable. The higher tariffs on China increased the aggregate trade-weighted tariff, but it has drifted back somewhat.

The increase in tariffs on Chinese goods has gradually reduced imports from China. In Figure 1d we plot the share of imports and tariff revenue from China (both the raw series and a 12-month moving average to remove some seasonality). Prior to the increase in tariffs, Chinese imports were about 21 percent of US imports. That has fallen to about 12.5 percent at the end of 2024. Owing to relatively high tariffs on Chinese imports, the share of total US tariff revenue that comes from Chinese imports exceeds the import share. It was about 40 percent prior to the imposition of tariffs. It rose to almost 70 percent and has now drifted down to about 60 percent as agents have substituted away from China.

These figures make clear that the substitution following the increase in tariffs in 2018 is taking time. To look more carefully at the dynamics of this substitution we undertake a product-level analysis of trade flows around two large changes in tariffs on US imports from China. Specifically we use an event-study design to estimate the responses of imports from China to the changes in tariffs in 1980—when China was granted normal trade relations (NTR) status—and since 2017:[3]

$$v_{jgt} = \sum_{t'=1974}^{2008} \beta_t^{NTR} \mathbf{1}\{t = t'\}\mathbf{1}\{j = \text{China}\}X_g + \delta_{jt} + \delta_{jg} + \delta_{gt} + u_{jgt}. \tag{1}$$

$$v_{jgt} = \sum_{t'=2015}^{2024} \beta_t^{TW} \mathbf{1}\{t = t'\}\mathbf{1}\{j = \text{China}\}X_g + \delta_{jt} + \delta_{jg} + \delta_{gt} + u_{jgt}. \tag{2}$$

The dependent variable is the log import value of good $g$ from country $j$ in year $t$. Our coefficients of interest, $\beta_t$, measure the elasticity of imports from China with respect to a change in tariffs, relative to the other countries with NTR status or no change in tariffs, and relative to a specific base year. We focus on two windows for China around the large tariff changes, from 1974 to 2008 and 2015 to 2024. We use the

[3]This analysis closely follows the work in Alessandria et al. (2025c,d,a)

change in tariffs that takes place in 1980 and between 2017 and 2020 as our independent variable $X_g$. We include country-year fixed effects ($\delta_{jt}$) to capture aggregate shocks to exporting countries, country-good fixed effects ($\delta_{jg}$) to capture the average level of exports and time-invariant bilateral trade barriers, and good-year fixed effects ($\delta_{gt}$) to capture good-level US demand shocks and good-specific trade barriers common to all exporters.[4] The elasticities are normalized to zero in the year before each reform. Our earlier sample uses goods aggregated to the SITC 5-digit while the later sample uses goods aggregated to the HS 6-digit level.

Figure 2a plots the estimated trade elasticities over both time frames, each normalized to zero in the year before the relevant reform. The elasticity dynamics in the two episodes are similar. In both cases, five years following the tariff change the trade elasticity was about 4.5. With the 1980 reform, we see that the NNTR-gap elasticity rose to almost 11 in 2001, when China joined the WTO, suggesting there is much more room for substitution to the tariff changes in 2018.[5]

### 2.1.2 Dynamics of Substitution at the Macro Level

While the China data show substantial substitution over time, one may suspect that substitution between different sources of imports is higher than substitution between imports and domestic goods. Thus, we study the substitution that takes place between imports and domestic expenditures with macro data. Figure 3 plots the log ratio of imports to finals sales of goods in nominal terms against the log of 1 + the ratio of tariff revenue to imports. The left panel plots the relationship with annual data from 1929 to 2024 and the right panel plots the relationship with quarterly data from 1959Q1 to 2024Q4. There is a strong negative relationship between the two series. The tariff measure has fallen about 12.5 percentage points and the import share of expenditures on goods has grown about 2.5 log points.

Most CES trade models assume a standard import demand structure of

$$M_t = N_t \left( \frac{p_{mt}}{P_{D,t}} \right)^{1-\theta} (1+\tau_t)^{-\theta} D_t \tag{3}$$

Here $M_t$ denotes nominal imports of goods, $D_t$ denotes final spending on goods, $N_t$ denotes the mass of exporters, $p_{mt}/P_{D,t}$ denotes the relative price of imports, inclusive of shipping costs, to final sales of goods, and $\tau_t$ is an ad-valorem tariff. In many dynamic models, and the data, the number of firms and the import price responds endogenously to changes in the tariff over time through changes in the number and quality of importers. And these decisions depend on changes to the entire path of tariffs. Since Feenstra (1994) it is understood that price indices do not include these variety effects. Nonetheless we include a proxy for this relative price, measured as the terms of trade (relative price of imports of goods to exports of goods) when estimating $\theta$. Moreover, to capture the different horizons of adjustment we run the regressions in

[4] This fixed-effects structure has been used frequently in the literature on China's NTR access, including by Pierce and Schott (2016) and Handley and Limão (2017).

[5] Alessandria et al. (2025c) argue that the dynamics of substitution are influenced by changes in expectations of the permanence of the reform. Alessandria et al. (2025a) show that these reduced form estimates of the trade response to a change in tariffs are biased downwards by the stochastic nature of trade policy.

first differences and with an error-correction adjustment as is common in international trade.[6] Consistent with the evidence from changes in tariffs on China, we find a short-run response to a tariff change that is relatively low, say 3 to 4 in a year, while the long-run response is considerably higher. Including these dynamic adjustment terms substantially improves the fit of the empirical model.

In Table 1 we report estimates of the trade elasticity with quarterly and annual data. In Column 1 we report the estimated trade elasticity in first differences of -2.41. In column 2, we report the results of an error correction regression. The short-run trade elasticity is slightly higher at -2.84 with the long-run about ten times as large at -27.7 with about 4 percent of the gap closed per period. In the third column we run the regression using the annual data and the yearly elasticity rises to -4 and the long-run elasticity is quite similar to our quarterly estimate. In the final column we run the same regression on the annual data back to 1929 and find an annual elasticity of -3.54 and the long-run remains close to -27.

These trade elasticities are higher than those found by Alessandria et al. (2025a), which finds an annual short-run elasticity of about 3 and long-run of about 14 using micro data to surprise permanent tariff reforms. Beyond differences owing to the anticipation and persistence of the reforms, one reason for the stronger long-run response is the tendency of applied tariffs to be considerably lower than statutory tariffs. [7] If changes in applied tariffs are smaller than the statutory tariffs then our estimates will be more aligned with those we find using Chinese data alone.

# 3 Model

We study trade and fiscal policy in an extension of the multi-country general equilibrium model of Mix (2023). This model builds on the international real business cycle model of Backus et al. (1994) and Alessandria and Choi (2007) to include firm and exporter dynamics, a roundabout production structure, a realistic composition of trade flows across good types, and multiple countries. These features are needed to most accurately capture the aggregate effects of changes in tariffs (Atkeson and Burstein, 2010; Alessandria and Choi, 2014a). Alessandria and Mix (2021) use a version of the model to study the effects of tariff phaseouts in the three GATT rounds. With no trade the model has the main features used in tax policy analysis (Prescott, 2004; House and Shapiro, 2006; Trabandt and Uhlig, 2011).

In the model, the global economy is assumed to have $\mathcal{I}$ regions, indexed by $i$ and $j$. In what follows, we describe the behavior of agents in each region in detail. We start with the households problem and then move to the intermediate goods producers and then move to the final goods producers.

[6] See for instance, Houthakker and Magee (1969); Hooper et al. (2000); Gallaway et al. (2003); Alessandria and Choi (2021)

[7] To provide some sense of the adjustment to our aggregate tariff measure to accurately capture change in tariffs and the amount of substitution, we compare the import tariff as a share of imports against the import tariff that uses fixed weights for US imports from 2001-2005. We do this for the ROW, Canada, and China in Figure 18. We focus on annual data from 1974 to 2024. Panel a shows that there is a large difference in the constant weight tariffs in the beginning and end of the sample. Over the whole period we find tariffs fall from close to 8.5 percent (10 percent to 1.5 percent) vs. 2.5 percent (4 percent compared to 1.5 percent). Panel b plots the two series for Canada and we see that constant weight tariffs fell twice as much as the trade-weighted tariff. These differences are a bit starker in for China (Panel C) as in 1985 tariffs fell about 33 percent while the trade weighted measure it was about eleven percent.

### 3.1 Households

Each region $i$ contains a representative household with time endowment $\bar{L}_i$ that chooses how much of that time to spend working $L_i$. The household also chooses quantities to consume $C_i$ and to invest in either physical capital $K_i$ (with investments in physical capital denoted by $X_i$) or a risk-free internationally traded bond $B_i$, which is denominated in the consumption good of country 1. The household's budget constraint is

$$\begin{aligned} P_{Ci}C_i + P_{Ii}I_i + \frac{P_{C1}B_i{}'}{R^B} \leq (1-\tau_i^L)W_iL_i + (1-\tau_i^K)(R_iK_i + \Pi_i) \\ + \tau_i^K \delta P_{Ii}K_i + P_{Ci}B_i - P_{C1}\frac{\phi}{2}(\frac{B_i}{Y_i^N} - \frac{\bar{B}_i}{\bar{Y}_i^N})^2 + T_i \end{aligned} \tag{4}$$

and capital evolves according to

$$K_i' = (1-\delta)K_i + X_i\left[1 - \frac{\psi}{2}\left(\frac{X_i}{X_{i,-1}} - 1\right)^2\right], \tag{5}$$

where the "prime" indicator on $K_i$ and $B_i$ denote quantities taken into the subsequent period; a subscript of $-1$ denotes the value of a variable in the previous period; $P_{Ci}$ and $P_{Ii}$ denote the region $i$ prices of consumption and physical capital investment; $R_B$ is the gross return on the risk-free bond; $W_i$ is the nominal wage; $R_i$ is the rental rate of physical capital; $\Pi_i$ denotes profits earned by firms in the economy and rebated to households; $T_i$ is a lump sum transfer to households from the government; $\tau_i^K$ is the tax on capital income including profits; and $\tau_i^L$ denotes the labor income tax. In this framework, $\delta$ is the depreciation rate of physical capital; and $\phi$ and $\psi$ determine the convex costs of adjustment in risk-free bond holdings and physical capital investment, respectively. The adjustment cost on risk-free bonds is included for computational reasons, and the cost is evaluated based on the value of bonds relative to nominal GDP $Y_i^N$ relative to the same ratio in the initial equilibrium, denoted by $\bar{B}_i/\bar{Y}_i^N$.

Each period, the household in region $i$ chooses consumption, leisure, and investment in capital and bonds to maximize its expected discounted lifetime utility subject to 4 and 5. The household's problem is expressed recursively as

$$V^H(K_i, B_i, S) = \max_{C_i, L_i, X_i, B_i'} \frac{\left[C_i^\mu(\bar{L}_i - L_i)^{1-\mu}\right]^{1-\sigma} - 1}{1-\sigma} + \beta V^H(K_i', B_i', S')$$

subject to 4 and 5, where $S$ is the aggregate state variable, which includes prices; $\beta$ is the discount rate; $1/\sigma$ is the intertemporal elasticity of substitution; and $\mu$ determines the relative marginal utilities of consumption and labor in equilibrium.

### 3.2 Intermediate Goods Producers

In each region $i$, there is a continuum of mass $N_i$ of monopolistically competitive firms that produce differentiated goods using labor and capital rented from domestic households and material inputs purchased

from domestic final goods producers (discussed in the next section). Firms in region $i$ must pay a sunk cost $f_{e,i}$ denominated in labor to begin producing and survive each period with probability $n_s$. Firms with a region $i$ all share the same productivity. Conditional on survival, firms may produce for the domestic market at zero cost, but exports to foreign markets are subject to both fixed and variable costs, both of which are heterogeneous across firms and depend on both the firm's export history and stochastic shocks. In particular, non-exporters pay higher fixed costs on average than exporters, leading to a delayed response of the extensive margin of trade to changes in trade costs. Furthermore, new exporters pay higher variable costs than experienced exporters on average. These features of the model parsimoniously capture features of the exporter life cycle from the data: that exporting exhibits strong hysteresis, and that exports grow with export tenure. More generally, these features imply a slower response of trade to changes in trade costs, in line with the trade literature that finds that the trade elasticity increases over time.

Export decisions and export costs across destinations $j$ are determined independently. Each period, a firm in region $i$ with export status $e_{ij} \in \{0, 1\}$ in destination $j$ draws a fixed cost $\kappa_{ij}$ that must be paid (in labor terms) for the firm to export to $j$ in the subsequent period. The fixed cost is drawn from a Generalized Pareto distribution

$$F_{i,e_{ij}}(\kappa) = 1 - \left(1 + \frac{v\kappa}{f_{e_{ij}}}\right)^{-\frac{1}{v}}.$$

With $v < 1$, the expected fixed cost draw of a firm with export status $e_{ij}$ is $f_{e_{ij}}/(1 - v)$. When matching moments related to exporter entry in calibration, we get $f_0 > f_1$, which implies that non-exporters ($e_{ij} = 0$) draw higher fixed costs on average than exporters ($e_{ij} = 1$).

Variable costs of exporting to destination $j$ also depend on both export history and stochastic shocks. Exports from $i$ to $j$ of intermediates that will be used in the production of a final good $G$ are subject to either a low iceberg cost $\xi_{GLij}$ or a high iceberg cost $\xi_{GHij}$. All new exporters (defined as firms that export in the current period but not the previous period) face the high iceberg cost. Conditional on continued export participation, firms have a constant probability $1 - \rho$ of switching to the other cost state. As such, new exporters export less than incumbent exporters on average.

As noted above, the iceberg costs on exports depend on the end-use of the export, whether it's used by final goods producers to produce consumption goods $G = C$, investment goods $G = X$, or material goods $G = M$. Heterogeneity in iceberg costs across good types allows the model to capture the relatively high intensity of trade in capital and material goods. Our calibration will map this composition into lower iceberg costs for capital and material goods and higher iceberg costs for consumption goods.

Because export decisions are made independently and we assume that production is constant returns to scale, we can consider the maximization problem of an intermediate goods producer for each destination separately. Let $l_{ij}$, $k_{ij}$, and $m_{ij}$ be the inputs of labor, capital, and materials that a firm uses in the production of goods sold to country $j$, and let $p_{Gij}$ be the price the firm charges for its good, conditional on the buyer's end use of the good $G$. Let $\xi_{ij} \in \{\infty, H, L\}$ denote the current cost-state of the firm: $\xi_{ij} = \infty$ denotes a non-exporter facing infinite iceberg costs, $\xi_{ij} = H$ denotes an exporter facing a high iceberg cost,

and $\xi_{ij} = L$ denotes an exporter facing a low iceberg cost. As discussed previously, the draw of the fixed cost $\kappa_{ij}$ depends on the firm's current export status $e_{ij}$ where $e_{ij} = 0$ corresponds to non-exporters with cost-state $\xi_{ij} = \infty$, and $e_{ij} = 1$ corresponds to exporters with cost-state $\xi_{ij} \in \{H, L\}$. The recursive maximization problem of this firm in aggregate state S is

$$V_{ij}(\xi_{ij}, \kappa_{ij}; F_{i,e_{ij}}, S) = \max_{e'_{ij}, p_{Gij}, l_{ij}, k_{ij}, m_{ij}} e_j \left[ \sum_G p_{Gj} G_{ij}(f) - W_i l_{ij} - R_i k_{ij} - P_{Mi} m_{ij} \right] - W_i e'_{ij} \kappa_{ij} + n_s \mathbb{E} D_i V_{ij}(\xi'_{ij}, \kappa'_{ij}; F_{i,e'_{ij}}, S')$$

subject to the demand functions that arise from CES aggregation of intermediates by final goods producers, which will be discussed in detail in later, and the production function

$$\sum_G \xi_{G\xi_{ij}ij} G_{ij}(f) = z_i (k_{ij}^{\alpha} l_{ij}^{1-\alpha})^{1-\alpha_m} m_{ij}^{\alpha_m},$$

where

$$D_i = \beta \frac{U'_{C_i}}{U_{C_i}} \frac{P_{Ci}}{P'_{Ci}}$$

is the subjective discount factor, $G_{ij}(f)$ is the firm's exports of goods used for end-use $G$, $P_{Mi}$ is the price of materials, $z_i$ is the common total factor productivity among all firms in region $i$, $\alpha$ is capital's share of value added in production, and $\alpha_m$ is the material share in total production.

The intermediate goods producer's problem can be broken into a static problem—choosing inputs and prices—and a dynamic problem—choosing tomorrow's export status. The static problem's solution is straightforward and common in the literature, as final goods producers' technology is CES. In particular, optimal prices are the familiar constant markup over marginal costs

$$p_{Gj} = \frac{\theta}{\theta - 1} \xi_{G\xi_j ij} MC_i = \frac{\theta}{\theta - 1} \xi_{G\xi_j ij} \frac{1}{z_i} \left( \frac{P_{Mi}}{\alpha_m} \right)^{\alpha_m} \left[ \frac{\left(\frac{R_i}{\alpha}\right)^{\alpha} \left(\frac{W_i}{1-\alpha}\right)^{1-\alpha}}{1 - \alpha_m} \right]^{1-\alpha_m}. \tag{6}$$

The parameter $\theta$ that determines the size of the markup is the elasticity of substitution across varieties from the same source, which enters the intermediate goods producer's problem through the demand functions described later. Given this structure, an exporters grows profit depends on an aggregate component and the firms idiosyncratic exporting technology and is denoted by $\pi_j$.

### 3.2.1 Dynamic exporting decision

A firm that decides to export in the next period not only receives revenue from foreign sales, but also a higher probability of lower fixed and variable costs going forward. Thus, part of the fixed cost paid to export is an investment in further market access. For ease of exposition, let $V_\xi(\kappa) = V_{ij}(\xi_{ij}, \kappa_{ij}; F_{i,e_{ij}}, S)$ for destination

$j$ for a firm in cost-state $\xi$ with fixed cost $\kappa$. The dynamic problems for firms of each type can be written as

$$\begin{aligned}
V_\infty(\kappa) &= \pi_\infty + \max\{-W\kappa + n_s \mathbb{E}DV_H(\kappa'), n_s \mathbb{E}DV_\infty(\kappa')\}, \\
V_H(\kappa) &= \pi_L + \max\{-W\kappa + n_s \mathbb{E}D[(1-\rho)V_L(\kappa') + \rho V_H(\kappa')], n_s \mathbb{E}DV_\infty(\kappa')\}, \\
\text{and } V_L(\kappa) &= \pi_H + \max\{-W\kappa + n_s \mathbb{E}D[(1-\rho)V_H(\kappa') + \rho V_L(\kappa')], n_s \mathbb{E}DV_\infty(\kappa')\}.
\end{aligned}$$

The decision to export for a firm in cost-state $\xi$ reduces to an evaluation of the fixed cost $\kappa$ relative to a threshold $\kappa^*_\xi$, defined for each cost-state as

$$W\kappa^*_\infty = n_s \mathbb{E}D[V_H(\kappa') - V_\infty(\kappa')], \tag{7}$$

$$W\kappa^*_H = n_s \mathbb{E}D[(1-\rho)(V_L(\kappa') - V_\infty(\kappa')) + \rho(V_H(\kappa') - V_\infty(\kappa')], \tag{8}$$

$$\text{and } W\kappa^*_L = n_s \mathbb{E}D[(1-\rho)(V_H(\kappa') - V_\infty(\kappa')) + \rho(V_L(\kappa') - V_\infty(\kappa')]. \tag{9}$$

To solve for the expectation terms on the right-hand side of equations 7–9, we take the expected difference between the value of exporters of each type and the value of non-exporters. To be specific, let $\pi^*(\xi)$ be the expected profits of a firm with export cost state $\xi$ where $\pi^*(\infty) = 0$. Let $dV_\xi \equiv \mathbb{E}(V_\xi(\kappa) - V_\infty(\kappa))$. Using the threshold values above, we can write these terms $dV_\xi$, which show up in the threshold fixed cost equations, as

$$\begin{aligned}
dV_H = \pi^*(H) &- W\left[\int_0^{\kappa^*_H} \kappa dF_1(\kappa) - \int_0^{\kappa^*_0} dF_0(\kappa)\right] \\
&+ n_s \mathbb{E}D\left[[\rho F_1(\kappa^*_H) - F_0(\kappa^*_\infty)]\, dV'_H + (1-\rho)F_1(\kappa^*_H) dV'_L\right] \\
dV_L = \pi^*(L) &- W\left[\int_0^{\kappa^*_L} \kappa dF_1(\kappa) - \int_0^{\kappa^*_\infty} dF_0(\kappa)\right] \\
&+ n_s \mathbb{E}D\left[[(1-\rho)F_1(\kappa^*_L) - F_0(\kappa^*_0)]\, dV'_H + \rho F_1(\kappa^*_L) dV'_L\right].
\end{aligned}$$

Conditional on being in the same cost state, firms make identical decisions over inputs, prices, and future export status. This model outcome greatly simplifies the state space of the problem as we only need to keep track of the number of firms in each cost-state for each destination, which can be easily derived given the fixed cost thresholds.

### 3.2.2 Free entry

Intermediate goods producers exogenously exit the market with probability $1 - n_s$. Each period, there is an unbounded mass of potential firms that may begin producing in the subsequent period by paying fixed cost $f_{e,i}$, denominated in labor. In the first year of production, firms only serve the domestic market and begin drawing export fixed costs for all destinations. Potential firms enter until the cost of entry $W_i f_{e,i}$ equates

to their expected lifetime profits:

$$W_i f_e = n_s \mathbb{E} D_i \left[ V'_{dom,i} + \sum_{j \neq i} V'_{\infty,ij} \right],$$

where

$$V_{dom,i} = \pi_{ii} + n_s \mathbb{E} D'_i V'_{dom,i},$$

and $\pi_{ii}$ is the optimal static profits from operating in the domestic region.

### 3.3 Final Goods Producers

Final goods—including consumption goods $C_i$, investment goods $X_i$ and material inputs $M_i$—are produced in each country using domestic and imported intermediate goods. As explained in the exposition of the intermediate goods producers' problem, the iceberg cost, and therefore the price of imported intermediates, depends on the type of final good being produced. Each type of final good $G \in \{C, X, M\}$ is produced by a continuum of competitive firms. The aggregation technology for final good $G$ is CES

$$G_i = \left[ \sum_{j \in \mathcal{I}} \left[ \int_{f \in \Omega_{ji}} G_{ji}(f)^{\frac{\theta-1}{\theta}} \right]^{\frac{\theta}{\theta-1}\frac{\gamma-1}{\gamma}} \right]^{\frac{\gamma}{\gamma-1}}$$

where $\Omega_{ji}$ is the set of firms in region $j$ that export to region $i$, $\theta$ is the elasticity of substitution across varieties of a common source region, and $\gamma < \theta$ is the elasticity of substitution across varieties from different source regions.

We represent the problem of final goods producers of good $G$ with a representative firm that chooses inputs to maximize profits

$$\pi_{Gi} = \max P_{Gi} G_i - \sum_{j \in \mathcal{I}} \tau_{ji} \int_{f \in \Omega_{ji}} P_{Gji}(f) G_{ji}(f) df$$

subject to the aggregation technology described above, with $P_{Gi}$ the familiar price index that arises with CES aggregation

$$P_{Gi} = \left[ \sum_{j \in \mathcal{I}} (\tau_{ji} P_{Gji})^{1-\gamma} \right]^{\frac{1}{1-\gamma}} \qquad \text{where} \qquad P_{Gji}^{1-\theta} = \int_{f \in \Omega_{ji}} P_{Gji}(f)^{1-\theta} df.$$

Tariffs imposed by region $i$ on imports from $j$ ($\tau_{ji}$) in our simulations will be the same for all good types, though the model easily allows for tariffs to differ by good type (Hoang and Mix, 2023).

### 3.4 Government Budget Constraint and Fiscal Policy

The government collects tax revenue on imports. Tariff revenue $TR_i$ is measured as

$$TR_i = \sum_{G \in \{C,X,M\}} \sum_{j \neq i} \tau_{ji} \int_{f \in \Omega_{ji}} P_{Gji}(f) G_{ji}(f) df$$

We assume that the government balances its budget each period, so the lump sum transfer is equal to the sum over all sources of government revenue

$$T_i = \tau_i^L W_i L_i + \tau_i^K (R_i K_i - \delta P_{Ii} K_i + \Pi_i) + TR_i$$

While it may seem extreme that the government balances its budget with lump sum taxes we can abstract from this fiscal issue. Instead, we can focus on how tax revenue from tariffs can be used to offset other taxes.

### 3.5 Aggregation and Market Clearing

While a model with heterogeneous firms would normally entail a very large state space, two assumptions make aggregation in our model quite simple. First, we assume that export and production decisions are made independently across destinations. Second, we assume that fixed cost draws are independently and identically distributed (iid) for all firms and periods conditional on having the same cost state. As such, the problem of keeping track of the fixed and iceberg costs of an individual firm reduce to keeping track of the number of firms in each cost state. Using the cost-state specific export thresholds, one can easily derive laws of motion for the number of firms in each state, as detailed in (Mix, 2023).

In equilibrium, the capital and materials market must clear such that the sum of capital demanded by intermediate producers is equal to the capital stock held by households and the sum of materials demanded by producers is equal to the materials sold by final goods producers. Similarly, the labor market such clear. Labor supplied by households must be equal to the sum of labor demanded for production *and* payment of exporting and entry fixed costs by intermediate goods producers. Finally, bonds are in zero net supply, $\sum_i B_i = 0$.

### 3.6 Calibration

Our baseline model has two symmetric countries. Given our focus on using tariff revenue for tax relief, this allows us to consider the broadest set of tariffs. We focus on a quarterly model to capture the dynamics of the reform and allow for some consideration of anticipation effects. The macro side of the model is calibrated to be consistent with typical international macro models and models of fiscal policy. The trade side is calibrated to be consistent with several aspects of firm and exporter dynamics and largely follows Mix (2023) and Alessandria and Mix (2021). Alessandria and Mix (2021) shows that these features on the

trade side make the model more consistent with cross-sectional aggregate behavior both in anticipation of and after widespread liberalizations.

We normalize the labor endowment $\bar{L}$ and productivity $z$ in each country to 1. As a quarterly model, we set the discount factor $\beta = 0.99$ and the capital depreciation rate $\delta = 0.025$. We set the intertemporal elasticity of substitution $1/\sigma = 1$. All these parameters are common values from the literature. We set the Frisch elasticity to 2 as in Alessandria and Mix (2021) as this calibration is able to capture the cross-sectional effects tariff changes from the GATT rounds. This is between the 3 that Prescott (2004) advocates for based on tax policy changes in the US and Europe and the 1 that is used in House and Shapiro (2006); Trabandt and Uhlig (2011) in their analyses.

With the use of materials in production, our model differentiates between gross output and value added in the economy. The materials share in intermediate goods production, $\alpha_m$, is chosen to deliver a gross-output-to-value-added ratio of 2, consistent with the US.

We assume the elasticity of substitution between varieties from the same source is $\theta = 6$. While the elasticity of substitution between different sources is set to $\gamma = 3.75$ countries. The elasticity of substitution between sources generates a short-run annual trade elasticity of 3.75. Together, $\gamma$ and $\theta$ (along with calibrated exporter behavior, discussed below) imply a long-run elasticity of just over 6. We also use the same shape parameter $v = 0.65$ for the generalized Pareto distribution. The survival rate of intermediate goods producers is set to $n_s$ =0.995 to match the labor share of exiting firms in the data.

There is disagreement on the dynamics of the trade elasticity, that is the change in trade flows from a change in tariffs. Following Head and Mayer (2014) and Simonovska and Waugh (2014), much quantitative work in static trade models targets a trade elasticity of 4-5. Recent work by Boehm et al. (2023) find a 1 year trade elasticity of less than 1 that rises to about 2 after ten years. In contrast, Alessandria et al. (2025a) recover a short-run elasticity of about 3 and long-run elasticity of 14 with about half the gap between short-run and long-run closed every five years for large permanent changes in US trade policy on China and Vietnam. Yi (2003) points out that the relationship between the growth in US imports and fall in tariffs points to a long-run elasticity that is between ten to fifteen. In the appendix we explore alternative estimates of the trade elasticity at various horizons.

Similar to House and Shapiro (2006), we use the estimates of marginal tax rates from the Congressional Budget Office (US Congress, CBO 2025) in 2025. Thus, we set the marginal labor tax to 27.2 percent and the marginal capital tax to 14.7 percent. Initial tariffs are set to 4 percent in line with recent tariffs. Even though some of these taxes are set to sunset, we assume these tax policies are expected to be constant. All told, government revenue (and spending) amounts to 22.3 percent of GDP in our initial steady state, with 18.0 percentage points of the revenue from labor taxes, 3.7 percent capital taxes, and 0.6 percent from tariff revenue. All revenue is rebated lump sum.

We calibrate the model to be consistent with aspects of the US economy from 2019-2024. Other parameters that still need to be calibrated include iceberg costs $\xi_{GTij}$, scale parameters $f_{ei}$, the probability of

changing shipping cost states $1-\rho_i$, the relative preferences for consumption and labor $\mu$, the labor share of value added $1-\alpha$, and taxes $\tau_{Ki}$ and $\tau_{Li}$. With our two-region symmetric model (so that the parameters are the same for each region), this list includes 11 parameters, 6 of which are iceberg costs. As in Mix (2023), we simplify the iceberg cost structure and impose the assumption that low-cost-state iceberg costs are proportional to high-cost-state iceberg costs $\xi_{GLij} = \zeta\xi_{GHij}$ with $\zeta < 1$. With this simplification, we reduce the parameters related to iceberg costs to 4 and the total parameters to be assigned to 9. We choose the parameters to jointly match the following moments in steady state:

1. Imports-to-GDP ratio = 0.14
2. Capital goods share of imports = 0.2
3. Material goods share of imports = 0.6
4. New exporter share of total exports = 0.05
5. Export share of exporters with five or less years of tenure = 0.4
6. Export participation rate = 0.2
7. Share of exporters that are new = 0.15
8. Frisch elasticity = 2
9. Labor share of value added = 0.66

These moments are consistent with the current structure of the US economy. The import share of 14 percent, for example, roughly matches the US import share in recent years, as does the split of imports between capital, material, and consumption goods. Moments related to the importance of new exporters are approximations of average export churning statistics taken from the World Bank Exporter Dynamics Database, as described by Mix (2023) and Steinberg (2023).

While these parameters are calibrated jointly to match all moments, some parameters are more influenced by one or more moments. The average level of iceberg costs, for example, are largely pinned down by the first three moments: the import share and the composition of imports. The relative costs for high-cost and low-cost exporters, along with the probability of switching to the opposite state, are most related to the share of exports sent by new exporters and how quickly new exporters' exports grow, which is captured by the share of exports made by firms with 5 or less years of tenure. The scale parameters are pinned down by the export participation rate and the share of exporters that are new each year. Preferences for consumption relative to leisure are pinned down by the Frisch elasticity and the capital share of value added pins down the parameter $\alpha$. We should note that in our model firms pay dividends as returns to their organizational capital (Atkeson and Kehoe (2005)) and rent capital. Given the markup and roundabout production this implies the capital share in production only 0.18, or about half of typical calibrations of competitive models.

In all our exercises in this paper, we assume that long-run bonds are equal to 0. That is, we assume $\bar{B}_i = 0$ for all countries $i$ both in the initial and terminal stationary equilibria. Of course, this assumption only matters when tariffs are applied unilaterally, as a global trade war among symmetric countries will not affect trade imbalances. Our preliminary analysis allowing for $\bar{B} \neq 0$ in the terminal equilibrium reveals that

our results about the optimal tariffs and the aggregate transition are largely unaffected. Our results about long-run aggregate effects are more sensitive, though they remain qualitatively very similar.

### 3.7 Fiscal Policies

We consider four uses of the tariff revenue. We allow for tariff revenue, $TR_t$, to either be rebated lump sum, reduce labor taxes, reduce capital taxes, or to subsidize investment. In each case, we calculate the subsidy with the tariff revenue. The government runs a balanced budget which allows us to calculate the subsidy financed by the tariff revenue.

*Labor subsidy*: After tax labor income is: $(1-\tau^L)(1+s_t^L)W_tL_t$ and then set the subsidy to equal

$$s_t^L = \frac{TR_t}{(1-\tau^L)W_tL_t}$$

*Capital subsidy:* After tax capital income is $(1+s_t^K)(1-\tau_t^K)(R_tK_t - \delta P_I K_t + \Pi_t)$ and then we set the subsidy to

$$s_t^K = \frac{TR_t}{(1-\tau^K)(R_tK_t - \delta P_{It}K_t + \Pi_t)}$$

*Investment subsidy*: Expenditure on investment equals $(1-s_t^I)P_{It}I_t$ yielding a subsidy of:

$$s_t^I = \frac{TR_t}{P_{It}I_t}$$

The case of the investment subsidy is worthwhile considering for three reason. First, capital income arises from rental of physical capital and the profits on firms. The investment subsidy allows us to more easily compare our results to work that is focused on building the capital stock. Second, as trade is intensive in capital goods, the price of investment will rise and the investment subsidy will more than offset this effect. Third, it yields the strongest economic response on the transition to the reforms, which may be important in ensuring the reform is sustainable.

### 3.8 Anticipation

Given the discussion of tariffs by candidate Trump in advance of the uncertain outcome of the US Presidential election, we assume agents anticipate tariffs may go up. Specifically, we start the economy in steady state in 2023Q4 and then change agents expectations so that there is a 50 percent chance of a change in trade policy with an import tariff of 20 percent that is permanent and global. Prior to the imposition of the tariffs we assume that agents expect tariff revenue to be rebated lump sum. With the imposition of tariffs, we assume agents understand how the tariff revenue will be used to offset other taxes. We only report the results of the path where tariffs are realized. In each of our scenarios, we assume agents have perfect foresight over whether tariffs are global or unilateral and temporary or permanent.

Figure 4 plots the first eight quarters of an expected global permanent tariff of 20 percent. The first three quarters have the same path owing to our assumption that agents expect tariff revenue to be rebated lump sum. Focusing on these first three quarters, the expected future tariff leads to a boost in economic activity as investment expands in anticipation of the expected rise in capital goods prices and the wealth effect of import taxes. This actually leads trade to rise in advance of the tariff (as demonstrated by the decline in the domestic expenditure share). Consumption falls slightly and labor rises, reflecting a negative wealth effect. There is a modest positive effect on employment, but a larger effect on GDP, as firms reallocate resources from investments in export participation and firm creation to production. Alessandria and Mix (2021) document these same effects in OECD countries but in reverse, in advance of the phaseouts of tariffs around three major GATT rounds.

When the tariff is implemented and the nature of the tax reform is understood, the transitions diverge dramatically. There is a sharp increase in the domestic expenditure share and acceleration in the reduction in export participation. All policies lead to a sharp drop in GDP and consumption even as employment rises, reflecting higher input costs and increased resource allocation toward firm creation rather than production.

To get a sense of how to identify expectations of trade policy, in figures 5 and 6 we plot the anticipatory dynamics in the four policy cases we consider when tariff revenue is rebated lump sum. Focusing on the US, we find that real effects in advance of the reform differ quite a bit. Only with the global permanent reform, which has the strongest wealth effect, does employment increase and consumption fall in the US. This is the case with the strongest investment expansion too.

The unilateral cases have important effects on the real exchange rate and the trade balance. The real exchange rate appreciates in advance of the tariff change, which eventually appreciates by about half of the tariff. With the unilateral permanent tariff more of the appreciation occurs with expectations. The US runs a trade deficit in advance of the tariffs with the deficit larger for permanent than temporary tariffs. There is clear evidence of these widening imbalances in recent US trade data.

# 4 Results

We now explore the aggregate implications of changes in trade policy that are paired with different fiscal adjustments. We focus on unilateral and global changes in tariffs of 20 percent with and without retaliation. We consider permanent and temporary reforms. Our temporary reforms are assumed to last for four years. We start with an analysis of the welfare changes of each scenario and then move to discuss the transition to permanent and then temporary reforms. The model is solved with a nonlinear shooting algorithm.

## 4.1 Welfare and Long-run changes

We now describe how these policies affect welfare and the long-run structure of the economy. To measure the welfare change, for each policy we calculate the compensating differential that would leave agents indifferent

to adopting the policy. That is, we solve for the proportional change in initial steady state consumption that would make an agent indifferent between that constant path of utility and the path induced by the policy:

$$\frac{U((1+\kappa)c_i, 1-l_i)}{1-\beta} = \sum_{s=t}^{\infty} \beta^{s-t} u(c_{it}, 1-l_{it}). \tag{10}$$

Our focus is on the change in welfare relative to a world with no shocks either over the business cycle or to trade policy. Recent work emphasizes trade integration may foster improved risk sharing and production allocations and so these estimates may understate the costs or benefits of trade reform.[8] If trade barriers were already forecast to rise (fall) then the welfare changes should be smaller (larger) if we take into account that counterfactual path. The welfare results for the US and the ROW for different scenarios are reported in Table 3. The long-run effects are reported in Table 4.

There are large differences in the compensating differential that depend on the duration of the policy changes, retaliation, fiscal changes, and the country. In the presence of distortionary taxes, the costs of a trade war are mitigated with fiscal adjustments. For instance, the compensating differential for a permanent trade war is -3.53% of initial consumption when redistributed lump sum but only -1.50% when used to subsidize investment. Likewise a temporary trade war has a small compensating differential of -0.17% when paired with the investment subsidy versus -0.64% with a lump sum rebate. Moreover, the unilateral permanent change in policy raises US welfare by 1.49 percent if there is an investment subsidy compared to a loss of -1.2 percent with a lump sum rebate. With unilateral policies, there are modest effects on the ROW from the interaction between fiscal reforms. For instance, the losses to the ROW from a permanent (temporary) trade war vary between -2.42% to -2.78% (-0.41% and -0.47%).

For the permanent reforms, we also report the change in steady state consumption, labor, capital, number of firms, and the value of the capital stock and firms. These steady state results provide a poor approximation of the welfare gains to these policies as well as the differences from the fiscal adjustment.[9] For instance, a permanent trade war with a lump sum rebate leads to a fall in consumption of 3.83 percent and a welfare loss of 3.53 but with the investment subsidy the welfare loss is 1.5 percent while steady state consumption only drops -0.25 percent. With the permanent unilateral reform and investment subsidy, long-run consumption rises by 3.55 percent, almost twice as much as the welfare gain. Importantly, the welfare gains understate the long-run changes in consumption induced by these fiscal adjustments. While welfare is about 2 to 2.5 percentage points higher with an investment subsidy compared to the lump sum rebate, steady state consumption is 3.6 to 5.5 percentage points higher.

The nature of the fiscal adjustment has an important effect on the productive capacity of the economy, measured by the steady state capital stock, the number of domestic producers, and labor supply. Owing to

[8]For instance, Alessandria and Choi (2021); Alessandria et al. (2017) shows that a key source of the widening US and China trade balances over time has been the fall in trade barriers. While Reyes-Heroles (2016); Alessandria et al. (2024); Fitzgerald (2025) show that these features may have lead to improved risk sharing.

[9]That the steady state provides a poor approximation of the welfare effects including the transition is a feature of dynamic trade models with firm-level dynamics and capital accumulation. See Alessandria and Choi (2014b); Alessandria et al. (2021); Mix (2023)

the pro-entry effects of tariffs, the stock of firms rises across all policies, with the increases between 4.7 and 6.7 percent. The largest increase in the number of firms comes with the labor tax cut as all fixed cost are labor intensive.

There are large differences in the steady state capital stock across the fiscal adjustments. In the permanent trade war case the capital stock falls by 13.8 percent with lump sum redistribution but rises by 6.0 percent with the investment subsidy. The capital stock also falls by around 11 percent when we use tariff revenue to lower taxes on capital or labor income. The negative effects on capital accumulation even with the cut in capital taxes is owing to the increase in the price of investment goods given the large role of foreign goods in the production of capital goods. In all cases, the price of investment rises by about 9 percent.

With the unilateral permanent tariff, the capital stock grows by nearly 23 percent with the investment subsidy.The value of firms rises by almost five percent with the investment subsidy while falls by -0.1 percent with the lump sum redistribution. In terms of employment, with a lump sum redistribution employment falls by 1.3 percent but rises by nearly 0.26 percent with the labor tax cut and only falls -0.36 percent with the investment subsidy.

## 4.2 Permanent

We start by describing the dynamic effects of a permanent global trade war under each tax response. We then move to the unilateral increase in tariffs. Agents have perfect foresight about the permanence of the tariffs, retaliation, and the use of tariff revenue for fiscal adjustment once the tariffs are implemented.

### 4.2.1 Permanent Trade War

Figure 7 shows the aggregate response of several macroeconomic variables to a 20% increase in bilateral tariffs, including the anticipatory period described in the previous section. The charts for most variables show the log point difference from steady state. We also include the new tax rate or investment subsidy rate, as well as trade and tariff revenue as a fraction of GDP. We focus on a window from 2024 to 2040.

The effects of tariffs on trade, exporting, firm creation and tariff revenue are quite similar across all fiscal strategies. The tariffs immediately shift expenditures towards domestic goods. Over time, exporters exit the market and new domestic firms enter, so that there is continued gradual substitution that ultimately increases domestic expenditures by a little over five percentage points.

In all cases, tariff revenue jumps sharply with implementation of the tariffs to at least 2 percent of GDP, much larger than it has been for at least the past several decades. Very quickly thereafter, however, tariff revenue as a fraction of GDP falls sharply, despite a deepening contraction in GDP. This decline in revenue reflects ongoing substitution of domestic firms and households away from more expensive imported goods. In the long run, tariff revenue as a fraction of GDP settles around 1.3 percent, about double its initial level. Long-run tariff revenue is highest when it used to subsidize investment or reduce capital taxes, as these uses both partially offset the higher costs of imported capital goods, weakening the degree to which households

and firms substitute away from imports. Since trade is capital-intensive, the subsidies induce a smaller effect on trade given the changing composition of final demand. The falling tariff revenue implies that tax or subsidy rates need to be adjusted over time. In the long run, tariff revenue can support a 12 percent investment subsidy, a five percent drop in the capital income tax, or a two percent drop in the labor income tax.

Among the four uses of tariff revenue considered, a lump sum rebate reduces employment and GDP the most. By reducing taxes or subsidizing investment, revenue can be used to reduce distortions in the economy elsewhere or encourage additional investment. Thus, GDP, consumption, investment, and labor, all fall less when tariffs are rebated to reduce taxes or subsidize investment. That said, the various tax reductions and subsidies all have unique aspects of their affects on the economy.

Reducing capital taxes or subsidizing investment both have strong positive effects on GDP *after* the tariff is implemented before GDP falls again. This brief boost comes from the relatively high values of tariff revenue in the short run relative to the long run. As tariff revenue falls, there is less funds available for tax cuts or subsidies, and GDP continues to fall. In the long run, however, entry of new firms boosts domestic capacity, so that we see the overshooting in GDP that is common in these models with dynamics trade adjustment and firm entry. Both investment subsidies and capital stock reductions generate a strong burst in investment. The investment boom crowds out consumption, which dips sharply on impact. That said, long-run consumption is highest with investment subsidies, as the larger capital stock expands the capacity of the economy. Wages are also higher in the long run with investment subsidies, as the complementarity between capital and labor production increases labor demand.

Reducing labor taxes weakens the usual substitution effects arising from a tariff. Tariffs are a tax on goods, so the substitution effect generally entices households to shift toward enjoying more leisure. But, when labor taxes fall, workers keep more of their wages, so leisure becomes more costly. Thus, while the labor effect in the lump sum scenario is about neutral on impact, labor jumps almost 5% with a labor tax reduction. Again, the effect of the tax reduction is largest on impact when tariff revenue is at its highest, though labor still remains higher in the long run than for any other revenue destination. Subsidizing labor also reduces the cost of firm entry, so that reducing labor taxes yields the highest growth in the number of firms in the economy. Higher labor and a greater number of firms contribute to a stronger long-run GDP response than in the lump sum rebate economy.

Our model has a number of features that have been shown to be important for the aggregate effects of changes in trade policy, but are traditionally absent from macroeconomic models of fiscal policy. First, we assume that there is roundabout production in the economy, meaning that some "final" goods are used as materials in the production of other goods. Roundabout production amplifies the effect of changes in trade policy on the economy, as it incorporates the direct effect of higher input costs in production (Alessandria and Choi, 2014b; Alessandria et al., 2021; Caliendo and Parro, 2014). Our model also assumes that these material goods, capital goods, and consumption goods, are subject to different iceberg costs. While this assumption

is not common in the macroeconomic literature, it allows us to capture the relatively high intensity of capital and intermediate goods in trade relative to consumption goods. As such, capital and materials prices react more than consumption prices to changes in tariffs, which feed through to economic activity through substitution effects (Mix, 2023). Finally, our model incorporates firm and exporter dynamics. Heterogeneous firms make endogenous decisions about market entry and exit. As described previously, these features allow us to capture the slow adjustment of trade to changes in tariffs, a necessary feature when considering the dynamics of tariff revenue over time. Furthermore, these dynamics have been shown to affect the transition path of the economy both in the short run and the long run (Alessandria and Choi, 2014b; Mix, 2023).

#### 4.2.2 US Tariffs with No Retaliation

Figure 8 shows the aggregate response of several macroeconomic variables in the US to a 20% increase in US import tariffs with one year of anticipation before the tariffs are applied and with no retaliation from foreign countries. As in the previous figure, most variables are shown as the log point difference from steady state, with the exception of the subsidy rates, trade over GDP, and tariff revenue over GDP, which are shown in levels. We also now include the trade balance, shown as its level relative to GDP, and the real exchange rate, shown as the log change from steady state.

With a unilateral change in tariffs there is a larger increase in tariff revenue as the real exchange rate appreciates by about half the change in the tariff. The appreciation reduces the price increase on imports from the tariff, so that imports fall by less. On impact, tariff revenue jumps sharply to almost 2.5 percent of GDP. It falls back a bit over time, but not nearly as much as in the scenario with foreign retaliation. Indeed, even in the long run, tariff revenue remains roughly 2 percent of GDP, much higher than it is with the global trade war. Similar to the trade war, using tariff revenue to reduce taxes on capital and investment yields larger and more persistent revenue increases. This allows for more tax relief in the US economy, with the investment subsidy around 19 percent and a reduction of the capital income tax to about five percent.

The aggregate effects on the US economy for a unilateral tariff are very different than in the trade war scenario. First, there is a smaller increase in employment, largely reflecting a smaller increase in the number of domestic firms. Unilateral tariff hikes are less costly than the trade war for exporters in both countries. In the US, exporters do not face large tariff hikes abroad. In the ROW, exporters do not see the same increase in input costs that they would if the ROW retaliated with similarly high tariffs. As such, the value of exporting falls by less, and the value of being a purely domestic firm—the value of concern for potential entrants—rises by less. With less labor needed for fixed entry costs, labor demand is not as high. The unilateral change in tariffs generally has a less negative effect on other aspects of the US economy than in the trade war scenario. Indeed, with the investment subsidy, GDP grows by almost 4 percent in the long-run. In all cases there is a long-run increase in consumption. Notice, however, that if tariff revenue continues to be rebated lump sum, GDP still falls sharply when tariffs are unilaterally applied.

The dynamics of the trade balance depend on the fiscal instrument used. In anticipation of higher tariffs,

there is a large trade deficit of almost 2 percent of GDP, as firm rush to build up capital stocks before tariffs make investment more expensive. This anticipatory spike in the trade deficit seems to be borne out in the data, as the real U.S. trade deficit increased from 4.5 percent of quarterly real GDP in the fourth quarter of 2024 to 5.8 percent of real GDP in the first quarter of 2025.[10] Our model attributes this spike in the trade deficit to a belief that at least some of the U.S. tariffs will not be met with foreign retaliation. When the tariff is implemented, the trade balance in our model swings to surplus as imports fall more sharply than exports. After that initial swing, imports fall more slowly when tariff revenue is used for capital or investment subsidies, and the trade surplus quickly moves toward a balance. With labor subsidies or lump sum rebates, by contrast, imports fall at a quicker pace, keeping the trade surplus higher for a couple more years.

Figure 9 depicts the changes in the ROW from the unilateral tariffs under each fiscal scenario. With the implementation of the tariffs, the ROW GDP and consumption fall while employment rises slightly on impact. Although the ROW does not impose additional tariffs on imports from the US, the real exchange rate depreciation still makes imports of US goods more expensive. As such, we still see "reshoring" in the ROW, as shown by the growth in the number of firms. This effect is smallest, and indeed, the total effect on the ROW economy is smallest, when the US uses tariff revenues to subsidize investment.

## 4.3 Temporary

We now discuss the same aggregate responses when the tariff is temporary. We assume that tariffs are applied for four years and that all agents know the tariffs are temporary with perfect foresight. As before we consider global and unilateral changes in tariffs. The temporary nature of these tariff, and fiscal policy, yields much larger swings in economic activity, particularly in the US.

### 4.3.1 Trade War

First, we consider a temporary trade war. We assume that tariffs are applied for four years and that all agents know the path of tariffs with perfect foresight. Results for this exercise are formatted similarly to the permanent global trade war and are found in Figure 10. We assume both countries use the revenue in the same way.

The response of tariff revenue as a fraction of GDP on impact is very similar to the permanent trade war. Indeed, the short-run tariff elasticity in this model is simply $\gamma$, so that we would expect similar responses in both models. Over time, however, we see that tariff revenue holds up better when the tariffs are expected to be temporary. This finding relates to the dynamics of trade adjustment, which happens more slowly and less than in the permanent trade war. The reason for this slow adjustment is that exporters have less incentive to give up their export fixed cost advantage by leaving the market when they expect tariffs to be repealed

[10] In the appendix, in Figure 19, we show these changes are more extreme when using monthly data as trade balance widens considerable from December 2024 to March 2025 and trade increases too.

soon. As such, more exporters stay in the market, which keeps the price of imported goods for the trading partner from rising too quickly.

While the temporary tariffs yield a more gradual response in tariff revenue and trade, they yield much sharper movements in other aggregate variables. If revenue is not used to subsidize investment, then investment falls very sharply for the duration of the tariffs. Because trade is intensive in capital goods, the price of investment goods is more affected by tariffs. When agents expect that the tariffs will be reversed soon and that the price of investment will reverse in turn, they optimize intertemporally by delaying capital investment. The one exception is when tariffs are used to subsidize investment. Then, the revenue offsets the increase in the price of investment and induces agents to increase investment sharply for the duration of the tariffs.

For many variables, including GDP, consumption, investment, and trade, the only revenue use that seems to be substantially different from the lump sum rebate is subsidies for investment. An exception to this is labor, where reduction in labor taxes boost labor sharply for the duration of the tariffs. Most of this labor seems to be used in the entry of new firms, which peaks at 4 percent above the steady state level, much higher than the peak for the lump sum rebate.

#### 4.3.2 US Temporary Tariffs with No Retaliation

The results for the temporary US import tariff are plotted in Figure 11 for the US and in Figure 12 for the ROW. Similar to the temporary trade war, the unilateral temporary case leads to very large swings in economic activity in the US. Similar to the permanent unilateral case there is a large appreciation and large swings in the trade balance. As before the US runs a larger trade deficit in advance of the temporary tariffs, but there is a sharp reversal with the tariffs as consumption falls off strongly. The swings in the trade balance are strongly influenced by the temporary nature of the reform. There are very large reversals in all cases by the investment subsidy.

## 5 Sensitivity

Here we study the importance of several assumptions related to the structure of the economy. For simplicity we only consider the effect of the permanent unilateral tariff that is used to subsidize investment. We find important differences related to the trade elasticity. Likewise, if we use a trade model without trade dynamics or producer creation margins we find substantial differences in the dynamics of the economy. We find that introducing initial trade deficits through asset positions have minor effects on our results. Likewise changing country sizes through differences in productivity, labor, or capital intensity yield similar results.

## 5.1 Lower trade elasticity

We lower the elasticity of substitution between domestic and imported goods to $\gamma = 2.75$ without changing the elasticity of substitution across varieties. The results are depicted in Figure 13. The lower Armington elasticity lowers the short-run and long-run trade elasticities, leading to less substitution away from imports, more tariff revenue, and a bigger tax cut. There is a slightly smaller depreciation after the tariff is imposed. Investment and thus consumption grow more in the long run. The lower elasticity yields slightly different short-run dynamics. There is a slightly stronger consumption and leisure on impact owing to the standard wealth channel. These have modest effects on the trade balance, but the real exchange rate appreciates a little more in impact.

## 5.2 No exporter dynamics

We now show that eliminating trade dynamics has a substantial impact on the path of the economy following the tariff and fiscal policy change. These dynamic differences are consistent with the findings in prior work.[11].

A key feature of our model is firm-level decisions on producer creation and exporting. These features imply that the dynamic trade response, and tax policy, depends on the persistence and size of trade policy and horizon considered. We now explore how abstracting from exporter dynamics and the firm creation margin influences the effect of the reform by eliminating the margins that make trade participation dynamic.[12] This yields a variation of the well-known Armington and Krugman models used in business cycle analysis.

We compare our baseline results to two variations with different Armington elasticities, $\gamma = \{3.75, 6.0\}$. In both cases we adjust the trade costs in the initial equilibrium to maintain the same level and composition of trade as in our baseline calibration. The results are plotted in Figure 14. Eliminating trade dynamics and changing the elasticity has predictable effects on the trade, tariff revenue, and the investment subsidy. Along these dimensions the low elasticity model starts out similar to our baseline while the higher elasticity model ends up similar to the long-run of our baseline model. The baseline model provides a gradual transition between the two models.

Despite these similarities on trade, the macroeconomic effects are quite different as the margins giving rise to the transition influence the long run. In the baseline model the stock of firms, capital, consumption and real wage grow substantially in the long run, but hardly change in the model without firm and exporter dynamics. As discussed in Alessandria and Choi (2014b), the additional margins in the baseline model allow for easier adjustment to the changes in policy. These long-run differences also imply bigger differences in the anticipation period on the trade balance and real exchange rate.

[11] For example see Alessandria and Choi (2014b,a); Alessandria et al. (2021); Mix (2023). Perhaps most related is Alessandria and Mix (2021) which explores the aggregate effects of tariff phaseouts empirically and in a related model

[12] In practice we eliminate firm-level export intensive margin and extensive margin dynamics and make firm creation exogenous by replacing dying firms one for one.

### 5.3 Asset Asymmetries

We now adjust the model to allow for an asymmetry in net foreign asset to capture the persistent US trade deficit. Specifically, we assume the US has positive net foreign assets ($B_0 > 0$) to generate a trade deficit of 3 percent annually. The bond is denominated in units of the US consumption bundle. Figure 15 plots the impact of the unilateral permanent increase in tariff on the US. Qualitatively the results are quite similar to the case with balanced trade. The main difference is that now the average trade deficit is 3 percent prior to the possibility of the war. However, the swings in the trade balance in percentage terms are similar to the case with trade initially balanced. In the long-run, the US benefits more from a unilateral tariff as this leads to larger real exchange rate appreciation which leads to a smaller decline in trade, more revenue, larger subsidy, and larger increase in investment.

### 5.4 Size differences

We now explore how differences in country sizes influence our findings. Specifically, we consider differences in country size from differences in productivity or capital-output ratios from differences in capital taxes. To capture size asymmetry, we recalibrate the model such that the ROW has 1.5 times the GDP of the US in the steady state by adjusting productivity. To capture differences in capital intensity, we introduce a 50 percent capital subsidy in ROW, which results in a 12 percent higher capital-output ratio relative to the US in the steady state. The results are shown in Figure 21. Quantitatively, these asymmetries have limited effects on US outcomes, except that the size asymmetry leads to larger changes in the US trade balance and net foreign asset position.

## 6 Optimal Tariffs

We now solve for the welfare-maximizing unilateral and global tariff in the spirit of Bickerdike (1907) and Johnson (1953) without distortions and Boadway et al. (1973) with distortions. Specifically, we revisit the aggregate implication of a range of permanent changes in tariffs under the traditional lump sum rebate and the investment subsidy cases. We find the optimal unilateral tariff with the investment subsidy is 18 percent while going to free trade is only optimal when tariff revenue is rebated lump sum. We also show that positive tariffs are welfare-maximizing in the global case when the revenue is used to fund investment subsidies. We explore the sensitivity of these results to the features that yield distortions, taxes, markups, and roundabout production. We show that our optimal tariff is largely invariant to the source of the inefficiency provided that the government is using tariff revenue to offset another tax. We find optimal unilateral tariffs are increasing in a country's net foreign assets and hence trade deficit.

## 6.1 Baseline case

Specifically, we solve for the transition for a permanent surprise change in tariffs[13] for a range of positive tariffs with tariff revenue either rebated lump sum or used to subsidize investment.[14] We do this for the unilateral and global tariff cases. In Figure 16, we plot the welfare and long-run effects of these reforms for each tariff with separate panels for the unilateral and global reforms.

From the top panel, depicting the permanent unilateral reform, we find that using tariff revenue to subsidize investment yields a maximum welfare gain of 1.6 percent and this occurs with an increase of tariffs to 18 percent. At this tariff level, in the long-run consumption is 3.53 percent above its initial level and employment is 0.16 percent above its initial level. In contrast, with lump sum redistribution, welfare and long-run consumption both fall monotonically with tariffs. There is a sizable gap in the welfare estimate when using the lump sum redistribution as with an 18 percent tariff, welfare would drop 0.76 percent and steady state consumption would fall 1.36 percent while steady state employment would be 1.29 percent lower. Note, the only difference across these models is in the use of the tariff revenue.

When we use the tariff revenue to fund the investment subsidy, there is an additional subtlety: We are really undertaking two reforms. First, we are taking the tariff revenue that is being redistributed lump sum at the initial steady state and using it to introduce the investment subsidy. As a consequence, welfare rises by 0.83 percent—more than half of the optimal tariff welfare increase—solely from this aspect of the reform. Second, as we vary the tariff we adjust our investment subsidy. From this perspective, going to free trade would eliminate any investment subsidy, so the only welfare gains come from the reduction in tariffs.

From the bottom panel depicting the global tariff reform we find that the welfare-maximizing reform that provides an investment subsidy occurs with a tariff of 2 percent. We find that the welfare gain is positive with tariffs up to 14 percent, with the recognition that the reform here includes use of all revenue toward an investment subsidy. The tariff that maximizes steady state consumption is 6 percent and long-run consumption increases for tariffs up to 23 percent. With lump sum redistribution of tariff revenue, welfare falls monotonically with tariffs.

## 6.2 Alternative structures

The finding that going to free trade unilaterally may increase welfare in the lump sum case may seem unusual given ability of the US to influence the terms of trade. However, there are some inefficiencies in our model. Beyond distortionary taxes, our model has two additional departures from efficiency related to monopolistic competition. First is the well-known distortion from the markup on goods and not on labor. Second, owing to the roundabout production structure, markups and import tariffs are compounded through the input-output structure. To explore the impact of these considerations we re-solve for the welfare-maximizing tariff with the lump sum rebate and our tariff revenue financed investment subsidy for four variations—each building

[13] We do not consider either the time-consistent tariffs nor the optimal path.

[14] Given our focus on distortionary taxes and tariffs, we do not allow for import subsidies in the lump sum case.

on the top of the last—reported in Table 5. First, we eliminate all distortionary taxes ($\tau_k = \tau_l = 0$). For the lump sum rebate case this raises the optimal unilateral tariff to zero from -6 percent. Second, we make labor supply exogenous and this raises the optimal tariff further to 9 percent. Third, we force iceberg costs to be equal across all good types so that tariffs no longer have an outsized effect on investment prices. With this additional restriction, the optimal tariff rises to 13 percent. Finally, we remove roundabout production which further boosts the optimal tariff to 18 percent. While the welfare-maximizing unilateral tariff with a lump sum rebate changes considerably as we change the structure of the economy, when we use tariff revenue to fund an investment subsidy the welfare-maximizing tariff remains between 17 and 20 percent. This suggests that discussions of tariff policy may be better framed through their effects on government revenue.

In the right panel of Table 5 we explore how the welfare-maximizing global tariff varies with the structure of the economy. Similar to the case with the unilateral tariff, the welfare-maximizing tariff varies very little when it is intermediated through the government budget constraint while it changes substantially when we rebate the tariff lump sum. With the investment subsidy funded from tax revenue, the optimal tariff is always positive and between 1 and 3 percent. With lump-sum redistribution we find that an import subsidy of 23 percent is optimal in our baseline calibration. Removing other distortionary taxes reduces the optimal import subsidy to 17 percent, then making labor exogenous reduces it further to 9 percent. Eliminating heterogeneous iceberg costs across goods further reduces the optimal subsidy to 5 percent, and removing roundabout production lowers it to 1 percent.

### 6.3 Net foreign assets and trade deficits

We now consider how the optimal tariff depends on the presence of US trade deficits. Specifically, we assume the US has a positive net foreign asset position consistent with the current trade deficit. While this case is inconsistent with observed US net foreign assets, it is consistent with the view that once we adjust for the return differentials on foreign assets, the US has some higher unmeasured foreign assets, $B_0$, as discussed in McGrattan and Prescott (2010). We consider the case when the bond is denominated in units of US consumption or foreign consumption goods. We then solve for the welfare-maximizing unilateral and global tariffs with the investment subsidy.

With positive US net foreign assets, we find the welfare-maximizing unilateral tariff increases to 27 percent and the welfare gain increases to 2.25 percent. Given the unbalanced demand for goods, the terms of trade change from the unilateral tariff is more valuable for the US. Additionally, the appreciation of US real exchange yields a capital gain on US savings. With the bond denominated in foreign consumption units, the US takes a capital loss on the asset. Consequently, the optimal tariff is closer to 23 percent and it yields a welfare gain of 1.9 percent.

### 6.4 Tax revenue

Given the focus on tariff revenue-funded reforms, we conclude by solving for the tariff that maximizes tariff revenue with and without retaliation. That is, we solve for the constant tariff that generates the largest present value of future revenue flows. We solve for the present value of tariff revenue using the endogenous discount factor for households and scale the tariff revenue by initial nominal GDP. The second row of Figure 17 shows this calculation for tariffs from 0 percent to 100 percent with global or unilateral tariffs. We plot the effects in the lump sum case, though tariff revenue behaves qualitatively similar with alternative rebate strategies. In the unilateral case, we find that a 38 percent tariff maximizes the present value of tariff revenue, generating revenue equal to 54 percent of initial annual GDP over the discounted future. By contrast, keeping tariffs at their initial value of 4 percent garners a present value tariff revenue of only 15 percent of initial GDP. The tariff-maximizing tariff when the rest of the world retaliates with matching tariffs is much smaller at 18 percent, which generates 30 percent of initial annual GDP in present value tariff revenue. The revenue-maximizing tariff is larger in the unilateral tariff case as a US real exchange rate appreciation in the unilateral case keeps US imports higher than in the case with retaliation.

To highlight the dynamics in tariff revenue, we also plot the revenue obtained for each tariff over several horizons. These calculations are shown in the first row of Figure 17. Owing to the substitution induced by the policy, the tariff that achieves the peak revenue starts out high and falls monotonically. The tariff that maximizes revenue in the first quarter after implementation is 38 percent with global tariffs and 82 percent with a unilateral tariff. The tariffs that maximize revenue in the quarter one year after implementation are much lower, about 26 percent and 56 percent for the global and unilateral cases, respectively. The revenue-maximizing tariff continues to fall over time as the elasticity of imports to the tariff change increases. In the long run, tariff revenue each quarter is maximized at 17 percent and 37 percent tariffs for the global and unilateral cases, respectively. Long-run maximum tariff revenue in both cases is just a bit over half of the maximum revenue on impact.

Given the relationship between tariff revenue and the trade elasticity, in the third row of Figure 17 we plot the revenue-maximizing tariff at each horizon against the inverse of the trade elasticity, which in many models is closely related to the optimal unilateral tariff. We find that revenue-maximizing is always greater than the inverse of the trade elasticity, with the gap much larger at high levels. The differences between these measures are largely related to the general equilibrium feedback and transitions.

The final row of Figure 17 reports our calculation for the 10-year revenue obtained from each tariff relative to the baseline case of leaving tariffs unchanged at 4 percent assuming initial nominal GDP of $29.7 trillion—US GDP in 2024. Our estimates for the tariff revenue from a 20 percent increase in tariffs to 24 percent are $1.9 trillion with retaliation and $4.2 trillion without retaliation. Both these estimates are in line with estimates from other budgetary models for the Trump administration's proposed tariff increases. Importantly, this increase in revenue is front loaded because import substitution is lowest in the initial periods after the tariffs. The blue dotted line in each figure shows the estimated tariff revenue if one were

to use the trade elasticity on impact to impute future revenue. This estimate is always above the actual model-implied estimate, increasingly so at higher tariff rates as it misses out on the substitution that should take place. The gap can be quite big. For instance the 41 percent increase in tariff would generate only $0.8 trillion in extra revenue with retaliation and dynamic substitution compared to $4.3 trillion using the impact trade response.

# 7 Final Thoughts

Using a dynamic heterogeneous firm model, we study the aggregate effects of changes in tariffs when the revenue from those tariffs are used to offset other distortionary taxes. Our model combines key elements from the analysis of fiscal and trade policy, including a realistic composition of trade across different types of goods and firm-level trade frictions that lead to firm and aggregate trade dynamics. We find that the aggregate effects of increasing tariffs depend on (1) the persistence of the policy, (2) the extent of foreign retaliation, and (3) the use of tariff revenue. Key to the aggregate response is the dynamics of tariff revenue, which depend on household and firm expectations of persistence and revenue use, which determine how quickly and how much agents substitute away from imports toward domestic goods. A temporary tariff is shown to generate the greatest revenue as agents are slow to substitute, but it can be strongly recessionary without labor tax cuts or investment subsidies.

Consistent with a large literature on optimal tariffs, we find that in the absence of foreign retaliation, there can be long-run benefits to raising tariffs, particularly if the revenue is used to offset labor taxes or subsidize investment. In the presence of distortionary taxes, tariffs accompanied by tariff revenue-funded fiscal reform always improves welfare outcomes, sometimes substantially. Even with retaliation, tariff revenue-funded fiscal reforms can greatly mitigate the costs of raising tariffs. Among all reforms, subsidizing investment generally yields the best welfare outcomes. This finding relates to the nature of trade. Given the high use of imported inputs in investment, the price of capital rises in response to tariffs, discouraging capital accumulation even with cuts to the capital tax. An investment subsidy directly offsets the increased price of investment, making it more effective than a cut to capital income taxes. Labor tax cuts are also more effective than capital tax cuts at boosting economic activity in our model given the important role of labor in the creation of new products.

We abstract from several key international asymmetries related to net foreign asset positions, capital intensity, and several margins that are likely to influence our quantitative results but can easily be incorporated into our analysis. Preliminary work suggests these margins have small effects holding tariff policy changes constant. However, we do find the welfare-maximizing tariff may differ substantially. Likewise we have focused on a broad and simple tariff. Heterogeneity in import tariffs across trading partner will matter for the aggregate effects and individual countries, but we expect the effects of the distribution of tariffs across trading partners on the US to be relatively small. Our model also ignores how the effects of the tariffs and

their incidence are spread across heterogeneous households.

Our emphasis is on understanding the interactions between tariff and tax reforms in a framework that captures domestic and international fiscal considerations and trade dynamics. We focus on a limited set of instrumentsand we take no stand on optimal policy, but the differences we identify between our dynamic trade model with exporter dynamics and models without export dynamics suggest this would be a fruitful area to explore. Moreover, our finding that lump sum rebates of tariff revenue always lead to worse outcomes than tax reform suggests existing results may need to be revisited. Indeed, we find the optimal tariff is quite stable to the structure of the model when tariff revenue is used for a tax cut. This envelope condition does not extend to analysis with lump sum redistribution of tariffs.

Finally, we evaluate the changes in current trade and tax policy relative to a world with no future changes in trade or tax policy. If a future trade disagreement was likely, then our analysis will imply smaller welfare effects. If a future agreement was likely, then these welfare effects will be larger. Understanding where trade policy was going and why is a fruitful direction of research and perhaps can be recovered by studying the dynamics of trade leading up to this period (Alessandria et al., 2025d; Hoang and Mix, 2023).

# References


**Alessandria, George A and Carter B Mix**, "Trade Policy is Real News: Theory and Evidence," Working Paper 28904, National Bureau of Economic Research June 2021.

**_ , Shafaat Yar Khan, Armen Khederlarian, Kim J Ruhl, and Joseph B Steinberg**, "Recovering Credible Trade Elasticities from Incredible Trade Reforms," Working Paper 33568, National Bureau of Economic Research March 2025.

**_ , Yan Bai, and Soo Kyung Woo**, "Unbalanced Trade: Is Growing Dispersion from Financial or Trade Reforms?," Working Paper 33101, National Bureau of Economic Research November 2024.

**Alessandria, George and Horag Choi**, "Do sunk costs of exporting matter for net export dynamics?," *The Quarterly Journal of Economics*, 2007, pp. 289–336.

**_ and _** , "Do falling iceberg costs explain recent U.S. export growth?," *Journal of International Economics*, 2014, *94* (2), 311 – 325.

**_ and _** , "Establishment heterogeneity, exporter dynamics, and the effects of trade liberalization," *Journal of International Economics*, 2014, *94* (2), 207–223.

**_ and _** , "The dynamics of the U.S. trade balance and real exchange rate: The J curve and trade costs?," *Journal of International Economics*, 2021, *132*, 103511.

**_ , _ , and Dan Lu**, "Trade Integration and the Trade Balance in China," *IMF Economic Review*, 2017, *65* (3), 633–674.

**_ , _ , and Kim J. Ruhl**, "Trade Adjustment Dynamics and the Welfare Gains from Trade," *Journal of International Economics*, 2021, *131*, Article 103458.

**_ , Shafaat Khan, and Armen Khederlarian**, "Inventories, Integration, Productivity and Welfare," *AEA Papers and Proceedings*, May 2025, *115.*

**_ , Shafaat Yar Khan, Armen Khederlarian, Carter Mix, and Kim J. Ruhl**, "The aggregate effects of global and local supply chain disruptions: 2020/–2022," *Journal of International Economics*, 2023, *146*, 103788. NBER International Seminar on Macroeconomics 2022.

**_ , _ , _ , Kim J. Ruhl, and Joseph B. Steinberg**, "Trade Policy Dynamics: Evidence from 60 Years of US-China Trade," *Journal of Political Economy*, 2025, *133* (3), 713–749.

**_ , _ , _ , _ , and _** , "Trade war and peace: U.S.-China trade and tariff risk from 2015–2050," *Journal of International Economics*, 2025, *155*, 104066.

**Atkeson, Andrew and Ariel Tomás Burstein**, "Innovation, Firm Dynamics, and International Trade," *Journal of Political Economy*, 2010, *118* (3), 433–484.

**_ and Patrick J. Kehoe**, "Modeling and Measuring Organization Capital," *Journal of Political Economy*, 2005, *113* (5), 1026–1053.

**Auerbach, Alan J. and Laurence J. Kotlikoff**, *Dynamic Fiscal Policy*, Cambridge University Press, 1987.

**Backus, David, Patrick Kehoe, and Finn Kydland**, "Dynamics of the Trade Balance and the Terms of Trade: the J Curve?," *American Economic Review*, 1994, pp. 84–103.

**Baldwin, Richard and Paul Krugman**, "Persistent Trade Effects of Large Exchange Rate Shocks," *The Quarterly Journal of Economics*, 1989, *104* (4), 635–654.

**Bhagwati, Jagdish N. and V. K. Ramaswami**, "Domestic Distortions, Tariffs and the Theory of Optimum Subsidy," *Journal of Political Economy*, 1963, *71* (1), 44–50.

**Bickerdike, Charles F.**, "The Theory of Incipient Taxes," *The Economic Journal*, 1907, *17*, 98–102.

**Boadway, R., S. Maital, and M. Prachowny**, "Optimal tariffs, optimal taxes and public goods," *Journal of Public Economics*, 1973, *2* (4), 391–403.

**Boehm, Christoph E., Andrei A. Levchenko, and Nitya Pandalai-Nayar**, "The Long and Short (Run) of Trade Elasticities," *American Economic Review*, 2023, *113(4)*, 861–905.

**Caliendo, Lorenzo and Fernando Parro**, "Estimates of the Trade and Welfare Effects of NAFTA," *The Review of Economic Studies*, 11 2014, *82* (1), 1–44.

_ **and** _ , "Trade policy," *Handbook of international economics*, 2022, *5*, 219–295.

**Corden, W.M.**, "Chapter 2 The normative theory of international trade," in "in," Vol. 1 of *Handbook of International Economics*, Elsevier, 1984, pp. 63–130.

**Das, Sanghamitra, Mark J. Roberts, and James R. Tybout**, "Market Entry Costs, Producer Heterogeneity, and Export Dynamics," *Econometrica*, 2007, *75* (3), 837–873.

**Feenstra, Robert C.**, "New Product Varieties and the Measurement of International Prices," *The American Economic Review*, 1994, *84* (1), 157–177.

**Fitzgerald, Doireann**, "3-D Gains From Trade," *Minneapolis Federal Reserve Bank, mimeograph*, 2025.

**Gallaway, Michael P., Christine A. McDaniel, and Sandra A. Rivera**, "Short-run and Long-run Industry level Estimates of U.S. Armington Elasticities," *The North American Journal of Economics and Finance*, 2003, *14(1)*, 49–68.

**Goulder, Lawrence H., John B. Shoven, and John Whalley**, "Domestic Tax Policy and the Foreign Sector: The Importance of Alternative Foreign Sector Formulations," in Martin Feldstein, ed., *Behavioral Simulation Methods in Tax Policy Analysis*, University of Chicago Press, 1983, pp. 333–379.

**Handley, Kyle and Nuno Limão**, "Policy Uncertainty, Trade, and Welfare: Theory and Evidence for China and the United States," *American Economic Review*, 2017, *107(9)*, 2731–2783.

**Head, Keith and Thierry Mayer**, "Chapter 3 - Gravity Equations: Workhorse,Toolkit, and Cookbook," in Gita Gopinath, Elhanan Helpman, and Kenneth Rogoff, eds., *Handbook of International Economics*, Vol. 4 of *Handbook of International Economics*, Elsevier, 2014, pp. 131–195.

**Hoang, Trang and Carter B. Mix**, "Trade Wars and Rumors of Trade Wars: The Dynamic Effects of the U.S.–China Tariff Hikes," 2023. Mimeo.

**Hooper, Peter, Karen Johnson, and Jaime Marquez**, "Trade Elasticities for the G-7 Countries," *Princeton Studies in International Economics*, 2000, *87*.

**Hopenhayn, Hugo A.**, "Entry, Exit, and firm Dynamics in Long Run Equilibrium," *Econometrica*, 1992, *60* (5), 1127–1150.

**House, Christopher L. and Matthew D. Shapiro**, "Phased-In Tax Cuts and Economic Activity," *American Economic Review*, December 2006, *96* (5), 1835–1849.

**Houthakker, H. S. and Stephen P. Magee**, "Income and Price Elasticities in World Trade," *The Review of Economics and Statistics*, 1969, *51* (2), 111–125.

**Irwin, Douglas A.**, "Changes in U.S. Tariffs: The Role of Import Prices and Commercial Policies," *The American Economic Review*, 1998, *88* (4), 1015–1026.

**Johnson, Harry G.**, "Optimum Tariffs and Retaliation," *The Review of Economic Studies*, 01 1953, *21* (2), 142–153.

**Lashkaripour, Ahmad**, "Can Trade Taxes Be a Major Source of Government Revenue?," *Journal of the European Economic Association*, 2021, *19* (5), 2399–2428.

**Lerner, Abba P.**, "The Concept of Monopoly and the Measurement of Monopoly Power," *The Review of Economic Studies*, 1934, *1* (3), 157–175.

**Lipsey, R. G. and Kelvin Lancaster**, "The General Theory of Second Best," *The Review of Economic Studies*, 1956, *24* (1), 11–32.

**McGrattan, Ellen R. and Edward C. Prescott**, "Technology Capital and the US Current Account," *American Economic Review*, September 2010, *100* (4), 1493–1522.

**Mendoza, Enrique G. and Linda L. Tesar**, "The International Ramifications of Tax Reforms: Supply-Side Economics in a Global Economy," *The American Economic Review*, 1998, *88* (1), 226–245.

**_ and _**, "Why hasn't tax competition triggered a race to the bottom? Some quantitative lessons from the EU," *Journal of Monetary Economics*, 2005, *52* (1), 163–204.

**Mix, Carter**, "The dynamic effects of multilateral trade policy with export churning," *International Economic Review*, 2023, *64* (2), 653–689.

**Pierce, Justin R. and Peter K. Schott**, "The Surprisingly Swift Decline of US Manufacturing Employment," *American Economic Review*, 2016, *106(7)*, 1632–1662.

**Prescott, Edward C.**, "Why do Americans work so much more than Europeans?," *Quarterly Review*, 2004, *28* (Jul), 2–13.

**Quadrini, Vincenzo and José-Víctor Ríos-Rull**, "International tax competition with rising intangible capital and financial globalization," *Journal of Monetary Economics*, 2024, *141*, 101–120. CARENGIE-ROCHESTER-NYU APRIL 2023 CONFERENCE.

**Ravikumar, B., Ana Maria Santacreu, and Michael Sposi**, "Capital accumulation and dynamic gains from trade," *Journal of International Economics*, 2019, *119*, 93–110.

**Reyes-Heroles, Ricardo**, "The role of trade costs in the surge of trade imbalances," *Princeton University, mimeograph*, 2016.

**Ruhl, Kim J. and Jonathan L. Willis**, "New Exporter Dynamics," *International Economic Review*, 2017, *58* (3), 703–726.

**Simonovska, Ina and Michael E. Waugh**, "The Elasticity of Trade: Estimates and Evidence," *Journal of International Economics*, 2014, *92* (1), 34–50.

**Spencer, Adam Hal**, "Policy Effects of International Taxation on Firm Dynamics and Capital Structure," *The Review of Economic Studies*, 10 2021, *89* (4), 2149–2200.

**Steinberg, Joseph B**, "Export market penetration dynamics," *Journal of International Economics*, 2023, *145*, 103807.

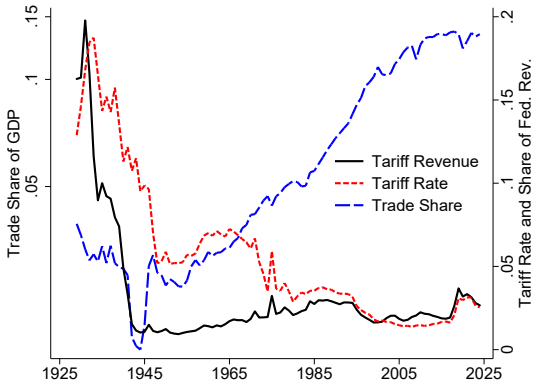
**Trabandt, Mathias and Harald Uhlig**, "The Laffer curve revisited," *Journal of Monetary Economics*, 2011, *58* (4), 305–327.

**Trump, Donald J.**, "America First," August, day = 14, howpublished = Speech transcript, note = North Carolina Rally, url = https://rollcall.com/factbase/trump/transcript/donald-trump-speech-political-rally-asheville-north-carolina-august-14-2024/ 2024.

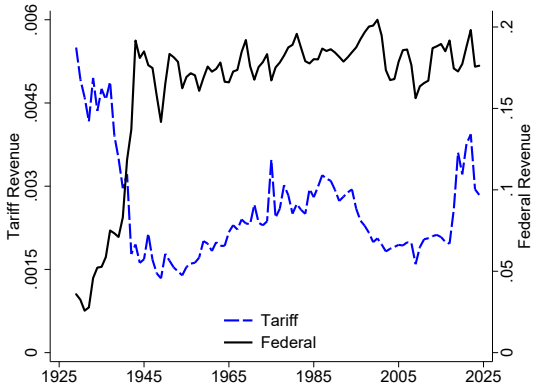
**Yi, Kei-Mu**, "Can vertical specialization explain the growth of world trade?," *Journal of Political Economy*, 2003, *111* (1), 52–102.

Figure 1: US Tariffs, Trade, Tariff Revenue and Federal Revenue

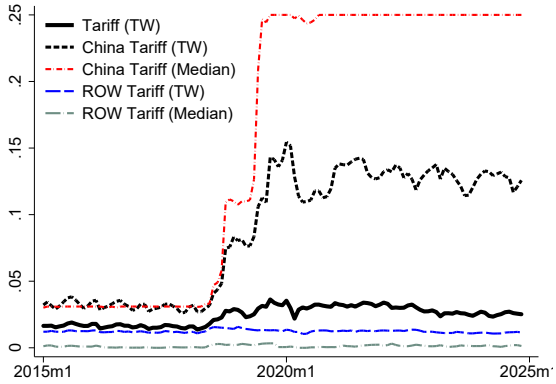
(a) US Tariffs, Trade, and Revenue



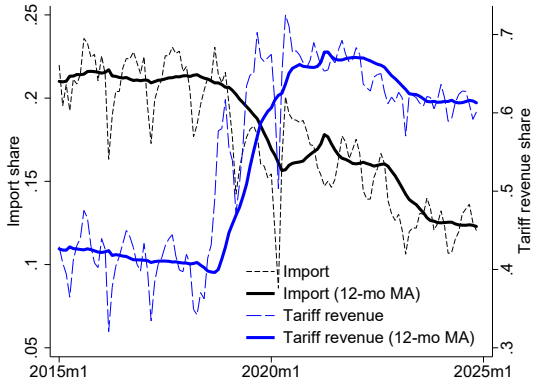

(b) Tariff and Federal Revenue




(c) Tariffs by Source and Weighting



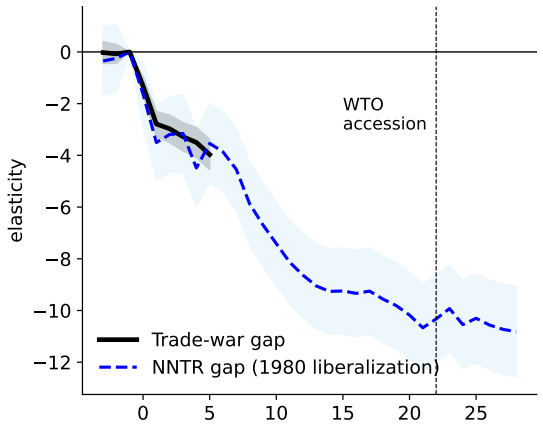

(d) China's Share of Trade and Tariff Revenue




*Notes:* Panel b shows the tariff revenue and total federal revenue as a fraction of GDP.

Figure 2

(a) Elasticity of Chinese Imports to Trade War and 1980 Tariff Changes




(b) Median US Tariff on Chinese Imports

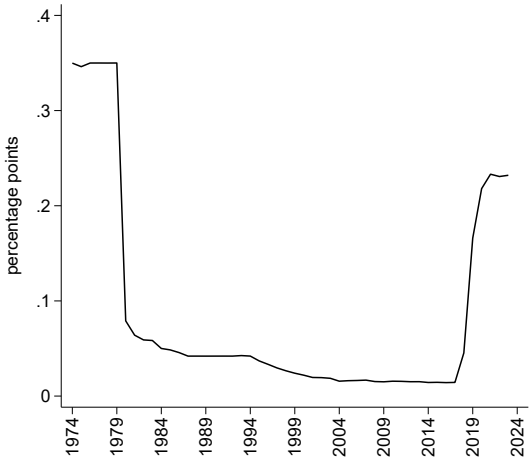


Figure 3: Imports and Tariffs in US (1929 - 2024)

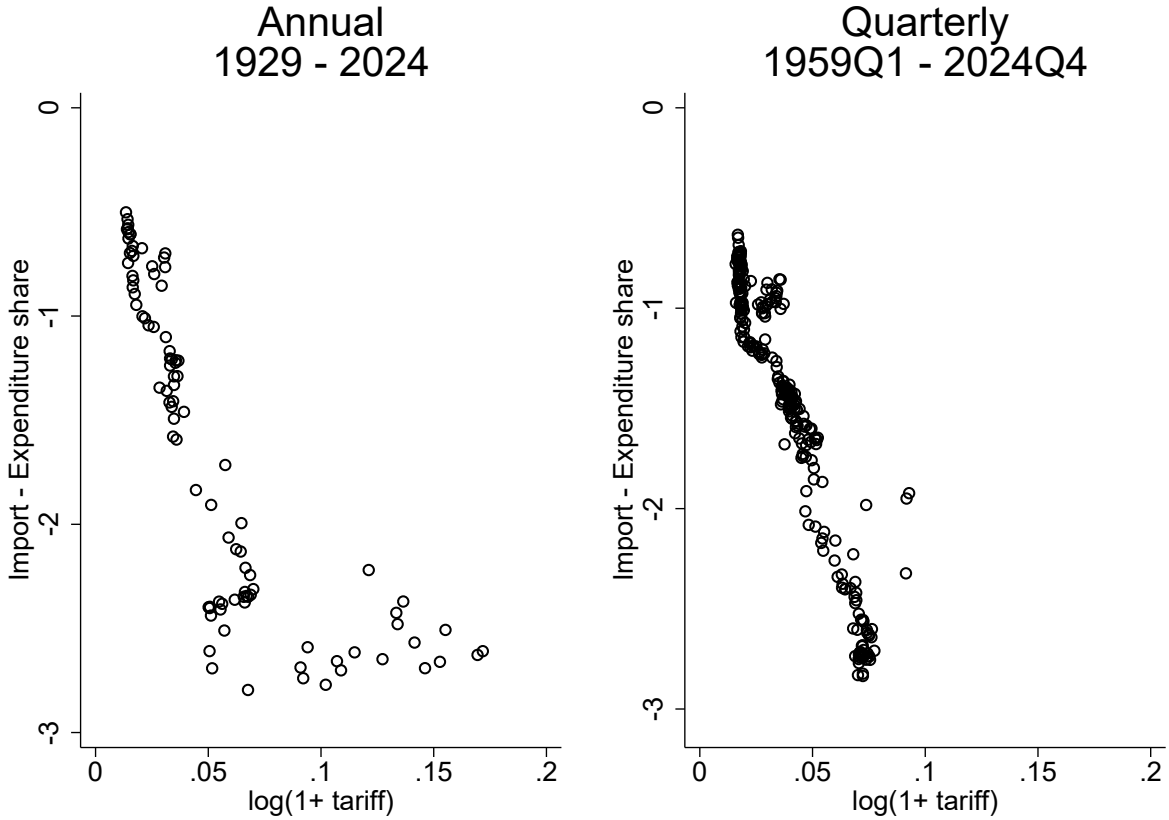


Figure 4: Anticipatory effects to Global Permanent Tariffs of 20%

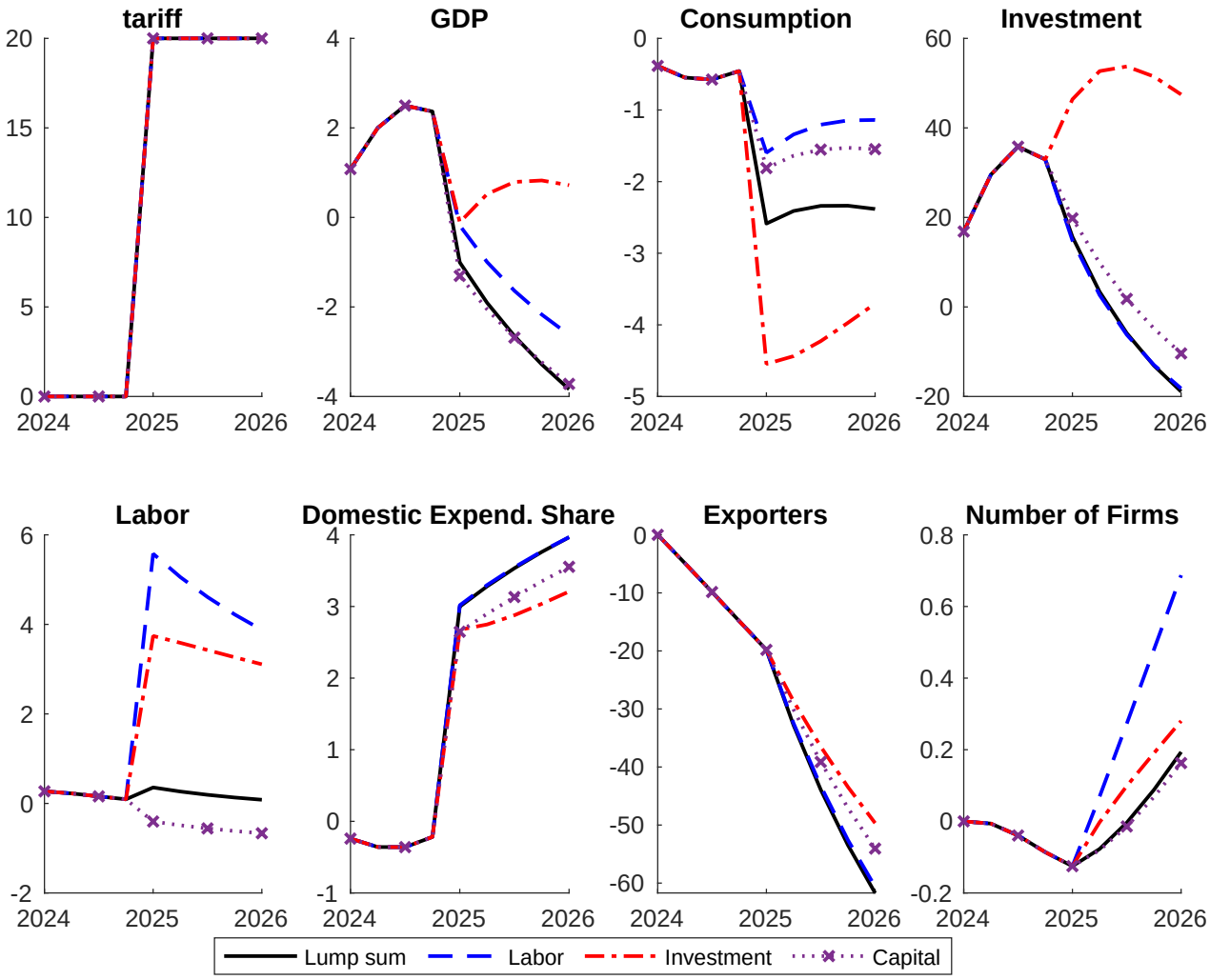


Figure 5: Anticipation Window for Alternative Reforms (US)

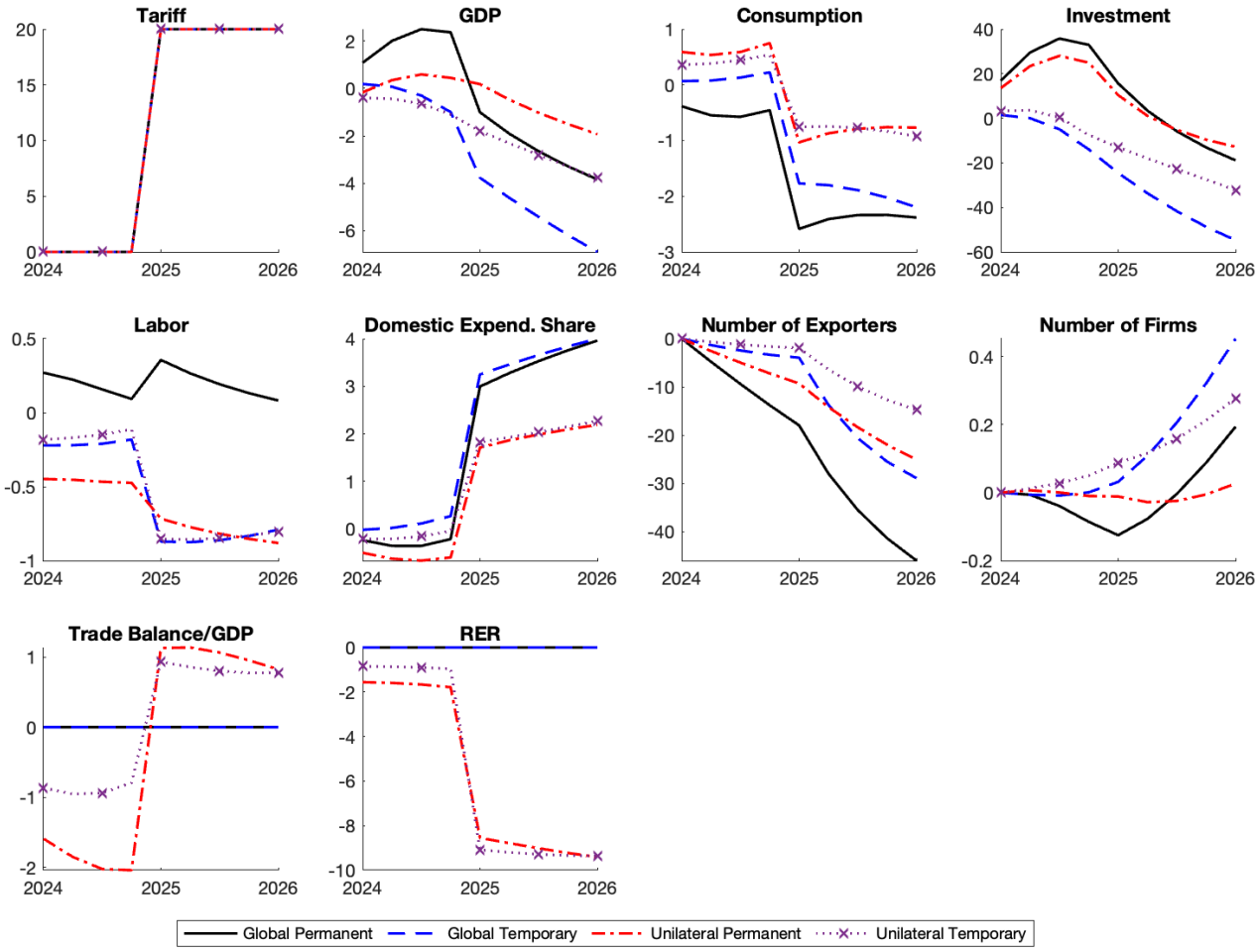


Figure 6: Anticipation Window (ROW)

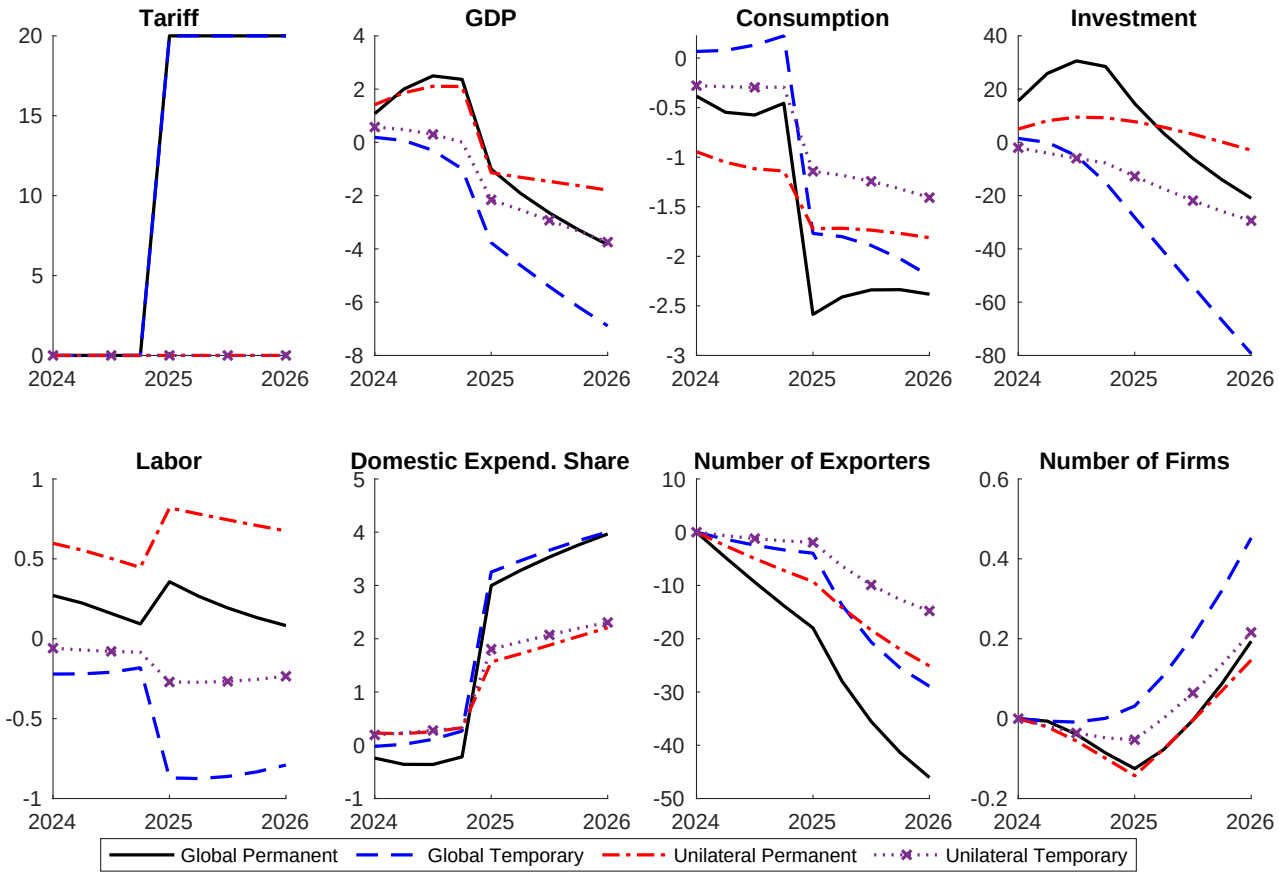


Figure 7: 20% Global Permanent Tariffs with Different Revenue Uses

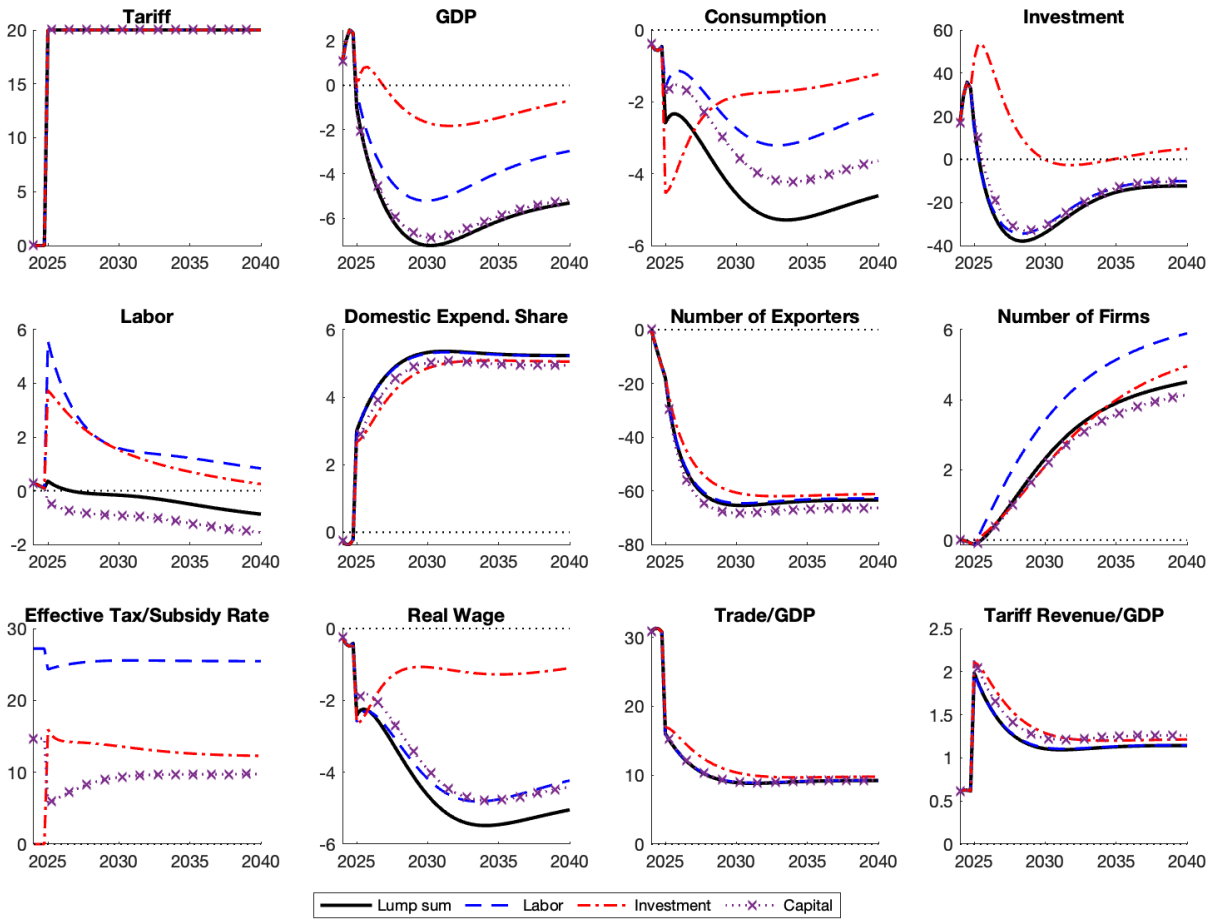


Figure 8: 20% Unilateral Permanent Tariffs with Different Revenue Uses (US)

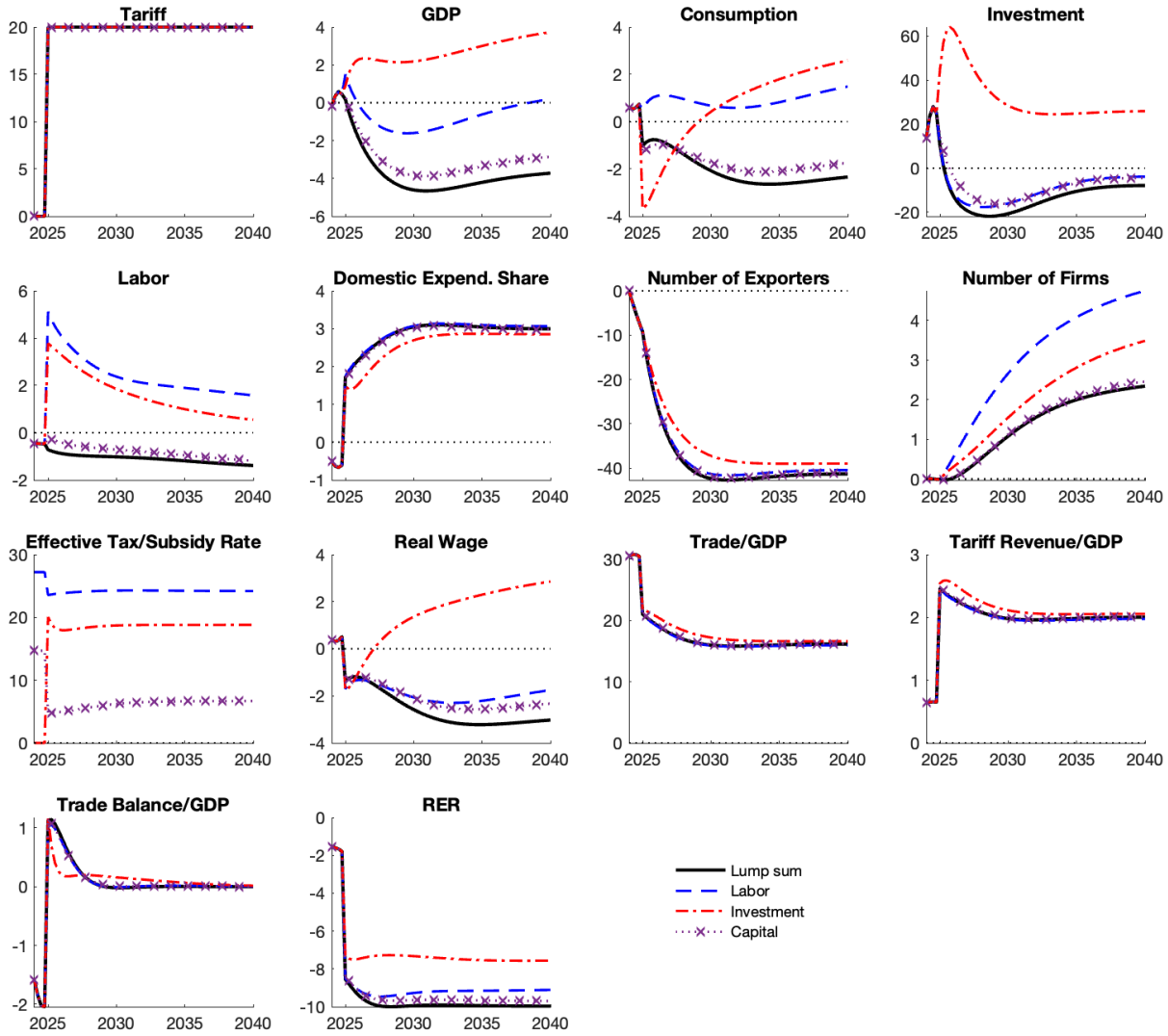


Figure 9: 20% Unilateral Permanent Tariffs with Different Revenue Uses (ROW)

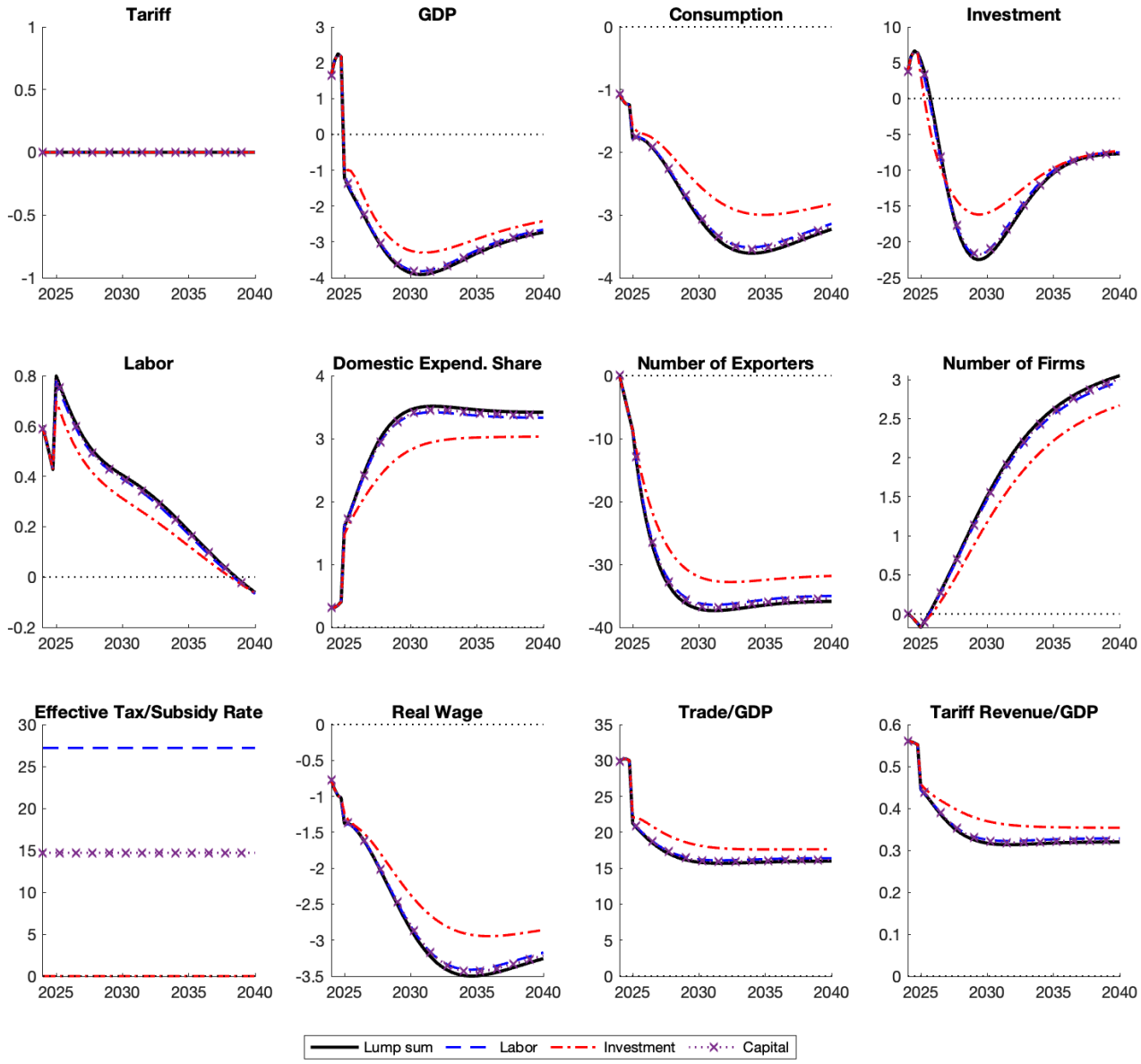


Figure 10: 20% Global Temporary Tariffs with Different Revenue Uses

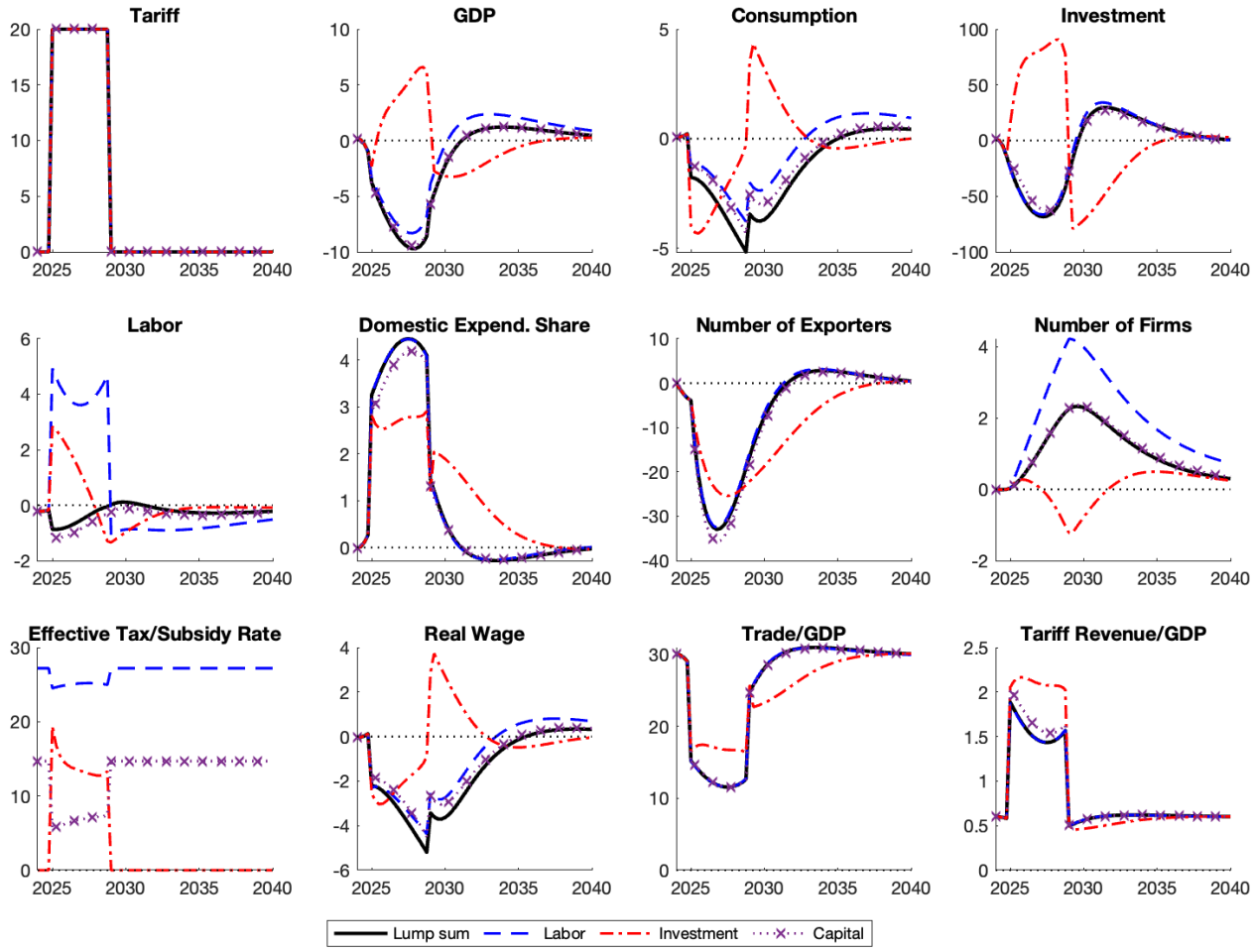


Figure 11: 20% Unilateral Temporary Tariffs with Different Revenue Uses (US)

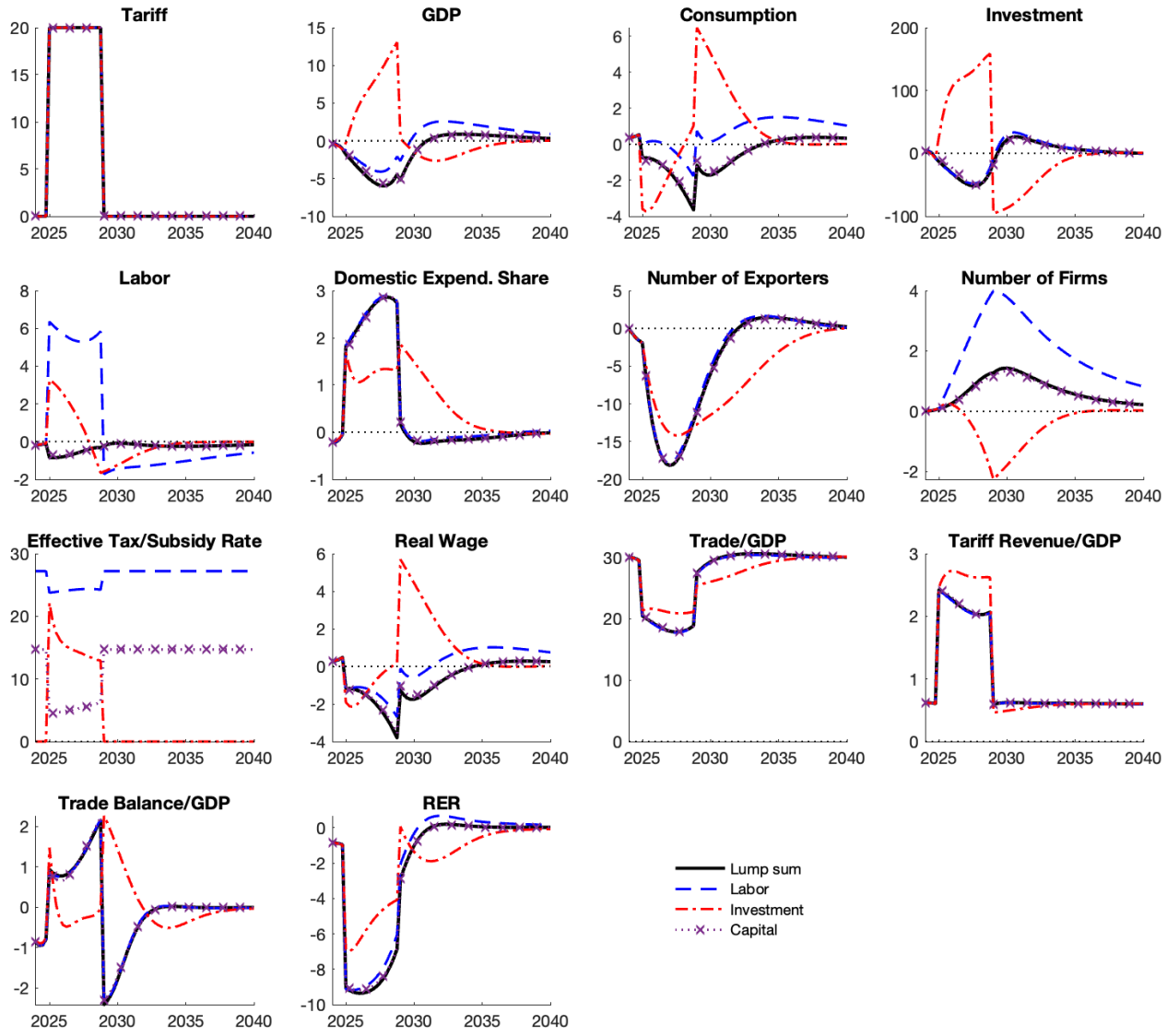


Figure 12: 20% Unilateral Temporary Tariffs with Different Revenue Uses (ROW)

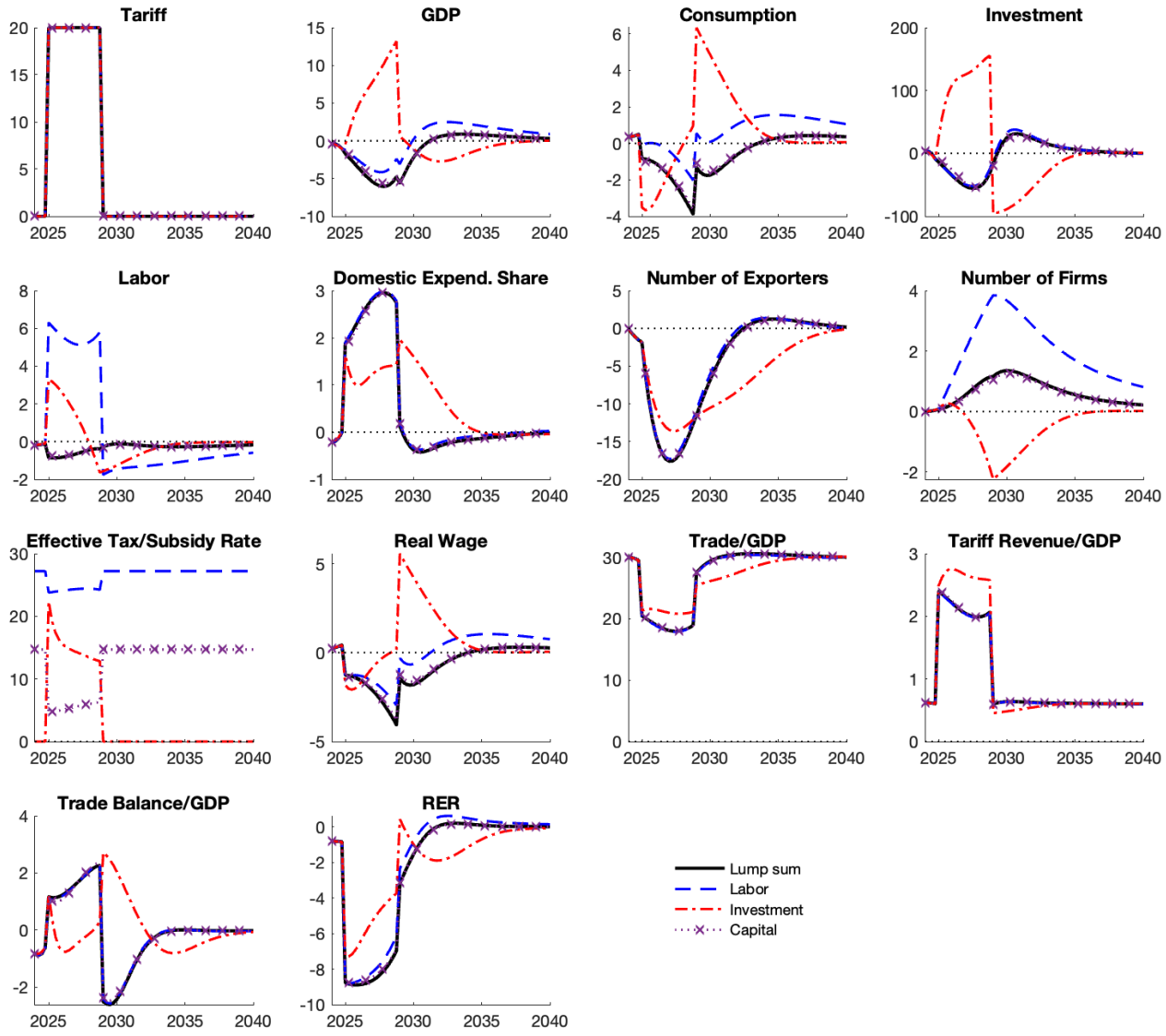
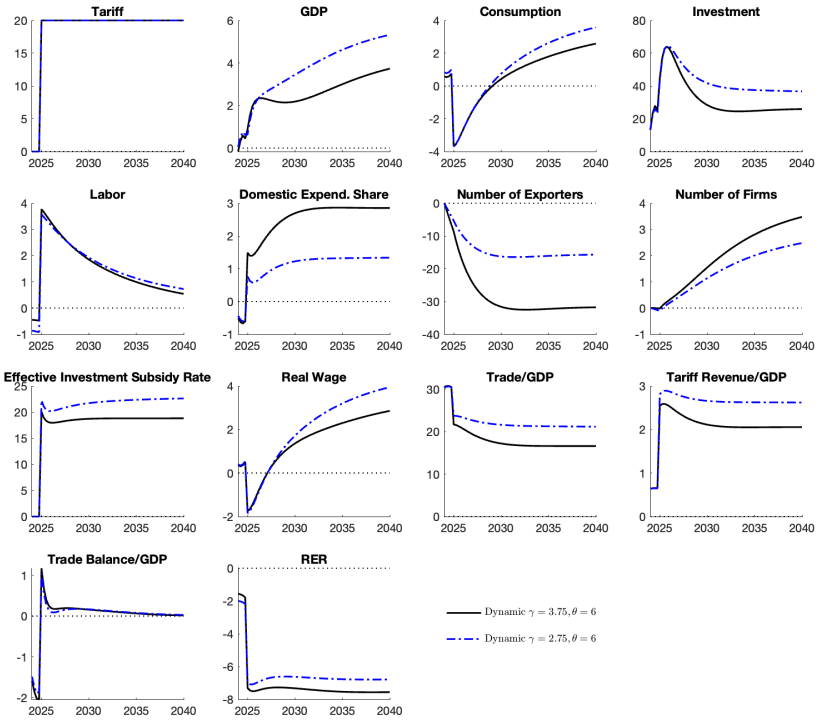


Figure 13: Sensitivity: Armington Elasticity
(Unilateral Permanent Tariff used to Subsidize Investment)

(a) US




(b) ROW

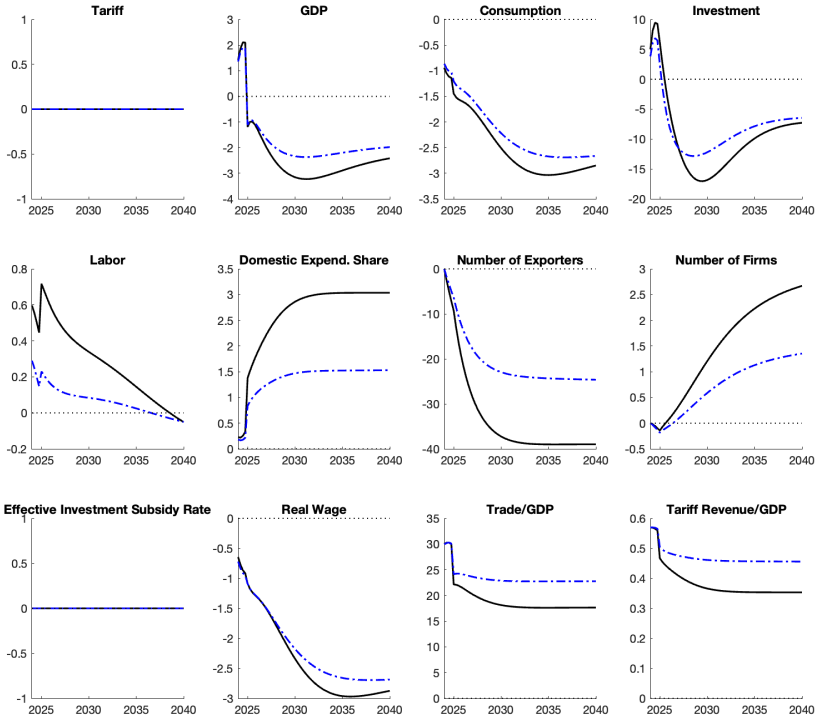
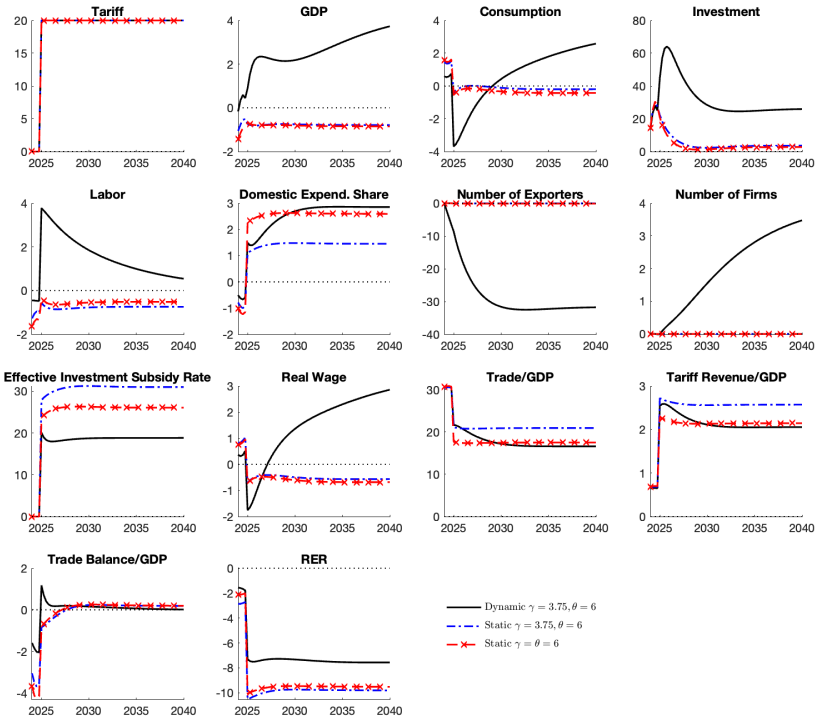


Figure 14: Sensitivity: Static vs Dynamic Trade
(Unilateral Perm. Tariff used to Subsidize Investment)

(a) US




(b) ROW

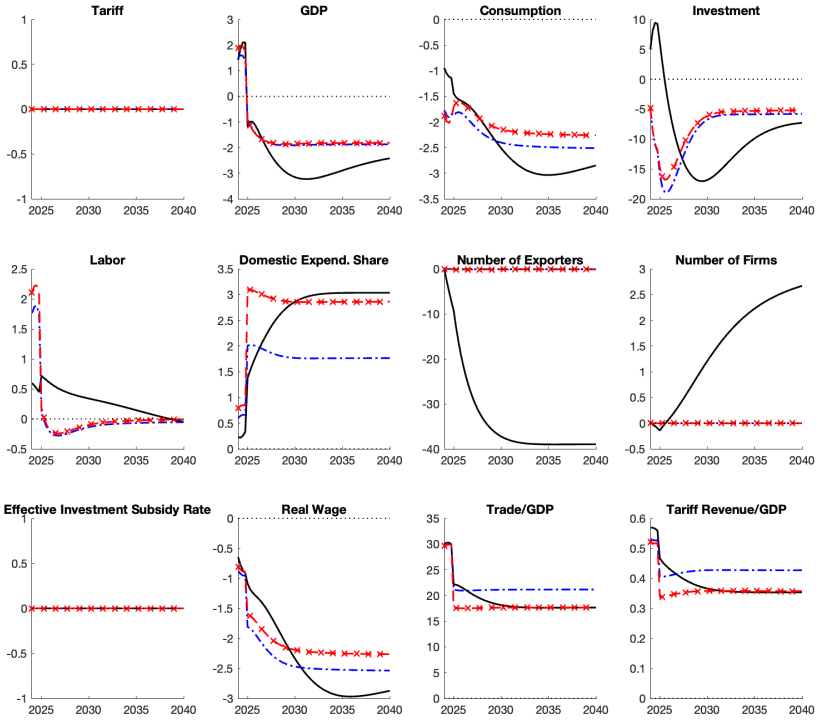


Figure 15: 20% Unilateral Permanent Tariff with initial Trade Deficit
(Investment Subsidy)

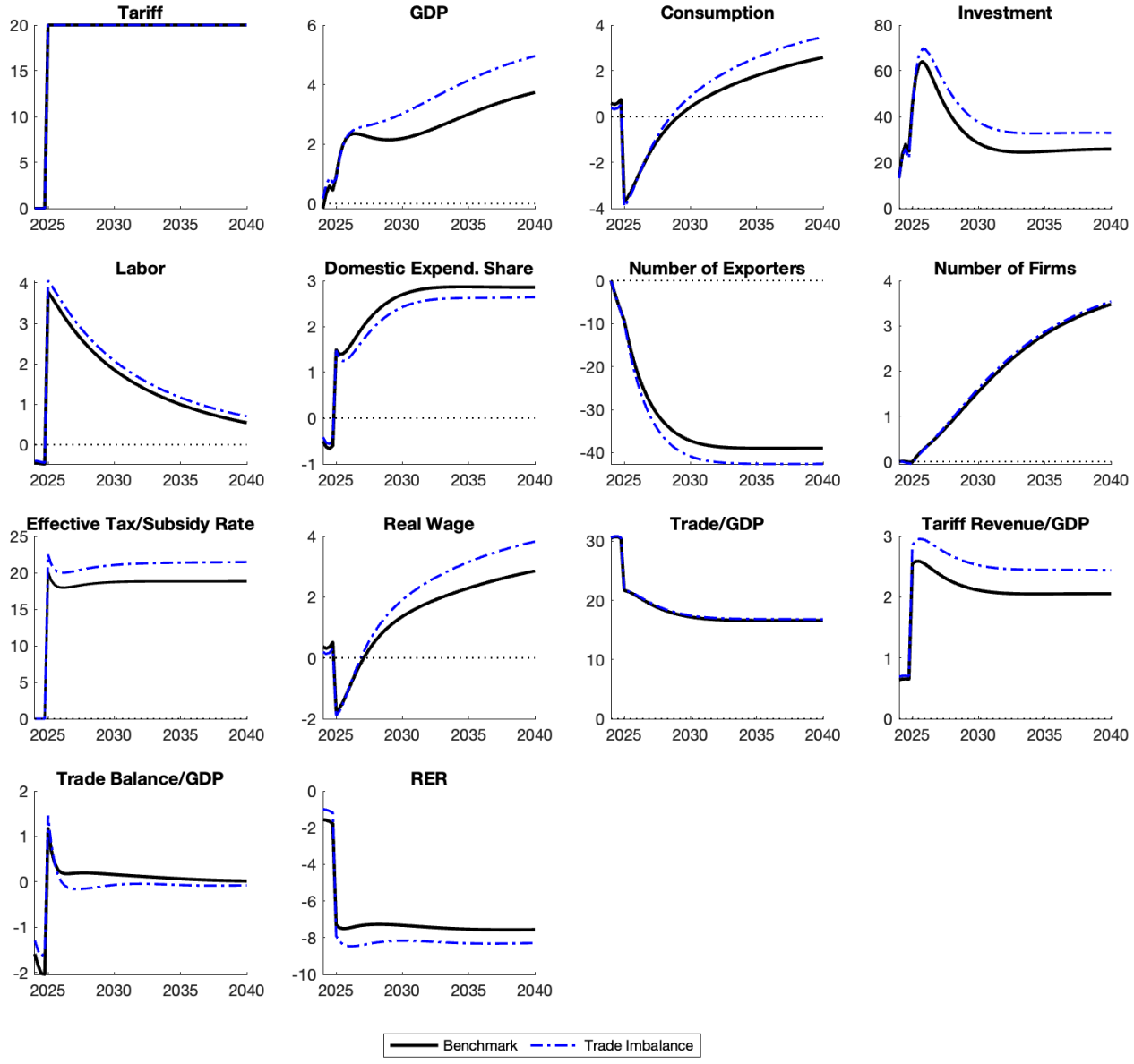
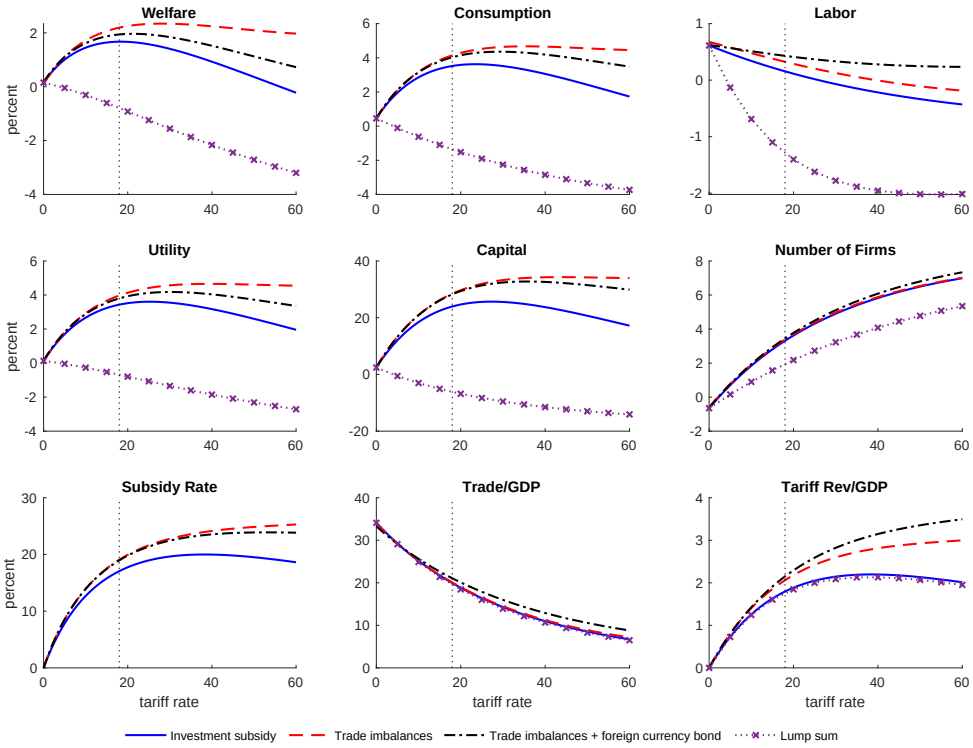


Figure 16: Optimal Tariffs

(a) Unilateral Permanent Tariff




(b) Global Permanent Tariff

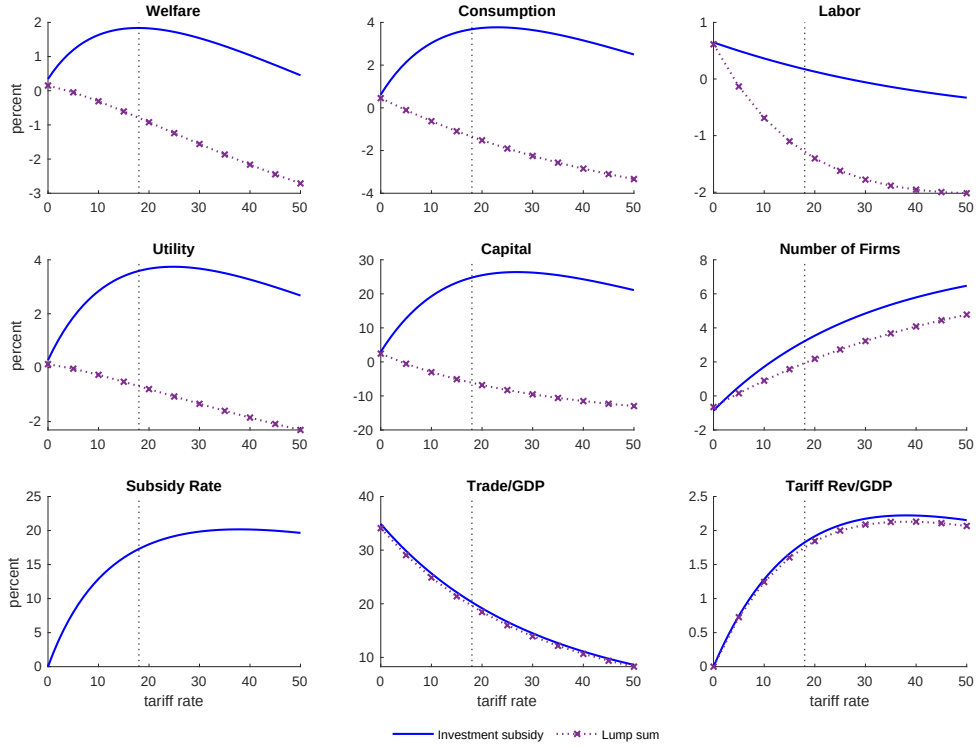


Figure 17: Tariff Laffer Curves

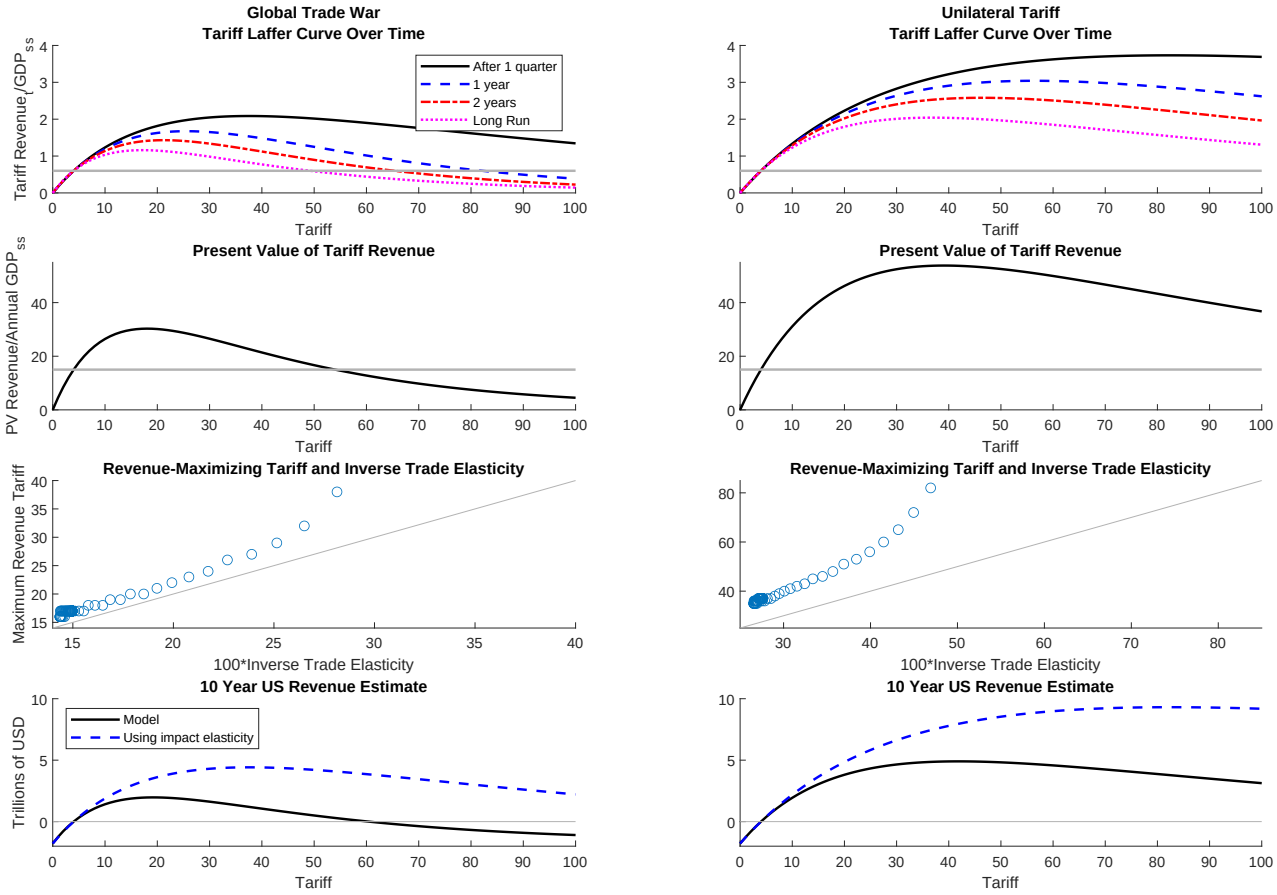


Table 1: Trade Elasticity (Aggregate)

| | $\Delta \ln M/D$ 1959Q1-2024Q4 | $\Delta \ln M/D$ 1959Q1-2024Q4 | $\Delta \ln M/D$ 1959-2024 | $\Delta \ln M/D$ 1929-2024 |
|---|---|---|---|---|
| Tariff-short-run | -2.41*** | -2.84*** | -4.04** | -3.54*** |
| | (0.61) | (0.63) | (1.56) | (1.03) |
| Rel-price-short-run | 1.06*** | 1.02*** | 1.05*** | 0.51*** |
| | (0.15) | (0.15) | (0.24) | (0.19) |
| Adjustment-speed | | -0.04*** | -0.09* | -0.03* |
| | | (0.01) | (0.05) | (0.02) |
| Tariff-Long-run | | -27.73*** | -26.70*** | -27.23*** |
| | | (3.74) | (5.70) | (8.25) |
| Observations | 263 | 263 | 65 | 95 |
| Adjusted $R^2$ | 0.20 | 0.22 | 0.33 | 0.26 |

*Notes:* Standard errors are reported in parentheses.*$p < 0.05$, **$p < 0.01$, ***$p < 0.001$.

Table 2: Quarterly calibration

| Param | Description | Value | Target |
|---|---|---|---|
| *Panel A: Externally Calibrated Parameters* | | | |
| $\beta$ | discount factor | 0.99 | |
| $\delta$ | capital depreciation rate | 0.025 | |
| $\sigma$ | CRRA parameter | 1 | |
| $\gamma$ | Armington elasticity | 3.75 | Quarterly trade elasticity = 3.75 |
| $\theta$ | Elasticity of substitution between varieties | 6 | Markup = 20% |
| $n_s$ | Firm survival rate | 0.995 | Surviving labor share |
| $\alpha_m$ | Share of materials in intermediate production | 0.6 | Gross output/value added in X & M |
| $\alpha_C$ | Share of materials in $C$ production | 0.99 | Gross output/value added in C |
| $\bar{L}_i$ | Labor endowment | 1 | Normalization |
| *Panel B: Internally Calibrate Parameters* | | | |
| $\mu$ | Relative preference C vs. L | 0.49 | Average Frisch elasticity=2 |
| $f_e$ | Entry cost | 10.26 | Average $N_i = \bar{L}_i$ |
| $\alpha$ | Capital share of value added | 0.19 | Average WL/VA = 66% |
| $f_0$ | Fixed cost scale (nonexporters) | 23.23 | Fraction exporters = 0.2 |
| $f_1$ | Fixed cost scale (exporters) | 0.030 | Incumbent export share = 0.95 |
| $\nu$ | Fixed cost shape parameter | 0.65 | Churning & export volume relationship |
| $\xi_{LH}$ | Ratio $\xi_{GL}/\xi_{GH}$ | 0.58 | Export share: firms $\leq$5 years tenure |
| $\xi_{CH}$ | Consumption-good iceberg cost | 3.54 | End-use trade flows |
| $\xi_{XH}$ | Investment-good iceberg cost | 1.10 | End-use trade flows |
| $\xi_{MH}$ | Material-good iceberg cost | 2.38 | End-use trade flows |
| $\rho$ | Persistency of efficiency state | 0.92 | Target jointly w/ other parameters |
| $\tau_k$ | Marginal Capital Tax | 0.147 | OMB (01/25) |
| $\tau_l$ | Marginal Labor Tax | 0.272 | OMB (01/25) |

Table 3: Welfare Changes

| Policy | Country | Lump sum | Labor | Investment | Capital |
|---|---|---|---|---|---|
| *Panel a: Permanent Tariffs* | | | | | |
| Global | US/ROW | -3.53 | -2.41 | -1.50 | -2.31 |
| Unilateral | US | -1.20 | 0.63 | 1.49 | -0.86 |
| Unilateral | ROW | -2.78 | -2.72 | -2.42 | -2.74 |
| *Panel b: Temporary Tariffs* | | | | | |
| Global | US/ROW | -0.64 | -0.35 | -0.17 | -0.38 |
| Unilateral | US | -0.20 | 0.17 | 0.25 | -0.18 |
| Unilateral | ROW | -0.48 | -0.47 | -0.41 | -0.48 |

Notes: Welfare based on compensating consumption equivalent that leaves an agent indifferent between initial steady state consumption forever and the transition path of consumption and leisure following the change in policy.

Table 4: Steady State Changes

| Variable | Lump sum | Labor | Investment | Capital |
|---|---|---|---|---|
| *Panel a: Global Tariffs* | | | | |
| K | -13.82 | -11.27 | 6.03 | -11.53 |
| L | -1.32 | 0.26 | -0.36 | -1.97 |
| C | -3.83 | -1.28 | -0.25 | -2.94 |
| Dom. Exp. Share | 5.26 | 5.26 | 5.06 | 4.97 |
| Number of Firms | 5.13 | 6.70 | 5.89 | 4.72 |
| $P_I$ | 9.41 | 9.41 | 9.23 | 8.85 |
| $P_I$K | -4.31 | -1.84 | 16.48 | -2.64 |
| Value of All Firms | -0.12 | 2.46 | 4.84 | 0.03 |
| *Panel b: Unilateral US Tariffs – Effects on the US* | | | | |
| K | -8.59 | -4.42 | 22.80 | -4.96 |
| L | -1.63 | 1.08 | 0.02 | -1.46 |
| C | -1.91 | 2.38 | 3.55 | -1.27 |
| Dom. Exp. Share | 3.01 | 3.10 | 2.89 | 3.00 |
| Number of Firms | 2.67 | 5.46 | 4.20 | 2.83 |
| $P_I$ | 5.17 | 5.32 | 5.44 | 5.20 |
| $P_I$K | -2.82 | 1.47 | 33.34 | 0.80 |
| Value of All Firms | -0.57 | 3.88 | 7.52 | 0.31 |
| *Panel c: Unilateral US Tariffs – Effects on the RoW* | | | | |
| K | -8.41 | -8.21 | -7.45 | -8.31 |
| L | -0.36 | -0.35 | -0.32 | -0.36 |
| C | -2.69 | -2.63 | -2.40 | -2.66 |
| Dom. Exp. Share | 3.44 | 3.36 | 3.06 | 3.40 |
| Number of Firms | 3.47 | 3.39 | 3.09 | 3.43 |
| $P_I$ | -4.00 | -3.20 | -2.20 | -3.80 |
| $P_I$K | -10.77 | -9.87 | -8.28 | -10.50 |
| Value of All Firms | -9.40 | -8.54 | -7.13 | -9.15 |

Notes: Steady state changes in key variables by trade policy, country, and fiscal adjustment.

Table 5: Welfare-maximizing Tariff

| | Unilateral | | Global | |
|---|---|---|---|---|
| Offset: | Investment | Lump sum | Investment | Lump sum |
| Baseline | 0.18 | -0.06 | 0.02 | -0.23 |
| No taxes ($\tau_k = \tau_L = 0$) | 0.17 | 0 | 0.01 | -0.17 |
| + Exogenous labor | 0.17 | 0.09 | 0.01 | -0.09 |
| + Common trade cost ($\xi_c = \xi_x = \xi_m$) | 0.18 | 0.13 | 0.03 | -0.05 |
| + No Roundabout | 0.20 | 0.18 | 0.03 | -0.01 |
| Trade imbalance | 0.28 | -0.04 | | |
| + Foreign currency bonds | 0.21 | -0.07 | | |

Notes: Welfare based on compensating consumption equivalent that leaves an agent indifferent between initial steady state consumption forever and the transition path of consumption and leisure following the change in policy. Unilateral assumes the other country does not respond. Global is the welfare-maximizing cooperative tariff. We do not consider the global tariffs with imbalances.

# 8 Appendix

This appendix reports four things. First, we compare alternative measures of tariffs. Second, we consider the recent dynamics of US trade and the trade balance. Third, we explore the dynamic impact of future tariffs in a general equilibrium model with inventory frictions. Finally, we summarize our data sources.

## 8.1 Tariff measures

Here we describe the relationship between a time varying trade-weighted measure of tariffs and a constant weight measure. We use product level tariff data by source from 1974 to 2024. We construct weights based on 2011-2015 country-product import shares. In Figure 18 we compare that to a measure of duties to imports for all US imports and separately for Canada and China. The top panel shows the constant weight tariff measure falls from about 10 percent to 1.5 percent before the rise in tariffs in 2018 while the trade-weighted falls from 4 percent to 1.5 percent. Thus the tariff measure used in our analysis may only capture 30 percent of the tariff changes.

Most of the gap between the two measures is in the 1970s and early 1980s. Panel b shows that for Canada the constant weight measure shows twice the change as the conventional measure. Panel (c), which plots the evolution of tariffs on China, shows that this gap is particularly large as the constant weight measured is roughly two to three times the trade weighted measure in the 1970s.

## 8.2 Recent trade and trade balance dynamics

Our theory allows agents to act in advance of a change in trade policy. Here we document two dimensions of these anticipatory effects. In Figure 19 we plot the monthly dynamics of US trade, measured as the average of imports of goods and exports of goods, divided by total business sales, and the the goods trade balance, again scaled by total business sales. We focus on a narrow window from January of 2023 through March of 2025. Two things stand out. First, trade was roughly stable prior to the 2024 election but has since increased by about ten percent. Likewise, the trade balance has widened considerably starting in December of 2024 and as of March 2024, is about 60 percent larger than a year earlier.

The data on exports, imports, and total sales are through February 2025. We use the advance economic indicators as measures of March 2025 exports and imports. For March 2025 total business sales we use the February measure.

## 8.3 Inventory Dynamics

Our focus has been on studying the interactions between trade policy in a model of exporter dynamics. Another margin that may influence the transition are inventory management considerations. Specifically, in advance of a possible tariff change firms have incentives to stockpile inputs whose costs may go up. To explore how this may influence the transition to tariffs we feed through the tariff process for the global permanent

tariffs into a variation of the inventory model in Alessandria et al. (2023, 2025b). The results for the lump sum redistribution case along with a static exporting (Armington) and our dynamic exporting models are plotted in Figure 20. The long-run effects in the inventory model are quite similar to the Armington model.

Giving agents in 2024Q1 news of a possible tariff increase in 2025Q1 leads firms to use inventories to shift the timing of their purchase of imports and domestic goods. The effects can be quite large in the short-run. Agents try to shift their purchases of imports to just in advance of the tariff increase. This leads to an increase in production (labor) and cut in consumption in advance of the tariffs. When the tariffs hit there is a sharp shift to purchase domestic inputs and the increased cost of inputs lowers production. As these inventory considerations can have large short-run effects on the economy some caution on recovering expectations from activity prior to the tariffs is in order.

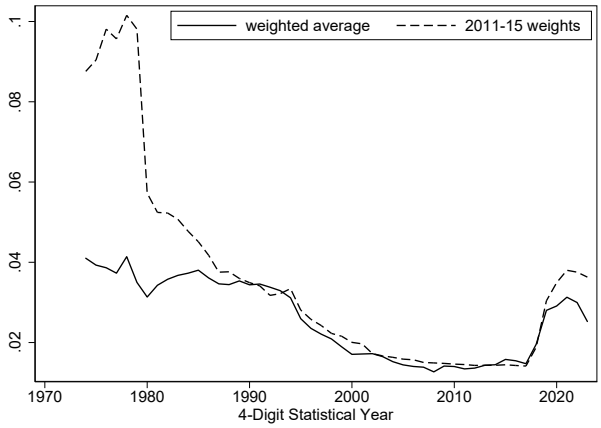
## 8.4 Data Sources

Most of the analysis is based on the following series that is freely accessible through FRED.

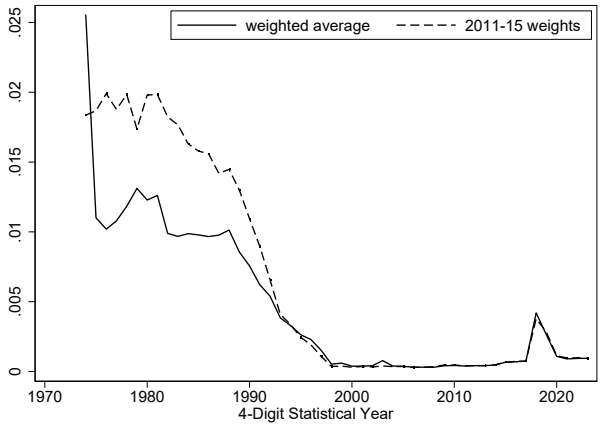
- Real and Nominal GDP (GDPA, GDPCA, GDPQ, BEA)
- Exports of Goods and Services (EXPGSA,EXPGSCA, BEA)
- Imports of Goods and Services (IMPGSA, IMPGSCA, BEA)
- Gross domestic product: Goods: Final sales (A325RC1A027NBEA, BEA)
- Federal government current tax receipts: Customs duties (B235RC1A027NBEA, BEA)
- Federal govt current tax receipts (W006RC1A027NBEA, BEA)
- Total Business Sales (TOTBUSSMSA, Census)
- Exports of Goods, Balance of Payments Basis (BOPGEXP, Census)
- Imports of Goods: Balance of Payments Basis (BOPGIMP, Census)
- Advance U.S. International Trade in Goods: Exports (AITGEXS, Census)
- Advance U.S. International Trade in Goods: Imports (AITGIXS, Census)

Figure 18: Constant and Trade-weighted duties

(a) All Imports




(b) From Canada




(c) From China

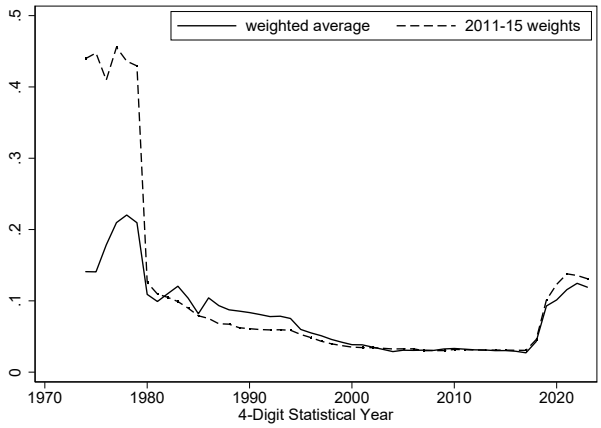


Figure 19: US Trade and Trade Balance: Anticipatory Dynamics

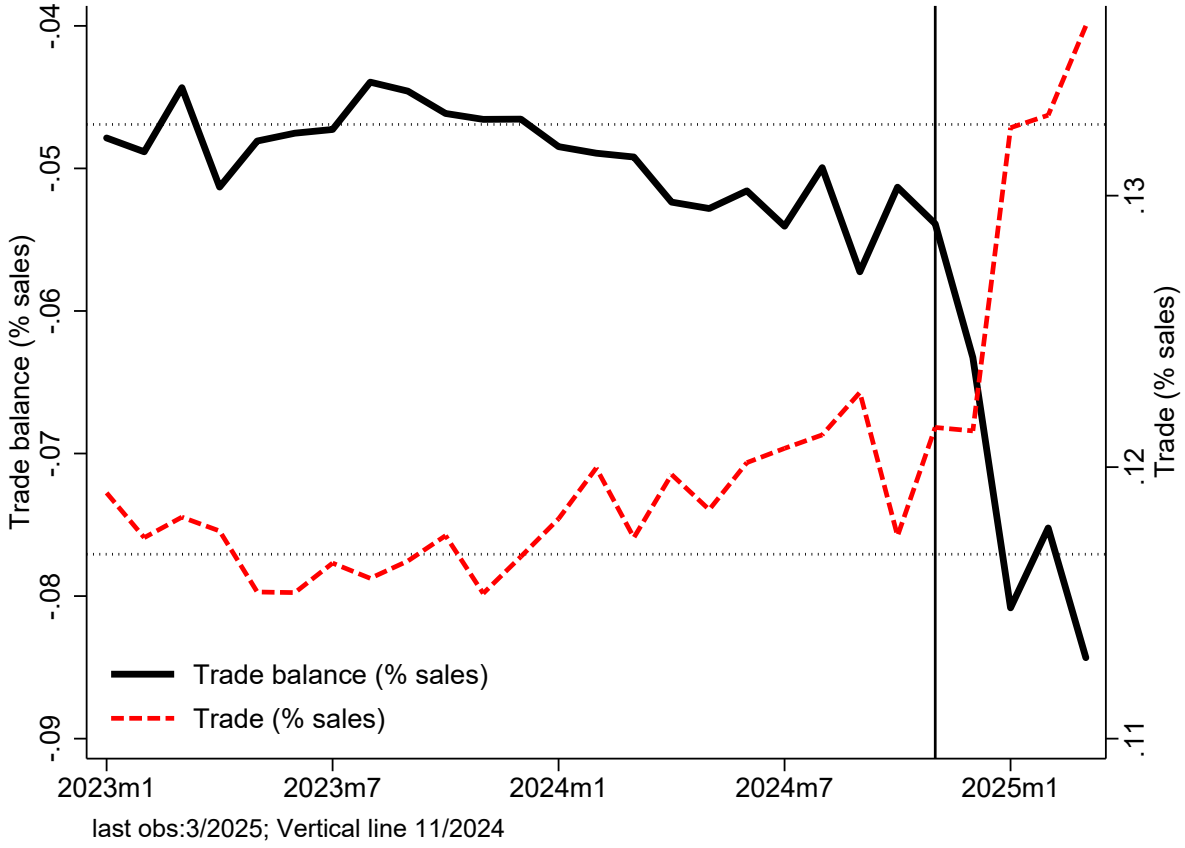
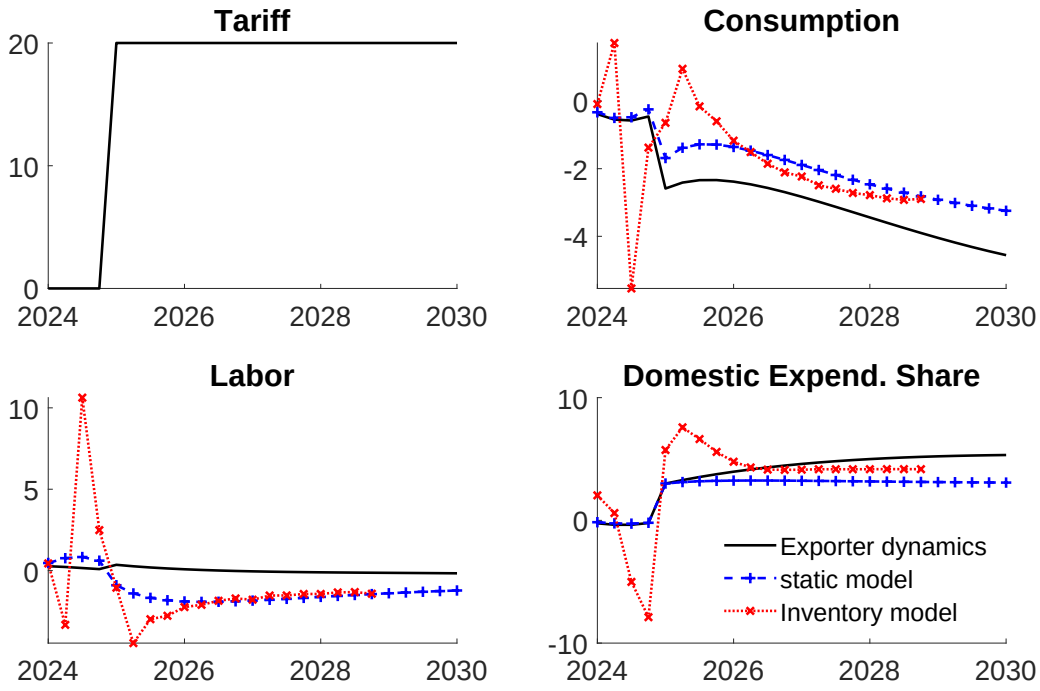


Figure 20: Comparison with Inventory Model



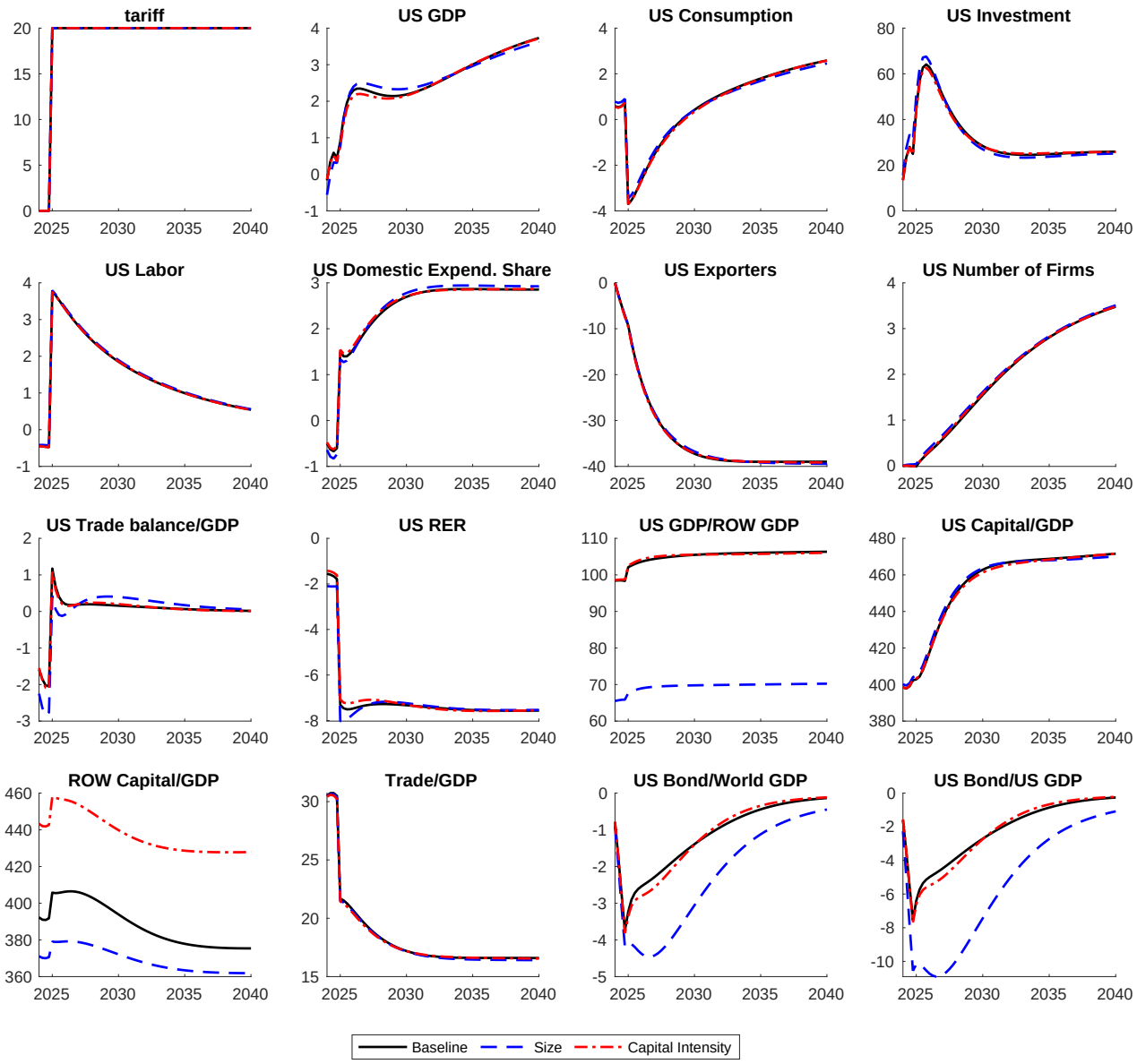



Figure 21: Effects with Country size and capital intensity differences: unilateral permanent tariff and investment subsidy