The World Bank Economic Review, 36(2), 2022, 361–381
https://doi.org10.1093/wber/lhab016
Article

The Macroeconomy After Tariffs

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Abstract

What does the macroeconomy look like in the aftermath of tariff changes? This study estimates impulse response functions from local projections using a panel of annual data that spans 151 countries from 1963 to 2014. Tariff increases are associated with persistent, economically and statistically significant declines in domestic output and productivity, as well as higher unemployment and inequality, real exchange rate appreciation, and insignificant changes to the trade balance. Output and productivity impacts are magnified when tariffs rise during expansions and when they are imposed by more advanced or smaller (as opposed to developing or larger) economies; effects are asymmetric, being larger when tariffs go up than when they fall. While firmly establishing causality is always a challenge, the results are robust to a large number of perturbations to the baseline methodology, and they hold using both macroeconomic and industry-level data.

JEL classification: F13, O11

Keywords: tariffs, output, productivity, unemployment, inequality, exchange rate, trade balance

1. Introduction

Perhaps more than on any other issue, there is agreement among economists that international trade should be free.[1] This foundational principle goes back at least to Adam Smith, and rests on the notion that—in the absence of distortions, externalities or other market failures—free and competitive markets do best in allocating resources to their most productive uses. In reality of course, the world is full of market imperfections, but tariffs seem poorly suited to addressing them in the many circumstances in which they

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1 For example, see the survey on free trade in Initiative on Global Markets (University of Chicago Booth School of Business), http://www.igmchicago.org/surveys/free-trade.

are actually applied. Indeed, oftentimes tariffs make matters worse by encouraging the deflection of trade to inefficient producers, or to smuggling and evasion: deadweight losses seem likely as broad losses by consumers exceed narrow gains by a few producers. The redistributions associated with tariffs create vested interests, and so harm persists. Broad-based protectionism can also provoke retaliation, which adds further to global costs. All these losses are exacerbated if inputs are protected, since this means output is produced less efficiently.

Because market imperfections are microeconomic at their core, a lot of the literature on trade barriers focuses on individual industries (Grossman and Rogoff (1995), for example). While average barriers have fallen over the decades, there are exceptions at the individual industry level: for example, in agriculture or apparel. The Great Depression illustrated the futility and destructiveness of using tariffs for macroeconomic purposes, and the consensus is that macro objectives are more easily attainable through macro tools such as monetary and fiscal policy. So, while protectionism *has* not been much used in practice as a macroeconomic policy in the postwar period (especially in advanced countries), most economists also agree that it *should* not be so used.

Times change. Newspapers are full of recent examples when tariffs have been used to achieve macroeconomic gains. For instance, tariffs are claimed to raise GDP and/or employment by improving the trade balance. So the present seems an opportune moment to see what the historical record has actually been in terms of the macroeconomic effects of tariff changes. Taking a fresh look at the macroeconomic evidence is also important because previous studies are dated.

The strategy of this study is to use a straightforward and established methodology that is fit for the purpose at hand. Jordà's (2005) local projection method is used to estimate impulse response functions, which makes it possible to account flexibly for non-linearities without imposing potentially inappropriate dynamic restrictions. This study also tries to account for potential endogeneity by allowing changes in tariffs to react to changes in economic activity within the same year—that is, by controlling for contemporaneous changes in economic activity—and via an instrumental variable approach in the spirit of Acemoglu et al. (2019) and Furceri and Loungani (2018), where changes in tariffs in major large trading partners are the instrument for national tariff rate changes. The panel of annual data used in this study is long if unbalanced, covering 1963 through 2014; more recent data are of greater relevance, but older data contain more protectionism. A broad span of 151 countries is used here, including 34 advanced and 117 developing countries.

The focus is on the key macroeconomic variables: output; productivity; unemployment; inequality; the real exchange rate; and the trade balance. The chief data set is aggregate in nature, but sectoral data are also used, both to control for macroeconomic shocks that may drive tariff changes and to identify some of the channels through which tariffs affect economic activity—the study differentiates between "input" and "output" tariffs. It also explores whether the results depend upon the stage of the business cycle, whether there are asymmetric effects of tariff rises and falls, and whether tariff consequences are similar for countries of different sizes or at different stages of development.

Tariffs are studied, rather than other types of protectionism, for three reasons. First, tariffs are the preferred protectionist policy of rich governments, past and present, and the recent episode was being driven by tariff changes in the world's largest economy. Second, tariffs are easier to measure in the aggregate than non-tariff barriers, and are available for a broader span of time and countries.[2] Third, to the degree that other forms of protection have greater costs than tariffs (for which there is abundant evidence), this study's results on tariffs might be considered as a lower bound on the macro effects of protection.

2 If changes in tariffs are correlated with changes in nontariff barriers (NTBs), there may be a concern with omitted variable bias. To test this, the study runs panel regressions on the relationship between three different measures of NTBs (antidumping cases initiated, safeguards, and WTO disputes) and changes in tariffs, controlling for country- and time-fixed effects (as in our estimation framework described in eq. 1). The study does not find evidence of any strong correlation, mitigating this concern in the setup. However, the results should be taken with a pinch of salt since NTBs are difficult to measure and data are scarce for this exercise.

So what does the macroeconomy look like in the aftermath of tariffs? This study finds that tariff increases are followed by declines of output and productivity in the medium term, as well as increases in unemployment and inequality. The study does not find much effect on the trade balance, consistent with the evidence in the data (and the literature) that tariff increases are followed by real exchange rate appreciations which might undo any direct impact of protection on the trade balance. The longer-term consequences of tariffs are likely higher than the effects that the study estimates since it truncates the analysis at a five-year horizon.

To check the robustness of its results, the study (i) controls for contemporaneous changes in economic activity, the trade balance and real exchange rates to address the concern that other shocks to trade might be driving the results; (ii) employs a VAR model where tariffs are ordered after the macroeconomic variable of interest so that changes in tariffs may react to changes in the relevant variable within the same year—in such a setup, tariff changes will be orthogonal to both past and contemporaneous changes in the macroeconomic variable of interest; (iii) controls for expected future growth to address the concern that governments may enact trade liberalization because of worries about declining future growth (the so-called problem of perfect foresight—Ramey, 2011); and (iv) applies an instrumental variable approach, using as instrument the changes in tariffs in major trading partners. The baseline results survive this battery of robustness checks.

The panel data set makes it possible to probe some additional questions about the effects of tariff changes. It is found that the medium-term decline in output following a tariff increase is larger if the tariff increase is undertaken during an economic expansion and that the output gains from trade liberalization are smaller during recessions (consistent with intersectoral resource shifts being costly when the macroeconomy is weak). There is, moreover, an asymmetry that runs through the data, whereby tariff increases lead to larger output changes (in absolute value) than tariff decreases. The output costs from tariff increases seem to be larger for advanced and small countries than for non-advanced and large countries, possibly reflecting optimal tariff considerations.

This paper relates to several strands of the literature on the impact of trade policies. Earlier studies have shown that there is no theoretical presumption about the effects of tariffs on output or the trade balance, with the impact depending on a host of factors including the timing and expected duration of the tariff change, the behavior of real wages and exchange rates, the values of various elasticities, and institutional factors like the exchange rate regime and degree of capital mobility (Ostry and Rose 1992). More recent work has drilled further into the reasons for possibly ambiguous effects on the macroeconomy including through: the impact of trade openness on currency movements and the trade balance (Santos-Paulino and Thirlwall 2004; UNCTAD 1999; Ju, Wu, and Zeng 2010; Li 2004), and productivity/output (Feyrer 2009; Alcala and Ciccone 2004; Estevadeordal and Taylor 2013); the impact of trade policies versus technology on inequality (Helpman 2016) or wage inequality (Artuç and McLaren 2015; Klein, Moser, and Urban 2010). More recently, the impact of temporary trade barriers on macroeconomic fluctuations has also been studied (Barattieri, Cacciatore, and Ghironi 2021).

Compared to this literature, the present paper is more ambitious in terms of data (across countries and time) and outcome variables explored, and the payoff is a fuller picture of the macroeconomic and distributional effect of tariffs. While recent simulation models shed light on the channels through which trade policies influence the macroeconomy, the gains (losses) from trade (protectionism) generated by these models are often implausibly small.[3] Hence, this paper considers a reduced-form approach that uses a wide span of data to be an essential contribution to the literature and the current policy debate; the correlations uncovered by this empirical exercise seem robust to the battery of checks undertaken, and

3 Kehoe (2003) compares the predictions of three ex-ante CGE studies of NAFTA with observed outcomes and concludes that trade increases in most sectors surpassed the predictions more than ten-fold. Corcos et al. (2012) find similar results for the EU.

as such will hopefully be considered useful from a policy perspective as well. The rest of the paper is organized as follows. Section 2 describes the empirical strategy and data. Section 3 discusses the results. Section 4 concludes.

2. Empirical Methodology

This paper's strategy is to allow the data to speak as clearly as possible using a reduced-form approach without imposing unreasonable constraints. Two levels of granularity are used. The first is more important; it is applied to country-level data and serves to quantify the macroeconomic effects of tariffs. As a robustness check, sector-level data are brought to bear, which provides insight into the channels through which the effects of tariffs are transmitted, while also addressing some of the inherent limitations of the macroeconomic analysis (by controlling for country shocks that may be correlated with tariff changes).

2.1. Country-Level Analysis

The local projection method (LPM, Jordà 2005) is used to estimate impulse-response functions. LPM allows to retrieve the dynamics of the dependent variable after a shock, and has been widely used in empirical macro, for example: Auerbach and Gorodnichenko (2013); Jordà and Taylor (2016); Ramey and Zubairy (2018); Alesina et al. (2019); Furceri, Lougani, and Ostry (2019). LPM seems relatively attractive in the present context because it does not impose the dynamic restrictions embedded in models like vector autoregressions or autoregressive-distributed lag specifications. The framework is flexible enough to accommodate a panel structure. It is particularly suited to estimating nonlinearities in the dynamic responses and state-dependencies that may be impractical in a multivariate context (Ramey and Zubairy 2018; IMF 2019). The estimates generated by LPM are more robust to misspecification of the data-generating process since each impulse response is estimated separately for each horizon (Ramey 2016; Biljanovska, Grigoli, and Hengge 2017). For the study's purposes, this approach provides a simple and flexible way of estimating the dynamic effects on a panel with a large number of observations. The state-dependent properties make possible to understand the asymmetric effects of tariffs across various dimensions. The baseline regression is specified as follows:

$$y_{i,t+k} - y_{i,t-1} = \alpha_i + \gamma_t + \beta \Delta T_{i,t} + \nu X_{i,t} + \varepsilon_{i,t} \tag{1}$$

where:

- $y_{i,t+k}$ is the outcome variable of interest (log of output, productivity, unemployment rate, Gini coefficient, log real exchange rate, or trade balance/GDP) for country i at time $t + k$;
- $\{\alpha_i\}$ are country fixed effects to control for unobserved cross-country heterogeneity;
- $\{\gamma_t\}$ are time fixed effects to control for global shocks;
- ΔT_{it} is the change in the tariff rate;
- ν is a vector of nuisance coefficients;
- $X_{i,t}$ is a vector of control variables, including two lags of: a) changes in the dependent variable, b) the tariff, c) log output, d) log of real exchange rates, and e) the trade balance in percent of GDP; and
- ε is an unexplained (hopefully well-behaved) residual.

The country fixed effects make it possible to control for all time-invariant country characteristics, while the time fixed effects control for all global or common shocks and factors. For each dependent variable, $k + 1$ regressions are run separately as specified in eq. (1). In other words, there is one regression for each time horizon. For present purposes, this represents six regressions showing the impact of tariff changes for the year of the tariff shock and five years afterwards. The coefficients of greatest interest are $\{\beta\}$, the impulse responses of the variables of interest to changes in the tariff rate.[4] The impulse responses

4 Since the set of control variables includes lags of output growth as well as the real exchange rate and trade balance, this approach is equivalent to a VAR approach in which tariff shocks do not respond to shocks in other variables within a year. This assumption is relaxed later as a robustness check.

are constructed by plotting the coefficient $\{\beta\}$ for the set of six regressions. The confidence bands are based on the respective standard errors estimated. Equation (1) is estimated at the annual frequency for an unbalanced sample of 151 countries from 1964 to 2014. Table S1.1 in the Supplementary Online Appendix, available at *The World Bank Economic Review* website, provides the list of countries used in the country-level analysis.

2.1.1. Data Sources

The macroeconomic series for annual GDP (in constant prices), labor productivity (defined as the ratio of GDP to employment), the unemployment rate, real effective exchange rates (period average, deflated by CPI), and the trade balance (period average, deflated by GDP) are taken from IMF WEO and World Bank WDI databases. Data on the Gini coefficient, a measure of inequality, come from the Standardized World Income Inequality Database (SWIID). Table S1.2 provides a summary of the data sources. The tariff series, T, is based on trade tariff rate data at the product level and aggregated to country level, with weights given by the import share of each product, measured as a fraction of value. The main source is the reform dataset compiled by the IMF (Ostry, Prati, and Spilimbergo 2009; Prati, Onorato, and Papageorgiou 2013; Giuliano, Mishra, and Spilimbergo 2013) which cover an unbalanced sample of 151 countries from 1964 to 2004. This study extends the data to 2014 using tariff data from the World Integrated Trade Solution (WITS) and World Development Indicators (WDI). In the supplementary online appendix, appendix S2 provides a description of the tariff data (including data sources) and presents key descriptive statistics for tariffs and tariff changes. Figures S2.1 and S2.2 show time series plots of tariffs for a number of individual countries as well as aggregated grouped by income.

2.2. Industry-Level Analysis

The empirical specification for industries is analogous to the macro specification:

$$y_{j,i,t+k} - y_{j,i,t-1} = \alpha_{ij} + \gamma_{it} + \rho_{jt} + \beta^{I} \Delta T_{j,i,t}{}^{I} + \beta^{O} \Delta T_{j,i,t}{}^{O} + \nu X_{j,i,t} + \varepsilon_{j,i,t} \tag{1'}$$

where $y_{j,i,t+k}$ is the log of sectoral output (or productivity) for industry j in country i at time $t+k$; γ_{it} are country-year effects to control for any variation that is common to all sectors of the country's economy, including, for instance, aggregate output growth or reforms in other areas; α_{ij} are country-industry fixed effects to control for industry-specific factors, including, for instance, cross-country differences in the growth of certain sectors that could arise from differences in comparative advantages; ρ_{jt} are industry-time fixed effects to control for common factors across countries that affect specific industries; $T_{j,i,t}{}^{O}$ and $T_{j,i,t}{}^{I}$ denote output and input tariffs, respectively; and $X_{j,i,t}$ is a vector of control variables, including two lags of changes in the dependent variables and output- and input-sectoral tariffs.

The output tariff, $T_{j,i,t}{}^{O}$, in each sector j is the 2-digit level corresponding tariff rate. Following closely Amiti and Konings (2007) and Topalova and Khandelwal (2011), input tariffs in each sector j are computed as a weighted average of output tariffs in all sectors, with weights reflecting the shares of imported inputs in each sector j's total input cost:

$$T_{j,i,t}{}^{I} = \sum_{k} \theta_{j,i,t} T_{k,i,t}{}^{O}$$

The underlying tariff data are obtained from World Integrated Trade Solution (WITS), while the information on the production structure is taken from OECD's input-output tables.

The input and output tariff rates are matched with sectoral-level data (output, value added, employment and productivity) from the United Nations Industrial Development Organization (UNIDO) database. This database provides information for 22 manufacturing industries based on the INDSTAT2 2016, ISIC Revision 3.[5] To match the sectoral information in the OECD input-output table, some of the

5 While the original INDSTAT 2 database includes 23 manufacturing industries, the study excludes the "manufacture of recycling" industry due to insufficient observations.

Table 1. Dependent Variable: Tariff Changes (ppt)

Variables	(1) Control for output growth	(2) No control for output growth
Unemployment rate, percent	−0.01	−0.03
	(0.05)	(0.05)
Inequality, percent	0.07	0.07
	(0.06)	(0.06)
Government budget, percent GDP	−0.03	−0.03
	(0.02)	(0.02)
M2 growth, percent	−0.00***	−0.00***
	(0.00)	(0.00)
Political regime (−10 autocracy; 10 democracy)	0.07	0.07
	(0.08)	(0.08)
Executive constraints (1 unlimited authority;	0.19	0.19
7 parity/subordination)	(0.34)	(0.34)
War (0 no war; 7 war)	0.14	0.13
	(0.16)	(0.16)
Crisis (1 crisis; 0 no crisis)	0.27**	0.25**
	(0.10)	(0.11)
Output growth		1.37
		(1.60)
Real GDP growth of top-five trading partners, percent	0.22	0.23
(trade weighted)	(0.19)	(0.19)

Source: Authors' estimations.
Note: Driscoll-Kraay standard errors in parentheses; $***p < 0.01$, $**p < 0.05$, $*p < 0.1$. Each cell represents the coefficient when tariff changes are regressed on the change of that variable, controlling for time and country fixed effects. Column 1 also controls for output growth.

sectors in the UNIDO database are combined. The resulting dataset comprise an unbalanced panel with 16 sectors for 39 countries over the period 1991–2014. Tables S1.3 and S1.4 in the supplementary online appendix provide the list of countries and sectors.

3. Results

3.1. Aggregate Results

A concern in the background is that tariff changes may themselves be a function of macroeconomic variables (reverse causality), which would contribute to biased coefficient estimates. A first pass at the relevance of such concerns in the data can be gleaned by regressing tariff changes on key macroeconomic and structural variables (one variable at a time), controlling for time and country fixed effects: table 1 reports the results. It is reassuring that, with the exception of M2 growth and financial crises, the other variables (e.g., the unemployment rate, inequality, fiscal deficit, political regime) are not correlated with tariff changes in the sense that the coefficients are not statistically significant; the issues of M2 growth and crises are addressed directly below by explicitly controlling for these variables in the regression. Moreover, to check whether tariff changes can be determined by external factors like foreign demand, tariff changes are regressed on the real GDP growth of top-five trading partners and again the study finds no statistical significance.

3.1.1. Baseline

The benchmark aggregate results are presented in fig. 1. Each of the six panels presents the estimated dynamic response for a variable of interest (output, productivity, and so forth) to a one-standard-deviation rise in the tariff rate. This is a moderate increase in the tariff rate, of about 3.6 percentage points, which lies

Table 2. The Aggregate and Distributional Effects of Tariffs

	A Output (%)	B Real exchange rate (%)	C Trade balance (ppt)	D Productivity (%)	E Unemployment (ppt)	F Inequality (ppt)
$t = 0$	0.013	0.196**	−0.02657	0.015	−0.02384	0.00308
	(−0.026)	(−0.076)	(0.01759)	(−0.037)	(0.01578)	(0.00460)
$t = 1$	−0.008	0.161	−0.00964	−0.040	0.00707	0.01498
	(−0.035)	(−0.099)	(0.03011)	(−0.048)	(0.01496)	(0.01017)
$t = 2$	−0.063	0.075	−0.00492	−0.107**	0.03176	0.02332*
	(−0.045)	(−0.103)	(0.03135)	(−0.049)	(0.02646)	(0.01344)
$t = 3$	−0.066	0.083	0.01719	−0.150***	0.04171	0.03732**
	(−0.052)	(−0.111)	(0.03704)	(−0.044)	(0.03187)	(0.01756)
$t = 4$	−0.111*	0.092	0.01488	−0.177***	0.02708	0.03380
	(−0.059)	(−0.128)	(0.04820)	(−0.055)	(0.02963)	(0.02017)
$t = 5$	−0.119*	0.180	−0.00042	−0.234***	0.04248	0.04030*
	(−0.063)	(−0.139)	(0.04308)	(−0.068)	(0.03035)	(0.02311)
Average number of observations	3468	3354	3466	2217	1350	2331
Average number of countries	148	147	148	102	86	128

Source: Authors' estimations.

Note: The table reports the response of outcome variables to 1 percentage point increase in tariffs t years after the tariff increase. For example, the data point for column A at t = 5 denotes that, following a 1 percentage point increase in tariffs, output declines by 0.119 percent five years after the tariff increase. Standard errors are reported in parenthesis. ***, **, and * denote significance at 1 percent, 5 percent, and 10 percent, respectively. Estimates based on eq. (1).

well within the standard range of the data.[6] Collectively, the impulse response functions in fig. 1 provide a convenient way to portray the responses of key indicators of the macroeconomy to tariff changes. Time is portrayed on the x axes; solid lines portray the average estimated response, and 90 percent confidence intervals (using Driscoll-Kraay standard errors) are shown as dotted lines.[7]

The results in panel A suggest that a one-standard-deviation (3.6 percentage point) tariff increase leads to a decrease in output of about 0.4 percent five years later. The study considers this effect to be plausibly sized and economically significant; it is also significantly different from zero in a statistical sense. Why does output fall after a tariff increase? Panel B indicates that a key channel is the statistically and economically significant decrease in labor productivity, which cumulates to about 0.9 percent after five years. Both these key findings make sense; the wasteful effects of protectionism eventually lead to a meaningful reduction in the efficiency with which labor is used, and thus output.[8] In addition, the decline in output seems to be driven by both declines in consumption (panel A of fig. 2) and investment (panel B), though the latter effect is not statistically significant. Both real exports and imports also decline, and these effects are statistically significant (panels C and D of fig. 2). Protectionism also leads to a small (statistically marginal) increase in unemployment, as shown in panel C. It is also found that tariff increases lead to more inequality, as measured by the Gini index; the effect becomes statistically significant two years after the tariff change (panel D).[9]

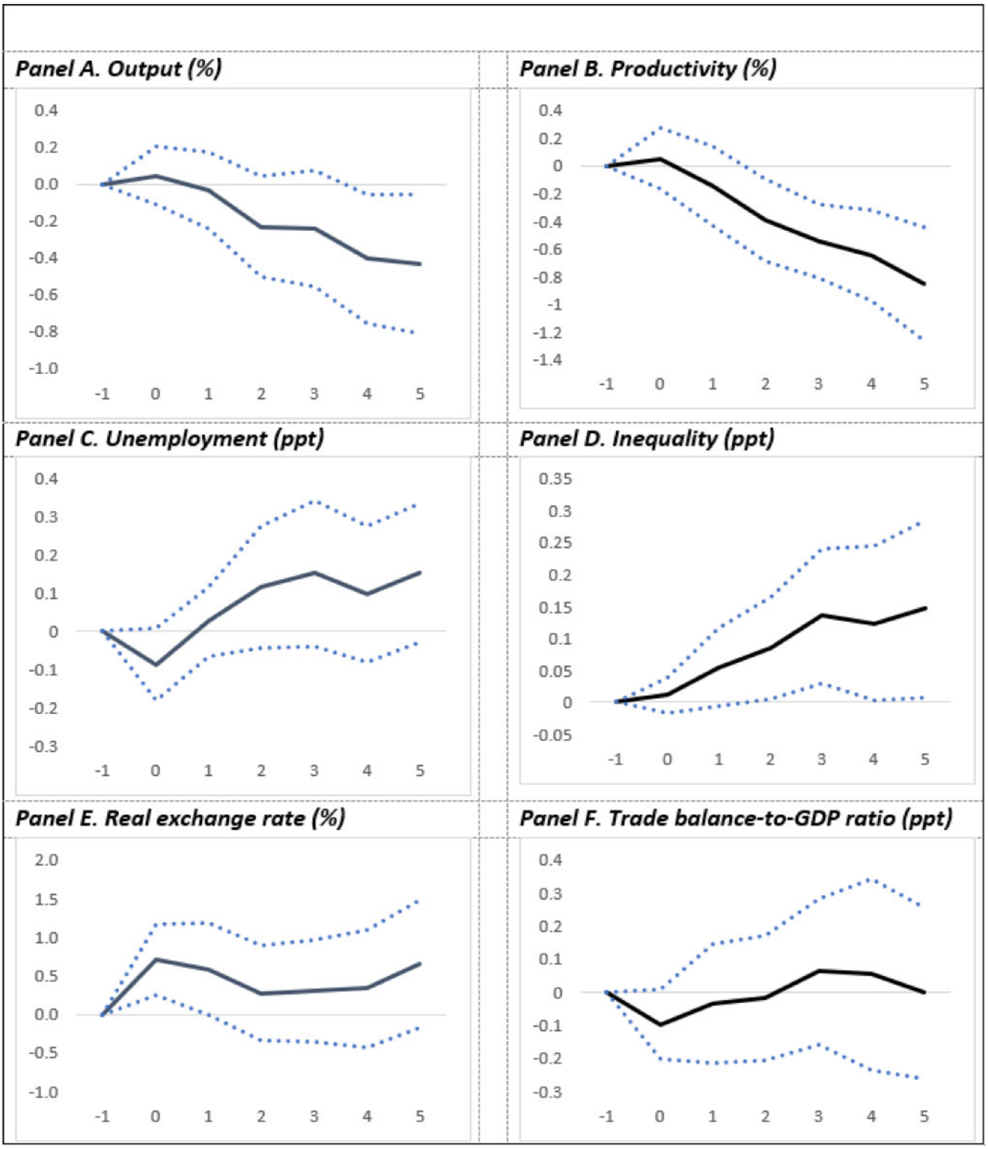
6 The average and standard deviation of the change in the tariff rate in the sample are –0.4 and 3.6 percentage points, respectively. Tariff changes range from –52.0 to 41.0 percentage points.

7 Table 2 tabulates the underlying regression results.

8 Employment increases by about 0.5 percent but the effect is not statistically significant.

9 This result is consistent with evidence in Jaumotte, Lall, and Papageorgiou (2013), who find that trade openness is associated with lower income inequality. While more work is needed to understand the distributional effects of tariffs, the authors believe that the increase in unemployment is a potentially important channel. Another possibility is that rent-seeking means that protectionism benefits the rich more than the poor.

Figure 1. The Effect of Tariffs



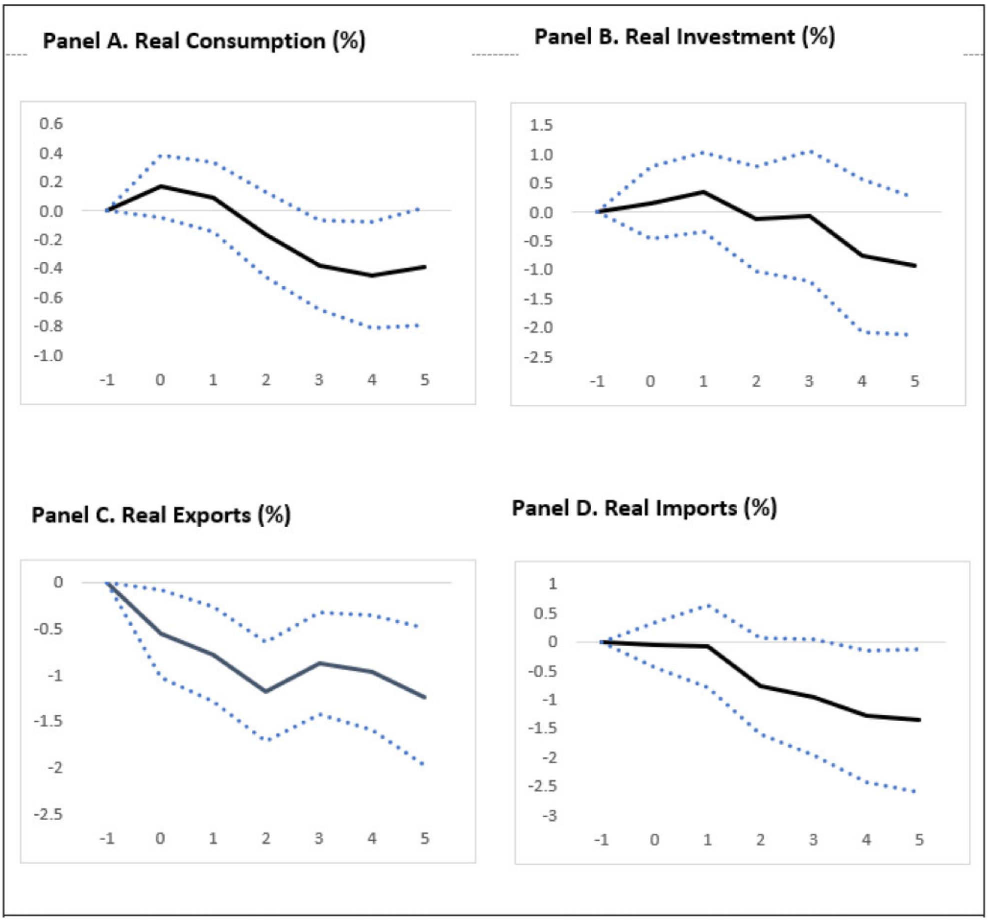
Source: Authors' estimations.

Note: The solid line indicates the response of output (real exchange rate, trade balance, labor productivity, unemployment, inequality) to a one-standard-deviation increase in tariff; the dotted lines correspond to 90 percent confidence bands. The x axis denotes time; $t = 0$ is the year of the change. The estimates are based on eq. (1).

Higher tariffs lead to an appreciation of the real exchange rate as shown in panel E, though the effect is only statistically significantly different from zero in the short term (this is unsurprising, given the noisiness of exchange rates). Panel F shows that the net effects of higher tariffs on the trade balance are small and insignificant; absent shifts in saving or investment, commercial policy has little effect on the trade balance.[10] The appreciation of the currency owing to tariffs leads to a deterioration of the trade balance

10 All the results are robust when the real trade balance is deflated by trend real output (instead of real output).

Figure 2. The Effect of Tariffs



Source: Authors' estimations.

Note: The solid lines indicate the response of consumption (investment, exports, and imports) to a one-standard-deviation increase in tariff. The dotted lines in both panels correspond to 90 percent confidence bands. The x axis denotes time. $t = 0$ is the year of the change. The estimates are based on eq. (1).

(panel A of fig. S6.1 in the supplementary online appendix), due to both a decline in exports (which is statistically significant in the short run) and an increase in imports (statistically significant in the outer years).

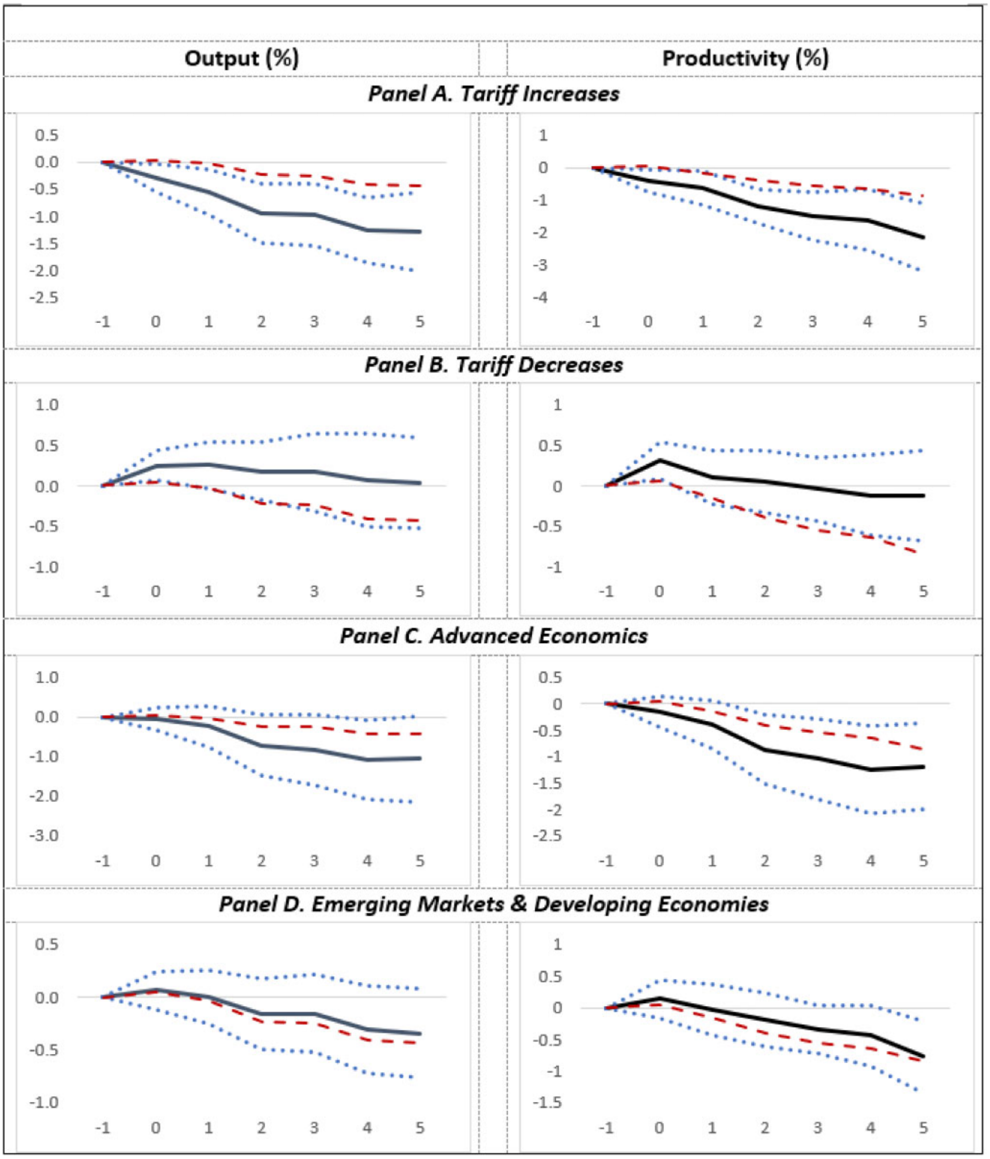
3.1.2. Tariff Increases vs. Decreases

The baseline specification assumes that tariff increases and decreases have symmetric effects. Is this assumption warranted? This is a simple matter to examine, since around 40 percent of the sample consists of tariff rises (with mean of 1.7 ppt and standard deviation of 3.3), while 53 percent of observations consist of tariff falls (with mean of −1.8 ppt and standard deviation of 3.4).[11] This variation makes it possible to test for asymmetry; this study extends the baseline specification to allow the response to vary with the sign of the tariff change:

$$y_{i,t+k} - y_{i,t-1} = \alpha_i + \gamma_t + \beta^P D^P{}_{i,t} \Delta T_{i,t} + \beta^N \left(1 - D^P{}_{i,t}\right) \Delta T_{i,t} + \nu X_{i,t} + \varepsilon_{i,t} \tag{2}$$

11 See S3 in the supplementary online appendix for some examples of major tariff increases in the sample.

Figure 3. The Effect of Tariffs: Tariff Increases vs. Decreases; Advanced Economies vs. Emerging Markets and Developing Economies



Source: Authors' estimations.

Note: The solid line indicates the response of output (productivity) to a one-standard-deviation increase and decrease in tariff (advanced economies and emerging markets and developing economies); the dotted lines correspond to 90 percent confidence bands; estimates for panel A and B are based on eq. (2); estimates for panel C and D are based on eq. (3). Dashed lines indicate the response of output (productivity) to a one-standard-deviation increase in tariff in the baseline; estimates based on eq. (1). The x axis denotes time; $t = 0$ is the year of the tariff change.

where $D^{P}_{i,t}$ is a binary variable that is equal to unity when the change in tariff is positive, and zero otherwise.

The results appear in the top half of fig. 3. The left column presents impulse response functions (estimated from (2) but otherwise similar to those of fig. 1), portraying the effects of tariff increases (in the top row) and decreases (immediately below) on output. The right column is similar, but portrays the response of productivity instead of GDP; the study focuses on output and productivity since they are two of the most important variables that are plausibly affected by protectionism. To facilitate comparison, the dynamic responses under the assumption of symmetry (estimated with (1), and thus presented in the top row of fig. 1) are also shown as dashed lines. Manifestly, the decline in output following a one-standard-deviation *increase* in the tariff rate is higher than the baseline; this effect is statistically significant, as shown in panel A of fig. 3 for both output and productivity. In contrast, panel B shows that the effects of a tariff fall on both output and productivity are much smaller. That is, there are asymmetric effects of protectionism; tariff increases hurt the economy more than liberalizations help.

One of the possible channels for the asymmetric effects is due to intertemporal effects on domestic demand (Irwin 2014). The decline in tariffs usually results in a slight, immediate increase in demand because purchasers know that lower prices will prevail in the future. In contrast, tariff increases usually lead to an increase in buying before policy implementation, followed by a collapse afterwards. In other words, the decline in domestic demand following a positive tariff shock is higher than the increase in domestic demand following a negative tariff shock. This line of argument is also supported by this study's results on consumption, as shown in fig. S6.2 (panels A and B): tariff increases lead to a higher decline in consumption than in the baseline. However, this intertemporal effect is not likely to be persistent, evident from the fact that consumption tends to return to precrisis levels towards the outer years. What then explains the persistent effect of positive tariff increases? While more work is needed on this question, this study's analysis points toward the persistent effect on investment (panels C and D of fig. S6.2 in the supplementary online appendix): a positive increase in tariffs leads to a decline in investment even after five years, possibly due to the negative effect on production chain and business confidence effects. In contrast, the effect of negative tariff changes peters out after five years. This is also supported by the industry-level analysis later in the paper, which finds that input tariffs lead to decline in output and productivity.

3.1.3. Advanced Economies vs. Emerging Markets and Developing Economies

The paper now explores whether the effect of tariffs depends on a country's development level, an important issue given that advanced economies use protectionism less than poorer economies.[12] The baseline regression is extended to test for asymmetry depending upon income level:

$$y_{i,t+k} - y_{i,t-1} = \alpha_i + \gamma_t + \beta^{AE} D^{AE}{}_i \Delta T_{i,t} + \beta^{Oth} \left(1 - D^{AE}{}_i\right) \Delta T_{i,t} + \nu X_{i,t} + \varepsilon_{i,t} \tag{3}$$

where $D^{AE}{}_{i,}$ is a binary variable that is equal to unity for advanced economies, and zero otherwise. The list of advanced economies follows the IMF classification and is tabulated in table S1.5 in the supplementary online appendix.

The results appear in the bottom part of fig. 3; the impulse response functions are analogous to those in the top half (which is based on eq. (2)), but for a different split of the data (based on eq. 3). An interesting asymmetry emerges. For advanced economies, the decline in output after tariff increases is larger than in the baseline. Panel C shows that output declines by about 1 percent after four years for advanced economies, compared to the 0.4 percent in the baseline over the same time horizon. Similarly, the effect on productivity is higher than in the baseline for advanced economies, but lower for other economies.

Why might this be the case? There is some evidence that trade liberalization's effects depend on the country's development level (Leibovici and Crews 2018). Factors like financial development, infrastructure quality, and human capital level may prevent poorer countries from increasing production for export following trade liberalization, leading to smaller output gains (Estevadeordal and Taylor 2013). Also, poorer countries rely more on tariffs for government revenue, which could imply that tariff increases give

12 Around 28 percent of the sample observations consist of tariff changes for advanced economies (with a mean of –.3 percentage points and standard deviation of 2.2) and 65 percent of the observations consist of tariff changes for other countries (with mean of –.3 and standard deviation of 4.1). While tariff changes have been less frequent in rich countries, the average magnitude of the changes is similar across the samples. Similarly, the study does not observe significant differences in the ratio of positive-to-negative changes between AEs (65 percent) and non-AEs (75 percent).

more latitude for stabilizing fiscal policies in poorer countries. Finally, richer countries may be more open and thus more exposed to tariff shocks than poorer countries.

3.1.4. Recessions vs. Expansions

Do the effects of tariff changes vary with the business cycle? Trade reforms, insofar as they induce resource shifts between industries, occupations, and firms, might lead to larger output losses during periods of weak economic activity. To test whether the effect of tariff changes is symmetric across expansions and recessions, a setup is used that permits the effect of tariff changes to vary smoothly across stages of the business cycle:

$$y_{i,t+k} - y_{i,t-1} = \alpha_i + \gamma_t + \beta^L{}_k F(z_{i,t})_i \Delta T_{i,t} + \beta^H{}_k \left(1 - F\left(z_{i,t}\right)\right) \Delta T_{i,t} + \varphi Z_{i,t} + \varepsilon_{i,t} \quad (4)$$

with

$$F\left(z_{i,t}\right) = \exp(-\theta z_{i,t})/(1 + \exp(-\theta z_{i,t}), \ \theta > 0,$$

where $z_{i,\,t}$ is an indicator of the state of the economy (such as GDP growth or unemployment) normalized to have zero mean and unit variance, and Z_{it} is the same set of control variables used in the baseline specification but now also including $F(z_{it})$. $F(.)$ is a smooth transition function used recently by Auerbach and Gorodnichenko (2012) to estimate the macroeconomic impact of fiscal policy shocks. This transition function can be interpreted as the probability of the economy being in a recession; $F(z_{it}) = 1$ corresponds to a very deep recession (z tends to minus infinity), while $F(z_{it}) = 0$ corresponds to a very strong expansion (z tends to plus infinity)—with the cutoff between expansions and contractions being 0.5. Like Auerbach and Gorodnichencko (2012), the study uses $\theta = 1.5$, which corresponds to the economy spending about 20 percent of time in recessions.[13]

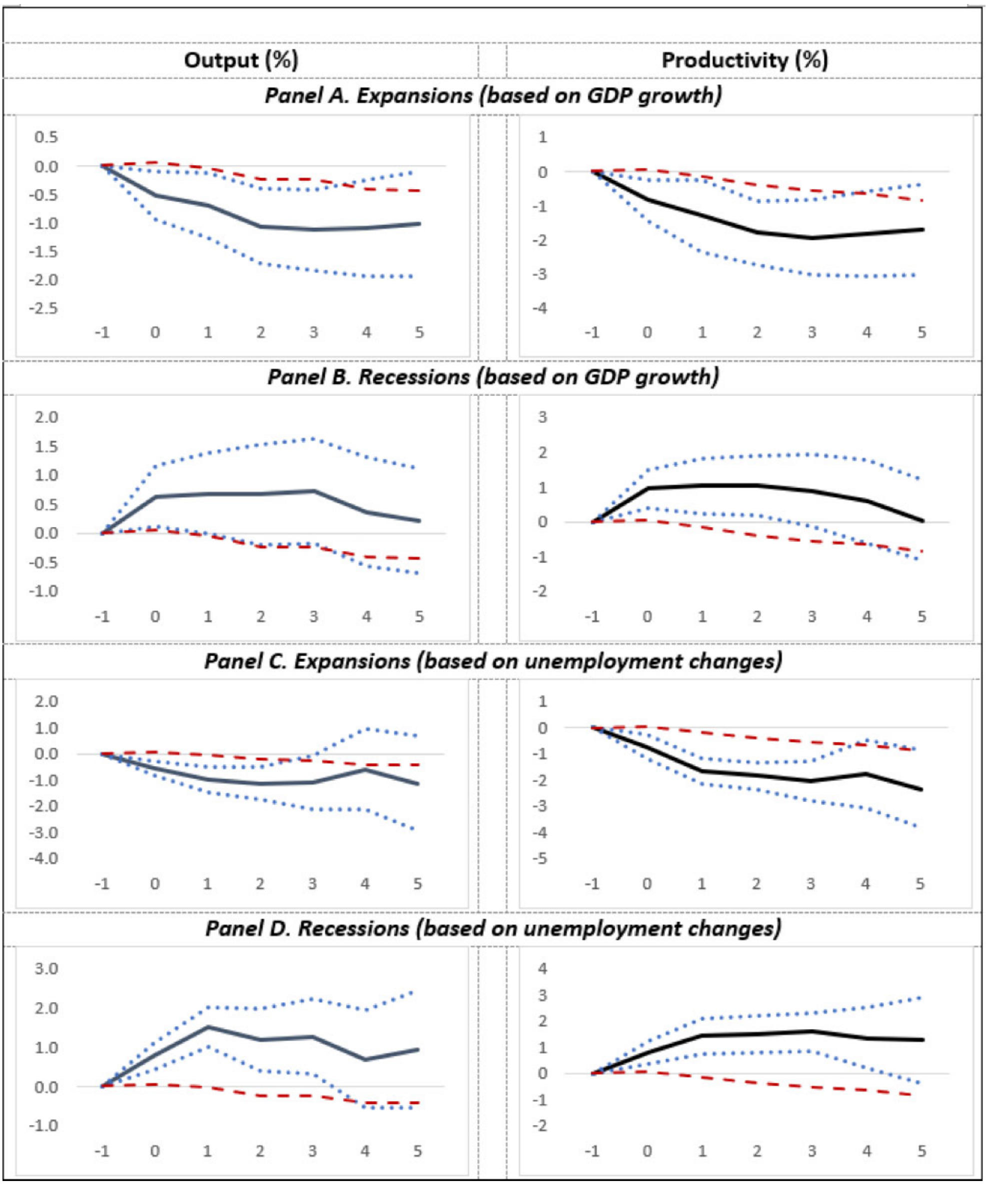
Estimation results for eq. (4) for output (left column) and productivity (right) are presented in fig. 4. Two different measures of business cycle conditions are used; the panels at the top use GDP growth, while those below use the unemployment rate. For each indicator, impulse responses for expansions are presented above those for recessions. Since the results from the two different indicators are similar, the study concentrates on the top four panels, which use GDP growth as the business cycle measure.

The results in fig. 4 suggest that the responses of both output and productivity are more dramatic during expansions. When tariffs increase by a standard deviation and the economy is enjoying good times, the medium-term output loss is higher than the baseline by about 1 percent; the productivity decline is also larger. Consistently, tariff increases during recessions seem to *increase* output and productivity in the medium-term, though the effects are not statistically significant; protection during recessions may have a mild stimulating effect.[14] A possible explanation for these findings relates to the role of monetary policies. To the extent that increases in tariffs lead to an increase in inflation during expansions and that monetary policies are tightened in response, the negative impact of tariffs would be magnified. This study's results on inflation seem to support this reasoning: using the standard regression-framework, the study finds that higher tariffs lead to an increase in inflation after two years, as shown in panel B of fig. S6.1 in the supplementary online appendix. Furthermore, the effect on inflation is stronger during economic expansions, as shown in panels A and B of fig. S6.3 in the supplementary online appendix. These results are consistent with Barattieri, Cacciatore, and Ghironi (2021) who find that protectionism acts as a supply

13 This approach is equivalent to the smooth transition autoregressive model developed by Granger and Terasvirta (1993). The results are robust to different values of θ, and to substituting $F(z_{it})$ with a dummy variable which takes a value for $F(z_{it})$ greater than 0.5.

14 In line with Rose (2013), the study finds no statistically significant correlation between changes in tariffs and the measure of state of economy used in the paper. In particular, the correlation between changes in tariffs and the smooth transition function $F(z_{it})$ is –0.001.

Figure 4. The Effect of Tariffs: Expansions vs. Recessions



Source: Authors' estimations.

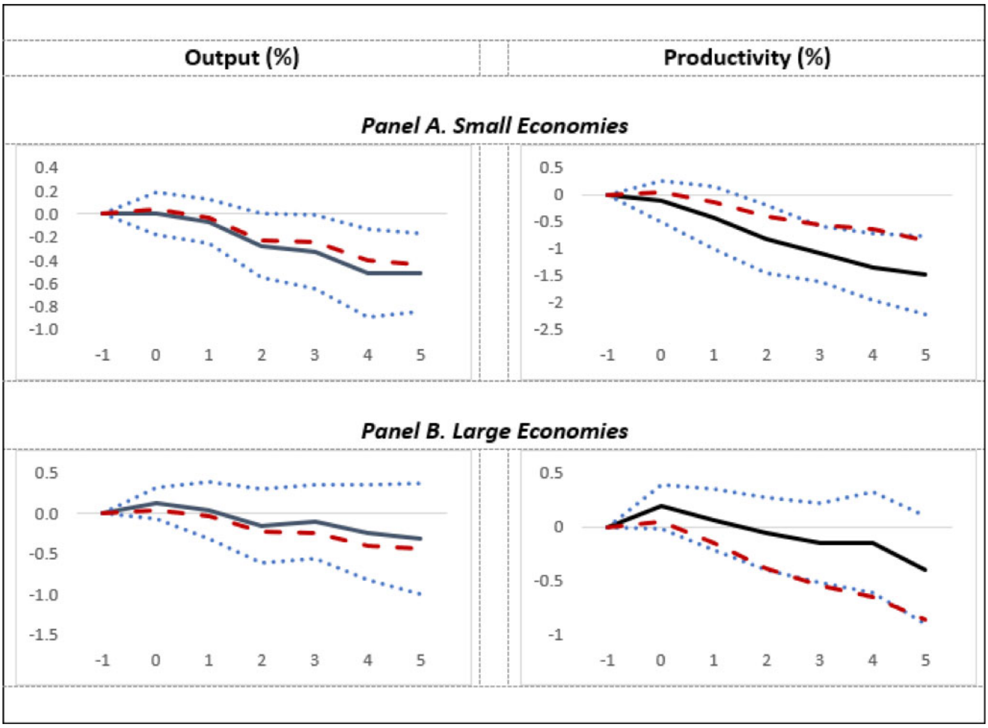
Note: The solid line indicates the response of output (productivity) to a one-standard-deviation increase in tariff during expansions and recessions; the dotted lines correspond to 90 percent confidence bands; estimates based on eq. (4); for panel A and B expansions and recessions are identified using GDP growth; for panel C and D using unemployment changes. Dashed lines indicate the response of output (productivity) to a one-standard-deviation increase in tariff in the baseline; estimates based on eq. (1). The x axis denotes time. $t = 0$ is the year of the tariff change.

shock by decreasing output and increasing inflation in the short run. They also find that protectionism leads to higher inflation which, in turn, prompts central banks to respond with a contractionary impulse.

3.1.5. Small versus Large Economies

Other things being equal, theory predicts that larger countries should experience a smaller decline in output following a tariff increase owing to optimal-tariff considerations (an improvement in the terms of

Figure 5. The Effect of Tariffs: Small vs. Large Economies



Source: Authors' estimations.

Note: The solid line indicates the response of output (productivity) to a one-standard-deviation increase in tariff; the dotted lines correspond to 90 percent confidence bands; estimates for panels A and B are based on eq. (5). Dashed lines indicate the response of output (productivity) to a one-standard-deviation increase in tariff in the baseline; estimates are based on eq. (1). The x axis denotes time. $t = 0$ is the year of the tariff change.

trade). This study extends the baseline regression to test for asymmetry depending on country size in the following way:

$$y_{i,t+k} - y_{i,t-1} = \alpha_i + \gamma_t + \beta^L D^L{}_i \Delta T_{i,t} + \beta^{Oth}\left(1 - D^L{}_i\right)\Delta T_{i,t} + \nu X_{i,t} + \varepsilon_{i,t} \tag{5}$$

where $D^L{}_{i,}$ is a binary variable that is equal to unity for large economies, and zero otherwise. For each year, large economies are countries that are above the 75$^{\text{th}}$ percentile of GDP in U.S. dollars.

Figure 5 reports the results. As expected, the decline in output is higher for smaller economies than the baseline, with a one-standard-deviation tariff change leading to an output decline of 0.5 percent over five years for smaller economies, compared to the baseline result of 0.4 percent. Similarly, the decline in productivity is also more pronounced, with productivity declining by 1.5 percent over five years following a one-standard-deviation tariff change, compared to the 0.9 percent in the baseline. Both effects are statistically significant. The impact on unemployment and inequality, reported in fig. S4.5 in the supplementary online appendix, likewise points toward more detrimental effects on small relative to large economies.[15]

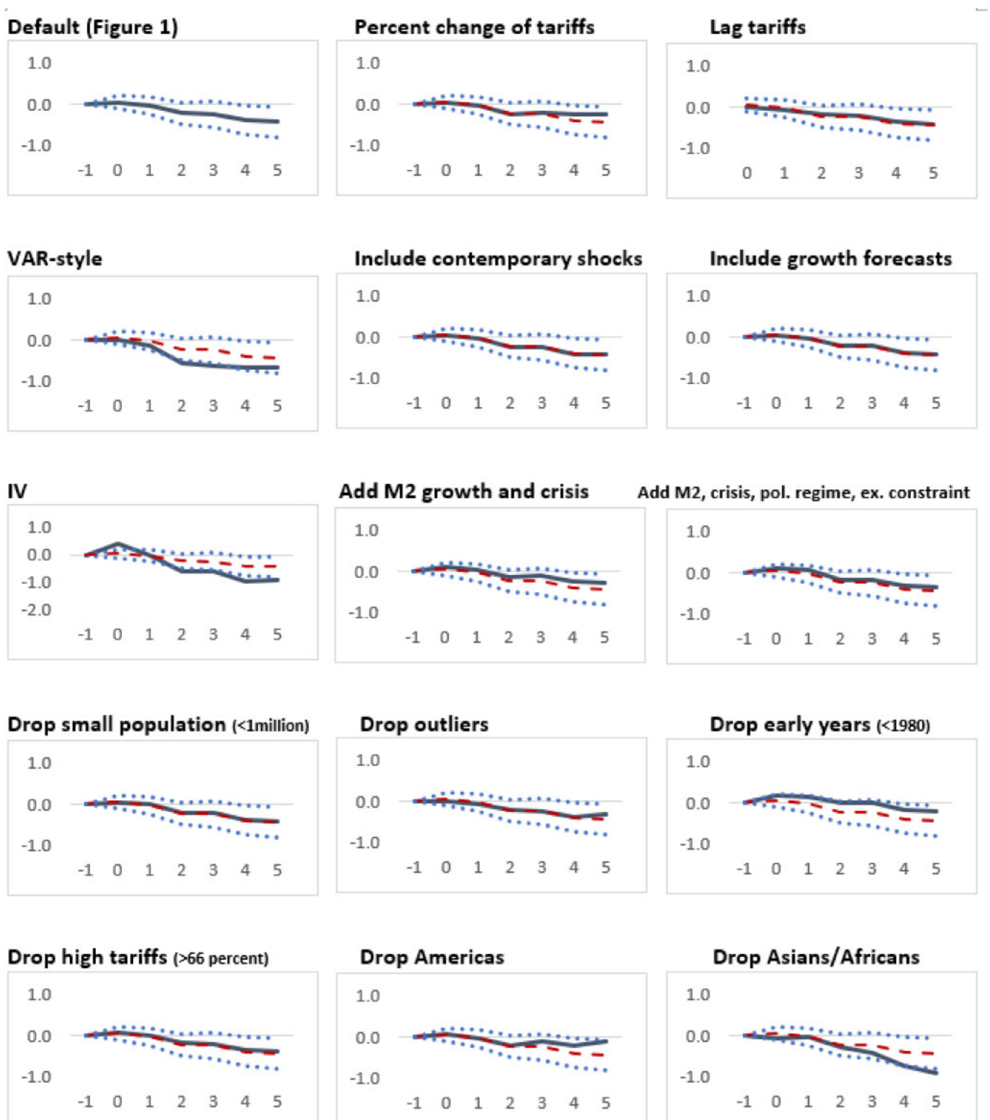
3.2. Robustness Checks

This section begins by considering sensitivity of the results to transformations of the key regressor.[16] The robustness analysis is presented in a series of fifteen IRFs, which are presented for output and productivity

15 The results for unemployment, inequality, real exchange rate, and trade balance for tariff increases versus decreases, advanced economies versus emerging markets and developing economies, recessions versus expansions, small versus large economies are presented in Appendix S4 (Figures S4.1-S4.5).

16 In addition to the robustness checks described in detail below, the study runs a version where the estimations include observations with trade balance between +/–50 percent of GDP given some of the extreme movements in this variable. The baseline results are robust to this specification.

Figure 6. Robustness for Output



Source: Authors' estimations.

Note: The solid line indicates the response of output to a one-standard-deviation increase in tariff using the scenarios described in each title of the chart. The dashed line represents the baseline results, estimated based on eq. (1). The dotted lines correspond to 90 percent confidence bands of the baseline. The x axis denotes time; $t = 0$ is the year of the change.

respectively in fig. 6 and fig. S5.1 in the supplementary online appendix.[17] The default results are presented in the top-left panel of the figures to facilitate comparison. In the two other top panels, the study transforms the key regressor, tariffs. The top-middle panel examines whether the results hold when considering tariff changes in percentage (that is, dividing the baseline measure by the lagged level of tariff), rather than

17 Analogous results for the other variables of interest (unemployment, inequality, the real exchange rate and the trade balance) are reported in figs. S5.2–5 in S5 of the supplementary online appendix; they demonstrate the basic insensitivity of the baseline results.

absolute terms. In the top-right panel, the study substitutes the lag of tariffs for its contemporaneous value. In both (and indeed all) panels, the default response and its confidence interval (taken from the top-left) is plotted; the mean response for the perturbation is plotted with a thick black line. If it lies within the confidence interval and is relatively close to the dashed line, the results are considered to be robust. Clearly, the way the regressor is transformed has little effect on the results. The IRFs for the different transformations indicate that the output response to changes in tariff are not statistically different from those reported in the baseline: in both cases, these responses lie well inside the confidence bands of the baseline responses.

3.2.1. Estimation Sensitivity

This study's specification implicitly assumes that shocks to the tariff do not respond to changes in the outcome variables within a year. A potential limitation of this assumption is that tariff changes are not exogenous, and may be correlated with other macroeconomic variables and with contemporaneous and future changes in economic activity. In line with Rose (2013), this study finds no statistically significant correlation between changes in tariff and changes in economic activity (e.g., the correlation between changes in tariff and output growth is 0.0006; this also holds when controlling for country and time fixed effects; see table 1). Nevertheless, three alternative estimation techniques are used to check whether the results are sensitive to this assumption. First, eq. (1) is modified by controlling for the contemporaneous changes in the trade balance and the real exchange rate—this is equivalent to considering tariff changes that are orthogonal to contemporaneous shocks in these variables.[18] Second, tariff changes are considered that are orthogonal to contemporaneous changes in economic activity, by performing a VAR analysis using a Cholesky decomposition with the following order to recover orthogonal shocks: the change in the log of output (or productivity), the change in tariff, the change in log of real exchange rate and the change in trade balance (in percent of GDP).[19] Alternatively, eq. (1) is also modified by allowing all explanatory variables, including changes in tariffs, to enter with a lag—that is, the effect of tariffs on the outcome variables is estimated only with a lag while controlling for contemporaneous changes in other macroeconomic variables. Third, the study follows Corsetti, Meier, and Müller (2012) and Duval and Furceri (2018) and estimates a specification that also controls for expected future GDP growth (using IMF WEO forecasts) in addition to past growth. These three perturbations are presented in the second row of fig. 6, and do not fundamentally change the study's conclusions. In addition, the results are robust to including regional time trends.

To address the concerns about endogeneity further, the study implements an instrumental variable (IV) approach in the same spirit as Acemoglu et al. (2019) and Furceri and Loungani (2018). As an instrument, the study uses the weighted-average of changes in the tariff in major (top five) trading-partner countries, where the weights are determined by the strength of trade linkages with other countries. Specifically, the instrument is computed as follows:

$$I_{i,t} = \sum_{j \in \Omega i} \Delta T_{j,t} w_{i,j,t} \tag{6}$$

where $I_{i,t}$ is the instrument of tariff for country i at time t; Ωi is the set of five largest trading partners of i; $\Delta T_{j,t}$ is the change in the tariff for country j (up to the five largest trading partners) at time t; and $w_{i,j,t}$ is the share of total exports and imports between country i and country j in the total exports and imports for country i: $\frac{Export_{i,j,t}+Import_{i,j,t}}{Export_{i,t}+Import_{i,t}}$.

18 Specifically, the study controls for contemporaneous changes in the trade balance and real exchange rate for the regressions on output, productivity, unemployment, and inequality. For the regression on trade balance (real exchange rate) the study controls only for simultaneous changes in the real exchange rate (trade balance).

19 The results are robust to alternative orderings.

The first-stage estimates suggest that this instrument is "strong" and statistically significant (see S7 in the supplementary online appendix for details).[20] What about the excludability of the instrument? To test the validity of the instrument, several checks are run. First, the study regresses the residual of the baseline against the instrument (table S7.3). Second, the study adds the instrument in the baseline specification (table S7.4). The results of these two exercises suggest that tariff changes in major trading partners do not have any effect on output or other outcome variables of interest in country *i*, if not through tariff changes in country *i*. Interestingly, the effect of domestic tariffs on output and productivity remains similar to, and not statistically different from, the baseline results (fig. S7.1).

Another concern is that the instrument could be correlated with the error term to the extent that changes in tariff rates in main large trading partners could affect domestic output through contemporaneous changes in the real exchange rate. To address this issue, the equation is modified to control for the contemporaneous changes in other control variables, including the real exchange rates. The results are robust to this specification (fig. S7.2).

The IV technique leads to an even larger decline in output within five years. This may suggest that changes in tariffs induced by retaliation are likely to have larger effects than changes in tariffs due to other motives.

Finally, the study controls for additional structural and cyclical variables in the regressions, namely political regime, executive constraints, income, trade openness, financial crises, conflicts, M2 growth, and budget deficit. The results for crises, M2 growth, political regimes, and executive constraints are reported in the third row, and the others are available upon request. These results do not fundamentally change the conclusions.

3.2.2. Sample Sensitivity

In the final set of aggregate results, the study checks the robustness of the results to a number of perturbations to the sample. The sample of data is changed in eleven ways: a) small countries (with population below a million are dropped); b) outliers are dropped (those observations corresponding to the residuals in the output regression in the bottom and top 1^{st} percentiles of the distribution);[21] c) the time sample is restricted to years after 1979; d) high tariff episodes are dropped (those with tariff rates above 66 percent—corresponding to the 99^{th} percentile of the distribution); e) observations from the Americas are dropped; f) Asian and Sub-Saharan African economies are dropped; g) series with gaps and less than 20 consecutive years are dropped; h) high inflation episodes are dropped (inflation above 100 percent); i) for output, the time sample is restricted to years after China's WTO entry (from 2002); j) for output and productivity, all the variables in the regressions at 1^{st} and 99^{th} percentiles are winsorized; and k) we remove country fixed effects are removed and region dummies are included for advanced Europe, developing Europe, Asia, MENAP (Middle East, North Africa, Afghanistan, and Pakistan), and Latin America. The last five results are not reported in the tables but are available upon request. The results persist through all these perturbations.

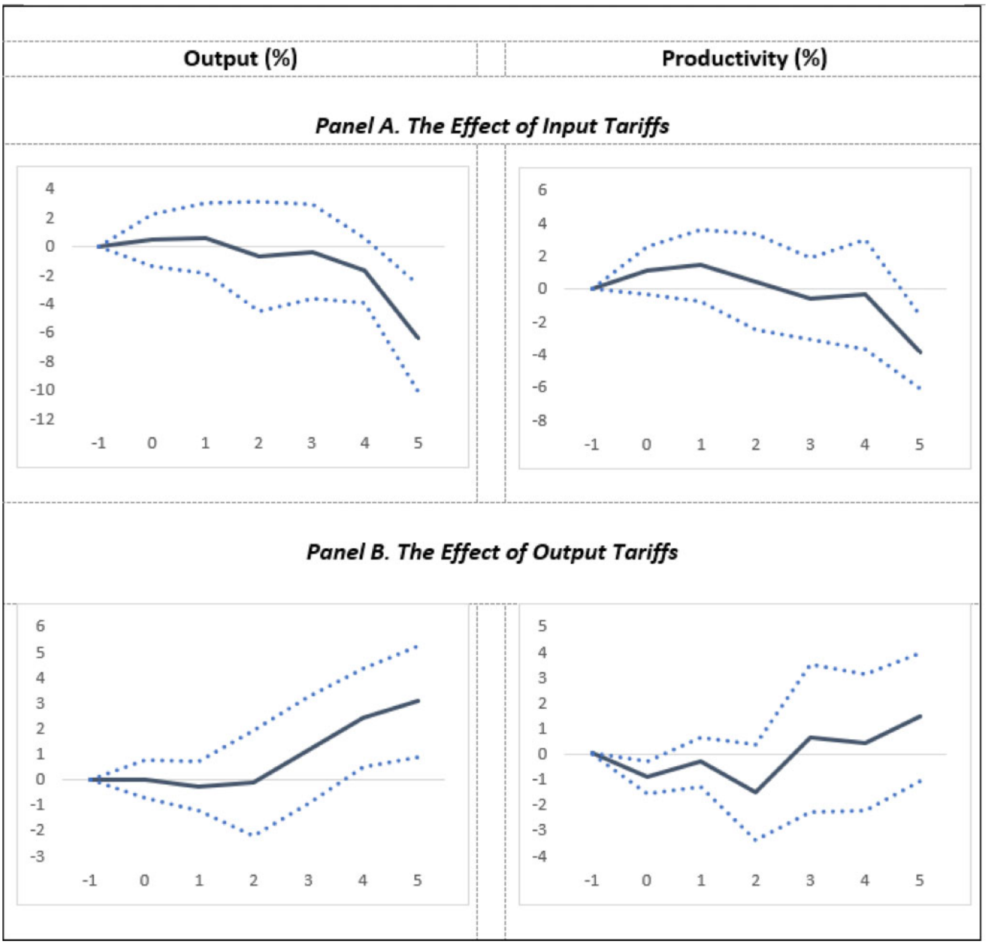
3.3. Industry-Level Results

This section explores the role of sectoral input and output tariffs in shaping the aggregate effect of protectionism. As a first step, it is useful to note that the effect on aggregate value-added of a tariff increase in sector *j* can be expressed (in the absence of output spillovers across sectors) as the sum of two components: the effect of the tariff increase on the value-added of sector *j* (that is, the output tariff effect); and

20 The Kleibergen–Paap rk Wald F statistic for each horizon of the IRF is always higher than the associated Stock-Yogo critical values.

21 Similar results are obtained when top and bottom 5^{th} percentiles of the same distribution are considered.

Figure 7. The Effect of Tariffs using Industry-Level Data



Source: Authors' estimations.

Note: The solid line indicates the response of output/labor productivity to a one-standard-deviation increase in input/output tariff; the dotted lines correspond to 90 percent confidence bands. The x axis denotes time. $t = 0$ is the year of the change. The estimates are based on eq. (1′).

its effect on the value-added of all remaining sectors (that is, effects through the input channel):

$$\frac{dY_t}{dT_{j,t}} = \frac{dY_{j,t}}{dT_{j,t}} + \sum\nolimits_{s \neq j} \frac{dY_{s,t}}{dT_{j,t}} \tag{7}$$

The four panels of fig. 7 show the estimated dynamic responses of sectoral output (on the left) and productivity (on the right) to one-standard-deviation increases in input tariffs (above, equivalent to an increase of about 0.4 ppt) and output tariffs (below, equivalent to a 2.0 ppt increase). As always, we portray results for the five years following the tariff change, and include 90 percent confidence intervals around the point estimate (computed using Driscoll-Kraay standard errors for the estimated coefficients).

The results in the top panels of fig. 7 suggest that an increase in the input tariff leads to a statistically-significant decline in sectoral output of about 6.4 percent five years after the tariff hike. It also results in a statistically significant decline in productivity (shown to the right) of about 3.9 percent five years after the tariff hike. While input tariff increases lead to declines in output and productivity, increases in output tariffs have a statistically positive impact on output, with output increasing by 3.1 percent in five years. The impact on productivity is positive but not statistically significant.[22]

4. Conclusion

Using impulse response functions from local projections on a panel of annual data spanning 151 countries over 1963–2014, the study finds that tariff increases are followed by adverse effects on output and productivity; these effects are economically and statistically significant. They are magnified when tariffs are used during expansions, for advanced economies, and for smaller economies. It is also found that tariff increases are followed by higher unemployment and inequality, further adding to deadweight losses. Tariffs have only small effects on the trade balance, in part because they are associated with offsetting real exchange rate appreciations. To the degree that tariffs are being deployed to achieve macroeconomic objectives (boost output, jobs, and the trade balance), the evidence presented in this paper—which seems robust to a long list of perturbations of the methodology—suggests that the chosen policy will fail miserably to achieve its goal. One caveat is that this paper does not analyze country- or region-specific trade impacts and does not include all the dimensions of how trade could affect people. Recent studies have found trade costs related to factors like labor adjustment to be substantial, particularly for subgroups of highly exposed workers (e.g., Autor et al. (2014) and Pierce et al. (2016) on the US; Helpman et al. (2016) and Dix-Carneiro et al. (2017) on Brazil). Pavcnik (2017) find that the effect of trade on poverty and inequality are context specific. For example, the effect of trade on earnings could be geographically concentrated, partly due to low and imperfect inter-regional worker mobility. This would suggest that country-specific factors and concomitant policies would be crucial in reaping the gains from trade, particularly in an inclusive manner.

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22 The result that input tariffs have a more detrimental output effect than output tariffs is consistent with previous empirical work examining the effect of input and output tariffs at the macro (e.g., Ahn et al. 2016) and at the firm level (e.g., Amiti and Konings 2007).

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