Tariffs, Productivity, and the Welfare Effects of Protectionism

Luca Guerrieri

November 2026

Federal Reserve Board

The views expressed here are solely the responsibility of the author and should not be interpreted as reflecting the views of the Board of Governors of the Federal Reserve System or of anyone else associated with the Federal Reserve System.

01

The question

A tariff can raise welfare through the terms of trade

- A country large enough to move world prices pays less for its imports when it taxes them. The tariff transfers income from foreign exporters to home households (Johnson, 1951).
- In open-economy macro models with heterogeneous firms, a unilateral tariff lowers physical productivity, yet home welfare rises.
- Itskhoki and Mukhin (2026) put the optimal unilateral U.S. tariff at 35 percent, and at 9 percent once they account for valuation losses on external positions.

I stress test that result with an exploration grounded in the data.

Assessments of the 2018 tariffs hold technology fixed

- In 2018 the United States raised tariffs on $303 billion of imports, 12.7 percent of the annual total. By the end of 2019 the tariffs on Chinese goods alone covered roughly $350 billion.
- The cost fell on U.S. buyers, and the aggregate loss in static assessments is small: about 0.04 percent of GDP in Fajgelbaum et al. (2020), and 0.01 to 0.1 percent in Fajgelbaum and Khandelwal (2022).
- These assessments are short-run and static by design, by their authors' own account.

Any cost that builds up through the productivity of the protected industries lies outside these assessments.

I ask two questions

a. Did the productivity of the protected industries change after 2018?

b. If it did, would a change of that size overturn the welfare gain from the terms of trade?

The first needs a design that compares industries. The second needs a macro model of trade in which industries differ in the same way, so that I can compare model and evidence like for like.

A sizable relative decline can reverse the welfare gain

- **Evidence.** Relative TFP of exposed industries broke in 2019: TFP about **2.3 percent** lower at the 75th percentile of exposure than at the 25th.
- **Model, tariffs alone.** The gap in measured TFP between the most and least exposed sectors is 0.01 percent by 2019, against −5.05 percent in the data.
- **Model, with the decline.** A home welfare gain of 0.30 percent of consumption becomes a change of −0.59 **percent**. A decline of 35 percent of the estimate erases the gain.

Two conditions apply, and I size both. The decline must persist (half-life above 27 quarters). And I identify only a relative decline, so the aggregate productivity response remains an important variable.

Roadmap

a. The evidence: the Flaaen-Pierce design applied to BLS productivity.
b. A tariff in the Ghironi-Melitz model: what it does to productivity and to welfare.
c. The evidence through the model: three sectors, two experiments, and the conditions for the reversal.
d. Caveats, conclusion, and further research.

02

The evidence

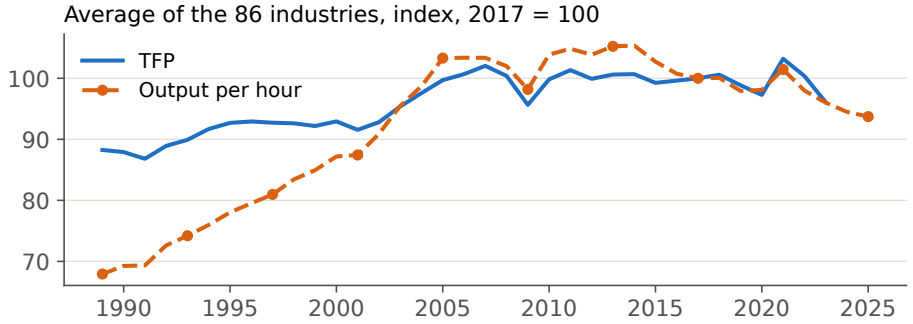
The added rate was nearly uniform, but exposure was not

- Three sets of actions in 2018: Section 301 on a broad range of products from China (Lists 1 to 3), Section 232 on steel and aluminum, and Section 201 on solar cells and large residential washers.
- Most covered goods faced an added 25 percent tariff. List 3 began at 10 percent and rose to 25 percent in May 2019, a rise scheduled when the list was adopted in September 2018. The measure uses the 25 percent rate.

Industries therefore differ mainly in how much of their home market was supplied by the newly tariffed imports.

I borrow the difference-in-differences design of Flaaen and Pierce (2026), who study the same tariffs at the same level of aggregation. They study employment, industrial production and producer prices. I apply their design to productivity.

I measure productivity with BLS TFP for 86 industries



BLS divides output, deflated product by product, by an index of all inputs, so an industry's own price is divided out. New varieties and quality changes are not fully captured, so I build the same measure into the model.

I regress detrended TFP on exposure, year by year

In words: I compare more and less exposed industries year by year, against their own pre-war trends, while trade-exposed industries are free to follow their own paths.

$$\tilde{y}_{jt} = b_t^P \,\text{Protection}_j + b_t^I \,\text{InputCost}_j + b_t^R \,\text{Retaliation}_j$$
$$+ b_t^M \,\text{ImpShare}_j + b_t^X \,\text{ExpShare}_j + b_t^C \,\text{ICShare}_j + b_t^K \ln(K/L)_j + d_j + d_t + \varepsilon_{jt}$$

- $\tilde{y}_{jt}$: log TFP net of the industry's own 2013–17 trend. 86 industries, 2013–2022, 2017 omitted.
- The second line holds the four controls of Flaaen and Pierce: import share, export share, imported share of input costs, log capital per worker.
- Standard errors clustered by three-digit sector. Each industry weighs the same.

Protection: the added duty relative to the home market

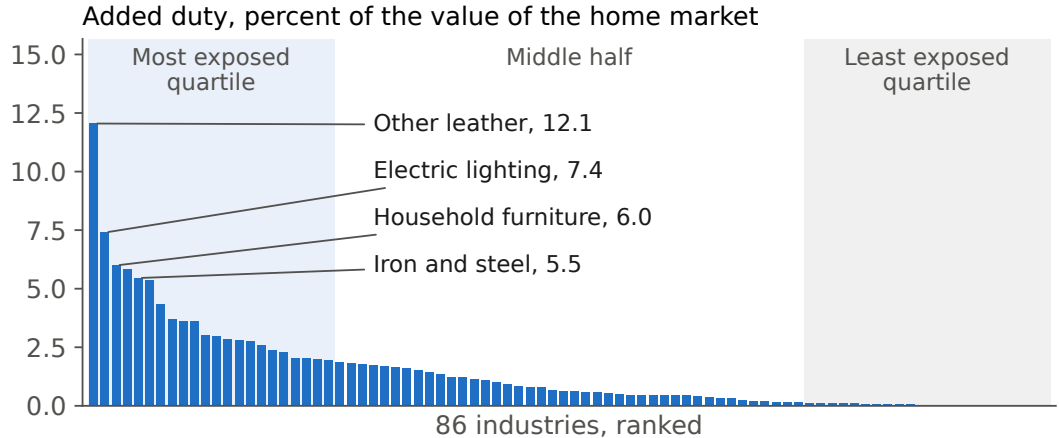
The protection measure is the added duty on an industry's imports as a share of those imports, measured on 2017 trade, times the share of imports in the industry's home market, measured as Flaaen and Pierce do on 2016 trade and shipments.

$$\text{Protection}_j = \sum_{pc \in \Omega} a_{pc} \frac{M_{j,pc}}{M_j} \cdot \frac{M_j}{Q_j + M_j - X_j}$$

- Ω denotes the set of product-country pairs newly covered by a 2018 U.S. tariff action, and a_{pc} the rate the action added on pair pc. A pair is one product from one country of origin.
- M, X and Q are an industry's general imports, domestic exports and own shipments.
- $Q_j + M_j - X_j$ is domestic absorption, the size of the home market. Exports are inside Q, so subtracting them removes the part of domestic output that left the country rather than a duplicate of imports.

Because the two years of imports differ by only one, the protection measure is, to a close approximation, the added duty on an industry's imports as a share of the value of its home market. China's share? Build

Protection is concentrated in a few industries



China's share? Build

Retaliation and InputCost capture the two other channels

$$\text{Retaliation}_j = \sum_{pc \in \Omega^*} a^*_{pc} \frac{X_{j,pc}}{X_j} \cdot \frac{X_j}{Q_j}$$

$$\text{InputCost}_j = \sum_c s_{cj}\, m_c \sum_{pc \in \Omega} a_{pc} \frac{M_{c,pc}}{M_c}$$

- Ω^* and a^*_{pc} are the pairs hit by foreign retaliation and the rates it added.
- s_{cj} is commodity c's share of industry j's costs, intermediate inputs and labor compensation, in the BEA 2012 detail Use table, and m_c is the share of imports in the domestic absorption of commodity c in 2016.

Retaliation scales the added duty on exports by output, since an export channel is measured against what an industry makes rather than against what its home market absorbs. The input term weights the added duty on each imported commodity by the commodity's import share and by its share of the industry's costs, so that it measures the rise in the industry's costs if the duties passed through in full.

Protection is highest in leather, lighting, furniture and steel

Most exposed quarter, largest eight	Protection, percent	Imports, percent
Other leather and allied product	12.05	98.2
Electric lighting equipment	7.42	57.4
Furniture and kitchen cabinets	6.01	43.6
Apparel accessories and other apparel	5.84	87.7
Iron and steel mills and ferroalloy production	5.46	26.1
Semiconductors and electronic components	5.34	58.9
Household appliances	4.33	64.2
Other electrical equipment and components	3.71	49.2

The 25th and 75th percentiles are forging and stamping (0.12 percent) and other furniture products (1.94 percent).

I measure the break against the pre-war drift

Remember that the regression equation is

$$\tilde{y}_{jt} = b_t^P \,\text{Protection}_j + b_t^I \,\text{InputCost}_j + b_t^R \,\text{Retaliation}_j + b_t^M \,\text{ImpShare}_j + b_t^X \,\text{ExpShare}_j + b_t^C \,\text{ICShare}_j + b_t^K \ln(K/L)_j + d_j + d_t + \varepsilon_{jt}$$

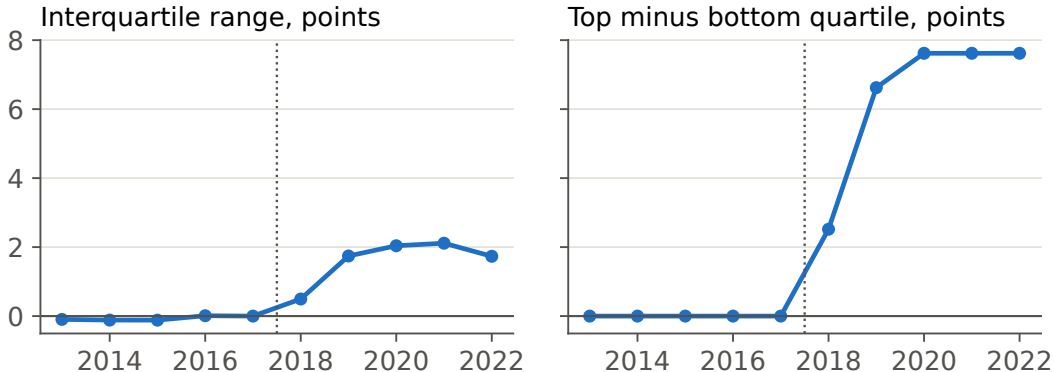
Because I remove the trend on 2013–17, flat pre-war coefficients say nothing about the design. Following Flaaen and Pierce, I base identification on the post-war separation net of the pre-war drift:

$$\Delta_{2019} = (b^P_{2019} - b^P_{2017}) - \tfrac{2}{3}(b^P_{2017} - b^P_{2014})$$

- The factor $\frac{2}{3}$ scales the three-year drift to the two-year post-war window.
- The statistic removes any industry-specific linear trend exactly, so it takes the same value with or without detrending.

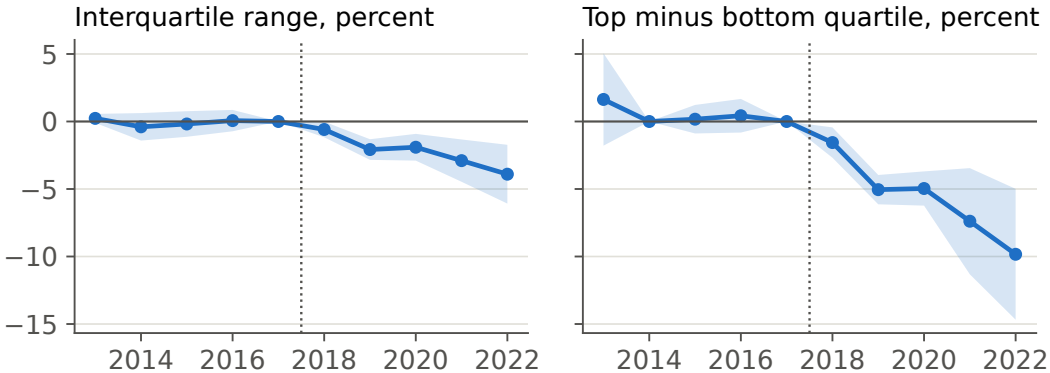
The path with no trend removed

The tariff gap opened in 2018 and was complete in 2019



Less than half of the 2019 gap was in place in 2018: 0.5 of 1.7 points at the interquartile range, 2.5 of 6.6 between the quartiles. Dotted line: the first 2018 tariffs.

Relative TFP of exposed industries broke in 2019



90 percent bands. Right panel: zero by construction in 2014 and 2017. Years after 2019 overlap the pandemic. Pandemic controls Statutory rate

The break is about 2.3 percent at the interquartile range

Year	Protection	Statutory, per 100 points
2016	0.04 (0.27)	−0.12 (0.09)
2018	−0.33 (0.19)	−0.12 (0.06)
2019	**−1.15 (0.26)**	−0.34 (0.09)
2020	−1.05 (0.33)	−0.36 (0.13)
2021	−1.60 (0.53)	−0.51 (0.20)
2022	−2.15 (0.73)	−0.59 (0.25)
Equation (8): net of the pre-war drift	**−1.29 (0.17)**	−0.39 (0.12)

Standard errors in parentheses. Scaling: 1.29 times the interquartile range of protection, 1.8 points, gives 2.3 percent. The statutory rate gives −2.7 percent at its own interquartile range.

Per point, the size of my estimate lies between two studies

Study	Policy	TFP	Period of the effect	Percent per point
Pierce (2011), plants reporting quantities	Duty **rise** (antidumping)	Physical	**Average over years 1–9** after the duty	−3.12, slope across protected plants
This paper, industries	Tariff **rise** (statutory)	BLS	**Total after 2 years**, 2017–19, net of the pre-war drift	**−0.39**
Bernard, Jensen and Schott (2006), industries	Trade cost **cut**	NBER-CES	**Total over 5 years**, after a 5-year cut	+0.152 to +0.190 per point of cut

Orange pairs a rise in barriers with a fall in TFP, and green pairs a cut with a rise in TFP. Higher barriers go with lower TFP in all three. All use U.S. data, and none is a rate per year. The periods differ, and Pierce cautions that his sample is selected, so I read them as a range and not as confirming my estimate. Revenue productivity studies

2.3 and 5.05 percent come from one coefficient

	Exposure gap, points	TFP gap, percent
75th against 25th percentile of protection	1.8	−2.3
Average top against average bottom quartile	3.9	−5.05

Both multiply the coefficient of −1.29 by a gap in exposure. The second is larger because the outer quartiles' average exposures (3.92 and 0.04 percent) lie further apart than the quartile edges.

I use the first to compare with Flaaen and Pierce, and the second as the target for the model, whose outer sectors stand for the whole outer quartiles.

The estimate rests on the pre-war relative rise continuing

Protection measure	TFP	Output per hour
Pre-war term, $\frac{2}{3}(y_{2017} - y_{2014})$	0.86 (0.29)	1.17 (0.56)
randomization p	0.004	0.022
Post-war change, $y_{2019} - y_{2017}$	−0.43 (0.33)	−0.52 (0.47)
randomization p	0.161	0.242
Equation (8), post minus pre	−1.29 (0.17)	−1.69 (0.59)
randomization p	0.001	0.011
Pre-war term, share of equation (8)	**0.67**	0.69

Before the war the more exposed industries were gaining on the others, and the gain stopped. The change after 2017 is not significant on its own. A tariff that slowed productivity would produce this pattern. So would a reversion after a pre-war run-up, which I cannot exclude with this design.

The break is not an artifact of chance in any sense I can test

	Protection measure	Statutory rate
Randomization across industries, *p*	0.001	0.005
Randomization within sectors, *p*	<0.001	0.001
Wild cluster bootstrap by sector, *p*	0.001	0.007
Placebo windows with as large a break	0 of 22	0 of 22
Sets of windows where 2019 is largest	6 of 6	6 of 6
Coefficient with the cyclical beta	−1.28 (0.19)	−0.0038 (0.0012)
Coefficient with the 2007–09 TFP change	−1.29 (0.18)	−0.0039 (0.0012)

A general tendency to give back gains would show up in earlier windows. No earlier window has as large a break. Placebo windows Fastest pre-war risers One industry out

Across measures the estimate is −1.9 to −4.0 percent

	Effect, percent	*t*	Wild *p*
Protection, rate-weighted (baseline)	**−2.3**	−7.6	0.001
Protection, coverage share	−1.9	−4.4	0.007
Flaaen and Pierce's published measure	−2.2	−4.5	<0.001
Import-weighted tariff change	−4.0	−3.7	0.010
Change in the statutory tariff	−2.7	−3.3	0.007
Value-added weights	−3.3	−4.7	0.002
Trade shares as the only controls	−2.2	−6.2	0.002
Trade shares capped	−2.4	−6.3	0.002

A gap of this size is close to two years of pre-2007 growth

- Average industry TFP rose by 11.8 percent over the decade to 2007, about 1.2 percent a year, and changed by —1.5 percent over the decade to 2017.
- A relative gap of about 2 percent that opens within two years is therefore close to two years of the earlier growth, and larger than the change of the whole decade before the war.

Output per hour breaks too; hours per worker do not fall

Coefficient on protection	Nominal, per hour	Real, per hour	TFP
Equation (8)	−1.14 (0.75)	−1.69 (0.59)	**−1.29 (0.17)**
2017–19 change alone	−0.04 (0.53)	−0.52 (0.47)	−0.43 (0.33)

Measured utilization does not account for the break: log hours per worker rise by 1.85 percent at the interquartile range, on the same statistic. In Flaaen and Pierce's versions of the measure the rise is not significant.

The evidence is relative. Everything common to manufacturing drops out, and the terms-of-trade gain drops out with it. To go further I need a model.

03

A tariff in the model

Ghironi-Melitz has both the gain and the reallocation

- Ghironi and Melitz (2005): two countries, heterogeneous firms, and a set of traded goods that moves with shocks. I add an import tariff, rebated lump sum.
- A fixed cost of exporting means only the most productive firms export, as in the data (Bernard et al., 2007).
- Entry is free but sunk. Firms draw productivity once, from a Pareto distribution. Households trade two bonds, so the welfare effect of an announced path can be computed in full.
- Under the published CES demand, measured TFP cannot see reallocation. My baseline uses translog demand (Bilbiie, Ghironi and Melitz, 2012; Rodríguez-López, 2011), and I compare it with CES throughout.

Under translog, larger firms charge higher markups

Under CES, the published model:

- Every firm charges the same markup over marginal cost, so a more productive firm charges a proportionally lower price.
- Valued at producer prices, output per unit of labor is then blind to how production is allocated across firms.

Under translog, my baseline:

- A firm's demand becomes less elastic as its market share grows, so larger, more productive firms charge higher markups.
- A shift of production toward less productive firms moves labor toward lower-markup firms and pulls measured TFP down.

So under translog, the reallocation the tariff causes registers in the measure the evidence is about.

Fixed costs select exporters, and entry is free

Selling abroad requires a fixed cost every period, whatever a firm sells. Only firms productive enough to clear it export, so exporters are the firms above a productivity cutoff. The cutoff moves with the real exchange rate, foreign demand and trade costs.

A prospective firm pays an entry cost, draws its productivity, and produces from the next period until an exit shock removes it. Free entry drives the expected value of entering down to its cost, which pins the number of firms.

The stock of producers plays the role a capital stock plays in other models. Entry is the investment and exit is the depreciation. Households save by holding claims to firms, and a firm's value acts as the price of capital.

Equations

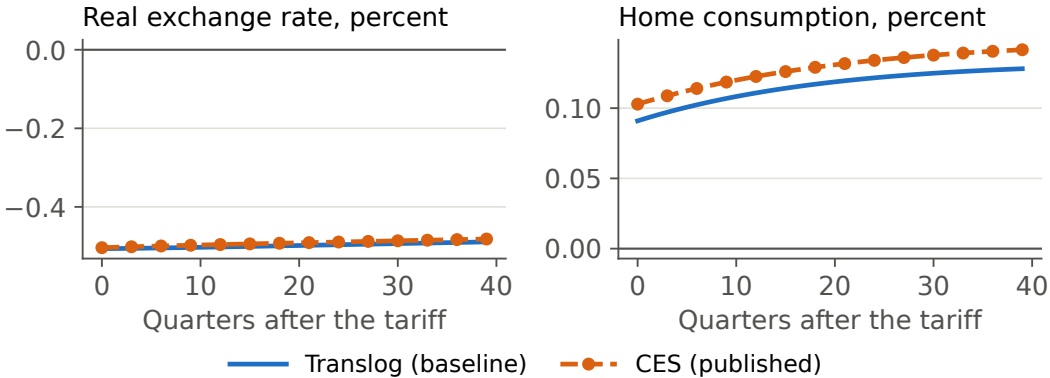
I keep the published calibration and solve exactly

Parameter	Controls or target	Value
β, γ, δ	discounting, risk aversion, exit	published: 0.99, 2, 0.025
θ, k	CES elasticity, productivity dispersion	published: 3.8, 3.4
τ	iceberg trade cost	published: 1.3
σ	translog: expenditure-weighted markup of 1.357	0.5654
f_X	21 percent of firms export	0.01035

The tariff is nearly permanent, with persistence 0.999 a quarter. I solve the exact deterministic path and compute conditional welfare as a consumption equivalent.

Solution method

A tariff improves the terms of trade and consumption



A one percent home tariff. A fall in the real exchange rate is a home gain: on impact −0.506 percent per point under translog.

With technology fixed, a tariff only reallocates

Reallocation. Production is reallocated among firms whose productivity is given.

- The tariff appreciates the real exchange rate, which makes exporting less profitable, so exporters, the most productive firms, sell less abroad.
- Home demand shifts toward domestic sales, which every firm makes, including the least productive.
- Production shifts toward less productive firms, so the average productivity of production falls although no firm's own productivity changes (a net **−0.138** percent per point on impact under translog).

Technology. Aggregate technology and the distribution of draws do not respond to a tariff in this model.

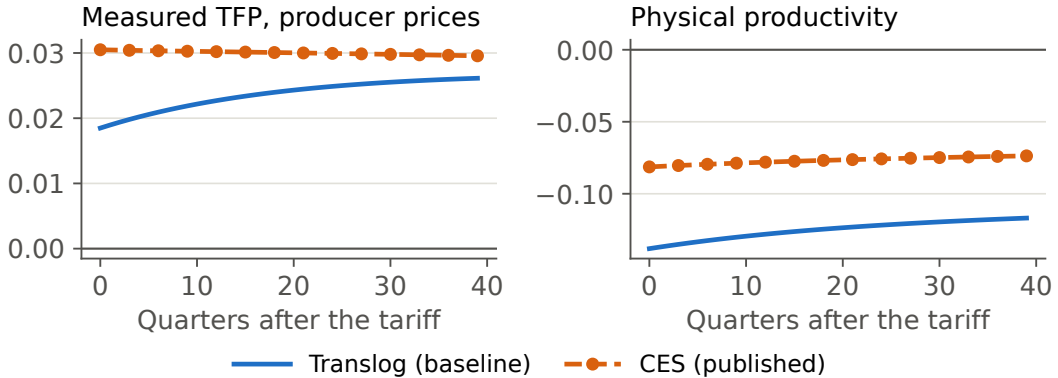
I call the outcome *physical productivity*, which is log technology plus the average log productivity of the firms, weighted by their production labor. Welfare depends on this concept.

Measured TFP rises while physical productivity falls

Percent per point of tariff, on impact	Translog	CES
Less labor in export overhead	+0.027	+0.030
Labor moves to low-markup firms	−0.008	0.000
= TFP at producer prices	**+0.018**	+0.030
TFP in units of consumption	−0.109	−0.115
TFP, data-consistent index	−0.071	−0.032
Physical productivity	**−0.138**	−0.081

BLS values output at producer prices. Lower export overhead pushes that measure up. Under translog the shift of labor toward low-markup firms offsets about a third.

Producer prices hide much of the physical loss



Under CES a more productive firm gives up in price what it gains in output per worker. I therefore match the model on measured TFP, built as BLS builds it, and read welfare from the physical change.

The home gain comes mostly at foreign expense

Percent of consumption, per point	Translog		CES	
	Home	Foreign	Home	Foreign
Home tariff only	+**0.12**	−0.12	+0.13	−0.14
Both countries levy it	0.00	0.00	0.00	0.00
Offsetting technology decline	0.12		0.12	

These figures already include the reallocation the tariff causes. Retaliation at the same rate makes the home gain disappear.

A productivity loss can reverse the sign only if it comes on top of that reallocation, from a margin the model holds fixed, and persists.

Firm heterogeneity leaves the optimal tariff large

	Gain per point	Optimal tariff	Welfare
CES, heterogeneous	0.14	38.1	2.03
Translog, heterogeneous (baseline)	0.12	**39.2**	1.86
CES, identical firms	0.13	47.3	2.33
Translog, identical firms	0.18	44.8	3.41
Gross positions of 2017	0.08	17.7	0.60
Net position only	0.11	31.9	1.45
Home a quarter of the world	0.11	35.9	1.59

Close to Itskhoki and Mukhin's 35 percent. The gross external position cuts it by more than half, against their cut to 9 percent. From these comparisons I cannot sign the effect of heterogeneity on the optimum. Exporters' elasticity

04

The evidence through the model

Three sectors let the model face the evidence

Sectors

The quarter of industries most exposed to the 2018 tariffs, the middle half and the least exposed quarter, ranked by the protection measure.

Households

They spend a fixed share on each sector. Within a sector they buy varieties under translog demand with its own parameter.

Tariffs

Each sector's tariff is the import-weighted tariff change of its industries, at the dates of the 2018 actions. The model reproduces the manufacturing-wide rise of 3.13 points.

Size and labor

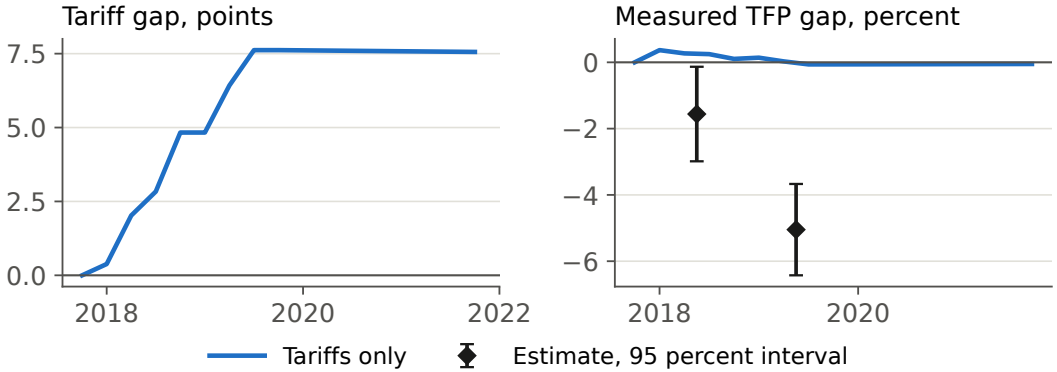
Home is a quarter of the world. Labor stays nearly fixed in each sector. At most 0.02 percent of the labor force moves.

I calibrate each sector and target the TFP gap

	Most exposed	Middle	Least exposed
Share of absorption	0.149	0.467	0.385
Markup, CES equivalent	1.25	1.36	2.14
S.d. of log domestic sales	0.82	0.82	0.82
Share of firms that export	0.24	0.22	0.16
Import share of absorption	0.51	0.32	0.21
Export share of shipments	0.31	0.22	0.14
Tariff change, points, 2019Q4	7.8	2.4	0.2

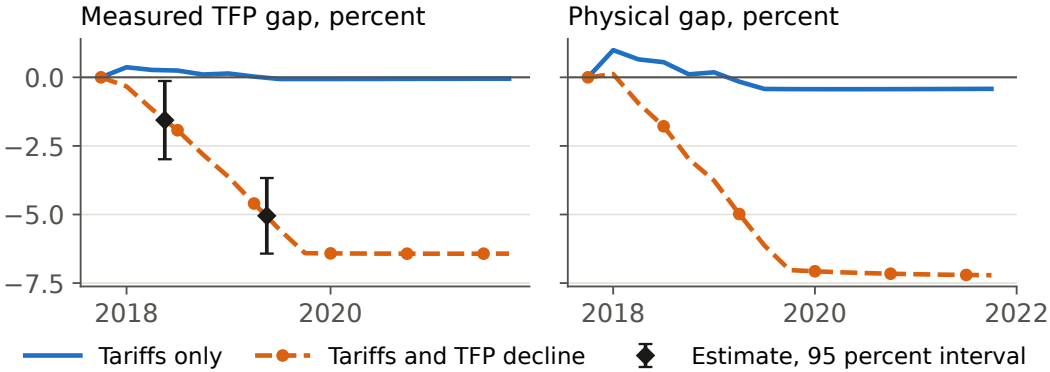
I size a technology decline in the most exposed sector so that the gap in measured TFP is −1.56 percent in 2018 and −5.05 percent in 2019. Parameters Tariff paths

The tariffs alone fall far short of the measured gap



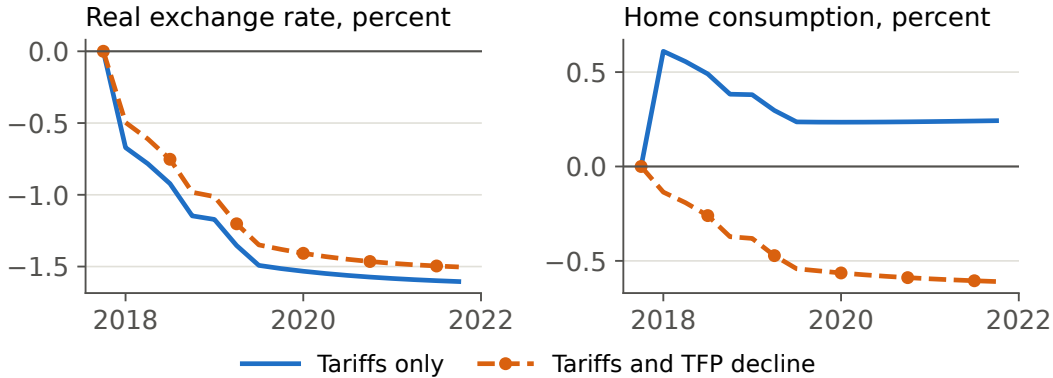
The measured gap is $+0.25$ percent in 2018 and $+0.01$ in 2019. Reallocation within the protected sector is small, and the overhead its exporters release works the other way.

Matching the gap takes a technology decline



The shock, announced in 2018Q1, stands for whatever lowered the productivity of the protected industries. Technology changes by —6.41 percent by 2019, and the physical gap averages —5.48 percent in 2019.

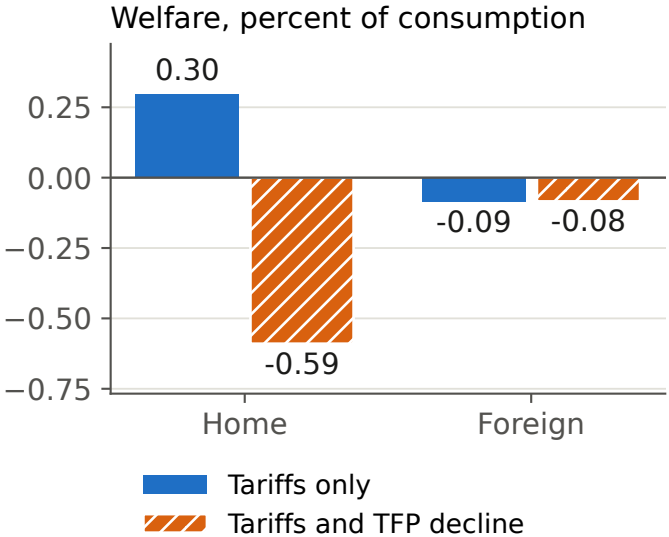
The decline turns consumption down



Consumption: $+0.51$ percent in 2018 with the tariffs alone, -0.49 by 2019 with the decline. Intuitively, the tariffs redirect home spending toward the very sector whose productivity falls.

Other model responses

The decline turns the welfare gain into a loss



The reversal does not need the full estimate.

- A decline of 35 **percent** of the estimated gap erases the gain.
- The end of the 95 percent interval nearest zero is about 73 percent of the estimate.

The gain in the model is generous by the standard of static estimates, so a small gain does not drive the reversal.

The sign turns on whether the loss is lasting

	Tariffs alone	With the decline	Physical gap, 2019
Persistent decline (baseline)	0.30	**−0.59**	−5.48
Transitory decline, $\rho = 0.95$	0.30	**0.11**	−5.38
Gross external position, 2017	0.22	**−0.71**	−5.38
Net position only	0.28	**−0.66**	−5.42

Fading at 5 percent a quarter, the decline leaves welfare at $+0.11$ percent, about two-fifths of the gain from the tariffs alone. The loss disappears if the half-life is below about 27 quarters.

I cannot tell these cases apart, since the estimates free of the pandemic end in 2019.

External positions matter less for announced tariffs

Home welfare, percent	2018–19, announced	Permanent, surprise
No external position	0.30	0.33
Net position only, home currency	0.28	0.30
Gross positions of 2017	0.22	0.15
Valuation effect, gross minus net	−0.06	−0.14

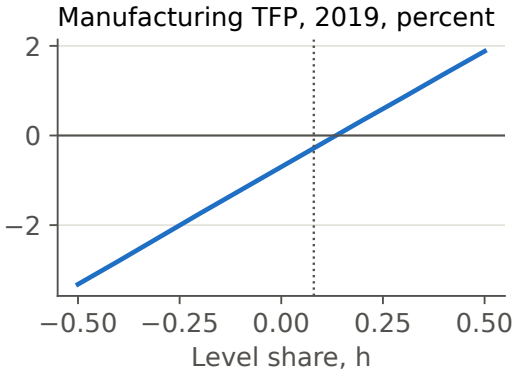
Liabilities of 181 and assets of 141 percent of GDP, end of 2017. The tariffs were announced and phased in, so only the surprise at announcement revalues positions. The channel of Itskhoki and Mukhin bites for a tariff imposed by surprise. With gross positions, welfare is +0.22 and −0.71 percent.

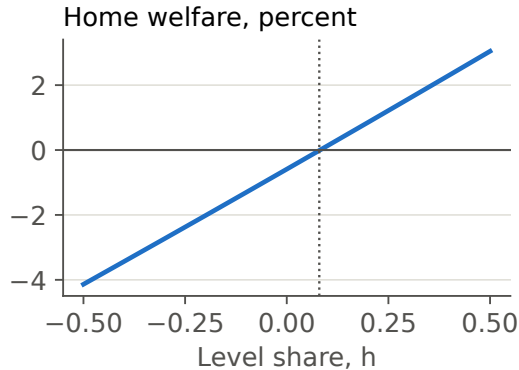
A small response brings the optimal tariff to zero

Uniform, nearly permanent tariff	No external position	Gross positions, 2017
Gain per point of tariff, a	0.114	0.056
Optimal tariff, percent	44.2	14.7
Welfare at the optimum, percent	1.85	0.38
Cost of a 1 percent technology decline, κ	1.16	1.17
Threshold a/κ, percent per point	0.10	0.05
share of the estimated response	**0.12**	0.06

Suppose the tariff lowers technology by a given percentage per point, in every sector. Beyond a/κ the optimal tariff is zero. At half the threshold it is already 14 percent rather than 44, because the marginal gain declines slowly. The result needs a lasting decline: a half-life above about 8 quarters.

The aggregate TFP level is not pinned down





The share h keeps the gap and moves its level. Welfare turns positive near $h = 0.08$, since the most exposed sector is a small part of spending. A positive h needs a rise elsewhere that the tariffs do not cause. Numbers

05

Caveats, conclusion, and further research

What the model leaves out, and in which direction

- **Retaliation.** Absent from the experiments. It would shrink the gain the decline has to overturn.
- **Input costs.** Absent from the model. They too would shrink the gain, and could spread a decline across sectors.
- **Labor reallocation across sectors.** Nearly shut down. So the model's real output gap is larger than the data's in 2018 and smaller in 2019. Output gaps
- **Uncertainty.** Welfare is deterministic, as in Itskhoki and Mukhin. Every path is known once announced.

What I cannot say with this design

- **Why technology fell.** In the model the decline comes from outside, and I do not explain it. With research and development and technology adoption as in Comin and Gertler (2006), a shock that depresses activity would deliver a persistent drop in the level of TFP.
- **Whether it is the tariff.** I estimate an association that nets out pre-war paths. A reversion specific to this episode remains possible.
- **The level.** Everything common to manufacturing drops out of comparisons across industries.
- **Persistence.** The estimates free of the pandemic end in 2019.

Conclusions

a. The more exposed industries broke from their relative productivity trend in 2019, by about **2.3 percent** at the interquartile range.
b. In the Ghironi-Melitz model the tariffs alone open almost none of that gap. Reallocation among firms is too small, and technology does not respond.
c. If the gap is a persistent decline, the welfare gain of 0.30 percent becomes a change of -0.59 **percent**, and a little over a third of the estimate suffices.

The case for the tariffs on terms-of-trade grounds therefore turns on a margin that standard welfare assessments hold fixed, and on how long it stays depressed.

Further research with R&D would deliver persistence

What is missing. The welfare reversal needs a decline with a half-life above about 27 quarters, and the estimates free of the pandemic end in 2019. Here the decline comes from outside the model.

Why Comin and Gertler (2006) is promising. R&D and the adoption of new technologies respond to economic conditions. In their model a shock that is not technological generates "a persistent decline in TFP," and "a permanent drop relative to trend."

What the extension would do. It could make the decline an outcome of the tariffs and determine its persistence, the condition I cannot settle with the evidence. Bringing it to the evidence requires many countries and many sectors.

06

Backup: evidence

China's import share does not produce the same break

Equation (8)	Interquartile effect, percent	*t*, by sector
Protection measure	**−2.3**	−7.6
China penetration, in its place	−1.9	−1.7
Protection, beside China penetration	−2.2	−5.8
China penetration, beside protection	−1.0	−1.2

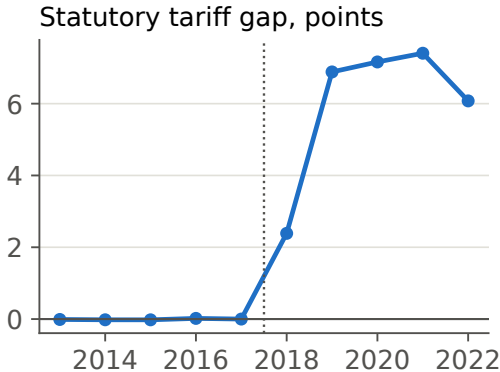
China penetration: China's share of an industry's imports times the import share of the home market, 2016. It correlates at 0.54 with protection. It counts imports from China that were never tariffed, and misses the tariffs on other origins. Wild bootstrap *p* with penetration in place of protection: 0.11. Back

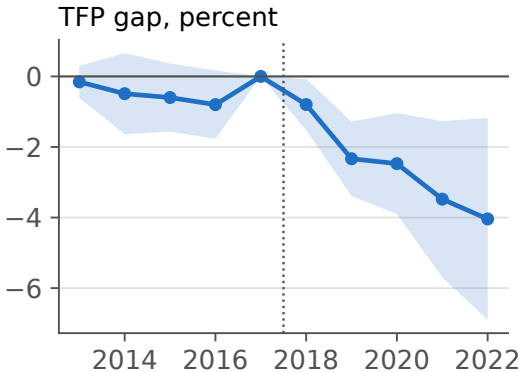
The measure counts every 2018 action, whatever the origin

- Section 232 (steel, aluminum) and Section 201 (solar cells, large residential washers) covered particular products and applied to imports from most countries.
- Section 301, Lists 1 to 3, covered a broad range of products from China alone.
- I rebuild the measures from public sources at four digits. The rebuild correlates at 0.997 with Flaaen and Pierce's rate-weighted measure, on the 83 codes that match. I take the covered products from the Federal Register notices and proclamations, which correct omissions in their lists.
- Data: BLS TFP 1987–2023; imports and exports from Schott; shipments and capital from NBER-CES; input weights from the BEA 2012 Use table.

Back

The statutory rate gives a similar contrast





The same specification with the 2017–19 change in the statutory output tariff as the measure of exposure, at its own interquartile range. Equation (8): —2.7 percent. Per point: —0.39 percent. Back

Before the war exposed industries were gaining

Log TFP, no trend removed, relative to 2017	Coefficient on protection
2014	−1.29
2015	−0.82
2016	−0.32
2018	0.03
2019	−0.43
2020	0.02
Equation (8)	**−1.29**

The statistic of equation (8) is the same with or without detrending. Back

Pandemic controls leave the path in place

Protection measure	Baseline	With pandemic controls
2018	−0.33 (0.19)	−0.43 (0.21)
2019	−1.15 (0.26)	−1.28 (0.21)
2020	−1.05 (0.33)	−1.17 (0.30)
2021	−1.60 (0.53)	−1.94 (0.44)
2022	−2.15 (0.73)	−2.58 (0.61)

Standard errors in parentheses. The target of the model is 2019, which precedes the pandemic. The later years overlap it, with or without these controls. Back

No earlier two-year window shows as large a break

Base year of the window	Coefficient	*t*
1994	0.64	1.00
1998	−0.48	−0.67
2000	−0.71	−0.73
2001	−0.71	−1.02
2002	0.69	1.75
2003	1.03	3.46
2008	−0.64	−0.92
2017 (actual)	**−1.29**	−7.64

Windows at each base year from 1990 to 2011; here the largest of each sign. With at most four non-overlapping windows to a set, the ranking alone cannot reach a conventional significance level. Back

Fastest pre-war risers show no larger break

Split at the median of	Below, percent	Above, percent	Interaction, RI *p*
China's share of imports	−4.6	−2.2	0.62
Import share of absorption	−2.7	−2.5	0.25
Price–cost margin	−2.8	−1.7	0.55
Change in China's import share	−2.5	−1.1	0.19
TFP growth, 2012–14	−3.6	−2.0	0.70
TFP growth, 2012–17	−0.8	−1.9	0.38

Interquartile effect of protection, by split. So I find no sign of a general reversion, though I cannot rule out one specific to this episode. Back

No single industry or sector carries the result

Equation (8), scaled by the full-sample interquartile range	Effect, percent	Smallest $\lvert t \rvert$
All 86 industries	**−2.3**	7.6
One industry out, range	−2.0 to −2.8	4.5
One three-digit sector out, range	−2.1 to −2.7	4.2
Three most exposed industries out	−3.0	3.3

Scaled by the interquartile range of all 86 industries. The three most exposed are other leather, electric lighting and household furniture. Back

Revenue productivity studies compare with the model

Study	Window	Estimate	Model	Model, weighted
Pierce (2011), plants	years 1–9 after the duty, pooled	−0.05	+0.088	+0.008
Konings-Vandenbussche (2008)	1 year after the duty	+4.2	+0.112	+0.094
Amiti-Konings (2007)	2-year difference	+0.01 to +0.14	−0.082	−0.003
Pavcnik (2002)	1982 (3 years after)	+3.0	−0.082	+0.005

First window of each study. Revenue productivity moves with prices and markups as well as with physical productivity, so I set each study beside the model's revenue productivity at the study's own window. Back

07

Backup: model

Model: demand, exporting and entry

$$s = \underbrace{1/N_t}_{\text{equal split}} + \underbrace{\sigma\left(\bar{L}_t - \ln p\right)}_{\text{price against the mean}}, \qquad \mu = 1 + s/\sigma$$

s: a variety's share of spending. p: its consumer price. N_t: measure of varieties sold. $\bar{L}_t$: their mean log price. $\sigma > 0$: preference parameter. μ: markup.

$$\underbrace{d_{X,t}(z_{X,t}) = 0}_{\text{zero export profit at the cutoff}}, \qquad \underbrace{N_{X,t}/N_{D,t} = \left(z_{\min}/z_{X,t}\right)^k}_{\text{share of firms that export}}$$

z: firm productivity. $d_{X,t}(z)$: export profit net of the fixed cost. $z_{X,t}$: export cutoff. $N_{X,t}$, $N_{D,t}$: masses of exporters and producers. $z_{\min}$, k: scale and shape of the Pareto draws.

$$\underbrace{\tilde{v}_t}_{\text{value of a firm}} = \underbrace{w_t f_E / Z_t}_{\text{entry cost}}, \qquad N_{D,t} = \underbrace{(1-\delta)\left(N_{D,t-1} + N_{E,t-1}\right)}_{\text{survivors among last period's producers and entrants}}$$

$\tilde{v}_t$: value of a firm. w_t: real wage. f_E: entry cost in effective labor. Z_t: aggregate technology. $N_{E,t}$: mass of entrants. δ: exit rate.

Households ◂ Back to demand ◂ Back to entry

Model: the household's budget

The household maximizes $E_t \sum_{s \geq t} \beta^{s-t} C_s^{1-\gamma}/(1-\gamma)$ and supplies labor inelastically, subject to

$$\underbrace{B_{t+1} + Q_t B_{*,t+1}}_{\text{bonds bought}} + \underbrace{\frac{\eta}{2} B_{t+1}^2 + \frac{\eta}{2} Q_t B_{*,t+1}^2}_{\text{bond fees}} + \underbrace{\tilde{v}_t N_{H,t} x_{t+1}}_{\text{shares bought}} + C_t$$

$$= \underbrace{(1 + r_t) B_t + Q_t (1 + r_t^*) B_{*,t}}_{\text{bond payoffs}} + \underbrace{(\tilde{d}_t + \tilde{v}_t) N_{D,t} x_t}_{\text{profits and share value}} + \underbrace{w_t L}_{\text{wages}} + \underbrace{T_t^f + T_t}_{\text{rebates}}$$

C_t: consumption. β: discount factor. γ: risk aversion. B_{t+1}, $B_{*,t+1}$: holdings of home and foreign bonds. Q_t: real exchange rate. η: bond fee. $\tilde{v}_t$: price of a claim to a firm. $N_{H,t} = N_{D,t} + N_{E,t}$: firms in existence. x_t: shares in the mutual fund. r_t, r_t^*: real bond returns. $\tilde{d}_t$: average profit per producer. w_t: real wage. L: labor. T_t^f, T_t: rebated bond fee and tariff revenue.

First-order conditions ◂ Back

Model: the household's first-order conditions

A claim to a firm pays only if the firm survives, so the survival rate $1-\delta$ discounts it.

$$\underbrace{\tilde{v}_t}_{\text{price of a claim}} = \beta \underbrace{(1-\delta)}_{\text{survival}} E_t\Big[\underbrace{\left(C_{t+1}/C_t\right)^{-\gamma}}_{\text{relative marginal utility}} \underbrace{\left(\tilde{v}_{t+1}+\tilde{d}_{t+1}\right)}_{\text{resale value and profit}} \Big]$$

The fee is a wedge in the bond conditions. Being rebated, it is not a resource cost.

$$C_t^{-\gamma} \underbrace{(1+\eta B_{t+1})}_{\text{fee wedge}} = \beta(1+r_{t+1})E_t C_{t+1}^{-\gamma}$$

$$C_t^{-\gamma}(1+\eta B_{*,t+1}) = \beta(1+r^*_{t+1})E_t\Big[\underbrace{\frac{Q_{t+1}}{Q_t}}_{\text{currency return}} C_{t+1}^{-\gamma}\Big]$$

All symbols as on the previous slide. δ is the exit rate.

Firms Back

Model: firms under translog

A firm's share of spending in a market depends on its own cost and on two aggregates of that market.

$$s + \sigma \ln(1 + s/\sigma) = \underbrace{1/N_t}_{\text{number of varieties sold}} + \underbrace{\sigma(\bar{L}_t - c)}_{\text{cost against the market's mean price}}$$

c: the firm's log marginal cost in the destination. At home $c = \ln[w_t/(Z_t z)]$, and abroad $c = \ln[(1 + t_t^*)\tau w_t/(Q_t Z_t z)]$. τ: iceberg trade cost. t_t, t_t^*: home and foreign tariffs.

A firm's profit in a market with real expenditure C, where t is that market's tariff, is

$$d(z) = \underbrace{\frac{C}{1+t}}_{\text{spending net of the tariff}} \underbrace{\frac{s(z)^2}{\sigma + s(z)}}_{\text{rises with the share}}$$

The export cutoff equates gross export profit with the fixed cost $w_t f_X/Z_t$, where f_X is the fixed export cost in effective labor.

Closing the model ◂ Back

Model: closing the model under translog

The price index, normalized to one, pins the real wage.

$$\bar{L}_t + \frac{1}{2\sigma N_t} - \frac{\sigma N_t}{2} \underbrace{\left(M_{2,t} - \bar{L}_t^2\right)}_{\text{dispersion of log prices}} = 0$$

$M_{2,t}$: second moment of log prices among varieties sold.

Labor is used in production for each market, in export overhead and in entry.

$$L = \underbrace{N_{D,t} E\left[\frac{s_D C_t}{\mu_D w_t}\right]}_{\text{for home sales}} + \underbrace{N_{X,t} E\left[\frac{Q_t s_X C_t^*}{(1+t_t^*)\mu_X w_t}\right]}_{\text{for export sales}} + \underbrace{\frac{N_{X,t} f_X}{Z_t}}_{\text{export overhead}} + \underbrace{\frac{N_{E,t} f_E}{Z_t}}_{\text{entry}}$$

s_D, s_X, μ_D, μ_X: shares and markups at home and abroad. Expectations are over producers and over exporters. C_t^*: foreign consumption.

Each bond is in zero net supply. Net foreign assets follow from combining the two budget constraints. Tariff revenue is rebated.

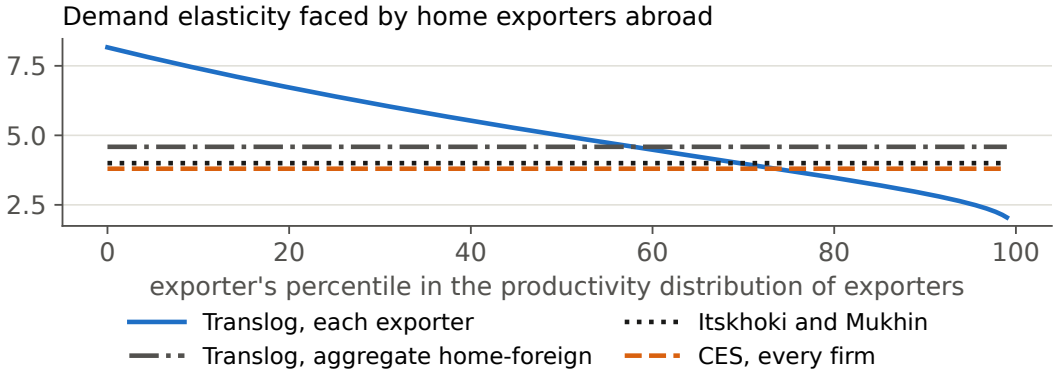
Back

I solve the model exactly, by perfect foresight

- I stack the equilibrium conditions over 6905 quarters, long enough for a shock of persistence 0.999 to decay to a thousandth of its size, and solve by Newton's method with the perfect-foresight solver of Dynare.
- The starting guess is the path implied by the linear decision rules. A solution that does not converge in a few Newton steps counts as a failure.
- Every expectation over Pareto draws is a Gauss-Laguerre sum at nodes that move with the cutoff, which keeps the extensive margin differentiable.
- The exact solution matters for the optimum. A second-order approximation places the one-sector translog optimum at 20 percent, about half the exact 39.

Back

Under translog the elasticity differs across exporters



From 8.16 at the export cutoff to 2.90 at the 90th percentile of exporters, with a sales-weighted mean of 4.27. Back

Parameters of the three-sector model

Parameter	Controls	Most exposed / middle / least exposed
α_j	size of the sector	0.149 / 0.467 / 0.385
τ_j^*	cost of home imports	1.198 / 1.671 / 8.949
τ_j	cost of home exports	1.351 / 1.671 / 5.551
$f_{X,j}$	fixed export cost	0.0065 / 0.0041 / 0.0007
σ_j	markup	6.346 / 1.165 / 0.253
k_j	productivity dispersion	4.768 / 3.297 / 1.171

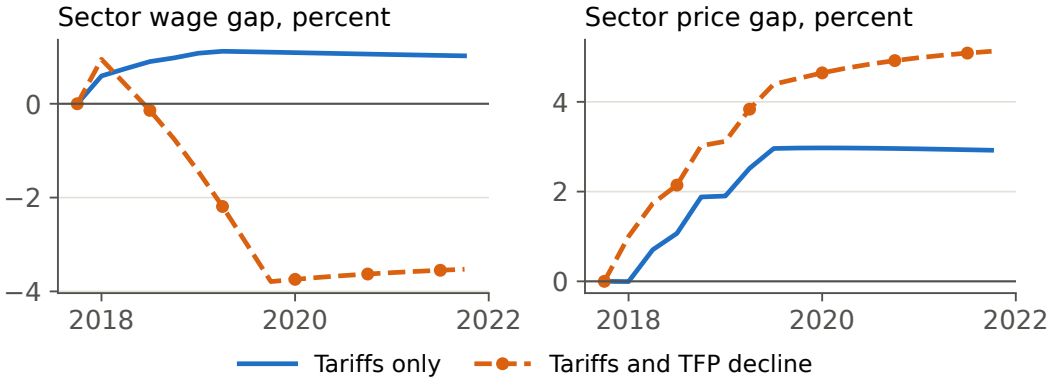
Imports and exports are scaled by a common factor of 1.28 so that trade balances. The markup rule adapts Bilbiie, Ghironi and Melitz (2012) to each sector. The Pareto shape matches the published dispersion of log domestic sales. Back

The model's tariffs follow the dates of the 2018 actions

Points	2018Q1	2018Q4	2019Q2	2019Q4
Most exposed	0.38	4.96	6.59	7.81
Middle	0.00	1.32	1.92	2.37
Least exposed	0.00	0.13	0.17	0.20

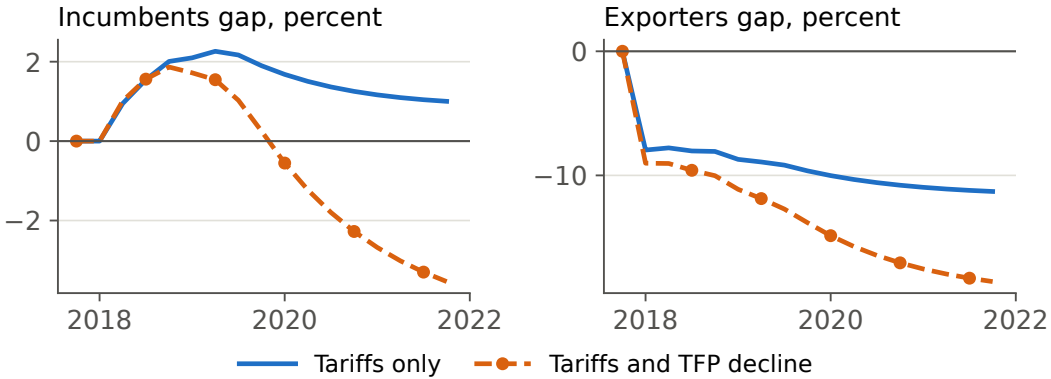
The gap between the outer sectors is 7.62 points by 2019Q4 and 6.6 points as an annual average of 2019, the figure that goes with the annual evidence. Back

With the decline, the protected sector's relative wage falls



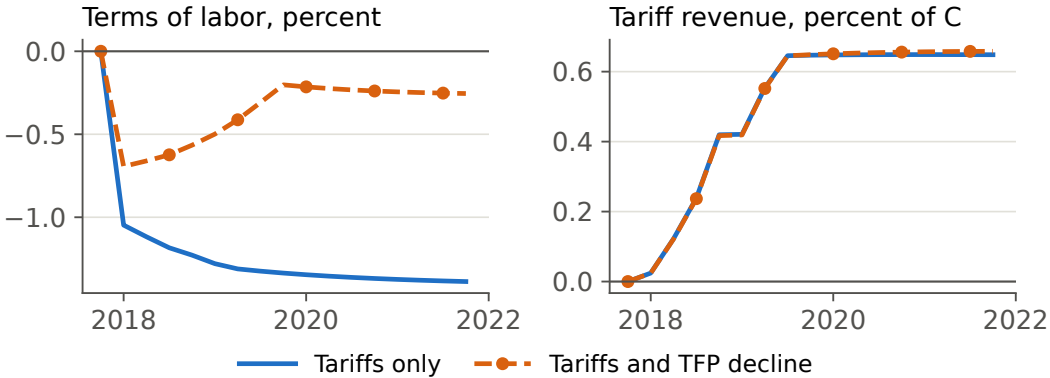
Labor is fixed, so the relative wage absorbs the tariff. With the decline, the sector's price index rises relative to the least exposed sector. Firms Back

The tariffs change the number of firms and exporters



Terms of labor and revenue
Back

The decline cuts the improvement in the terms of labor



The improvement by 2019 goes from —1.31 to —0.36 percent. A fall is a home gain. Back

The real output gap opens earlier in the model

Real output gap, percent	2018	2019
Model, tariffs and technology decline	−4.52	−2.43
Data	−2.54	−6.07

The anticipated tariffs draw a rush of entrants into the protected sector. With labor fixed, the labor they use comes out of production. Back

Level shares: technology, manufacturing TFP and welfare

Share h	Tech., most exposed	Tech., others	Mfg. TFP	Welfare
−0.50	−9.68	−3.23	−3.32	−4.14
−0.20	−7.71	−1.28	−1.74	−2.02
−0.10	−7.06	−0.64	−1.22	−1.31
0.00	−6.41	0.00	−0.70	−0.59
0.10	−5.76	0.64	−0.18	0.13
0.20	−5.11	1.28	0.34	0.85
0.50	−3.18	3.18	1.88	3.04

Percent. The level share h moves part of the gap. The most exposed sector's technology changes by $1-h$ times the news of 2018 and 2019, and the other sectors' by $-h$ times it. The reversal holds as long as manufacturing TFP in 2019 is below −0.27 percent; in the baseline it is −0.70. Back