Tariffs, Automation, and Business Dynamism*

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June 11, 2026

Keywords: Protectionism, Trade Wars, Automation, Business Dynamism

JEL: F30, F40, F41

Abstract

Can protectionism slow automation and revive business dynamism? We study this question in a dynamic open-economy model with heterogeneous firms, endogenous entry, exporter selection, and task-based production in which routine tasks can be performed by workers or robots. Import tariffs reallocate expenditure toward domestic producers, reshape entry and export incentives, and generate revenues rebated to households. In the baseline, a permanent tariff temporarily raises entry and expands domestic varieties, but reduces output per firm, trade volumes, and intermediate production at factor prices. It also lowers CPI-based marginal costs, making automation less attractive and persistently shifting production toward routine labor. Routine workers benefit from transfers, reduced training, and lower automation, while non-routine workers face wage compression and owners gain from domestic demand and aggregate profits. Aggregate welfare effects depend on automation, training, entry, and rebate incidence. Evidence from the 2018–2019 U.S. tariff episode supports the model's task-reallocation and entry-timing mechanisms.

1 Introduction

Automation has transformed manufacturing by raising productivity and product quality, but it has also shifted tasks away from routine workers and contributed to labor-market polarization. This task-based view of automation, and the distinction between productivity gains and displacement effects, is central to the work of Acemoglu and Restrepo (2020) and Acemoglu and Restrepo (2022). At the same time, advanced economies, and the United States in particular, have

*We thank seminar participants at the University of Victoria and University of Nottingham for comments. Devereux thanks SSHRC for research funding. Auray and Eyquem acknowledge financial support from the French National Research Agency (ANR-20-CE26-0018-01).

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increasingly turned to tariffs and related trade restrictions as instruments of industrial policy. These two developments now interact in real time: can higher trade barriers slow automation, tilt the functional distribution of income toward labor, preserve routine jobs, and even help to re-industrialize manufacturing regions that have experienced secular decline? This formulation is reminiscent of the classic infant-industry logic of Hamilton (1790) and List (1841), but with a contemporary twist: the goal is not to protect new industries from foreign competition, but to protect old industries from both trade exposure and technology-induced task displacement. Whether tariffs can do so, and through which margins, depends on how trade policy affects firms' entry decisions, production at incumbent firms, and workers' incentives to acquire non-routine skills.

This paper studies these questions in a dynamic two-country general equilibrium model with heterogeneous firms, endogenous entry, and task-based production. Routine tasks can be performed either by workers or by robots, while non-routine tasks are supplied by skilled workers. Firms choose the degree of automation, routine workers decide whether to acquire non-routine skills through costly training, and potential producers decide whether to enter before learning their productivity. We embed these choices in a Ghironi and Melitz (2005) trade environment with iceberg costs, selection into exporting, and ad valorem import tariffs. The framework therefore allows tariffs to affect not only import demand and exporter selection, but also the extensive margin of domestic production, output per firm, technology adoption, and the allocation of labor across routine and non-routine tasks.

Our main result is that a permanent tariff produces sharply different dynamics across these margins. Protection temporarily shelters domestic producers from foreign competition and induces a short-run increase in the entry rate. As new firms enter, domestic competition intensifies and the flow of entry undershoots and quickly returns toward its steady state, but the cumulative effect is an expansion in the stock of domestic varieties. The response of automation is more persistent. The tariff lowers the producer price of intermediate goods and real marginal cost in CPI units. With the price of robots fixed, automation becomes relatively more expensive, so firms substitute routine labor for robots.[1] The non-routine wage premium falls, the return to training declines, and the economy converges to a permanently lower level of automation and a permanently higher routine employment share. Thus, the tariff's lasting effect is not a sustained entry boom or a strong expansion of productive capacity, but a change in the way incumbent firms produce and in the types of labor they use.

This distinction between the entry and output margins is central to the aggregate results. The tariff redirects domestic expenditure toward home varieties and initially raises the value of serving the domestic market, generating entry and expanding the number of local varieties. Yet total intermediate production falls. The expansion in the stock of domestic varieties is more than offset by a contraction in output per firm, as weaker export demand and the endogenous adjustment of task inputs reduce production along the intensive margin. Counterfactual exercises show that

[1] Our analysis abstracts from trend productivity growth that may be associated with a persistent decline in automation costs. Thus, the results should be interpreted as predicting a decline in automation *relative* to the underlying trend.

shutting down firm entry changes the aggregate output response only modestly. Shutting down automation, by contrast, nearly eliminates the decline in intermediate output and the persistent fall in the non-routine wage premium. The automation margin, rather than the entry margin, is therefore the principal mechanism through which tariffs affect real production and labor demand in the model.

The labor-market consequences are correspondingly uneven. Routine workers benefit from tariff-revenue transfers and from lower training, which raises their effective current labor income; the persistent reduction in automation also preserves a larger role for routine labor in production. Non-routine workers receive the same transfer in the baseline, but their wage falls as demand shifts away from non-routine tasks. Their consumption consequently rises by less than that of routine workers, and their employment share declines over time. Firm owners gain the most under uniform rebates: although entry lowers profits and firm values on a per-firm basis, the number of firms, aggregate profits, and tariff transfers raise owners' consumption. Tariffs therefore do not simply shift income from capital to labor. They redistribute within labor types, toward routine and away from non-routine workers, while potentially benefiting owners through the expansion of domestic varieties and aggregate profits.

Tariff revenues and terms-of-trade movements also raise household purchasing power in the unilateral experiment. As a result, consumption and GDP measured at market prices rise initially even though trade volumes and intermediate output contract. We retain the distinction between market-price and factor-price activity because it is necessary for consistent national accounting and welfare measurement. But it is not the core economic mechanism. The more important finding is that protection changes the composition of activity: an increase in the stock of domestic varieties coexists with lower output per firm, less automation, less training, and a persistent reallocation toward routine labor. Market-price gains therefore should not be interpreted as evidence that tariffs expand productive capacity.

These mechanisms matter for welfare and for the design of trade policy. In the baseline with uniform per-capita rebates, a unilateral tariff raises welfare modestly because tariff revenues and the terms-of-trade improvement increase consumption purchasing power. These gains coexist with lower production and sharply reduced trade. They also depend on the economy's internal adjustment margins. When automation is fixed, intermediate output and the non-routine wage premium respond little, and the welfare gain is larger. Endogenous automation absorbs part of the tariff shock through a socially consequential change in factor use, lowering output and shifting income away from non-routine labor.

As a consequence, the use of tariff revenues is a first-order determinant of both transmission and incidence. Rebating all revenues to routine workers produces a much larger decline in automation and training and a stronger increase in entry, but it also deepens the contraction in output and imposes uncompensated losses on non-routine workers and owners. Under this scheme the welfare-maximizing tariff falls to zero or below. Rebating revenues to owners leaves most aggregate dynamics close to the baseline but concentrates the gains on them and lowers aggregate welfare. A proportional wage subsidy shifts more purchasing power toward non-

routine workers, moderates the reallocation of tasks, and raises the welfare-maximizing tariff relative to the baseline. These experiments show that fiscal incidence not only affects who gains from protection, but also shapes market size, entry, training, and firms' technology choices.

We complement the quantitative analysis with evidence from the 2018–2019 U.S. tariff episode. Using commuting-zone shift-share measures, we distinguish exposure to protection on an industry's output, cost-side exposure transmitted through input requirements, and foreign retaliation. The task-reallocation evidence lines up with the model's novel predictions. Commuting zones with greater cost-side tariff exposure shifted less rapidly away from production- and routine-intensive tasks and less rapidly toward digital or training-intensive manufacturing activity. Evidence on business formation is weaker but displays the predicted timing: realized manufacturing entry is positively associated with tariff cost-side exposure in 2017–2018 and negatively associated with it in 2018–2019. These estimates are suggestive rather than causal, but together they support the model's contrast between a persistent slowing of task reallocation and a short-lived entry response.

Contributions. The paper makes three contributions. First, it develops a framework in which trade protection, business dynamism, and automation are jointly endogenous. Existing models with heterogeneous firms show how tariffs affect markups, export cutoffs, entry, and varieties (e.g. Melitz (2003); Ghironi and Melitz (2005)), while task-based models explain how changes in relative factor prices alter automation and labor-market polarization (e.g. Acemoglu and Restrepo (2020); Acemoglu and Restrepo (2022)). Combining these mechanisms reveals a distinction that is absent when either margin is studied in isolation: tariffs can stimulate entry and expand the stock of domestic varieties while simultaneously reducing production per firm, and the technology response can dominate the extensive margin in determining aggregate output.[2]

Second, we show that tariffs have persistent effects on the composition of technology and labor even when their effect on the entry rate is transitory. A permanent tariff permanently lowers automation, the non-routine wage premium, training, and the non-routine employment share. This result changes how the effects of protection should be interpreted. Tariffs do not merely delay robot adoption before the economy returns to its previous path. They move the economy to a different long-run allocation, with greater relative reliance on routine labor and lower intermediate production. The relevant policy trade-off is therefore between preserving routine tasks and weakening automation, skill acquisition, and output, not between a temporary pause in automation and an otherwise unchanged long run.

Third, the paper provides a distributional and welfare analysis in which the rebate of tariff revenues interacts with entry and technology adoption. Because household groups differ in their

[2]The automation margin has not previously been embedded in an open-economy tariff model, and the variety margin has only recently been considered in Barattieri, Cacciatore, and Ghironi (2021), Bergin and Corsetti (2023), or Alessandria et al. (2025), without emphasizing the competition-sheltering channel. Mandelman and Zlate (2022) develop an open-economy model with immigration, offshoring, and automation to show that forces pushing toward offshoring and automation can contribute to labor-market polarization, but tariffs are absent from their analysis.

labor income, training choices, and ownership of firms, alternative rebate schemes reshape aggregate demand and firms' incentives to enter and automated production as well as the distribution of consumption. The welfare-maximizing tariff can consequently move from an interior positive rate to zero or below depending on who receives the revenue. This result places the fiscal design of protection alongside trade elasticities, market power, and production structure as a central determinant of tariff policy.

The paper proceeds as follows. Section 2 sets out the model and presents an illustrative simple version of the model. Section 3 discusses the calibration. Section 4 presents unilateral tariff experiments focusing on aggregate and distributional effects. Section 5 provides empirical evidence consistent with the main task-reallocation and entry mechanisms. Section 6 reports robustness exercises for the trade elasticity, rebate schemes, and retaliation. Finally, Section 7 looks into the determinants of welfare-maximizing tariffs and their incidence across the population. Section 8 concludes.

Related literature. Our paper bridges the recent macro literature on tariff shocks with research on automation and task reallocation, in a setting that features firm heterogeneity, selection, and entry.

A first strand studies aggregate and distributional responses to tariff shocks in dynamic open-economy models. Early contributions emphasize how protection affects macro aggregates through expenditure switching, relative prices, and the real exchange rate (Erceg, Prestipino, and Raffo, 2023; Lindé and Pescatori, 2019). In models with firm entry and endogenous tradability, protectionist shocks can reshape the extensive margin of trade and production (Barattieri, Cacciatore, and Ghironi, 2021), a mechanism that becomes central once policy also moves markups and cutoffs. Relatedly, Bergin and Corsetti (2020) and Bergin and Corsetti (2023) embed tariffs in international-macro environments with firm entry and monetary policy, showing that the sign and persistence of real effects depend on selection, pass-through, and policy reactions. Carroll and Hur (2023) focus on the distributional implications of the 2018 tariff hikes within a model of heterogeneous agents and in interaction with other distortions (taxes in particular). Our framework shares the emphasis on extensive margins and the structure of trade, but adds an endogenous automation margin that interacts with selection and entry, providing a novel channel through which tariffs alter technology adoption and the composition of labor supply and demand. We also complement these contributions by making fiscal incidence an explicit policy margin: in our environment, the design of tariff-revenue rebates can overturn the sign of welfare effects and affect the welfare-maximizing tariff.

The most recent wave of research focuses on the 'Liberation Day' tariff program: Kalemli-Özcan, Soylu, and Yildirim (2025) highlight the importance of production networks, complementarity in global value chains and sectoral heterogeneity in price rigidities in shaping the effects of tariff hikes; Auclert, Rognlie, and Straub (2025) show how tariffs can improve the trade balance temporarily via contractionary effects on imports and highlight the role of trade elasticities and retaliation; Bianchi and Coulibaly (2025) and Monacelli (2025) focus on the optimal monetary policy response; Auray, Devereux, and Eyquem (2025b) and Auray, Devereux, and Eyquem (2025a)

show the importance of relative size and openness as well as global value chains and nominal rigidities. Using more extensive trade models with sectoral specialization, Rodríguez-Clare, Tintelnot, and Traiberman (2025) and Ignatenko et al. (2025) provide quantitative assessments of the distributional and welfare impacts in the U.S. and globally. We adopt a complementary approach by looking at the entry and automation margins.

Second, micro-to-macro incidence is crucial for evaluating tariffs. Empirically, the 2018 U.S. tariff wave mostly translated into higher domestic prices, limiting producer-surplus gains and lowering real income (Amiti, Redding, and Weinstein, 2019; Fajgelbaum and Khandelwal, 2022). Canonical quantitative trade models have been used to measure general-equilibrium incidence and cross-sector spillovers of trade policy (Caliendo and Parro, 2021). We adopt a compatible demand system (CES across varieties with endogenous cutoffs) so that our tariff experiments map to pass-through and welfare metrics in this literature, while tracking how those same price changes feed back into firms' automation incentives and the wage premium for non-routine skills. Further, our product-market block follows the heterogeneous-firm tradition in which openness affects selection, markups, and aggregate productivity (Melitz, 2003; Ghironi and Melitz, 2005). This provides the backbone for evaluating how tariff-driven changes in market size and expenditure composition translate into cutoffs, entry, and profits – objects that also govern the return to automating tasks in our model.

Third, we connect to the literature on automation as task replacement with displacement and productivity effects (Acemoglu and Restrepo, 2020, 2022). Empirically, industrial robots and related technologies raise productivity but have heterogeneous effects on employment and wages across space and occupations (Graetz and Michaels, 2017; Goos, Manning, and Salomons, 2009). General-equilibrium treatments with taxes or wedges study the efficiency and incidence of automation (Guerreiro, Rebelo, and Teles, 2021; Beraja and Zorzi, 2025); recent work quantifies automation as a shift in factor shares (Moll, Rachel, and Restrepo, 2022) and estimates key switching costs and reallocation frictions (Humlum, 2019). Global value-chain adjustments further affect how automation propagates to labor outcomes (Fontagné et al., 2024). Relative to this literature, we place automation inside an open-economy model with endogenous entry, endogenous tradability and tariffs, so that technology adoption, demand composition, and training co-determine the relative routine wage and the extent of task replacement.

Finally, our emphasis on entry and cutoffs resonates with the macro evidence on rising concentration/markups and declining business dynamism (Decker et al., 2016; De Loecker, Eeckhout, and Unger, 2020; De Loecker, Eeckhout, and Mongey, 2021), and addresses the question of whether tariffs can stimulate business dynamism, which has been declining in the U.S. (Akcigit and Ates, 2023).

2 Model

We build a two-country open-economy model with endogenous entry and export participation, endogenous automation, and heterogeneous labor. In each country there are two families of

workers and a family of firm owners. Families of workers supply differentiated labor – routine and non-routine labor. The relative size of each family of workers is endogenous and responds to the wage premium. The size of the family of firm owners remains fixed.

2.1 Families

We consider two symmetric countries of equal size. The Home economy represents the U.S. while the Foreign economy represents a pool of advanced economies. We focus on the Home economy and assume perfect symmetry in structure and parameters – except for access to international financial markets.

Home families. In the Home economy, there are three families: non-routine workers (h), routine workers (u), and firm owners (e).[3] Let $\lambda_t \in [0,1]$ be the relative size of the non-routine family. Workers can switch family: a fraction s_t of routine workers acquire non-routine skills by paying training costs and become skilled workers, and a fraction δ_w of non-routine workers face skill depreciation and become unskilled workers. The non-routine share evolves as:

$$\lambda_t = (1-\delta_w)\lambda_{t-1} + s_{t-1}(1-\lambda_{t-1}). \tag{1}$$

Both worker families are hand-to-mouth. The non-routine family does not choose any control, while the routine head chooses training s_t to maximize lifetime per-capita welfare:

$$V_t^u = \log(c_t^u) - \frac{\varpi}{\zeta} s_t^\zeta + \beta \mathbb{E}_t \Big\{ (1-s_t) V_{t+1}^u + s_t V_{t+1}^h \Big\}, \tag{2}$$

where $\varpi s_t^\zeta / \zeta$ is a non-convex utility cost of training, and where:

$$V_t^h = \log(c_t^h) + \beta \mathbb{E}_t \Big\{ (1-\delta_w) V_{t+1}^h + \delta_w V_{t+1}^u \Big\}, \tag{3}$$

In these equations, c_t^i is per-capita consumption for family $i \in \{h,u\}$. Optimal training chosen by the routine family gives:

$$\frac{w_t^u \chi^u}{c_t^u} + \varpi s_t^{\zeta-1} = \beta \, \mathbb{E}_t \Big\{ V_{t+1}^h - V_{t+1}^u \Big\}. \tag{4}$$

and shows that higher prospective non-routine wage (or consumption) pushes up acceptable training costs and enlarges the non-routine family. We rebate tariff revenues in equal amounts *per capita*. Defining TR_t as the Home per-capita transfer (to be detailed below), per capita budgets constraints are given by:

$$c_t^h = w_t^h \chi^h + TR_t, \text{ and } c_t^u = (1-s_t) w_t^u \chi^u + TR_t, \tag{5}$$

where χ^h and χ^u are exogenous hours worked per worker.

Firm owners. Owners represent a proportion μ of the population. They produce robots x_t and sell them at exogenous (world-determined) price ϕ_t with zero profits, own intermediate

[3] We separate the distribution of firm profits and access to international financial markets to isolate the effects of shocks on labor-market reallocation.

firms – perfect competition implying zero profits as well in this sector, own current final-goods producers – which make positive profits – and invest in new final-goods producers via a mutual fund. They also hold local bonds. Their (aggregate) budget constraint is:

$$\mu c_t^e + sh_t(n_t + n_{et})\tilde{v}_t + b_t = r_{t-1}b_{t-1} + sh_{t-1}(\tilde{\kappa}_t + \tilde{v}_t)n_t + \phi_t x_t + \mu\, TR_t, \tag{6}$$

where n_t is the number of firms/varieties, n_{et} the number of new firms, $\tilde{v}_t$ the average value of firms and $\tilde{\kappa}_t$ the average profit of these firms. With log preferences so that $\beta^e_{t,t+1} = \beta c^e_t / c^e_{t+1}$, first-order conditions imply:

$$\mathbb{E}_t\{\beta^e_{t,t+1} r_t\} = 1, \tag{7}$$

$$\mathbb{E}_t\{\beta^e_{t,t+1}(1-\delta)(\tilde{\kappa}_{t+1} + \tilde{v}_{t+1})\} = \tilde{v}_t. \tag{8}$$

Imposing $sh_t = sh_{t-1} = 1$,

$$\mu c_t^e + n_t^e \tilde{v}_t + b_t = r_{t-1}b_{t-1} + n_t\tilde{\kappa}_t + \phi_t x_t + \mu\, TR_t. \tag{9}$$

Consumption baskets. For each family $i \in \{h, u, e\}$, consumption is a CES bundle of domestic and imported varieties:

$$c_t^i = \left[n_t^{\frac{\varsigma-1}{\theta}} \int_\Omega c^i_{dt}(\omega)^{\frac{\theta-1}{\theta}}\, d\omega + (n^*_{xt})^{\frac{\varsigma-1}{\theta}} \int_\Omega c^i_{xt}(\omega^*)^{\frac{\theta-1}{\theta}}\, d\omega^* \right]^{\frac{\theta}{\theta-1}}. \tag{10}$$

where n_t and n^*_{xt} are the numbers of domestic and imported varieties per capita, ς governs love for variety and θ is the elasticity of substitution. Let T_t and T^*_t be ad valorem *import* tariffs imposed by the Home and Foreign governments respectively, applied *on top* of iceberg costs. With producer (pre-tariff) prices $\rho_{dt}(\omega)$ and $\rho^*_{xt}(\omega^*)$, the consumer prices of imported varieties are:

$$\rho^{*,c}_{xt}(\omega^*) = (1+T_t)\rho^*_{xt}(\omega^*), \text{ and } \rho^c_{xt}(\omega) = (1+T^*_t)\rho_{xt}(\omega), \tag{11}$$

so optimal demands per capita are:

$$c^i_{dt}(\omega) = \rho_{dt}(\omega)^{-\theta}(n_t)^{\varsigma-1}c^i_t, \text{ and } c^i_{xt}(\omega^*) = \rho^{*,c}_{xt}(\omega^*)^{-\theta}(n^*_{xt})^{\varsigma-1}c^i_t. \tag{12}$$

Foreign families. The Foreign side is analogous, except that firm owners trade both a dollar bond and a local bond and face an adjustment cost on dollar-asset changes $ac^*_t = \frac{\phi_b}{2}\left(b^*_t/q_t - b^*/q\right)^2$ which have the same structure – and generate similar demands – as the consumption good. Note that q_t is the consumption-based real exchange rate from the perspective of the Home economy (an increase in q_t means a real depreciation).

2.2 Production

Intermediate goods. In the intermediate sector, a representative firm uses a quantity of non-routine labor ℓ^h_t and a combination of routine labor ℓ^u_t and robots x_t to produce y_t units of intermediate goods. Among automatable tasks, only a time-varying fraction $a_t \in [0,1]$ of automatable tasks are effectively automated and performed by robots, and the remaining fraction

$1 - a_t$ is performed by routine workers. As shown by Acemoglu and Restrepo (2022), the key underlying assumption is that routine labor and robots are strong substitutes to perform automated tasks.[4] Guerreiro, Rebelo, and Teles (2021) build on this idea for automatable tasks and assume a Cobb-Douglas combination of automatable and non-automatable tasks. We adopt a more general CES representation, allowing both types of tasks to be complement. Our production function of intermediate goods is thus:

$$y_t = \left(\alpha \left(\psi_t \xi \ell_t^h\right)^\nu + (1-\alpha)\,\mathcal{A}_t^\nu\right)^{\frac{1}{\nu}}, \tag{13}$$

where ξ is the relative productivity of non-routine workers, ψ_t is the productivity of labor, ν determines the substitutability of routine and non-routine tasks, and $\mathcal{A}_t$ is a bundle of routine tasks:

$$\mathcal{A}_t = \left[\int_0^{a_t} (x_{it})^\iota \, di + \int_{a_t}^1 (\psi_t \ell_{it}^u)^\iota \, di\right]^{\frac{1}{\iota}}, \tag{14}$$

where ι determines the elasticity of substitution among automatable tasks. Let mc_t denote the relative price at which the intermediate good is sold to final goods producers – which will also be their marginal production cost, the representative intermediate firm maximizes its profits:

$$\Pi_{yt} = mc_t y_t - \phi_t \int_0^{a_t} x_{it} di - w_t^u \int_{a_t}^1 \ell_{it}^u di - w_t^h \ell_t^h. \tag{15}$$

The first-order condition with respect to non-routine labor is independent from the type of task completed and yields:

$$\alpha \left(\frac{y_t}{\psi_t \xi \ell_t^h}\right)^{1-\nu} = \frac{w_t^h}{\psi_t \xi m c_t}. \tag{16}$$

This equation shows that the demand for non-routine labor depend positively on the production of intermediate goods y_t and negatively on the non-routine real wage relative to the price of the intermediate good. The first-order conditions for routine labor and robots depend on whether task i is automated or not:

$$(1-\alpha)\left(\frac{\mathcal{A}_t}{x_{it}}\right)^{1-\iota}\left(\frac{y_t}{\mathcal{A}_t}\right)^{1-\nu} = \frac{\phi_t}{mc_t}, \text{ for } i \in [0, a_t], \tag{17}$$

$$(1-\alpha)\left(\frac{\mathcal{A}_t}{\psi_t \ell_{it}^u}\right)^{1-\iota}\left(\frac{y_t}{\mathcal{A}_t}\right)^{1-\nu} = \frac{w_t^u}{\psi_t mc_t}, \text{ for } i \in (a_t, 1]. \tag{18}$$

As discussed in Guerreiro, Rebelo, and Teles (2021), it follows that anything else than $w_t^u/\psi_t = \phi_t$ either yields full automation ($a_t = a = 1$ if $\phi_t < w_t^u/\psi_t$) or null automation ($a_t = a = 0$ if $\phi_t > w_t^u/\psi_t$). If a_t is to be interior, a necessary condition is thus $w_t^u/\psi_t = \phi_t$. Finally, since the production technology has constant returns to scale, $\Pi_{yt} = 0$ and mc_t, the real price of the intermediate good, is also the real marginal production cost. An equilibrium with interior

[4] Acemoglu and Restrepo (2022) show clearly that this type of productive transformation is different from any alternative way of modeling automation (including skill-biased or capital-biased technical change).

automation thus implies $x_{it} = \psi_t \ell_{jt}^u$ for any $i \in [0, a_t]$ and for any $j \in (a_t, 1]$. As a consequence, the degree of automation is given by:

$$a_t = \frac{x_t}{x_t + \psi_t \ell_t^u}, \tag{19}$$

where $x_t = a_t x_{it}$ is the aggregate stock of robots. Accordingly, using $x_{it} = \frac{x_t}{a_t} = \frac{\psi_t \ell_t^u}{1-a_t} = \mathcal{A}_t$, the aggregate production function writes:

$$y_t = \psi_t \left(\alpha \left(\xi \ell_t^h \right)^\nu + (1-\alpha) \left(\frac{\ell_t^u}{1-a_t} \right)^\nu \right)^{\frac{1}{\nu}}, \tag{20}$$

and the first-order condition on robots implies:

$$a_t = 1 - \left(\frac{1}{\alpha} \left(\frac{\phi_t}{(1-\alpha)\, mc_t} \right)^{\frac{\nu}{1-\nu}} - \frac{1-\alpha}{\alpha} \right)^{\frac{1}{\nu}} \frac{\ell_t^u}{\xi \ell_t^h}, \text{ with } 0 \leq a_t \leq 1. \tag{21}$$

Equation (21) is key. It shows that the dynamics of automation critically depends on the relative price of robots ϕ_t relative to the marginal cost mc_t. As the latter moves, a first direct effect stems from the direct substitution (displacement) of routine workers in the production process, pushing a_t up (down) when ϕ_t / mc_t goes down (up). Further, as ϕ_t / mc_t moves, the price of other production factors may change, changing the non-routine wage premium, which may alter relative labor supply and thus $\ell_t^u / \left(\xi \ell_t^h \right)$, which can act as reinforcing or dampening automation. As a consequence, in this framework, any shock affecting the marginal production cost or the relative amounts of labor types used in production has implications for endogenous automation.

Final goods. A continuum of heterogeneous firms transform intermediates one-for-one, pay a sunk entry cost f_e paid in units of intermediate goods, and – if exporting and pricing in the local currency – pay a per-period export cost f_x (also paid in units of intermediate goods) and iceberg trade costs τ. With firm-specific productivity z (following a Pareto distribution with lower bound $z_{\min}$ and shape parameter $\varepsilon > \theta - 1$), the production of each firm writes $y_t(z) = z\, y_{mt}(z)$ and optimal local-currency pricing is:[5]

$$\rho_{dt}(z) = \frac{\theta}{\theta - 1} \frac{mc_t}{z}, \text{ and } \rho_{xt}(z) = (1+\tau) \frac{\theta}{\theta - 1} \frac{mc_t}{q_t z}. \tag{22}$$

The corresponding profits made on domestic and export sales at producer prices are thus:

$$\kappa_{dt}(z) = \left(\rho_{dt}(z) - mc_t / z \right) y_{dt}(z), \text{ and } \kappa_{xt}(z) = \left(q_t \rho_{xt}(z) - (1+\tau) mc_t / z \right) y_{xt}(z) - f_x mc_t. \tag{23}$$

Entry occurs one period before production and thus the expected average value of a firm $\tilde{v}_t$ must equal the entry cost $f_e mc_t$. Given the Euler equation on the mutual fund, this implies:

$$\mathbb{E}_t \left\{ \beta_{t,t+1}^e (1-\delta) \left(\widetilde{\kappa}_{t+1} + f_e mc_{t+1} \right) \right\} = f_e mc_t, \tag{24}$$

[5]The Ghironi and Melitz (2005) model features local currency pricing as a baseline assumption.

and the export productivity cutoff is determined by a zero-profit condition on the marginal exporter:

$$z_{xt} = \frac{(1+T_t^*)(1+\tau)}{\theta-1}\left(\frac{\theta mc_t}{q_t}\right)^{\frac{\theta}{\theta-1}}\left(\frac{f_x}{n_{xt}^{\varsigma-1}\Phi_t^*}\right)^{\frac{1}{\theta-1}}, \tag{25}$$

where $\Phi_t^* = (1-\mu)\left(\lambda_t^* c_t^{h*} + (1-\lambda_t^*)c_t^{u*}\right) + \mu(c_t^{e*} + ac_t^*)$ is Foreign consumption. The export cut-off rises with trade costs τ, the tariff rate applied to Home exporters by the Foreign government T_t^*, the marginal production cost mc_t or the export cost f_x, which lowers the number of exporters in the Home economy. On the contrary, the cut-off declines with total Foreign consumption Φ_t^* or with the real exchange rate depreciation – signalling more competitive exports when q_t increases.

2.3 Aggregation and Data Consistency

We define average productivities as in Melitz (2003): $Z_t = n_t^{\frac{\varsigma}{\theta-1}} \bigtriangledown z_{\min}$ for domestic producers and $Z_{xt} = n_{xt}^{\frac{\varsigma}{\theta-1}} \bigtriangledown z_{xt}$ for exporters with $\bigtriangledown = (\varepsilon/(\varepsilon-(\theta-1)))^{1/(\theta-1)}$. We normalize $z_{\min} = 1$ without loss of generality. Average producer prices are:

$$\widetilde{\rho}_{dt} = \frac{\theta}{\theta-1}\frac{mc_t}{\bigtriangledown}, \text{ and } \widetilde{\rho}_{xt} = (1+\tau)\frac{\theta}{\theta-1}\frac{mc_t}{q_t \bigtriangledown z_{xt}}, \tag{26}$$

while consumer prices for imports include tariffs:

$$\widetilde{\rho}_{xt}^{c} = (1+T_t^*)\,\widetilde{\rho}_{xt}, \text{ and } \widetilde{\rho}_{xt}^{*,c} = (1+T_t)\,\widetilde{\rho}_{xt}^{*}. \tag{27}$$

Average profits per capita are $\widetilde{\kappa}_t = \widetilde{\kappa}_{dt} + (n_{xt}/n_t)\widetilde{\kappa}_{xt}$ with:

$$\widetilde{\kappa}_{dt} = \frac{1}{\theta}\widetilde{\rho}_{dt}^{1-\theta} n_t^{\varsigma-1}\Phi_t, \text{ and } \widetilde{\kappa}_{xt} = \left(\frac{\theta-1-\varepsilon T_t^*/(1+T_t^*)}{\varepsilon-(\theta-1)}\right) f_x mc_t, \tag{28}$$

Variety effect and consumption price index. The consumption aggregator exhibits love for variety across domestic and imported goods. The corresponding dual price index embeds both the number of available varieties and the prices at which they are consumed. Since imports are subject to tariffs, the relevant import price entering the consumption price index is the tariff-inclusive price $\rho_{xt}^{*,c}$. The condition:

$$n_t^{\varsigma}\widetilde{\rho}_{dt}^{1-\theta} + (n_{xt}^*)^{\varsigma}(\widetilde{\rho}_{xt}^{*,c})^{1-\theta} = 1$$

therefore implicitly normalizes the CPI to unity. Under this convention, changes in tariffs affect the CPI not only through relative prices but also through the variety channel. Consequently, the consumption index c_t^i consistently measures real consumption in CPI units, which is the relevant object for welfare analysis.

Market clearing, GDP, and external accounts Labor markets clear at:

$$\ell_t^h = (1-\mu)\lambda_t\chi^h, \text{ and } \ell_t^u = (1-\mu)(1-\lambda_t)(1-s_t)\chi^u. \tag{29}$$

Letting aggregate per-capita consumption in each country be:

$$\Phi_t = (1-\mu)\left(\lambda_t c_t^h + (1-\lambda_t)c_t^u\right) + \mu c_t^e, \text{and } \Phi_t^* = (1-\mu)\left(\lambda_t^* c_t^{h*} + (1-\lambda_t^*)c_t^{u*}\right) + \mu(c_t^{e*} + a c_t^*), \tag{30}$$

the Home intermediates market clearing is:

$$y_t = \widetilde{\rho}_{dt}^{-\theta} \bigtriangledown^{-1} n_t^{\varsigma} \Phi_t + (1+\tau)\ (\widetilde{\rho}_{xt}^{c})^{-\theta}\ (\bigtriangledown z_{xt})^{-1} n_{xt}^{\varsigma}\, \Phi_t^* + n_{et} f_e + n_{xt} f_x, \tag{31}$$

Let the Home and Foreign import bills per capita at consumer (i.e. local) prices be:

$$\text{IM}_t = \text{EX}_t^* = (n_{xt}^*)^{\varsigma} (\widetilde{\rho}_{xt}^{*,c})^{1-\theta} \Phi_t, \text{ and } \text{IM}_t^* = \text{EX}_t = (n_{xt})^{\varsigma} (\widetilde{\rho}_{xt}^{c})^{1-\theta} \Phi_t^*, \tag{32}$$

then the final-goods sales by Home producers are:

$$y_t^c = n_t^{\varsigma} \widetilde{\rho}_{dt}^{1-\theta} \Phi_t + q_t \text{EX}_t / (1+T_t^*). \tag{33}$$

Market-price versus factor-price measures of GDP. In the presence of tariffs, it is useful to distinguish between GDP evaluated at market prices and at factor prices. In the model, three fully equivalent and data-consistent measure of GDP per capita are:

$$y_t^{gdp} = \underbrace{\Phi_t + n_t^e f_e mc_t + nx_t}_{\text{Expenditure}} = \underbrace{\Pi_t + \phi_t x_t + w_t^h \ell_t^h + w_t^u \ell_t^u + TR_t}_{\text{Income}} = \underbrace{y_t^s + n_{et} f_e mc_t + TR_t}_{\text{Sales/production}} \tag{34}$$

where $\Pi_t = y_t^s/\theta - n_{xt} f_x mc_t$. These are measures of GDP *at market prices*, since product taxes (here, tariffs) are part of national income in national accounts. A model-consistent measure of GDP *at factor prices* excludes product taxes and is obtained by netting out tariff revenues:

$$y_t^{gdp,f} \equiv y_t^{gdp} - TR_t. \tag{35}$$

Because the model is written in CPI units (with the consumption price index normalized through the dual price-index/variety condition), both y_t^{gdp} and $y_t^{gdp,f}$ are expressed in the same numeraire. If one wishes to express factor-price GDP in *producer-price (PPI) units* – i.e., as a measure closer to "real production" evaluated at producer prices – one can further rescale by the relative price wedge between the CPI and a producer-price index P_t^P:

$$\widetilde{y}_t^{gdp,f} \equiv \frac{P_t^C}{P_t^P}\, y_t^{gdp,f}, \tag{36}$$

where under our normalization $P_t^C = 1$. This distinction clarifies why tariffs may increase GDP at market prices through tariff revenues while reducing factor-price output by distorting production and trade patterns, without implying any inconsistency for welfare analysis based on consumption in CPI units.

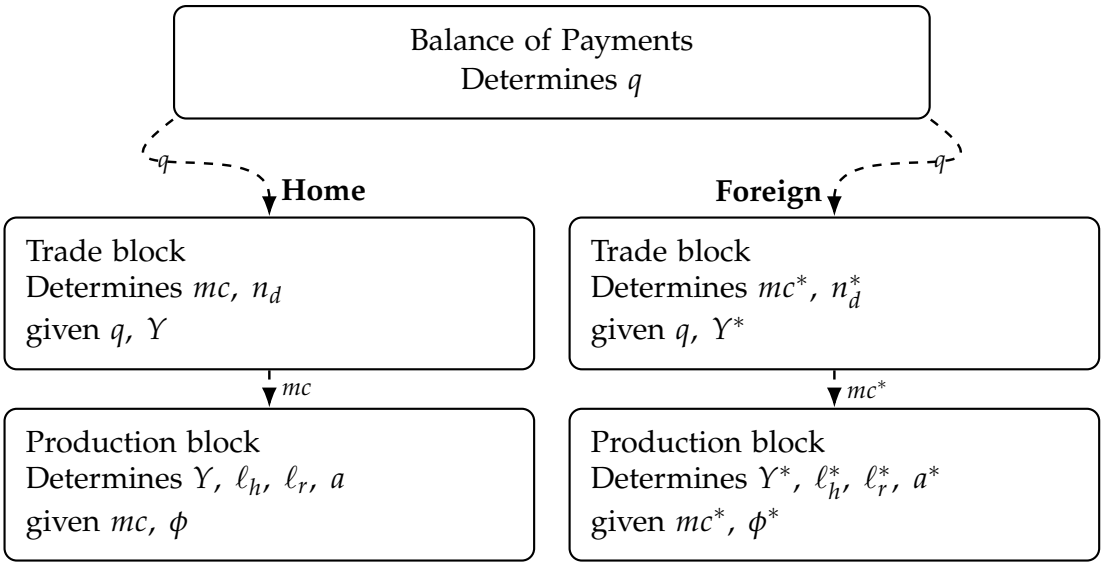
Government budget, per-capita rebates and NFA dynamics. Tariff revenues per capita are:

$$TR_t = \frac{T_t}{1+T_t}\,\text{IM}_t, \qquad TR_t^* = \frac{T_t^*}{1+T_t^*}\,\text{IM}_t^*. \tag{37}$$

which enter each family's budget. Bond-market clearing and NFA dynamics (removing tariff revenues) are given by:

$$q_t b_t + b_t^* = 0, \text{ and } b_t - r_{t-1} b_{t-1} = q_t \frac{\text{EX}_t}{1+T_t^*} - \frac{\text{IM}_t}{1+T_t}. \tag{38}$$

Figure 1: Plan of the Static Example



2.4 A Simple Static Example

Before turning to the calibration and solution of the full model, we present a simplified static version that isolates the main mechanisms in the paper. The example combines a two-country trade block with a static production block featuring non-routine labor, routine labor, and endogenous automation. The objective is not to reproduce all margins of the quantitative model, but to clarify how tariffs affect relative prices, marginal costs, labor allocation across tasks, and automation.

Figure 1 summarizes the structure of the example. Countries are linked through balanced trade. In each country, the trade block determines the real marginal cost of final producers and the mass of active firms, taking the real exchange rate and intermediate output as given. The production block then determines intermediate output, task allocation, and automation, taking marginal cost and the robot price as given. To keep the algebra transparent, we abstract from firm heterogeneity and assume that all firms export. Hence, contrary to the full model already discussed, the static example does not distinguish firms serving only the domestic market from exporters.

We use the same notation as in the full model whenever possible. Home variables are unstarred and Foreign variables are starred. The Home tariff is T, with $T = 0$ in the symmetric benchmark. The real exchange rate is q, which is defined as the Foreign CPI relative to the Home CPI in a common currency, so q is defined so that a fall in q is a Home real appreciation. The elasticity of substitution across varieties is $\theta > 1$. The CPI-deflated producer price of a Home variety is ρ_d, and profit maximization implies $\rho_d = \frac{\theta}{\theta-1} mc$, where mc is the CPI-deflated marginal cost (and price) of producing the intermediate input. Foreign variables satisfy analogous conditions.

Trade block. Consider first the trade block. Taking aggregate intermediate output in each country, Y and Y^*, as given, final-goods firms maximize profits subject to CES demand. Since all firms export, the demand faced by a Home firm is:

$$\tilde{y} = \rho_d^{-\theta} c + \left(\frac{\rho_d}{q}\right)^{-\theta} c^*.$$

With a fixed operating cost f_e (in terms of the intermediate good), free entry implies constant per-firm output: $\tilde{y} = (\theta - 1) f_e$. Then for a given level of intermediate output, the measure of Home and Foreign firms is given by $n_d = \frac{Y}{\theta f_e}$, $n_d^* = \frac{Y^*}{\theta f_e}$.

For given Y and Y^*, the trade block solves for c, c^*, ρ_d, ρ_d^*, and q from the two goods-market-clearing conditions:

$$\tilde{y} = \rho_d^{-\theta} c + \left(\frac{\rho_d}{q}\right)^{-\theta} c^*, \qquad \tilde{y} = \left[(1+T) q \rho_d^*\right]^{-\theta} c + (\rho_d^*)^{-\theta} c^*$$

the two CPI normalizations:

$$1 = n_d \rho_d^{1-\theta} + n_d^* \left[(1+T) q \rho_d^*\right]^{1-\theta}, \qquad 1 = n_d \left(\frac{\rho_d}{q}\right)^{1-\theta} + n_d^* (\rho_d^*)^{1-\theta}$$

and the balanced-trade condition at producer prices:

$$q n_d \left(\frac{\rho_d}{q}\right)^{1-\theta} c^* = n_d^* (q \rho_d^*)^{1-\theta} (1+T)^{-\theta} c. \tag{39}$$

Tariff revenues are rebated lump-sum to the representative household.

Log-linearizing around a symmetric zero-tariff benchmark gives:

$$\widehat{q} = -\frac{T}{2}, \tag{40}$$

$$\widehat{\rho}_d = \widehat{\rho}_d^* = -\frac{T}{4} + \frac{\widehat{Y} + \widehat{Y}^*}{2(\theta - 1)}, \tag{41}$$

$$\widehat{c} = \frac{T}{4} + \frac{(2\theta - 1)\widehat{Y} + \widehat{Y}^*}{2(\theta - 1)}, \tag{42}$$

$$\widehat{c}^* = -\frac{T}{4} + \frac{\widehat{Y} + (2\theta - 1)\widehat{Y}^*}{2(\theta - 1)}. \tag{43}$$

These expressions solve the trade block conditional on $\widehat{Y}$ and $\widehat{Y}^*$. They do not impose symmetry in production responses. A tariff increase leads to an appreciation of the Home real exchange rate and for given output levels raises Home consumption while lowering Foreign consumption. This reflects the standard terms-of-trade and tariff-revenue channel. The real exchange rate is independent of relative output levels, since in this symmetric example, purchasing power parity would hold, absent the tariff. A rise in output in either country increases consumption in both countries, but a rise in Y raises Home output more, due to the rise in demand for Home exports shown by (39). The direct impact of the tariff reduces producer prices in both countries equally, but again the response of producer prices also depends on the endogenous response of output, through the change in the mass of active firms.

Production and automation. The production block determines intermediate output, task allocation, and automation. Each Home firm's intermediate output is produced according to:

$$Y = A(\ell^h)^{\alpha}\left(\frac{\ell^u}{1-a}\right)^{1-\alpha}, \tag{44}$$

where ℓ^h is non-routine labor, ℓ^u is routine labor, and $a \in [0,1)$ is the share of routine tasks performed by robots. The first-order conditions for non-routine labor and the routine labor - automation composite are:

$$\rho_d \alpha Y = w^h \ell^h, \qquad \rho_d (1-\alpha) Y = w^u \frac{\ell^u}{1-a}.$$

Routine labor is paid its outside option, pinned down by the robot cost $w^u = \phi$.

Instead of modelling endogenous training explicitly, we summarize short-run frictions in reallocating labor into non-routine tasks through the following reduced form relationship:

$$w^h = w^u (\ell^h)^{\omega_\ell}$$

Finally, labor-market clearing requires:

$$\ell^h + \ell^u = L. \tag{45}$$

Now define the following expressions:

$$\gamma \equiv \frac{1+(1-\alpha)\omega_\ell}{\alpha\omega_\ell}, \qquad \Delta \equiv 1 - \frac{\gamma}{\theta - 1}, \qquad \kappa \equiv \frac{\bar{\ell}_h}{\bar{\ell}_r}.$$

In what follows, we assume that $\Delta > 0$. The production block implies:

$$\widehat{Y} = \gamma \widehat{\rho}_d, \qquad \widehat{Y}^* = \gamma \widehat{\rho}_d^*.$$

Total output (and therefore the mass of firms) depends uniquely on the movement in producer prices. Combining this relation with the trade-block solution yields:

$$\begin{aligned}
\widehat{q} &= -\frac{T}{2}, \\
\widehat{\rho}_d = \widehat{\rho}_d^* &= -\frac{T}{4\Delta}, \\
\widehat{Y} = \widehat{Y}^* &= -\frac{\gamma T}{4\Delta}, \\
\widehat{\ell}_h = \widehat{\ell}_h^* &= -\frac{T}{4\alpha\omega_\ell\Delta}, \\
\widehat{\ell}_r = \widehat{\ell}_r^* &= \frac{\kappa T}{4\alpha\omega_\ell\Delta}, \\
\Delta a = \Delta a^* &= -\frac{\chi_a T}{4\alpha\omega_\ell\Delta},
\end{aligned}$$

where:

$$\chi_a \equiv (1-\bar{a})(1+\omega_\ell+\kappa).$$

We can explain these responses as follows. Note from the trade block results, a tariff shock reduces producer prices directly as in Equation (41). But the fall in producer prices leads to a fall in intermediary production which in turn reduces firm entry. This leads to a multiplier effect, since $\Delta^{-1} > 1$, so that producer prices must fall even more. The fall in producer prices lowers the value marginal product of both non-routine labor and routine labor. But since the wage of routine labor is set equal to the cost of robots, all adjustment has to take place through a fall in the non-routine wage premium. This leads to a reallocation of labor toward routine tasks. At the same time, the fall in producer prices must lead to a downward adjustment in the routine labor-automation composite $\left(\frac{\ell^u}{1-a}\right)$. Automation therefore falls. The tariff shock therefore reduces the incentive to replace routine workers with robots.[6]

The corresponding consumption responses are:

$$\widehat{c} = \frac{T}{4}\left[1 - \frac{\theta\gamma}{(\theta-1)-\gamma}\right], \qquad \widehat{c^*} = -\frac{T}{4}\left[1 + \frac{\theta\gamma}{(\theta-1)-\gamma}\right]. \tag{46}$$

Foreign consumption falls unambiguously. Home consumption may rise or fall. The first term in the expression of $\hat{c}$ is the terms-of-trade and tariff-revenue gain. The second term captures the endogenous contraction in production.

GDP at market prices versus factor cost A different interpretation may be shown by linking the discussion to Equation (34) of the general model. From the trade block we may write the home economy budget constraint (given balanced trade) in the following way:

$$c = \rho_d Y + T n_x^* (q\rho_d^*)^{1-\theta}(1+T)^{-\theta} c$$

The first expression on the right hand side is GDP at factor cost, while the second expression is revenue collected from the tariff. The equation indicates that total GDP at market prices, which is c (given that the CPI is normalized to unity) is the sum of the two. In this example, the tariff unambiguously reduces GDP at factor cost. But the rise in tariff revenue may be sufficient to raise overall GDP, and hence welfare for the Home country. Thus, a tariff can raise purchasing power through valuation and fiscal channels, but that this effect can be overturned by the fall in factor-price output.

Firm entry and exporting In this simple version, firm entry falls because $\widehat{n}_d (= \widehat{n}_d^*) = \widehat{Y} = -\frac{\gamma T}{4\Delta}$. This is a consequence of the assumption that all firms export and that the model does not distinguish purely domestic producers from exporters. The full model restores this distinction and shows that a tariff can increase the mass of firms serving the domestic market while reducing export participation. Even in the static example, however, firms redirect sales toward the domestic

[6]Note, if we removed the automation margin, it is straightforward to show that intermediate output would be unchanged, since the fall in producer costs would leave the non-routine / routine employment margin unchanged, and with inelastic labor supply total employment in each task would be unchanged. This property carries over to the full model, as shown below. It illustrates an important general result of the paper, showing that the task automation margin plays a large role in shaping the response to tariff increases.

market. Let $s_d \equiv n_d \rho_d^{-\theta} c$ denote total sales of Home varieties to Home consumers. Then:

$$\widehat{s}_d = \widehat{c} + \frac{\theta - \gamma}{4\Delta} T.$$

Since $\theta > \gamma$, an increase in Home consumption is sufficient, though not necessary, for domestic sales to rise despite the fall in total production. Thus the static model captures the expenditure-switching force that reallocates demand toward Home varieties, while the full model is needed to evaluate the associated entry and exporter-selection margins.

In summary, this static example shows that tariffs affect the economy through more than trade flows and the terms of trade. A tariff appreciates the Home real exchange rate, lowers CPI-deflated marginal costs, reduces non-routine labor demand, reallocates labor toward routine tasks, and slows automation. We now turn to the full dynamic model, where exporter selection, domestic entry, tariff-revenue incidence, and intertemporal firm values are disciplined jointly.

3 Calibration

Our baseline inherits the model environment, parameterizations logic, and steady-state mapping from Auray and Eyquem (2025). We keep most parameters to their value but reset moments that have significantly moved since the mid 1980's: (i) the extent of automation (share of automatable tasks actually automated in steady state (a); (ii) the share of routine labor in total employment; and (iii) gross trade openness of the U.S. economy (exports+imports over GDP). The first reflects the diffusion of robotization and task-biased technologies over the last decades (Acemoglu and Restrepo, 2022, 2020; Graetz and Michaels, 2017); the second captures the post-1990 rise in U.S. trade exposure.

Preferences, training, and demographics. We retain the workers' discount factor $\beta = 0.96$, the owner share $\mu = 0.10$, and fixed hours $(\chi^h, \chi^u) = (0.27, 0.30)$. The steady-state non-routine share is $\lambda^{ss} = 0.6$ to match the observed non-routine employment to routine employment $\lambda^{ss}/(1 - \lambda^{ss}) = 1.5$. Incidentally this number is very close to the share reported by Jaimovich and Siu (2020) for 2017. Skill depreciation is $\delta_w = 0.025$, and the steady-state training rate s^{ss} is implied by (1). The curvature of training costs is $\zeta = 4.4372$, as estimated in Auray and Eyquem (2025) and $\varpi = 2.2345 \times 10^5$ adjusts to be consistent with other targets.

Technology and tasks. We keep the CES aggregator across task bundles with $\nu = -4.4384$ as in Auray and Eyquem (2025), and the task share parameter $\alpha = 0.48$, as in Guerreiro, Rebelo, and Teles (2021). Labor-efficiency terms ψ are normalized to one to isolate the effects of trade and automation.[7] The relative efficiency of non-routine labor ξ is set to match the non-routine wage premium (1.56) last computed from the Eden and Gaggl (2018) series for 2013.

[7] In robustness we allow $(\psi, \psi^*) \neq (1, 1)$ to match relative income per capita differentials.

Varieties and market structure. The elasticity across varieties is $\theta = 3.8$ and the Pareto shape $\varepsilon = 3.4$ (see Ghironi and Melitz (2005)). The love-for-variety parameter is $\varsigma = 0.1863$ as estimated by Auray and Eyquem (2025). The exit rate is $\delta = 0.125$, in line with the average annual death rate of firms reported by the U.S. Census Bureau Business Dynamics Statistics. These values pin down markups, selection, and the value of an entrant exactly as in Auray and Eyquem (2025). Regarding varieties, we normalize $n = n^* = 1$ and impose a 20% fraction of exporting firms by adjusting $f_e = f_e^*$ and $f_x = f_x^*$.

Automation. We set the steady-state automation share to $a = 0.205$, consistent with a value of 0.06 for the mid-1980's (as in Auray and Eyquem (2025)) and with a +14-15pp task displacement between 1984 and 2016 reported by Acemoglu and Restrepo (2022) for their median group. Given (α, ν) and the wage premium, we adjust $\bar{\phi}$ and ξ from (21) to implement the target a while achieving the targeted wage premium.

Trade, tariffs and Financial sector. Baseline ad valorem import tariffs are set to $\bar{T} = 0.03$ in both countries, in line with small MFN tariffs prevailing before 2025. We target *gross trade openness* to 25% for the U.S. in steady state and impose an iceberg cost $\tau = 0.615$ to match the ratio.[8] All experiments start from the symmetric baseline $(\bar{T}, \bar{T}^*) = (0.03, 0.03)$; counterfactual tariff shocks are then introduced as permanent changes to (T_t, T_t^*) on top of iceberg costs, with tariff revenue rebated lump-sum to households. The adjustment cost on changes in U.S. bonds purchased by Foreign firm owners is $\phi_b = 0.01$ as in Ghironi and Melitz (2005).

Table 1 summarizes the baseline calibration and targets.

4 Baseline experiment

Starting from a symmetric steady state with $(T, T^*) = (0.03, 0.03)$, we raise the U.S. import tariff permanently to $T = 0.13$, holding T^* fixed.[9] Figure 2 reports impulse responses for output, consumption, entry, variety counts, automation a_t, exports and imports, and the trade balance. We further decompose the responses by shutting down (i) variety margins (both domestic and traded), (ii) automation, and (iii) training.

Expenditure switching and the real exchange rate. The tariff increase has the standard effects on demand and relative prices. There is an expenditure switching away from imports and towards domestic varieties, as the consumer price of imports rises. This leads to an appreciation of the CPI-based real exchange rate (panel o). Imported quantities fall sharply on impact (panel k). US exports, measured in units of domestic goods and net of foreign tariffs, also decline (panel j) as the real appreciation erodes U.S. export competitiveness and tightens the export cutoff.

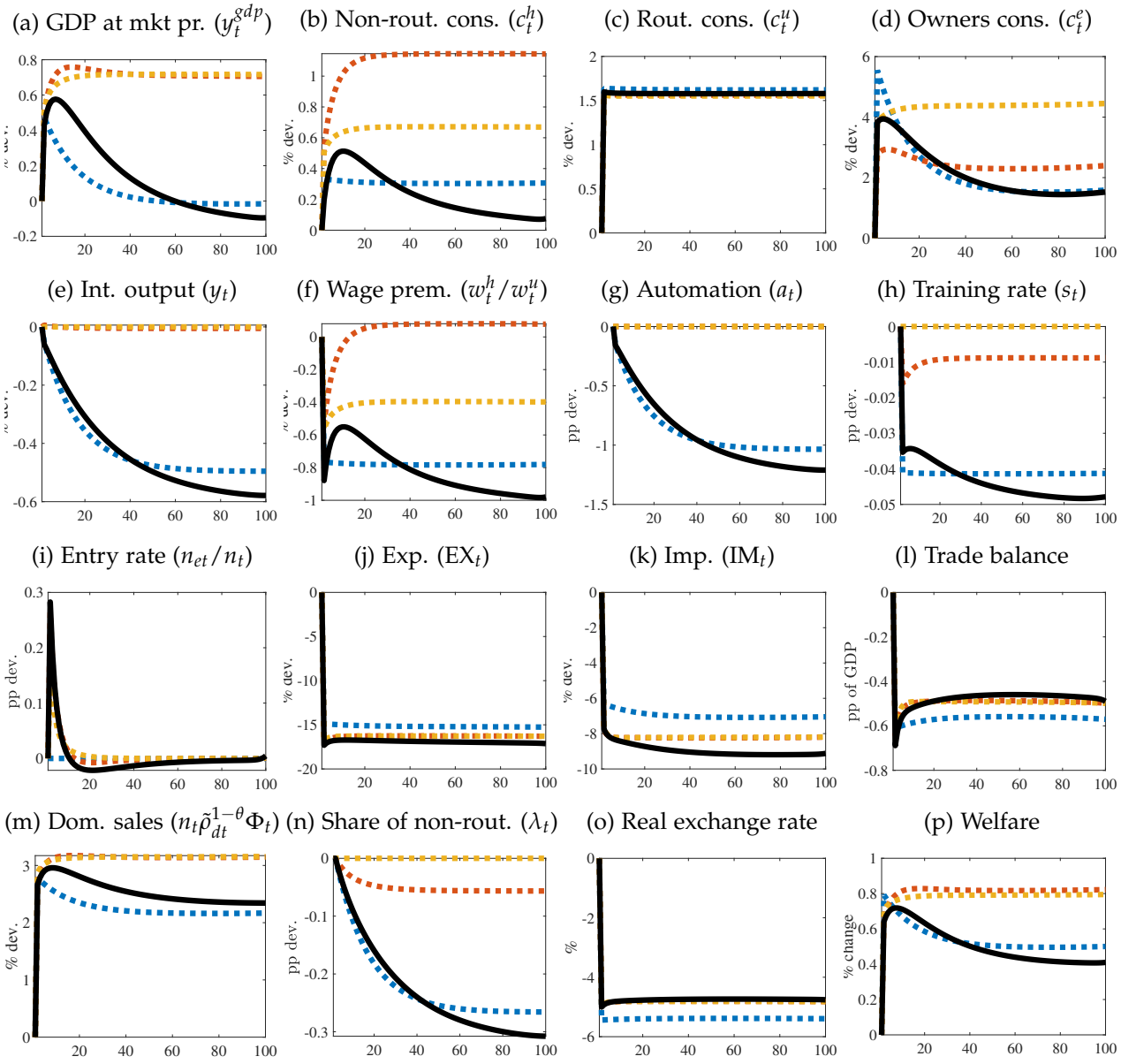
[8] The mapping uses the model-consistent GDP measure (including tariff rebates) described in the text, i.e. GDP at market prices.

[9] Given the size of the perturbation and the importance of non-linear mechanisms—entry, selection, and technology choice—we solve the model using perfect-foresight non-linear simulations.

Table 1: Baseline calibration and targets

Parameter / Moment	Symbol	Value	Target / Source
Preferences, training, demographics			
Discount factor	β	0.96	Annual frequency.
Owner share	μ	0.10	Auray and Eyquem (2025).
Hours (non-routine, routine)	(χ^h, χ^u)	(0.27, 0.30)	Auray and Eyquem (2025).
Non-routine share (SS)	λ^{ss}	0.60	Jaimovich and Siu (2020).
Skill depreciation	δ_w	0.025	Auray and Eyquem (2025).
Training curvature	ζ	4.4372	Auray and Eyquem (2025).
Training cost scale	ϖ	2.2345×10^5	Adjusted.
Technology and tasks			
Task-bundle CES	ν	-4.4384	Auray and Eyquem (2025).
Non-routine task weight	α	0.48	Guerreiro, Rebelo, and Teles (2021).
Labor efficiency (Home, Foreign)	(ψ, ψ^*)	(1, 1)	Normalized.
Non-routine labor efficiency	ξ	implied	Non-routine wage premium $= 1.56$.
Varieties and market structure			
Elasticity across varieties	θ	3.8	Ghironi and Melitz (2005).
Pareto shape	ε	3.4	Ghironi and Melitz (2005).
Love of variety	ς	0.1863	Auray and Eyquem (2025).
Exit rate	δ	0.125	U.S. firm death rate (Census BDS).
Variety normalization	n, n^*	1	Normalization.
Exporter share	$n_x/n, n_x^*/n^*$	0.20	Imposed.
Automation			
Automation share	a	0.205	Acemoglu and Restrepo (2022).
Robot price, non-routine efficiency	(ϕ^{ss}, ξ)	implied	Adjusted.
Trade, tariffs and financial sector			
Baseline tariff (both)	$\bar{T}$	0.03	Pre-2025 tariffs.
Iceberg cost	τ	0.615	U.S. Trade openness $\equiv$ 25%.
Bond adjustment cost	ϕ_b	0.01	Ghironi and Melitz (2005).

Figure 2: Effects of a 10pp tariff hike (U.S. economy).



Note **Black**: baseline, **Blue**: no variety margins, **Red**: No automation ($a_t = a$), **Yellow**: No automation & no training ($a_t = a, s_t = s$). Red vs. black isolates the automation contribution; Yellow vs. red isolates training effects. Variables are reported in percents or percentage points.

GDP, production, and valuation effects. GDP at market prices rises on impact (panel (a)), reflecting tariff revenues rebated to households and a terms-of-trade appreciation that raises the purchasing power of domestic income. By contrast, intermediate output – the quantity of resources used in production – corresponding to GDP at factor cost, falls unambiguously (panel (e)). As in the simple static model, the fall in factor cost GDP is driven by the fall in producer prices of intermediate goods. While the tariff reallocates demand toward home varieties (panel (m)), it reduces prices for intermediate suppliers, and simultaneously reduces selection into exports. Reading from Equation (25), the tariff has the effect of reducing marginal costs, which would stimulate entry into exporting for final goods firms, but this is more than offset by the combination of the real exchange rate appreciation and a fall in foreign demand. The gap between GDP and real production is an important distinction in evaluating the impact of the tariff. The economy expands in value terms even as actual resource use in production contracts.[10] However, we see from panel (a) in Figure 2 that the rise in market GDP is temporary. As intermediate output falls to a lower long run level, so does GDP at market prices, although the final decline is less than that of intermediate output.

Entry, selection, and variety margins. The entry response differs sharply from the output response. By sheltering the domestic market from foreign competition, the tariff raises expected profits and generates a surge in entry (panel i). This expansion is short-lived. As new firms enter, domestic competition intensifies, per-firm profits are diluted, and the entry rate quickly returns toward its steady state. The number of domestic varieties nevertheless rises, while the number of exported varieties contracts.

The temporary expansion of the extensive margin coexists with a persistent contraction along the intensive margin. Domestic sales rise (panel m), but weaker export demand and the adjustment of task inputs reduce output per firm by enough that total intermediate production falls. Consistent with this interpretation, shutting down variety margins (blue) has little effect on the decline in intermediate output (panel e). The tariff therefore stimulates business formation without producing a sustained expansion of productive capacity. It reallocates activity toward domestic varieties and away from exports, while the main aggregate output adjustment occurs within firms.

Labor markets, wage premia, and automation. As in the static model, the fall in the producer's price and marginal cost leads to a fall in demand for non-routine labor. This leads to a persistent fall in the non-routine wage premium (panel (f)). At the same time, this raises the relative cost of automation, measured by ϕ_t / mc_t, and induces firms to substitute away from automation on impact (panel (g)). The decline in the non-routine wage also reduces the return to training, causing the training rate to fall (panel (h)). As a result, there is a rise in routine employment, and a decline in non-routine employment (panel (n)), coupled with a decline in automation.

[10] Our accounting framework makes this distinction explicit and ensures that welfare is evaluated using consumption at market prices, consistent with household optimization.

All these responses are persistent. Since the tariff is permanent, producer prices and real marginal costs remain permanently lower, leading to a permanent fall in the wage premium, a persistent reduction in training and non-routine employment, and a permanent decline in automation, with a higher long run routine employment rate. These dynamics are little changed when we shut down the extensive margin. In this case, all the aggregate output response is achieved by a fall in production at the firm level.

The red dotted lines in Figure 2 show that automation is the central mechanism behind these responses. If firms cannot substitute routine labor for robots, there is little reason to reallocate labor away from non-routine tasks. The non-routine wage premium then moves only slightly and is unchanged in the long run. Intermediate output also responds very little, either on impact or in the long run, and market-price GDP converges to a permanently higher level. Thus, endogenous automation converts the tariff from primarily an expenditure-switching shock into a persistent change in factor use, labor composition, and production.

Distributional incidence and owners' consumption. While entry dilutes per-firm profits and lowers firm values, aggregate profits and owners' consumption rise, as the increase in the number of firms and in market-price income dominates. So with extensive margins active (black), owners' consumption increases (+4%), reflecting the rise in aggregate profits and the rebate of tariff revenues. Since $w_t^u / \psi_t = \phi_t$ and hours are fixed, routine per-capita consumption responds to tariffs through the positive rebate TR_t and through reduced training s_t. Our simulations show that these two channels generate a sizeable increase (about +1.5%) in routine workers' consumption. The consumption of non-routine workers rises less because, despite receiving the tariff rebate, these workers experience a decline in their wage. As shown in Section 2.4, a tariff shock lowers the marginal cost mc_t, which, with a constant robot price and routine wage, requires a fall in the non-routine wage. By contrast, if we shut down automation, after a small dip, the non-routine wage premium remains unaffected by the tariff shock, and non-routine consumption rises much more than in the baseline case.

Trade flows and the trade balance. Both exports and imports decline following the tariff increase (panels (j)-(k)). In quantity terms, exports fall sharply – by about 17-18% – while imports contract by around 8-9%. The decline in exports occurs despite unchanged foreign trade policy and reflects two mechanisms: real exchange rate appreciation reduces exporter competitiveness, and the home tariff lowers foreign demand by shrinking the effective size of the export market and tightening exporter selection. Valuation effects partly offset these quantity adjustments. The real appreciation lowers the home-currency value of exports by about 5%, so export revenues fall by less than export quantities. On the import side, tariff-inclusive consumer prices rise, and the tariff-exclusive import value relevant for national accounts, $IM_t/(1+T_t)$, declines by more than import quantities. Together, these effects imply a modest deterioration of the trade balance of about 0.7% of GDP (panel l). This deterioration reflects valuation and quantity effects rather than an expansion of domestic demand financed by foreign borrowing. In volume terms, trade contracts in both countries.

We note that neither the extensive margin nor the automation margin have a significant effect on the response of exports, imports and the trade balance. As predicted by standard open economy theories, a permanent increase in an import tariff reduces trade volume, and has only a small effect on the trade balance. This conclusion remains even as that impact of the tariff on the domestic economy depends critically on the automation margin.

Welfare. Aggregate welfare rises by about 0.7% on impact (panel (p)). The increase is driven primarily by tariff revenues rebated lump-sum to households and by a terms-of-trade appreciation that raises consumption purchasing power. These valuation effects dominate the decline in intermediate output and trade volumes, so welfare gains coexist with lower production at factor prices. Welfare gains are significantly larger when automation and training margins are shut down (red and yellow). In these counterfactuals, firms cannot adjust along the intensive margin, so tariff-induced demand reallocation translates more directly into higher wages and consumption, particularly for non-routine workers. When automation and training are active (baseline), firms absorb part of the shock by adjusting their task and skill composition, dampening the welfare response. Importantly, higher welfare following a unilateral tariff does not reflect improved productive efficiency or sustained expansion of economic activity. Instead, it arises from redistribution and valuation effects, and depends on the presence of transfers and on internal adjustment margins.

The role of automation and training. Our results show that the two novel mechanisms in the model play a critical role in the response to an import tariff shocks. As discussed above, the ability to substitute routine jobs for robots leads to a large negative response of output and a large fall in the non-routine wage premium and non-routine employment. The latter adjustment takes place through a fall in the training rate. With fixed automation, neither margin plays a significant role, and the effect of the tariff shock simply redirects spending into domestic varieties and reduces the volume of international trade, with negligible effects on production.

By contrast, the extensive margin, allowing for endogenous entry of firms and endogenous selection into exporting, has a much less important role to play in the response of the aggregate economy to the tariff shock. Turning off training in addition to automation (yellow) generates only minor differences, confirming that training plays a second-order role once automation is inactive.

Automation is also important for distributional effects. Shutting down automation benefits non-routine workers, while reducing the gains to firm owners. By contrast, the consumption of routine workers is essentially unaffected by the automation margin.

Discussion. The responses documented in this section combine standard expenditure-switching mechanisms with novel margins that are central to our research question. As in conventional open-economy models, a unilateral tariff raises import prices, reallocates expenditure toward domestic goods, and appreciates the real exchange rate. Trade volumes contract sharply, and ex-

ports fall even without foreign retaliation, reflecting weaker foreign demand and tighter exporter selection.

What distinguishes our results is the joint treatment of endogenous business dynamism and technology choices. Tariff revenues and terms-of-trade appreciation raise household purchasing power and GDP at market prices, while intermediate output falls unambiguously. Higher consumption and welfare therefore coexist with lower production and contracting trade. Valuation effects dominate real activity effects in the short run.

The model also highlights a sequencing in changes in competition. Tariffs temporarily shelter domestic firms from foreign competition, raising expected profits and inducing entry. Over time, domestic competition intensifies, diluting per-firm profits and reversing part of the initial sheltering. This interaction shapes business dynamism without generating a sustained expansion in production.

The endogenous technological margin is a central transmission channel, and plays a key role in the aggregate response to the tariff shock. By lowering the non-routine wage and marginal cost, tariffs reduce the profitability of automation and slow down robot adoption. Automation falls persistently and converges to a lower long run level, as does intermediate goods production. Distributional effects are uneven but transparent: owners gain most from aggregate profits and transfers, routine workers benefit through transfers and non-routine workers face wage losses that partly offset the tariff rebate. Aggregate welfare rises modestly, driven by redistribution and valuation effects rather than by productivity gains.

Overall, these results offer a nuanced answer to our central question. Unilateral tariffs can stimulate entry, reduce automation, and reallocate activity toward domestic producers. However, this reindustrialization reflects changes in market structure and factor use rather than an expansion of productive capacity. We have seen in fact that the automation margin is itself a key mechanism leading tothe negative effect of the tariff on the overall economic activity. With endogenous automation, tariffs reshape the composition of economic activity, but do not expand the productive frontier.

5 Empirical Evidence

The model predicts that import tariffs can affect technology adoption and business dynamism through the same price and selection forces that shape the quantitative transition. In the short run, a tariff lowers CPI-deflated marginal production costs, reduces the incentive to substitute robots for routine labor, and slows reallocation away from routine tasks. At the same time, protection can raise the value of serving the domestic market, generating a temporary entry response followed by a subsequent undershooting as domestic competition intensifies. We now ask whether the the 2018–2019 U.S. tariff episode led to such effects.

The exercise is deliberately modest. We do not claim to estimate the structural model, nor do we treat the 2018 tariff changes as randomly assigned. The tariff increases likely targeted sectors and places already exposed to import competition, routine-task decline, and automation.

We therefore view the evidence as a set of conditional shift-share tests: among commuting zones with similar baseline characteristics, Census division, and observed pre-2017 trends, did the places more exposed to the tariff episode move in the directions predicted by the model?

As shown by Autor et al. (2024), a single tariff shift-share is not adequate because it mixes several forces, including retaliation. We therefore decompose exposure into three components. First, *protection-side exposure* measures tariff increases on goods produced by an industry. Second, *cost-side exposure* propagates those tariff increases through the BEA direct-requirements matrix. The latter is a reduced-form proxy for the producer-side price environment that maps most closely into the model's CPI-based marginal-cost mechanism. Third, *retaliation exposure* measures foreign tariffs faced by U.S. exports. We then allocate these industry-level shocks to commuting zones using pre-tariff manufacturing employment shares:

$$EXP_c = \sum_i \frac{L_{ci,2017}}{\sum_j L_{cj,2017}} EXP_i, \qquad EXP_i \in \{Cost_i, Protect_i, Retal_i\}, \tag{47}$$

where $L_{ci,2017}$ is the 2017 CBP level of employment in commuting zone c and NAICS-3 manufacturing industry i. The construction therefore follows the spirit of the local-exposure approach in Autor et al. (2024), while separating cost-side, protection-side, and retaliation margins. Appendix B details the data construction for exposure measures.

For each outcome y_c, we estimate:

$$\Delta y_c = \beta_c Cost_c + \beta_p Protect_c + \beta_r Retal_c + W_c'\Gamma + \lambda_{div(c)} + \varepsilon_c. \tag{48}$$

All regressions are weighted by 2017 CBP employment levels and include Census division fixed effects. Outcome varaibles pertain to tasks and business formation. Task specifications control for the 2012–2017 outcome pretrend, baseline task content, manufacturing employment share, total employment, robot exposure, capital intensity, and import exposure. Business-formation specifications control for analogous baseline and pretrend variables. In the first specification, we use all positive U.S. tariff increases across trading partners and set $\beta_r = 0$. In the second, we add foreign retaliation. In the third, we restrict the U.S. tariff exposure and retaliation measures to China.

5.1 Task Reallocation

The clearest evidence is on task reallocation. We combine CBP NAICS-3 manufacturing employment by commuting zone with BLS/O*NET industry task measures. Outcomes are 2017–2019 changes in production-task intensity, digital-task intensity, routine-minus-digital intensity, and in-plant training intensity. These are industry-mix measures: they ask whether tariff-exposed commuting zones shifted toward industries with more routine production task content and away from industries with more digital or training-intensive task content.

Table 2 reports the results. Across all three specifications, cost-side exposure predicts higher production-task intensity, lower digital-task intensity, higher routine-minus-digital intensity, and

lower in-plant training intensity. These signs match the model's task-side prediction: tariff-exposed places move less rapidly away from routine or automatable production activity and less rapidly toward digital or training-intensive margins.

The magnitudes should be read as reduced-form semi-elasticities with respect to percentage-point tariff exposure, not as a quantitative calibration test. In the all-partner specification, a one-standard-deviation increase in cost-side exposure is about 0.32 percentage points. Multiplying this by the cost-side coefficients implies movements of roughly 0.01 in production-task intensity, -0.03 in digital-task intensity, 0.10 in routine-minus-digital intensity, and -0.03 in in-plant training. Relative to the cross-CZ standard deviations of these outcome changes, these are moderate effects, around one-fifth to one-third of a standard deviation. The empirical result therefore supports the model qualitatively: places exposed more intensively to tariff hikes appear to experience a slowdown in reallocation away from automatable or routine tasks.

The protection-side and retaliation coefficients are not the main object of interest here. Their sometimes different signs reinforce the need to separate tariff channels rather than rely on a single exposure measure. The key information however, is that the cost-side coefficients remain stable after adding retaliation exposure, suggesting that the task-reallocation pattern is not simply driven by export-side retaliation or generic trade-war exposure.

Table 2: Tariff exposure and task reallocation, 2017–2019

Outcome	All partners			All partners + retaliation			China + retaliation		
	Cost	Protect.	Retal.	Cost	Protect.	Retal.	Cost	Protect.	Retal.
Production-task intensity	0.0304**	-0.0137**	–	0.0284*	-0.0152**	0.0085**	0.0111**	0.0006	0.0010
	(0.0150)	(0.0067)	–	(0.0148)	(0.0069)	(0.0042)	(0.0049)	(0.0030)	(0.0009)
R^2		0.223			0.229			0.231	
Observations		451			451			451	
Digital-task intensity	-0.0881***	0.0347***	–	-0.0917***	0.0324***	0.0139*	-0.0217***	0.0088*	0.0036*
	(0.0250)	(0.0105)	–	(0.0254)	(0.0107)	(0.0080)	(0.0083)	(0.0052)	(0.0019)
R^2		0.206			0.211			0.214	
Observations		451			451			451	
Routine minus digital	0.3078***	-0.1232***	–	0.3168***	-0.1173***	-0.0351	0.0789**	-0.0267	-0.0104
	(0.0913)	(0.0387)	–	(0.0922)	(0.0396)	(0.0279)	(0.0306)	(0.0190)	(0.0065)
R^2		0.214			0.216			0.219	
Observations		451			451			451	
In-plant training	-0.0927***	0.0195***	–	-0.0914***	0.0204***	-0.0051	-0.0402***	0.0117***	-0.0014
	(0.0193)	(0.0074)	–	(0.0198)	(0.0073)	(0.0074)	(0.0065)	(0.0035)	(0.0018)
R^2		0.204			0.205			0.209	
Observations		451			451			451	
Controls	Task controls + pretrend + FE			Task controls + pretrend + FE			Task controls + pretrend + FE		

Notes: Unit of observation is a 2020 ERS commuting zone. Outcomes are 2017–2019 changes in manufacturing task content, computed from CBP NAICS-3 employment shares and BLS/O*NET industry task measures. All specifications include Census division fixed effects. Controls are listed in Appendix B Table 4 and include the corresponding 2012–2017 task pretrend. Robust standard errors are in parentheses.

5.2 Business Formation

We next examine business formation. The model predicts a non-monotone entry response: entry rises on impact as protection raises the value of serving the domestic market, then undershoots as intensified domestic competition erodes continuation values. This timing matters empirically, as a two-year 2017–2019 difference can average together the impact response and the subsequent reversal.

We use two public metrics. Census Business Formation Statistics (BFS) business applications capture business-formation *intent* through EIN applications, although not all applications become active employer establishments. Census Business Dynamics Statistics (BDS) manufacturing establishment entry captures *realized* employer establishment births and is therefore closer to the model's entry margin. We aggregate both measures from counties to commuting zones and scale them by the corresponding 2017 establishment base.

Table 3 splits the outcome into 2017–2018 and 2018–2019 changes. The BFS application margin is noisy and does not line up cleanly with the model. The BDS manufacturing-entry margin is more informative. Cost-side exposure is positively associated with realized manufacturing entry between 2017 and 2018, and negatively associated with realized manufacturing entry between 2018 and 2019. The estimates are not strong enough to stand alone as a decisive business-dynamism result, but the timing is exactly the one implied by the model: a short-run entry increase followed by an undershooting. This also explains why the two-year business-formation estimates reported in Appendix B Table 6 are weak.

Overall, the empirical patterns are consistent with the model's core mechanisms. The task evidence is the clearest: cost-side tariff exposure is associated with a slower movement away from routine production tasks and toward digital or training-intensive task content. The entry evidence is weaker, but the realized manufacturing-entry measure displays the model's short-run up-then-down timing. We interpret these results as suggestive evidence from public data that aligns with the model's predictions, rather than as causal estimates of the underlying structural mechanisms. Appendix B further shows that the task-reallocation results – and to a lesser extent the business formation results – are robust to a harmonized GTD construction of U.S. tariff exposure and foreign retaliation.

6 Sensitivity

Before turning to the question of welfare-maximizing tariffs, we explore how the main results depend on the elasticity of substitution across varieties, and on the rebate scheme or retaliation by the est of the world.

First, the elasticity of substitution θ plays a dual role. It governs both the substitutability between Home and Foreign goods (and thus the strength of expenditure switching) and the slope of demand curves faced by individual firms. Through the latter channel, θ determines the size of markups, the value of an entrant, and hence the scale of distortions associated with imperfect

Table 3: Tariff exposure and business formation, split by year

Outcome	All partners			All partners + retaliation			China + retaliation		
	Cost	Protect.	Retal.	Cost	Protect.	Retal.	Cost	Protect.	Retal.
BFS applications, 2017–2018	1.1765	-0.3472	–	1.9245	-0.4119	-0.5862	-0.9458**	0.2661	0.0993
	(1.6140)	(0.6451)	–	(1.8010)	(0.6669)	(0.4915)	(0.4509)	(0.2892)	(0.1016)
R^2		0.382			0.384			0.390	
Observations		466			466			466	
BFS applications, 2018–2019	2.1423	-0.7223	–	1.6091	-0.6762	0.4179	1.8298***	-0.1105	0.0556
	(2.1690)	(0.9788)	–	(2.3085)	(0.9876)	(0.5660)	(0.5382)	(0.3741)	(0.1078)
R^2		0.211			0.212			0.236	
Observations		466			466			466	
BDS mfg entry, 2017–2018	2.8202**	-0.7557	–	2.8357*	-0.7567	-0.0140	0.5977*	-0.0670	0.1599**
	(1.3905)	(0.5465)	–	(1.5149)	(0.5523)	(0.4077)	(0.3256)	(0.2303)	(0.0788)
R^2		0.384			0.384			0.383	
Observations		466			466			466	
BDS mfg entry, 2018–2019	-3.7145***	1.0901*	–	-3.1893**	1.0567*	-0.4747	-0.9019**	0.1328	-0.1945**
	(1.4210)	(0.5901)	–	(1.5645)	(0.5917)	(0.4104)	(0.3987)	(0.2436)	(0.0879)
R^2		0.047			0.049			0.049	
Observations		466			466			466	
Controls	Outcome controls + FE			Outcome controls + FE			Outcome controls + FE		

Notes: Unit of observation is a 2020 ERS commuting zone. The one-year BFS and BDS outcomes are scaled by the 2017 establishment base. All specifications include Census division fixed effects. Controls are listed in Appendix B Table 4. Robust standard errors are in parentheses.

competition. When varying this elasticity, we recalibrate f_e and f_x to keep $n = 1$ and $n_x = 0.2n$ in steady state, so changes in θ do not affect steady-state extensive margins by construction. Instead, changes in this elasticity shift the strength of tariff pass-through, the sensitivity of entry distortions to changes in tariffs, and the distributional consequences of protection.

Second, we investigate the effects of the rebate scheme has on the transmission mechanisms of a unilateral tariff shock and the associated welfare/distributional consequences. As will be clear, the rebate scheme not only affect the distribution of welfare gains, but also shapes the transmission. The reason is simple: in a model with endogenous entry the dynamics of varieties depends on market size, and rebate scheme affect market size (aggregate demand) on top of affecting labor reallocation through training.

Last, we look at the effects of retaliation, when the Foreign economy also raises its tariff on imports from the U.S., to shut down the terms-of-trade benefit for the U.S. economy, and look at the pure effect of reduced openness resulting for larger tariffs worldwide.

6.1 Different elasticities of substitution

The elasticity of substitution across varieties, θ, matters for how tariffs propagate in our framework. Beyond capturing the standard trade elasticity – the ease with which consumers reallocate expenditure across Home and Foreign goods – θ also shapes steady-state markups and

the profitability of entry. This dual role makes it a potentially important parameter for business dynamism.

To isolate its impact, we recalibrate entry and export costs so that the steady-state number of producers and exporters remains fixed ($n = 1$, $n_x = 0.2n$). Hence differences across experiments strictly reflect the dynamic response of markups, selection, and expenditure switching. Figure 3 shows the effects of a U.S. unilateral tariff hike under alternative substitution elasticities: a lower-elasticity case ($\theta = 3.4$), and a higher-elasticity case ($\theta = 4.2$), both contrasted against the baseline calibration ($\theta = 3.8$).

Figure 3 shows that the transmission of tariffs is sensitive to the elasticity of substitution across varieties. When θ is lower (blue, $\theta = 3.4$), higher steady-state markups make domestic profits more responsive to trade protection. Even though expenditure switching is weaker, the tariff generates larger profit, entry, and income effects. GDP at market prices and workers' consumption rise more (panels (a)-(c)), the non-routine wage premium falls by less (panel (f)), automation contracts less (panel (g)), and entry responds more strongly (panel (i)). By contrast, a higher elasticity (red, $\theta = 4.2$) leads to opposite effects.

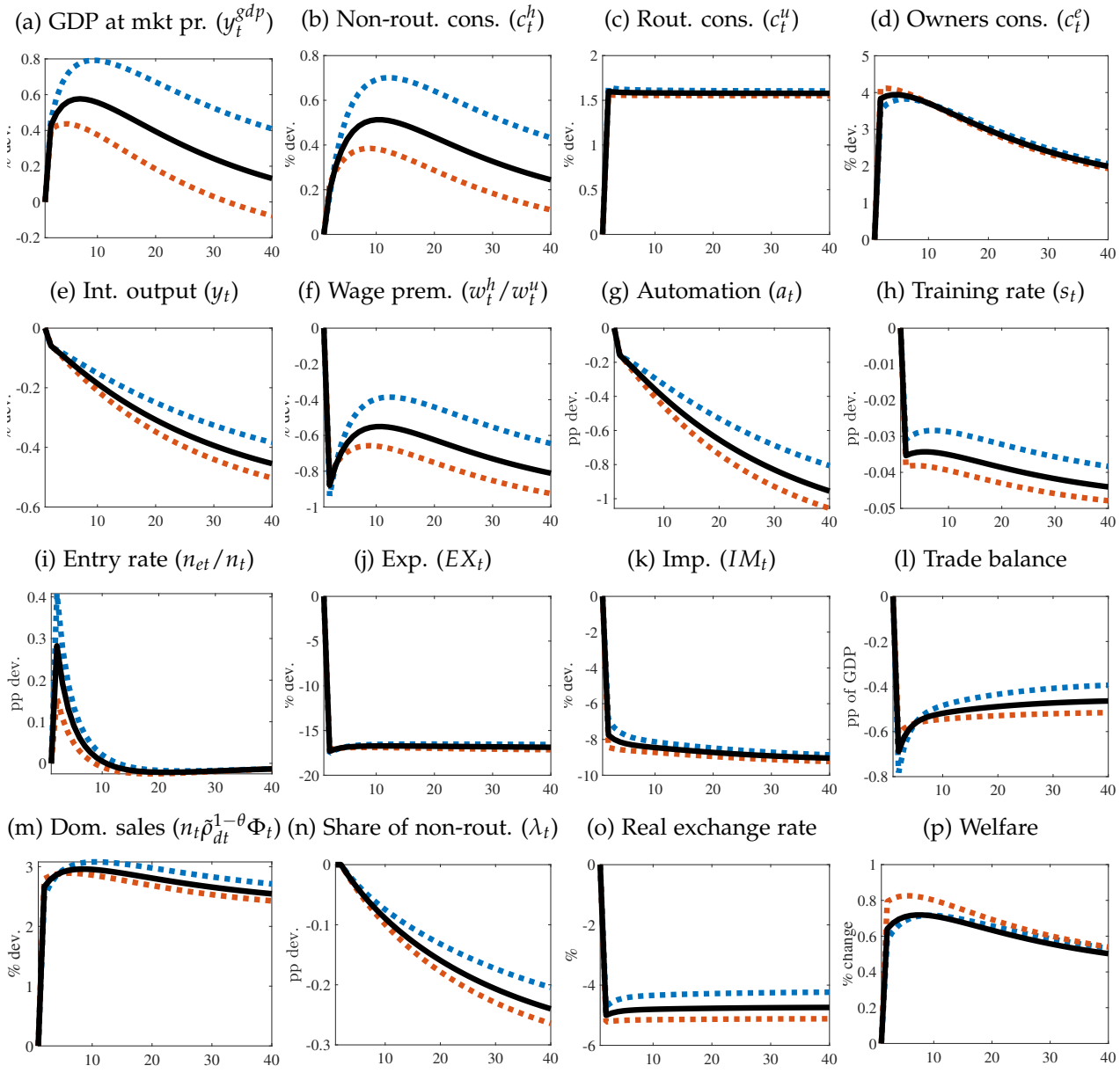
Production-side adjustments follow the same logic. Intermediate output falls in all cases (panel (e)), but the contraction is smaller when θ is lower and larger when θ is higher. With lower θ, the tariff compresses marginal costs less through the non-routine wage, weakening the substitution away from automation and reducing the reallocation toward routine labor. Training therefore falls by less when θ is low and by more when θ is high (panel (h)).

Trade responses display a different sensitivity. The real exchange rate appreciates by essentially the same amount across values of θ (panel (o)), but selection at the extensive margin depends directly on the elasticity of substitution. With lower θ, exported and imported varieties fall by less, even though aggregate export and import quantities respond only modestly differently across cases (panels (j)-(k)). In other words, changes in θ primarily reshape how adjustment occurs along extensive margins of trade, rather than the overall contraction in trade volumes.

Short-run welfare gains (panel (p)) follow a distinct pattern. Despite weaker expansions in GDP and non-routine consumption when θ is high, welfare gains are larger in that case and smaller when θ is low. This reflects the role of training disutility: higher θ leads to a stronger compression of the non-routine wage and a larger decline in training effort, which generates sizable utility gains. As a result, welfare does not move one-for-one with output or consumption responses but also depend on the training cost.

Overall, these results highlight that the effectiveness of tariffs in slowing automation and fostering business dynamism depends not only on the strength of pass-through, but also on how the elasticity of substitution reshapes selection, entry, and training incentives. Lower θ amplifies reallocation toward domestic production and entry, while higher θ dampens these channels but can generate larger short-run welfare gains through reduced training/reallocation costs.

Figure 3: Effects of a 10pp tariff hike (U.S. economy) – Alternative values of θ.



Note **Black**: baseline ($\theta = 3.8$), **Blue**: $\theta = 3.4$, **Red**: $\theta = 4.2$. Variables are reported in percents or percentage points.

6.2 Alternative rebate design

In the previous experiments, tariff revenues have been rebated lump-sum on a per-capita basis across all households. This assumption is convenient, but it has direct consequences for incidence. In practice, governments may design transfers in a more targeted way, either for distributional reasons or as part of an industrial-policy narrative. We therefore consider three alternative rebating schemes (full rebate to routine workers, full rebate to owners, wage subsidy) and report the resulting effects from a 10pp tariff hike in Figure 4.

Full rebate to routine workers. In this case, all tariff revenues are redistributed to routine workers:

$$(1-\mu)(1-\lambda_t)\, TR_t^u = TR_t, \qquad TR_t^h = TR_t^e = 0. \tag{49}$$

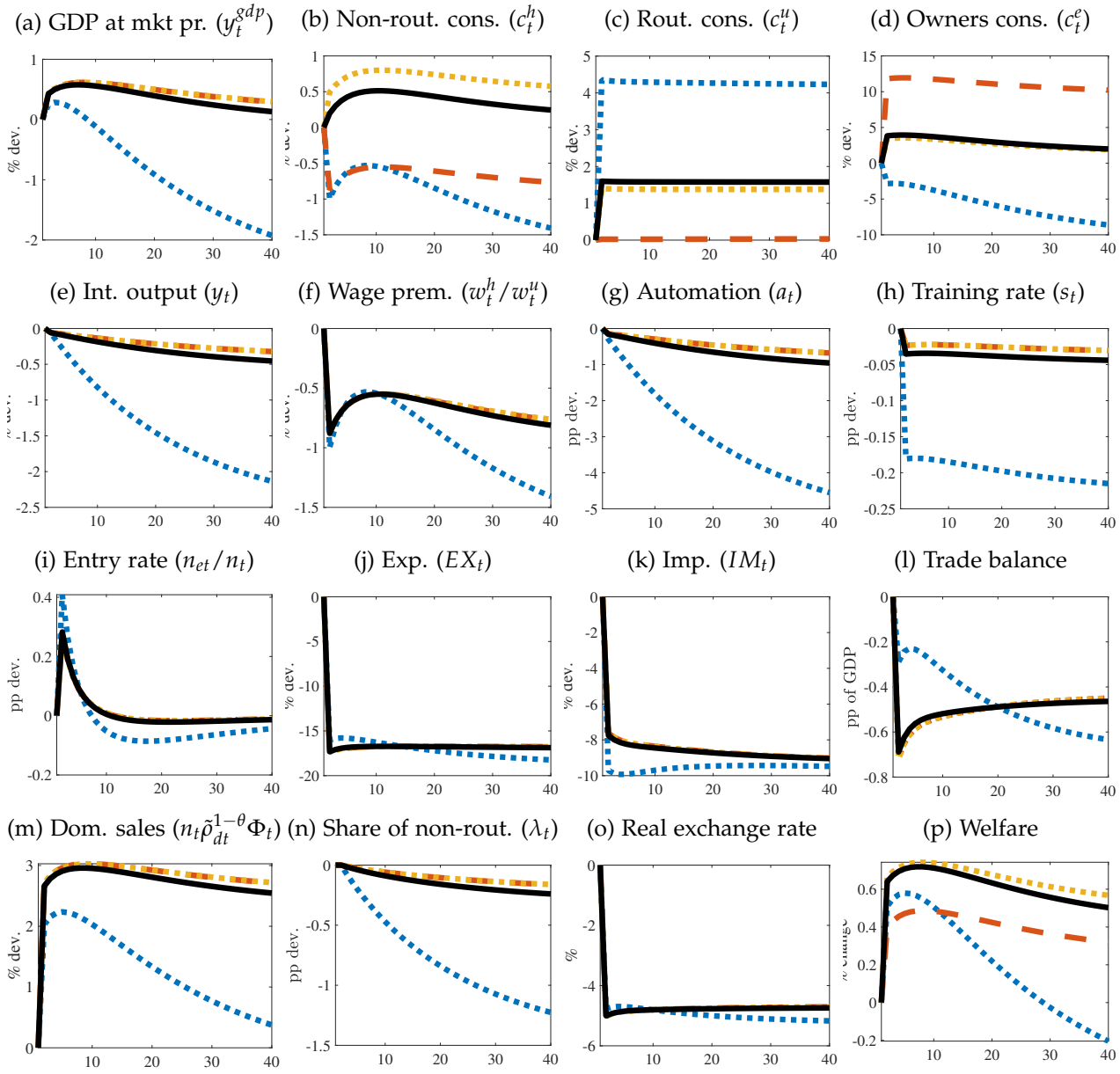
This rebate scheme amplifies the pro-routine shift, further raising their consumption directly (panel (c): +4.2% vs +1.5% in the baseline). Non-routine workers and owners, by contrast, receive no rebate at all, so the welfare distribution skews heavily toward routine workers. Since transfers significantly reinforce the fall in training – a wealth effect on training, shown in panel (g) – and raise the supply of routine tasks, this redistribution of tariff revenues also slows automation much more than the baseline rebate scheme (panel (f): -4.5pp versus -0.7pp). On the production side, the stronger use of routine tasks boosts entry – extensive margin – more but depresses the intensive margin, so that now both intermediate output and GDP at market prices fall. Imports contract further. Short-run aggregate welfare rises less than in the baseline case (panel (p)): firm owners' and non-routine workers' consumption now decline, and the extra routine consumption gains do not compensate these losses. In the long run, aggregate welfare even turns negative under this rebate scheme.

Full rebate to firm owners. In the next case, all tariff revenues are directed to firm owners:

$$\mu\, TR_t^e = TR_t, \qquad TR_t^u = TR_t^h = 0. \tag{50}$$

When tariff revenues are rebated entirely to owners (red), owners' consumption rises much more than in the baseline (panel (d): +12% versus +4%) because a large amount of tax revenue is rebated to a small fraction of population (10%), while non-routine workers lose instead of gaining (-1% on impact, around -0.75% in the medium run) and the consumption of routine workers is essentially flat while they gain in the baseline scheme (panel (c)). Since owners represent only a small fraction of the population, this redistribution has limited impact on aggregate demand and thus on trade flows and most macro quantities: imports, exports, the real exchange rate, intermediate output, training, the entry rate or automation are close to their baseline paths. Aggregate welfare gains are reduced (panel (p): +0.45% vs. +0.7% in the baseline case), as larger gains for firm owners are outweighed by smaller gains for workers. In 'political' terms, this case is closest to the combination of an import tariff coupled with a tax cut that directly rewards 'capital' owners, but it does so at the cost of lower aggregate welfare.

Figure 4: Effects of a 10pp tariff hike (U.S. economy) – Alternative rebate schemes.



Note **Black**: baseline (uniform rebate per capita), **Blue**: full rebate to routine workers, **Red**: full rebate to firm owners, **Yellow**: wage subsidy. Variables are reported in percents or percentage points.

Wage subsidy to all workers. Finally, we consider a balanced-budget wage subsidy to both types of labor. The government budget requires:

$$TR_t = \eta_t \left(w_t^h \ell_t^h + w_t^u \ell_t^u \right) \tag{51}$$

$$TR_t = \eta_t (1-\mu) \left(w_t^h \lambda_t \chi^h + w_t^u (1-\lambda_t)(1-s_t)\chi^u \right) \tag{52}$$

so that workers' per-capita budget constraints become:

$$c_t^h = (1+\eta_t) w_t^h \chi^h, \qquad c_t^u = (1+\eta_t) w_t^u (1-s_t) \chi^u, \tag{53}$$

for non-routine and routine households, respectively. Note that the introduction of a wage subsidy affects directly the training decision as well:

$$\frac{(1+\eta_t) w_t^u \chi^u}{c_t^u} + \varpi s_t^{\zeta-1} = \beta \, \mathbb{E}_t \left\{ V_{t+1}^h - V_{t+1}^u \right\}. \tag{54}$$

Firms are only indirectly affected through equilibrium wages, but the incidence falls on workers, not producers. As shown by Figure 4 (yellow), the wage subsidy being proportional to wage bills shifts tariff revenues more toward high-wage non-routine workers. Non-routine consumption gains are thus larger than in the baseline (panel (b), +0.8% against +0.5%in the baseline), while routine gains are somewhat smaller (panel (c)). On technology margins, automation falls slightly less than in the baseline (panels (f)-(g)), mostly driven by the dynamics of training, which falls less because the consumption of routine workers increases less than in the baseline. With costs and relative prices at the firm level close to baseline, trade flows and the real exchange rate move only marginally. Netting everything out, GDP remains near the baseline path, owners lose as much as in the baseline case, non-routine workers gain somewhat more, which matters in aggregate because they represent a large share (arounf 60%) of the household sectorn, and routine workers gain a bit less. As a result aggregate welfare ends up slightly above the benchmark and more consistently so in the long run.

Summary. These experiments show that the design of tariff-revenue rebating strongly conditions both distributional outcomes and aggregate dynamics. Directing all transfers to routine workers amplifies the redistribution: their consumption rises the most and automation slows much further, but aggregate efficiency falls because owners and non-routine workers bear disproportionate losses. Rebating to firm owners has little aggregate macro effects but aggregate welfare gains shrink since the bulk of the population (workers represent 90% of total population) sees little improvement – non-routine workers lose and routine workers have zero consumption gains. A proportional wage subsidy shifts revenues toward labor income delivering moderate higher gains to non-routine workers and reducing a bit the gains for routine workers. Overall, whether tariffs can stimulate business dynamism depends not only on trade and technology channels, but also on how tariff revenues are used – a point emphasized by Alessandria et al. (2025) in a representative-agent setting, and extended here to a three-agent economy. The incidence of transfers can either reinforce, attenuate, or mute the tilt toward routine labor, highlighting that 'who gets what' matters not only for the political economy of tariffs but also for their macroeconomic transmission.

6.3 Retaliation

We now consider a symmetric tariff increase in both countries. Figure 5 compares the effects of a worldwide 10pp tariff hike (blue) to the unilateral benchmark (black). Reciprocity removes the terms-of-trade advantage that drives part of the unilateral expansion and instead triggers a contractionary adjustment.

The mechanism at work is the same relative-price channel as before: each country's tariff lowers its own marginal cost mc_t via the domestic-variety expansion, but the partner's retaliation dramatically lowers the number of imported varieties in both countries, which magnifies the drop in mc_t. With ϕ_t fixed, the relative robot price $\phi_t/[(1-\alpha)mc_t]$ rises more, which lower automation quite a lot. In addition, the larger fall in mc_t is met by a much larger drop in the non-routine wage w_t^h, which also lowers the incentive to train and accentuates the tilt toward routine labor.

Trade openness declines sharply on impact, with (now) symmetric drops in export and import volumes (panels (j)–(k)). The number of exported and imported varieties adjusts similarly (not reported), and the real exchange rate does not move at all (panel (o)). The entry rate n_t/n_t^* (panel (h)) spikes slightly more than in the unilateral case, because a global tariff shock produces an overall larger retrenchment in trade and magnifies the competition sheltering effect.

As both markets face higher import prices and weaker external demand, both GDP at market prices and intermediate output are now depressed, as opposed to the boost in GDP at market prices observed in the unilateral case (panel (a)). The consumption of non-routine workers now falls relative to the unilateral case (panels (b)), because their wage is much more depressed, which more than compensates the tariff rebate. The consumption of routine workers still rises but by less, mostly because imports fall by more, which reduces tax revenues to be rebated. Owners' consumption now drops instead of rising in the unilateral case (panel (d)), reflecting both lower profits and the erosion of markups due to simultaneous higher entry in both countries.

Overall, retaliation generates aggregate welfare losses (panel (p)), around 0.45% on impact and slowly dropping further to 0.75%. The initial redistribution toward routine workers is still present but slightly weaker, but losses now characterize firm owners and non-routine workers. In equilibrium, retaliation neutralizes most of the domestic gains from protection, while leaving the automation and distributional margins open and, for automation, magnified.

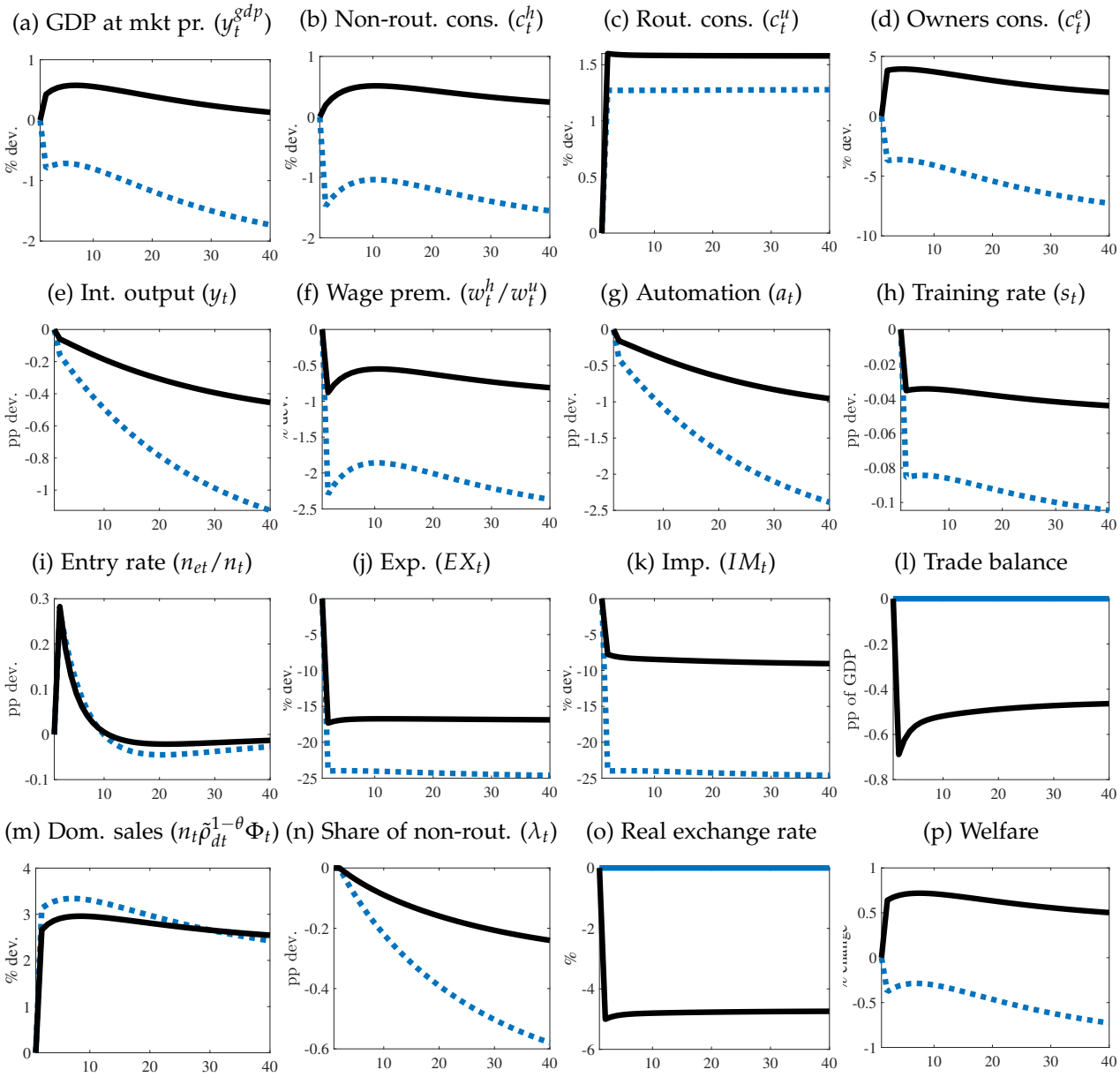
7 Welfare-maximizing Unilateral Tariff

A natural question arising is then how the welfare-maximizing unilateral tariff in our framework compares to the classic benchmark of Johnson (1953), which we will label the classical monopoly formula. In the canonical setting with CES demand and no internal margins, the optimal tariff satisfies:

$$1 + T^{\text{opt}} = \frac{\theta}{\theta - 1},$$

reflecting a pure country-size and terms-of-trade logic. Our environment modifies this benchmark in three ways. First, entry and variety margins introduce a love-of-variety gain that interacts

Figure 5: Effects of a worldwide 10pp tariff hike (retaliation).



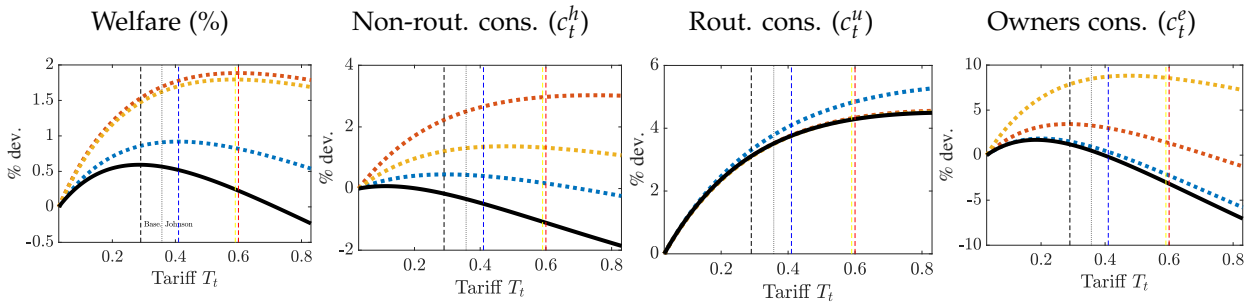
Note **Black**: baseline (unilateral), **Blue**: Retaliation. Variables are reported in percents or percentage points.

with tariff-induced reallocation of demand. Second, automation and training alter the factor-content of domestic production, changing the incidence of tariffs across households. Third, tariff revenues are rebated lump-sum, so their contribution to welfare depends on the relative size of transfers compared to the income base.

To make these mechanisms transparent, we compute the terminal change (i.e. steady-state after taking account of the full transition) in Home aggregate welfare produced by alternative tariff levels applied by the Home economy in the four different sets of experiments already conducted. In all cases, the Johnson benchmark (dashed vertical line) serves as a reference point.

Baseline versus alternative models. Figure 6 compares welfare and consumption outcomes across model variants as a function of the Home tariff. In the baseline economy (black), welfare is maximized at a tariff of about $T \simeq 0.29$, below the value implied by the classical monopoly formula ($T \simeq 0.357$). While tariffs still generate positive welfare gains through tariff revenues and terms-of-trade effects, these gains are partially offset by endogenous responses on the production side: entry, automation, and training all adjust in ways that attenuate the benefits of higher protection. As a result, the welfare-maximizing tariff in the baseline is moderate and interior.

Figure 6: Welfare and consumption as a function of the Home tariff T_t – Baseline vs. alternative models.



Note **Black**: baseline, **Blue**: no variety margins, **Red**: no automation, **Yellow**: no auto + no training.

By contrast, restricting adjustment margins systematically shifts the optimal tariff upward. When variety margins are shut down (blue), the optimal tariff rises to about $T \simeq 0.41$ – against 0.35 for the classical formula. In this case, protection no longer triggers entry or variety expansion, so the main offsetting force comes from weaker pass-through and a shrinking import base. When automation is disabled (red), the welfare peak moves further to the right, around $T \simeq 0.6$, as the reallocation induced by tariffs must be absorbed by labor rather than by task substitution. Finally, shutting down both automation and training (yellow) yields a roughly similar optimal tariff around 0.6: non-routine workers gain less per-capita than with an active training margin, but firm owner gain more, and both effects roughly offset each other.

The monotonic response of routine workers' consumption (panel (c)) is a central driver of these results. Across all model variants, routine households benefit from tariffs through the rebate of tariff revenues and through the reorientation of production toward routine tasks through

lower training. Although the tax base shrinks as imports contract, these gains remain positive for all tariff levels considered, leading to a strictly increasing – albeit concave – relationship between tariffs and routine consumption.

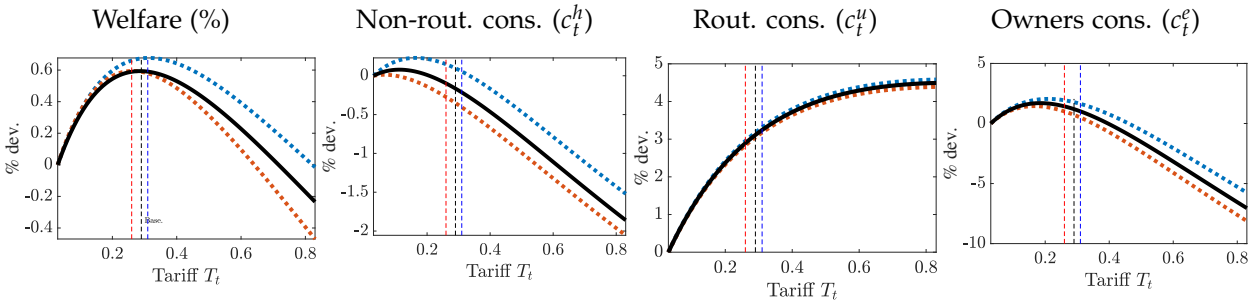
By contrast, the consumption of non-routine workers and firm owners exhibits an inverted U-shape (panels (b) and (d)). For non-routine households, two opposing forces are at play. On the one hand, the tariff compresses the non-routine wage premium by shifting production toward routine labor and away from non-routine tasks, which lowers their labor income. On the other hand, non-routine workers benefit from the rebate of tariff revenues, just like other household members. In the baseline, the rebate dominates at low tariff levels, so non-routine consumption initially rises, but the wage effect becomes increasingly dominant as protection intensifies, eventually driving consumption down. When variety margins are shut down (blue), the wage compression is milder relative to the rebate, so non-routine consumption declines at higher tariff levels. Similarly, when automation is disabled (red), the wage premium falls less, allowing non-routine workers to gain more from protection. This mechanism is attenuated when the training margin is shut down (yellow).

Firm owners face a similar but more pronounced trade-off. Entry and competition dilute per-firm profits as tariffs rise, while tariff revenues are rebated uniformly across households. As a result, owners' consumption peaks at relatively low tariff levels and declines thereafter in all cases. The automation margin plays a particularly important role here: when automation is active, firms can substitute away from labor toward robots, limiting profit losses; when automation is shut down, profits are eroded more quickly, but aggregate income rises more strongly, shifting the welfare peak right towards higher tariffs. Training interacts with this channel by reallocating income between workers and owners when active (red compared to yellow), amplifying gains for non-routine workers and dampening gains for owners.

Overall, Figure 6 highlights that the welfare-maximizing tariff is sensitive to endogenous adjustment margins. Extensive margins (entry and varieties) and intensive margins (automation and training) act as buffers that absorb part of the reallocation induced by tariffs, lowering the optimal level of protection. When these margins are restricted, welfare-maximizing tariff levels are higher – not because they expand production, but because fewer endogenous responses offset the revenue and valuation gains. These results highlight that optimal tariff prescriptions depend critically on the structure of production and adjustment in the economy, and that ignoring business dynamism and automation can lead to systematically higher recommended levels of protection.

Role of the elasticity of substitution. Figure 7 illustrates how the welfare–tariff profile varies with the elasticity of substitution across varieties, θ. In the baseline calibration ($\theta = 3.8$, black), welfare is maximized at a tariff of about $T \simeq 0.29$. Lowering the elasticity to $\theta = 3.4$ (blue) shifts the welfare peak to a higher tariff, around $T \simeq 0.31$, while raising it to $\theta = 4.2$ (red) moves the optimum down to about $T \simeq 0.26$. Thus, as in the classical Johnson formula, lower elasticities are associated with higher optimal tariffs and higher elasticities with lower ones.

Figure 7: Welfare and consumption as a function of the Home tariff T_t – The role of the elasticity θ.



Note **Black**: baseline, **Blue**: $\theta = 3.4$, **Red**: $\theta = 4.2$.

However, the sensitivity of the optimal tariff to θ is markedly smaller than in the canonical benchmark. Under the classical formula, the same change in θ would imply a shift in the optimal tariff from about 0.312 to 0.416, compared with a range of 0.26 to 0.31 in our model. The reason is that tariffs here operate not only through terms-of-trade manipulation, but also through business dynamism: protection raises expected profits, stimulates entry, and expands the set of available varieties, which lowers marginal production costs and partly offsets the welfare distortions associated with higher markups when θ is low.

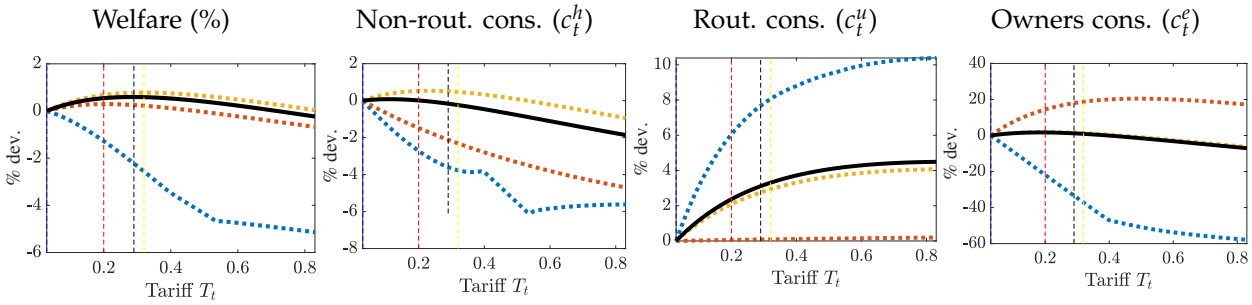
From a distributional perspective, variations in θ mainly reshape how tariff gains and losses are shared across households, rather than overturning the qualitative pattern. Routine workers continue to gain monotonically from higher tariffs, largely independently of θ, while non-routine households remain pivotal in determining the welfare maximum: their consumption responds positively to tariffs at low levels, through the rebate, but eventually declines as the non-routine wage premium is compressed. Lower elasticities amplify the gains both for workers and for owners, while higher elasticities attenuate them, shifting the welfare peak accordingly.

Empirically, a growing body of evidence documents a rise in markups over recent decades (De Loecker, Eeckhout, and Unger (2020), De Loecker and Eeckhout (2018)), often interpreted as a decline in effective substitution elasticities. In a canonical terms-of-trade framework, this would translate into a sharp increase in the optimal tariff. Our results suggest a more nuanced conclusion: once business dynamism, entry, and endogenous cost adjustments are taken into account, lower elasticities do increase the desired level of protection, but the sensitivity of the optimal tariff to θ is attenuated.

The role of the rebate scheme. Figure 8 finally shows how the welfare–tariff profile depends on how tariff revenues are rebated. The differences are striking.

When all tariff revenues are rebated to routine workers (blue), aggregate welfare is maximized at $T = 0$ – or even negative, and the welfare schedule becomes strictly downward sloping for $T > 0$. In this case, tariffs generate short-run welfare gains but substantial long-run *losses*, reaching up to 5 percent for high tariff levels. The mechanism mirrors the impulse-response functions:

Figure 8: Welfare and consumption as a function of the Home tariff T_t – The role of the rebate scheme.



Note **Black**: baseline, **Blue**: full rebate to routine workers, **Red**: full rebate to firm owners, **Yellow**: wage subsidy.

routine workers appropriate the entire transfer and absorb much of the demand reallocation, but this comes at the cost of a sharper slowdown in automation, a deeper fall in training, and sizable losses for firm owners and non-routine workers, who receive no compensation. These distributional costs dominate the gains accruing to routine workers, so aggregate welfare declines with protection. In this sense, a small import subsidy would dominate a small tariff under this pro-routine rebate scheme.

Rebating all tariff revenues to firm owners (red) instead delivers an interior optimum at a much lower tariff than in the baseline, around $T \simeq 0.2$. While owners benefit directly from the transfer workers experience uncompensated losses. Routine workers' consumption is nearly flat in T: their income is largely pinned down by the price of robots – equal to the routine wage – and by training decisions, neither of which responds strongly under this scheme. The welfare problem therefore reduces to trading off owners' gains against non-routine workers' losses. The resulting optimum lies slightly below the baseline value (0.2 instead of 0.29), reflecting the absence of redistribution toward workers.

Finally, a balanced-budget wage subsidy to workers (yellow) shifts the welfare peak slightly to the right, from $T \simeq 0.29$ in the baseline to about $T \simeq 0.32$. Because the subsidy is proportional to wage income, it tilts transfers toward non-routine workers – the largest group in the population – while leaving firm owners' consumption almost unchanged. At the same time, markups, entry, and prices remain close to their baseline paths, so the variety and business-dynamism channels are largely preserved and so the gains for owners. The wage subsidy thus limits the compression of non-routine wages without raising firms' costs, making protection more attractive from a welfare perspective.

Overall, these profiles highlight that the welfare-maximizing tariff depends as much on fiscal incidence as on trade elasticities or production structure. Concentrating transfers on routine workers amplifies the pro-routine reallocation but undermines aggregate efficiency and drives the optimal tariff to zero. Rebating revenues to firm owners lower the optimum level of protection. By contrast, redistributing tariff revenues through a proportional wage subsidy strengthens workers' purchasing power, especially for non-routine workers, without hurting firms' incentives,

thereby raising the desirability of protection. In short, optimal tariff policy cannot be separated from the way tariff revenues are rebated.

8 Conclusion

This paper studies how import tariffs interact with automation, training, and firm dynamics in an economy with heterogeneous households and endogenous production choices. The analysis highlights a central tension: unilateral tariffs can slow down automation and stimulate business dynamism through demand reallocation and entry, while simultaneously reducing trade volumes and intermediate output at factor prices. Whether such policies are desirable depends critically on how these forces interact and on how tariff revenues are recycled.

In the model, a unilateral tariff raises domestic demand for home varieties and generates fiscal revenues that are rebated to households. These forces increase consumption and GDP measured at market prices, even though intermediate output declines once markups, iceberg trade costs, and task substitution are taken into account. On the production side, reduced import competition lowers marginal costs and weakens incentives to automate, leading firms to rely more on routine labor in the short run. Entry responds positively but only temporarily, as sheltering from foreign competition gives way to stronger domestic competition over time. As a result, tariffs reshape the composition of production and employment rather than generating a sustained expansion of factor-price output.

The distributional consequences are central. Routine workers benefit as they gain from tariff rebates and from the slowdown in automation. Non-routine workers face opposing forces: they receive transfers, but suffer from a compression of the wage premium as production tilts toward routine tasks. Firm owners experience an initial rise in profits due to competition sheltering. These distributional patterns are robust across calibrations, but their magnitude depends on key structural features such as the elasticity of substitution across varieties and the availability of automation and training margins.

The welfare implications are therefore nuanced. In the baseline economy with a uniform per-capita rebate, moderate tariffs raise short-run welfare by improving consumption purchasing power and slowing automation, but these gains coexist with falling trade volumes and lower intermediate output. Once alternative rebate schemes are considered, the optimal tariff varies widely. Concentrating transfers on routine workers undermines aggregate efficiency and drives the optimal tariff to zero or below. Rebating revenues to firm owners lowers the optimal tariff below the baseline value. A proportional wage subsidy, by contrast, strengthens workers' purchasing power – especially for non-routine workers – without affecting firms' incentives much, raising the welfare-maximizing level of protection. Fiscal incidence thus plays a key role in determining whether tariffs are welfare-improving or not, as well as their macroeconomic consequences.

More broadly, the results caution against interpreting tariffs as a simple and straightforward tool for 'reindustrialization'. While protection can slow down automation and temporarily boost

business dynamism, it does so by reallocating demand and altering relative prices, not by expanding production at factor prices. The apparent expansion in GDP reflects valuation and redistribution effects rather than an increase in real productive capacity. From a policy perspective, this distinction matters: the same tariff can look expansionary when evaluated at market prices and contractionary when evaluated at the level of intermediate production.

Finally, the analysis sheds light on the interaction between trade policy and long-run structural change. By affecting automation, training, and entry, tariffs influence not only the level of economic activity but also its composition and distribution. Understanding these interactions is essential for evaluating protectionist policies in economies where technological change and labor-market polarization are central concerns. Future work could extend this framework to study dynamic political economy considerations or the joint design of trade and fiscal policies.

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A Details of GDP calculations

Start from the budget constraints:

$$
\begin{aligned}
c_t^h &= w_t^h \chi^h + TR_t, && (55)\\
c_t^u &= (1-s_t) w_t^u \chi^u + TR_t && (56)\\
\mu c_t^e + n_t^e \tilde{v}_t + b_t &= r_{t-1} b_{t-1} + n_t \tilde{\kappa}_t + \phi_t x_t + \mu\, TR_t. && (57)
\end{aligned}
$$

and weight them:

$$
\begin{aligned}
(1-\mu)\,\lambda_t c_t^h &= w_t^h \underbrace{(1-\mu)\,\lambda_t \chi^h}_{\ell_t^h} + (1-\mu)\,\lambda_t TR_t, && (58)\\
(1-\mu)\,(1-\lambda_t) c_t^u &= w_t^u \underbrace{(1-\mu)\,(1-\lambda_t)(1-s_t)\chi^u}_{\ell_t^u} + (1-\mu)\,(1-\lambda_t) TR_t && (59)\\
\mu c_t^e + n_t^e \tilde{v}_t + b_t &= r_{t-1} b_{t-1} + n_t \tilde{\kappa}_t + \phi_t x_t + \mu\, TR_t. && (60)
\end{aligned}
$$

Summing and denoting $b_t - r_{t-1} b_{t-1} = nx_t$ yields:

$$
\underbrace{(1-\mu)\left(\lambda_t c_t^h + (1-\lambda_t) c_t^u\right) + \mu c_t^e}_{\Phi_t} + n_t^e \underbrace{\tilde{v}_t}_{f_e mc_t} + nx_t = n_t \tilde{\kappa}_t + \phi_t x_t + w_t^h \ell_t^h + w_t^u \ell_t^u + TR_t, \quad (61)
$$

Then starting from $n_t \widetilde{\kappa}_t = n_t \widetilde{\kappa}_{dt} + n_{xt} \widetilde{\kappa}_{xt}$ with:

$$
\begin{aligned}
\widetilde{\kappa}_{dt} &= \frac{1}{\theta} \widetilde{\rho}_{dt}^{1-\theta} n_t^{\varsigma-1} \Phi_t, && (62)\\
\widetilde{\kappa}_{xt} &= \left(q_t \widetilde{\rho}_{xt} - (1+\tau)\frac{mc_t}{\bigtriangledown z_{xt}}\right) \left(\widetilde{\rho}_{xt}^c\right)^{-\theta} (n_{xt})^{\varsigma-1} \Phi_t^* - f_x mc_t, && (63)
\end{aligned}
$$

and recalling that:

$$
\widetilde{\rho}_{xt}^c = (1+T_t^*)\,\widetilde{\rho}_{xt} = (1+T_t^*)(1+\tau)\frac{\theta}{\theta-1}\frac{mc_t}{q_t \bigtriangledown z_{xt}} \quad (64)
$$

then:

$$
(1+\tau)\frac{mc_t}{\bigtriangledown z_{xt}} = \frac{\theta-1}{\theta} q_t \widetilde{\rho}_{xt} \quad (65)
$$

which, after defining $\mathrm{EX}_t = (n_{xt})^{\varsigma} (\widetilde{\rho}_{xt}^c)^{1-\theta} \Phi_t^*$ implies:

$$
\begin{aligned}
n_t \widetilde{\kappa}_t &= \frac{1}{\theta}\left(n_t \widetilde{\rho}_{dt}^{1-\theta} n_t^{\varsigma} \Phi_t + q_t \frac{\mathrm{EX}_t}{(1+T_t^*)}\right) - n_{xt} f_x mc_t && (66)\\
&= \underbrace{\widetilde{\rho}_{dt}^{1-\theta} n_t^{\varsigma} \Phi_t + q_t \frac{\mathrm{EX}_t}{(1+T_t^*)}}_{y_t^s} - \frac{\theta-1}{\theta} y_t^s - n_{xt} f_x mc_t. && (67)
\end{aligned}
$$

Incorporating in Equation (61) we get:

$$
\Phi_t + n_t^e f_e mc_t + nx_t = y_t^s/\theta - n_{xt} f_x mc_t + \phi_t x_t + w_t^h \ell_t^h + w_t^u \ell_t^u + TR_t, \quad (68)
$$

and rearranging:

$$y_t^{gdp} = \underbrace{\underbrace{\Phi_t}_{\text{Cons.}} + \underbrace{n_t^e f_e mc_t}_{\text{Investment}} + \underbrace{nx_t}_{\text{Net exports}}}_{\text{Expenditure side}} = \underbrace{\underbrace{y_t^s/\theta - n_{xt} f_x mc_t}_{\text{Profits}} + \phi_t x_t + w_t^h \ell_t^h + w_t^u \ell_t^u + TR_t}_{\text{Income side}}, \tag{69}$$

where

$$\text{Final sales:} \qquad y_t^s = n_t^{\varsigma} \widetilde{\rho}_{dt}^{1-\theta} \Phi_t + q_t \text{EX}_t/(1+T_t^*), \tag{70}$$

$$\text{Home consumption:} \qquad \Phi_t = (1-\mu)\left(\lambda_t c_t^h + (1-\lambda_t) c_t^u\right) + \mu c_t^e, \tag{71}$$

$$\text{Foreign consumption:} \qquad \Phi_t^* = (1-\mu)\left(\lambda_t^* c_t^{h*} + (1-\lambda_t^*) c_t^{u*}\right) + \mu(c_t^{e*} + a c_t^*), \tag{72}$$

Let's now write domestic and export profits slightly differently:

$$n_t \widetilde{\kappa}_{dt} = \left(\widetilde{\rho}_{dt} - \frac{mc_t}{\bigtriangledown}\right) \widetilde{\rho}_{dt}^{-\theta} n_t^{\varsigma} \Phi_t, \tag{73}$$

$$n_{xt} \widetilde{\kappa}_{xt} = \left(q_t \widetilde{\rho}_{xt} - (1+\tau)\frac{mc_t}{\bigtriangledown z_{xt}}\right) \left(\widetilde{\rho}_{xt}^c\right)^{-\theta} \left(n_{xt}\right)^{\varsigma} \Phi_t^* - n_{xt} f_x mc_t, \tag{74}$$

so that:

$$n_t \widetilde{\kappa}_t = \underbrace{\widetilde{\rho}_{dt}^{1-\theta} n_t^{\varsigma} \Phi_t + q_t \frac{\text{EX}_t}{(1+T_t^*)}}_{\text{Sales}} - \underbrace{\left(\widetilde{\rho}_{dt}^{-\theta} \bigtriangledown^{-1} n_t^{\varsigma} \Phi_t + (1+\tau)\ \left(\widetilde{\rho}_{xt}^c\right)^{-\theta} \left(\bigtriangledown z_{xt}\right)^{-1} n_{xt}^{\varsigma} \Phi_t^* + n_{xt} f_x\right) mc_t}_{\text{Costs}}, \tag{75}$$

and notice that the bracketed term corresponds to total intermediate production net of entry goods, i.e. $y_t - n_{et} f_e$, so that:

$$n_t \widetilde{\kappa}_t = y_t^s - (y_t - n_{et} f_e)\, mc_t, \tag{76}$$

and,

$$y_t^{gdp} = y_t^s - (y_t - n_{et} f_e)\, mc_t + \phi_t x_t + w_t^h \ell_t^h + w_t^u \ell_t^u + TR_t, \tag{77}$$

Next use the zero-profit condition in the intermediate good sector:

$$mc_t y_t = \phi_t x_t + w_t^h \ell_t^h + w_t^u \ell_t^u, \tag{78}$$

to subsitute:

$$y_t^{gdp} = y_t^s - \left(\phi_t x_t + w_t^h \ell_t^h + w_t^u \ell_t^u - n_{et} f_e mc_t\right) + \phi_t x_t + w_t^h \ell_t^h + w_t^u \ell_t^u + TR_t, \tag{79}$$

$$= y_t^s + n_{et} f_e mc_t + TR_t, \tag{80}$$

So that overall GDP at market prices can be written in the three following ways:

$$y_t^{gdp} = \underbrace{\Phi_t + n_t^e f_e mc_t + nx_t}_{\text{Expenditure}} = \underbrace{\Pi_t + \phi_t x_t + w_t^h \ell_t^h + w_t^u \ell_t^u + TR_t}_{\text{Income}} = \underbrace{y_t^s + n_{et} f_e mc_t + TR_t}_{\text{Sales/production}}$$

where $\Pi_t = y_t^s/\theta - n_{xt} f_x mc_t$.

B Empirical Evidence: Data Construction and Robustness

This appendix provides details on exposure construction, outcomes, controls, and robustness checks for Section 5.

B.1 U.S. tariff exposure

We use the Census Import Merchandise Database and the Census HTS–NAICS concordance. For each HTS10 product-country pair, the effective duty rate is:

$$\tau_{hpt} = \frac{\text{calculated duties}_{hpt}}{\text{customs value}_{hpt}}.$$

The tariff shock is the change between 2017 and 2019. The broad measure uses all positive product-country tariff increases:

$$\Delta\tau^{+}_{hp} = \max\{\tau_{hp,2019} - \tau_{hp,2017}, 0\}.$$

The industry protection-side exposure is the 2017 import-share-weighted tariff increase:

$$Protect_i = 100 \times \sum_{h,p \in i} s_{ihp,2017} \Delta\tau^{+}_{hp},$$

where $s_{ihp,2017}$ is the share of industry i's 2017 import basket accounted for by product-partner cell (h, p):

$$s_{ihp,2017} = \frac{M_{ihp,2017}}{\sum_{h',p' \in i} M_{ih'p',2017}}.$$

Here $M_{ihp,2017}$ denotes the 2017 customs value of U.S. imports of product h from partner p mapped to NAICS-3 industry i. For the China-only specification, the same object is computed after restricting p to China.

B.2 Cost-side exposure

Cost-side exposure uses the BEA 2017 direct-requirements table after redefinitions. Let a_{ji} be the dollars of commodity j directly required to produce one dollar of output in industry i. We build:

$$Cost_i = \sum_j a_{ji} Protect_j.$$

This is a reduced-form cost-side exposure. Since the model does not have a literal roundabout traded-input structure, we interpret $Cost_i$ as a proxy for the producer-side price environment around tariffed product markets, not as a structural imported-input wedge.

B.3 Retaliation exposure

Retaliation is built from the Global Tariff Database U.S. Trade War Extension distributed on Feodora Teti's data page. The HS6 bilateral file reports tariffs imposed by and faced by the United States, including foreign retaliatory tariffs, and includes 2017 trade values. Following the citation guidance for the dataset, we cite the U.S. Trade War extension as Rodríguez-Clare et al. (2025), based on the GTD methodology in Teti (2024).

We define foreign retaliation as the positive change in tariffs faced by U.S. exports between January 1, 2018 and September 1, 2019:

$$Retal_i = 100 \times \sum_{h,p \in i} s^{exports}_{ihp,2017} \max\{\tau^{foreign}_{hp,2019} - \tau^{foreign}_{hp,2018}, 0\}.$$

Here $s^{exports}_{ihp,2017}$ is the export-market analogue of the protection-side share:

$$s^{exports}_{ihp,2017} = \frac{X_{ihp,2017}}{\sum_{h',p' \in i} X_{ih'p',2017}}.$$

where $X_{ihp,2017}$ is the 2017 value of U.S. exports of HS6 product h to foreign destination p, allocated to NAICS-3 industry i. HS6 products are mapped to NAICS-3 industries using the HTS–NAICS concordance. When an HS6 code maps to multiple NAICS-3 industries, we allocate it using 2017 U.S. import values in the concordance.

B.4 Commuting-zone shift-shares

The local design uses 2017 CBP manufacturing employment shares. For any industry-level exposure $EXP_i \in \{Cost_i, Protect_i, Retal_i\}$, the corresponding commuting-zone exposure is:

$$EXP_c = \sum_i \frac{L_{ci,2017}}{\sum_j L_{cj,2017}} EXP_i.$$

The denominator sums employment over manufacturing industries in the commuting zone. This is a Bartik or shift-share design: national industry-level tariff shocks are assigned to places according to their pre-determined manufacturing composition. We use within-manufacturing shares and control for the 2017 manufacturing employment share, so the comparison is across commuting zones with different manufacturing composition rather than simply different manufacturing intensity.

B.5 Outcomes and controls

Task reallocation outcomes combine CBP NAICS-3 manufacturing employment by commuting zone with BLS/O*NET industry task content. Outcomes are 2017–2019 changes in production-task intensity, digital-task intensity, routine-minus-digital intensity, and in-plant training intensity. These variables capture changes in local manufacturing industry mix, not individual worker transitions.

Business formation is measured in two ways. Census Business Formation Statistics provide annual county business applications, which we aggregate to 2020 ERS commuting zones and scale by the pre-tariff establishment base:

$$\Delta EntryRate_c^{BA} = 100 \times \frac{BA_{c,t_1} - BA_{c,t_0}}{Establishments_{c,2017}}.$$

Census Business Dynamics Statistics provide actual manufacturing establishment entry. We construct:

$$\Delta EntryRate_c^{BDS} = 100 \times \frac{Entry_{c,t_1}^{mfg} - Entry_{c,t_0}^{mfg}}{Establishments_{c,2017}^{mfg}}.$$

BFS is an application flow, while BDS is an employer establishment-birth flow. For this reason, BDS is closer to the model's entry margin.

Table 4 lists the control variables used in the reported specifications. Table 5 reports summary statistics. The unconditional task changes are informative: between 2017 and 2019, the average commuting zone became slightly less production-task intensive and slightly more digital-task intensive. The model-relevant question is therefore whether tariff exposure slows this secular reallocation, not whether routine tasks rise in absolute terms everywhere.

B.6 Additional business-formation results

Table 6 reports the two-year 2017–2019 business-formation differences. These estimates are weaker than the split-year evidence in Table 3. This is consistent with the model's non-monotone entry response: averaging 2017–2018 and 2018–2019 combines the impact rise and subsequent undershooting.

B.7 GTD harmonized robustness

The baseline estimates use Census effective duty rates for U.S. import-side tariff exposure because those rates are based on actual duties paid over customs values. This is the most direct public measure of the realized U.S. tariff wedge. However, the baseline combines Census data for U.S. tariffs with GTD data for foreign retaliation. To check that the results are not driven by mixing sources, we also construct a harmonized GTD robustness measure.

For this robustness exercise, protection-side exposure is built from GTD rows with importer equal to the United States (Teti, 2024; Rodríguez-Clare et al., 2025). We use the positive change in the U.S. tariff on exporter-product cells between January 1, 2018 and September 1, 2019, weighted by GTD 2017 bilateral trade values. We then propagate this GTD protection-side exposure through the same BEA direct-requirements matrix to obtain cost-side exposure and combine it with the same GTD foreign-retaliation measure.

Tables 7 and 8 repeat the main task exercise and the split-year business-formation exercise using GTD for the U.S. import-side tariffs as well as retaliation. The task result is robust: cost-side exposure remains positively associated with production-task and routine-minus-digital growth,

Table 4: Controls used in the commuting-zone regressions

Variable block	Variable and level	Role in reported specifications
Business formation variables	BFS applications per 100 establishments, 2017–2019 (CZ; BFS/CBP)	Application-based outcome
	BDS manufacturing entry per 100 establishments, 2017–2019 (CZ; BDS)	Realized-entry outcome
	Analogous one-year changes for 2017–2018 and 2018–2019	Timing checks
	Baseline levels and pretrends for the corresponding source	Outcome-specific controls
	Digital-task intensity, 2017 (CZ industry-mix shift-share)	Business-formation control
Task variables	Production-task intensity, 2017 (CZ industry-mix shift-share)	Baseline task control
	Production, digital, routine-minus-digital, and in-plant-training changes, 2017–2019 (CZ industry-mix shift-shares)	Main task outcomes
	Analogous task changes, 2012–2017 (CZ industry-mix shift-shares)	Outcome-specific pretrends
Common controls	Log total CBP employment and manufacturing employment share, 2017 (CZ)	All reported tables
	Robot plants and robot-exposed workers, 2018 (CZ shift-shares from NAICS-3 robot intensity)	All reported tables
	Capital intensity and import exposure, 2017 (CZ shift-shares from NAICS-3 controls)	All reported tables
	Census division fixed effects (CZ regional indicators)	All reported tables

Notes: CZ means commuting zone. Industry-mix shift-shares are constructed by assigning NAICS-3 industry measures to CZs using 2017 CBP manufacturing employment shares. Control variables are standardized in the regression except for the tariff-exposure regressors.

Table 5: Summary statistics for regression variables

Sample	Variable	N	Mean	SD	Min	Max
Business formation	BFS apps Δ17–19	469	2.8943	6.4244	-22.0579	99.3183
	BFS apps Δ17–18	469	2.9268	5.5821	-12.4429	82.6429
	BFS apps Δ18–19	469	-0.0325	4.8392	-42.9787	27.2475
	BFS apps pre Δ12–17	469	6.0754	15.0768	-12.9993	307.0267
	BDS mfg entry Δ17–19	469	-0.1149	3.0898	-16.6667	13.5593
	BDS mfg entry Δ17–18	469	0.3694	3.8856	-16.6667	22.2222
	BDS mfg entry Δ18–19	469	-0.4843	3.4915	-15.9091	13.2075
	BDS mfg entry pre Δ12–17	469	-0.1595	3.4202	-16.2162	20.0000
	All partners: cost-side	466	0.8359	0.3204	0.0000	1.7043
	All partners: protection-side	466	2.6207	0.6967	0.8187	5.8260
	All partners: retaliation	466	1.2084	0.7593	0.3190	4.9798
	China: cost-side	466	4.3411	0.6269	2.7449	6.9598
	China: protection-side	466	11.8101	1.3942	5.9988	14.9927
	China: retaliation	466	12.0976	2.9762	2.3095	23.2788
GTD robustness	GTD all: cost-side	466	1.2104	0.4357	0.0000	2.2065
	GTD all: protection-side	466	4.6146	1.0900	1.5763	9.3880
	GTD China: cost-side	466	5.0804	1.7458	0.0000	8.6787
	GTD China: protection-side	466	19.7643	1.6844	13.4054	24.0487
Task outcomes	Production task Δ17–19	466	-0.0055	0.0460	-0.2472	0.2511
	Digital task Δ17–19	466	0.0049	0.0997	-0.5347	0.6335
	Routine minus digital Δ17–19	466	-0.0247	0.3507	-2.0762	1.9138
	In-plant training Δ17–19	466	-0.0151	0.0991	-0.5966	0.5702
	Production task pre Δ12–17	451	-0.0025	0.0514	-0.1861	0.2611
	Digital task pre Δ12–17	451	-0.0016	0.1134	-0.6317	0.5215
	Routine minus digital pre Δ12–17	451	0.0347	0.3943	-1.7651	2.1932
	In-plant training pre Δ12–17	451	-0.0141	0.0947	-0.5785	0.3688
Common CZ controls	Log employment, 2017	469	11.3941	1.3578	9.2493	15.7335
	Mfg emp. share, 2017	469	0.0771	0.0545	0.0000	0.3198
	Log BFS apps, 2017	469	7.5867	1.4173	5.2311	12.1079
	BFS apps/estab., 2017	469	32.7540	17.8608	14.1602	333.0362
	Log BDS mfg estab., 2017	469	5.4625	1.2328	2.8904	9.8534
	BDS entry/estab., 2017	469	4.3893	3.2839	0.0000	20.0000
	Avg mfg estab. size, 2017	469	48.3457	24.4608	4.3415	195.3158
	Production task, 2017	466	-0.0000	1.0000	-4.1672	2.3615
	Digital task, 2017	466	3.3373	0.1433	2.9451	3.7498
	Robot plants, 2018	469	0.9511	0.8175	0.0000	5.7386
	Robot workers, 2018	469	1.5860	1.2837	0.0000	8.4437
	Capital intensity, 2017	466	12.8004	4.0850	7.2642	49.0555
	Import exposure, 2017	466	0.3204	0.1418	0.0757	1.5855

Notes: Summary statistics are unweighted. Exposure variables are CZ-level shift-shares measured in percentage points. Task variables, robot exposure, capital intensity, and import exposure are industry-level measures aggregated to the CZ using 2017 manufacturing employment shares.

Table 6: Tariff exposure and business formation, 2017–2019

Outcome	All partners			All partners + retaliation			China + retaliation		
	Cost	Protect.	Retal.	Cost	Protect.	Retal.	Cost	Protect.	Retal.
BFS applications / incumbent estab.	3.3188	-1.0695	–	3.5336	-1.0881	-0.1683	0.8840	0.1556	0.1549
	(2.0267)	(0.8505)	–	(2.3046)	(0.8642)	(0.5841)	(0.5865)	(0.4238)	(0.1124)
R^2		0.382			0.383			0.386	
Observations		466			466			466	
BDS actual mfg entry / incumbent estab.	-0.8943	0.3344	–	-0.3536	0.3000	-0.4886*	-0.3042	0.0658	-0.0346
	(0.9895)	(0.4082)	–	(1.0983)	(0.4122)	(0.2903)	(0.3327)	(0.2382)	(0.0648)
R^2		0.379			0.383			0.380	
Observations		466			466			466	
Controls	Outcome controls + FE			Outcome controls + FE			Outcome controls + FE		

Notes: Unit of observation is a 2020 ERS commuting zone. BFS outcome is the change in annual business applications divided by 2017 CBP establishments. BDS entry is the change in actual manufacturing establishment entry divided by 2017 BDS manufacturing establishments. Cost-side, protection-side, and retaliation exposure are computed with 2017 within-manufacturing employment shares. All specifications include Census division fixed effects. Controls are listed in Table 4. Robust standard errors are in parentheses.

and negatively associated with digital-task and in-plant-training growth. The business-formation robustness remains suggestive and should be read with the same caution as the baseline split-year evidence.

Table 7: GTD robustness: tariff exposure and task reallocation, 2017–2019

Outcome	GTD all partners			GTD all partners + retaliation			GTD China + retaliation		
	Cost	Protect.	Retal.	Cost	Protect.	Retal.	Cost	Protect.	Retal.
Production-task intensity	0.0115	-0.0045	–	0.0085	-0.0044	0.0070*	0.0017	0.0034	-0.0001
	(0.0080)	(0.0036)	–	(0.0082)	(0.0035)	(0.0040)	(0.0015)	(0.0022)	(0.0010)
R^2		0.219			0.223			0.223	
Observations		451			451			451	
Digital-task intensity	-0.0526***	0.0198***	–	-0.0604***	0.0201***	0.0177**	-0.0094***	-0.0018	0.0072***
	(0.0139)	(0.0063)	–	(0.0147)	(0.0063)	(0.0078)	(0.0026)	(0.0034)	(0.0020)
R^2		0.218			0.227			0.228	
Observations		451			451			451	
Routine minus digital	0.1770***	-0.0671***	–	0.1983***	-0.0679***	-0.0485*	0.0311***	0.0091	-0.0228***
	(0.0487)	(0.0220)	–	(0.0516)	(0.0222)	(0.0273)	(0.0093)	(0.0128)	(0.0068)
R^2		0.223			0.227			0.228	
Observations		451			451			451	
In-plant training	-0.0697***	0.0160***	–	-0.0685***	0.0159***	-0.0027	-0.0134***	-0.0024	0.0045**
	(0.0120)	(0.0052)	–	(0.0127)	(0.0052)	(0.0072)	(0.0022)	(0.0021)	(0.0018)
R^2		0.224			0.225			0.222	
Observations		451			451			451	
Controls	Task controls + pretrend + FE			Task controls + pretrend + FE			Task controls + pretrend + FE		

Notes: Cost-side and protection-side exposure are built from GTD U.S.-import tariff changes. Retaliation exposure is built from GTD foreign tariffs faced by U.S. exports. Controls match Table 2, including Census division fixed effects and outcome-specific 2012–2017 task pretrends. Robust standard errors are in parentheses.

Table 8: GTD robustness: tariff exposure and business formation, split by year

Outcome	GTD all partners			GTD all partners + retaliation			GTD China + retaliation		
	Cost	Protect.	Retal.	Cost	Protect.	Retal.	Cost	Protect.	Retal.
BFS applications, 2017–2018	-0.2424	0.2810	–	0.5728	0.0983	-0.5044	-0.2358	-0.0477	0.2476*
	(0.9225)	(0.3088)	–	(1.2958)	(0.3705)	(0.5875)	(0.2412)	(0.1580)	(0.1496)
R^2		0.383			0.384			0.385	
Observations		466			466			466	
BFS applications, 2018–2019	0.5908	-0.0619	–	-0.4935	0.1811	0.6708	0.5549*	0.4422**	-0.2850
	(1.1291)	(0.4151)	–	(1.5925)	(0.4804)	(0.6419)	(0.2928)	(0.2127)	(0.1796)
R^2		0.210			0.211			0.227	
Observations		466			466			466	
BDS mfg entry, 2017–2018	1.7900**	-0.3616	–	2.4705**	-0.5137*	-0.4380	0.2408	0.1036	0.0116
	(0.7982)	(0.2522)	–	(1.1136)	(0.3036)	(0.4929)	(0.1971)	(0.1261)	(0.1221)
R^2		0.384			0.385			0.382	
Observations		466			466			466	
BDS mfg entry, 2018–2019	-1.7999**	0.3374	–	-1.2106	0.2056	-0.3793	-0.2238	-0.0885	-0.0363
	(0.8097)	(0.2723)	–	(1.2215)	(0.3410)	(0.5250)	(0.2193)	(0.1295)	(0.1483)
R^2		0.040			0.041			0.037	
Observations		466			466			466	
Controls	Outcome controls + FE			Outcome controls + FE			Outcome controls + FE		

Notes: Cost-side and protection-side exposure are built from GTD U.S.-import tariff changes. Retaliation exposure is built from GTD foreign tariffs faced by U.S. exports. Outcomes and controls match Table 3, including Census division fixed effects. Robust standard errors are in parentheses.