Tariffs, Automation, and Business Dynamism*

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Abstract

Can protectionism revive domestic production, slow automation, and help routine workers? We address this question in a dynamic open-economy model with heterogeneous firms, endogenous entry, and task-based production in which routine tasks can be performed by workers or robots. Import tariffs reallocate demand toward domestic goods, reshape markups and entry incentives, and generate fiscal revenues rebated to households. As a result, tariffs raise GDP and consumption measured at market prices and temporarily slow automation, even though intermediate output at factor prices and trade volumes decline. The gains are unevenly distributed: routine workers benefit robustly through transfers and reduced training, non-routine workers face opposing wage and rebate effects, and firm owners gain in aggregate as higher domestic demand and entry expand total profits despite lower per-firm values. Aggregate welfare gains hinge critically on key assumptions (automation, training, endogenous entry) and on how tariff revenues are rebated. In the baseline with uniform transfers, the welfare-maximizing tariff lies below the classical monopoly formula, while alternative rebate schemes can shift it substantially. Overall, the results caution against viewing tariffs as a simple tool for reindustrialization and highlight the role of technology adoption and fiscal incidence in evaluating protectionist policies.

1 Introduction

The diffusion of automation technologies has boosted productivity and product quality, yet also reallocated tasks away from routine occupations, putting sustained *pressure* on middle-skill

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employment and the wage distribution. In parallel, advanced economies – the U.S. in particular – are increasingly turning to tariffs and related trade instruments as tools of industrial policy. These two forces – automation and protection – now interact in real time. Policymakers wonder whether higher trade barriers can slow down automation, tilt the functional distribution of income toward labor (and, in particular, toward low-skill routine workers), and even help to "re-industrialize" manufacturing regions that have experienced secular decline. This argument in favor of protectionism dates back to the "protection of infant industries" (Hamilton, 1790; List, 1841) but would apply here to the protection of "old" industries, not only from trade partners but also potentially from automation and its distributional consequences.

This paper studies these questions in a dynamic two-country general equilibrium model in which firms endogenously choose their degree of task automation. We embed a tractable task-based production technology, in which routine tasks can be performed either by workers or by robots, into a Ghironi and Melitz (2005) environment with iceberg trade costs, ad valorem import tariffs, endogenous firm entry, and selection into exporting. On the labor side, households supply routine and non-routine labor, and routine workers can acquire non-routine skills through costly training. On the firm side, producers choose whether to replace routine labor with automation. These decisions interact with market size, markups, and selection, so that trade policy affects not only prices and quantities, but also technology adoption and business dynamism.

Tariffs operate in our framework through three tightly connected channels. First, they reallocate demand toward domestic goods by raising the relative price of imports. Second, they affect relative prices and markups, reshaping exporter selection, entry incentives, and the profitability of automation. Third, tariffs generate fiscal revenues that are rebated to households, shifting purchasing power and feeding back into domestic demand. A key implication of these channels is that tariffs can raise GDP measured at market prices through valuation effects and transfers, even when production measured at factor prices contracts. This distinction plays a central role in reconciling higher consumption and welfare with falling intermediate output and collapsing trade volumes following a tariff shock.

Our contribution is threefold. First, we provide a disciplined framework that jointly evaluates trade reallocation, endogenous automation, and firm entry, with a transparent mapping from primitives to distributional and welfare outcomes. While the trade literature has emphasized how tariffs affect markups, cutoffs, and varieties (Melitz (2003), Ghironi and Melitz (2005), Barattieri, Cacciatore, and Ghironi (2021), Bergin and Corsetti (2023)), and the automation literature has focused on task substitution and labor-market polarization (Acemoglu and Restrepo (2020), Acemoglu and Restrepo (2022)), these two dimensions have largely been studied in isolation. By combining them, we show how tariff-induced changes in market size and competitive pressure feed back into firms' automation choices and workers' training incentives – a channel that is absent from existing tariff models.

A second contribution is to quantify the conditions under which unilateral tariffs can (or cannot) achieve three objectives emphasized in the policy debate: (i) promoting business dynamism through entry and variety expansion, (ii) shifting purchasing power toward routine workers, and

(iii) slowing the pace of automation. A central finding is that tariffs do slow automation in the short run, not because production expands, but because lower marginal costs – driven by a compression of the non-routine wage – reduce the profitability of replacing workers with robots. At the same time, the sheltering of domestic firms from foreign competition triggers a short-lived entry boom, followed by intensified domestic competition that dilutes per-firm profits over time.

Our third contribution is to show that the design of tariff-revenue rebates is a first-order determinant of both distributional outcomes and the welfare-maximizing tariff. While routine workers benefit robustly from tariffs through rebates and reduced training, non-routine workers face opposing forces from wage compression and transfers. Firm owners typically gains due to competition sheltering. As a result, the welfare-maximizing tariff departs from the classical monopoly benchmark in ways that depend critically on fiscal incidence. In the baseline with uniform per-capita rebates, the welfare-maximizing tariff lies below the classical benchmark, while alternative rebate schemes – including transfers targeted to owners or wage subsidies – can shift the welfare-maximizing tariff substantially.

Four results emerge from our analysis. First, we find that unilateral tariffs can indeed stimulate domestic business dynamism. By redirecting demand toward home goods, they raise the profitability of marginal firms, trigger entry, and expand the set of available local varieties. This reallocation lowers marginal costs and raises GDP measured at market prices, even though production evaluated at factor prices declines once markups, iceberg trade costs, and task substitution are accounted for. As a result, in the short run tariffs act as an expansionary force for GDP at market prices, while intermediate production contracts. At the same time, lower marginal costs reduce the incentive to substitute robots for routine labor, temporarily slowing down automation.

A second insight is that consumption gains are distributed unevenly across households even with uniform lump-sum rebates of tariff revenues. Routine workers benefit systematically, through transfers and a slight decline in training that raises their effective labor income. Non-routine workers face opposing forces: they benefit from rebates, but suffer from a compression of the non-routine wage as production tilts toward routine tasks. Firm owners gain most in the baseline case with a uniform rebate of tariff revenues. Aggregate welfare reflects a balance between redistribution, entry-driven variety gains, and the endogenous response of automation and training.

A third key result is that the welfare-maximizing tariff differs markedly from the classical monopoly formula. In the baseline case with uniform per-capita rebates, the welfare-maximizing tariff lies below the classical formula once automation, entry, and Endogenous varieties are taken into account. While tariffs exploit market power over imports, they also distort production through reduced trade volumes and lower factor-price output. Entry and variety expansion improve welfare but dampen the sensitivity of the welfare-maximizing tariff to key parameters such as the trade elasticity or relative productivity. In short, business dynamism reshapes tariff optimality by weakening the tight link between trade elasticities and welfare that characterizes classical trade models.

Finally, the way tariff revenues are rebated is *crucial* both for transmission and for distri-

butional outcomes. Directing all transfers to routine workers amplifies the pro-routine tilt but magnifies losses for non-routine workers and owners, and drives the welfare-maximizing tariff to zero or below. Rebating revenues to firm owners implies an welfare-maximizing tariff below the baseline, as the contraction in production and the absence of worker compensation dominate. Financing a proportional wage subsidy shifts gains toward workers – especially non-routine workers – without raising firms' marginal costs, and pushes the welfare-maximizing tariff above the baseline. In all cases, welfare is evaluated using CPI-deflated consumption rather than output or PPI-deflated measures.

Overall, these results suggest that tariffs can, under specific conditions, promote business dynamism and slow automation, thereby shifting purchasing power toward routine labor. However, the aggregate gains remain modest, trade volumes collapse, and intermediate output declines, generating strong distributional tensions. The desirability of protection therefore depends less on its ability to raise output than on how it reshapes technology adoption, firm dynamics, and fiscal redistribution.

Methodologically, we integrate three building blocks that jointly generate these mechanisms. We use a tractable formulation of task automation akin to Acemoglu and Restrepo (2022), in which routine and non-routine tasks are complementary and routine tasks performed by workers or robots are substitutable. This provides a margin for endogenous automation to react to policy shocks, including tariffs. We embed this structure into a heterogeneous-firm trade model à la Ghironi and Melitz (2005), so that tariffs affect not only import prices but also selection, entry, and the slope of demand curves. Finally, we introduce worker training dynamics to capture the slow reallocation of labor across tasks, consistent with evidence that skill acquisition responds gradually to relative wages and local demand conditions. Together, these ingredients form a framework in which tariffs, automation, and business dynamism interact endogenously.

Relative to the literature, our analysis bridges two strands that are usually studied separately. The trade literature emphasizes how tariffs affect markups, cutoffs, and varieties (e.g. Melitz (2003); Ghironi and Melitz (2005)), while the automation literature focuses on task substitution, wage premia, and labor-market polarization (e.g. Acemoglu and Restrepo (2020); Acemoglu and Restrepo (2022)). By combining both, we quantify how tariff-induced changes in market size and markups feed back into firms' automation choices and workers' training incentives. This interaction is central for evaluating whether tariffs can tilt the distribution of income toward routine workers *without* accelerating task replacement. In this sense, our framework is novel: 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.[1]

The paper proceeds as follows. Section 2 sets out the model and presents an illustrative simple

[1] 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.

version of the model. Section 3 discusses the calibration. Section 4 presents unilateral tariff experiments focusing on aggregate and distributional effects. Section 5 runs sensitivity analyses highlight the key role of the trade elasticity and the rebate scheme. Finally, and Section 6 looks into the determinants of welfare-maximizing tariffs and their incidence across the population. Section 7 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: 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).[2] 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:

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

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

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

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

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

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 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:

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

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 $\beta_{t,t+1}^e = \beta c_t^e / c_{t+1}^e$, first-order conditions imply:

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

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

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

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

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

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

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

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:

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

so optimal demands per capita are:

$$c_{dt}^i(\omega) = \rho_{dt}(\omega)^{-\theta}(n_t)^{\varsigma-1} c_t^i, \text{ and } c_{xt}^i(\omega^*) = \rho_{xt}^{*,c}(\omega^*)^{-\theta}(n_{xt}^*)^{\varsigma-1} c_t^i. \tag{12}$$

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_t^h and a combination of routine labor ℓ_t^u 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.[3] 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:

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

[3] 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).

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:

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

where μ 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:

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

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:

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

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

We assume $\mu \to 1$, implying perfect substitutability among routine automatable tasks. 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 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:

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

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:[4]

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

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:

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

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

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

where $\Phi_t^* = (1-\mu)\left(\lambda_t^* c_t^{h*} + (1-\lambda_t^*)c_t^{u*}\right) + \mu(c_t^{e*} + a c_t^*)$ 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): $Z_t = n_t^{\frac{\zeta}{\theta-1}} \bigtriangledown z_{\min}$ for domestic producers and $Z_{xt} = n_{xt}^{\frac{\zeta}{\theta-1}} \bigtriangledown z_{xt}$ for exporters with $\bigtriangledown = (\varepsilon/(\varepsilon-(\theta-1)))^{1/(\theta-1)}$. We normalize $z_{\min} = 1$

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

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:

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

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

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

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 $\rho^{*,c}_{xt}$. The condition:

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

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^i_t 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:

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

Letting aggregate per-capita consumption in each country be:

$$\Phi_t = (1-\mu)\left(\lambda_t c^h_t + (1-\lambda_t)c^u_t\right) + \mu c^e_t, \text{and } \Phi^*_t = (1-\mu)\left(\lambda^*_t c^{h*}_t + (1-\lambda^*_t)c^{u*}_t\right) + \mu(c^{e*}_t + ac^*_t), \tag{30}$$

the Home intermediates market clearing is:

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

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

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

then the final-goods sales by Home producers are:

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

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:

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

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

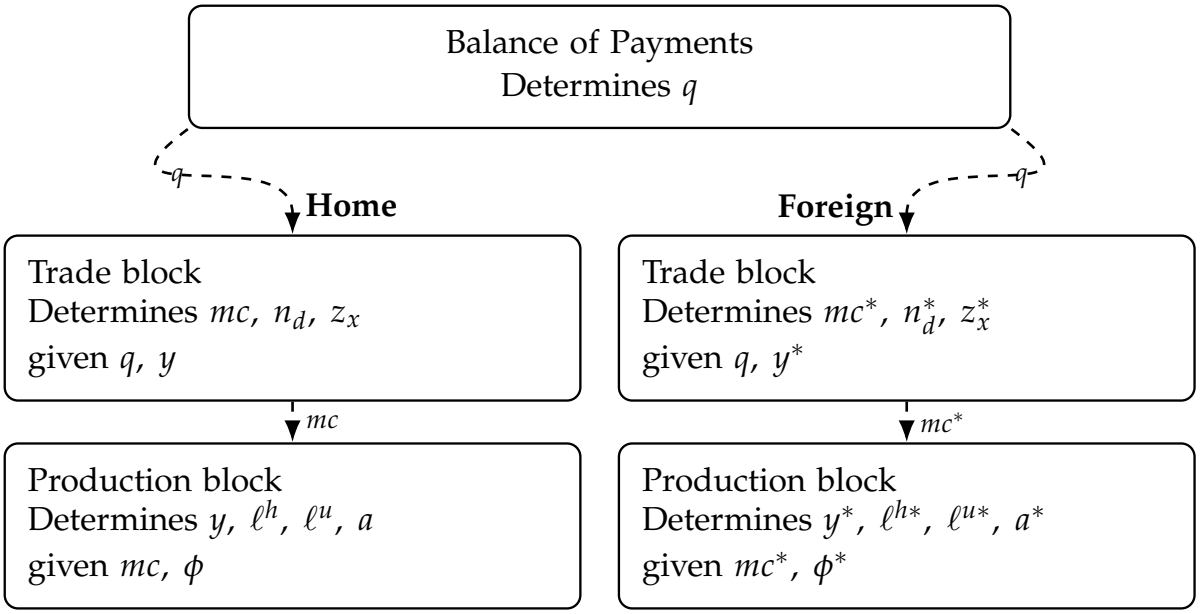
$$q_t b_t + b_t^* = 0, \text{ and } b_t - r_{t-1} b_{t-1} = q_t \frac{\mathrm{EX}_t}{1+T_t^*} - \frac{\mathrm{IM}_t}{1+T_t}. \tag{38}$$

2.4 A Simple Static Example

Before we discuss the calibration and solution of the main model, we present a much simplified version of the model to help gain intuition. This subsection presents a static two-country model which combines the Ghironi-Melitz trade block with a static production bloc allowing for non-routine and routine labor combined with endogenous automation. Figure 1 describes the structure of the simplified model. We continue to assume endogenous entry and selection into exporting status on the part of more productive firms, but we abstract away from household heterogeneity and instead assume there is a representative family that receives wages, profits, and

allocates labour to routine and non-routine tasks, subject to moving frictions. We also shut down the variety offset parameter so that $\varsigma = 1$. As noted, all actions take place within a single period, so that there are no trade balance dynamics and inter-task labor mobility takes place fully within the period. Finally, tariff revenue is rebated in a lump-sum to the single household.

Figure 1: Plan of the Static Example



The Figure shows that countries are linked through trade, which is balanced. Each country has a trade bloc, which determines real marginal cost (equal to the price of the intermediate input produced by labor and robots), total firm entry, and the threshold productivity level for exporting. Trade balance determines the real exchange rate q. Given real marginal cost and the exogenous cost of robots, the production bloc in each country determines total output of intermediate goods, labor allocation between tasks, and the level of automation. The simplified equations of the trade bloc, just for the home country, can be described as follows:

$$f_e mc = \frac{1}{\theta}(\rho_d)^{1-\theta}(mcy + n_d mc f_e) + \Lambda_2 mc z_x^{-\epsilon} \tag{39}$$

$$\frac{q}{\theta}(\rho_x)^{1-\theta}(mc^* y^* + n_d^* mc^* f_e)/\mathcal{B} = mc f_x \Psi_1 \tag{40}$$

$$n_d(\rho_d)^{1-\theta} + n_d^*(z_x^*)^{-\epsilon} \bigtriangledown^{\epsilon} (\tau(1+T)\rho_x^*)^{1-\theta} = 1. \tag{41}$$

$$q z_x^{-\epsilon}(\tau\rho_x)^{1-\theta}(mc^* y^* + n_d^* f_e mc^*) = (z_x^*)^{-\epsilon}(1+T)^{-\theta}(\tau\rho_x^*)^{1-\theta}(mcy + n_d f_e mc)/\mathcal{B} \tag{42}$$

Here, $\Lambda_2 = \bigtriangledown^{\epsilon} f_x \frac{\theta-1}{\epsilon-(\theta-1)}$ and $\Psi_1 = (1 + \frac{\theta-1}{k-(\theta-1)})$. Equation (39) is the entry condition for the home country in the static model, while (40) is the analogous cutoff condition for the marginal

exporter. Equation (41) is the price index for the home country normalized to 1, and (42) is the balance of payments condition. The term $\mathcal{B}$ acts so as to reconcile the income effects of the tariff rebate in the simple static model. Note that in this system the tariff T reduces the number of foreign exporters, it raises overall price level and reduces home demand for foreign goods through the balance of payments equation.

The production bloc for the home country in the simple model can be described by the following equations:

$$y = A\ell_h^{\alpha}\left(\frac{\ell_r}{1-a}\right)^{1-\alpha} \tag{43}$$

$$mc\alpha Y = w_h\ell^h \tag{44}$$

$$mc(1-\alpha)y = w_r\frac{\ell^u}{1-a} \tag{45}$$

$$w_r = \phi \tag{46}$$

$$w_h = w_r\ell^h\psi \tag{47}$$

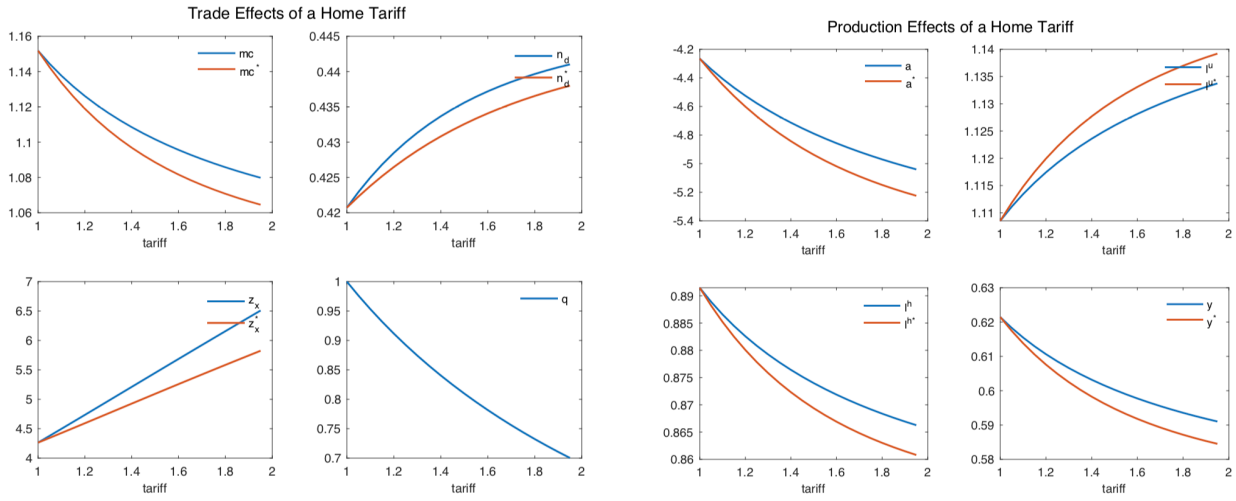
$$\ell^h + \ell^u = L; \tag{48}$$

Equation (43) is the simplified production function over non-routine labor, routine labor, and automation, assuming unit elasticity of substitution between routine and non-routine tasks. Equations (44) and (45) are first order conditions for optimal non-routine labor and routine labor-automation mix, while Equation (46) shows routine labor wage is pinned down by cost of automation. Rather than modeling endogenous training, Equation (47) determines the wage of non-routine labour as an endogenous markup over wage of routine labor. This is meant to capture some added labor market frictions in moving from routine to non-routine tasks. Finally Equation (48) represents labor market clearing.

Figure 2 shows the effect of a home country ad valorem tariff in the simple model. The left panel shows the effects on the trade bloc and the right panel shows the variables in the production bloc. The fall in demand for domestic imports leads to a real exchange rate appreciation for Home (q falls). At the same time, since it protects domestic industry, we see an increase in domestic entry of new firms, so that n_d rises, both in the home and foreign countries, although entry is greater in the home country. The overall rise in the CPI price relative to domestic costs leads to a fall in both mc and mc^* and as a result the total production of intermediate goods falls in both countries.The fall in mc leads a rise in the domestic export threshold and a move out of exporting for domestic firms. Hence the tariff reduces trade volume, although in this example the trade balance does not change. It is notable that the fall in exporting intensity is greater for the home country, that imposes the tariff, than the foreign country, which has not imposed a tariff.

The fall in mc in each country, combined with a fixed real cost of automation ϕ first leads to a fall in non-routine employment. This must lead to an expansion in routine employment. At the same time, equation (45) implies a fall in $\frac{\ell_r}{1-a}$, requiring a fall in automation The net effect is a fall in intermediate good production per firm.

Figure 2: Effect of a tariff in the static model.



(a) Trade Bloc

(b) Production Bloc

In summary, in this static version of the model, we already see that the tariff has a range of effects beyond the direct effect on trade flows and the terms of trade. We now turn to the solution of the general model, first discussing the model calibration.

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.[5] 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.

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.[6] 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.[7] Figure 3 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.

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

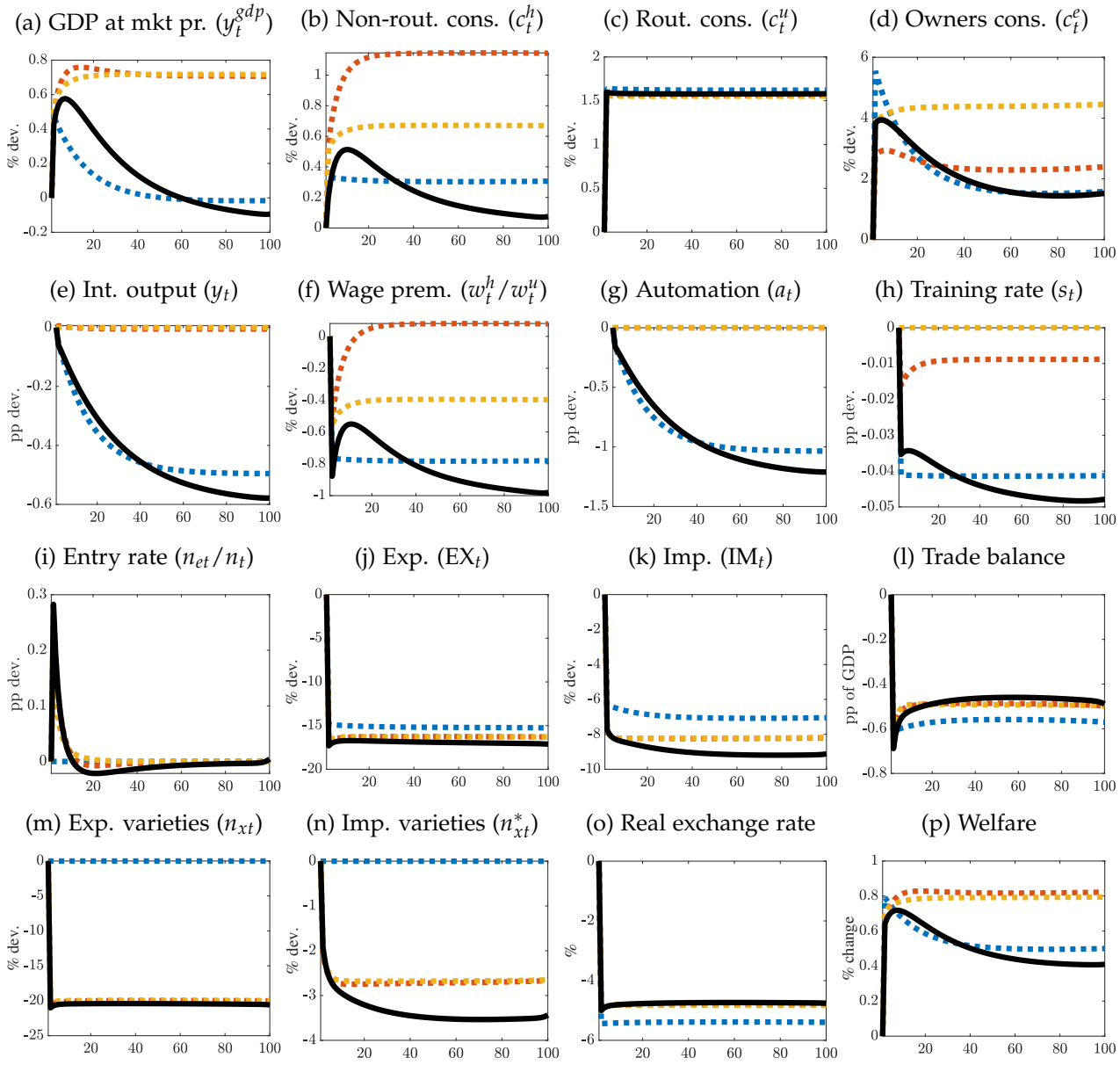
[6] The mapping uses the model-consistent GDP measure (including tariff rebates) described in the text, i.e. GDP at market prices.

[7] 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 3: 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.

Expenditure switching and the real exchange rate. A 10pp increase in the U.S. import tariff generates a standard expenditure-switching response. The consumer price of imports rises, U.S. absorption tilts toward domestic varieties, and the CPI-based real exchange rate appreciates (panel o). Imported quantities fall sharply on impact (panel k). Exports, measured in units of domestic goods and net of foreign tariffs, also decline (panel j): the real appreciation erodes U.S. export competitiveness and tightens the export cutoff.

GDP, production, and valuation effects. A key distinction in our framework is between GDP measured at market prices and production measured at factor prices. 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 – falls unambiguously (panel e). While the tariff reallocates demand toward home varieties, it simultaneously reduces export production and destroys resources through iceberg trade costs. This wedge between GDP and production is central for interpretation. The economy appears to expand in value terms even as actual resource use in production contracts. Our accounting framework makes this distinction explicit and ensures that welfare is evaluated using consumption at market prices, consistent with household optimization.

Entry, selection, and variety margins. With endogenous variety margins (black), the expansion of the home market raises expected profits for domestic producers and triggers entry (panel i). The number of domestic varieties increases, intensifying competition over time. On the import side, the tariff directly lowers foreign export profits, leading to a decline in the number of imported varieties (panel n). Freezing variety margins (blue) shuts down this amplification channel. Traded quantities then react less, but since exports and imports both adjust at the extensive margin, the trade balance is only weakly affected.

Demand reallocation, entry, and production. The tariff reallocates domestic expenditure toward home varieties, but this reallocation does not translate into higher production. On impact, higher import prices shift U.S. absorption toward domestic goods, while exports fall because the real exchange rate appreciates and the foreign market shrinks through tighter exporter selection and weaker foreign demand. As a result, total delivered demand for domestic intermediates declines, and intermediate output falls unambiguously. At the same time, tariff revenues and the terms-of-trade appreciation raise household purchasing power, so consumption measured at market prices increases for all agents despite the contraction in production.

The response of entry reflects a short-run competition sheltering effect. The tariff temporarily protects the domestic market from foreign competition, raising expected profits and inducing a surge in entry on impact. This effect is short-lived. As new domestic firms enter, competition intensifies and per-firm profits are diluted, causing the entry rate to revert quickly toward its steady state. In parallel, the sharp contraction in exports and in the number of exported varieties frees resources previously devoted to export fixed costs, partially offsetting the resource

use associated with entry. The extensive margin of local producers expands temporarily, while the intensive margin of production contracts. All together, the tariff raises GDP at market prices through valuation effects and transfers, while it reduces production at factor prices. The economy reallocates activity away from export production and toward domestic entry, with lower automation and training reflecting weaker incentives along the intensive margin.

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 sizable 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.

Labor markets, wage premia, and automation. The non-routine wage premium falls persistently following the tariff shock (panel f). The reallocation of demand toward domestic goods compresses the non-routine wage and lowers the marginal cost mc_t, as shown in Section 2.4. 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). At the same time, the decline in the non-routine wage reduces the return to training, causing the training rate to fall (panel h).

Subsequent automation dynamics reflect the interaction between profits and market structure. In the baseline (black), entry rises temporarily, increasing the number of domestic competitors. Although aggregate profits increase, per-firm profits and production decline over time, weakening incentives to adopt automation technologies. As a result, automation continues to drift downward beyond the initial impact. When the extensive margin is frozen (blue), the initial decline in automation is slightly larger, reflecting more persistent sheltering from foreign competition. However, in the absence of domestic entry, markups and per-firm profits stabilize in the medium run, attenuating the long-run decline in automation relative to the baseline. Overall, automation dynamics are driven by the composition of competition rather than by its aggregate intensity.

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.

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 factor utilization, wages, and consumption. 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. Comparing the baseline (black) to the no-automation economy (red) highlights automation as an internal adjustment margin to tariff-induced demand reallocation. When automation is shut down, firms cannot adjust the task composition, so demand reallocation translates more directly into higher factor use and production. Intermediate output declines by less, remaining close to its steady-state level, and GDP at market prices rises by more (panel a), generating larger welfare gains (panel p). Distributional effects are also altered. Non-routine households benefit more: the lower fall in the demand for non-routine tasks leads to a lower wage decline (the non-routine wage eventually increases), and tariff-revenue rebates further support consumption (panel b). Owners' consumption responds more moderately (panels c–d). Entry rises slightly more (panel i), while training incentives decline by less (panel h). External margins are only weakly affected. Overall, automation acts as a buffer. When active, firms absorb part of the tariff-induced demand shift through task reallocation rather than factor use, moderating responses in output, wages, and welfare. When automation is shut down, this buffer disappears and adjustment operates more strongly through quantities. Turning off training in addition to automation (yellow) generates only minor differences, confirming that training plays a second-order role once automation is inactive.

Discussion. The responses documented in this section combine standard expenditure-switching mechanisms with 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 exports 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. By lowering the non-routine wage and marginal cost, tariffs reduce the profitability of automation and slow down robot adoption. Automation drops on impact and recovers only gradually as domestic competition strengthens. 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. Tariffs reshape the composition of economic activity, but do not expand the productive frontier.

5 Sensitivity

Before turning to the question of welfare-maximizing tariffs, we explore how the main results depend on key parameters, such as 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 this latter channel, θ determines the size of markups, the value of an entrant, and hence the scale of distortions associated with imperfect competition. As with TFP, 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, they shift the strength of tariff pass-through, the size of entry distortions, 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.

5.1 Different elasticities of substitution

The elasticity of substitution across varieties, θ, is central 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 key 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 4 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 ($\theta = 3.8$).

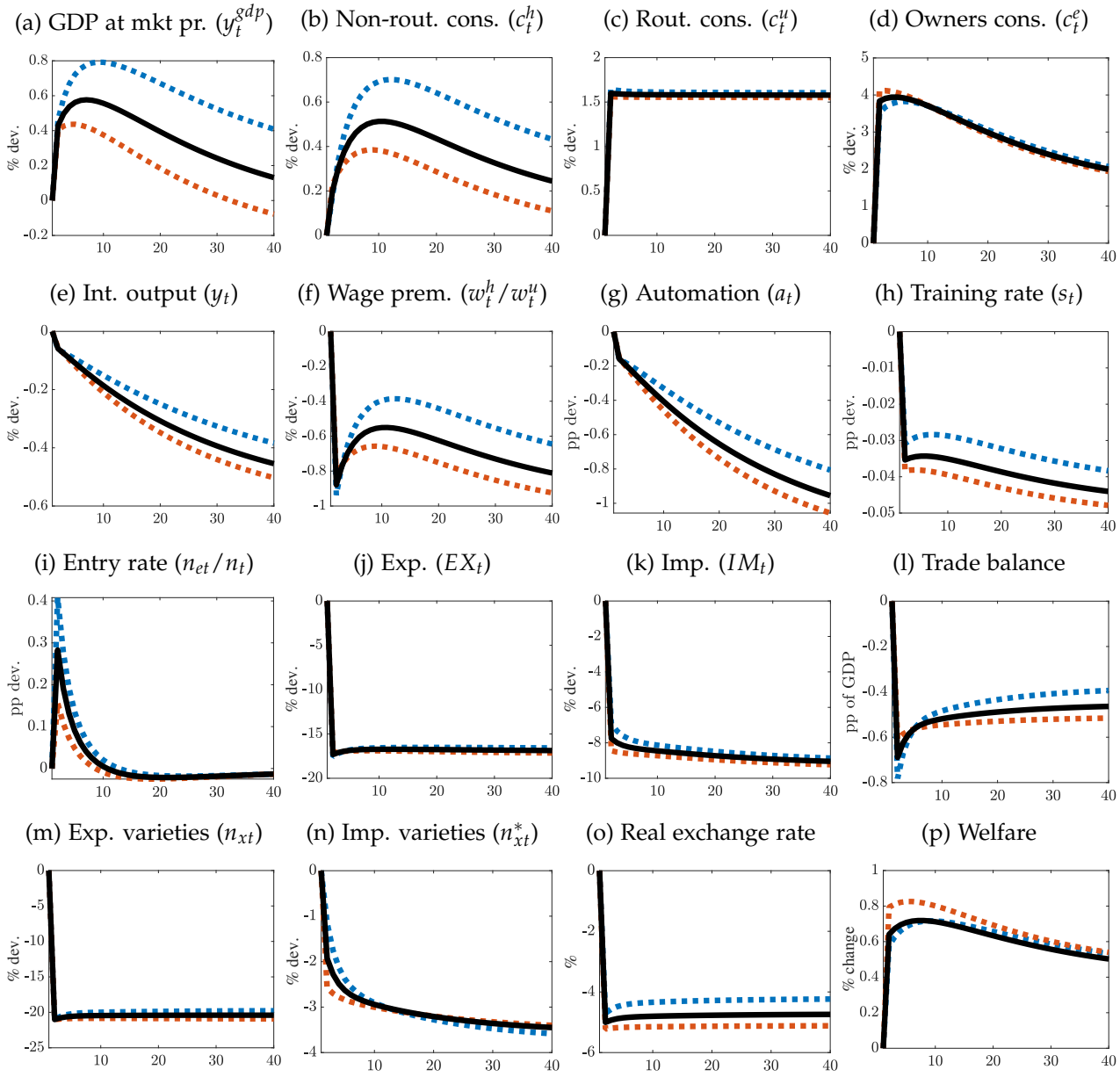
Figure 4 shows that the transmission of tariffs is highly sensitive to the elasticity of substitution across varieties. When θ is lower (blue, $\theta = 3.4$), higher steady-state markups make domestic profits more responsive to trade protection. Even though expenditure switching is weaker, the tariff 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 (panels m-n), 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, 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

Figure 4: 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.

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 adjustment costs.

5.2 Alternative rebate design

So far, 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 5.

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

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

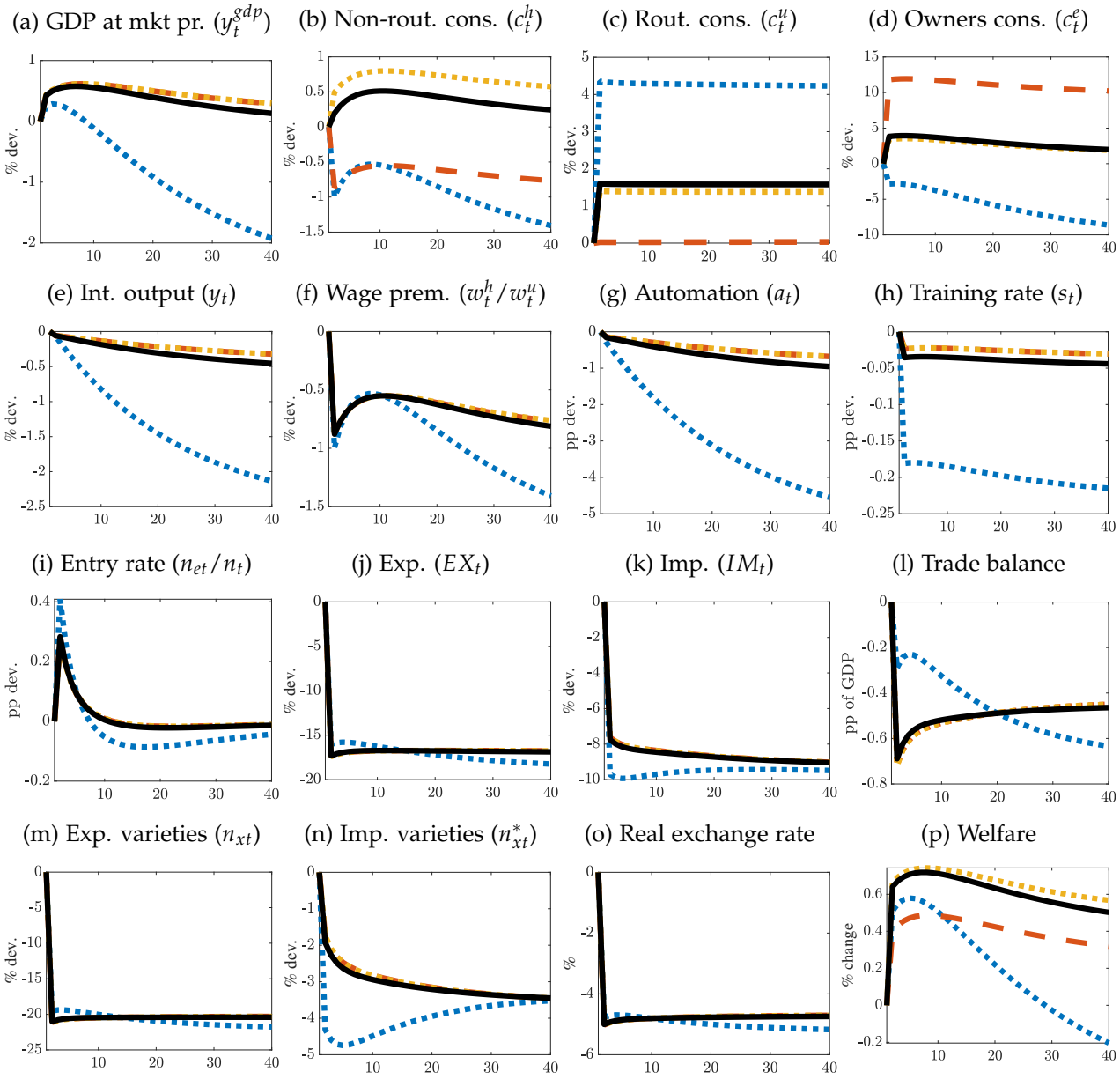
This rebate scheme amplifies the pro-routine shift, further raising their consumption directly (panel c: +4.2% vs +1.5% in the baseline). Non-routine workers and owners, by contrast, receive no rebate at all, so the welfare distribution skews heavily toward routine workers. Since transfers significantly 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. 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.

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 routine workers are essentially

Figure 5: 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.

unaffected 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.

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 5 (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, routine workers a bit less, and aggregate welfare ends up slightly above the benchmark.

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 recycled – 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.

5.3 Retaliation

We now consider a symmetric tariff increase in both countries. Figure 6 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.

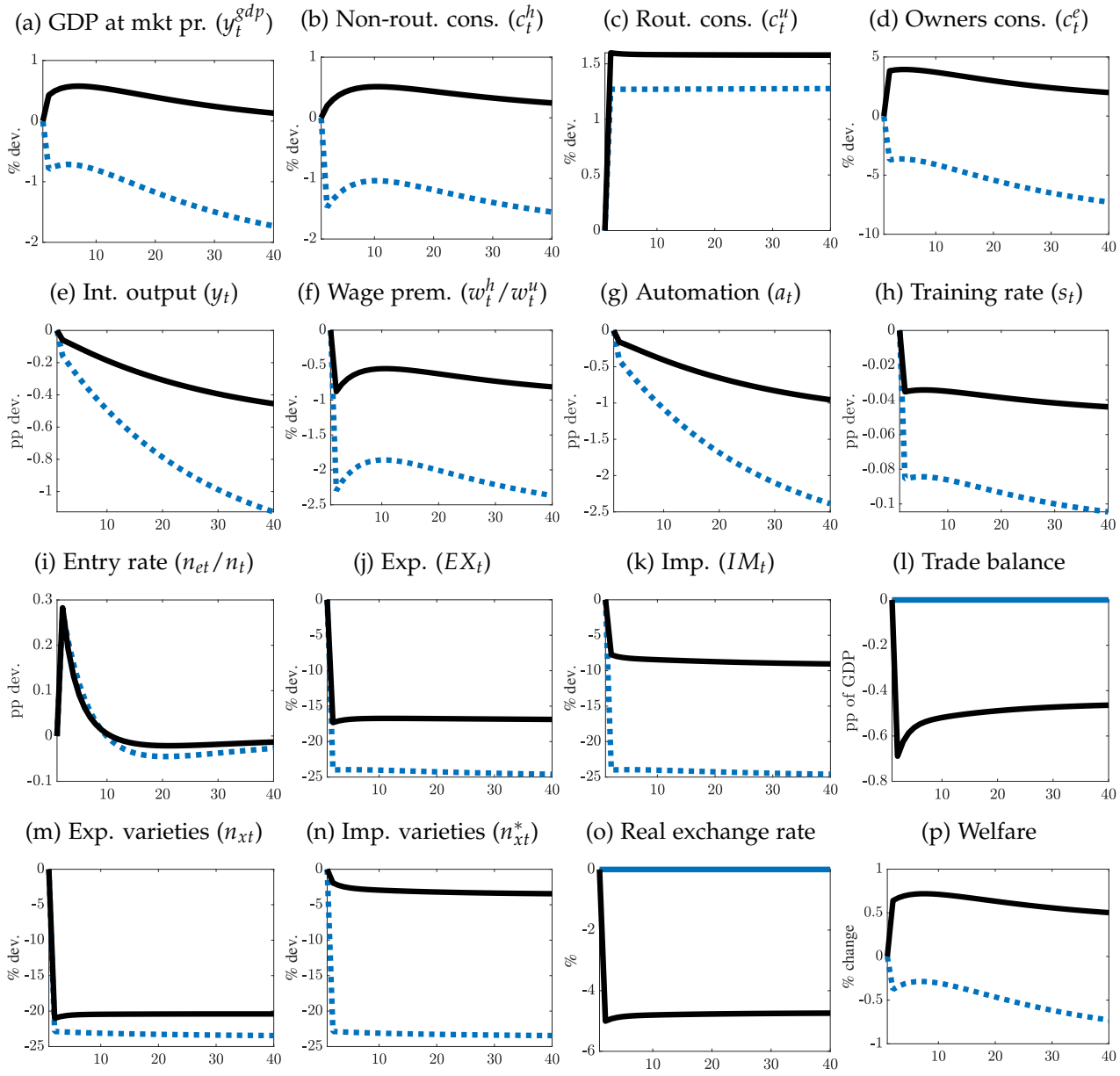
The mechanism at work is the same relative-price channel as before: each country's tariff lowers its own marginal cost mc_t via the domestic-variety expansion, but the partner's retaliation dramatically lowers the number of imported varieties in both countries, which magnifies the drop in mc_t. With 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 (panels m–n), 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, more than compensating 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 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.

Figure 6: Effects of a worldwide 10pp tariff hike (retaliation).



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

6 Welfare-maximizing Unilateral Tariff

A natural question then is 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

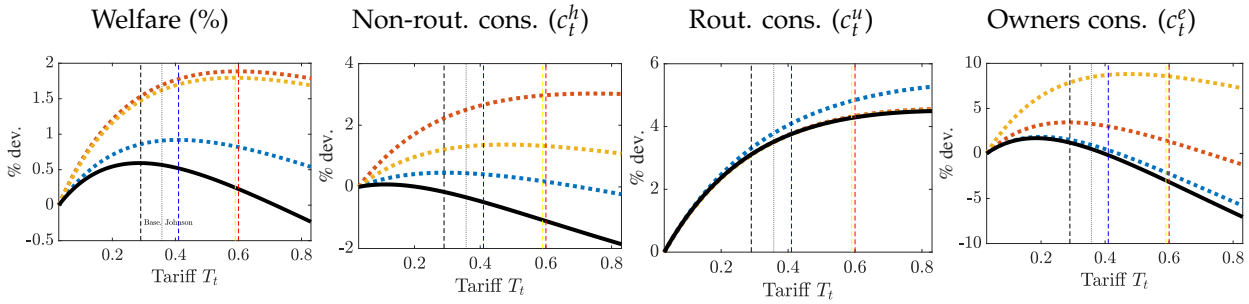
$$1 + T^{\text{opt}} = \frac{\theta}{\theta - 1},$$

reflecting a pure 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 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 (i.e. steady-state) change 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 7 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 7: 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 $T \simeq 0.41$. 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 the highest optimal tariff: without endogenous factor substitution or skill investment, the economy behaves closer to a static environment in which tariff revenues dominate the welfare calculus.

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 routine households. In the baseline, the rebate dominates at low tariff levels, so non-routine consumption initially rises, but the wage effect becomes increasingly important 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 compresses less, allowing non-routine workers to share more in the gains from protection. This mechanism is attenuated when the training margin is shut down (yellow).

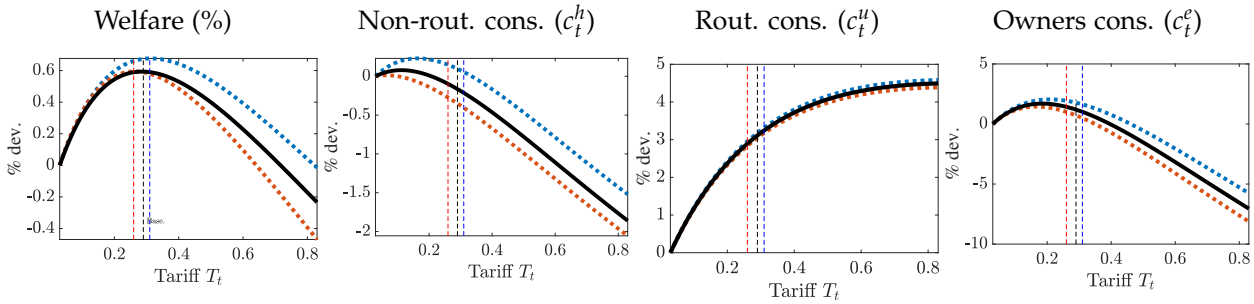
Firm owners face a similar but more pronounced trade-off. Entry and competition dilute per-firm profits as tariffs rise, while tariff revenues are rebated uniformly across households. As a result, owners' consumption peaks at relatively low tariff levels and declines thereafter in all cases. The automation 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 7 highlights that the welfare-maximizing tariff is quite 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 8 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 8: 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.

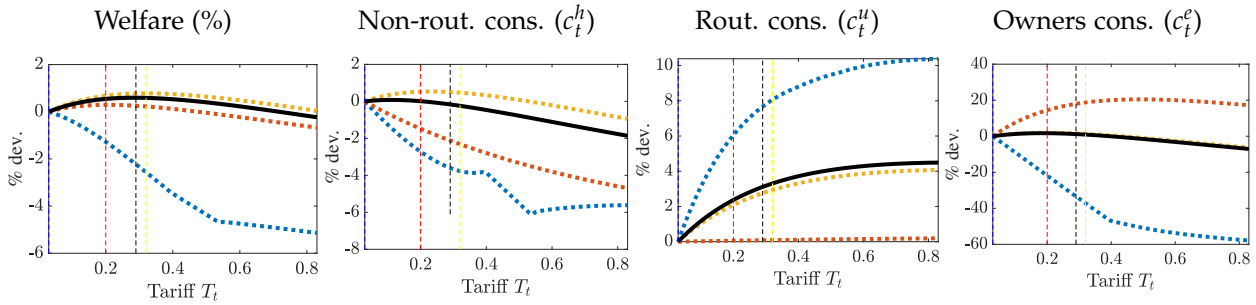
From a distributional perspective, variations in θ mainly reshape how tariff gains and losses are shared across households, rather than overturning the qualitative pattern. Routine workers continue to gain monotonically from higher tariffs, largely independently of θ, while non-routine households remain 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 markedly attenuated around this higher level. In the baseline economy with a uniform per-capita rebate, the welfare-maximizing tariff remains in the vicinity of $T \simeq 0.29$.

The role of the rebate scheme. Figure 9 shows how the welfare–tariff profile depends on how tariff revenues are recycled. The differences are striking.

Figure 9: 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.

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: 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 rebate rule.

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, both routine and non-routine 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 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. 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.

7 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:

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

and weight them:

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

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

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

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

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

and recalling that:

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

then:

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

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

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

Incorporating in Equation (61) we get:

$$\Phi_t + n_t^e f_e m c_t + n x_t = y_t^s/\theta - n_{xt} f_x m c_t + \phi_t x_t + w_t^h \ell_t^h + w_t^u \ell_t^u + TR_t, \tag{68}$$

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