Patterns of Labor Market Adjustment to Trade Shocks with Imperfect Capital Mobility

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Abstract

This paper explores how different investment frictions affect the patterns of responses of labor markets to tariff cuts. To investigate these patterns, this paper formulates a multi-sector dynamic model featuring capital and labor adjustment costs that is fitted to Argentine data. Counterfactual simulations of a tariff decline in the textile sector are used to show that capital adjustment can create long-run responses of real wages that are larger than the short-run

responses. This happens as textile firms disinvest during the transition. This paper also shows that the reduction of tariffs on capital inputs boosts investment and real wages across sectors. This paper assesses the nature of capital adjustment costs, including fixed, convex, and irreversibility costs in determining these patterns of labor market responses to trade reforms.

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1 Introduction

Trade policy causes some sectors to expand and others to shrink, creating winners and losers along the way. The magnitudes of these impacts depend on factor adjustments to shocks. If labor and capital react slowly and can only be imperfectly reallocated from shrinking to expanding sectors, then the negative effects of a trade policy shock can be amplified. To account for imperfect factor adjustments, early international trade research mostly focused on the capital adjustment process (Mussa, 1978). More recent research focused instead only on labor market adjustments (Davidson and Matusz, 2004; Davidson and Matusz, 2006; Artuc, Chaudhuri and McLaren, 2010). This paper offers a new analysis that incorporates both labor mobility costs and capital adjustment costs and assesses their significance simultaneously. This allows for an accurate quantification of the impact of trade policy because we not only measure both mechanisms in a consistent framework, but we also account for interactions that occur when the labor adjustment process affects the capital adjustment process and vice versa.

We claim that capital adjustment can re-shape the short- to long-run transition of wages. After a tariff cut, the wages in the affected sector typically decline in the short-run.¹ When firms can disinvest in response to the loss of protection, the capital stock sluggishly decreases, thus further reducing labor productivity and wages through time. The impacts on wages can consequently be magnified. If instead capital adjustment is ignored, as it is often the case in the trade literature on labor markets, the wage impact of the tariff cuts will be eroded in the long-run as labor moves out of the de-protected sectors and the marginal product of labor thus increases.²

To investigate these issues and the attendant patterns of labor market adjustment, we formulate a dynamic structural model of trade with worker’s intersectoral choice and firm’s capital accumulation decisions. Our framework combines the labor supply model with workers’ mobility costs of Artuc, Chaudhuri and McLaren (2010), extended to include non-employment as in Caliendo, Dvorkin and Parro (2019), with the labor demand model with capital adjustment costs of Bloom (2009) and

¹See Goldberg and Pavcnik (2005), Kovak (2013), Autor, Dorn and Hanson (2013), Autor, Dorn, Hanson, and Song (2014) and Hakobyan and McLaren (2016).

²The labor adjustment cost literature is abundant, including models with workers’ moving costs across sectors (Artuc, Chaudhuri and McLaren, 2010; Artuc and McLaren, 2015; and Dix-Carneiro, 2014) and workers’ sector-specific experience (Cosar, 2013; Dix-Carneiro, 2014; Davidson and Matusz, 2004; Davidson and Matusz, 2006; Ritter, 2014). Another branch focuses on firm behavior and studies firing and hiring costs (Kambourov, 2009; Dix-Carneiro, 2014) and market search frictions (Cosar, 2013; and Cosar, Guner and Tybout, 2016). The treatment of capital adjustment costs is succinct in the related trade literature. Dix-Carneiro (2014) works out examples of ad-hoc capital adjustment costs and labor markets; Rho and Rodrigue (2016) analyze the interaction between investment and export costs.

Cooper and Haltiwanger (2006). The labor supply side is characterized by a rational expectations optimization problem of workers facing mobility costs and time-varying idiosyncratic shocks. The labor demand side is characterized by the rational expectations intertemporal profit maximization problem of firms facing costs for adjusting their capital stock and time-varying technology shocks. To deal with trade shocks, our model features multiple sectors. To deal with general equilibrium effects and labor market responses, we endogenize equilibrium wages across sectors.³

We fit our model to plant-level panel data and household survey data from Argentina for the 1994-2001. We use the firm-level data to identify the technology and capital adjustment cost parameters that define labor demand. We use the panel component of the household survey data to identify the labor mobility costs parameters. We recover the structural parameters that characterize the frictions faced by both workers and firms. A major feature of our estimation strategy is the joint estimation of these parameters: firms internalize workers decisions when choosing investment and workers internalize firm decisions when choosing sector of employment. Finally, we use the estimated parameters to compute counterfactual stationary adjustments of investment, capital, labor allocations and wage distributions across sectors following a cut in tariffs. We use these counterfactual adjustments to carefully assess the implication of imperfect capital adjustment when the economy responds to trade shocks.

We focus on tariffs on textiles, a major import sector in Argentina that enjoyed significant tariff protection during the 1994-2001 period. In the benchmark simulation, we work with the full elimination of an initial tariff on Textiles of 19.4 percent. This reduces textile prices and decreases profitability in the sector. Capital gradually declines, as textile firms disinvest, and employment gradually declines, as workers are displaced. The capital stock decreases by 9.41 percent initially and by 25.47 percent in the new steady state. Employment decreases by 2.91 percent initially and by 4.64 percent in the new steady state. These are sizeable impacts.

At the time of the tariff cut, the nominal wage in the textile sector goes down in proportion to the initial price decline. Lower textile prices imply a decline in the price index that reduces the cost of living. However, the real wage in textiles decreases on impact by 15.04 percent. Because of the dynamic adjustment of capital and labor during the transition, real wages continue declining gradually. In the new steady state, real wages are 20.32 percent lower than in the initial equilibrium.

³This feature is shared by the trade model of Artuc, Chaudhuri and McLaren (2010) but it is a major difference with the capital adjustment costs models of Cooper and Haltiwanger (2006) and Bloom (2009) in which wages are exogenous.

There is no overshooting of wages as in fixed capital models. This is because the negative effects of the reduction in capital caused by firm disinvestment on the marginal product of labor outweigh the positive effects caused by displaced workers. The possibility that capital mobility may impede the wage overshooting was advanced by Dix-Carneiro (2014). Using ad-hoc capital adjustment rules, Dix-Carneiro shows how the responses of the capital stock can indeed undo the overshooting of wages in Brazil. Our results confirm these predictions in a more complex model of capital adjustment costs. We also provide quantitative evidence of when the overshooting of wages may or may not take place. We show that even with capital mobility, though costly and imperfect, the overshooting of wages may occur if labor mobility costs are lower. In this case, workers can move out of the shocked sector faster than firms disinvest.

We model capital frictions to include fixed costs, convex costs and irreversibility costs. This complex structure has implications for labor markets adjustment. We uncover an asymmetric response of the economy to negative shocks and positive shocks (of equal size). Concretely, the positive shock triggers a proportionately larger response of the capital stock, the real wage and employment than the negative shock, especially in the first years of the transition. The reason is that a positive shock induces investment in the most productive firms. Instead, when the shock is negative, firms let capital depreciate and disinvest proportionately less in order to save on the capital adjustment costs.

We also explore the role of input tariffs on capital goods, which face a tariff of 12.3 percent in the initial equilibrium. Because of lower prices of capital goods, textile firms still disinvest but much less. The total capital stock declines only by about 10 percent, compared to 25.47 percent in the benchmark experiment. The reduced disinvestment implies a higher capital stock that attenuates the continuous decline of the real wage. There is no overshooting, however: real wages are 16 percent lower in the new steady state, 1 percentage point lower than the initial decline. In the non-textile sectors, the reduction of tariffs on capital goods boosts investment, employment and real wages. The liberalization of tariffs on capital goods also has sizeable impacts across industries and can cushion some of the direct negative effects on output of de-protected sectors (textiles).

The tariff cuts on textiles have general equilibrium effects. As prices are initially lower, real wages increase on impact in all other sectors of the economy. This attracts workers from textiles, employment expands more than capital, and real wages decline slightly during the transition (in all non-textile sectors). Finally, as the textile sector shrinks because of the loss of tariff protection, some

of the displaced workers end up non-employed, so that aggregate employment decreases steadily but only slightly during the transition. With tariff cuts on capital goods as well, however, aggregate employment actually increases.

For robustness, we explore simulations where we allow for firm entry and exit. While our qualitative results do not change, the entry-exit mechanism amplifies the impacts of the shock on investment, especially in the short-run. On impact, the capital stock in the textile sector declines by 40 percent more than in the baseline model without exit. In the steady state, the capital stock is only 2 percent smaller. There is also a more pronounced decline in employment and in real wages.

For modeling tractability, we abstract from two additional channels that are sometimes present in the literature. Our model features intermediate inputs that are sourced only from own-sector output, and thus we do not incorporate comprehensive input-output linkages as in Caliendo and Parro (2015) or Caliendo, Dvorkin and Parro (2019). Also, because of data limitations, we do not study geographical patterns of adjustment, as in Dix-Caneiro and Kovak (2017), Caliendo, Dvorkin and Parro (2019) and others.

The paper is organized as follows. In section 2, we discuss the theoretical model of firm and worker behavior in the presence of capital adjustment costs and labor mobility costs. In section 3, we discuss the data, the estimation strategy and the main results. In section 4, we compute a stationary rational expectations equilibrium and we estimate the effects of tariff cuts on investment and labor markets by performing counterfactual simulations. Finally, section 5 concludes.

1.1 Discussion

Here, we briefly discuss some of the distinguishing features of our model vis-à-vis the related trade and macro literature. In this paper, we are interested in trade shocks and, for this purpose, we need to develop a multi-sector model. Some sectors compete with imports, others are net exporters, and yet others are non-traded. These sectors in principle respond differently to trade shocks. In addition to the multi-sector feature, we endogenize equilibrium wages across sectors. This is done, as explained, by modeling labor demand on the firm side and labor supply of the workers side. This implies that sectoral wages respond to the trade shock, which allows us to study labor market adjustment and distributional issues. This is a major difference with the seminal papers on capital adjustment costs such as Bloom (2009) and Cooper and Haltiwanger (2006).

There is another important difference with the literature. Bloom (2009) models a one-sector

economy where firms face both capital and labor adjustment costs but workers move freely (and wages are not determined endogenously). We develop a model where workers face mobility costs and firms face capital adjustment costs, but not labor adjustment costs (such as firing and hiring costs). Our setting does not lend itself to adding labor adjustment costs on the firm side. The estimated labor mobility costs, as in Artuc, Chaudhuri, and McLaren (2010), are a reduced form measure of mobility costs imposed by labor market frictions, including the costs faced by both firms and workers. Thus, including labor adjustment costs to the firm optimization problem implies a double counting of some of the labor mobility costs. We prefer this setting because it allows for differences in wages across sectors and for general equilibrium effects, in particular on wages.

2 Model

In this section we develop a multi-sector dynamic model. Our objective is to provide a framework that will allow us to describe how labor markets adjust to a trade shock to a specific sector in the presence of capital adjustment costs and labor mobility costs. We characterize the dynamic optimizing behavior of firms and workers and equilibrium results for employment, wages and investment.

In our model there are J sectors of production: $J - 1$ tradable manufacturing sectors and a large non-manufacturing non-tradable sector. They are indexed by j . There is also unemployment, or more generally non-employment, which we refer to as sector 0, or outside sector.⁴ Within sectors, products are homogeneous and markets are competitive. The country is small and faces exogenously given international prices p_{jt}^* at time t . We allow for tariffs τ_{jt} so that domestic prices are $p_{jt} = p_{jt}^*(1 + \tau_{jt})$. In the non-tradable sector, prices are endogenously determined in a competitive domestic market. Wages are determined endogenously in each sector as well.

2.1 Firms

Each production sector j is composed of a continuum of firms. Firms produce output by combining labor, capital and materials. In each time period they face productivity shocks and price shocks that follow first order Markov processes. Labor and materials are flexible inputs that can be adjusted instantaneously through a static profit maximization problem. Capital is subject to adjustment

⁴In the empirical implementation of the model we work with 5 manufacturing sectors: food and beverages, textiles and apparel, minerals, metals, other manufactures; and 1 non-tradable sector: services; for a total of $J = 6$ production sectors plus non-employment.

costs, as in Bloom (2009) and Cooper and Haltiwanger (2006), which makes the investment decision dynamic. At time t capital is predetermined; investment made at t transforms into working capital in $t + 1$.

We make two simplifying assumptions regarding participation. In our baseline specification, we do not model the decision to enter or exit the domestic market. That is, the number of firms is fixed and there are no fixed costs of production so that even the least productive firms find it profitable to produce. In the simulations (section 4), however, we explore an extension of our baseline model that allows for entry and exit of firm. We also do not model the decision to export. Since firms face a perfectly elastic demand, the decision to export does not play any role in this model.

We start by describing the production technology and the static profit maximization. The production function is a Leontief combination of materials and a Cobb-Douglas index of labor and capital given by

$$(1) \quad Y_{ijt} = \min \left\{ (b_{jt}^0 A_{ijt}) L_{ijt}^{\alpha_L} K_{ijt}^{\alpha_K}, \frac{M_{ijt}}{v_M} \right\},$$

where Y_{ijt} is output, L_{ijt} is labor, K_{ijt} is the capital stock, and M_{ijt} is materials. The variables b_{jt}^0 and A_{ijt} are sector-level and firm-level productivity shocks, respectively. Both are Hicks-neutral in the three inputs. The parameters α_K and α_L are the Cobb-Douglas output elasticities and v_M is the unit input requirement for materials. The intuition behind the functional form is that there is substitution between labor and capital, with the capital-labor intensity being chosen by firms, whereas materials transform into output in fixed proportions and cannot be substituted for with labor or capital.

We furthermore assume that firms source materials from their own sector only. Under these assumptions we can write instantaneous profits as a function of labor and capital as

$$(2) \quad \Pi_{ijt} = p_{jt} b_{jt}^0 A_{ijt} (1 - v_M) K_{ijt}^{\alpha_K} L_{ijt}^{\alpha_L} - w_{jt} L_{ijt},$$

where w_{jt} is the sector wage and p_{jt} the sector domestic price including tariffs. Notice that the price and productivity shocks enter instantaneous profits multiplicatively. We combine the two sector-level shocks into one *profit* shock, denoted by $b_{jt} = p_{jt} b_{jt}^0$. This profit shock includes price shocks and technology shocks that are common to all firms in a sector. It can also include uncertainty shocks to tariffs or trade policy (Handley and Limao, 2015). Firm-level shocks are only productivity

shocks (A_{ijt}), since this is a perfect competition model and all firms face the same price. We treat the sector-level profit shock b_{jt} as a single random variable, and we assume that A_{ijt} and b_{jt} follow two independent time-invariant first-order Markov processes. As in Cooper and Haltiwanger (2006), we assume that the profit shock b_{jt} has two states, *high* and *low*.

The two assumptions on materials—that materials transform into output in fixed proportions and that firms source materials from their own sector only—are key to keep the estimation tractable. Sourcing only from own-sector implies that firms consider only own-sector state variables in the dynamic optimization problem; whereas the combination of the two assumptions on materials results on sector-level shocks entering multiplicatively into profits and therefore being treated as a single state variable. This is not the case in a Cobb-Douglas or CES production function case. We further assume that technology parameters are the same across sectors, so that all sectors can be treated symmetrically in the estimation. For sufficiently aggregate sectors such as ours, evidence from input-output tables shows that most input-output sourcing does occur within each sector. Calculations from IO tables from Argentina for the year 1997 show that materials sourced from own-sector account for 75 percent of all materials for food and beverages, 59 percent for textiles, 80 percent for metals, 26 percent for minerals, and 70 percent for other manufacturing industries. To assess the fixed proportions technology assumption, we present an alternative specification with a Cobb-Douglas technology in on-line Appendix B. The qualitative conclusions of the paper remain unchanged.

Given the firm-level predetermined capital and the idiosyncratic productivity shock (K, A), as well as the sector-level profit shock and wage (b, w), firms choose labor to maximize instantaneous profits. From the static profit maximization problem we obtain firm-level labor demand, output supply, and indirect instantaneous profits. We denote the indirect instantaneous profit function with $\pi(K_{ijt}, A_{ijt}, b_{jt}, w_{jt})$. Let μ_{jt} denote the cross-section joint distribution of capital and productivity shocks (K, A) in sector j at time t , and let the mass of firms be normalized to one. Integrating firm-level labor demand over the distribution of firms we obtain aggregate sector-level labor demand given by

$$(3) \quad N^d(b_{jt}, w_{jt}, \mu_{jt}) = \int_{(K,A)} \left[(1 - v_M) \left(\frac{\alpha_L b_{jt}}{w_{jt}} \right) A K^{\alpha_K} \right]^{1/(1-\alpha_L)} \mu(dK \times dA).$$

We now turn to the dynamic problem. Firms choose gross investment I_{ijt} to maximize intertemporal

profits net of capital adjustment costs. Investment becomes productive with a one period lag. We adopt the specification of Bloom (2009) and Cooper and Haltiwanger (2006), with three types of costs of adjustment of the capital stock: fixed adjustment costs, quadratic adjustment costs, and partial investment irreversibilities. The investment cost function is

$$(4) \quad G(K_{ijt}, I_{ijt}) = \gamma_1 K_{ijt} \mathbf{1}[I_{ijt} \neq 0] + \gamma_2 (I_{ijt}/K_{ijt})^2 K_{ijt} + \\ + p_b(1 + \tau_K) I_{ijt} \mathbf{1}[I_{ijt} > 0] + p_s I_{ijt} \mathbf{1}[I_{ijt} < 0],$$

where $\mathbf{1}[I_{ijt} \neq 0]$, $\mathbf{1}[I_{ijt} > 0]$ and $\mathbf{1}[I_{ijt} < 0]$ are indicator variables that are equal to one when investment is non-zero, strictly positive, and strictly negative, respectively.

The first term captures fixed adjustment costs, which are paid whenever investment or disinvestment take place. Fixed costs are independent of the investment level in order to capture non-convexities and increasing returns to the installation of new capital.⁵ The second term captures the quadratic adjustment costs. These are variable costs that increase with the level of the investment rate (Dixit and Pindyck, 1994). Finally, the last two terms in (4) capture partial irreversibilities related to transactions costs, reselling costs, capital specificity and asymmetric information (as in the market for lemons). These costs are incorporated into the model by assuming a gap between the buying price $p_b(1 + \tau_K)$, which includes the tariff on imported capital goods τ_K , and selling price p_s of capital so that $p_b > p_s$.

The presence of fixed costs and irreversibilities generates a region of inaction for the firm, as well as regions of investment and disinvestment bursts. Following a negative shock firms may hold on to capital in order to avoid fixed costs and reselling losses; conversely, in periods of high profitability, firms may choose not to increase the capital stock as much, in anticipation of eventual future costs of selling that capital, or not at all, to avoid fixed costs. Quadratic adjustment costs, on the other hand, create incentives to smooth out investment over time. The patterns of capital adjustment in turn affect next period's labor demand.

⁵We assume that these costs are proportional to the pre-existing stock of capital K_{ijt} at the firm level. Proportionality with respect to K captures the fact that as a firm grows larger fixed costs of investment do not become irrelevant, and, on the contrary, the importance of indivisibilities, plant restructuring, worker retraining and production interruption, increase with firm size. Fixed costs can be modeled as proportional to the level of sales or profits at the plant-level; see for example Bloom (2009), Cooper and Haltiwanger (2006), Caballero and Engel (1999). Alternatively fixed costs can also be modeled as independent of firm size, as in Rho and Rodrigue (2016).

The dynamic firm problem is represented by the following Bellman equation:

$$(5) \quad V(K_{ijt}, A_{ijt}, \mathbf{\Lambda}_{jt}) = \max_{I_{ijt}} \{ \pi(K_{ijt}, A_{ijt}, b_{jt}, w_{jt}) - G(K_{ijt}, I_{ijt}) + \beta E_t V(K_{ijt+1}, A_{ijt+1}, \mathbf{\Lambda}_{jt+1}) \},$$

where π are maximized instantaneous profits, G is the cost of adjusting the capital stock, $\mathbf{\Lambda}_{jt}$ is a set of aggregate state variables, $\beta \in (0, 1)$ is a discount factor, and E_t is the expectation operator conditional on the set of state variables at time t . The vector of aggregate state variables $\mathbf{\Lambda}$ includes sector profit shocks, b_{jt} , and sector wages, w_{jt} . Since the sector wage is an endogenous variable determined in equilibrium, we assume that economic agents form expectations about wages following a linear prediction rule as in Krusell and Smith (1998) and Lee and Wolpin (2006). Details are discussed in Section 2.3 after introducing the worker problem and the equilibrium in labor markets.

The solution to the Bellman equation leads to an investment policy function that we denote with $I(K_{ijt}, A_{ijt}, \mathbf{\Lambda}_{jt})$, and an optimal capital stock for next period given by $K(K_{ijt}, A_{ijt}, \mathbf{\Lambda}_{jt})$. Aggregating over next period's capital stock K_{ijt+1} and the first order Markov distribution of idiosyncratic shocks A_{ijt+1} , we obtain next period's firm distribution μ_{jt+1} .

2.2 Workers

To characterize the behavior of workers, we follow the labor mobility cost model of Artuc, Chaudhuri, and McLaren (2010). Workers choose next period's sector of employment based on sector wages, sector job quality, and idiosyncratic shocks to preferences for being employed in each sector. We extend the model to allow for the choice of non-employment, as in Caliendo, Dvorkin and Parro (2019) and Dvorkin (2014). We treat non-employment as an outside option. Switching from the current sector of employment (or non-employment) to a different sector has a fixed mobility cost. The model predicts equilibrium worker mobility, equilibrium wage differentials across sectors, and dynamic responses in aggregate sector employment.

The economy is populated by a continuum of risk-neutral workers with measure $\bar{N}$ and indexed by ℓ . A worker that is employed in sector j receives a wage w_{jt} , and derives utility from a Cobb-Douglas composite of consumption of goods and from the time-invariant average job quality in his sector, denoted by η_j , which is the same for all workers. Workers can also be in the outside sector, or non-employment, which we denote with $j = 0$. The wage of non-employed workers is set to zero and the average job quality is $u_{0t} = \eta^0$ (Dvorkin, 2014).

At the end of period t , workers choose their sector of employment for the next period. The utility cost of moving from sector j to sector k is denoted by C_{jk} . The mobility cost is assumed to be C_u when moving in or out of non-employment, C_e when moving across production sectors, and zero when workers remain in their current sector. Formally

$$(6) \quad C_{jk} = C_u \mathbf{1}[k = 0 \vee j = 0, k \neq j] + C_e \mathbf{1}[k \neq 0 \wedge j \neq 0, k \neq j],$$

where $\mathbf{1}[\cdot]$ are indicator functions. Workers are further assumed to have idiosyncratic preference shocks over the next sector of employment, denoted by $\varepsilon_{\ell kt}$.

Utility is assumed to be additive in its components. Consumption of goods is optimized by spending a constant fraction ϕ^j of the labor income in good j . Utility of worker ℓ , consuming an optimal bundle of goods, employed in sector j and switching to sector k is thus given by

$$(7) \quad u_{\ell jkt} = \frac{w_{jt}}{P_t} + \eta^j - C_{jk} + \varepsilon_{\ell kt},$$

where P_t is a Cobb-Douglas price index.⁶

The worker's problem is to choose the optimal sector of employment for next period taking into consideration the mobility cost, the idiosyncratic shock and the expected discounted value. We assume that $\varepsilon_{\ell kt}$ is iid over workers, sectors and time, and that it follows a type 1 extreme value distribution with location parameter $-\nu\gamma$ and scale parameter ν .⁷ This assumption is standard in the discrete choice literature because of its analytical convenience. The idiosyncratic preferences can be integrated out to achieve closed form solutions for aggregate choices (conditional probabilities of each sector of employment given the current sector). When estimating parameters and simulating scenarios it is thus only necessary to simulate aggregate choices and not individuals.

Given these assumptions it is convenient to define a Bellman equation as an ex-ante value function, by integrating the expected discounted value of sector j over the distribution of idiosyncratic

⁶Utility prior to optimization with respect to consumption is $\tilde{u}_{\ell jkt} = \frac{\prod_{h=1}^J x_h^{\phi^h}}{\prod_{h=1}^J (\phi^h)^{\phi^h}} + \eta^j - C_{jk} + \varepsilon_{\ell kt}$, where x_h denotes consumption of good h and $\sum_{h=1}^J \phi^h = 1$. Optimizing with respect to x we obtain the indirect utility function (7) with a price index given by $\log P = \sum_{h=1}^J \phi^h \log p_h$.

⁷The cdf is $F(\varepsilon_{\ell jt}) = \exp(-\exp(-\varepsilon_{\ell jt}/\nu - \gamma))$, with $E(\varepsilon_{\ell jt}) = 0$, and $Var(\varepsilon_{\ell jt}) = \pi^2 \nu^2 / 6$. The parameter γ is the Euler's constant.

shocks. For an individual employed in sector j the ex-ante value function is

$$(8) \quad W^j(\mathbf{\Lambda}_{jt}) = \frac{w_{jt}}{P_t} + \eta^j + E_\epsilon \max_k \left\{ -C_{jk} + \varepsilon_{\ell kt} + \beta E_t W^k(\mathbf{\Lambda}_{jt+1}) \right\},$$

where E_ϵ is the expectation taken over the $(J+1) \times 1$ vector of idiosyncratic shocks of worker ℓ . The ex-ante value function is interpreted as the value of being in sector j prior to the realization of the idiosyncratic shocks. It depends on current sector wage and mean job quality, and on optimally choosing a sector for next period. The choice for next period depends on the mobility costs, the idiosyncratic shocks and the expected discounted values.

The state variables in the decision are the current sector of employment j and the vector of aggregate variables $\mathbf{\Lambda}_{jt}$. Variables in $\mathbf{\Lambda}_{jt}$ are vectors of wages and profit shocks in all sectors, $\mathbf{w}_t$ and $\mathbf{b}_t$. Like firms, workers form expectations about future wages following a linear prediction rule.

Let m^{jk} be the probability of choosing k conditional on being in j . Under the extreme value distributional assumption m^{jk} takes the usual multinomial logit form

$$(9) \quad m^{jk}(\mathbf{\Lambda}_{jt}) = \frac{\exp\left((-C_{jk} + \beta E_t W^k(\mathbf{\Lambda}_{jt+1})) \frac{1}{\nu}\right)}{\sum_{h=1}^J \exp\left((-C_{jh} + \beta E_t W^h(\mathbf{\Lambda}_{jt+1})) \frac{1}{\nu}\right)}.$$

The conditional probability is the share of agents who switch from sector j to sector k . The total number of workers moving from j to k , or gross flow, is equal to $m^{jk}(\mathbf{\Lambda}_{jt})N_{jt}$, where N_{jt} is the number of workers employed in sector j at time t . The transition equation governing the allocation of labor between sectors, or labor supply, is thus given by

$$(10) \quad N_{kt+1}(\mathbf{\Lambda}_{jt}) = \sum_{j \neq k} m^{jk}(\mathbf{\Lambda}_{jt})N_{jt} + m^{kk}(\mathbf{\Lambda}_{kt})N_{kt}.$$

On aggregate, individual choices at t determine sector-level labor supply and non-employment at time $t+1$.⁸

⁸A useful result for the empirical implementation is the closed form solution of the ex-ante value function (Rust, 1987), given by

$$W^j(\mathbf{\Lambda}_{jt}) = \frac{w_{jt}}{P_t} + \eta^j + \nu \log \sum_{h=1}^J \exp \left(\left(-\mathbf{1}_{i \neq j} C + \beta E_t W^h(\mathbf{\Lambda}_{jt+1}) \right) \frac{1}{\nu} \right).$$

Notice that (8) is true for any iid distribution of the idiosyncratic shocks, while the latter holds in the extreme-value case. A closed form solution for the ex-ante value function in turn implies a closed form solution for the conditional probabilities m^{jk} and for labor supply in equation (10).

Regarding aggregate consumption, with Cobb-Douglas preferences aggregate expenditure in each good is a fixed share ϕ_j of total income, given by the sum of total labor income and profits net of adjustment costs across all sectors.

2.3 Equilibrium

We start by discussing equilibrium in labor markets. At time t workers define their sector of employment for time $t+1$. This implies that at time t , sector labor supply is fixed at the current labor allocations, given by N_{jt} (equation 10). Sector labor demand is given by equation (3). The predetermined allocations together with labor demand determine equilibrium wages across sectors. Labor demand is shifted by sector-level profit shocks b_{jt} and the distribution of firms μ_{jt} . Consequently, we can write equilibrium wages as function of current state variables

$$(11) \quad w_{jt} = w^j(b_{jt}, \mu_{jt}, N_{jt}).$$

Regarding dynamic decisions, firms choose investment and future capital stock based on current profitability shock and capital stock, and future profit shocks and wages. Supply of capital is assumed to be perfectly elastic with time-invariant prices (as in a small economy open to international capital flows). Workers choose their sector of employment for next period based on current sector of employment, idiosyncratic shocks, and future sector wages.

Future wages are endogenous variables determined by equation (11). To keep the computation of the Bellman equations (5) and (8) feasible, we follow Krusell and Smith (1998) and Lee and Wolpin (2006) and use a linear prediction rule for wages.⁹ We adopt an augmented AR(1) process for the stochastic evolution of wages, given by

$$(12) \quad \log w_{jt+1} = a_1 + \rho_w \log w_{jt} \times D_{1jt+1} + (1 - a_2) \log w_{jt} \times D_{2jt+1} + (1 + a_3) \log w_{st} \times D_{3jt+1} + \epsilon_{jt}^w,$$

where $\epsilon_{jt}^w \sim N(0, \sigma_w^2)$ and where D_{1jt+1} is an indicator variables that is equal to one when the sector shocks b_{jt} and b_{jt+1} are both *high* or both *low*; D_{2jt+1} is equal one when the sector shocks b_{jt} and b_{jt+1} switch from *high* to *low*; and D_{3jt+1} is equal to one when the sector shocks b_{jt} and b_{jt+1} switch

⁹Using a linear prediction rule avoids having to deal with labor allocations N_{jt} and, in particular, with firm distributions μ_{jt} as state variables.

from *low* to *high*. The intuition is that when there are no changes in aggregate shocks ($D_1 = 1$), wages follow an AR(1) with correlation coefficient ρ_w . When instead there are changes in aggregate conditions ($D_2 = 1$ or $D_3 = 1$); wages jump discretely downwards or upwards in the first period (they overshoot) and adjust gradually afterwards. This first-period response occurs in models with imperfect labor mobility such as Artuc, Chadhuri and McLaren (2010) and Dix-Carneiro (2014).

Product prices of tradable sectors are determined in international markets. Domestic prices are equal to international prices plus tariffs. Sectors in which supply is larger than demand are net exporters, whereas sectors in which supply is smaller than demand are net importers. Gross trade flows are not determined. In the non-tradable sector, prices are determined endogenously by the equilibrium of domestic supply and domestic demand.

The previous equilibrium conditions hold for all time periods and all vectors of aggregate state variables. We are also interested in defining a *stationary equilibrium*, which we will use in simulation exercises to study trade shocks. In a stationary equilibrium, there are firm-specific productivity shocks A_{ijt} and worker-specific utility shocks $\varepsilon_{\ell t}$, but there are no aggregate profit shocks b_{jt} . As a consequence, while we observe fluctuations in firm-level labor demand, investment and output, and in worker-level mobility, there are no fluctuations at the aggregate level. Labor allocations, aggregate capital, output, wages, prices of non-tradables, and the distribution of firms are time-invariant in a stationary equilibrium.

3 Estimation

In this section we discuss the estimation of the model structural parameters. We use two sources of data from Argentina. The first is the Encuesta Industrial Anual (EIA, Annual Industrial Survey), from INDEC. This is a panel of firms spanning the period 1994 to 2001, with information on investment, disinvestment, employment, revenue, production and materials. The second source of data is the Encuesta Permanente de Hogares (EPH, Permanent Household Survey), a standard labor force survey with a panel component, also from INDEC. It spans the period 1996 to 2006 and has information on sector of employment (or non-employment) and wages. We use the panel component of the survey to compute movements of workers across sectors. Firms and workers are aggregated into 6 sectors: food and beverages; textiles, apparel and leather; nonmetallic minerals; primary metals and fabricated metal products; other manufactures; and non-traded goods. Workers are further grouped into non-employment. We refer the reader to on-line Appendix A for more details

on the data.

3.1 Demand and technology parameters

Our main parameters of interest are the capital adjustment cost and labor mobility cost parameters. We denote them with the vector $\Gamma = (\gamma_1, \gamma_2, \gamma_3; C_e, C_u)$. We estimate Γ by simulated method of moments (SMM, McFadden, 1989; Pakes and Pollard, 1989). Prior to the estimation of Γ we define or estimate values for the other model parameters.

Table 1 provides a list of the parameters that are predefined or estimated prior to the SMM. We set the discount factor β to 0.95. The depreciation rate δ is 0.0991. Due to lack of data for Argentina, we compute it as a weighted average of sectoral depreciation rates for the U.S. reported by the Bureau of Economic Analysis, using number of firms as weights. From National Accounts, we recover the consumption weights for each sector ϕ_j in order to compute sector demand. Because demand is assumed to be Cobb-Douglas, a constant fraction given by the CPI weights is spent on each product. Argentine families spend on average 31.3 percent of the budget on food and beverages, 37.4 percent on non-tradables and 21.1 percent on other manufactures; textiles and apparel account of 5.2 percent, and minerals and metals for about 2.5 percent each.

The technology parameters, including coefficients of the production function and the stochastic processes for the sector-level and firm-level shocks, are estimated with the firm panel and reported in Table 1 as well. We estimate the Cobb-Douglas output elasticities using the regression method of Akerberg, Caves and Frazer (2015) with data on revenue, employment and capital stock. The estimates for α_L and α_K are 0.619 and 0.283, both statistically significant. The input requirement for materials v_m is computed as a weighted average of the share of expenditure in materials on total value of production. The estimate is 0.41.

We assume that the sector-level and firm-level shocks, b_{jt} and A_{ijt} follow independent AR(1) processes with correlation coefficients ρ_b , ρ_a , variance of the innovation terms σ_b^2 and σ_a^2 , constant $\bar{b}$ for the aggregate shocks and, without loss of generality, a constant of zero for the idiosyncratic shocks. Since the shocks are not observable we first infer firm-level profit shocks from data on profits and inputs, the functional form assumption of the profit function, and the estimates of the production function parameters, as in Cooper and Haltiwanger (2006). We split firm-level profit shocks into b and A by computing sector-year means and subtracting them from firm-level shocks. We then run two separate AR(1) regressions to estimate the correlation coefficients, variance and

constant.

For the firm-level shocks we estimate a correlation coefficient of $\rho_a = 0.902$ and a variance for the innovation term of $\sigma_a^2 = 0.118$. For the sector-level shocks we estimate a constant of $\bar{b} = 0.318$, a correlation coefficient of $\rho_b = 0.777$, and variance of $\sigma_b^2 = 0.044$. Once we have the AR(1) parameters we discretize the state space for A_{ijt} and b_{jt} and compute their Markov transition matrices following the approximation of Tauchen-Hussey. We define an 8-point grid for A_{ijt} and two values for b_{jt} , high and low. The estimated probability of staying in the same state is 0.827 and the probability of switching is 0.172 (Table 1). More details about the estimation of the production function and stochastic process parameters are in on-line Appendix A.

Note that the firm survey covers only the manufacturing sector. For the non-manufacturing sector, which we want to include in the analysis given its importance in the overall economy, we use the production function and shock processes parameters estimated for the manufacturing sector.

3.2 Adjustment cost parameters

We now turn to the estimation of the vector of adjustment cost parameters $\Gamma = (\gamma_1, \gamma_2, \gamma_3; C_e, C_u)$. Recall that γ_1 , γ_2 and γ_3 are the capital adjustment parameters: the fixed cost, the convex cost and the irreversibility cost. On the worker side, C_e and C_u are the costs of moving between production sectors and in or out of non-employment.

The SMM is based on comparing a vector of empirical moments computed from firm and worker actual data, with moments computed from firm and worker simulated data. The simulated moments depend on the choice of Γ through optimal investment I_{ijt} and equilibrium labor allocation N^{jt} . The estimator for the adjustment costs minimizes the weighted distance between the empirical and simulated moments.¹⁰

Within the SMM algorithm we further estimate the worker utility function parameters η (sector quality shifters) and ν (worker shock variance) using a linear regression derived from the workers' Bellman equation. This step is done within the SMM because the Bellman equation is a function

¹⁰We use six moments: the serial correlation of the investment rate, $\text{corr}(I_{ijt}, I_{ijt-1})$; the correlation between the investment rate and the profitability shocks, $\text{corr}(I_{ijt}, A_{ijt})$; the negative spikes rates, defined as the percentage of firms with investment below negative 10 percent; the correlation between sector deviations in wages and employment with respect to the sector mean, $\text{corr}((w_{jt} - \bar{w}_j), (N_{jt} - \bar{N}_j))$; the serial correlation in non-employment, $\text{corr}(N_{0t}, N_{0t-1})$; and the correlation between the change in non-employment and the change in the average wage across sectors, $\text{corr}((N_{0t} - N_{0t-1}), (\bar{w}_t - \bar{w}_{t-1}))$. We search over values of Γ using a combination of fine grid search and coordinate descent search, which works better than second-derivative Newton-Raphson or quasi-Newton methods in a case like ours with a discretized state space.

of the mobility costs C_e and C_u . This strategy follows the conditional choice probability (CCP) approach of Hotz and Miller (1993). More details about the SMM estimation including the estimation of η and ν are in on-line Appendix A.

Results are reported in Table 2. Standard errors for the estimates are computed analytically, as in Bloom (2009). The estimated capital adjustment costs are sizeable and significantly different from zero (panel A). We estimate a fixed cost $\hat{\gamma}_1 = 0.038$. This is a substantial cost since it implies that the fixed cost of adjustment is about 3.8 percent of the average plant-level capital value. The estimated coefficient for the quadratic adjustment cost parameter ($\hat{\gamma}_2$) equals 0.18. Using the quadratic adjustment cost function and a steady state investment rate equal to the depreciation rate ($I/K = \delta = 0.0991$), the estimated parameter implies an adjustment cost relative to the average plant-level capital of 0.175 percent. Finally, our estimate of the transaction costs ($\hat{\gamma}_3 = 0.840$) implies that resale of capital goods would incur a loss of about 16 percent of its original purchase price.¹¹

The estimates of the labor mobility costs are in panel B of Table 2. The SMM estimates are $\hat{C}_e = 3.72$ and $\hat{C}_u = 4.22$. The estimated variance is $\nu = 2.63$. All our estimates are statistically significant. On average, a worker wishing to switch sectors would pay a mobility cost equivalent to 3.72 times his annual wage earnings. Instead, a worker moving from non-employment to employment would pay a higher cost of 4.22 times the annual wage. These estimated costs are high, revealing large labor friction in Argentine labor markets. Our estimates are lower than those reported in Artuc, Chaudhuri, and McLaren (2010) for the U.S., where the average moving cost is around 6.565, and ν is 1.884. Allowing for job quality terms η , Artuc and McLaren (2015) estimate more modest C , ranging from as low as 0.99 to as high as 1.54 (with $\nu=0.257$), also for the U.S. Finally, estimating a comprehensive model that allows for worker heterogeneity with Brazilian data, Dix-Carneiro (2014) finds median mobility costs ranging from 1.4 to 2.7, which are smaller than ours (though Dix-Carneiro's estimates show large dispersion across the population).¹²

¹¹Our estimates of capital adjustment cost parameters for Argentina can be directly compared with those in Cooper and Haltiwanger (2006) for the U.S. as we use the same specifications. Cooper and Haltiwanger (2006) estimate comparable fixed costs ($\gamma_1^{US} = 0.039$), but lower quadratic adjustment costs ($\gamma_2^{US} = 0.049$) and lower irreversibilities ($\gamma_3^{US} = 0.975$). This implies that capital is more flexible in the U.S. than in Argentina, especially in terms of the irreversibility cost of investment. These differences, as well as the magnitudes of the estimates, are, however, sensible and plausible. Bloom (2009) reports larger values for the partial irreversibility cost, with capital reselling losses of 42.7 percent, and for the quadratic adjustment cost parameter (0.996). The fixed cost parameter γ_1 , which is estimated in terms of annual sales (instead of average capital), is 1.1 percent. Note that these results are not directly comparable to ours because of some differences in specification.

¹²In Panel C of Table 2, we report the parameters of the wage process. They support the conjecture that wages follow an AR(1) and that they make a discrete (positive or negative) jump of an order of magnitude between 0 and

Table 2 also shows the empirical and simulated moments, which match well. More details about the SMM estimator as well as an assessment of identification and predictive power are given in on-line Appendix A.

4 Trade Shocks and Capital Adjustment

We now use the model and the estimated parameters to simulate the dynamic implications of tariff reductions in the presence of imperfect capital mobility. Since the distinctive feature of our paper is the introduction of capital adjustment in models of labor frictions, we focus our discussion and simulations to illustrate the patterns of responses in sectoral capital, employment and wages that are the consequence of investment frictions.

In order to assess the impact of an unexpected cut in tariffs, we create a stationary economy and shut down all aggregate shocks.¹³ To do this, we work with permanent unforeseen price changes that occur at time $t = 1$. We allow for firm-specific productivity shocks A_{ijt} given by (16), but we close down the aggregate productivity shocks, that is, we set $b_t = b \forall t$ in (15). In the initial stationary equilibrium, at time $t = 0$, firms are subject to Markov productivity shocks that create individual fluctuations in investment, employment and output, while workers are subject to utility shocks that create labor mobility. At the aggregate level, however, labor allocations, wages, capital, output, and firm distributions are constant in the initial stationary equilibrium. At time $t = 1$ there is a permanent elimination of tariffs that triggers dynamic responses. After a transition period, the economy converges to a new stationary equilibrium, at time T . Shutting down other price shocks and aggregate productivity shocks allows us to isolate the effect of a pure trade shock. We use the model parameters to solve for the initial stationary equilibrium, the transition period, and the new stationary equilibrium, jointly for firms and workers.

4.1 The Consequences of a Tariff Cut in Textiles

We begin the analysis by exploring the impacts of a reduction in prices due to tariff cuts. The motivation to use tariff reductions as a source of price shocks is to link our work to the trade

1 when there are (positive or negative) shocks.

¹³Note that aggregate shocks are needed in the estimation of the structural parameters in order to build simulated moments that match moments computed from real data. Whereas for the simulation of a given price shock, random aggregate shocks are not needed and a stationary equilibrium is a better framework to study the patterns of adjustment of endogenous variables.

reforms literature. We also study price hikes below, for example due to increases in trade protection as a result of the recent waves of protectionism. Using tariff data from Brambilla, Galiani and Porto (2018), we report in Table 3 the average sectoral tariff in place in Argentina during 1994-2000 (the period spanned by our data). There is a fair degree of protection, with average tariffs of 19.4 percent in textiles, 13.9 percent in food and beverages, 14.2 percent in metals, 14.1 percent in other manufactures, and 11.6 percent in minerals. The tariff on capital goods is also fairly high, 12.3 percent.

Our benchmark simulation is the full elimination of tariffs on textiles. We chose textiles because it is the most heavily protected sector of the economy and because this simulation allows us to document in a neat way the generic dynamic responses of the economy to a tariff cut. For a small country and homogeneous goods, we have that $p_{jt} = p_{jt}^*(1 + \tau_{jt})$ and, consequently, the impact of the elimination of tariffs on prices is given by $d \ln p_{jt} = -\tau_{jt}/(1 + \tau_{jt})$. As a result, such a cut in tariffs would bring textiles prices down by 16.2 percent. The other tariffs and prices of traded goods remain unaffected, while the price of the non-traded goods responds in equilibrium.

Figure 1 illustrates the mechanics of the impacts on capital (panel a), real wages (panel b) and employment (panel c). Note that, in the model, imperfect factor mobility creates cross-industry spillover effects. To show these general equilibrium responses, we consider impacts on other tradables (for simplicity of exposition we group the four non-textile traded sectors using employment weights) and on the non-tradable sector. In each panel, the solid line corresponds to textiles, the dashed line to other tradables, and the dotted line to non-tradables. The magnitudes of the responses are given in Table 4. All the results in the paper are very robust to the Leontief production function assumption. Indeed, a Cobb-Douglas specification delivers very similar results both qualitative and quantitatively.

The immediate implication of lower textile prices is a decrease in profitability for firms in the sector. Textile firms want to contract. However, capital and employment are predetermined and do not respond initially (i.e., at $t = 1$).¹⁴ The nominal wage in the textile sector goes down proportionately to prices due to the decrease in the value of the marginal product of labor. But lower textile prices imply a decline in the price index that brings up real wages in all sectors. In addition, the price of non-traded goods declines by 1.36 percent because of the negative income

¹⁴Note that investment at t becomes productive capital in $t + 1$. In consequence, while there is an investment response in the first year of the shock, the capital stock remains at the steady state level for one period before adjusting.

shock and the consequent lower aggregate demand. The net effect on the real wage in textiles is, however, a decline of 15.04 percent. Real wages instead increase by 1.45 percent in the other tradable sector. In the non-traded sector, there is only a very mild increase in real wages of 0.06 percent. This is because of two opposing effects: lower prices reduce the CPI but the decrease in the output price of non-tradables reduces nominal wages on impact.

In the following periods textile firms disinvest to adjust their stock of capital and workers flow out of the sector attracted by higher real wages elsewhere. Capital and employment gradually decline until they converge to a new steady state level. In the full tariff elimination simulation, the capital stock in textiles decreases by 9.41 percent initially (Year 2), by 14.62 percent in Year 3, and by 25.47 percent in the new steady state; 95 percent of the transition is covered in 9 years. Employment decreases by 2.91 percent in Year 2, 3.90 percent in Year 3, and 4.64 percent in the new steady state; convergence of employment is faster than of capital, covering 95 percent of the transition in 5 years.

The dynamic adjustment of capital and labor has implications for factor returns during the transition. After the on-impact decline in the real wage in textiles of 15.04 percent at the time of the shock, it continues declining gradually. By Year 2, the decline is 17.25 percent, then 18.45 percent in Year 3; in the new steady state, real wages are 20.32 percent lower than in the initial equilibrium. This is due to the joint investment and employment decisions that determine the evolution of capital and labor in the sector.

There are general equilibrium effects on other traded goods sectors. The initial higher real wages in the non-textile manufacturing sector attract workers and employment expands by 0.59 percent (Year 2), 0.77 percent (Year 3) and 0.91 percent in the new steady state. There is a very minor response of the capital stock, which increases only by 0.09 percent initially and by 0.57 percent in steady state. These changes in capital and employment imply a gradual but slight reduction in real wages during the transition. In non-textile manufacturing, while real wages increase by 1.45 percent in Year 1, the long-run increase is of 1.20 percent (with respect to the initial steady state). Unlike what happens in textiles, there is a very slight overshoot of the real wage in these sectors.

There are general equilibrium effects on the non-traded sector as well. As shown above, real wages remain essentially unchanged (with an increase of only 0.06 percent in Year 1). Employment increases but the magnitudes are almost negligible. In addition, because of lower non-traded prices, profitability in these sectors is eroded and this triggers disinvestment during the transition. For

example, in the new steady state, employment increases by only 0.34 percent, while the capital stock declines by 1.34 percent. In the end, this decreases labor productivity and wages in the sector. In the new steady state, real wages are slightly lower with a reduction of 0.39 percent.

Finally, there is an effect on non-employment. As the textile sector shrinks because of the loss of tariff protection, some of the displaced workers are absorbed by the other traded sectors as well as the non-traded sectors. Some others end up in non-employment, which increases steadily but only slightly during the transition: non-employment grows by 0.29 percent in Year 2, by 0.41 percent in Year 3 and by 0.53 percent in the new steady state.

We can also calculate changes in welfare for producers and workers. Because of lower prices, textiles firms lose value instantaneously and this becomes exacerbated as firms disinvest: the initial decline in producer welfare is 16.91 percent, while the long-run decline is 25.73 percent. Producer welfare increases in other traded sectors, because of relative price changes, and it declines in non-traded sectors, because of the direct effect of the tariffs on non-traded prices. The evolution of worker welfare is more complex. Since workers can change sectors at any time period, welfare in one sector affects workers in all sectors. Thus, the changes in worker welfare in all sectors tend to be highly correlated with each other, unlike producer welfare (Artuc, Chaudhuri and McLaren, 2010). Therefore, the change in worker welfare does not resemble the change in real wages or in employment. Initially, annualized worker welfare decreases in all sectors, by 1.38 percent in textiles, and around 0.9 percent in other sectors.¹⁵ In the long-run, the annual welfare loss of a textile worker escalated to 1.5 percent, while the loss for other workers is slightly below 1 percent.

4.2 Overshooting of Real Wages

The responses of the economy to a trade shock (and more generally to price shocks) is very rich and complex. This is because our model features costs of adjusting both capital and labor in a multi-sector economy. The labor market frictions create inter-industry wage differences and, as we have shown, the interplay of capital and labor mobility jointly determine employment and investment decisions, which in turn affect the real returns to factors of production. We know from the literature what the role of labor mobility costs with fixed capital is: the overshooting of real wages (Artuc, Chaudhuri and McLaren, 2008; Artuc, Chaudhuri and McLaren, 2010; Artuc, Lederman, and Porto,

¹⁵The welfare metrics of workers are the value functions deflated by the price index, annualized and reported relative to average annual wage. In addition, we distribute the tariff revenue back to the workers uniformly. 1.38 percent decline means a welfare loss equivalent to a loss of 1.38 percent of average wage every year.

2015; Dix-Carneiro, 2014). An important finding of our paper is that capital adjustment, though costly and imperfect, prevents this overshooting of real wages. To illustrate this more clearly, we compare the behavior of our model, with both capital and labor imperfections, with a model that features imperfectly mobile labor but fixed capital—the most common environment in the literature. Following a full tariff cut in textiles, we solve the model assuming a constant capital stock in all sectors during the transition and we compute the evolution of wages and employment.

Figure 2 plots the responses of the real wage in the textile sector. The solid line depicts real wage dynamics for the benchmark model with imperfect mobility of both labor and capital (from Figure 1, panel b, and Table 4). The dashed line depicts the dynamic responses of real wages for the fixed-capital model. Comparing these two models, there are striking differences. In both models, because capital and employment are predetermined, the real wage declines on impact in Year 1. However, while real wages continue to decline in the benchmark model, they increase in the fixed-capital model. This is the typical overshooting in fixed- K models. As explained, the tariff shock creates wage differences that induce workers to move out of sector 2. When firms can adjust the capital stock in response to a negative tariff shock, the capital stock shrinks. As a result, labor productivity further declines and, in fact, this effect dominates the increase in the marginal product of labor created by the outflow of workers. In the end, real wages continue to drop. By contrast, when the capital stock is fixed, labor productivity increases in the sector as workers are displaced during the transition and, as a result, real wages recover. This mechanism is mild in our simulation for textiles (but it might not be in other cases). To see this, note that the real wage in the new steady state of the fixed- K model is 13.93 percent lower. Compared to the initial decline of 15.04 percent, this implies a recovery of roughly 1 percentage point. Moreover, the transition is much shorter, 3-4 years only.¹⁶

It is important to note that whether wage overshooting occurs or not depends on the interaction between the capital adjustment costs relative to the labor adjustment costs. This is because the labor market response depends on the speed and magnitude of disinvestment relative to the speed and magnitude of the outflow of workers. If, in a given sector, a trade shock can trigger a sufficiently large exodus of workers, then the longer run recovery of real wages that is distinct to recent frictional models of trade such as Artuc, Chaudhuri and McLaren (2010) or Artuc, Lederman and Porto (2015) could be preserved. To explore this, we simulate a model with reduced C in which we set the labor

¹⁶The role of capital adjustment in impeding the overshooting of real wages is also present in the other sectors. However, these effects are very small in our current setting and are thus not shown to ease the exposition.

mobility costs to US levels from Artuc and McLaren (2015). This simulation delivers a response of real wages that is represented by the dotted line in Figure 2. The overshooting, which is mild in the fixed- K model and the estimated mobility costs, become much sharper when C is lower. Given the size of the shock, this higher labor mobility induces a sufficiently large outflow of labor to actually compensate for the declining capital stock. In the new steady state, real wages would decline by 9.15 percent. Compared with the initial drop of 15.04 percent, this implies an overshooting of real wages of almost 6 percentage points.

These findings have relevant implications for the interpretation of some of the results recently found in the literature. Our structural model with market frictions shows that tariff reforms can actually have long-lasting impacts and that the patterns of adjustment, especially in the long-run, strongly depend on the nature of capital adjustment costs. In a setting with fixed capital, while tariff cuts positively correlate with wage changes in the short-run, this correlation can become negative in the long-run. In models with capital adjustment costs, tariff changes positively correlate with wage changes not only in the short-run but possibly also in the long-run. The notion that capital adjustment costs can play a role is discussed in Dix-Carneiro (2014). Using ad-hoc imperfect capital adjustment rules, he shows that sluggish capital responses can affect the wage dynamics. Dix-Carneiro (2014) corroborates that, as expected, wages respond negatively to an adverse trade shock in the short-run but that, along the transition, these responses can become attenuated or amplified. There is also solid reduced-form evidence showing that the long-run wage responses can be larger than the short-run effects (Dix-Carneiro and Kovak, 2017). The results of our paper, based on a full structural estimation, put these intuitions into context and quantitatively elucidate how capital and labor market frictions interact in shaping them.

4.3 Trade Shocks and the Nature of Capital Adjustment

We model capital frictions in a complex way, which includes fixed, convex, and irreversibility costs. We do this because the nature of the capital adjustment costs function plays an important role in the way the economy responds to trade shocks. To show why our complex structure of capital adjustment costs matters, we compare the evolution of the economy in two experiments. One is our benchmark case with full tariff cuts in textiles, which is a negative shock to the sector. The other is the opposite case of a positive shock to the textile sector (for example due to tariff protection). To get the comparison right, we set the price increase equal to the negative of the price decline in

the benchmark simulation.

The results are in Table 5. What emerges from this exercise is an intriguing asymmetry between the negative shock and the positive shock (of equal size). Concretely, the positive shock triggers a proportionately larger response of the capital stock than the negative shock. Moreover, this asymmetry is stronger in the short-run and it partially dilutes during the transition. In the benchmark, the initial decline of K is -9.4 percent. In the opposite positive shock, the increase is 12.72 percent. The positive shock thus triggers a response of K that is 35 percent higher in Year 2. It is 20 percent higher in Year 3, 12 percent higher in Year 4, and 9 percent higher in the steady state. This can be seen clearly in Figure 3, which shows the evolution of the capital stock in the positive shock (solid line) and the mirrored (changed sign) benchmark response (dashed line), which is how a positive symmetrical response would look like. The gap between these two responses starts wide at Year 2 and decreases slowly after that.

The reason for the asymmetry is the nature of the capital adjustment costs. There are convex costs of investment, which provide incentives to smooth (dis)investment over time. There are also fixed costs and irreversibility costs of investment. At the firm level, these costs operate in the opposite direction to convex costs, providing an incentive to concentrate (dis)investment in one period and remain inactive in others. At the aggregate level, however, fixed costs and irreversibility costs together with firm heterogeneity generate a gradual reaction to a trade shock. Consider now a positive price shock, which gives firms incentives to invest if they are productive enough (relative to their capital stock). Because idiosyncratic productivity fluctuates over time and is heterogeneous across firms, firms react to the price shock sequentially upon receiving idiosyncratic shocks and contributing to a gradual increase in the aggregate capital stock. The outcome of this process is the solid black line in Figure 3.

When faced with a negative price shock, firms decide to disinvest if they are not productive enough (relative to their capital stock). However, when the optimal choice is to disinvest, firms have the option of (partially) adjusting capital automatically via depreciation. Depreciation is a free way to reduce capital. As a result, the disinvestment decision is smaller and the capital stock decreases proportionately less. This type of asymmetry cannot be created by a model with fixed capital. It cannot either be the result of a model with a simpler structure of capital adjustment costs, such as convex costs alone or ad-hoc specifications as in Dix-Carneiro (2014).

The fact that the capital stock in the sector reacts proportionately more to a positive shock than

to a negative (and equal) shock, especially in the short-run, has similar implications for employment and real wages. In Table 5, we show that the more pronounced response of capital raises real wages and employment proportionately more in the positive shock as well. These asymmetries are much stronger in the short-run than in the long-run as expected. In fact, note that the asymmetric response in real wages disappears eventually in steady state.

Qualitatively, these results suggest that in the presence of a complex structure of capital adjustment costs, the economy can respond differently to positive than to negative shocks and to shocks of different sizes. In the simulations, these differences are large enough to warrant attention in the assessment of trade shocks.

4.4 The Consequences of Tariff Cuts on Capital Goods

In this section, we explore the implications of tariff cuts on capital goods. In our model, we assume capital goods can be imported at given international prices plus any tariffs, as in Rho and Rodrigue (2016)—see Eq. (4). With an average tariff on capital goods of 12.3 percent, the elimination of tariffs would cause the price of capital to decline by 10.9 percent. This experiment allows us to explore the implications for the labor market of reductions in input tariffs—a prevalent topic in the literature. In particular, Argentine firms heavily rely on imported capital to build their capital stock and, thus, trade liberalization of capital goods can induce sizeable firm responses. To this end, we study the evolution of the economy following a joint elimination of output tariffs in textiles and input tariffs on capital goods.

The results are presented in Figure 4 which shows the evolution of capital (panel a), real wages (panel b) and employment (panel c). For each variable, we reproduce on the left the responses following a reduction of textile tariffs (as in Figure 1). We then perform two simulations. In the first one, we only allow the textile sector to import capital at the lower prices. These results are reported on the center panel of Figure 4. In the second experiment, we assume the tariff cuts on capital apply to all sectors. These results are on the right panel.

A lower price of capital goods for textile firms dampens the disinvestment caused by the loss of output protection during the transition. The total capital stock declines only by about 10 percent, compared to about 25 percent in the benchmark experiment. The speed of adjustment is slightly faster. The initial decline in real wages (15.4 percent) is the same in the two scenarios, because L and K are predetermined at $t = 1$. However, the additional decline in real wages observed in the

benchmark disappears, to a large extent. Instead of a long-run decline of 20 percent, real wages decline by about 16 percent. This is because, while firms disinvest less, workers are still being displaced to other sectors at the same time. In the end, the marginal product of labor does not decrease by much. The responses of employment are attenuated: there is a smaller contraction of employment in textiles (again, because the capital stock is higher than in the benchmark) and a consequent smaller expansion of the other sectors, including non-employment. We can conclude that while the textile sector suffers from the loss of tariff protection, the opportunity for cheaper investment helps cushioning some of the negative impacts. This effect is not strong enough in our case to overdo the consequences of the tariff de-protection on final goods so that there is no wage overshooting. But the magnitudes are sizeable nevertheless.

The impacts of the liberalization of capital import tariff across all sectors (right panel of Figure 4), are as follows. A lower price of capital goods creates investment incentives in other traded manufactures as well as in non-traded sectors. The magnitudes are large, between 15-17 percent depending on the sector. This is important for various reasons. Real wages in these sectors increase by much more than before (up to 5 percent in other traded goods). This attracts more workers from the textile sector, which thus shows a higher decline in employment. Finally, the expansion of the non-textile sectors absorbs unemployed workers. More specifically, while non-employment increases with the reduction in output tariffs in textiles, it instead declines by more than 1 percent when capital goods tariffs are removed as well.

4.5 Extensive Margin Adjustments

The responses of labor market outcomes and investment to sector shocks are the aggregation of firm-level responses and as such they depend on the distribution of firms. In our baseline model aggregate responses only have an intensive margin dimension, as we do not consider firm turnover. However, there is a large literature on industry dynamics that argues that entrants and exiters are systematically different from incumbents (Dunne, Roberts and Samuelson, 1988; 1989; Jovanovic, 1982; Hopenhayn, 1992). Firm entry and exit can amplify or reduce the impact of aggregate shocks and have persistent consequences on capital accumulation, employment and wages over time (see Clementi and Palazzo, 2016, and Sedlacek, 2020). In this section we explore how aggregate responses change when we add an extensive margin in the domestic market.¹⁷

¹⁷There is a vast literature of selection into export markets based on heterogeneous firm characteristics starting with Melitz (2003). This literature is based on firms that produce differentiated varieties and face a downward sloping

We adopt a simple specification that allows for entry and exit. In this section we provide a brief description, while more details are discussed in on-line Appendix B. In each period there is a fixed mass of potential entrants in each sector j that face a stochastic iid sunk cost of entry given by F_0 . Upon entry firms receive a draw of productivity (A) and initial capital (K) from a distribution μ_0 . Firms start operating in the following period after entry and from then on their productivity and capital evolve in the same manner as for incumbent firms. We augment the Markov process of productivity to include an absorbing state of exit. The Markov process is a mixture model. With probability ζ , productivity A evolves according to the Markov process in the baseline model without exit, and with probability $(1 - \zeta)$ the firm falls into an absorbing state of $A = 0$ and exits the market. To introduce a simple selection mechanism into the exit process, we further assume that only firms with idiosyncratic productivity below the 75th percentile face the possibility of falling into the absorbing state.

In every period the entry equilibrium is defined by a cutoff in the sunk cost of entry F_0 . Let $\bar{V}_{0jt}$ denote the expected value prior to entry in sector j , integrated over draws of initial productivity and capital stock. The expected value $\bar{V}_{0jt}$ is the same for all firms. Firms enter as long as their draw of F_0 is lower than the expected value prior to entry. The equilibrium mass of entrants in sector j , n_{0jt} , is given by

$$(13) \quad n_{0jt} = \int_0^{\bar{V}_{0jt}} H(dF_0),$$

where H is the cdf of the cost of entry.

The expected value $\bar{V}_{0jt}$ varies across periods according to state variables b_{jt} and w_{jt} . Equilibrium sector wages further depend on labor allocations, N_{jt} , distributions of active firms, μ_{jt} , and the mass of active firms, which we denote with n_{jt} . When there is a negative sector shock due to a tariff reduction, the expected firm value decreases and fewer firms enter. This in turn reduces the number of active firms in the market, n_{jt} . A reduction in the number of active firms leads to a decrease in labor demand and wages, which in turn drives up the firm expected value again. In the post-shock stationary equilibrium the number of active firms is lower than prior to the shock.

demand curve. Exporting allows firms to grow and increase revenue and profits after paying export participation costs. By contrast, in our model products are homogeneous and firms face an infinitely elastic demand. This setting does not lend itself to the introduction of export participation costs and decisions. Moreover, at the firm level, the possibility of exporting does not play a role on labor demand, investment, and the decision to enter into the domestic market.

In a stationary equilibrium, the expected value prior to entry and the number of active firms in the market are constant over time, while there is firm turnover with an equal number of entrants and exiters.

To simulate aggregate responses to tariff shocks we use our previous estimates for the baseline model parameters, including capital adjustment costs, labor mobility costs, production function coefficients, and the stochastic evolution of shocks. We calibrate the distribution of the sunk costs of entry and the distribution of entrants and dropouts to match exit rates and relative size of firms from Dunne, Roberts and Samuelson (1988).

We summarize the main implications of the extensive margin of adjustment by comparing the evolution of capital, real wages and employment in the Textile sector in the baseline model and in the extended model with entry and exit. The results are in Table 6. The negative short-run response of the capital stock is much larger when we allow for exit and entry. The negative tariff shock reduces profitability in the sector, there is less entry than exit (during the short-run), and capital is consequently destroyed more quickly. With this additional margin of adjustment, the aggregate capital stock declines by 40 percent more on-impact (Year 2) and by 14 percent more along the first five years of the transition to the steady state. In the long-run, the decline in the steady state capital stock is only 2 percent larger. There is a more pronounced decline in labor, too. The higher rate of exit accounts for a 2 to 3 percent lower level of employment in the sector in the short-run and a 5 percent lower employment in the long-run. Finally, there is a correspondingly larger decline in real wages, which is more pronounced in the long-run (6 percent larger decline) than in the short-run (2 to 4 percent). To sum up, with entry and exit, the adjustments are sharper than in the baseline, especially in the short-run.

5 Conclusions

We have developed a structural dynamic general equilibrium model of trade and the labor market with factor adjustment costs. Firms make intertemporal investment decisions facing capital adjustment costs that include fixed costs, convex costs and investment irreversibility costs. Workers choose employment sector based on equilibrium intersectoral wage differences and labor mobility costs. These costs include various labor market frictions such as imperfections in firing and hiring workers as well as specific utility shocks. The model features general equilibrium effects, articulating both the product and the labor market, in a multisector economy. This allows us to analyze the

interplay between trade shocks and factor adjustment costs. We have fitted our model to household survey panel data and plant-level panel data from Argentina and recovered measures of the adjustment frictions faced both by workers and firms. Using the structural parameters, we have simulated the response of the model, both of firms and workers, following a tariff cut episode.

Our paper combines labor market frictions with a complex model of capital adjustment costs, which few papers do. This matters for the patterns of responses of investment, employment and wages. Following a tariff cut in textiles, factor market frictions amplify the labor market responses so that the long-run responses of real wages are larger than the short-run responses. There is no overshooting of real wages, as in fixed capital models. Our results suggest that the cost of adjusting capital is a fundamental driver of these patterns. After losing protection, real wages decline on impact. Moreover, as firms disinvest in response to the negative trade shock, labor productivity continues to decline during the transition, and real wages further decline as the economy approaches the new steady state. The results are also consistent with the recent findings in the empirical trade literature, notably those reported by Dix-Carneiro and Kovak (2017). By combining capital and labor adjustment costs, our analysis complements the growing literature on the role of factor market frictions in shaping the way employment and labor adjust to the elimination of tariffs.

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Figure 1
Tariff Cuts in Textiles
Capital, Real Wages, Employment

Notes: responses of capital (panel a), real wages (panel b) and employment (panel c) to a full elimination of tariffs on textiles. Simulation results from estimated structural model. In each panel, the solid black line represents the textile sector, the solid gray line represents the non-textile manufacturing sector, and the gray dotted lines represents the non-traded sector. The solid gray line in panel c corresponds to non-employment.

Figure 2
Real Wage Overshooting in Textiles

Notes: real wage responses in the textile sector. The solid black line corresponds to the benchmark model with capital adjustment costs; the dashed gray line corresponds to a fixed- K model; the dotted gray line corresponds to a model with capital adjustment costs and lower labor mobility costs (set to U.S. values from Artuc and McLaren, 2015).

Figure 3
Asymmetric Response of the Capital Stock
Positive and Negative Price Shocks in Textiles

Notes: evolution of the capital stock in the positive shock (solid line) and the mirrored (changed sign) benchmark response (dashed line).

Figure 4
Tariff Cuts in Textiles & in Capital Goods
Capital, Real Wages, Employment

(a) Capital

(b) Real Wages

(c) Employment

Notes: responses of capital (panel a), real wages (panel b) and employment (panel c) to a full elimination of tariffs on textiles (benchmark), to a full elimination of tariffs in textiles and in capital goods in the textile sector (Liberalization K —textiles), and to a full elimination of tariffs in textiles and in capital goods in all sector (Liberalization K —all sectors). Simulation results from estimated structural model. In each panel, the solid black line represents the textile sector, the gray dashed line represents the non-textile manufacturing sector, and the gray dotted lines represents the non-traded sector. The solid gray line in panel c corresponds to non-employment.

Table 1
Estimates of Structural Parameters

Parameter	Estimate	Description
Discount factor β	0.95	Predetermined
Depreciation rate δ	0.0991	Computed from BEA and firm data
Expenditure shares		
Food and beverages	0.313	National accounts
Textiles and apparel	0.052	National accounts
Minerals	0.025	National accounts
Metals	0.025	National accounts
Other manufactures	0.211	National accounts
Non-traded goods	0.374	National accounts
Production function parameters		
α_L	0.619 (0.036)	ACF regression
α_K	0.283 (0.029)	ACF regression
v_m	0.410 (0.003)	Computed from firm data
Stochastic processes of shocks A and b		
ρ_a	0.902 (0.008)	AR(1) regression
σ_a^2	0.118 (0.00009)	AR(1) regression
$\bar{b}$	0.318 (0.156)	AR(1) regression
ρ_b	0.777 (0.116)	AR(1) regression
σ_b^2	0.044 (0.00011)	AR(1) regression
$P(b_t = high b_t = high)$	0.827	Tauchen-Hussey approximation
$P(b_t = high b_t = low)$	0.173	Tauchen-Hussey approximation

Notes: list of estimates and source of each parameter value. Standard errors in parenthesis.

Table 2
Estimates of Labor and Capital Adjustment Costs

Estimates			
	Estimate	Std. Error	Description
A) Capital Adjustment Costs			
Fixed Cost γ_1	0.0379	(0.008)	SMM
Quadratic Cost γ_2	0.178	(0.016)	SMM
Irreversibility Cost γ_3	0.84	(0.057)	SMM
B) Labor Mobility Costs			
C_e	3.72	(0.48)	SMM
C_u	4.22	(0.26)	SMM
Utility parameters variance ν	2.63	(0.395)	CCP within SMM
η_1	0		Normalized
η_2	0.049	(0.233)	CCP within SMM
η_3	-0.411	(0.280)	CCP within SMM
η_4	-0.543	(0.286)	CCP within SMM
η_5	-0.255	(0.202)	CCP within SMM
η_6	0.671	(0.348)	CCP within SMM
η_0	0.232	(0.307)	CCP within SMM
C) Wage Process			
a_1	0.027		Simulated
ρ_w	0.943		Simulated
a_2	0.410		Simulated
a_3	0.623		Simulated
σ^w	0.017		Simulated
Moments			
	Empirical	Simulated	
$Corr(I, I_{-1})$	0.145	0.163	
$Corr(I, A)$	0.046	0.048	
<i>Negative spike</i>	0.014	0.004	
$Corr(w - \bar{w}, N - \bar{N})$	0.313	0.301	
$Corr(N_0, N_{0,-1})$	0.887	0.828	
$Corr(N_0 - N_{0,-1}, \bar{w} - \bar{w}_{-1})$	-0.101	-0.071	

Notes: table shows the capital adjustment cost and labor mobility cost parameters; utility function parameters; wage stochastic process parameters; and the empirical and simulated moments. Standard errors in parenthesis.

Table 3
Tariffs Cuts in Textiles and Price Changes

	Tariff	Price Change
Food & Beverages	13.9	—
Textiles	19.4	-16.2
Minerals	11.6	—
Metals	14.2	—
Other Manufactures	14.1	—
Capital Goods	12.3	—
Non-Tradables		
short-run		-1.36
long-run		-1.30

Source: Tariffs τ_j (in percent) are from Brambilla, Galiani and Porto (2018). Price changes are computed as $-\tau_j/(1 + \tau_j)$. The change in the prices of the non-traded goods comes from the simulations.

Table 4
Responses to Tariff Cuts in Textiles
Capital, Employment, Real Wages and Welfare
(percent)

	Year 1	Year 2	Year 3	Steady State
Capital				
Textiles	0.00	-9.41	-14.62	-25.47
Other Traded Goods	0.00	0.09	0.24	0.57
Non-Traded Goods	0.00	-0.62	-0.83	-1.34
Real Wage				
Textiles	-15.04	-17.25	-18.45	-20.32
Other Traded Goods	1.45	1.21	1.19	1.20
Non-Traded Goods	0.06	-0.19	-0.28	-0.39
Employment				
Textiles	0.00	-2.91	-3.90	-4.64
Other Traded Goods	0.00	0.59	0.77	0.91
Non-Traded Goods	0.00	0.20	0.28	0.34
Non-employment	0.00	0.29	0.41	0.53
Producer Welfare				
Textiles	-16.91	-20.21	-22.00	-25.73
Other Traded Goods	0.82	0.90	0.10	0.11
Non-Traded Goods	-1.31	-1.50	-1.57	-1.75
Worker Welfare				
Textiles	-1.38	-1.44	-1.47	-1.53
Other Traded Goods	-0.89	-0.90	-0.91	-0.92
Non-Traded Goods	-0.93	-0.96	-0.97	-0.98
Non-employment	-0.94	-0.95	-0.95	-0.96

Notes: Simulation of the transitional dynamic responses of capital, real wages, employment and producer and worker welfare following the full elimination of tariffs on the textile sector.

Table 5
Tariff Cuts or Tariff Protection
Asymmetric Responses
Textile Sector
(percent)

	Year 2	Year 3	Year 4	Year 5	Year 10	Steady State
Capital						
negative shock (1)	-9.41	-14.62	-18.08	-20.66	-24.73	-25.47
positive shock (2)	12.72	17.61	20.21	22.84	26.97	27.26
(2)/(1)	1.35	1.20	1.12	1.11	1.09	1.07
Real Wage						
negative shock (4)	-17.25	-18.45	-19.10	-19.62	-20.18	-20.32
positive shock (5)	18.90	19.53	19.61	20.02	20.40	20.34
(5)/(4)	1.10	1.06	1.03	1.02	1.01	1.00
Employment						
negative shock (7)	-2.91	-3.90	-4.27	-4.44	-4.61	-4.64
positive shock (8)	3.18	4.21	4.54	4.69	4.78	4.78
(8)/(7)	1.09	1.08	1.06	1.06	1.04	1.03

Notes: Simulation of the transitional dynamic responses of capital, real wages and employment in the benchmark case (full elimination of tariffs on textiles) and in a positive shock scenario with positive benchmark price changes (price changes with changed sign).

Table 6
Extensive Margin Responses: Entry and Exit of Firms
Textile Sector
(percent)

	Year 2	Year 3	Year 5	Year 10	Steady State
Capital					
baseline (1)	-9.41	-14.62	-20.66	-24.73	-25.47
entry-exit (2)	-13.13	-19.70	-23.56	-24.84	-25.94
(2)/(1)	1.40	1.35	1.14	1.01	1.02
Real Wage					
baseline (4)	-17.25	-18.45	-19.62	-20.18	-20.32
entry-exit (5)	-17.58	-19.14	-19.96	-20.54	-21.58
(5)/(4)	1.02	1.04	1.02	1.02	1.06
Employment					
baseline (7)	-2.91	-3.90	-4.44	-4.61	-4.64
entry-exit (8)	-2.97	-4.01	-4.53	-4.69	-4.92
(8)/(7)	1.02	1.03	1.02	1.02	1.06

Notes: Simulation of the transitional dynamic responses of capital, real wages and employment in the benchmark case and in the extended model with entry and exit. The shock is the full elimination of tariffs on textiles.

A On-line Appendix: Estimation Details

This appendix provides more details on the estimation procedures introduced in section 3 of the paper. We estimate the parameters related to the firm and worker decision problems using Argentine data. We combine a panel of firms with a panel of workers.

A.1 Data

Firm data

The estimation of the firm problem requires panel data with detailed information on the investment decision of firms. In particular, to fit the capital adjustment cost model, we need data on purchases of new capital as well as on sales of installed capital. We use the Encuesta Industrial Anual (EIA, or Annual Industrial Survey), which meets these requirements. In the EIA panel, we have data for the period 1994-2001. The EIA dataset provides information on revenue, value of production, employment, wages, costs, intermediate inputs, inventory stock, and both gross expenditures and gross sales of capital.

We express all monetary variables in real terms using different deflators. For wages we use the consumer price index; for investment, capital and intermediate inputs we use the general level wholesale price index; and for revenue, sales and profits a wholesale price index at a four digit level of disaggregation according to the ISIC classification.

To construct the real investment series, we generate an initial measure of the real capital stock at the plant-level and then complete the series using the perpetual inventory method according to the rule $K_{ijt+1} = (1 - \delta)K_{ijt} + I_{ijt}$. Real investment is defined as $I_{ijt} = E_{ijt} - S_{ijt}$, where E_{ijt} is real gross expenditures on capital equipment, and S_{ijt} is real gross retirements of capital equipment.

Since our dataset does not contain information on the book value of capital, we approximate the initial capital stock of the firm as the average across years of the ratio between the amount of capital depreciation declared by the firm and the estimated depreciation rate. We deflate our measure of initial capital stock by the general level of the wholesale price index. We use depreciation rates estimated by the Bureau of Economic Analysis (BEA) as described before. Our depreciation rates include both in-use depreciation (which reflects declines in the efficiency of the asset because of aging or wear and tear) as well as retirements or discards (which reflects, for example, obsolescence).

Labor force survey

The estimation of the parameters of the workers' problem requires panel data on workers' sector of employment and wages or non-employment status. We use the panel sample of the Encuesta Permanente de Hogares (EPH, Permanent Household Survey). The database contains information on individual wages, employment sector, non-employment and other standard variables in labor force surveys. Part of the EPH is a panel and we can use it to track employment decisions across sector pairs, across employment and non-employment, and average sector wages. We use the available panel from 1996 to 2006.

A.2 Estimation of the technology parameters

Production function parameters

We postulate a production function which is Leontief in materials M_{ijt} and a Cobb-Douglas index of capital K_{ijt} and labor L_{ijt} . To estimate the Cobb-Douglas production function coefficients on labor and capital, we follow the regression approach of Akerberg, Caves and Frazer (2015). It is important to note that the structural assumptions of the estimation method are compatible with our own structural model. We use value of production (Y_{ijt}) on the left-hand side, capital (K_{ijt}) and labor (L_{ijt}) on the right-hand side, and following the Leontief specification of the production function we exclude materials from the regression at this stage. The regression equation for this stage takes the form

$$(14) \quad \ln Y_{ijt} = \alpha_L \ln L_{ijt} + \alpha_K \ln K_{ijt} + \epsilon_{ijt},$$

where ϵ is a combination of productivity shocks and measurement error in output. The equation reflects the contribution of labor and capital to output and is therefore conceptually a value-added production function (given the Leontief specification), even though total value of production is on the left-hand side. See Akerberg, Caves and Frazier (2015). We use the predetermined variables K_{ijt} , K_{ijt-1} and L_{ijt-1} as instruments. Standard errors are computed from 500 bootstrap replications. The labor coefficient α_L is 0.619 and the capital coefficient α_K is 0.283. Both are statistically significant. These results are comparable to those obtained by Pavcnik (2002) for Chile.

We calibrate the unit input requirement for materials v_M by computing the mean of M_{ijt}/Y_{ijt} across firms. The estimated value for the unit input requirement is 0.41. As a robustness exercise we

Table A1
Intermediate Input Requirements

	Firm data	Input-output data
Average intermediate input requirement	0.41	0.42
Intermediate inputs sourced from own sector		
Food and beverages		0.38
Textiles		0.31
Minerals		0.04
Metals		0.40
Other manufactures		0.36

Source: INDEC. Input-output table for year 1997.

also compute the unit input requirements from an input-output table and we average them across sectors. The resulting coefficient is 0.42. The input-output coefficients used in the estimation of the production function parameters are presented in Table A1. The data come from the IO Tables for 1997 published by INDEC (Instituto Nacional de Estadística y Censos).

In the model of section 2 we further assume that firms source intermediate inputs from their own sector of production only. This assumption is key for the viability of the estimation procedure as it allows us to treat firms in all sectors symmetrically. It is based on the notion that sectors are aggregate enough so that products are sufficiently different within a same sector, but related through the production chain. For example, the main material in the production of shirts is fabric, and both shirts and fabrics are products within the textile sector. As a back-of-the-envelope test of the assumption we compute coefficients for own-sector sourcing from the input-output table. These are 0.38, 0.31, 0.40, 0.04, and 0.36 for food and beverages, textiles, metals, minerals and other manufacturing sectors. The own-sector coefficients are very close to the calibrated intermediate input requirement of 0.41 in 4 out of the 5 manufacturing sectors, which implies that the assumption agrees with the data relatively well, with the exception of the small minerals sector. See Table A1.

Stochastic process for sector and firm-level shocks

Firms face sector-level profit shocks b_{jt} , that include shocks to aggregate productivity and to prices, and firm-level shocks A_{ijt} . We assume that b and A follow AR(1) stochastic processes given by

$$(15) \quad \ln b_{jt+1} = \bar{b} + \rho_b \ln b_{jt} + \epsilon_{jt+1}^b,$$

$$(16) \quad \ln A_{ijt+1} = \rho_a \ln A_{ijt} + \epsilon_{ijt+1}^a,$$

with $\epsilon_{ijt+1}^b \sim N(0, \sigma_b^2)$ and $\epsilon_{ijt+1}^a \sim N(0, \sigma_a^2)$. We further assume that the shocks b_{jt} are independent across sectors and the shocks A_{ijt} are independent across firms. Since b_{jt} and A_{ijt} are not observable, we infer them from data on operating profits as follows. From the definition of instantaneous profits we can write the combination of sector-level and firm-level profitability shocks as

$$(17) \quad b_{jt}A_{ijt} = \left(\frac{\pi_{ijt}}{1 - \alpha_L} \right)^{1 - \alpha_L} \alpha_L^{-\alpha_L} w_{jt}^{\alpha_L} K_{ijt}^{-\alpha_K} \frac{1}{1 - v_M}.$$

Let x_{ijt} denote the product of the firm and sector level shocks, with $x_{ijt} = b_{jt}A_{ijt}$. We compute the right-hand size of (17) from data $(\pi_{ijt}, K_{ijt}, w_{jt})$ and the estimates from the previous step $(\alpha_L, \alpha_K, v_M)$. This gives us estimates for x_{ijt} . To estimate the A parameters, we first compute deviations of x_{ijt} from sector-year means (to get rid of b_{jt}) and then regress this on one lag (no constant)

$$(18) \quad \log x_{ijt+1} - \log \bar{x}_{jt+1} = \rho_a (\log x_{ijt} - \log \bar{x}_{jt}) + \epsilon_{ijt+1}^a.$$

To estimate the b parameters we compute the sector-year means of x_{ijt} and run the regression using the means, at the sector-year level

$$(19) \quad \log \bar{x}_{jt+1} = \bar{b} + \rho_b \log \bar{x}_{jt} + \epsilon_{jt}^b.$$

In Table 1 in the paper, we report $\rho_a = 0.902$, $\sigma_a^2 = 0.118$, $\bar{b} = 0.318$, $\rho_b = 0.777$, and $\sigma_b^2 = 0.044$.

A.3 SMM estimator

The adjustment costs parameters are given by the vector $\Gamma = (\gamma_1, \gamma_2, \gamma_3; C_e, C_u)$, which we estimate by simulated method of moments (SMM). The SMM estimator is based on comparing a vector of empirical moments computed from firm and worker actual data, denoted by Ψ , with moments computed from firm and worker simulated data, denoted by $\Psi^s(\Gamma)$. The simulated moments depend on the parameters Γ through the investment policy function and the employment transition probability policy function, given that the moments are based on firm-level investment and labor allocations across sectors. The estimator for the adjustment costs minimizes the weighted distance between the empirical and simulated moments. Formally,

$$(20) \quad \hat{\Gamma} = \arg \min_{\Gamma} [\Psi - \Psi^s(\Gamma)]' \Omega [\Psi - \Psi^s(\Gamma)]$$

where Ω is the optimal weighting matrix.

The estimation procedure involves iterating over possible values of Γ . At each iteration there are two steps: (i) we solve Bellman equations and policy functions for firms and workers for a discretized state space; (ii) we draw a Markov chain of aggregate shocks b_{jt} and simulate an equilibrium path for the endogenous variables from which we compute the simulated moments and the distance function.

The problem is computationally challenging. Some model assumptions have been made to keep the estimation tractable. In the case of firms, we assume symmetry across production sectors and input sourcing within sector. This allows us to solve only one firm Bellman equation and firm policy function instead of one for each sector. In the case of workers we cannot treat the sectors symmetrically. We need to solve seven worker Bellman equations (one for each production sector and one for non-employment) in order to compute the transition probabilities across sectors. We therefore follow a different modelling strategy to reduce the state space by assuming that idiosyncratic shocks are iid and follow a type-I extreme value distribution. In the case of firms, on the other hand, we allow for autoregressive shocks.

To further reduce the state space, we take advantage of the fact that several aggregate state variables enter the firm and worker problems solely through wages, which are an endogenous variable from the point of view of the equilibrium of the economy but an exogenous variable from the point of view of firms and workers. Following Krusell and Smith (1998) and Lee and Wolpin (2006) we impose an ad-hoc stochastic process for wages that workers and firms use in computing expected values (equation 12).

Finally, we reduce the SMM to iterating through the capital and labor mobility cost parameters Γ . This keeps the estimation more tractable, and the minimization of the distance function more precise and reliable. We estimate the production technology parameters prior to the SMM, as described above, and the worker utility function parameters as a linear function of Γ within the SMM. More details on the estimation of the utility function parameters are given below.

We discretize the state variables to construct grids. We discretize capital K with a grid of 150 points, and wages w with a grid of 50 points. Aggregate shocks b take two values, high and low. Idiosyncratic shocks take 8 values. We approximate the transition probability matrices of b and A with the method of Tauchen-Hussey, and the transition matrix for w from the stochastic evolution given by equation (12). To compute the distance function (20) we use the optimal weighting matrix

given by the inverse of the variance covariance matrix of $[\Psi - \Psi^s(\Gamma)]$.¹⁸ We search over values of Γ using a combination of fine grid search and coordinate descent search, which works better than second-derivate Newton-Raphson or quasi-Newton methods in a case like ours with a discretized state space. Standard errors for the estimates are computed analytically, as in Bloom (2009).

Estimation of worker utility parameters ν and η

The vector of sector employment quality η and the variance of the idiosyncratic utility shocks ν can be estimated as a linear function of the mobility cost parameters C_e and C_u . The estimation strategy for η and ν is based on Hotz and Miller (1993) and the ensuing CCP-estimator literature. In the trade literature, a similar approach is utilized by Artuc and McLaren (2015) and Caliendo, Opromolla, Parro and Sforza (2020).

Given the extreme value distribution of ε , from the ex-ante value function (8) and the conditional choice probabilities (9), we can write the ex-ante value function as a function of the probability of staying in the initial sector of employment as

$$W_t^j = \frac{w_{jt}}{P_t} + \eta_j + \beta E_t W_{t+1}^j - \nu \ln m_t^{jj}.$$

We can also write the difference in expected continuation values between sectors k and j as a function of the difference in choice probabilities of switching to k or staying in j as

$$\beta (E_t W_{t+1}^k - E_t W_{t+1}^j) = \nu (\ln m_t^{jk} - \ln m_t^{jj}) + C_{jk}.$$

Combining these two results, we get

$$E_t \left[(\ln m_t^{jk} - \ln m_t^{jj}) - \beta (\ln m_{t+1}^{jk} - \ln m_{t+1}^{kk}) - (\beta - 1) \frac{C_{jk}}{\nu} - \frac{\beta}{\nu} \left(\frac{w_{kt+1}}{P_{t+1}} - \frac{w_{jt+1}}{P_{t+1}} \right) - \frac{\beta}{\nu} (\eta_k - \eta_j) \right] = 0.$$

This is an Euler equation that can be estimated conditional on C_e and C_u with a linear regression, from actual data, as in Artuc, Chaudhuri and McLaren (2010), by allowing for a disturbance term ω_{t+1} which captures the innovation in the stochastic process of wages, unforeseen at time t . The employment quality parameters η are the coefficients on sector dummy variables (sector 1 is normalized to zero). Since there is a potential correlation between real wage differences across

¹⁸Lee and Ingram (1991) show that the inverse of the variance-covariance matrix of the actual moments is a consistent estimator for the optimal weighting matrix. We use 1,000 bootstrap replications on actual data to generate the variance-covariance matrix of the actual moments.

sectors and the disturbance term ω_{t+1} because this includes unexpected shocks to wages, we follow Artuc, Chaudhuri and McLaren (2010) and use past wage differences as an instrument. Given the assumptions of the labor choice model, past wage differences should be uncorrelated with shocks at $t + 1$. The key identification assumptions for this IV to work are that i) the idiosyncratic shocks ε are iid shocks; ii) the state of the economy evolves as a Markov process. The Markov assumption is straightforward.¹⁹

Assessment and Goodness of Fit

We end this section with an assessment of the estimation. First of all, note that the observed moments and simulated moments (at the estimated parameters) are well-matched by the SMM. This can be seen at the bottom of Table 2.

Figure A1 below establishes that the SMM objective function is well-behaved around the solution and that a minimum is achieved. To show this, we plot the SMM objective function as a function of one of the adjustment cost parameters while keeping the other four parameters constant at their solution value. In each panel, the dashed vertical line denotes the solution to the minimization problem.

Figure A2 provides more intuition about how the SMM identifies these different parameters. Each panel shows the response of the difference between the observed and the simulated moments (squared) to a different adjustment cost parameter. In panel A, we show that moment 2 (the correlation between investment and profitability) identifies the fixed cost parameter γ_1 . The quadratic cost parameter (γ^2) and the irreversibility parameter (γ^3) are both identified from the opposing forces of moment 1, the serial correlation in investment, and moment 3, the negative spike moment (panels B and C). The labor mobility cost across sectors (C_e) is identified from the serial correlation between the change in wages and the change in employment (moment 4). The mobility cost in and out of non-employment (C_u) is identified from the serial correlation in non-employment (moment 5) and the correlation between the change in non-employment and in the average wage (moment 6). These are shown in panels D and E of Figure A2.²⁰

¹⁹Note that in this Euler equation the expectation is taken over realizations of all the state variables so that it is consistent with any structure in the economy provided it evolves as a Markov process. In particular, workers expectations are perfectly consistent with our formulation of firm behavior.

²⁰Note that our model does not match the “spikes” as well as it does the other moments. This is because the spikes correspond to estimating a percentile of firms located in the tail of the firm distribution, which is much harder to replicate in the simulation of the model than a measure of central tendency such as a mean (or a correlation). As Figure A2 shows, the moment does however play a crucial role in identifying the trade-offs between inaction in investment or smoothing investment faced by firms.

The model also matches important moments of the data that we did not include in the SMM. The top panel of Table A2 reports the average sector wage as well as the employment transition probabilities.²¹ As it can be seen, the model and the data correspond quite well. We can also assess investment patterns by looking at the direction of investment. In the bottom panel of Table A2, we show the percentage of firms that disinvest ($I < 0$), the percentage of firms with investment inaction ($I = 0$), and the percentage of firms that invest ($I > 0$). We do this unconditionally and for two types of firm: low-capital (below the average capital stock) and high-capital (above the average capital stock). On average, the data and the model also correspond well, and especially so for low- K firms.

To further analyze the goodness of fit of the model, we present the comparison of several firm-level outcomes in Figure A3. Panels (a)-(c) show the kernel density estimates of the distribution of employment, capital and profits using the firm data—solid line—and the simulated data from the SMM—dashed line. The densities fit well. In panels (d) and (e) we present the distribution of log employment and profits conditional of different percentiles of the firm capital stock. This prediction corresponds well with the log employment from the firm-level data.²² We can match the conditional distribution of profits as well.

²¹Wages are normalized with respect to the average wage across sectors and time.

²²In the SMM simulated data, there is a linear relationship between log employment and log capital due to the homotheticity of the Cobb-Douglas index in the production function.

Figure A1
Identification in SMM. Minimization of objective function

Notes: Graph plots the SMM objective function as a function of one adjustment cost parameter keeping the other four parameters constant at their solution value. The dashed vertical lines denote the solution to the minimization problem.

Figure A2
Identification in SMM. Difference between Empirical and Simulated Moments

Notes: Each panel shows the difference between the observed and the simulated moments (squared) as a function of an adjustment cost parameter. Moment 2 (the correlation between investment and profitability) identifies the fixed cost parameter γ_1 . The quadratic cost parameter (γ^2) and the irreversibility parameter (γ^3) are both identified from the opposing forces of moment 1, the serial correlation in investment, and moment 3, the negative spike moment. The labor mobility cost across sectors (C_e) is identified from the serial correlation between the change in wages and the change in employment (moment 4). The mobility cost in and out of non-employment (C_u) is identified from the serial correlation in non-employment (moment 5) and the correlation between the change in non-employment and in the average wage (moment 6).

Figure A3
Comparison of empirical data and simulated data

Notes: comparison of firm-level outcomes from firm data (EIA, Annual Industrial Survey) and the SMM simulated data. Panels (a) to (c) present the kernel density estimates of log employment, log capital and profits. Panels (d) and (e) present the mean of log employment and profits conditional on percentiles of the log capital distribution.

Table A2
Comparison of empirical data and simulated data

Wages and employment transition probabilities									
	Wages	Food & beverages	Textiles	Minerals	Metals	Other manuf.	Non traded	Unemp.	
A) Simulated data									
Food & Beverages	0.958	0.866	0.023	0.030	0.023	0.029	0.029	0.001	
Textiles	0.955	0.023	0.864	0.031	0.023	0.029	0.029	0.001	
Minerals	1.039	0.018	0.018	0.902	0.018	0.022	0.023	0.001	
Metals	0.959	0.023	0.023	0.030	0.867	0.028	0.029	0.001	
Other Manuf.	1.012	0.020	0.020	0.026	0.020	0.891	0.024	0.001	
Non-Traded	1.016	0.019	0.019	0.026	0.020	0.023	0.893	0.001	
Unemployment	–	0.086	0.086	0.115	0.087	0.106	0.108	0.413	
B) Empirical data									
Food & Beverages	0.943	0.717	0.002	0.001	0.005	0.015	0.205	0.059	
Textiles	0.953	0.005	0.748	0.000	0.011	0.029	0.123	0.093	
Minerals	1.169	0.018	0.025	0.692	0.046	0.087	0.136	0.076	
Metals	0.876	0.021	0.024	0.016	0.615	0.170	0.122	0.064	
Other Manuf.	1.039	0.007	0.009	0.005	0.041	0.713	0.166	0.062	
Non-Traded	1.020	0.008	0.004	0.001	0.003	0.015	0.908	0.061	
Unemployment	–	0.014	0.018	0.002	0.008	0.029	0.374	0.556	
Firm Investment									
Percentage of Firms									
	All firms			Low- <i>K</i> firms			High- <i>K</i> firms		
	<i>I</i> <0	<i>I</i> =0	<i>I</i> >0	<i>I</i> <0	<i>I</i> =0	<i>I</i> >0	<i>I</i> <0	<i>I</i> =0	<i>I</i> >0
Data	3.87	35.63	60.49	3.85	41.84	54.31	3.90	29.42	66.68
Simulated data	8.45	43.72	47.83	3.25	31.21	65.54	13.65	56.23	30.12

Notes: Comparison of data from EPH (Encuesta Permanente de Hogares, Permanent Household Survey) and from EIA (Encuesta Industrial Anual, Annual Industrial Survey), and simulated data based on parameter estimates.

B On-line Appendix: Robustness and extensions

This appendix provides more details about the extension of the model to include firm entry and exit (Section 4.5); and a robustness exercise in which we assume a Cobb-Douglas production function in labor, capital and materials (instead of our baseline case in which the production function combines materials and a Cobb-Douglas index of labor and capital in fixed proportions given by equation 1).

B.1 Firm entry and exit

The extension of the model to study the role of the extensive margin introduces firm entry and exit based on selection. We assume that in every sector and time period there is a continuum of firms with measure one that are waiting to enter. They each take an iid draw of the sunk cost of entry, F_0 , from a Frechet distribution with cdf H and shape parameter h . Firms compare the sunk cost of entry with the expected value prior to learning their productivity and capital, $\bar{V}_{0jt}$. Firms that take a draw of F_0 between 0 and $\bar{V}_{0jt}$ enter the market. This rule defines the mass (or “number”) of entrants, n_{0jt} , as defined in equation (13). We denote the number of entrants, active and exiting firms with n_{0jt} , n_{jt} and n_{xjt} . Notice that the expected value at entry, $\bar{V}_{0jt}$, is time-varying outside of a stationary-equilibrium, as firm profits depend on sector shocks and wages, which in turn are also time-varying.

After paying the sunk entry cost F_0 , firms take productivity and initial capital draws (A_0, K_0) from a firm distribution μ_0 . We assume that the distribution of entrants (μ_0) is proportional to the distribution of incumbents (μ) and right-truncated on both dimensions (A and K), so that μ stochastically dominates μ_0 and entrants are on average less productive and smaller than incumbents. We arbitrarily truncate the productivity of entrants at the 80th percentile.²³ Firms further need to pay the investment cost to achieve the random initial level of capital, which we assume is not subject to adjustment costs and is equal to the initial level of capital. In period 1, new firms become active firms, with productivity and capital initially drawn from μ_0 . They make their first decisions regarding employment, production and investment, and are subject to adjustment costs. From period 1 onwards, idiosyncratic productivity evolves according to the Markov process for active firms as in the baseline model without entry and exit.

²³We have experimented with alternative truncation points such as the mean and the median. However, the alternative lower truncation points do not allow us to correctly match the truncation point for capital. We discuss this below.

We define two groups of firms, according to whether their idiosyncratic productivity A is below or above the 80th percentile, and denote them with Z_L and Z_K . In each period, firms in the group Z_L (low productivity firms) face a probability $(1 - \zeta)$ of falling into an absorbing state of $A = 0$, which means exiting the market as present and future profits become zero. The probability of exit is zero for firms in Z_H (high productivity firms). These simplifying assumptions are based on the empirical observations of Dunne et al (1988, 1989), who find that exiting firms are smaller than continuing firms, and in the simulations of Clementi and Palazzo (2016), who estimate close-to-one probabilities of survival for firms with high productivity. The probability of exit introduces a simple mechanism of selection that correlates with productivity. Notice that because the distribution of entrants is truncated at the 80th percentile, all new firms fall into the Z_L group and face a positive probability of falling into the absorbing state $(1 - \zeta)$. This matches the empirical fact that entrants are more likely to exit than incumbents (Dunne et al, 1988).

In any given period, the probability of being in group Z_L , denoted with ρ_{Lt} , is given by

$$(21) \quad \rho_{Ljt} = \int_{(A,K) \in Z_L} \mu_{jt}(dK \times dA).$$

The probability of exit, denoted with ρ_{xt} , is $\rho_{xjt} = (1 - \zeta)\rho_{Ljt}$. The number of firms that exit the market is given by $n_{xjt} = \rho_{xjt}n_{jt-1}$.

Under these assumptions, the expected firm value prior to entry is given by

$$(22) \quad \bar{V}_{0jt} = \beta\zeta_L \int_{(A,K) \in Z_L} E_t V(A_0, K_0, b_{jt+1}, w_{jt+1}) \mu_0(dK \times dA) - \int_{(A,K)} K_0 \mu_0(dK \times dA),$$

where the expectation E_t is taken over next period's values of sector shocks and wages. The last term corresponds to the required stochastic initial investment drawn from μ_0 . The expected value $\bar{V}_{0jt}$ varies across periods according to state variables b_{jt} and w_{jt} . Wages are determined in equilibrium (equation 11). They depend on the current labor allocations between sectors, and on aggregate shocks and firm distributions through labor demand. With the introduction of entry and exit, wages further depend on the mass of active firms, n_{jt} . When there are sector shocks, incentives to enter the market are affected, and equilibrium is restored through changes in number of firms, labor demand, equilibrium wages, and firm profits.

To simulate aggregate responses to tariff shocks we use our previous estimates for the baseline model parameters, and calibrate the new parameters to match statistics from Dunne et al (1988).

The calibration is based on the initial stationary equilibrium. We arbitrarily truncate productivity at the 80th percentile as discussed above. We truncate capital so that the average optimal labor demand of entrants is 25.63 percent of the average labor demand of incumbents.²⁴ We set the exit rate ρ_x to 0.098 based on the annualized average exit rate in Dunne et al (1988). We compute the expected value at entry, V_0 , from equation (22).²⁵ In a stationary equilibrium the number of entrants is equal to the number of exiting firms. With the number of entrants and the expected value at entry we pin down the distribution of entry costs from equation (13). The shape parameter is $h = 1.5961$. We then proceed with the simulations of the trade policy shock, which are discussed in the main text.

B.2 Cobb-Douglas production function

In our model we assume that the technology of production is Leontief in materials and a Cobb-Douglas index of labor and capital. This is a convenient assumption so that productivity and price shocks enter multiplicatively into the profit function and can be treated as a single profit shock. In this section we re-estimate the adjustment cost parameters and simulation results assuming a Cobb-Douglas production function in the three inputs, given by

$$(23) \quad Y_{ijt} = (b_{jt}^0 A_{ijt})(L_{ijt})^{\alpha_L}(K_{ijt})^{\alpha_K}(M_{ijt})^{\alpha_M},$$

The variables are defined as before, with aggregate and idiosyncratic productivity shocks b_{jt}^0 and A_{ijt} , and the new parameter α_M which is the output elasticity of materials. The objective of this exercise is to check whether the qualitative implications of the model remain unchanged under a different functional form assumption for the technology of production.

Under the new technology assumptions instantaneous profits are

$$(24) \quad \pi_{ijt} = (1 - \alpha_L - \alpha_M) \left[\left(\frac{\alpha_L}{w_{jt}} \right)^{\alpha_L} \left(\frac{\alpha_M}{p_{jt}} \right)^{\alpha_M} b_{jt}^0 p_{jt} A_{ijt} K^{\alpha_K} \right]^{1/(1-\alpha_L-\alpha_M)},$$

where the aggregate shocks b_{jt}^0 and p_{jt} do not enter multiplicatively. As before, we define the combined profitability shock as $b_{jt} = b_{jt}^0 p_{jt}$ and treat it as a single state variable that follows the AR(1) process in equation (15). We further make the following two assumptions to pin down the

²⁴Dunne et al report that on average the size of entrants is 25.63 percent of the size of incumbents.

²⁵In a stationary equilibrium aggregate variables b and w are fixed over time and consequently the expectation operator E_t is dropped from the equation.

Table B1
Estimates of Labor and Capital Adjustment Costs
Leontief and Cobb-Douglas Production Functions

Estimates	Baseline	Cobb-Douglas	
Fixed Cost γ_1	0.0379 (0.008)	0.026 (0.005)	
Quadratic Cost γ_2	0.178 (0.016)	0.163 (0.067)	
Irreversibility Cost γ_3	0.84 (0.057)	0.854 (0.096)	
Mobility cost across employment sectors C_e	3.72 (0.48)	2.51 (0.22)	
Mobility cost in or out of non-employment C_u	4.22 (0.26)	4.24 (0.20)	
Moments	Baseline	Cobb-Douglas	Data
$Corr(I, I_{-1})$	0.163	0.173	0.145
$Corr(I, A)$	0.048		0.046
$Corr(I, A)$		0.044	0.044
<i>Negative spike</i>	0.004	0.002	0.014
$Corr(w - \bar{w}, N - \bar{N})$	0.301	0.173	0.313
$Corr(N_0, N_{0,-1})$	0.828	0.738	0.887
$Corr(N_0 - N_{0,-1}, \bar{w} - \bar{w}_{-1})$	-0.101	-0.299	-0.101

Notes: The baseline column reproduces results from Table 2. The Cobb-Douglas column shows results under the Cobb-Douglas technology assumption in equation (23).

values of b_{jt}^0 and p_{jt} , which we need to input separately into the profit function: $\log b_{jt}^0 = 0.5 \log b_{jt}$; $\log b_{jt}^0 = 0.5 \log b_{jt}$.

We calibrate the output elasticities α_L , α_K and α_M from the 1997 input-output table for Argentina. From the firm data we estimate the stochastic process for b_{jt} and A_{ijt} given by equations (18) and (19). We estimate the adjustment cost parameters $\Gamma = (\gamma_1, \gamma_2, \gamma_3, C_e, C_u)$ following the SMM objective function (20). We first recompute the second empirical moment, which is the correlation between investment and idiosyncratic shocks $Corr(I_{ijt}, A_{ijt})$, as the shocks A_{ijt} need to be recomputed under the new technology specification.

Table B1 reports the results, both for our baseline Leontief case and the alternative Cobb-Douglas specification. The estimates of capital and labor adjustment costs are comparable in order of magnitude under the two technology specifications. The moments are also well-matched in the Cobb-Douglas case, although moments related to labor allocations are a better matched in the baseline Leontief case.

Figure B1 reports simulation results of a tariff cut in textiles. To facilitate the comparison we reproduce simulation results for the dynamics of capital, wages and employment from Figure 1 in the left panel. Simulations following the Cobb-Douglas specification are in the right panel. The qualitative results of both models are very similar. Quantitatively, responses are higher in the baseline case, especially for employment, but of similar orders of magnitude. Results are consistent across both specifications and do not hinge on a particular specification for the production function.

Figure B1
 Tariff Cuts in Textiles
 Capital, Real Wages, Employment
 Baseline (left) & Cobb-Douglas (right)

Notes: responses of capital, real wages and employment to a full elimination of tariffs on textiles. Simulation results from the baseline Leontief specification for the production technology on the left and from the Cobb-Douglas specification on the right.