LABOR ADJUSTMENT AND THE STAGING OF TARIFF REDUCTIONS

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Abstract

Staging the tariff reductions in trade agreements can help to mitigate labor losses. In this paper, we develop an industry-specific model of the impact of the timing of tariff reductions on the wages and employment of experienced workers in the domestic industry. The model demonstrates how labor market effects are linked to the rate of attrition in the industry's workforce, import penetration and substitution rates, and several other factors. Staging delays the loss of the value of industry-specific human capital, but it also delays consumer gains and tariff revenue losses. We apply the model to recent data for the electrical equipment, appliances, and component manufacturing industry in the United States in a series of illustrative simulations.

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1 Introduction

One critical aspect of international trade agreements is the staging of negotiated tariff reductions. Even after an agreement enters into force, staging schedules can postpone tariff reductions for some imports for ten years or more. Staging can mitigate labor losses and might lessen opposition to a trade agreement.

When evaluating alternative staging schedules, it is important to recognize that experienced workers in the domestic industry typically have significant industry-specific human capital and earn wage premia that reflect their higher productivity. Their income will likely be reduced, and possibly eliminated, when tariff reductions increase imports and reduce domestic labor demand in the industry. To illustrate these economic effects, we develop a relatively simple, dynamic, industry-specific model of trade that focuses on the costs and benefits of staged and immediate tariff reductions. The effects of staging on wages and employment are linked to the rate of attrition in the industry's workforce, import penetration and substitution rates, and several other factors.

Then we apply the model to recent data for a specific industry: electrical equipment, appliances, and component manufacturing in the United States. The model only requires data on the initial values of the industry's tariff rate, import penetration rate, supply of experienced workers, market size, elasticity of substitution between imports and domestic products, and productivity increase from industry-specific experience. We use the model to estimate the economic effects of immediate elimination of the current 2.9% average tariff rate on industry imports, and then to estimate the effects of a delayed tariff reduction.

Although the timing of implementation is a practical consideration whenever trade policies are changed, there are relatively few studies in the literature that directly address how the staging of tariff reductions affects the wages and employment of domestic, import-competing workers. Leamer (1980) is most on-point. He presents several variations on a two-period, two-sector model of international trade, and then he uses the models to compare the production efficiency and income distribution effects of immediate and staged tariff reductions. Leamer includes a distinction between experienced and inexperienced workers based on their level of industry-specific human capital. In a related study, Mussa (1984) discusses how the unemployment and income redistribution consequences of trade liberalization can be shaped by the timing of tariff reductions.

There is another branch of the literature that focuses on the political economy of staging. These studies focus on the determinants of staging schedules rather than the effects of staging. For example, Grossman and Helpman (1995) demonstrates that the exclusion of import-sensitive sectors from trade agreements through extended staging can protect the profits of industry-specific factors and can increase the likelihood that the agreements will succeed politically. Bond (2008) demonstrates that sequencing the liberalization of sectors within an agreement, rather than simultaneously liberalizing all sectors, can make a politically fragile trade agreement self-enforcing and can also avoid congestion effects and other negative inter-sectoral spillovers. There are also interesting econometric studies of the determinants of staging categories in trade agreements, including Clark (2007) and Choi (2011).

In addition to contributing to this literature, our model can provide insights for trade policy design. It suggests that staging tariff reductions can mitigate and even avoid short-term labor losses, and in this way staging can be a useful complement to trade adjustment assistance and retraining subsidies. Staging also benefits owners of industry-specific capital and postpones the reduction in tariff revenue collection. Of course there is a trade off, since staging also delays consumer gains from lower prices.

In theory, there is an optimal staging schedule that will strike the right balance; however, the optimal schedule will depend not only on the magnitude of these labor, consumer, and tariff revenue effects that we quantify with the model but also on the weights that policy makers and society assign to each of the effects. Our model does not attempt to assign these weights. We focus on quantifying each of the component effects for several alternative staging schedules without drawing normative conclusions.

The rest of the paper is organized into three parts. Section 2 presents the modeling framework and explains how we calibrate the parameters of the model. Section 3 applies the model to recent data for the electrical machinery, appliances, and components industry. It describes the sources of industry data and then presents a series of simulations of the wage and employment effects under alternative staging schedules. Section 4 concludes with a summary of findings from the industry application and a discussion of areas for further research.

2 Modeling Framework

In this section, we describe the structure of the model. We identify industry factors that affect the magnitudes of the wage and employment effects of tariff reductions under alternative staging schedules. Some of these factors are directly observable, while others are not but can be calibrated from data on initial market outcomes using the equations of the model.

2.1 Assumptions and Equations

The model tracks a specific industry over time. Initially, before the trade agreement is signed, the import penetration ratio is μ_0, the supply of experienced workers in the industry is X_0, the industry wage is w_0, and the tariff factor, defined as one plus the tariff rate, is ϕ_0. The tariff is either eliminated immediately and permanently in period 1, or its elimination is postponed until a later period according to the staging schedule in the agreement. The model takes the staging of the tariff reduction as an exogenous policy action, in contrast to the political economy studies mentioned in the Introduction.

Experienced and inexperienced workers are perfect substitutes in production, though they have different productivity levels. Each worker with industry experience is as productive as $\theta > 1$ newly hired inexperienced workers. θ represents human capital that is industry-specific: work experience is not transferable to other industries. The wage of experienced workers in period t, w_t, is limited by competition from inexperienced workers, so the upper bound on the wage of experienced workers is $\theta\ w_t^*$, where w_t^* is the wage of inexperienced workers.[1] If there is adequate labor demand, then experienced workers slightly under-price potential new hires on a productivity-adjusted basis, and this limit pricing ensures that the retention of experienced workers is prioritized over new hiring. There is also a lower bound on the wages of experienced workers in the industry, $w_t \geq w_t^*$, since these workers could exit the industry and take a job in another industry as inexperienced workers. Experienced workers earn a wage premium when employed in the industry equal to $w_t\ -\ w_t^*$.

Labor demand in the domestic industry in period t varies with the wage rate w_t and the tariff factor ϕ_t. The wage rate of experienced workers in period t is determined by the labor market clearing condition in equation (1), unless it is bounded from above by $\theta\ w_t^*$ or from below by w_t^*.

$$L_t = X_t \tag{1}$$

The supply of experienced workers in the domestic industry, X_t, evolves over time according to equation (2).

$$X_t = X_0\ (1\ -\ n\ (t\ -\ 1)) \tag{2}$$

n is the annual rate of attrition of the industry workforce after the first period. This exogenous rate of attribution includes retirements and turnover for other reasons.

The production technology in the domestic industry has a Cobb-Douglas form with three factors of production. The first factor, labor, includes experienced and possibly also inexperienced workers, with a combined cost share β. Experienced workers are available in inelastic

[1] This outside wage w_t^* is an exogenous variable in the model.

supply X_t and earn wage w_t. Inexperienced workers are available in unlimited supply at wage w_t^* in each period. The second factor of production is a composite of inputs that are not industry-specific, including energy and purchased intermediates. These inputs are available in unlimited supply at price z_t, and they have a combined cost share α. The third factor of production is industry-specific capital, with inelastic supply Y_t, price r_t, and cost share $1 - \alpha - \beta$.

The industry's domestic product market is perfectly competitive, so the price of the domestic product equals marginal cost.

$$p_t = (z_t)^{\alpha} \ (w_t)^{\beta} \ (r_t)^{1 - \alpha - \beta} \tag{3}$$

Imports and domestic products within the industry are imperfect substitutes in demand, with a constant elasticity of substitution $\sigma > 1$.[2] Total expenditures on the products of the industry in the domestic market (E_t) and the foreign producer price (p_t^*) are exogenous variables in the model. Equation (4) is the total labor demand of the domestic industry in period t.[3]

$$L_t = E_t \left(\frac{p_t}{P_t}\right)^{1 - \sigma} \left(\frac{\beta}{w_t}\right) \tag{4}$$

Equation (5) is the CES industry price index in period t.

$$P_t = \left((p_t)^{1 - \sigma} + (p_t^* \ \phi_t)^{1 - \sigma}\right)^{\frac{1}{1 - \sigma}} \tag{5}$$

Equation (6) is total demand for industry-specific capital in period t.

$$Y_t = E_t \left(\frac{p_t}{P_t}\right)^{1 - \sigma} \left(\frac{1 - \alpha - \beta}{r_t}\right) \tag{6}$$

[2]There are Cobb-Douglas preferences over industry composites of products, and this unitary elasticity of substitution implies that total expenditure on the products of the industry are a constant share of aggregate expenditures in the domestic market.

[3]The model focuses on the domestic shipments of domestic producers and does not include their exports.

Equation (7) is the industry's import penetration rate in period t.

$$\mu_t = \left(\frac{p_t^* \ \phi_t}{P_t} \right)^{1 \ - \ \sigma} \tag{7}$$

Equation (8) is the total value of the wage premium earned by experienced workers in the domestic industry.

$$TWP_t = (w_t - w_t^*) \ \ X_t \tag{8}$$

Equation (9) is the total return to industry-specific capital in period t.

$$TRK_t = (1 \ - \ \alpha \ - \ \beta) \ (1 \ - \ \mu_t) \ E_t \tag{9}$$

Finally, equation (10) is the total value of the tariff revenue collected on industry imports in period t.

$$TTR_t = \mu_t \ E_t \ \ (\phi_t \ - \ 1) \tag{10}$$

2.2 Calibration Using Initial Market Outcomes

Five of the model parameters (p_0^*, β, α, Y_0, and w_0^*) might not be observable for some industries, but they can be calibrated to observable initial market outcomes μ_0, w_0, ϕ_0, X_0, and E_0 given an estimate of σ and normalized values of r_0 and z_0, using the equations of the model:

$$p_0^* = (z_0)^{\alpha} \ (w_0)^{\beta} \ (r_0)^{1 \ - \ \alpha \ - \ \beta} \ \left(\frac{\mu_0}{1 \ - \ \mu_0} \right)^{\frac{1}{1 \ - \ \sigma}} \tag{11}$$

$$\beta = \frac{w_0 \ X_0}{(1 \ - \ \mu_0) \ E_0} \tag{12}$$

$$\alpha = \frac{G_0}{(1 \; - \; \mu_0) \; E_0} \tag{13}$$

$$Y_0 = \frac{(1 \; - \; \mu_0) \; E_0 \; (1 \; - \; \alpha \; - \; \beta)}{r_0} \tag{14}$$

$$w_0^* = \frac{w_0}{\theta} \tag{15}$$

The variable G_0 represents the domestic industry's initial expenditure on factors of production that are not industry-specific.

3 Application of the Model

Next, we apply the model to recent data for the U.S. electrical equipment, appliances and components manufacturing industry (NAICS code 335) in a series of illustrative simulations.

3.1 Industry Data

We calculate this industry's import penetration rate, average tariff rate, and elasticity of substitution between imports and domestic products using 2018 data from the Annual Survey of Manufactures (ASM) and the USITC's Trade Dataweb.[4] The import penetration rate is calculated as the ratio of the landed duty paid value of imports to apparent consumption, defined as the total value of shipments minus the value of exports plus the landed duty paid value of imports. Table 1 reports key economic statistics for the industry.

[4]The ASM is available online at `census.gov/programs-surveys/asm/data/tables.html`. The Trade Dataweb is available online at `dataweb.usitc.gov`.

Table 1: Data for the Industry

Measure	2018 Value
Total Value of Shipments of the Domestic Industry	$132.7 billion
Payroll of the Domestic Industry	$20.5 billion
Employment of the Domestic Industry	347,561 workers
Total Value of Industry Exports	$46.2 billion
Total Value of Industry Imports	$130.7 billion
Total Value of Expenditure on the Industry	$217.2 billion

The import penetration rate was 60.2% (so $\mu_0 = 0.602$). The average tariff rate was 2.9% (so $\phi_0 = 1.029$).

We use an econometric model to estimate the elasticity of substitution σ by applying the trade cost method in Riker (2020) to data on industry imports in 2019. Equation (16) is the econometric specification.

$$ln\ v_{jd} = a_j \ + \ b_d \ + \ (1 \ - \ \sigma) \ ln\ f_{jd} \ + e_{jd} \tag{16}$$

$ln\ v_{jd}$ is the log of the landed duty-paid value of imports from country j into district d. $ln\ f_{jd}$ is the log of the trade cost factor, which includes tariffs and freight costs of the imports. a_j and b_d are country and district fixed effects, and e_{jd} is the error term of the model. The estimated value of σ for the electrical equipment, appliances, and component manufacturing industry is 4.672, with a robust standard error of 0.632.

We use 2018 data from the Current Population Survey (CPS) to estimate the industry's attrition rate n. We estimate that approximately 1.5% of the industry's initial workforce retires each year, based on the age profile of individual workers in the industry in the CPS sample.[5] To account for other non-retirement turnover, we add another 1.5% for a total annual attrition rate of 3.0%.[6] Each period in the model corresponds to one year.

[5]This is the difference between the average share of workers each age from 60 to 64 (2.0%) and the average share of workers each age after 64 (0.5%).

[6]This is comparable to the 3% inter-sectoral gross transition rates in Artuç, Chaudhuri and McLaren

We use the Occupational Mobility and Job Tenure Supplement of the CPS in 2016 and 2018 from Flood, King, Rodgers, Ruggles and Warren (2020) to estimate the experience parameter θ. We classify workers with ten or more years working in their current job as experienced. We use an econometric model to relate average weekly earnings to an individual's work experience, educational attainment (high school graduate or college graduate), and a combination of state, year, industry, and occupation fixed effects. It was not feasible to estimate this econometric model narrowly for NAICS 335, because there is only a small sample of workers from that industry in the public use microdata sample from the Occupational Mobility and Job Tenure Supplement, so we pool together the sample of CPS workers employed in all manufacturing industries in the econometric estimation. The estimated coefficient on the indicator variable for experience is 0.09, with a robust standard error of 0.03. This suggests that $\theta = 1.09$.

There are two constant parameters in the model that we cannot directly measure or calibrate from the equations of the model: the initial prices of industry-specific and non-specific factors, r_0 and z_0. This is not a limitation, because the simulated effects of tariff reductions, when expressed as *changes relative to baseline values*, are not sensitive to these parameter values. We set $r_0 = z_0 = 1$ in the simulations.

3.2 Benchmark Simulations

In all of the simulations, the tariff rate is reduced from 2.9% to 0.0%. Table 2 reports the simulated increase in the import penetration rate relative to the baseline. The baseline represents the time path of the import penetration rate taking into account the attrition of experienced workers but absent any reduction in the tariff on industry imports. Each column in the table reports a separate simulation with an alternative assumption about the timing of the tariff reduction. Each row reports economic effects in one time period across

(2010).

the alternative staging scenarios. There are no effects on the import penetration rate in periods before the tariff reduction and then the import penetration rate increases with the tariff reduction before leveling off.

Table 2: Changes in the Industry Import Penetration Rate

Change in Percentage Points Relative to Baseline	Full Liberalization in Period 1	Full Liberalization in Period 2	Full Liberalization in Period 3
Period 1	0.98	0	0
Period 2	1.22	1.22	0
Period 3	1.23	1.23	1.23
Period 4	1.23	1.23	1.23

Table 3 reports the simulated reductions in the industry's CES price index relative to the value of the price index in the baseline. There are no price effects before the tariff reduction. If the trade liberalization occurs immediately or in the second period, then the decline in consumer prices is temporarily greater than the long-run change, because wages are temporarily reduced before returning to the baseline over time. The changes in wages relative to the baseline are reported in Table 4.

Table 3: Changes in the Industry Price Index

Change in Percentage Points Relative to Baseline	Full Liberalization in Period 1	Full Liberalization in Period 2	Full Liberalization in Period 3
Period 1	-2.391	0	0
Period 2	-2.285	-2.285	0
Period 3	-2.281	-2.281	-2.281
Period 4	-2.281	-2.281	-2.281

To understand why the wage effects vary with the timing of tariff reductions, it is useful to compare the magnitude of the shift in labor demand to the magnitude of the gradual reduction in the supply of experienced workers in the industry through attrition. In the long

Table 4: Changes in Industry Annual Wages

Change in Annual Wage Relative to Baseline	Full Liberalization in Period 1	Full Liberalization in Period 2	Full Liberalization in Period 3
Period 1	-1,451	0	0
Period 2	-44	-44	0
Period 3	0	0	0
Period 4	0	0	0

run, labor demand in the industry declines from an initial 347,561 workers to 336,814 as a result of the tariff reduction, while the supply of experienced workers declines gradually from an initial 347,561 workers to 337,134 in the second period, 326,707 in the third period, and 316,281 in the fourth period as a result of the 3% attrition rate. If the staged tariff reduction occurs in the third period or later, the long-run shift in labor demand is less than the cumulative reduction in labor supply to date, and wages do not need to decline to ensure the continued employment of all remaining experienced workers. If the staged tariff reduction occurs before the third period, then wages decline to ensure the employment of all remaining experienced workers.

The magnitude of the reduction in the total value of wage premium payments in the industry reflects these wage effects as well as the attrition rate (Table 5).

Table 5: Changes in the Total Value of Wage Premium Payments

Change in Millions of Dollars Relative to Baseline	Full Liberalization in Period 1	Full Liberalization in Period 2	Full Liberalization in Period 3
Period 1	-504	0	0
Period 2	-15	-15	0
Period 3	0	0	0
Period 4	0	0	0

The reduction in the total return to industry-specific capital also depends on the timing of the tariff reduction (Table 6). There is no reduction in the total return relative to the baseline until the tariff reduction. After the tariff reduction, the drop in the total return to industry-specific capital is magnified as the supply of experienced workers declines through attrition, until it levels off in the third period.

Table 6: Change in the Total Returns to Industry-Specific Capital

Change in Millions of Dollars Relative to Baseline	Full Liberalization in Period 1	Full Liberalization in Period 2	Full Liberalization in Period 3
Period 1	-982	0	0
Period 2	-1,228	-1,228	0
Period 3	-1,236	-1,236	-1,236
Period 4	-1,236	-1,236	-1,236

To summarize, the reduction in the supply of experienced workers through attrition increases the total value of the wage premium and reduces the total returns to industry-specific capital each period. This occurs in the baseline, even if there is no tariff reduction. The decline in labor income is magnified by the tariff reduction, especially when an industry's import penetration ratio, elasticity of substitution, and initial tariff rate are large.

Finally, Table 7 reports the reduction in total tariff revenue from industry imports.

Table 7: Change in the Total Tariff Revenue

Change in Millions of Dollars Relative to Baseline	Full Liberalization in Period 1	Full Liberalization in Period 2	Full Liberalization in Period 3
Period 1	-3,791	0	0
Period 2	-3,791	-3,791	0
Period 3	-3,791	-3,791	-3,791
Period 4	-3,791	-3,791	-3,791

Staging involves a trade off between the gains to consumers from lower prices in Table 3, the income losses of experienced workers and industry-specific capital in Tables 5 and 6, and the loss of tariff revenue in Table 7. Navigating this trade off and designing an optimal staging schedule would require assigning weights to each of these component effects that reflect the priorities of policy makers and society, as we discussed in the Introduction, and this normative analysis is beyond the scope of our model.

3.3 Sensitivity Analysis

In this section, we report the results of additional model simulations that assess the sensitivity of the estimated effects to assumptions in the benchmark simulations. We focus on one specific outcome, the reduction in the total value of the wage premium relative to the baseline (TWP_t), though all of the simulated outcomes will vary with the assumptions and data inputs of the model.

The alternative simulations in Table 8 estimate the reduction in TWP_t relative to the baseline when there is a more gradual reduction in the tariff rate: a 50% reduction in the first period, with the remaining reduction in the second period. This gradual tariff reduction is smaller labor losses in the first period for a given initial tariff rate.

Table 8: Alternative with Gradual Reduction in the Tariff

Change in TWP_t in \$ Millions Relative to Baseline	Benchmark: Full Liberalization in Period 1	50% Reductions in Periods 1 and 2
Period 1	-504	-252
Period 2	-15	-15
Period 3	0	0
Period 4	0	0

The simulations in Table 9 estimate the reduction in TWP_t relative to the baseline if the initial tariff rate were 10% rather than 2.9%. Labor losses are larger the greater is the initial tariff rate, since the tariff reduction would have a greater negative impact on domestic labor demand.

Table 9: Alternative with Lower ϕ_0, Set at 0.10

Change in TWP_t in \$ Millions Relative to Baseline	Full Liberalization in Period 1	Full Liberalization in Period 2	Full Liberalization in Period 3
Period 1	-1,645	0	0
Period 2	-1,150	-1,150	0
Period 3	-658	-658	-658
Period 4	-170	-170	-170

The simulations in Table 10 estimate the reduction in TWP_t if the elasticity of substitution σ is higher, at 7 rather than 4.672. Labor losses are increasing in the elasticity of substitution, since the tariff reduction has a greater negative impact on domestic labor demand.

Table 10: Alternative with Higher σ, Set at 7

Change in TWP_t in \$ Millions Relative to Baseline	Full Liberalization in Period 1	Full Liberalization in Period 2	Full Liberalization in Period 3
Period 1	-593	0	0
Period 2	-126	-126	0
Period 3	0	0	0
Period 4	0	0	0

The simulations in Table 11 estimate the reduction in TWP_t if there is a 5% annual decline in total expenditures on the products of the industry. In a shrinking market, labor losses from tariff reductions are larger after period 1 and are more persistent over time.

The simulations on Table 12 estimate the reduction in TWP_t if there is a 2% annual decline in import prices each year. The declining price competitiveness of domestic producers prolongs and magnifies the labor losses, though they gradually diminish with the attrition of experienced workers in the domestic industry.

As a final sensitivity analysis, we consider how the estimates of the labor losses would

Table 11: Alternative with Annual 5% Declines in E_t

Changes in $TVWP_t$ in \$ Millions Relative to Baseline	Full Liberalization in Period 1	Full Liberalization in Period 2	Full Liberalization in Period 3
Period 1	-504	0	0
Period 2	-409	-409	0
Period 3	-307	-307	-307
Period 4	-198	-198	-198

Table 12: Alternative with Annual 2% Declines in p_t^*

Change in TWP_t in \$ Millions Relative to Baseline	Full Liberalization in Period 1	Full Liberalization in Period 2	Full Liberalization in Period 3
Period 1	-504	0	0
Period 2	-364	-364	0
Period 3	-219	-219	-219
Period 4	-69	-69	-69

change if the model allowed for partial transfer of human capital across industries, for example if an experienced worker would be as productive as $\lambda\ (\theta\ -\ 1)\ +\ 1$ inexperienced workers after moving to another industry. As long as $\lambda > 0$, the skill transfer would raise the lower bound on the wages of experienced workers in the industry, from w_t^* to $(\lambda\ (\theta\ -\ 1)\ +\ 1)\ w_t^*$. However, since this lower bound on wages is not binding in our application of the model, allowing a small skill transfer would not affect our estimates of the magnitudes of the labor losses.

4 Conclusions

The model quantifies the costs and benefits of staging tariff reductions. It demonstrates how delaying the tariff reductions can avoid the loss of the value of human capital that would otherwise retire gradually. By keeping the industry-specific model relatively simple, we have limited its data requirements to economic characteristics of the industry that are practical to measure. We illustrate this practicality in an application to recent data from the U.S. electrical equipment, appliances, and component manufacturing industry. In the benchmark version of the model simulations, labor losses are mitigated if staging postpones the tariff reduction for a year, and labor losses are avoided entirely if the tariff reduction is postponed for two years.

There are several extensions of the model that might be useful. For example, the framework could try to explain retirement, job transitions across industries, and skill accumulation decisions. In this way, it could move toward the more complex dynamic structural models in Artuç et al. (2010), Dix-Carniero (2014), and Caliendo, Dvorkin and Parro (2019).[7] In addition, the model could be extended to consider alternative assumptions about how a shift in labor demand affects wages and employment. With fixed wages, for example, there would be displacement of experienced workers and probably short-run unemployment. While these model extensions will likely improve the fit of the model to a specific industry, they will likely significantly increase its data requirements.

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