LABOR MOBILITY AND THE IMPACT OF IMPORT PRICES ON U.S. WAGES

David Riker

ECONOMICS WORKING PAPER SERIES
Working Paper 2020–05–F

U.S. INTERNATIONAL TRADE COMMISSION
500 E Street SW
Washington, DC 20436

May 2020

 Please address correspondence to david.riker@usitc.gov.

Labor Mobility and the Impact of Import Prices on U.S. Wages
David Riker
Office of Economics Working Paper 2020–05–F
May 2020

Abstract

Changes in import prices affect labor demand in the United States and translate into changes in real wages. The diffusion of wage effects between sectors of the economy and between worker occupations depends on labor mobility across these dimensions. Computable general equilibrium models of trade usually assume that labor is perfectly mobile across sectors. In contrast, we construct an empirical structural model of the effects of trade on labor markets that emphasizes limitations on the mobility of workers. We calibrate the model to recent data for the U.S. economy and then use the model to simulate the wage effects of different combinations of import price shocks. We find that increases in import prices generally have a negative effect on real wages, though there can be significant differences in magnitude across occupations and sectors. Inter-sector labor mobility is an important determinant of the magnitude, concentration and even sign of these wage effects. The wage effects are also transmitted across sectors by input-output links and changes in aggregate income, the cost of living, and the cost of other factor inputs. Finally, we use the model to estimate the impact of recent changes in U.S. tariffs on real wages in different occupations and sectors.

David Riker, Office of Economics
david.riker@usitc.gov

Key words: wages, imports, labor mobility, specific factors

JEL codes: F14, F16, F66, J2, J3

1 Introduction

Changes in import prices can reflect changes in tariffs, exchange rates, and foreign production costs. They affect labor demand in the United States and translate into changes in real wages. These wage effects are unevenly distributed across sectors of the economy and worker occupations. They can be concentrated within a sector or broadly diffused across sectors depending on the extent of labor mobility between sectors, as well as input-output links between sectors and effects on aggregate income, the cost of living, and the cost of other factor inputs. The idea that factor specificity shapes the distributional effects of trade is well-known from textbook presentations of the Hecksher-Ohlin model and the Specific Factors (also known as Ricardo-Viner) model like Feenstra (2016), yet factor specificity is not emphasized in most computable general equilibrium models of trade.

To investigate the impact of inter-sectoral labor mobility on the wage effects of changes in import prices, we construct a multi-sector model of trade and wages. Section 2 presents the structure of the model. We calibrate the model to recent U.S. data that are described in Section 3. In Section 4, we use the model to simulate the effects of illustrative sector-specific import price shocks. We consider two alternative assumptions about inter-sectoral labor mobility: either workers in all occupations are perfectly mobile across sectors or they are not mobile at all. Restrictions on labor mobility concentrate real wage effects. In some sectors there are relatively large increase in real wages, while in other sectors there are relatively small reductions in real wages. On the other hand, when there are no restrictions on labor mobility there are negative real wage effects in almost all sectors. The magnitude of wage effects depends in a complicated way on import penetration rates, occupation intensities, and input-output links in each sector.

In Section 5, we use the model to estimate the real wage effects of recent changes in U.S. tariff rates on manufacturing imports, again with an emphasis on how assumptions about labor mobility distribute these effects across sectors and occupations. For these historical simulations, we include a mix of mobile and immobile occupations calibrated to evidence about the extent of inter-sectoral wage arbitrage in different occupations. The skills of management, financial, and computer professionals seem to be more transferable to jobs in other sectors, while sales, legal, and scientific occupations seem to be more specialized, relying on sector-specific experience, networks, and relationships that are less transferable. We find that half of the sectors experienced positive real wage effects in the relatively immobile occupations, while half experienced negative effects. Generally, there were real wage increases in sectors with large recent tariff increases, but there are significant differences in the magnitudes of the wage effects across sectors. The real wage effects for the relative mobile occupations were all negative, reflecting the relatively large increase in the cost of living, though the increase in the wages of production workers nearly matched in the increase in the cost of living.

Our model contributes to the economics literature on the effects of trade on the wages of workers in different occupations and sectors in the U.S. economy. Ebenstein, Harrison, McMillan and Phillips (2014) emphasizes how occupation determines a worker's exposure to globalization shocks. A significant difference in our approach is that we develop a full structural model with many inter-sectoral links and explicit assumptions about inter-sectoral labor mobility, while the reduced-form econometric specification in Ebenstein et al. (2014) calculates occupational exposure to sector-specific shocks as an average of sector-specific shocks that is simply weighted by the sector shares of employment within each occupation.[1] Artuc and McLaren (2015) emphasizes restrictions on labor mobility across sectors and across occupations. Their structural dynamic model provides explicit micro-foundations for these restrictions, and they calibrate moving costs to data on U.S. labor transitions. A significant

[1] A reduced-form econometric specification that is consistent with all of the occupations, sectors, and inter-sectoral links in our model would be intractable.

difference in our approach is that we include inter-sectoral links through intermediate goods and more detailed sectors and occupations, but we do not model the timing of the adjustment. Our model is probably most similar to the calibrated general equilibrium model in Carrico and Tsigas (2014). They also focus on the wage effects of trade on workers in different occupations, though their model has significantly different assumptions about inter-sectoral labor mobility. Compared to all of these related studies, our model is calibrated to more recent data (for 2018), and we focus in our simulations on the impact of recent changes in U.S. tariff rates.

2 Structural Model of Trade and Wages

The model distinguishes between workers based on their sector of employment (indexed by i) and occupation (indexed by j). It treats the prices of imported intermediate and final goods as exogenous variables, determined by world prices and tariff rates. Demand in sector i has a Constant Elasticity of Substitution (CES) form, with elasticity equal to σ_i. Preferences across sector composites are Cobb-Douglas, so each sector receives a constant share of aggregate expenditures.

Percent changes in prices are equal to percent changes in marginal costs of production. This is consistent with perfect competition in product markets and also with monopolistic competition with CES demand and fixed mark-ups. Equation (1) is the percent change in the price of domestic products in sector i.

$$\hat{p}_i = \sum_j \lambda_{ij}\ \hat{w}_{ij}\ +\ \gamma_i\ \hat{r}_i + \sum_n \theta_{in}\left((1\ -\ \omega_{ni})\ \hat{p}_n\ +\ \omega_{ni}\ \hat{p}^*_n\right) \tag{1}$$

λ_{ij} is the direct cost share of occupation j workers in sector i, and $\hat{w}_{ij}$ is the percent change in the wages of these workers. γ_i is the direct cost share of a non-labor primary input that is specific to sector i, and $\hat{r}_i$ is the percent change in its factor price. ω_{ni} is the import penetration rate for intermediate inputs from sector n in production in sector i, and $(1 - \omega_{ni})\ \theta_{in}$ and $\omega_{ni}\ \theta_{in}$ are the cost shares of domestic and imported versions of intermediate input n in sector i. $\hat{p}_n$ and $\hat{p}_n^*$ are the percent changes in the prices of these intermediate inputs. The cost shares in (1) sum to one. Equation (2) is the percent change in the price index for final goods and services in sector i.

$$\hat{P}_i = (1 - \mu_i)\ \hat{p}_i + \mu_i\ \hat{p}_i^* \tag{2}$$

$\hat{p}_i^*$ is the percent changes in the price of imports.

Equation (3) is the percent change in the value of domestic shipments in i, $\hat{d}_i$.

$$\hat{d}_i = \hat{y} + (1 - \sigma_i) \left(\hat{p}_i - \hat{P}_i\right) \tag{3}$$

$\hat{y}$ is the percent change in aggregate expenditure in the domestic market. Equation (4) is the percent change in the value of the exports of sector i.

$$\hat{x}_i = \hat{y}^* + (1 - \sigma_i) \left(\hat{p}_i - \hat{P}_i^*\right) \tag{4}$$

$\hat{y}^*$ and $\hat{P}_i^*$ are the foreign market counterparts of $\hat{y}$ and $\hat{P}_i$. Equation (5) is the percent change in aggregate income in the domestic economy. The model assumes that this is equal to the percent change in aggregate expenditures.

$$\hat{y} = \sum_{i,j} \left(\frac{w_{ij}\ \left(L_{ij} + L_{ij}^*\right)}{y} \right) \hat{w}_{ij} + \sum_{i} \left(\frac{y_i}{y}\right) \gamma_i\ \hat{r}_i \tag{5}$$

L_{ij} is the number of workers in occupation j employed in sector i production that serves the domestic market, and L_{ij}^* is the corresponding employment in production that serves export markets. y_i is defined as the value of the total output in sector i.

We close the general equilibrium model with labor market clearing conditions defined by the inter-sectoral mobility of workers in different occupations. In equilibrium, the same market-clearing wage rate is paid to all workers who compete in the same labor supply pool. We assume that workers cannot move between pools. The labor supply pools for some occupations are limited to a single sector, while others span many sectors. Equation (6) is the labor market clearing condition for a pool of workers who are specific to sector i and occupation j, receive wage w_{ij}, and cannot move between sectors or occupations.

$$\hat{L}_{ij} = \left(\frac{L_{ij}}{L_{ij} + L^*_{ij}}\right)\left(\sum_{i' \neq i} \psi_{ii'}\ \hat{d}_{i'} + \left(1 - \sum_{i' \neq i} \psi_{i'i}\right)\hat{d}_i\right) + \left(\frac{L^*_{ij}}{L_{ij} + L^*_{ij}}\right)\hat{x}_i\ -\ \hat{w}_{ij} \qquad (6)$$

$\psi_{ii'}$ is the share output of sector i that is used as an intermediate input in sector i' production. In contrast, (7) is the labor market clearing condition for a pool of workers who are specific to occupation j', receive wage $w_{j'}$, and can move between sectors but not between occupations.

$$\hat{L}_{j'} = \sum_i \left(\frac{L_{ij'}}{\sum_{i'} L_{i'j'} + L^*_{i'j'}}\right)\left(\sum_{i' \neq i} \psi_{i'i}\ \hat{d}_{i'} + \left(1 - \sum_{i' \neq i} \psi_{ii'}\right)\hat{d}_i\right) + \sum_i \left(\frac{L^*_{ij'}}{\sum_{i'} L_{ij'} + L^*_{ij'}}\right)\hat{x}_i - \hat{w}_{j'} \qquad (7)$$

Equation (8) is the market clearing condition for the non-labor primary input specific to sector i.

$$\hat{K}_i = \sum_i \left(\frac{\gamma_i\ y_i}{y}\right)\left(\left(\frac{d_i}{d_i\ +\ x_i}\right)\hat{d}_i\ +\ \left(\frac{x_i}{d_i\ +\ x_i}\right)\hat{x}_i\ -\ \hat{r}_i\right) \qquad (8)$$

$\hat{K}_i$ is the percent change in this non-labor primary input. The supply of the sector-specific factor, K_i, and the total number of workers in each labor supply pool are exogenous variables in the model.

We calculate the percent change in the real wage in each labor supply pool as the difference between the percent change in its wage and the percent change in a consumer price index that reflects the consumer expenditure share of the goods and services produced by each sector.

An import price change in one sector is transmitted to the real wages of workers in other sectors through four distinct channels in the model. The first is the inter-sectoral reallocation of workers in occupations that are not sector-specific. Even workers in occupations that are sector-specific are affected by product demand shocks in other sectors if some of their co-workers in other occupations can move between sectors. The second channel is changes in the prices of intermediate inputs purchased from other sectors. The third is changes in aggregate income, which in turn affects labor demand in all sectors. The fourth is changes in the cost of living in the denominator of real wages.

3 Calibration to U.S. Data

3.1 Data Sources

We calibrate the model to U.S. economic data from several sources. Employment and wage data by three-digit NAICS sectors and two-digit occupation codes are from the 2018 Occupational Employment Statistics (OES) tables published by the U.S. Bureau of Labor Statistics.[2] We calculate the import penetration rate and export share for each sector using data on U.S. imports and exports from the International Trade Commission's Trade DataWeb and data on the value of shipments of U.S. producers from the 2017 Economic Census of the United States.[3] We calculate the cost shares of labor and intermediate inputs and the shipment shares by sector using 2018 direct requirement and use tables published by the U.S. Bureau

[2]These employment and wage data are available at `https://www.bls.gov/oes/home.htm`.

[3]The trade data are available at `https://dataweb.usitc.gov/`. The domestic shipment data are available at `https://www.census.gov/programs-surveys/economic-census/data/tables.html`.

of Economic Analysis (BEA).[4] Finally, we estimate the elasticity of substitution parameters for the manufacturing sectors using data from the 2017 Economic Census and the methodology in Ahmad and Riker (2020) applied at the level of three-digit NAICS sectors.[5]

3.2 Data Aggregation

The model aggregates industries into the 21 three-digit manufacturing sectors listed in Table 1, as well as three sector aggregates that represent the rest of the economy. We aggregate U.S. workers into the two-digit occupation groups listed in Table 2.

3.3 Descriptive Statistics

The 24 sectors are very different in size. Table 1 reports total employment and average annual wages for each of the sectors. Services is the largest sector overall, and transportation equipment is the largest manufacturing sector.

The sectors also have very different occupation intensities. Table 2 reports payroll shares by occupation for four broad sector aggregates: agriculture, mining, services, and manufacturing. The payroll shares of production workers and engineers are largest in manufacturing, while the payroll shares of sales and office support are largest in services. Very specialized occupations like farming and construction are mostly concentrated in the agriculture and mining sectors.

Finally, the BEA data indicate that there are significant input-output links that can transmit labor demand shocks across sectors. For example, primary and fabricated metal products are significant inputs into the production of machinery and motor vehicles, accounting for 25.1% and 17.4% of the value of intermediate inputs. Likewise, chemical products are significant inputs into the production of plastic and rubber products, accounting for 37.0%

[4] These data are available at `https://www.bea.gov/industry/input-output-accounts-data`.

[5] For the non-manufacturing sectors, tbe model assumes that the elasticity of substitution is equal to 3.

Table 1: Employment and Average Wages by Sector in 2018

Abbreviated Sector Name (NAICS code)	Total Employment (Thousands)	Average Annual Wage (Dollars)
Agriculture (11)	378	30,819
Mining (21)	652	64,689
Services (22-23, 42-92)	131,022	51,851
Food Products (311)	1,598	38,912
Beverage and Tobacco (312)	271	45,150
Textile (313)	110	39,957
Textile Mill (314)	115	37,271
Apparel (315)	113	38,074
Leather (316)	27	38,715
Wood (321)	403	38,886
Paper (322)	362	50,159
Printing (323)	435	45,149
Petroleum and Coal (324)	112	74,277
Chemicals (325)	828	67,066
Plastic and Rubber (326)	722	45,215
Non-Metallic Mineral (327)	416	47,015
Primary Metal (331)	374	50,293
Fabricated Metal (332)	1,445	48,770
Machinery (333)	1,094	57,065
Computers and Electronics (334)	1,042	80,499
Electrical Equipment (335)	392	55,377
Transportation Equipment (336)	1,671	60,004
Furniture (337)	394	41,908
Miscellaneous Manufacturing (339)	601	53,029

Table 2: Payroll Share of Workers within Sector Aggregates in 2018

Abbrev. Occupation Name (Occupation Code)	Manufacturing (%)	Services (%)	Mining (%)	Agriculture (%)
Management (11)	14.23	12.14	12.71	6.40
Financial (13)	5.60	8.15	6.33	1.07
Computer (15)	4.53	5.45	2.54	0.02
Engineering (17)	10.73	2.18	8.98	0.06
Scientific (19)	1.40	1.15	3.97	1.13
Social Services (21)	0.00	1.57	0.00	0.00
Legal (23)	0.17	1.78	1.07	0.00
Training (25)	0.00	7.31	0.00	0.15
Arts and Media (27)	0.00	1.64	0.11	0.05
Healthcare Practitioners (29)	0.32	1.78	1.07	0.16
Healthcare Support (31)	0.01	7.31	0.00	0.02
Protective Services (33)	0.09	1.64	0.11	0.10
Food Preparation (35)	0.29	5.00	0.01	0.02
Maintenance (37)	0.29	1.91	0.08	1.54
Personal Care (39)	0.01	2.25	0.01	1.25
Sales (41)	4.21	8.51	2.61	1.46
Office Support (43)	7.05	11.79	5.59	5.22
Farming (45)	0.17	0.08	0.01	66.07
Construction (47)	1.52	4.15	30.61	0.06
Installation (49)	4.98	3.52	7.68	2.38
Production (51)	38.39	1.44	6.03	3.44
Transportation (53)	5.27	5.17	10.73	9.23

of the value of intermediate inputs.

4 Model Simulations

We use the calibrated model to simulate the effects of sector-specific exogenous shocks to import prices ($\hat{p}^*$) under alternative assumptions about labor mobility, assuming no changes in foreign aggregate expenditure ($\hat{y}^*$=0), the supply of non-labor primary inputs ($\hat{K}_i = 0$), or the number of workers in each labor supply pool.

In this Section, we focus on two polar assumptions about inter-sectoral labor mobility. The first case assumes that labor supply pools are occupation-specific and sector-specific. This assumption of no inter-sectoral labor mobility is similar to the short-run, immediate effects of labor demand shocks in Artuc and McLaren (2015). The second case assumes that labor supply pools are occupation-specific but not sector-specific. This assumption of perfect inter-sectoral labor mobility corresponds to the long-run effects of labor demand shocks in the standard GTAP computable general equilibrium model described in Corong, Hertel, McDougall, Tsigas and van der Mensbrugghe (2017).

Table 3 reports simulation estimates for the case with no inter-sectoral labor mobility. Each column corresponds to a 10% increase in import prices in one specific sector. The estimated real wage effects are sector-specific in this case.[6] They do not vary across occupations within each sector, even though there is no inter-occupational labor mobility, because the import price shocks affect labor demand in all occupations. The real wage effects are generally negative and small in absolute magnitude. The exception is the real wage increases in the sector directly affected by the change in import prices. These concentrated real wage increases are greater than 1% and are generally an order of magnitude greater in absolute

[6]This is similar to the industry exposure measure in Ebenstein et al. (2014). However, there is an important difference: in our model the effect in each sector is not limited to import price shocks within the sector but is a weighted average of the import price shocks in all sectors.

value than the real wage declines in the remaining sectors.

Table 3: Effects of 10% Increase in Import Price in Specific Industry

All Labor Types Immobile, % Change in Real Wages

Sector	Chemicals	Machinery	Electr. Eq.	Furniture
Agriculture	-0.362	-0.059	-0.097	-0.054
Mining	-0.310	-0.126	-0.086	-0.054
Services	-0.260	-0.037	-0.077	-0.053
Food Products	-0.294	-0.048	-0.084	-0.054
Beverage and Tobacco	-0.270	-0.041	-0.079	-0.053
Textile	-0.789	-0.048	-0.089	-0.054
Textile Mill	-0.904	-0.050	-0.092	-0.055
Apparel	-0.345	-0.047	-0.086	-0.055
Leather	-0.368	-0.051	-0.089	-0.055
Wood	-0.315	-0.054	-0.127	-0.066
Paper	-0.383	-0.052	-0.088	-0.054
Printing	-0.295	-0.045	-0.078	-0.053
Petroleum and Coal	-0.357	-0.091	-0.087	-0.054
Chemicals	**1.542**	-0.056	-0.082	-0.054
Plastic and Rubber	-0.681	-0.057	-0.098	-0.057
Non-Metallic Mineral	-0.302	-0.041	-0.080	-0.053
Primary Metal	-0.304	-0.075	-0.141	-0.055
Fabricated Metal	-0.296	-0.059	-0.100	-0.054
Machinery	-0.311	**3.586**	-0.266	-0.057
Computers	-0.268	-0.038	-0.092	-0.053
Electrical Equipment	-0.326	-0.088	**4.933**	0.054
Transportation Equipment	-0.344	-0.204	-0.159	-0.056
Furniture	-0.355	-0.046	-0.092	**4.515**
Miscellaneous. Manufacturing	-0.346	-0.056	-0.105	-0.058

Table 4 reports simulation estimates for the opposite case with perfect inter-sectoral labor mobility. Again, each column corresponds to a 10% increase in import prices in one specific sector. In this case, the wage effects are occupation-specific.[7] The wage effects do not vary across sectors, because there is wage-arbitraging labor mobility.

[7]This is similar to the occupation exposure measure in Ebenstein et al. (2014), though our implicit weights on sector-specific shocks are different than the sector employment shares used in Ebenstein et al. (2014). The weights in our model reflect all four inter-sectoral channels.

The real wage effects are generally negative and small in absolute value. There are a few occupations with real wage increases in some sectors: engineering occupations when there are shocks to machinery import prices and production occupations when there are shocks to machinery and furniture import prices. These positive real wage effects reflect the occupation intensities of these sectors.

Table 4: Effects of 10% Increase in Import Price in Specific Industry

All Labor Types Mobile, % Change in Real Wages

Occupation	Chemicals	Machinery	Electr. Eq.	Furniture
Management	-0.245	-0.015	-0.068	-0.040
Financial	-0.249	-0.024	-0.070	-0.044
Computer	-0.252	-0.028	-0.072	-0.048
Engineering	-0.245	**0.067**	-0.043	-0.036
Scientific	-0.168	-0.038	-0.075	-0.049
Social Services	-0.254	-0.040	-0.076	-0.049
Legal	-0.252	-0.039	-0.075	-0.049
Training	-0.254	-0.040	-0.076	-0.049
Arts and Media	-0.254	-0.035	-0.074	-0.043
Healthcare Practitioners	-0.253	-0.040	-0.076	-0.049
Healthcare Support	-0.254	-0.040	-0.076	-0.049
Protective Services	-0.254	-0.040	-0.076	-0.049
Food Preparation	-0.254	-0.040	-0.076	-0.049
Maintenance	-0.254	-0.038	-0.076	-0.048
Personal Care	-0.254	-0.040	-0.076	-0.049
Sales	-0.252	-0.033	-0.074	-0.046
Office Support	-0.252	-0.027	-0.072	-0.041
Farming	-0.296	-0.059	-0.088	-0.048
Construction	-0.256	-0.037	-0.076	-0.040
Installation	-0.250	-0.018	-0.071	-0.042
Production	-0.255	**0.121**	-0.030	**0.073**
Transportation	-0.254	-0.031	-0.072	-0.036

These two cases are extreme, and there could be a *mixed case* with some occupations that are mobile across sectors and other occupations that are not. We consider a mixed case in the next Section and calibrate the mix to evidence about the extent of inter-sectoral wage arbitrage within each occupation.

Over long periods of time, workers might also switch occupations if there are large and persistent differences in wages that are greater than differences in the costs of training for new occupations and other compensating differentials, and there could be a shift in the occupation choices of new entrants into the labor force. This longer term mobility of the labor force across occupations and the resulting wage arbitrage are not reflected in these model simulations. Including inter-occupational mobility would broaden the labor supply pools and would reduce the concentration of wages effects relative to the estimated effects reported in Tables 3 and 4.

5 Wage Effects of Recent Tariff Changes

Next, we estimate the effects on real wages of recent changes in sector-average U.S. tariff rates on imports in manufacturing sectors, once we have calibrated the inter-sectoral mobility of workers in each occupation to historical variation in wage growth.

5.1 Labor Mobility and Wage Arbitrage

There are several reasons why workers in some occupations may not move freely between sectors, including sector-specific human capital and job search frictions.[8] For example, the skills of management, financial, and computer professionals seem to be more transferable to jobs in other sectors, while sales, legal, and scientific occupations seem to be more specialized,

[8] Davidson, Martin and Matusz (1999) and Helpman and Itskhoki (2010) demonstrate that search frictions can create sector-specific rents in models of international trade.

relying on sector-specific experience, networks, and relationships that are less transferable.

One way to gauge the extent of labor mobility across sectors is to examine whether wage rates are mostly explained by a worker's occupation or sector. If the worker were perfectly mobile between sectors, then the sector of employment of the worker would not be a significant determinant of the wage rate. In fact, the OES data indicate that a worker's occupation accounted for a large share of wage variation in the United States in 2018, but the worker's sector did not. A regression with only occupation fixed effects explains 92.41% of the variation in sector-occupation annual wages in 2018. On the other hand, a regression with only industry fixed effects explains only 4.98% of the wage variation.[9] This suggests significant mobility across sectors but not across occupations.

Another way to gauge the extent of labor mobility is to examine the similarity of wage growth across sectors. There may be large inter-sectoral differences in wage *levels* due to compensating differentials related to work conditions, for example, even if there is wage-arbitraging labor mobility across sectors. However, if these compensating differentials are mostly fixed over time, they will be differenced-out of the growth rates of wages. Table 5 reports the standard deviation of the 3-year wage growth rates from 2015 to 2018 in the OES wage data for each of the 22 occupations. The occupations are sorted in ascending order of their standard deviation. We expect that occupations with greater mobility across sectors will exhibit less inter-sectoral variation in wage growth rates. The occupations at the top of the table are apparently more mobile than those at the bottom of the table. In the simulations below, we group the occupations into two categories. We assume that workers in occupations above construction are mobile across sectors, while workers in occupations below transportation are not mobile. In the sensitivity analysis below, we consider alternative assumptions about labor mobility within each occupation.

[9]Alternatively, adding industry fixed effects to a specification that already includes occupation fixed effects increases the R^2 statistic only marginally, from 0.9241 to 0.9739.

Table 5: Variation in 3-Year Wage Growth Rates

Occupation	Standard Deviaton across Sectors 2015–2018
Office Support	0.0316
Management	0.0378
Financial	0.0443
Installation	0.0534
Production	0.0576
Maintenance	0.0632
Computer	0.0724
Healthcare Practitioners	0.0745
Transportation	0.0770
Construction	0.0914
Sales	0.0925
Engineering	0.1027
Healthcare Support	0.1095
Social Services	0.1131
Protective Services	0.1136
Scientific	0.1277
Food Preparation	0.1293
Arts and Media	0.1376
Legal	0.1388
Personal Care	0.1419
Farming	0.1678
Training	0.1698

5.2 Simulation Estimates

Table 6 reports the changes in U.S. tariff rates in manufacturing sectors between 2016 and 2019. The first column of estimates reports the percent change in the power of the tariff (i.e., one plus the tariff rate). The simulation assumes that these tariff changes are fully passed through in the prices of the imports. The simulation combines these historical shocks across all of the sectors. The second column in Table 6 reports estimated real wage effects for the 13 occupations with workers who are not mobile across sectors, based on the analysis of wage variation in Table 5. Half of the sectors experienced positive real wage effects in the 13 relatively immobile occupations, while half experienced negative effects. Generally, there were real wage increases in sectors with large tariff increases, but there are significant differences in the magnitudes of the wage effects across the sectors due to differences in import penetration rates, occupational intensity, and inter-sectoral input-output links. Table 7 reports real wage effects for the nine occupations with workers who are mobile across sectors (again based on the analysis of wage variation in Table 5). The real wage effects for these nine mobile occupations were all negative, reflecting the relatively large increase in the cost of living, though the increase in the wages of production workers nearly matched the increase in the cost of living.

5.3 Sensitivity Analysis

To evaluate the sensitivity of the estimated real wage effects to assumptions about inter-sectoral labor mobility, we reran the simulation of historical tariff changes with different assumptions about labor mobility, specifically the two polar cases in Section 4 (all occupations are mobile, all occupations are not mobile). Table 8 reports the estimate real wage effects with no inter-sectoral labor mobility. These effects vary by sector but not across occupations. Compared to the hypothetical sector-specific import price shocks in the simulations

Table 6: Real Wage Effects of 2016–19 Change in U.S. Tariffs on Manufacturing Imports

Industry	**Sector-Specific Tariff** % Change	**Immobile Occupations** % Change
Agriculture		-0.217
Mining		-0.237
Services		-0.224
Food	0.59	-0.191
Beverage and Tobacco	0.14	-0.230
Textile	2.77	0.660
Textile Mill	1.94	0.582
Apparel	0.95	0.411
Leather	1.92	2.379
Wood	2.17	0.183
Paper	2.21	-0.036
Printing	2.18	-0.212
Petroleum and Coal	-0.03	-0.266
Chemicals	0.33	-0.155
Rubber and Plastic	2.81	0.036
Non-Metallic Mineral	2.90	-0.006
Primary Metal	4.51	1.048
Fabricated Metal	3.84	0.067
Machinery	2.20	0.023
Computers and Electronics	1.30	0.071
Electrical Equipment	4.48	0.791
Transportation Equipment	0.67	-0.421
Furniture	6.92	2.422
Miscellaneous Manufacturing	0.40	-0.234

Table 7: Additional Real Wage Effects of 2016–19 Tariff Changes

	Mobile Occupations % Change
Management	-0.199
Finance	-0.209
Computer	-0.210
Healthcare Practitioners	-0.224
Maintenance	-0.221
Office Support	-0.209
Installation	-0.197
Production	-0.006
Transportation	-0.199

reported in Table 3, there are many more manufacturing sectors with positive real wage effects when we consider the historical tariff changes in Table 8, since there were increases in average tariff rates in almost all of the manufacturing sectors between 2016 and 2019. Compared to the simulation of historical shocks in Tables 6 and 7, there are more immobile occupations in the simulation reported in Table 8 and consequently two more sectors with increases in real wages.

Table 8: Alternative with All Occupations Immobile

Sector	% Change in Real Wages
Agriculture	-0.269
Mining	-0.300
Services	-0.236
Food Products	-0.181
Beverage and Tobacco	-0.238
Textile	0.947
Textile Mill	0.790
Apparel	0.274
Leather	1.504
Wood	0.310
Paper	0.027
Printing	-0.068
Petroleum and Coal	-0.300
Chemicals	-0.206
Plastic and Rubber	0.416
Non-Metallic Mineral	0.260
Primary Metal	1.766
Fabricated Metal	0.388
Machinery	0.212
Computers	0.171
Electrical Equipment	1.678
Transportation Equipment	-0.360
Furniture	2.708
Miscellaneous. Manufacturing	-0.236

At the other extreme, Table 9 reports the estimated real wage effects on each occupation assuming perfect inter-sectoral labor mobility. Compared to the hypothetical sector-specific shocks in the simulations reported in Table 4, the effects of the historical tariff changes on real wages are negative for all 22 occupations.

Table 9: Alternative with All Occupations Mobile

Occupation	% Change in Real Wages
Management	-0.200
Financial	-0.209
Computer	-0.210
Engineering	-0.151
Scientific	-0.213
Social Services	-0.225
Legal	-0.223
Training	-0.225
Arts and Media	-0.214
Healthcare Practitioners	-0.224
Healthcare Support	-0.225
Protective Services	-0.224
Food Preparation	-0.224
Maintenance	-0.221
Personal Care	-0.225
Sales	-0.217
Office Support	-0.209
Farming	-0.212
Construction	-0.213
Installation	-0.198
Production	-0.005
Transportation	-0.199

6 Conclusions

The calibrated simulation model of the U.S. economy demonstrates that labor mobility across sectors and occupations is an important determinant of the distribution of the real wage effects of changes in import prices. We find that increases in import prices generally have negative effects on real wages, though there can be significant differences across occupations and sectors. Inter-sector labor mobility affects the concentration, and even sign, of these wage effects. The inter-sector mobility of co-workers and input-output links between sectors are also important.

In terms of future research, the modeling framework could be extended to include more disaggregated sectors and occupation groups: at its most disaggregated, the 2018 OES data include wage and employment data by six-digit NAICS code and six-digit occupation codes. The model could also be improved by developing better measures of the inter-sectoral mobility of workers in different occupations. It also might be useful to extend the model to explicitly examine labor adjustment dynamics, as in Artuc, Chaudhuri and McLaren (2010) and Artuc and McLaren (2015), though this will probably require sacrificing much of the sector and occupation detail in our model.[10]

References

Ahmad, S. and Riker, D. (2020). Updated Estimates of the Trade Elasticity of Substitution, U.S. International Trade Commission, Office of Economics Working Paper 2020–05–A.

Artuc, E., Chaudhuri, S. and McLaren, J. (2010). Trade Shocks and Labor Adjustment: A Structural Empirical Approach, *American Economic Review* **100**(3): 1008–1045.

[10]Caliendo, Dvorkin and Parro (2019) is another example of a general equilibrium model of trade and labor dynamics. Riker and Swanson (2016) survey this literature.

Artuc, E. and McLaren, J. (2015). Trade Policy and Wage Inequality: A Structural Analysis with Occupational and Sectoral Mobility, *Journal of International Economics* **97**: 278–294.

Caliendo, L., Dvorkin, M. and Parro, F. (2019). Trade and Labor Market Dynamics: General Equilibrium Analysis of the China Trade Shock, *Econometrica* **87**(3): 741–835.

Carrico, C. and Tsigas, M. (2014). Enriching US Labor Results in a Multi-Regional CGE Model, *Economic Modelling* (36): 268–281.

Corong, E. L., Hertel, T. W., McDougall, R., Tsigas, M. E. and van der Mensbrugghe, D. (2017). The Standard GTAP Model, Version 7, *Journal of Global Economic Analysis* **2**(1): 1–119.

Davidson, C., Martin, L. and Matusz, S. (1999). Trade and Search Generated Unemployment, *Journal of International Economics* **48**: 271–299.

Ebenstein, A., Harrison, A., McMillan, M. and Phillips, S. (2014). Estimating the Impact of Trade and Offshoring on American Workers Using the Current Population Surveys, *Review of Economics and Statistics* **96**(4): 581–95.

Feenstra, R. C. (2016). Advanced International Trade: Theory and Evidence, 2nd Edition. Princeton, NJ: Princeton University Press.

Helpman, E. and Itskhoki, O. (2010). Labour Market Rigidities, Trade and Unemployment, *Review of Economic Studies* **77**: 1100–1137.

Riker, D. and Swanson, W. (2016). A Survey of Empirical Models of Labor Transitions Following Trade Liberalization, *Journal of International Commerce and Economics* .