INCORPORATING THE ECONOMIC DOWNTURN INTO INDUSTRY-SPECIFIC MODELS OF TRADE

David Riker

ECONOMICS WORKING PAPER SERIES
Working Paper 2020–07-A

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

July 2020

Incorporating the Economic Downturn into Industry-Specific Models of Trade
David Riker
Office of Economics Working Paper 2020–07–A
July 2020

Abstract

We use a set of industry-specific economic models to estimate changes in U.S. manufacturing exports and employment implied by IMF forecasts of the growth in national aggregate expenditure levels in 2020 and 2021. Then we estimate the effects of potential future reductions in the costs of exporting, with a focus on how changes in baseline trade shares and employment levels implied by the growth forecasts affect the economic benefits of reducing the costs of exporting. While the economic downturn will likely lead to a significant decline in the exports and employment of U.S. manufacturing industries in the short term, the smaller downturn in foreign markets will increase U.S. export intensity and will increase the potential U.S. export and employment gains from reducing the costs of exporting.

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

1 Introduction

The IMF's April 2020 World Economic Outlook (WEO) predicts a significant downturn in national aggregate expenditure levels throughout the world in 2020, with a subsequent recovery in 2021. The WEO predicts that U.S. nominal GDP will decrease by 5.31 percent between 2019 and 2020 and then increase by 6.78 percent between 2020 and 2021, for a small 1.11 percent cumulative increase over the two years. In contrast, it predicts that the sum of nominal GDP in countries that serve as U.S. export markets will decrease by only 2.06 percent between 2019 and 2020 and then increase by 7.98 percent between 2020 and 2021, for a much larger 5.76 percent cumulative increase over the two years. These macroeconomic fluctuations have direct implications for international trade, and they affect the potential gains in U.S. employment from reducing the costs of supplying U.S. export markets.[1]

In this paper, we use a set of industry-specific simulation models to tie changes in the exports and employment of specific U.S. industries to WEO macroeconomic forecasts. The effects on U.S. exports vary across industries, depending on growth in the specific countries that account for large shares of the U.S. industry's exports. The one-year declines in the exports of the U.S. manufacturing industries (from 2019 to 2020) range from 3.46 to 4.99 percent, with a weighted average decline of 4.31 percent. The two-year cumulative increases (from 2019 to 2021) range from 0.92 to 4.32 percent, with a weighted average cumulative increase of 1.89 percent.

The estimated effects on employment varies across the U.S. manufacturing industries depending on the overall export intensity of each industry and the destination markets of its exports. The one-year declines in the number of production workers in U.S. manufacturing

[1]The April 2020 WEO is the most recent version of the IMF's WEO database. The IMF published a partial update in June 2020 that includes significant downward revisions to its forecast growth rates for selected countries. For example, the IMF revised its forecast for global growth in 2020 from -3.0 percent to -4.9 percent. However, the June 2020 update does not provide revisions to many parts of the April 2020 database that are used in the calculations in this paper, so we will have to wait for the release of the October 2020 WEO to update the model estimates.

industries due to the forecast growth range from 3.79 to 5.29 percent, with a weighted average decline of 5.13 percent. The two-year cumulative increases range from 1.06 to 3.07 percent, with a weighted average cumulative increase of 1.26 percent.

Next, we model the employment effects of potential future reductions in the costs of exporting, using baseline trade shares and employment levels that are adjusted for the forecast growth in national aggregate expenditures. We compare these estimated employment effects to alternative estimates that are not adjusted for the forecast changes in aggregate expenditures. This comparison demonstrates the value of updating baseline trade shares and employment levels to reflect the macroeconomic fluctuations. The estimated employment effects depend on the magnitude of the reduction in the costs of exporting, the elasticity of substitution between foreign and domestic products in the industry, and the export intensity of the U.S. producers. The WEO growth forecasts imply an increase in the export intensity of most of the U.S. manufacturing industries. We estimate that a hypothetical ten percent reduction in the costs of exporting to all foreign markets (either by reducing tariffs, non-tariff barriers, international freight costs, or a combination of these) would increase U.S. manufacturing sector employment by approximately 250,000 production workers, holding all else constant.

The rest of this paper is organized in four parts. Section 2 introduces the modeling framework. Section 3 identifies data sources and descriptive statistics. Section 4 reports the simulated changes in industry exports and employment. Section 5 summarizes the model estimates and discusses limitations and potential extensions.

2 Industry-Specific Model

In this section, we develop an economic model of exports and employment in manufacturing industry j.[2] The model calculates the changes in the industry's shipments due to changes in aggregate expenditures in different national markets served by the domestic industry and changes in the costs of supplying its export markets. Then the model translates the changes in shipments into changes in industry employment.

We assume that the demands for shipments in each of the national markets has a Constant Elasticity of Substitution (CES) form with income elasticity of demand α_j. $\hat{v}_{jdd}$ in equation (1) is the percent change in the value of domestic shipments of industry j.

$$\hat{v}_{jdd} = \alpha_j \ \hat{y}_d + (1 \ - \ \sigma_j) \left(\hat{p}_{jd} \ - \ \hat{P}_{jd}\right) \tag{1}$$

$\hat{x}_{jdc}$ in equation (2) is the percent change in the value of industry j exports to country c.

$$\hat{x}_{jdc} = \alpha_j \ \hat{y}_c + (1 \ - \ \sigma_j) \left(\left(\hat{p}_{jd} \ + \ \hat{t}_{jdc}\right) \ - \ \hat{P}_{jc}\right) \tag{2}$$

$\hat{y}_d$ and $\hat{y}_c$ are the percent change in aggregate expenditure levels in domestic market d and in foreign country c. σ_j is the elasticity of substitution between industry j products sourced from different countries. $\hat{p}_{jc}$ is the percent change in the price of industry j products from country c. $\hat{t}_{jdc}$, the percent change in the trade cost factor for industry j exports to country c, includes changes in tariffs, non-tariff barriers to trade, and international freight costs.

$\hat{P}_{jd}$ in equation (3) is the CES price index in the domestic economy d for industry j.

$$\hat{P}_{jd} = \left(1 \ - \ \sum_c \mu_{jcd}\right) \ \hat{p}_{jd} \ + \ \sum_c \mu_{jcd} \ \left(\hat{p}_{jc} \ + \ \hat{t}_{jcd}\right) \tag{3}$$

μ_{jcd} is country c's share of total industry j expenditures in the domestic economy. $\hat{P}_{jc}$ in

[2] Riker and Schreiber (2020) provide many examples of this type of industry-specific simulation model.

equation (4) is the CES price index in country c for industry j.

$$\hat{P}_{jc} = \left(1 - \sum_{c' \neq c} \mu_{jc'c} - \mu_{jdc}\right) \hat{p}_{jc} + \sum_{c' \neq c} \mu_{jc'c} \left(\hat{p}_{jc'} + \hat{t}_{jc'c}\right) + \mu_{jdc} \left(\hat{p}_{jd} + \hat{t}_{jdc}\right) \quad (4)$$

We assume that the production function in each of the manufacturing industries has a Cobb-Douglas form with a constant labor cost share. There is perfect competition in product markets, so the percent change in price is equal to a cost share-weighted average of the percent change in the prices of factor inputs.

$$\hat{p}_{jd} = \theta_{jd} \hat{w}_{jd} + (1 - \theta_{jd}) \hat{r}_{jd} \quad (5)$$

θ_{jd} is the labor cost share in industry j in the domestic economy, $\hat{w}_{jd}$ is the percent change in wages, and $\hat{r}_{jd}$ is the percent change in the price of a composite of the non-labor factor inputs.

The domestic industry supplies its products to domestic and foreign markets. Given the constant labor cost share, the industry's total labor payments are proportional to the value of its global sales, and the growth rate of the former is equal to the growth rate of the latter:

$$\hat{w}_{jd} + \hat{L}_{jd} = s_{jdd} \hat{v}_{jdd} + \sum_{c} s_{jdc} \hat{x}_{jdc} \quad (6)$$

$\hat{L}_{jd}$ is the percent change in labor demand in industry j in the domestic economy, s_{jdd} is the share of total shipments of industry j that supply the domestic market, and s_{jdc} is the share of total shipments that are exported to country c.

Equation (7) is the percent change in the value of exports of industry j to all countries implied by the percent changes in national aggregate expenditures in each foreign country $\hat{y}_c$.

$$\hat{x}_j = \sum_c \left(\frac{s_{jdc}}{1 - s_{jdd}} \right) \hat{y}_c \tag{7}$$

It is an export share-weighted average of the percent changes in aggregate expenditures in the foreign markets that the industry supplies.[3] If exports to a specific country initially account for a large share of the total exports of industry j, then the growth rate of that country will be weighted heavily in this average.

We make the simplifying assumption that domestic factor prices and foreign product prices are fixed. This is a useful way to represent a major economic downturn with significant slack in factor markets and downward rigidity in wages. Under this assumption, equation (8) is the percent change in total employment in industry j in the domestic economy.

$$\hat{L}_{jd} = s_{jdd}\ \alpha_j\ \hat{y}_d + \sum_c s_{jdc}\ \alpha_j\ \hat{y}_c \tag{8}$$

It is a weighted average of the changes in aggregate expenditures in the domestic economy and in all of the foreign countries that the industry supplies. The weights are the shares of the countries in the U.S. industry's global shipments. The employment changes consist of two terms on the right-hand side of equation (8). The first is the employment changes associated with domestic shipments, and the second is the employment changes associated with exports.

The model can also be used to simulate the change in the number of production workers employed in each domestic industry from a hypothetical reduction in the costs of exporting. First, we use equations (7) and (8) to calculate the future baseline trade shares and employment levels implied by the shocks to national aggregate expenditures. Then we simulate the effects of the reductions in the costs of exporting and the resulting reduction in delivered prices. The reductions in the costs of exporting increase the volume of exports

[3] The shipment share $\frac{s_{jc}}{1 - s_{jd}}$ is country c's share of the total exports of industry j.

and the number of domestic workers that supply them. The magnitude of the employment effects depends on the magnitude of the reduction in costs, the elasticity of substitution in the industry, and the export intensity of the domestic producers. Equation (9) is the percent change in the number of production workers in the domestic industry implied by $\hat{t}_{jcd}$.

$$\hat{L}_{jd} = (1 - \sigma_j) \sum_c s_{jdc} \, \hat{t}_{jdc} \tag{9}$$

$\sum_c s_{jdc}$ is the total export share and export intensity of industry j taking into account the forecast growth in aggregate expenditures in all of the countries that the industry supplies and assuming that the U.S. exports only account for a small share of the foreign markets.[4] The change in the number of workers is the product of the percent change in equation (9) and the baseline level of employment in the industry.

3 Data Sources and Descriptive Statistics

The model incorporates April 2020 WEO forecasts for 2020 and 2021 GDP by country from International Monetary Fund (2020). Table 1 summarizes the forecast one-year and cumulative two-year growth rates for selected countries and for the global economy. Compared to the world as a whole, the United States is forecast to experience a greater economic slump from 2019 to 2020 and a smaller economic recovery from 2020 to 2021. Still, the United States has a more favorable growth forecast than many of its major trade partners.

In our modeling analysis, we quantify the effects of aggregate expenditure shocks $\hat{y}_c$. These shocks are exogenous inputs of our industry-specific models. The goal is to illustrate the impact of aggregate expenditure shocks. For the sake of illustration, we calibrate these shocks in our models to the WEO forecasts, viewing the forecasts as likely magnitudes of future macroeconomic fluctuations but recognizing that a different model underlies the WEO

[4] This small exporter assumption simplifies the data requirements of the model, since $\hat{P}_{jc} = 0$.

Table 1: WEO Forecast Percent Changes in GDP

Country Group	One-Year 2019–20 (%)	One-Year 2020–21 (%)	Two-Year 2019–21 (%)
Global Economy	-2.55	7.81	5.06
United States	-5.31	6.78	1.11
Canada	-5.63	6.28	0.29
Japan	-4.56	5.02	0.23
United Kingdom	-5.91	6.06	-0.20
Germany	-6.36	7.20	0.38
China	1.82	11.34	13.37
Mexico	-6.04	5.03	-1.31

forecasts.[5] We are not trying to consistently embed the WEO forecasts in our industry-specific models. Instead, we are modeling what happens to industry-specific exports and employment if there were exogenous aggregate demand shocks that match the *magnitudes* of the macroeconomic fluctuations forecast in the WEO.

We model industries at the level of the 21 three-digit NAICS codes in the U.S. manufacturing sector.[6] We use data on the total value of shipments and costs of materials and labor from the 2017 U.S. Economic Census and equation (10) to calculate the elasticity of substitution σ_j for three-digit industries using the methodology in Ahmad and Riker (2020).[7]

$$\sigma_j = \frac{TVS_j}{TVS_j \; - \; TCM_j \; - \; PWW_j} \tag{10}$$

TVS_j, TCM_j, and PWW_j represent the total value of shipments, total cost of materials,

[5]We do not know the specific combination of supply and demand shocks that are incorporated into the IMF's macroeconomic forecasts for each country.

[6]All of the effects could be recalculated using more disaggregated data, at the level of 86 four-digit NAICS industries or the 360 six-digit NAICS codes in manufacturing to provide a narrower analysis, since all of the data sources with an industry dimension are publicly available at this greater level of detail.

[7]The data on U.S. manufacturing industries is from the 2017 Economic Census are publicly available at `https://www.census.gov/data/tables/2017/econ/economic-census/naics-sector-31-33.html`.

and total payroll of production workers in U.S. industry j. We also use the total value of shipments from the Economic Census to calculate initial trade shares. The data on U.S. exports are from the U.S. International Trade Commission's Trade Dataweb.[8] The data on the number of production workers in each industry in 2019 are from the Current Employment Survey.[9] Table 2 reports the number of production workers, the estimated elasticity of substitution, and the export share for each three-digit manufacturing industry.

We set α_j, the income elasticity of demand, equal to one. To test this standard modeling restriction, we estimated the value of this parameter using an econometric model and a 2010–19 panel of annual U.S. bilateral export values for the 21 three-digit NAICS manufacturing industries. We regressed the annual growth rate of industry exports on the annual growth rate of national aggregate expenditures and a set of industry-year fixed effects. This econometric specification is consistent with equation (2). The point estimate when we pooled all 21 manufacturing industries was 1.007, with a robust standard error of 0.134, so we do not reject that the income elasticity of exports is equal to one.

4 Estimated Effects on Exports and Employment

The first set of simulations uses the model to estimate the impact of the forecast economic downturn and recovery on U.S. exports and employment in each industry in 2020 and 2021. The second set of simulations uses the model to demonstrate how the benefits of reducing the costs of exporting will be magnified by the forecast changes in baseline trade shares and employment levels.

[8]The source for the export data is the U.S. International Trade Commission's Dataweb at `https://dataweb.usitc.gov/`.

[9]The source for the employment data is the U.S. Bureau of Labor Statistics' Current Employment Survey at `https://www.bls.gov/ces/`.

Table 2: Employment, Substitution, and Export Share by Industry

Industries (NAICS codes)	Number of Production Workers (thousands)	Estimated Elasticity of Substitution	Export Share (%)
Food Products (311)	1,229	3.18	7.99
Beverages and Tobacco (312)	119	1.67	4.59
Textile Products (313)	77	3.18	30.23
Textile Mill Products (314)	82	2.75	12.14
Apparel (315)	68	2.59	27.16
Leather Products (316)	20	3.30	60.94
Wood Products (321)	322	3.09	7.05
Paper Products (322)	262	2.70	12.74
Printing (323)	310	2.29	5.93
Petroleum and Coal Products (324)	71	5.69	15.15
Chemicals (325)	486	2.02	24.00
Rubber and Plastic Products (326)	589	2.56	12.60
Non-Metallic Mineral Products (327)	306	2.23	8.68
Primary Metals (331)	289	3.38	23.62
Fabricated Metals (332)	1,039	2.45	11.44
Machinery (333)	665	2.45	32.74
Computers and Electronics (334)	386	1.94	36.95
Electrical Equipment (335)	234	2.44	36.10
Transportation Equipment (336)	1,104	3.35	26.10
Furniture (337)	278	2.49	6.30
Miscellaneous Manufacturing (339)	335	1.87	30.03

4.1 Effects of Forecast GDP Growth

Tables 3 and 4 report the estimated effects of the forecast GDP growth on U.S. exports and the employment of production workers by industry. Table 3 reports one-year changes from 2019 to 2020, while Table 4 reports two-year changes from 2019 to 2021. The model estimates that the one-year declines in the exports of each U.S. manufacturing industry range from 3.46 to 4.99 percent, with a weighted average decline of 4.31 percent. The two-year cumulative increases range from 0.92 to 4.32 percent, with a weighted average cumulative increase of 1.89 percent. The model estimates that the one-year declines in the number of production workers in each U.S. manufacturing industry range from 3.79 to 5.29 percent, with a weighted average decline of 5.13 percent. The two-year cumulative increases range from 1.06 to 3.07 percent, with a weighted average cumulative increase of 1.26 percent.

Table 3: One-Year Changes in the Value of Exports and Employment, 2019–2020

Industries (NAICS codes)	Industry Exports (%)	($mill)	Production Workers (%)	(headcount)
Food Products	-3.63	-4,719	-5.18	-6,361
Beverages and Tobacco	-3.91	-578	-5.25	-624
Textile Products	-4.04	-678	-4.93	-379
Textile Mill Products	-4.99	-263	-5.27	-432
Apparel	-4.73	-287	-5.15	-350
Leather Products	-2.81	-161	-3.79	-76
Wood Products	-3.97	-532	-5.22	-1,679
Paper Products	-4.10	-1,873	-5.16	-1,351
Printing	-4.96	-450	-5.29	-1,640
Petroleum and Coal Products	-4.68	-8,731	-5.21	-370
Chemicals	-4.41	-17,367	-5.09	-2,476
Rubber and Plastic Products	-4.91	-2,988	-5.26	-3,098
Non-Metallic Mineral Products	-4.54	-976	-5.24	-1,604
Primary Metals	-4.95	-4,653	-5.23	-1,510
Fabricated Metals	-4.48	-3,789	-5.21	-5,418
Machinery	-4.15	-9,868	-4.93	-3,278
Computers and Electronics	-3.46	-7,783	-4.63	-1,786
Electrical Equipment	-4.54	-4,162	-5.03	-1,178
Transportation Equipment	-4.44	-22,520	-5.08	-5,612
Furniture	-4.78	-446	-5.28	-1,467
Miscellaneous Manufacturing	-4.57	-4,249	-5.09	-1,705

Table 4: Two-Year Changes in the Value of Exports and Employment, 2019–2021

Industries (NAICS codes)	Industry Exports (%)	($mill)	Production Workers (%)	(headcount)
Food Products	2.51	3,254	1.22	1,501
Beverages and Tobacco	2.44	361	1.17	139
Textile Products	1.74	292	1.30	100
Textile Mill Products	0.92	49	1.09	89
Apparel	0.93	57	1.06	72
Leather Products	4.32	248	3.07	61
Wood Products	2.74	366	1.22	394
Paper Products	2.35	1,076	1.27	332
Printing	1.12	102	1.11	344
Petroleum and Coal Products	0.77	1,436	1.06	75
Chemicals	1.88	7,407	1.30	629
Rubber and Plastic Products	1.01	617	1.10	647
Non-Metallic Mineral Products	1.72	371	1.16	356
Primary Metals	0.99	933	1.08	313
Fabricated Metals	1.54	1,299	1.16	1,204
Machinery	2.16	5,132	1.45	966
Computers and Electronics	3.30	7,404	1.92	740
Electrical Equipment	1.50	1,375	1.25	293
Transportation Equipment	1.83	9,297	1.30	1,434
Furniture	1.15	107	1.11	309
Miscellaneous Manufacturing	1.59	1,481	1.26	420

4.2 Effects of Reducing the Costs of Exporting

Table 5 reports the estimated employment effects of hypothetical ten percent reductions in the U.S. manufacturing industries' costs of exporting. These reductions could reflect changes in several factors that determine the cost of exporting, including tariffs, non-tariff barriers, and international freight costs.[10]

The table reports one-year changes (from 2019 to 2020) and two-year changes (from 2019 to 2021). We compare estimates that use revised baseline trade shares and employment levels to estimates that use the trade shares and employment levels in 2019 in the baseline. The comparison illustrates the value of updating the baseline using the growth forecasts.

The sum of the estimated increases in the numbers of production workers is 248,604 using the 2019 baseline. It is 237,852 using a forecast-updated 2020 baseline and 253,270 using a forecast-updated 2021 baseline.

[10]Alternatively, the modeling framework could also be applied to estimate the effects of reducing the costs of exporting to specific countries (like China) in specific industries (like food products), though this more focused application would require detailed predictions about the magnitude of potential reductions in the costs of exporting.

Table 5: Potential Increase in Production Workers for Different Baselines

Industries (NAICS codes)	Using 2019 Non-Updated Baseline (thousand)	Using Baseline Updated to 2020 (thousand)	Using Baseline Updated to 2021 (thousand)
Food Products	21.41	20.63	21.94
Beverages and Tobacco	0.37	0.35	0.37
Textile Products	5.07	4.87	5.16
Textile Mill Products	1.74	1.66	1.76
Apparel	2.94	2.80	2.96
Leather Products	2.80	2.72	2.92
Wood Products	4.74	4.56	4.87
Paper Products	5.67	5.44	5.81
Printing	2.37	2.25	2.40
Petroleum and Coal Products	5.04	4.81	5.08
Chemicals	11.90	11.37	12.12
Rubber and Plastic Products	11.58	11.00	11.69
Non-Metallic Mineral Product	3.27	3.12	3.32
Primary Metals	16.25	15.44	16.41
Fabricated Metals	17.23	16.46	17.50
Machinery	31.57	30.26	32.25
Computers and Electronics	13.41	12.94	13.85
Electrical Equipment	12.16	11.61	12.35
Transportation Equipment	67.71	64.71	68.96
Furniture	2.61	2.48	2.64
Miscellaneous Manufacturing	8.75	8.35	8.89

5 Conclusions, Limitations and Extensions

The models are useful tools for translating forecasts for GDP growth into industry-specific changes in U.S. exports and the employment of production workers. They adopt a set of assumptions that reflect the global economic downturn, and they imply export and employment effects that are simple to calculate as weighted averages of the WEO growth forecasts. While the economic downturn will likely lead to a significant decline in the exports and employment of U.S. manufacturing industries in the short term, a smaller downturn in foreign markets will increase export intensity and will magnify potential U.S. export and employment gains from any reductions in the costs of exporting.

There are several limitations of the models. First, the estimated changes in exports and employment only try to quantify the effects of forecast GDP growth *holding all else constant*. There are many other factors that affect industry exports and employment, including variation in trade and production costs and shifts in the composition, rather than aggregate level, of demand. These factors could also be incorporated into the models if we could forecast their future values.

Second, the industry-specific models are partial equilibrium rather than general equilibrium. They focus on direct effects and do not try to quantify economic spillovers between industries. For example, an increase the demand for exports of machinery increases the demand for the products of the upstream domestic steel industry, and this indirect effect is not included in the estimates produced by our models.

Finally, there are many potential extensions of the model. The WEO forecasts could be replaced with alternative growth forecasts, including future updates of the WEO. The next full update of the WEO forecasts is scheduled for release in October 2020. The model could be easily applied to less aggregated data for the manufacturing industries, as noted above. It could also be applied to services and agriculture, though these extensions would face their own challenges. In the case of services, there is less information on cross-border trade than is available for commodity trade. In the case of agriculture, there are often tariff rate quotas and other quantitative restrictions on trade that need to taken into account when modeling how trade responds to GDP growth.

References

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

International Monetary Fund (2020). World Economic Outlook: Chapter 1 The Great Lockdown. On-line at http://imf.org/en/Publications/WEO/Issues/2020/04/14/weo-april-2020/.

Riker, D. and Schreiber, S. (2020). Trade Policy PE Modeling Portal. U.S. International Trade Commission. https://www.usitc.gov/data/pe_modeling/index.htm.