IMPORTS OF PLASTIC AND RUBBER PRODUCTS FROM CHINA: AN APPLICATION OF THE CALIENDO DVORKIN PARRO MODEL

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Abstract

Caliendo, Dvorkin and Parro (2019) presents a dynamic structural general equilibrium model of trade that is very useful for analyzing the effects of trade shocks on employment and economic welfare in different sectors and U.S. states over time. In this paper, I provide a simple application of this very complex model. While the simulations in Caliendo et al. (2019) combine shocks to all Chinese manufacturing sectors, my simulation isolates the effects of productivity growth in a single sector, Plastics and Rubber Products in China, in order to illustrate how a shock in one sector spills over to sectors directly upstream and downstream and to the rest of the economy. I focus on labor transitions over the short and long run and the distribution of employment and welfare effects across U.S. states.

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1 Introduction

Caliendo, Dvorkin, and Parro (2019) presents a dynamic structural general equilibrium model of trade that is very useful for analyzing the effects of trade shocks on employment and economic welfare in different sectors and U.S. states over time. The authors use this CDP model to run simulations of the economic effects in the United States of the China trade shock due to the increase in the productivity of all Chinese manufacturing sectors between 2000 and 2007.

In this paper, I describe a simple application of this very complex CDP model. In contrast to the simulations reported in Caliendo et al. (2019), my application of the model isolates the effects of productivity growth in a single sector, Plastics and Rubber Products (PRP) in China.

The model simulation generates interesting estimates of labor transitions between sectors in the short and long run and estimates of the distribution of employment effects across U.S. states. First, labor adjustment is not immediate, with less than two tenths of the long run nationwide decline in sector employment completed after one year, seven tenths completed after five years, and nine tenths completed after ten years. Second, the estimated negative employment effects are relatively concentrated in the PRP sector, the upstream Chemicals sector, and the downstream Computer and Electronics and Furniture Manufacturing sectors. There are positive employment effects in all other sectors, as workers reallocate from the PRP sector in the United States. There is a negative effect on the number of workers who are not employed, and therefore an increase in total employment in the United States, in the short run and especially in the long run. Third, the percent change in PRP sector employment is similar across states in the long run, but a few populous states with high initial level of employment in the PRP sector (most notably New York and Michigan) contribute the most to the nationwide decline in sector employment.

The model simulation also generates interesting estimates of the distribution of economic welfare effects across sectors and across U.S. states. Two sectors experience negative welfare effects on average nationwide, the PRP sector and the closely related Textiles sector, due to the prolonged reduction in labor demand and wages within these sectors. Worker who are initially employed in all other sectors experience welfare gains since the benefit from reduced prices for the goods and services that they consume without direct effects on labor demand. The averages of welfare effects across all sectors within each state are all positive, and they are similar in magnitude across the states.

Section 2 describes key features of the model, and Section 3 describes the dimensions of the model and its data inputs. Section 4 reports a simulation that isolates the economy-wide effects of the growth in productivity in the Chinese PRP sector between 2000 and 2007. Section 5 concludes with ideas for next steps and a discussion of the usefulness of the CDP model as a tool for trade policy analysis.

2 Key Features of the CDP Model

In this section, I provide a brief description of key features of the model. For a detailed exposition of the CDP model, readers should examine Caliendo et al. (2019) and the associated replication files.

The CDP model is a dynamic general equilibrium model, with households making forward-looking decisions about their sector of employment within their state. The speed of labor adjustments is shaped by costs of moving from one sector to take a job in another sector, as in Artuç, Chaudhuri and McLaren (2010) and the literature that built upon it.

The CDP model is based on a Ricardian model of trade following the model structure in Eaton and Kortum (2002). Production in each sector of the economy combines labor with local immobile (state-specific) factors of production and intermediate inputs. Workers do not move between states or countries. Wages clear sector- and state-specific labor markets, and labor supply fluctuates as workers enter or leave the Non-Employment sector in the model. Some workers leave the labor force, but there is no unemployment in the model.

3 Dimensions and Data Inputs of the Model

The model divides the global economy into 38 countries or country groups, and it divides the United States into 50 individual states. The economy in each country group or state is further divided into 22 sectors. There are 200 time periods included in the model, representing quarters of a year. The CDP model estimates the distribution of the economic effects of trade shocks in different sectors of the economy and U.S. states at different time horizons.

The data inputs of the CDP model include trade and production data from the World Input-Output Database (WIOD); domestic shipments from the U.S. Commodity Flow Survey; regional employment estimates from the U.S. Bureau of Economic Analysis; labor transitions from the U.S. Current Population Survey and American Community Survey; and econometric estimates of trade elasticity values from Caliendo and Parro (2015).

4 Simulation

4.1 Historical Shock to Productivity

The China trade shock simulations in Caliendo et al. (2019) compute the productivity shocks in China's manufacturing sectors between 2000 and 2007 that replicate the increases in U.S. manufacturing imports from China estimated in Autor, Dorn and Hanson (2013). Instead of simulating the combined effects of productivity growth in all of the manufacturing sectors as in Caliendo et al. (2019), My simulation isolates the effects of the growth in productivity in a single sector, China's PRP sector, and I hold productivity constant in all other sectors.

Specifically, the shock in my simulation is a compounding 14.6% quarterly increase in productivity in China's PRP sector in the period 2000–2017. This is the estimate for the PRP sector in China in Caliendo et al. (2019). This quarterly growth rate implies a compounded annual growth rate of 72.7%. The simulation compares (i) an economy that experienced the actual historical changes in fundamentals, including the estimated productivity shocks to (ii) a counter-factual economy that does not include the productivity growth in China's PRP sector but does include the productivity growth in all other Chinese manufacturing sectors. In the terminology of Caliendo et al. (2019), my simulation includes a counterfactual with time-varying fundamentals.

4.2 Simulated Employment Effects

Table 1 reports the simulated percent reduction in total U.S. employment in the PRP sector at four different time horizons. Labor market adjustment is not immediate, with less than two tenths of the long run nationwide decline in sector employment completed after one year, seven tenths completed after five years, and nine tenths completed after ten years.

Table 1: Reductions in U.S. PRP Employment

Time Horizon	%
After One Year	-0.560
After Five Years	-2.669
After Ten Years	-3.349
In the Long Run	-3.775

Table 2 reports simulated one-year and long-run percent changes in U.S. employment in each of the 22 sectors. As the time horizon is extended, the change in employment is magnified in all sectors (except the Entertainment sector, where the one-year and long-run employment effects are the same). There is a concentrated negative effect on employment in the PRP sector, the upstream Chemicals sector, and the downstream Computers and

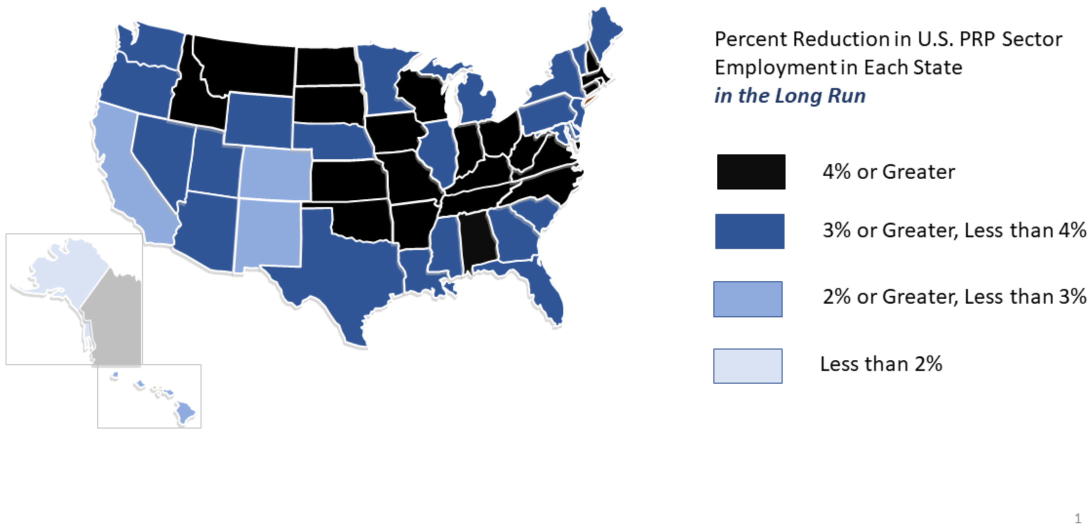
Electronics and Furniture Manufacturing sectors. There are positive employment effects in all other sectors (except for the Non-Employment sector), as workers reallocate. There is a negative effect on the number of workers who are not employed, and therefore an increase in total employment in the United States, in the short run and especially the long run.

Table 2: Percent Changes in Sector Employment Nationwide

CDP Sector	**% Change After One Year**	**% Change In the Long Run**
Non-Employment	-0.013	-0.143
Food and Beverages	0.020	0.133
Textiles	0.041	0.500
Wood and Paper	0.009	0.110
Petroleum and Coal	0.009	0.027
Chemicals	-0.050	-0.257
Plastics and Rubber Products	-0.560	-3.775
Non-Metallic Mineral Products	0.016	0.053
Metal Products	0.012	0.210
Machinery	0.006	0.056
Computers and Electronics	-0.146	-1.310
Transport Manufacturing	0.010	0.061
Furniture Manufacturing	-0.014	-0.010
Trade	0.008	0.075
Construction	0.015	0.095
Transport Services	0.011	0.155
Information Services	0.010	0.118
Finance	0.011	0.011
Real Estate	0.010	0.118
Education	0.012	0.119
Healthcare	0.021	0.116
Hospitality	0.017	0.121
Entertainment	0.012	0.012

The blue-shaded map in Figure 1 focuses on the negative employment effects within the U.S. PRP sector. It depicts simulated *percent changes* in PRP sector employment in the long run in each of the states. These percent reductions in sector employment are similar in magnitude across states. The minor variation across states reflects differences in the employment share of the PRP sector in the states.

Figure 1: Simulated PRP Employment Effects by State



The orange-shaded map in Figure 2 depicts the simulated *share* of the PRP sector's long-run employment decline that occurs in each of the states (in other words, the state's contribution to the nationwide decline in sector employment). This depends not only on the percent changes in Figure 1 but also on the initial level of sector employment in each state. There is a high concentration of the sector's employment declines in populous states like New York, Michigan, California, Texas, and Illinois.

Figure 2: Simulated Share of the Decline in PRP Sector Employment by State

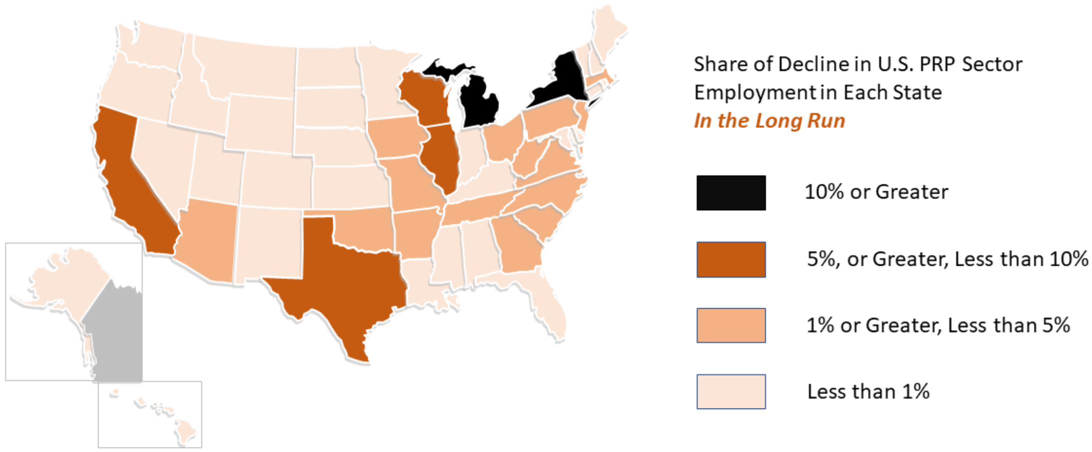


Table 3 summarizes the speed of adjustment in PRP sector employment in the different states. The ratios in the table compare the percent change in PRP sector employment after one year to the percent change in sector employment in the long run, so a small ratio indicates slower labor adjustment. The speed of adjustment in each state reflects employment opportunities available to the workers in other sectors within their state: workers move to other sectors more quickly if wage differences across sectors exceed inter-sectoral moving costs. This is more likely in states where the PRP sector is a small share of total employment in the state. The most rapid adjustments are in Nevada, Tennessee, and West Virginia. The slowest adjustments are in Connecticut, Michigan, Montana, and Wyoming.

Table 3: Speed of Adjustment by State

State	**Ratio of One-Year to to Steady State Employment Effects**	**State**	**Ratio of One-Year to to Steady State Employment Effects**
Alabama	0.12	Nebraska	0.19
Arizona	0.29	Nevada	0.36
Arkansas	0.24	New Hampshire	0.11
California	0.08	New Jersey	0.15
Colorado	0.28	New Mexico	0.10
Connecticut	0.07	New York	0.25
Delaware	0.09	North Carolina	0.14
Florida	0.12	North Dakota	0.27
Georgia	0.11	Ohio	0.09
Idaho	0.17	Oklahoma	0.17
Illinois	0.10	Oregon	0.15
Indiana	0.08	Pennsylvania	0.09
Iowa	0.22	Rhode Island	0.14
Kansas	0.23	South Carolina	0.13
Kentucky	0.08	South Dakota	0.11
Louisiana	0.21	Tennessee	0.30
Maine	0.22	Texas	0.16
Maryland	0.08	Utah	0.26
Massachusetts	0.15	Vermont	0.07
Michigan	0.07	Virginia	0.27
Minnesota	0.05	Washington	0.10
Mississippi	0.09	West Virginia	0.31
Missouri	0.19	Wisconsin	0.21
Montana	0.07	Wyoming	0.07

4.3 Simulated Welfare Effects

The CDP model can also calculate the effects of Chinese productivity growth on the economic welfare of U.S. workers in different sectors and different U.S. states. The welfare measure in Caliendo et al. (2019) is consumption equivalent variation. This measure includes the present discounted value of changes in real wages and also the change in the workers' option value given the adjustment costs that the workers face.

Table 4 reports simulated percent changes in the welfare of U.S. workers within each of the 22 sectors, averaging across workers nationwide. The effects are positive and relatively small, less than 0.04%. (In contrast, the estimate of the increase in U.S. aggregate welfare in Caliendo et al. (2019) is 0.2%). This is not surprising, since the PRP sector is not a large share of the Chinese or U.S. economies in China or the United States. There are only two sectors with negative welfare effects in Table 4, the PRP sector and the closely related Textiles sector. These negative effects reflect the prolonged reduction in labor demand and wages in the sector as PRP imports from China rise. Workers who are initially employed in all other sectors experience welfare gains because they face reduced prices for the goods and services that they consume without direct effects on labor demand. The variation across states in Table 3 reflects in part the differences in the sector composition of employment across the states.

Table 4: Economic Welfare Effects Across Sectors

Worker's Initial Sector	**% Change in Equivalent Variation**
Non-Employment	0.029
Food and Beverages	0.034
Textiles	-0.006
Wood and Paper	0.030
Petroleum and Coal	0.052
Chemicals	0.021
Plastics and Rubber Products	-0.039
Non-Metallic Mineral Products	0.020
Metal Products	0.029
Machinery	0.032
Computers and Electronics	0.013
Transport Manufacturing	0.034
Furniture Manufacturing	0.029
Trade	0.031
Construction	0.031
Transport Services	0.031
Information Services	0.031
Finance	0.032
Real Estate	0.031
Education	0.033
Healthcare	0.035
Hospitality	0.032
Entertainment	0.032

Finally, Table 5 reports simulated welfare effects in each of the states, averaging across the 22 sectors in the U.S. economy. In contrast to Table 4, where workers experience welfare gains or losses depending on their initial sector of employment, the welfare effects are positive and similar in magnitude across the states, since the state effects reported in Table 5 are averaging across all of the sectors.

Table 5: Economic Welfare Effects Across States

State	**% Change**	**State**	**% Change**
Alabama	0.030	Nebraska	0.036
Arizona	0.029	Nevada	0.035
Arkansas	0.030	New Hampshire	0.034
California	0.029	New Jersey	0.029
Colorado	0.032	New Mexico	0.030
Connecticut	0.031	New York	0.027
Delaware	0.032	North Carolina	0.030
Florida	0.032	North Dakota	0.034
Georgia	0.031	Ohio	0.032
Idaho	0.032	Oklahoma	0.030
Illinois	0.029	Oregon	0.030
Indiana	0.034	Pennsylvania	0.031
Iowa	0.028	Rhode Island	0.033
Kansas	0.030	South Carolina	0.029
Kentucky	0.033	South Dakota	0.033
Louisiana	0.026	Tennessee	0.030
Maine	0.032	Texas	0.029
Maryland	0.035	Utah	0.031
Massachusetts	0.029	Vermont	0.030
Michigan	0.028	Virginia	0.032
Minnesota	0.031	Washington	0.032
Mississippi	0.031	West Virginia	0.031
Missouri	0.028	Wisconsin	0.029
Montana	0.032	Wyoming	0.032

5 Next Steps

The CDP model is an excellent tool for analyzing the impact of changes in trade and trade policy for several reasons. First, it is a carefully constructed, state-of-the-art structural model that is tied to the data and useful for calculating welfare effects in counterfactual analysis. Second, it provides estimates of general equilibrium effects, including spillovers between sectors, but at a more granular level than most general equilibrium models of trade, along the sector, state, and time dimensions. Third, while the model is computationally complex, it is easy to operate thanks to the authors' relative time difference method and the excellent replication files that they have published. Fourth, the model is forward-looking, and the magnitude and even sign of estimated economic effects are different in the short run and long run. Labor market frictions generate interesting transition dynamics.

The main limitations of the model is that there is not unemployment and the only dynamic mechanism in the CDP model is costly labor adjustment. Related model add some of these features. Rodriguez-Clare, Ulate and Valsquez (2022) adds nominal rigidity to the CDP model and this generates unemployment. A similar dynamic general equilibrium model in Dix-Carneiro, Pessoa, Reyes-Heroles and Traiberman (2022) includes unemployment and also endogenous trade imbalances. This is an important additional dynamic mechanism.

The CDP model could also be useful in analysis of changes in U.S. trade policy. For example, Caliendo and Parro (2021) update the data and then apply the model in a retrospective analysis of recent tariff changes. The model could also be used in prospective analysis of trade policy, by incorporating forecasts of future fundamentals. The perfect foresight aspect of the model is a good fit for analyzing the economic impact of staging or delaying proposed reductions in tariffs and other barriers to trade.

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