MISALLOCATION AND TRADE POLICY*

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Abstract

This study investigates whether the Canada-U.S. Free Trade Agreement (CUSFTA) reduced resource misallocation in Canada. The implementation of CUSFTA can be viewed as a natural experiment, which makes it an ideal setting for estimating the causal effect of trade policy on the misallocation of resources. I perform this estimation using a dynamic panel data model with data from the Canadian Annual Surveys of Manufactures (ASM) for the period from 1980 to 1996. I use tariff rates from Trefler (2004) and measure resource misallocation using the dispersion in revenue total factor productivity (TFP) within industries. I find that CUSFTA did reduce resource misallocation by approximately four percent and, consequently, increased TFP by around four percent in Canada. This increase in TFP translates into a contribution of 23 percent to the overall TFP growth of Canada's manufacturing sector.

Keywords: Misallocation, Trade policy, CUSFTA, Productivity

JEL Codes: O11, O47, F14, F13.

I. INTRODUCTION

It has been well established that resource misallocation – the allocation of resources to firms with lower rather than higher returns – explains a very large portion of cross-country

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differences in total factor productivity (TFP) (Restuccia and Rogerson, 2008; Hsieh and Klenow, 2009). In addition, the literature has emphasized understanding the evolution of the misallocation of resources across firms over time (Gopinath et al., 2017). The literature also finds that international trade agreements generate productivity gains by exposing domestic firms to foreign competition (Pavcnik, 2002; Melitz, 2003; Trefler, 2004) and by reducing secondary distortions (Khandelwal et al., 2013; McCaig and Pavcnik, 2014). However, the literature does not examine the link between the degree of resource misallocation, as measured by the dispersion in log revenue TFP, and a particular trade policy. Thus, in this study, I integrate these two aspects of the literature to answer the question of whether the Canada-U.S. Free Trade Agreement (CUSFTA) reduced resource misallocation in Canada.

I find that CUSFTA did reduce resource misallocation. Specifically, CUSFTA reduced resource misallocation by approximately four percent and, consequently, increased TFP by around four percent in Canada. This increase translates into a contribution of 23 percent to the overall TFP growth of the manufacturing sector in Canada for the period from 1988 to 1996. The results have important implications for contemporary policy issues in North America. In particular, this study sheds light on the importance of having CUSFTA in place should the North American Free Trade Agreement (NAFTA) negotiations collapse.

To establish these results, I use the Canadian Annual Surveys of Manufactures (ASM) database. For tariff rates, I use data from Trefler (2004). To document stylized facts, in Figure I, I plot the average dispersion (measured by the standard deviation) of within-industry labor productivity weighted by the employment share on the left axis and tariff rates on the right axis.[1] Consistent with the evidence for the U.S. economy in Kehrig (2015), productivity dispersion has risen since 1973. Although tariff rates have generally declined since 1981, the pace of tariff reduction picked up speed after the implementation of CUSFTA in 1989.[2] Specifically, both the Canadian tariff rates on American exports and the American tariff rates on Canadian exports declined sharply during the CUSFTA period relative to the Canadian tariff rates on rest of world (ROW) exports and the American tariff rates on

[1]I also plot a similar graph in Figure A1 to show that the average dispersion of within-industry labor productivity with weights and that without weights are similar.

[2]The decision to implement CUSFTA was reached on October 4, 1987, and it was signed on January 2, 1988.

ROW exports. The most striking feature of this figure is that the average dispersion of labor productivity dropped substantially in 1988 even though it started rising again in 1990.[3] This increase could have been due to a recession in 1990, which, as Alam (2017) explains, was due to an increase in capital misallocation during recessions.

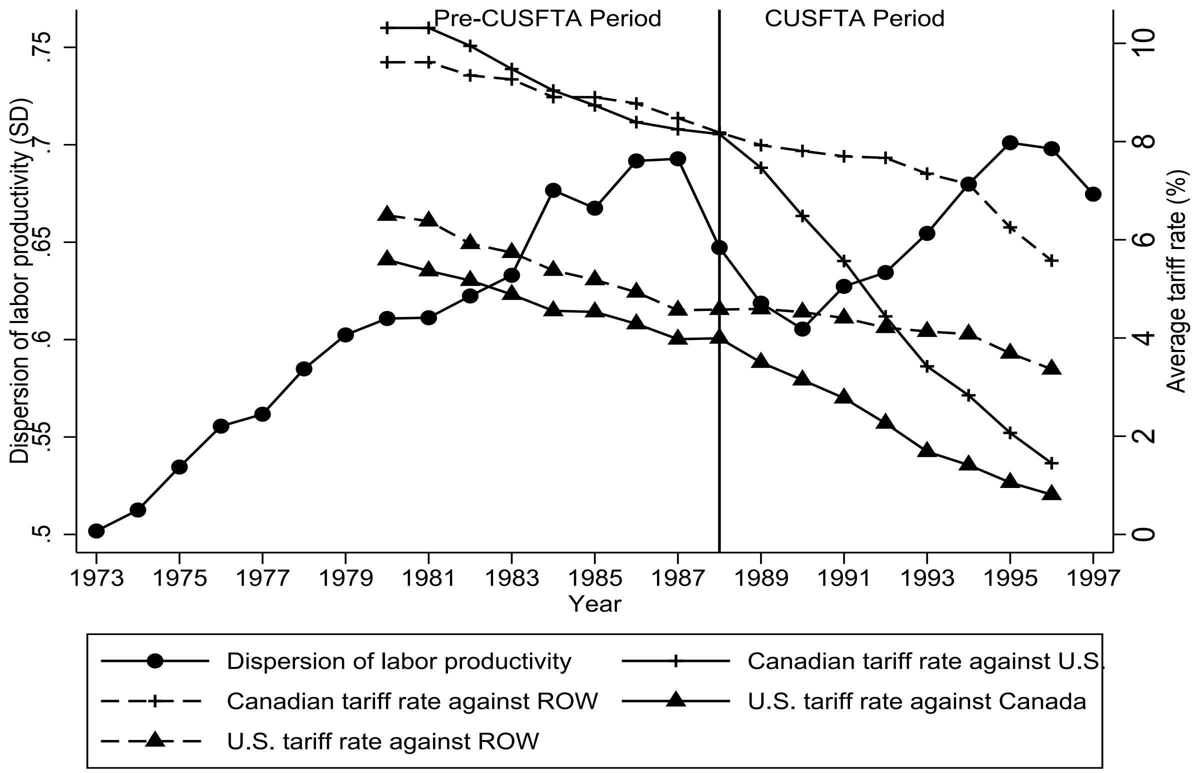


FIGURE I
DISPERSION OF LABOR PRODUCTIVITY AND AVERAGE TARIFF RATES

Note: I use plant-level data from the ASM (cross-sectional file 1973-1999) and tariff data from Trefler (2004). The vertical line shows the pre-CUSFTA and CUSFTA periods. The plot shows the average within-industry standard deviation of log labor productivity, which is measured as the value added per worker, across plants. The weights are industry employment shares.

The implementation of CUSFTA can be viewed as a natural experiment, which makes it an ideal setting for isolating the effects of trade policy on the misallocation of resources in Canada. In particular, unlike many other trade liberalization initiatives undertaken in some developing countries, CUSFTA was not accompanied by other macroeconomic reforms or implemented in response to a particular macroeconomic crisis. CUSFTA mandated annual

[3] It is worth noting that Canada also introduced the goods and services tax (GST) on January 1, 1991.

reductions in tariff rates and other trade barriers across industries over a ten-year period starting on January 1, 1989. I exploit variations in tariff rates by industry and time to identify the causal effect of CUSFTA on resource misallocation using a dynamic panel data model with a first-order moving average. This specification captures the evolution of the misallocation of resources across firms over time and possible adjustment costs to productivity shocks.

Over the years, several studies have estimated the effect of CUSFTA on the Canadian manufacturing sector. For example, Baldwin et al. (2002) find that each manufacturing sector experienced a dramatic reduction in its product offerings, as each sector concentrated on a smaller number of products. Baldwin and Gu (2006) show that CUSFTA substantially raised exit rates. Using the results from Trefler (2004) and Lileeva and Trefler (2010), Melitz and Trefler (2012) document that CUSFTA raised Canadian manufacturing labor productivity by 13.8 percent, which includes both gains from reallocations between plants and within-plant growth. Hsieh et al. (2016) show that, after implementing CUSFTA, Canada experienced net losses in terms of both variety and productivity gains.

With very few exceptions, as pointed out by Goldberg and Pavcnik (2016), secondary distortions with regard to the effects of trade policy, such as those in domestic product or factor markets, have not received much attention in the literature. If resources are misallocated, the effects of trade policy that operate through secondary distortions might be just as important as the primary effects related to product prices. For example, Khandelwal et al. (2013) examine distortions in trade institutions in China in the context of the elimination of the Multi Fibre Agreement (MFA) in 2005. They find that liberalized trade policy generates greater productivity gains through the elimination of secondary distortions than through that of primary distortions. Another study by McCaig and Pavcnik (2014) finds that reductions in trade barriers to exporting (a product market distortion, which disproportionately lowers the profitability of more productive establishments) lead to reallocations of workers from the informal to the formal sector. Tito and Wang (2017) examine the impact of international trade on input market distortions and find smaller distortions across exporting firms.

The remainder of this paper is organized as follows. Section II provides a detailed description of the data and methods. Section III discusses the estimation results. Section IV provides evidence that misallocation declined and that, consequently, productivity in the manufacturing sector in Canada increased. Finally, Section V concludes.

II. METHOD

II.A. Data

In this study, I employ various sources of data, which are listed in Table I. As a primary database, I use the cross-sectional file 1973-1999 from the Canadian ASM,[4] which is the confidential database. The ASM covers the entire Canadian manufacturing sector, using survey data for large plants, which accounts for over 90 percent of shipments, and administrative data from tax records, which accounts for the remainder. The plants in the ASM are classified into 236 manufacturing industries (four-digit 1980 Standard Industrial Classification (SIC) level). Of the 236 industries, four industries were dropped from the cross-sectional file (see Appendix 8.2 for details).

TABLE I
SOURCES OF DATA

Data	**Data Source**	**Data Level**
Primary database	ASM cross-sectional file 1973-1999	Plant-level
Capital stock	Statistics Canada's capital stock database 1999	SIC3 1980
Energy input costs	Statistics Canada's KLEMS database 1997	SIC4 1980
Tariff rates	Trefler (AER, 2004)	SIC4 1980
Nominal exchange rate	Penn World Table 9.0	Country-level
Canada industry-specific prices	Statistics Canada's KLEMS database 1997	SIC4 1980
U.S. shipment deflator	NBER-CES	U.S. SIC4 1987
U.S. TFP	NBER-CES	U.S. SIC4 1987

I use both large plants (which filled out the long-form questionnaire) and small plants (which filled out the short-form questionnaire). I drop observations that have zero or missing values for the number of employees, the number of production workers, the number of hours worked by the production workers, manufacturing production, manufacturing value added,

[4]The ASM has been developed and used extensively for longitudinal analyses of dynamic change. The ASM, originally called the Census of Manufactures, is a survey of the manufacturing industries of Canada that has been conducted since 1917. See the Canadian Centre for Data Development Economic Research website for details on receiving access to the ASM confidential database (`https://www.statcan.gc.ca/eng/cder/index`).

total value added, payroll, wages, or material costs. Appendix Table A3 shows the number of observations that I dropped in each year using these conditions (see column 2).

Unfortunately, the ASM does not record capital stock or investment data. To impute capital stock at the plant level, I use two methods, following Baldwin and Gu (2003) and Tomlin (2014). First, to impute capital stock, following Baldwin and Gu (2003), I allocate industry group (three-digit 1980 SIC code) capital stock using the plant-level capital service cost (defined as the nominal value added minus wages and salaries).[5] For data on industry group capital stock, I use Statistics Canada's capital stock database 1999 from the Investment and Capital Stock Division (see Statistics Canada (1999) for details).[6] Second, to impute capital stock, I use plant-level energy costs. Energy costs have been used as a proxy for capital stock in a number of previous studies (Baldwin and Gu, 2003; Tomlin, 2014). In this case, following Tomlin (2014), I scale plant-level energy costs by the industry-level capital-energy ratio (using the ratio of capital stock and energy input costs) from Statistics Canada's KLEMS productivity database 1997.[7]

Since the ASM has been conducted annually since 1917, its survey method has changed over time to collect representative samples. To check the representativeness of this database, I compare the coverage of large plants relative to that of small plants (Table II) using the number of plants, value added, labor, capital (based on the measure of Baldwin and Gu (2003)), fuel and power, the ages of plants, and productivity. With the exception of the number of large plants relative to that of small plants, all variables are consistent over time with modest variation. I also compare the coverage of foreign-controlled plants relative to that of domestic-controlled plants (Appendix Table A5).

I use tariff data from the database of Trefler (2004), which only includes 213 industries for the period of 1980-1996 after aggregating 16 industries into eight categories.[8] Since four industries were dropped from the cross-sectional file 1973-1999, as mentioned before, I ultimately use 209 industries during the period from 1980 to 1996 in my primary analysis.

[5] I dropped observations with negative values for the capital service cost (see Appendix Table A4).

[6] The capital stock data are available upon request from the Economic Analysis Division of Statistics Canada. Thanks to Wulong Gu for providing the capital stock data.

[7] Statistics Canada's KLEMS productivity database 1997 is available upon request from the Economic Analysis Division of Statistics Canada. This KLEMS productivity database is also available at a higher aggregate level on the older CANSIM Table 383-0023.

[8] `http://www-2.rotman.utoronto.ca/~dtrefler/files/Data.htm#Trefler_AER_2004`

I impute the tariff rates that are missing from the Trefler (2004) database as a robustness check.

TABLE II
COVERAGE OF LARGE PLANTS RELATIVE TO THAT OF SMALL PLANTS

	# of plants		Percentage of aggregate				Ratio of mean	
year	**Large**	**Small**	**Value added**	**Labor**	**Capital**	**Fuel & Power**	**Age**	**Productivity**
1980	13434	13063	96.67	92.76	98.74	100.00	1.35	1.29
1981	13333	13098	96.81	93.08	98.67	100.00	1.36	1.29
1982	13580	11988	96.94	93.32	98.72	98.08	1.40	1.33
1983	13601	13422	96.85	92.84	98.86	97.89	1.53	1.36
1984	13551	15204	96.30	92.40	98.25	97.62	1.52	1.36
1985	10724	19060	92.86	86.55	96.80	95.91	1.41	1.33
1986	10142	20403	91.69	84.16	96.42	95.53	1.62	1.29
1987	9545	19805	90.65	81.02	96.26	94.48	1.55	1.32
1988	10288	21612	92.47	82.16	97.48	94.08	1.87	1.26
1989	11141	20110	92.85	82.10	97.59	93.89	2.09	1.23
1990	15493	16213	94.13	85.45	98.14	95.53	1.93	1.23
1991	11769	14974	92.94	82.93	97.63	94.36	1.54	1.21
1992	13149	12264	93.54	85.00	97.80	93.05	1.44	1.23
1993	12801	11759	94.42	85.40	98.15	93.66	1.36	1.22
1994	12889	11555	94.96	86.54	98.20	94.26	1.34	1.23
1995	12859	12070	94.88	86.60	98.19	93.97	1.47	1.23
1996	12793	14767	94.21	83.92	98.11	92.89	1.56	1.21

Note: For this table, I use the form-type variable that indicates whether a plant filled out the short-form questionnaire (which implies that the plant is a small plant) or the long-form questionnaire (which implies that the plant is a large plant). I use the capital stock measure based on Baldwin and Gu (2003).

To calculate the industry-specific exchange rate, I use data from various sources. For Canadian industry prices, I use the price index of gross domestic product data from Statistics Canada's KLEMS productivity database 1997. For American industry prices, I use the shipments deflator from the National Bureau of Economic Research (NBER) and the U.S. Census Bureau's Center for Economic Studies (CES) productivity database for 1958-2011 (Bartelsman and Gray, 1996). Since ASM data are classified by SIC codes, I use the 1987 SIC version (Becker et al., 2018).[9] I match both databases using the Canadian SIC80 code

[9] `http://www.nber.org/nberces/`

and the American SIC 1987 code. To set a comparable base year for both databases, I convert Canadian prices relative to 1987. I use the nominal exchange rate from the Penn World Table (PWT) 9.0 (Feenstra et al., 2015),[10] and take the inverse to express the exchange rate in terms of U.S. dollars per Canadian dollar. Since I do not have access to plant-level data for the U.S. economy, in order to control for U.S. resource misallocation, I use TFP at the industry level from the NBER-CES productivity database to calculate the dispersion of TFP at the industry sector-level (two-digit SIC 1980 code).

II.B. Method for Measuring Misallocation

To measure resource misallocation, I use the dispersion of the log of the revenue total factor productivity (TFPR) for plant i in industry s following Hsieh and Klenow (2009), $TFPR_{si} \equiv \frac{P_{si}Y_{si}}{K_{si}^{\alpha}(w_{si}L_{si})^{1-\alpha}}$, where $P_{si}Y_{si}$ is the value added in production activities. To measure the elasticity of output with respect to capital (α) and labor ($1-\alpha$), I use the methodology developed by Wooldridge (2009) based on that of Levinsohn and Petrin (2003).[11]

Using the methodology developed by Wooldridge (2009), I estimate TFPR as the residual of the plant-level production function separately for each two-digit industry, s, as follows:

$$(1) \qquad log v_{it} = \beta_l^s log l_{it} + \beta_k^s log k_{it} + log \omega_{it} + \epsilon_{it},$$

where v_{it} denotes the log of the real value added for plant i and time t, l_{it} is the log of the labor input measured by the real wage bill (I also measure the labor input as hours worked by production workers) for plant i and time t, k_{it} represents the log of the deflated capital stock for plant i and time t, β_l^s is the labor elasticity, and β_k^s denotes the capital elasticity. All nominal variables are deflated using industry-specific prices from Statistics Canada's KLEMS productivity database.

[10] DOI: 10.15141/S5J01T

[11] Olley and Pakes (1996) develop an estimator that uses investment as a proxy for observable productivity shocks. Levinsohn and Petrin (2003) propose a modification of the Olley and Pakes (1996) approach to address the problem of lumpy investment and suggest using intermediate inputs as a proxy for unobserved productivity. Whereas Levinsohn and Petrin (2003) invert the intermediate input demand function that is not conditional on the labor input, Ackerberg et al. (2015) argue that the moment condition underlying the first-stage estimating equation does not identify the labor coefficient and suggest inverting the intermediate input demand functions that are conditional on the labor input. Wooldridge (2009) proposes estimating the first- and second-stage moments in the structure of Levinsohn and Petrin (2003) simultaneously.

Table III shows that the labor and capital elasticities using the capital service cost are more meaningful than those using energy costs. Furthermore, I need to drop the first year of data if I use energy costs. In addition, since the wage bill controls for differences in the quality of the workforce across plants, to measure TFPR and, therefore, misallocation, I use the labor elasticity based on the wage bill and the capital elasticity based on the capital service cost.

TABLE III
LABOR AND CAPITAL COEFFICIENTS

	Energy costs (Tomlin, 2014)				Capital cost (Baldwin & Gu, 2003)				KLEMS	
SIC	**hrwork**	**Capital**	**Wage**	**Capital**	**hrwork**	**Capital**	**Wage**	**Capital**	**Labor**	**Capital**
10	0.64	0.05	0.71	0.02	0.46	0.38	0.52	0.38	0.53	0.47
11	0.26	0.34	0.22	0.35	0.32	0.46	0.31	0.46	0.48	0.52
12	0.61	-0.05	0.87	0.07	0.07	0.54	0.21	0.52	0.35	0.65
15	0.47	0.08	0.51	0.06	0.40	0.32	0.41	0.32	0.78	0.22
16	0.57	0.06	0.62	0.04	0.38	0.33	0.43	0.33	0.63	0.37
17	0.71	0.05	0.75	0.02	0.59	0.30	0.63	0.29	0.76	0.24
18	0.55	0.13	0.64	0.09	0.46	0.34	0.46	0.33	0.63	0.37
19	0.65	0.00	0.71	-0.01	0.54	0.29	0.57	0.29	0.71	0.29
24	0.56	0.07	0.62	0.06	0.44	0.31	0.49	0.30	0.73	0.27
25	0.65	0.06	0.67	0.04	0.58	0.26	0.57	0.25	0.75	0.25
26	0.55	0.12	0.60	0.10	0.51	0.28	0.55	0.27	0.74	0.26
27	0.53	0.11	0.55	0.09	0.47	0.34	0.48	0.34	0.67	0.33
28	0.79	-0.03	0.80	-0.03	0.72	0.25	0.73	0.26	0.68	0.32
29	0.62	0.11	0.65	0.08	0.45	0.33	0.47	0.33	0.72	0.28
30	0.70	0.05	0.69	0.07	0.59	0.29	0.58	0.29	0.71	0.29
31	0.54	0.12	0.59	0.10	0.51	0.33	0.52	0.32	0.67	0.33
32	0.69	0.13	0.72	0.08	0.60	0.30	0.59	0.29	0.70	0.30
33	0.39	0.17	0.49	0.12	0.36	0.33	0.42	0.32	0.66	0.34
35	0.68	-0.01	0.73	-0.04	0.52	0.34	0.53	0.33	0.62	0.38
36	0.40	0.06	0.47	0.06	0.29	0.47	0.36	0.46	0.63	0.37
37	0.34	0.12	0.44	0.10	0.52	0.42	0.52	0.41	0.48	0.52
39	0.72	0.03	0.70	0.03	0.59	0.29	0.57	0.29	0.67	0.33
Mean	0.57	0.08	0.62	0.07	0.47	0.34	0.50	0.34	0.65	0.35

Note: hrwork represents hours worked by production workers. To estimate the coefficients, I use the method developed by Wooldridge (2009). I use the labor and capital shares from Statistics Canada's KLEMS database 1997. As mentioned in the previous section, I impute capital stock in this study. To do so, I allocate the industry group-level capital stock following Baldwin and Gu (2003), and I scale plant-level energy costs following Tomlin (2014).

As a robustness check, to calculate TFPR using Solow residuals, I set the elasticities using the labor and capital shares from Statistics Canada's KLEMS database, as shown in the last two columns of Table III. I also measure resource misallocation by the dispersion of labor productivity. Following Trefler (2004), I define labor productivity as the value added in production activities per hour worked by production workers.

II.C. Econometric Model

CUSFTA mandated annual reductions in tariff rates and other trade barriers across industries over a ten-year period. I exploit variations in tariff rates by industry and time to identify the causal effect of CUSFTA on resource misallocation using a dynamic panel data model with a first-order moving average. This specification captures the evolution of the misallocation of resources across firms over time and possible adjustment costs to productivity shocks. Specifically, I estimate the following regression equation:

$$\begin{aligned} Y_{st} &= \beta_0 + \theta Y_{st-1} + \delta \tau_{st} + X_{st}^T \beta + \lambda_t + u_{st}, \quad |\theta| < 1 \\ u_{st} &= \alpha_s + \upsilon_{st} \\ \upsilon_{st} &= \epsilon_{st} + \gamma \epsilon_{st-1}, \quad 0 < \gamma < 1, \end{aligned} \tag{2}$$

where Y_{st} represents one of the three measures of resource misallocation, as explained in the previous section, for industry s in year t; Y_{st-1} denotes resource misallocation for industry s in year $t-1$ (this value captures the evolution of resource misallocation across firms over time); τ_{st} is the tariff rate; X_{st}^T is a vector of covariates; λ_t is year fixed effects; and u_{st} is the error term. The parameter of interest is δ, which measures the causal effect of tariff rates on resource misallocation.

To estimate this regression model, I use two tariff rates: Canadian tariff rates on American exports and American tariff rates on Canadian exports. Since both tariff rates are highly correlated, I estimate this regression model separately for each tariff rate.[12] A vector of covariates accounts for plant and industry heterogeneity. This heterogeneity includes an industry-specific exchange rate, the share of value added by foreign-controlled plants within industries, and the within-industry mean age of plants. In addition, I include the normalized Herfindahl index to control for market concentration. Since the plant-specific variation in

[12] The correlation between Canadian tariff rates on American exports and American tariff rates on Canadian exports is 0.72, according to tariff data from Trefler (2004).

markups is an important component to take into account for TFPR dispersion (Haltiwanger et al., 2018), the normalized Herfindahl index can also serve as a proxy for those markups. Furthermore, I include a misallocation measure for the U.S. economy as another covariate to capture demand and supply shocks that are common to both American and Canadian industries, as Trefler (2004) justifies in his specification. In addition, I include year fixed effects to capture time trends that may also affect resource misallocation.

The error term includes an unobserved time-invariant industry-specific effect (α_s) and the first-order moving average (MA(1)) error term ($v_{st} = \epsilon_{st} + \gamma\epsilon_{st-1}$). I include the first-order moving average to capture possible adjustment costs due to TFPR shocks.

The key identifying assumption for causal inference in this case is:

$$E[Y_{0st}|\alpha_s, Y_{st-1}, X_{st}, \tau_{it}] = E[Y_{0st}|\alpha_s, Y_{st-1}, X_{st}]. \tag{3}$$

As Y_{st-1} is possibly correlated with α_s because Y_{st-1} is a function of α_s, ordinary least squares (OLS) estimators are biased and inconsistent. To remove unobserved time-invariant industry-specific effects (α_s), I take the first difference:

$$\Delta Y_{st} = \theta\Delta Y_{st-1} + \delta\Delta\tau_{st} + \Delta X_{st}^T\beta + \Delta\lambda_t + \Delta\epsilon_{st} + \gamma\Delta\epsilon_{st-1}, \tag{4}$$

where $\Delta\epsilon_{st}$ is correlated with the lagged dependent variable, ΔY_{st-1}, because both are a function of ϵ_{st-1}. To correct this endogeneity problem, I use the system generalized method of moments proposed by Arellano and Bover (1995) and Blundell and Bond (1998). In this method, they propose using appropriate instruments for both the level and difference equations.

Because the composite error, $\epsilon_{st} + \gamma\epsilon_{st-1}$, is MA(1), only lags two or higher are valid instruments for the level. Lagging the level equation (2) by two periods implies that only ϵ_{st-2} and ϵ_{st-3} appear in the equation for Y_{st-2}, which implies that ΔY_{st-2} is a valid instrument for the level equation with errors $\alpha_s + \epsilon_{st} + \gamma\epsilon_{st-1}$. For the first-difference equation 4, because ϵ_{st-2} is the longest lag of ϵ_{st} that appears in the difference equation, lags three or higher are valid instruments for the differenced composite errors. Lagging the level equation (2) three periods implies that only ϵ_{st-3} and ϵ_{st-4} appear in the equation for Y_{st-3}, which implies that Y_{st-3} is a valid instrument for the difference equation. For both cases, an analogous argument works for higher lags.

II.D. Variable Descriptions

- **Misallocation**: I use three misallocation measures: the dispersion of TFPR that is estimated using the method developed by Wooldridge (2009), the dispersion of TFPR that is calculated using the Solow residual method, and the dispersion of labor productivity.

- **Tariff rates**: I use data on both Canadian tariff rates on American exports and American tariff rates on Canadian exports at the industry level from Trefler (2004). Since the tariff rates for some industries are missing in this database, I impute those values using tariff rates at the industry group or industry sector level.

- **Industry-specific exchange rate**: The industry-specific exchange rate (e_{st}) is constructed by multiplying the nominal exchange rate (NER_t, expressed in terms of U.S. dollars per Canadian dollar) by the ratio of Canadian (P_{st}^{CA}) to American (P_{it}^{US}) industry prices, following Baldwin and Yan (2012). In other words, $e_{st} = NER_t * \frac{P_{st}^{CA}}{P_{st}^{US}}$. Data on the price index of the gross domestic product (P_{st}^{CA}) come from Statistics Canada's KLEMS productivity database. For data on P_{st}^{US}, I use the shipments deflator data from the NBER and the U.S. Census Bureau's CES productivity database. I match both databases using Canadian SIC 1980 codes and American SIC 1987 codes. I use nominal exchange rate data from the PWT 9.0 (Feenstra et al., 2015) and take the inverse to express the exchange rate in terms of U.S. dollars per Canadian dollar (NER_t).

- **Share of foreign-controlled plants**: To calculate the share of value added by foreign-controlled plants within industries, I use the classification of the foreign-controlled plants flag from the Canadian ASM database.

- **Mean age of plants**: I calculate the mean age of plants by industry and year.

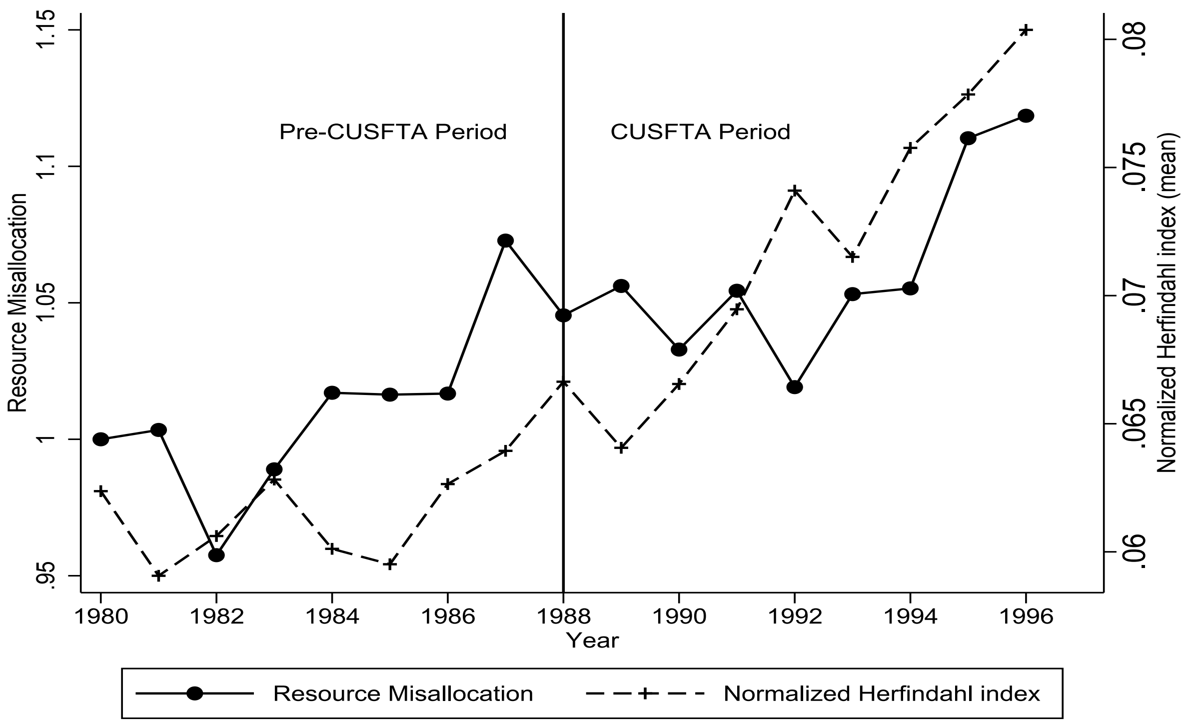
- **Herfindahl index**: To control for market concentration, I use the normalized Herfindahl index, $H^* = \frac{H-\frac{1}{N}}{1-\frac{1}{N}}$, where $H = \sum_{i=1}^{N} S_i^2$, N is the number of plants, and S_i is the market share measured by the value added of plant i.

- **U.S. control**: Since I do not have access to plant-level data for the U.S. economy, in order to control for misallocation in the U.S., I calculate the dispersion of productivity at the industry sector level using TFP at the industry level from the NBER-CES productivity database 1958-2011.

II.E. Descriptive Statistics

Figure II shows the dispersion of TFPR that is estimated using the method developed by Wooldridge (2009) and the normalized Herfindahl index. These two trends are highly correlated. This figure also shows that the dispersion of TFPR that is estimated using the method developed by Wooldridge (2009) is similar to the dispersion of labor productivity shown in Figure I.

FIGURE II
RESOURCE MISALLOCATION AND HERFINDAHL INDEX



Note: To measure resource misallocation, I use the dispersion of TFPR that is calculated based on estimated labor and capital elasticities applying the method developed by Wooldridge (2009). I use the normalized Herfindahl index as $H^* = \frac{H - \frac{1}{N}}{1 - \frac{1}{N}}$, where $H = \sum_{i=1}^{N} S_i^2$, N is the number of plants, and S_i is the market share (measured by value added) of plant i.

III. RESULTS AND DISCUSSIONS

Table IV shows the causal effect of tariffs on resource misallocation. In this section, I treat all coefficients as the change in resource misallocation associated with the respective variable. In section 5, the meaning of the magnitudes of coefficients is discussed to calculate the causal effect of CUSFTA on resource misallocation.

For each of the three measures of resource misallocation (referred to as Wooldridge (2009), Solow Residual, and Labor Productivity), I estimate one model for Canadian tariff rates on American exports (see column (1)) and another model for American tariff rates on Canadian exports (see column (2)). To check the validity of the model, I use two tests. First, to test for autocorrelation, I use the $m2$ test of Arellano & Bond (1991). In the table, I report the z-test statistic for the $m2$ test for zero autocorrelation in first-differenced errors for order two.[13] Second, I use the Sargan test to verify the validity of the instrument subsets (shown in the last two rows of the table). Since the Sargan test fails when all instruments are included, I restrict the instruments to include only ΔY_{st-2} for the level equation and Y_{st-3} for the difference equation.[14]

In all specifications, Canadian tariff rates on American exports and American tariff rates on Canadian exports are positive and significant. This result implies that higher tariff rates lead to greater resource misallocation, as expected. Thus, imposing higher tariffs causes higher input distortions. I find similar effects for all control variables for all three misallocation measures, with the exception that the coefficient on the standardized Herfindahl index is negative when the dispersion of TFPR is calculated using the Solow residual method.

The industry-specific exchange rate is positively correlated with resource misallocation. Thus, a real appreciation of the Canadian dollar increases resource misallocation; a one percentage point rise in the real exchange rate increases resource misallocation by 0.05. This increase in misallocation could be realized through two channels: 1) the exit of less productive domestic producers and 2) the reallocation of resources from the most productive firms, which lose export markets, to less productive firms that do not export. The latter

[13] Appendix Table A1 shows the Arellano-Bond test for zero autocorrelation in first-differenced errors for orders up to four.

[14] I use 50 instruments in total for both the difference and level equations with 27 degrees of freedom for the primary result.

channel is stronger than the former channel, and, therefore, I expect misallocation to increase due to the appreciation of the industry-specific exchange rate.

TABLE IV
THE CAUSAL EFFECT OF TARIFFS ON RESOURCE MISALLOCATION

Dependent Variable: Resource misallocation (standard deviation of TFPR or labor productivity)						
	Method used to calculate TFPR or labor productivity					
Independent Variables	**Wooldridge (2009)**		**Solow Residual**		**Labor Productivity**	
	(1)	(2)	(1)	(2)	(1)	(2)
AR(1) Coefficient	0.49***	0.49***	0.26***	0.26***	0.71***	0.71***
	(0.08)	(0.08)	(0.08)	(0.08)	(0.10)	(0.10)
Canada tariffs against U.S.	0.19***		0.12***		0.08**	
	(0.03)		(0.03)		(0.04)	
U.S. tariffs against Canada		0.20***		0.20***		0.15**
		(0.04)		(0.04)		(0.06)
Exchange rate (industry specific)	0.05***	0.05***	0.05***	0.05***	0.03*	0.02
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Share of foreign-controlled plants	0.06***	0.06***	0.03***	0.03***	0.06***	0.06***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.02)	(0.02)
Mean age of plants	-0.06***	-0.06***	-0.09***	-0.09***	-0.03**	-0.03**
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.02)
Standardized Herfindahl index	0.06***	0.06***	-0.06***	-0.06***	0.06**	0.06**
	(0.02)	(0.02)	(0.02)	(0.02)	(0.03)	(0.03)
U.S. control	0.21***	0.21***	0.13***	0.14***	0.06	0.07
	(0.03)	(0.03)	(0.04)	(0.04)	(0.05)	(0.05)
N	3344	3344	3344	3344	3344	3344
m2	0.74	0.74	0.04	0.05	2.29	2.26
Sargan test (df=27)	32.40	32.33	30.98	30.95	23.65	23.60
P value of Sargan test	0.22	0.22	0.27	0.27	0.65	0.65

Note: An observation is a year and an industry. Column (1) describes Canadian tariff rates on American exports, and column (2) describes American tariff rates on Canadian exports. In this table, $m2$ is the Arellano-Bond test for zero autocorrelation in the first-differenced errors for order two. Standard errors are in parentheses. ***, **, and * indicate statistically significant coefficients at the 1%, 5%, and 10% percent levels, respectively.

To account for plant characteristics, I include the share of value added by foreign-controlled plants within industries, the mean age of plants, and the Herfindahl index to control for market concentration or to proxy for markups. I find that the share of value added by foreign-controlled plants within an industry is positively correlated with resource misallocation. This result could occur because foreign-controlled plants are typically more productive (Baldwin et al., 2005). The plant age coefficient is negative, meaning that industries with more young plants could have more dispersion of labor productivity or TFP. Industries that are highly concentrated, less competitive, and generate higher markups by plant may have more misallocation. The coefficient for U.S.-controlled firms is positive for all specifications. This result is to be expected if this variable is picking up structural factors (demand and supply shocks) that are common to both American and Canadian industries.

IV. ROBUSTNESS CHECKS

My primary results are consistent across several robustness checks. First, as a robustness check, I impute tariff rates because the tariff rates of some industries are missing in the Trefler (2004) database, as mentioned previously. I calculate the mean tariff rates at the industry group or industry sector level and use these tariff rates for the missing industries. Table V shows that the results are similar but with slightly lower tariff coefficients.

As a second robustness check, I treat the tariff rate as a predetermined variable. To justify this robustness check, I regress tariff rates on the lagged misallocation (see Appendix Table A2).[15] The government could reduce tariff rates for industries that have more resource misallocation. My results for this robustness check, shown in Table VI, are also consistent with the primary results.

As a third robustness check, I include the exporting characteristics of plants in the estimation. The ASM provides only four years (1984, 1990, 1993, and 1996) of data for the exporting characteristics of plants. Due to this data limitation, I use OLS instead of a dynamic panel data model. In this case, I consider the misallocation measure based on the Wooldridge (2009) method. My OLS results (the first specification in Table VII) are consistent with my primary results with some variations in magnitude. I include the percentage of exporters (second specification) and the percentage of exports (third specification), both of which are negatively related with resource misallocation, as expected. Including these two exporting characteristics of plants does not significantly change the predictions of my primary results.

[15] Even though the coefficients on the lagged misallocation for American tariff rates on Canadian exports (see column (2)) are significant, the $R-squared$ values for the misallocation measures based on Wooldridge (2009) and the Solow residual are close to zero (see Appendix Table A2).

TABLE V
IMPUTING MISSING TARIFF RATES

Dependent Variable: Resource misallocation (standard deviation of TFPR or labor productivity)

	Method used to calculate TFPR or labor productivity					
Independent Variables	**Wooldridge (2009)**		**Solow Residual**		**Labor Productivity**	
	(1)	(2)	(1)	(2)	(1)	(2)
AR(1) Coefficient	0.50***	0.51***	0.33***	0.33***	0.66***	0.66***
	(0.09)	(0.09)	(0.09)	(0.09)	(0.08)	(0.08)
Canada tariffs against U.S.	0.08***		0.09***		0.08**	
	(0.02)		(0.03)		(0.04)	
U.S. tariffs against Canada		0.05*		0.14***		0.14**
		(0.03)		(0.04)		(0.05)
Exchange rate (industry specific)	0.04***	0.04***	0.05***	0.05***	0.02*	0.02*
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Share of foreign-controlled plants	0.06***	0.06***	0.03***	0.03***	0.07***	0.07***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.02)	(0.02)
Mean age of plants	-0.07***	-0.07***	-0.08***	-0.08***	-0.03**	-0.03**
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Standardized Herfindahl index	0.05***	0.05***	-0.06***	-0.06***	0.00	0.00
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
U.S. control	0.20***	0.19***	0.15***	0.15***	0.15***	0.15***
	(0.03)	(0.03)	(0.04)	(0.04)	(0.05)	(0.05)
N	3706	3706	3706	3706	3706	3706
m2	0.98	0.99	0.60	0.60	2.26	2.25
Sargan test (df=27)	22.75	22.51	25.67	25.56	23.37	23.25
P value of Sargan test	0.70	0.71	0.54	0.54	0.66	0.67

Note: An observation is a year and an industry. Column (1) describes Canadian tariff rates on American exports, and column (2) describes American tariff rates on Canadian exports. In this table, $m2$ is the Arellano-Bond test for zero autocorrelation in the first-differenced errors for order two. Standard errors are in parentheses. ***, **, and * indicate statistically significant coefficients at the 1%, 5%, and 10% percent levels, respectively.

TABLE VI
ENDOGENOUS TARIFF RATES

Dependent Variable: Resource misallocation (standard deviation of TFPR or labor productivity)

	Method used to calculate TFPR or labor productivity					
Independent Variables	**Wooldridge (2009)**		**Solow Residual**		**Labor Productivity**	
	(1)	(2)	(1)	(2)	(1)	(2)
AR(1) Coefficient	0.45***	0.52***	0.28***	0.23***	0.66***	0.66***
	(0.07)	(0.07)	(0.07)	(0.07)	(0.08)	(0.08)
Canada tariffs against U.S.	0.19***		0.11***		0.07**	
	(0.03)		(0.03)		(0.03)	
U.S. tariffs against Canada		0.18***		0.20***		0.16***
		(0.04)		(0.04)		(0.06)
Exchange rate (industry specific)	0.06***	0.05***	0.05***	0.05***	0.03**	0.03**
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Share of foreign-controlled plants	0.07***	0.06***	0.03***	0.03***	0.07***	0.07***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.02)	(0.02)
Mean age of plants	-0.07***	-0.06***	-0.09***	-0.10***	-0.04***	-0.04***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
U.S. control	0.22***	0.21***	0.14***	0.14***	0.06	0.06
	(0.03)	(0.03)	(0.04)	(0.04)	(0.05)	(0.05)
Standardized Herfindahl index	0.07***	0.05**	-0.06***	-0.06***	0.05**	0.05**
	(0.02)	(0.02)	(0.02)	(0.02)	(0.03)	(0.03)
N	3344	3344	3344	3344	3344	3344
m2	0.65	0.80	0.11	-0.03	2.35	2.31
Sargan test (df=54)	64.96	83.31	61.67	61.95	72.16	72.26
P value of Sargan test	0.15	0.01	0.22	0.24	0.05	0.06

Note: An observation is a year and an industry. Column (1) describes Canadian tariff rates on American exports, and column (2) describes American tariff rates on Canadian exports. In this table, $m2$ is the Arellano-Bond test for zero autocorrelation in the first-differenced errors for order two. Standard errors are in parentheses. ***, **, and * indicate statistically significant coefficients at the 1%, 5%, and 10% percent levels, respectively.

TABLE VII
INCLUDING EXPORTING CHARACTERISTICS OF PLANTS

Dependent Variable: Resource misallocation (standard deviation of TFPR)

Independent Variables	**First Specification**		**Second Specification**		**Third Specification**	
	(1)	(2)	(1)	(2)	(1)	(2)
Canada tariffs against U.S.	0.42***		0.35***		0.37***	
	(0.07)		(0.07)		(0.08)	
U.S. tariffs against Canada		0.52***		0.44***		0.44***
		(0.11)		(0.11)		(0.11)
Exchange rate (industry specific)	0.13***	0.12***	0.13***	0.12***	0.13***	0.13***
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
Share of foreign-controlled plants	0.11***	0.11***	0.12***	0.11***	0.11***	0.11***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Mean age of plants	-0.11***	-0.11***	-0.07***	-0.07***	-0.11***	-0.11***
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
U.S. control	0.31***	0.32***	0.33***	0.33***	0.33***	0.34***
	(0.09)	(0.09)	(0.09)	(0.09)	(0.09)	(0.09)
Standardized Herfindahl index	0.22***	0.21***	0.23***	0.23***	0.23***	0.22***
	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)
Percentage of exporters			-0.07***	-0.08***		
			(0.02)	(0.02)		
Percentage of exports					-0.03	-0.04**
					(0.02)	(0.02)
N	836	836	836	836	836	836
R^2	0.26	0.25	0.27	0.27	0.26	0.26

Note: An observation is a year and an industry. Column (1) describes Canadian tariff rates on American exports, and column (2) describes American tariff rates on Canadian exports. In this table, I use four years (1984, 1990, 1993, and 1996) of data since the ASM covers the exporting characteristics of plants only in those years. Due to this data limitation, I use OLS instead of a dynamic panel data model. Standard errors are in parentheses. ***, **, and * indicate statistically significant coefficients at the 1%, 5%, and 10% percent levels, respectively.

V. MISALLOCATION AND PRODUCTIVITY GAINS

To estimate the causal effect of CUSFTA on resource misallocation, I exclude the effect of Canadian and American tariff rates on ROW exports on misallocation and focus on the effects of Canadian tariff rates on American exports and American tariff rates on Canadian exports on misallocation. In this section, I first explain how I calculate the causal effect of CUSFTA on resource misallocation and the contribution to the overall productivity growth of the manufacturing sector in Canada, and I then explain the results.

Using both the AR(1) coefficient (θ) and the tariff coefficient (δ) from Table IV, I calculate the long-run effects of Canadian tariff rates on American exports and American tariff rates on Canadian exports on resource misallocation as follows:

$$\eta^j = \frac{\delta^j}{1-\theta^j}, \; j = CA, US, \tag{5}$$

where η^{CA} is the long-run effect of Canadian tariff rates on American exports on resource misallocation and η^{US} is the long-run effect of American tariff rates on Canadian exports on resource misallocation. To calculate the change in resource misallocation due to CUSFTA for each tariff rate (j), I use the following equation, applying the long-run tariff coefficient from the above equation:

$$\Delta Y_s^j = \eta^j \left[(\tau_{s1}^j - \tau_{s1}^{j,ROW}) - (\tau_{s0}^j - \tau_{s0}^{j,ROW}) \right], \; j = CA, US, \tag{6}$$

where ΔY_t^{CA} is the change in resource misallocation due to changes in Canadian tariff rates on American exports and Canadian tariff rates on ROW exports, τ_{s1}^{CA} is the Canadian tariff rate on American exports in 1996, $\tau_{s1}^{CA,ROW}$ is the Canadian tariff rate on ROW exports in 1996, τ_{s0}^{CA} is the Canadian tariff rate on American exports in 1988, and $\tau_{s0}^{CA,ROW}$ is the Canadian tariff rate on ROW exports in 1988. The expressions for the U.S. are similar. Since the Canadian tariff rates on ROW exports and the American tariff rates on ROW exports changed during this period, I subtract the effects of these tariff rates from my calculation.

To calculate the change in resource misallocation from CUSFTA, I add both the change in resource misallocation due to the Canadian tariff reduction on American exports and ROW exports and the American tariff reduction on Canadian exports and ROW exports using the above equation:

$$\Delta Y_s = \Delta Y_s^{CA} + \Delta Y_s^{US}. \tag{7}$$

To calculate the reduction in the aggregate misallocation due to CUSFTA, I aggregate the resource misallocation reductions at the industry level using the value added share for the TFPR-based misallocation and the labor share for the labor productivity-based misallocation. Table VIII presents the percentage change in resource misallocation relative to the resource misallocation in 1988. These results show that CUSFTA did reduce resource misallocation by approximately four percent using the labor and capital elasticities estimated using the Wooldridge (2009) method to calculate TFPR.[16]

TABLE VIII
THE EFFECT OF CUSFTA ON MISALLOCATION AND PRODUCTIVITY (PERCENTAGE)

Method	**Misallocation**	**Productivity Gains**	**Contribution to Growth**
Wooldridge (2009)	-4.15	4.07	23.11
Solow residual	-3.08	2.12	12.07
Labor productivity	-2.85	4.44	14.87

Note: Here, *Method* indicates the method used to calculate TFPR or productivity for measuring resource misallocation. In this table, misallocation represents the percentage change in resource misallocation relative to that in 1988. During the period from 1988 to 1996 for the manufacturing sector, I find, using the ASM database, that the TFP growth rate is 17.6 percent and that the labor productivity growth rate is 29.83 percent. I use these two growth rates to calculate the contribution of CUSFTA to the manufacturing sector in Canada.

To understand the implications of this result, I calculate TFP gains as well as labor productivity gains due to the reduction in resource misallocation because of CUSFTA. For this analysis, I use equation (16) from Hsieh and Klenow (2009, page 1411) and assume that

[16] Since I added results from two independent estimations, the effect of CUSFTA on resource misallocation could be over-estimated.

σ is 5, as the standard in the trade and industrial organization literature typically ranges from three to ten, and I use the long-run coefficient from equation (5).

$$
\begin{aligned}
\Delta logTFP_s^j &= -\frac{\sigma}{2}\Delta Y_s^j,\ j = CA, US \\
&= -\frac{\sigma}{2}\eta^j\left[(\tau_{s1}^j - \tau_{s1}^{j,ROW}) - (\tau_{s0}^j - \tau_{s0}^{j,ROW})\right], \qquad (8)
\end{aligned}
$$

where σ is the elasticity of substitution between plant value added. To calculate aggregate TFP or labor productivity gains using the gains at the industry level, I use the value added share for the TFPR-based misallocation and the labor share for the labor productivity-based misallocation. To calculate TFP gains due to CUSFTA, I add both the gains from the Canadian tariff reduction on American exports and those from the American tariff reduction on Canadian exports.

$$
TFP\ gains = \Delta logTFP_s^{CA} + \Delta logTFP_s^{US} \qquad (9)
$$

Table VIII also shows that CUSFTA increases TFP by around four percent using the labor and capital elasticities estimated by the Wooldridge (2009) method to calculate TFPR.

To calculate the overall contribution of CUSFTA in the manufacturing sector, I calculate the TFP and labor productivity growth rates for the period from 1988 to 1996. I find that the TFP growth rate is 17.6 percent and that the labor productivity growth rate is 29.83 percent. Thus, the overall TFP contribution of CUSFTA in the manufacturing sector, using the labor and capital elasticities estimated by the Wooldridge (2009) method to calculate TFPR, is 23 percent ($23 = 4.04/17.6 * 100$).

VI. CONCLUSION

This study investigates whether CUSFTA reduced resource misallocation in Canada. The implementation of CUSFTA can be viewed as a natural experiment, which makes it an ideal setting for estimating the causal effect of trade policy on the misallocation of resources. I use tariff rates from Trefler (2004) and measure resource misallocation using the within-industry dispersion in revenue TFP. I use a dynamic panel data model with data from the ASM for the period from 1980 to 1996. This specification captures the misallocation of resources across firms evolving over time as well as possible adjustment costs to productivity shocks.

I find that CUSFTA did reduce misallocation by approximately four percent and, consequently, that it increased TFP by around four percent in Canada. This increase translates into a contribution of 23 percent to the overall TFP growth of the manufacturing sector in Canada for the period from 1988 to 1996. The results have important implications for contemporary policy issues in North America. In particular, this study sheds light on the importance of having CUSFTA in place should NAFTA negotiations collapse.

The proper channel or mechanism by which a trade agreement reduces resource misallocation remains an important question for further investigation.

Appendix I: A BRIEF OVERVIEW OF THE HSIEH-KLENOW MODEL

Hsieh and Klenow (2009) assume that each industry contains a continuum of monopolistic competitive firms (indexed by i) that differ in their productivity levels, A_i. Firms in an industry face a Dixit-Stiglitz-type constant elasticity demand system (each faces a residual demand curve with elasticity η), and they each choose a quantity (equivalently, price) to maximize the profit function,

$$\pi_i = (1-\tau_{Y_i})P_iQ_i - wL_i - (1+\tau_{K_i})RK_i, \tag{10}$$

subject to the firm's inverse residual demand curve, $P_i = Q_i^{-\frac{1}{\sigma}}$, and the production function, $Q_i = A_iK_i^{\alpha}L_i^{1-\alpha}$. τ_{Y_i} is a firm-specific distortion (effectively a tax or subsidy on the firm's output) and τ_{K_i} is a firm-specific factor price distortion (this distortion is high for firms that do not have access to credit but low for firms with access to cheap credit). The factor prices–assumed constant across firms–are w for labor and R for capital.

Given the isoelastic residual demand curve, firm i's profit-maximizing price is then

$$P_i = \frac{\sigma}{\sigma-1}MC_i, \tag{11}$$

where MC_i is the firm's marginal cost, equal to

$$MC_i = \left(\frac{R}{\alpha}\right)^{\alpha}\left(\frac{w}{1-\alpha}\right)^{1-\alpha}\frac{(1+\tau_{K_i})^{\alpha}}{A_i(1-\tau_{Y_i})}. \tag{12}$$

Both distortions (τ_{Y_i} and τ_{K_i}) affect the firm's marginal cost and price, and firms with higher values of A_i have lower marginal costs and prices.

At the optimal price and quantity, a firm's marginal revenue product of labor ($MRPL_i$) and that of capital ($MRPK_i$) are proportional to the product of the factor price and functions of one or both distortions:

$$MRPL_i \propto w\frac{1}{1-\tau_{Y_i}} \tag{13}$$

$$MRPK_i \propto R\frac{1+\tau_{K_i}}{1-\tau_{Y_i}}. \tag{14}$$

In the absence of distortions, the marginal revenue products of both factors are equalized across firms.

Using (13) and (14), firm TFPR is proportional to a weighted geometric average of the marginal products of labor and capital, where the weights are the factors' output elasticities:[17]

$$TFPR_i \propto (MRPK_i)^{\alpha} \propto (MRPL_i)^{1-\alpha} \propto \frac{(1+\tau_{K_i})^{\alpha}}{1-\tau_{Y_i}}. \tag{15}$$

This equation is the key result of Hsieh and Klenow (2009); TFPR does not vary across firms within an industry unless the firms face capital and/or output distortions. In the absence of distortions, more capital and labor should be allocated to firms with higher values of A_i to the point at which their higher outputs result in lower prices and the exact same TFPR levels as those of smaller firms. Thus, to infer the presence and size of misallocation, we can measure the differences in TFPR across firms within an industry.

[17] Thus, firm-specific distortions can be measured by a firm's revenue productivity:

$$TFPR_i \equiv P_i A_i,$$

where P_i is derived by substituting the expression above for the firm's marginal cost in the optimal pricing equation:

$$P_i = \frac{\sigma}{\sigma-1}\left(\frac{R}{\alpha}\right)^{\alpha}\left(\frac{w}{1-\alpha}\right)^{1-\alpha}\frac{(1+\tau_{K_i})^{\alpha}}{A_i(1-\tau_{Y_i})}.$$

Appendix II: ASM DATABASE

There are four different questionnaires used by the Canadian Census of Manufactures: (a) short form, (b) long form, (c) head office, and (d) commodity questionnaires (see Baldwin and Gibson (2016) for details). The short and long form questionnaires are used to obtain principal statistics on commodities shipped from establishments classified as belonging to manufacturing industries, and they differ only in the amount of detail requested. The short form is a single-sheet questionnaire sent to small manufacturers generally reporting shipments of less than $100,000; this cut-off, however, varies somewhat across industries. The head office questionnaire is generally used for company head offices and/or auxiliary units located separately from the manufacturing establishment(s). The commodity questionnaire is used to survey certain establishments that are coded (on the basis of their principal activity) as belonging to industries other than manufacturing in the SIC system but that undertake some manufacturing as a subsidiary activity. This single-sheet questionnaire is designed to collect information on the quantity and value of goods of own manufacture shipped by such establishments in order to achieve full coverage of domestically manufactured commodities.

To remove false births from these files, these ASM records were linked to the Business Register's Central Frame Data Base (CFDB) to obtain 1980 SIC codes, and all non-manufacturing records were then deleted from the 1998 and 1999 files. The majority of the false deaths occurred in the printing and publishing industries (1980 SIC 2831, 2839, 2841, and 2849) in 1997. In order to achieve consistency in the file over time, all printing and publishing operations in these industry codes were removed from the file for the years from 1973 to 1997.

In 1982, for the first time, fuel and electricity costs were compiled separately for small firms instead of being included in the "cost of materials and supplies." Therefore, starting with the year 1982, the fuel and electricity figures reflect all establishments rather than just large establishments, as was the case in prior years starting in 1970. The fuel data refer to the amounts actually used, including the fuel used in cars, trucks, locomotives, and so on. Any fuel or electricity produced by establishments for internal consumption are not included in the total cost. Although fuel and electricity used is considered part of manufacturing activity, it should be noted that it also includes relatively small amounts used in non-manufacturing activities since these amounts cannot be reported separately.

Appendix III: TABLES

TABLE A1
ARELLANO-BOND TEST FOR ZERO AUTOCORRELATION IN THE FIRST-DIFFERENCED ERRORS

Order	Method used to calculate TFPR or productivity											
	Wooldridge (2009)				**Solow Residual**				**Labor Productivity**			
	Canadian Tariffs		**U.S. Tariffs**		**Canadian Tariffs**		**U.S. Tariffs**		**Canadian Tariffs**		**U.S. Tariffs**	
	z	**p-value**	**z**	**p-value**	**z**	**p-value**	**z**	**p-value**	**z**	**p-value**	**z**	**p-value**
1	-4.14	0.00	-4.16	0.00	-3.31	0.00	-3.30	0.00	-4.80	0.00	-4.75	0.00
2	0.74	0.46	0.74	0.46	0.04	0.97	0.05	0.96	2.29	0.02	2.26	0.02
3	0.04	0.97	0.04	0.97	1.16	0.24	1.19	0.24	-0.98	0.33	-0.97	0.33
4	-1.25	0.21	-1.17	0.24	-0.85	0.40	-0.84	0.40	0.91	0.36	0.90	0.37

Note: In this table, I report the z-test statistic for the $m2$ test for zero autocorrelation in the first-differenced errors for orders up to four.

TABLE A2
THE EFFECT OF THE LAGGED MISALLOCATION ON TARIFF RATES

Dependent Variable: Tariff rates

Independent Variables	Method used to calculate TFPR or labor productivity					
	Wooldridge (2009)		**Solow Residual**		**Labor Productivity**	
	(1)	(2)	(1)	(2)	(1)	(2)
Lagged Misallocation	0.01	0.01**	-0.01	0.02**	-0.05***	-0.01***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.00)
Constant	0.06***	0.03***	0.07***	0.03***	0.10***	0.04***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
N	3344	3344	3344	3344	3344	3344
R^2	0.00	0.00	0.00	0.00	0.02	0.00

Note: An observation is a year and an industry. Column 1 describes Canadian tariff rates on American exports, and column 2 describes American tariff rates on Canadian exports. Standard errors are in parentheses. ***, **, and * indicate statistically significant coefficients at the 1%, 5%, and 10% percent levels, respectively.

TABLE A3
DROPPED OBSERVATIONS

year	# of plants	Percentage of Missing								
		totalemp	prdwrk	hrwork	payroll	wage	tmatcost	vpm	vam	vat
1980	3907	33.89	89.10	59.07	3.17	58.38	54.08	54.11	54.08	54.08
1981	3947	32.43	89.79	63.62	5.90	63.24	55.92	55.97	55.94	55.94
1982	4013	32.05	87.47	62.55	6.95	62.37	54.07	54.82	54.12	54.12
1983	3820	31.73	89.58	64.69	6.70	64.55	56.47	56.57	56.49	56.49
1984	3843	32.42	87.67	64.40	8.80	64.04	53.92	53.99	53.97	53.97
1985	3018	20.01	84.59	73.72	8.61	73.23	63.88	63.92	63.95	63.95
1986	3204	19.66	80.40	68.20	7.18	67.92	59.52	59.52	59.52	59.52
1987	2981	21.10	84.30	68.94	5.77	68.94	62.83	62.86	62.83	62.83
1988	2782	21.35	91.88	78.04	7.51	78.04	69.30	69.30	69.27	69.30
1989	2440	13.77	94.06	81.56	0.57	80.86	76.02	76.11	76.07	76.07
1990	2382	11.17	94.12	86.06	2.90	85.85	75.99	76.07	76.11	76.03
1991	2790	15.81	87.46	83.41	5.66	77.28	63.80	63.80	63.69	63.69
1992	2900	15.10	90.76	81.45	5.38	81.03	65.41	65.62	65.45	65.41
1993	2766	15.15	90.49	81.67	5.46	81.06	64.68	64.71	64.68	64.64
1994	2567	14.18	90.61	81.57	4.67	81.07	64.90	65.06	64.86	64.82
1995	2510	13.82	89.16	80.48	4.90	80.20	61.39	61.43	61.35	61.39
1996	2464	17.78	87.58	73.38	3.21	72.85	57.83	58.44	57.83	57.71
Mean	3078	21.26	88.77	73.69	5.49	72.99	62.35	62.49	62.37	62.35

Note: totalemp is the sum of production workers and salaried employees, *prdwrk* is production workers, *hrwork* is production hours worked, *payroll* is the sum of wages and salaries, *wage* is production workers' wages, *tmatcost* is total material costs, *vpm* is manufacturing production, *vam* is manufacturing value added, and *vat* is total value added.

TABLE A4
COVERAGE OF POSITIVE RELATIVE TO MISSING CAPITAL COST

	# of plants		Percentage of aggregate				Ratio of mean	
year	**Capital cost**	**Missing**	**Value added**	**Labor**	**Capital**	**Fuel & Power**	**Age**	**Productivity**
1980	26522	2846	98.34	94.82	100.00	96.20	1.13	1.22
1981	26454	2993	98.38	94.50	100.00	95.70	1.16	1.24
1982	25593	3647	97.41	92.02	100.00	92.31	1.06	1.18
1983	27032	3395	97.88	93.57	100.00	92.25	1.10	1.18
1984	28776	2635	98.60	95.31	100.00	95.26	1.14	1.25
1985	29810	2618	98.38	94.88	100.00	95.27	1.11	1.24
1986	30559	3131	98.40	94.42	100.00	95.12	1.09	1.23
1987	29358	3062	98.48	94.74	100.00	95.87	1.18	1.21
1988	31913	3805	97.72	93.15	100.00	95.79	1.29	1.20
1989	31271	3748	97.93	92.92	100.00	94.22	1.22	1.15
1990	31717	3820	97.69	92.99	100.00	93.62	1.16	1.14
1991	26867	5095	96.68	90.74	100.00	91.20	1.12	1.13
1992	25415	4711	97.43	91.83	100.00	90.63	1.09	1.12
1993	24572	4168	97.82	92.81	100.00	92.58	1.10	1.16
1994	24468	3480	98.46	94.15	100.00	96.47	1.06	1.19
1995	24936	3686	98.57	93.58	100.00	95.92	1.15	1.16
1996	27573	4259	98.33	93.61	100.00	94.40	1.18	1.18

Note: For this table, I use the capital stock based on the measure of Baldwin and Gu (2003). I define labor productivity as the value added per worker.

TABLE A5
COVERAGE OF FOREIGN-CONTROLLED RELATIVE TO DOMESTIC-CONTROLLED PLANTS

	# of plants		Percentage of aggregate				Ratio of mean	
year	**Large**	**Small**	**Value added**	**Labor**	**Capital**	**Fuel & Power**	**Age**	**Productivity**
1980	3375	23122	46.20	38.03	49.49	47.81	1.17	1.03
1981	3295	23136	46.53	37.24	46.47	44.13	1.17	1.02
1982	3233	22335	45.40	36.67	45.95	44.20	1.20	1.02
1983	3179	23844	45.15	35.89	46.84	42.56	1.23	1.02
1984	3161	25594	44.96	35.87	46.84	42.45	1.25	1.02
1985	3055	26729	44.38	34.72	44.61	42.76	1.30	1.01
1986	3042	27503	43.35	33.86	45.88	44.18	1.37	1.02
1987	3072	26278	44.20	33.78	47.77	45.87	1.38	1.02
1988	3143	28757	44.28	32.99	48.82	46.64	1.45	1.03
1989	3199	28052	46.89	33.86	51.28	48.92	1.48	1.03
1990	3174	28532	47.65	35.04	52.92	49.67	1.48	1.02
1991	3013	23730	48.27	36.17	55.24	50.74	1.39	1.01
1992	2982	22431	47.57	36.41	53.71	49.84	1.37	1.01
1993	2903	21657	48.98	36.05	53.42	50.61	1.34	1.02
1994	2895	21549	47.87	35.42	52.73	49.05	1.34	1.02
1995	2802	22127	47.93	34.29	52.24	48.88	1.37	1.03
1996	2825	24735	47.21	32.94	50.54	47.71	1.50	1.02

Note: For this table, I use the classification of the foreign-controlled plants variable from the ASM and the capital stock based on the measure of Baldwin and Gu (2003). I define labor productivity as the value added per worker.

Appendix IV: FIGURE

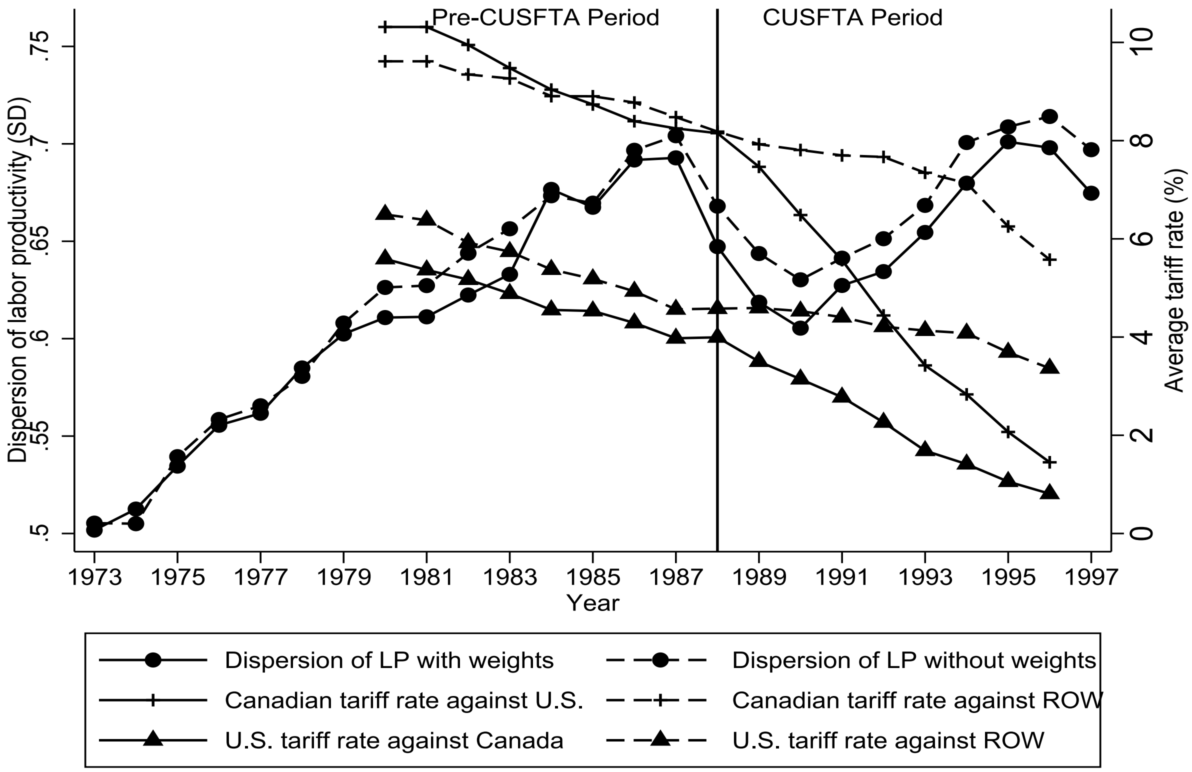


FIGURE A1

DISPERSION OF LABOR PRODUCTIVITY WITH AND WITHOUT EMPLOYMENT WEIGHTS

Note: I use plant-level data from the ASM (cross-sectional file 1973-1999) and tariff data from Trefler (2004). CUSFTA mandated annual reductions in tariffs and other trade barriers across industries over a ten-year period starting on January 1, 1989. The plot shows the average within-industry standard deviation of log labor productivity (LP), which is measured as value added per worker, across plants. The weights are industry employment shares.

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