Replication of "The Structure of Tariffs and Long-Term Growth" by Nathan N. & Trefler D.

Project 2

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April 2022

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1. Introduction

A tariff is a tax policy imposed on goods imported into a country. Other than serving as an income source for the government, policies revolving around tariffs aim to protect domestic industries by making imported goods more expensive than the corresponding domestic goods. The tariff also works as a shield against the act of "dumping" in international trade, which is to "dispose surpluses" in other countries. This brings adverse impact to the receiving end of the act as the huge influxes of extra goods at a cheaper price would impact the sale of domestic goods, eventually hurting local businesses. While many argue that tariffs discourage free trade between countries, it is an essential tool for most developing countries; it creates a trade barrier that strategically shields the local economy from foreign economic factors or other external factors such as public health issues or humane factors.

"The Structure of Tariffs and Long-Term Growth" by Nunn & Trefler (2010) studies the relationship between skill-biased tariffs and the long-term per capita GDP growth, by constructing a model that incorporates a cross-industry tariff structure. The consideration of customized tariff levels on different industries with differing skill-intensity measures is due to the authors' hypothesis of potential mechanisms between tariffs in skill-intensive industries and growth. In simple words, the authors' objective is to determine the independent variables that are strongly correlated with long-term per capita GDP growth in a country and look at the correlations, and then form a model which can precisely test the relationship between independent variables and how they form a strong correlation with the dependent variable, long-run economic growth.

The authors conducted empirical research by utilizing economic data and variables from various credible sources which will be described by us in the "Data" section. The authors discuss how a tariff influences a country's long-term economic growth and form a comprehensive view of the effect of tariffs (Nunn & Trefler, 2010). To replicate the empirical procedures conducted by the authors, we will be constructing a model with a cross-industry tax structure, separated into two groups based on the ratio of skill intensity of eighteen industries. The ratio is computed by comparing the number of skilled workers and unskilled workers in the same industry. While the authors used two cut-off points, we are using the assigned cut-off of #248 industry code, which is the "Footwear" industry. This means that any industry with a skill intensity ratio/level of greater than 0.315 is considered as "high", while the remainders are considered as "low".

The structure of our paper is as follows: we will first explain the methodology/econometric strategy used in our replication of Nunn & Trefler's (2010) empirical results. Then, we will explain the dataset used and what variables are we including in the base models for the subsequent statistical analysis. Empirical results consist of regression outputs produced using the SAS data tool and will be explained in detail in reference to the appendixes attached at the end of this paper. Finally, we will conclude our results and verify whether they are in line with the authors' findings.

2. Methodology/ Economic Strategy

As mentioned above, the industries have been separated into 2 groups based on the computed skill intensity levels. The list of industries and their corresponding skill intensity levels have been displayed in (Appendix B) TABLE 3 – SKILL INTENSITY: CHOOSING CUT-OFFS

FOR SKILLED AND UNSKILLED CATEGORIES. The cut-off line indicates that any industry above the line would be in the "low-skill intensity industries" group, while the industries under the cut-off line are in the "high-skill intensity industries" group. Therefore including the "Footwear" industry itself, industries with a skill intensity ratio/level of equal to or less than 0.315 are considered "low-skill intensity industries".

The first equation in our model is:

$$lny_{c1}/lny_{c0} = \alpha + \beta_{SB}\tau_{c0} + X_{c0}\beta_X + \epsilon_t \qquad (1)$$

where lny_{c1}/lny_{c0} denotes the average annual log change in per capita GDP in country *c*. τ_{c0} denotes the average tariffs in country *c*, while X_{c0} denotes the covariates, which are standard controls for initial country characteristics, for instance, the initial income, lny_{c0}, the initial human capital per capita, lnh_{c0}, initial investment, $lninv_{c0}$, and the initial period of real GDP per capita of the country. On the other hand, we have α as the intercept and ϵ_t as the error term of this equation. (Nunn & Trefler, 2020) This equation is used by us to determine the impacts of average tariffs, $ln\tau^{Skill}$ on long-run economic growth, *growth*.

Among the assumptions listed by the authors, one major assumption is that protection against high-skill intensity industries leads to positive externality in the industry, which will then lead to an increase in GDP per capita's growth rate. This implies that all industries under the protection should have higher output growth than unprotected industries as they have the capacity to produce more due to the "shield" protecting the local economy from disruptions. In other words, an implementation of a tariff increases the output of the industries under its protection, and this is referred to as the own-industry effect. Equation (2) below is constructed to test whether the own-industry effect will certainly take place when a tariff is implemented:

$$ln q_{ic1}/q_{ic0} = \alpha + \beta_q ln q_{ic0} + \beta_\tau ln \tau_{ic0} + \beta_E \sigma_{c0} + \beta_{SB} \tau_{c0} + X_{c0}\beta_X + \epsilon_{ic} \tag{2}$$

where $ln q_{ic1}/q_{ic0}$ denotes the average annual log change of output in an industry *i* in country *c*. In equation (2), the estimated coefficient β_{SB}represents the own-industry effects. $ln q_{ic0}$ denotes the log of output in the industry *i* in country *c* at initial period t = 0, while $ln \tau_{ic0}$denotes the log of average tariff at initial period t = 0. Similar to above, X_{c0} denotes the covariates for our cross-country regressions, which are standard controls for initial country characteristics, for instance, the initial income, $ln y_{c0}$, the initial human capital per capita, $ln h_{c0}$, initial investment, $ln inv_{c0}$, and initial period of real GDP per capita of the country.

3. Data

The authors have utilized various variables in other studies and economic data from credible sources for their empirical analysis. We have used a dataset that incorporates all of the above, provided to us by the course instructor.

There are 63 countries in the authors' sample determined by the availability of industry-level tariff data. The source of Tariff data is from Huiwen Lai and Daniel Trefler (2002) and the United Nations Conference on Trade and Development (UNCTAD) (1994), while production data is collected and published by the United Nations Industrial Development Organization (UNIDO) (2003). As the authors wish to match the Standard International Trade Classification (SITC) tariff data with International Standard Industrial Classification (ISIC) production data, they aggregated the available data into a common set of 18 agricultural and manufacturing industries.

Multiple regression models have been constructed to replicate some tables in Nunn & Trefler's (2010) paper. In Appendix A, we replicated Table 2 in which results for average tariff were shown. In both versions 1 & 2 of Table 4 in Appendix B & C respectively, we ran country-level per capita GDP growth regression to investigate the skill bias of tariff structures taking country characteristics and fixed effects into account. As opposed to Table 4, Table 5, which is available in Appendix E, displays the statistical output for industry-country level output growth regressions. Finally, we replicated authors' Table 6, which displays the outcomes of industry-country level output growth regressions, which were controlled for own=industry channels.

4. Empirical Results

TABLE 2 – RESULTS FOR AVERAGE TARIFFS (Appendix A)

Table 2 shows the regression results for average tariffs, $ln\tau_{c0}$ which were estimated using equation (1). The coefficient of -0.00238 indicates that the average tariffs have a very low and negative impact on annual log change in output growth per capita. Resulting from the introduction of cohort fixed effects as demonstrated in Column (1) of Table 2, unknown effects caused by the country characteristics such as initial income lny_{c0}, initial investment $lninv_{c0}$, and initial human capital lnh_{c0} are isolated from our model, as when regional fixed effects are captured, the coefficients of the country characteristics variables reduced substantially in ratio, for instance, $lninv_{c0}$'s coefficient reduced from 0.01105 to 0.00085206. At the same time, after the introduction of region fixed effects as demonstrated by regressing equation (1) in Column (2), the t-statistic for all three variables has reduced by more than 1, leading their absolute value of t-statistic to be even smaller than 2. This matches the procedure performed as we do not wish to use the country characteristics variables' coefficients as predictors in our regression model. In addition to the above analysis, we now have a much higher R^2 value of 0.5974 as opposed to 0.3711. This shows that the model represented by Table 2's Column (2) explained 59.74% of the variation in average annual log change in per capita GDP of country *c* and are explained by the movements in the independent variables that we chose.

TABLE 3 – SKILL INTENSITY: CHOOSING CUT-OFFS FOR SKILLED AND UNSKILLED CATEGORIES (Appendix B)

The description of Table 3 has been included in both "Data" and "Methodology / Econometric strategy" sections. In simple words, using the skill intensity ratio/level computed, and based on the assigned cut-off which is the "Footwear" industry with a skill intensity of 0.315, industries above the cut-off line including "Footwear" itself are considered as "low-skill intensity industry" while the industries below the cut-off line are "high-skill intensity industries". What we can further study from this table would be the last column of Table 3, which measures how much skill intensity level has increased in percentage between countries.

TABLE 4 - COUNTRY-LEVEL PER CAPITA GDP GROWTH REGRESSIONS. DEPENDENT VARIABLE IS LN YC1/YC0 (Appendix C) (Version 1)

TABLE 4 - COUNTRY-LEVEL PER CAPITA GDP GROWTH REGRESSIONS. DEPENDENT VARIABLE IS LN YC1/YC0 (Appendix D) (Version 2)

In Table 4, while equation (1) is still the base model being regressed, the tariff differential, variable $DIFF_c$, is included in the new estimation. The purpose of including tariff differential is to examine the potential effects of tariff differential between low and high skill intensity industries on long-run economic growth. The authors also included tariff structure, $ln\bar{\tau}_{c0}$, and production structure variables, lnq^{Skill} and $lnq^{Unskill}$ in the regression model.

From Column (2), as the coefficient for tariff differential $DIFF_c$ is 0.01134, this indicates that tariff differential might have a small positive impact on long-term economic growth. While this coefficient is not a large number, it is still evidence of the following statement, "The larger the skill-bias, or skill intensity level between high and low skill intensity industries, the large the increase in average annual growth of per capita GDP". In Column 3, the tariff differential variable is now differentiated into the log of skilled tariff with a coefficient of 0.1177, and the log of unskilled tariff with a coefficient of -0.01023. These coefficients imply that an introduction of tariff will protect high skill intensity industries, causing the industries to produce higher outputs which contribute to the increase in average annual growth of per capita GDP, while the introduction of tariff will discourage low skill intensity industries from producing at the initial output, negatively impact the average annual growth of per capita GDP. Combining the effects of both variables, we can summarize that the tariff differential variable impacts the average annual growth of per capita GDP positively.

Table 4, version 2 differs from its counterpart by now taking the correlation between skill intensity level of industries and the fixed effects of industries as dummy variables. We can observe immediately that the results in Table 4, version 2 is highly identical to version 1: all coefficients are identical if not the exact same, but now with a much higher t-statistics for all predictor variables. Note that both R^2 and adjusted R^2 remained the same, which is 0.6774 and 0.6783 respectively. With a relatively high R^2 which remained unchanged after a modification of model, this implies that our model specification is solid, and this led to an important inference -- we are now much more confident with using the variables as predictor variables in regression models, as indicated by the substantial increases in all t-statistics in Table 4, Version 2.

TABLE 5 - INDUSTRY-COUNTRY LEVEL OUTPUT GROWTH REGRESSIONS. DEPENDENT VARIABLE IS $\ln q_{ic1}/q_{ic0}$. (Appendix E)

Table 5 displays the regression results of which models were regressed to examine the own-industry effect at the industry level. As we are now looking at the tariff's potential impacts on industry-country level output growth, equation (2) listed in "Methodology" is estimated, with average annual log change of output in an industry *i* in country *c*, lnq_{ic1}/q_{ico} as the new dependent variable.

Aside from identical coefficients from Table 4, Version 2, the t-statistic in Table 5 are relatively high and differs only by an insignificant amount. Hence, the direct learning outcome from studying the outputs produced from regressing this model is that introduction of a tariff policy with the consideration of skill bias included, has potential positive impacts on average industry output growth in a country. The outcomes of tariff structures, modelled in both Table 4 (Version 2) and Table 5, should be identical as they are driven by similar mechanisms. Therefore, we argue that while the skill bias of tariffs will impact long-term industry output growth positively, there is no own-industry effect as indicated by the identical coefficients of the regression outputs.

TABLE 6 - INDUSTRY-COUNTRY LEVEL OUTPUT GROWTH REGRESSIONS, CONTROLLING FOR OWN-INDUSTRY CHANNELS. DEPENDENT VARIABLE IS $\ln q_{ic1}/q_{ic0}$. (Appendix E)

Table 6, in which regression models are also based on equation (2), serves as a supplementary statistical analysis for Table 5 by specifying a variation of the previous model which considers the learning-by-doing externalities. This is demonstrated through the inclusion of the “Tariff-skill interaction” variable, $ln\tau_{ico}$ × S_i/L_i under the Own-industry channels in Table 6, Columns (4) and (6). We observed that the coefficients for the $ln\tau_{ico}$ × S_i/L_i variable are extremely small, which are 0.00017064 and -0.00002011 respectively. This means that the tariff-skill interaction within industries is not statistically significant, and this finding rules out the possibility of learning-by-doing externality being an existing factor that impacts an industry’s long-term output growth.

On top of that, we can assess whether the own-industry effect presents itself in Table 6’s models. Compared to Table 5, as the variables under Skill Bias of Tariff Structure have identical coefficients after the introduction of $ln\tau_{ico}$ × S_i/L_i variable in Table 6, we can conclude that the annual log change of output in the industry *i* in country *c* is not affected by any own-industry effect.

5. Conclusions

To conclude, our findings are in line with the results obtained by Nunn & Trefler (2010). The empirical results demonstrated above support the following: i. There is a positive correlation between the skill bias, in other words, the difference in skill intensity levels of industries and economic growth, specifically both average annual growth of per capita GDP, and annual log change of output in the industry. ii. While different tariff structures, as shown in Tables 2-6, have different impacts on economic growth, the difference is not significant as all models explain approximately 67% of variation in long-run economic growth around its mean. iii. Learning-by-doing externalities do not impact long-run economic growth through skill intensity levels of industry; the own-industry effect can exist, but the statistically insignificant coefficient indicates that there is little to no impact on long-run economic growth.

References

1. Nunn, N., & Trefler, D. (2010). The Structure of Tariffs and Long-Term Growth. *American Economic Journal: Macroeconomics*, *2*(4), 158–194. https://doi.org/10.1257/mac.2.4.158

Appendix

(Appendix A) Table 2

TABLE 2 – RESULTS FOR AVERAGE TARIFFS

	(1)		(2)	
	β	*t*-statistic	β	*t*-statistic
Tariff Structure				
Average tariffs: $ln\tau_{c0}$	-0.00238	(1.36)	0.00067412	(0.38)
Country Characteristics				
Initial income: lny_{c0}	-0.00861	(1.81)	-0.00117	(0.24)
Initial investment: $lninv_{c0}$	0.01105	(2.46)	0.00085206	(0.18)
Initial human capital: lnh_{c0}	0.01071	(3.78)	0.00214	(0.64)
Region fixed effects				
West Africa			-0.06410	(3.04)
East Africa			-0.04780	(2.35)
South Central Africa			-0.05350	(2.48)
North Africa, Middle East			-0.04167	(2.14)
Eastern Europe			-0.02091	(1.01)
Latin America			-0.03597	(1.91)
East Asia			0.00137	(0.09)
South East Asia			-0.01649	(0.84)
South West Asia			-0.03041	(1.53)
Cohort Fixed Effects				
1980-1983	0.00916	(1.28)	0.03607	(1.98)
1985-1987	-0.00203	(0.30)	0.02390	(1.33)
R^2	0.3711		0.5974	
Observations	63		63	

Notes: The dependent variable is the average annual log change in per capita GDP in country *c*, ln y_{c1} / y_{c0}. There are 63 observations, one for each country.

(Appendix B) Table 3

TABLE 3 – SKILL INTENSITY: CHOOSING CUT-OFFS FOR SKILLED AND UNSKILLED CATEGORIES

Industry Code	Description	Skill Intensity	%△ in Skill
241	Leather & Travel goods.	0.079	
			47%
110	Agricultural products	0.116	
			10%
243	Wood Products	0.128	
			3%
245	Textiles & Clothing	0.132	
			17%
247	Furniture	0.154	
			19%
150	Non-ferrous metals	0.184	
			9%
246	Non-metallic mineral prod.	0.201	
			32%
220	Iron & Steel	0.266	
			18%
248	Footwear	0.315	
--	------ Cut-Off ------	--	26%
244	Paper products	0.397	
			4%
231	Non-electric machinery	0.414	
			12%
242	Rubber products	0.462	
			0.8%
233	Transport equipment	0.466	
			32%
140	Mineral fuels	0.593	
			4%
232	Electric machinery	0.617	
			16%
211	Medicaments, toiletry & perf.	0.718	
			2%
213	Manufactured fertilizers	0.731	
			9%
249	Professional equipment	0.797	

Notes: Data are from Antweiler and Trefler (2002). Skill intensity is scaled so that the most skill-intensive industry in the Antweiler-Trefler database (electricity generation) has a skill intensity of unity.

(Appendix C) Table 4, Version 1

TABLE 4 - COUNTRY-LEVEL PER CAPITA GDP GROWTH REGRESSIONS. DEPENDENT VARIABLE IS LN YC1/YC0

(Version 1)

	Cut-Off	
	(2)	(3)
Skill bias of tariff structure		
Tariff differential: $DIFF_c$	0.01134	
	(2.62)	
Skilled tariff: $ln\tau^{Skill}$		0.01177
		(2.73)
Unskilled tariff: $ln\tau^{Unskill}$		-0.01023
		(2.25)
Other tariff structure		
Average tariff: : $ln\bar{\tau}_{c0}$	0.00151	
	(0.85)	
Initial production structure		
Skilled-sector output: lnq^{Skill}	0.00326	0.00354
	(1.44)	(1.54)
Unskilled-sector output: $lnq^{UnSkill}$	-0.00567	-0.00617
	(1.81)	(1.89)
3 country characteristics	Yes	Yes
9 region fixed effects	Yes	Yes
2 cohort fixed effects	Yes	Yes
R^2	0.6774	0.6783

Notes: The dependent variable is the average annual growth of per capita GDP in country c, $\ln y_{c1}/y_{c0}$. There are 63 observations, one for each country. In q_{c0}^{Skill} is log output of all skill-intensive industries. In $q_{c0}^{Unskill}$ is log output of all unskilled-intensive industries. The "3 country characteristics" are initial-year per capita GDP, initial year investment-to-GDP ratio, and initial-year human capital stock. See Table 2 for a description of the region and cohort fixed effects.

(Appendix D) Table 4, Version 2

TABLE 4 - COUNTRY-LEVEL PER CAPITA GDP GROWTH REGRESSIONS. DEPENDENT VARIABLE IS LN YC1/YC0

(Version 2)

	Cut-Off	
	(2)	(3)
Skill bias of tariff structure		
Tariff differential: $DIFF_c$	0.01134	
	(13.1)	
Skilled tariff: $ln\tau^{Skill}$		0.01177
		(13.72)
Unskilled tariff: $ln\tau^{Unskill}$		-0.01023
		(11.34)
Other tariff structure		
Average tariff: : $ln\bar{\tau}_{c0}$	0.00151	
	(4.27)	
Initial production structure		
Skilled-sector output: lnq^{Skill}	0.00326	0.00354
	(7.18)	(7.73)
Unskilled-sector output: $lnq^{UnSkill}$	-0.00567	-0.00617
	(9.06)	(9.49)
3 country characteristics	Yes	Yes
9 region fixed effects	Yes	Yes
R^2	0.6774	0.6783

Notes: The dependent variable is the average annual growth of per capita GDP in country c, $\ln y_{c1}/y_{c0}$. There are 63 observations, one for each country. ln q_{c0}^{Skill} is log output of all skill-intensive industries. ln $q_{c0}^{Unskill}$ is log output of all unskilled-intensive industries. The "3 country characteristics" are initial-year per capita GDP, initial year investment-to-GDP ratio, and initial-year human capital stock. See Table 2 for a description of the region and cohort fixed effects.

(Appendix E) Table 5

TABLE 5 - INDUSTRY-COUNTRY LEVEL OUTPUT GROWTH REGRESSIONS. DEPENDENT VARIABLE IS $\ln q_{ic1}/q_{ico}$.

	Low cut-off	
	(2)	(3)
Skill bias of tariff structure		
Tariff differential: $DIFF_c$	0.01134	
	(13.21)	
Skilled tariff: $ln\tau^{Skill}$		0.01184
		(13.13)
Unskilled tariff: $ln\tau^{Unskill}$		-0.01005
		(9.00)
Initial industry output: lnq_{ic0}	Yes	Yes
Average tariffs: $ln\tau_{ic0}$	Yes	Yes
Initial production structure	Yes	Yes
3 country characteristics	Yes	Yes
All fixed effects	Yes	Yes
R^2	0.6774	0.6783

Notes: "3 country characteristics" are initial-year per capita GDP, initial-year investment-to-GDP ratio, and initial-year human capital stock. "All fixed effects' are the 9 region fixed effects and 2 cohort fixed effects listed in Table 2, as well as 16 industry fixed effects.

(Appendix F) Table 6

TABLE 6 - INDUSTRY-COUNTRY LEVEL OUTPUT GROWTH REGRESSIONS, CONTROLLING FOR OWN-INDUSTRY CHANNELS. DEPENDENT VARIABLE IS $\ln q_{ic1}/q_{ic0}$.

	Cut-off			
	(3)	(4)	(5)	(6)
Skill Bias of Tariff Structure				
Tariff differential: $DIFF_c$	0.01132	0.01133		
	(13.15)	(12.76)		
Skilled tariff: $ln\tau^{Skill}$			0.01184	0.01185
			(13.00)	(12.62)
Unskilled tariff: $ln\tau^{Unskill}$			-0.01005	-0.01005
			(8.94)	(8.60)
Own-industry channels				
Initial industry tariff: $ln\tau_{ic0}$	0.00010715	0.00020383	1.04408E-15	0.00000141
	(0.44)	(0.47)	(0.00)	(0.00)
Tariff-skill interaction: $ln\tau_{ico} \times S_i/L_i$		0.00017064		-0.00002011
		(0.19)		(0.04)
Initial industry output: lnq_{ic0}	Yes	Yes	Yes	Yes
Average tariffs: $ln\tau_{ic0}$	Yes	Yes	Yes	Yes
Initial production structure	Yes	Yes	Yes	Yes
3 country characteristics	Yes	Yes	Yes	Yes
All fixed effects	Yes	Yes	Yes	Yes
R^2	0.6774	0.6774	0.6783	0.6783

Notes: “3 country characteristics” are initial-year per capita GDP, initial-year investment-to-GDP ratio, and initial-year human capital stock. “All fixed effects’ are the 9 region fixed effects and 2 cohort fixed effects listed in Table 2, as well as 16 industry fixed effects.