The Interwar U.S.–Cuban Sugar Trade and the Hawley Smoot Tariff

Mason Scott Reasner

Department of Economics, Vanderbilt University

Honors Thesis

Advised by Professor Mario J. Crucini

April 2016

Contents

Abstract:

This paper explores the changes in the U.S.–Cuban sugar trade that followed from the enactment of the Hawley–Smoot Tariff Act of 1930. Cuban exports of sugar products faced increased trade barriers in the form of specific tariffs under the Hawley–Smoot legislation. However, while the overall level of Cuban sugar imported into the United States declined significantly with increased trade barriers, the composition of the remaining trade shifted significantly. Indeed, Cuban exports of refined sugar increased rapidly despite the economic slowdown of the Great Depression and increased tariff rates. While these drastic shifts in the composition of trade in sugar products between the U.S. and Cuba cannot be explained by simple analysis of the ad valorem equivalent rates imposed on Cuban exports by the United States, a careful analysis of the effective rate of protection on the process of sugar refining provides an explanation for the otherwise counterintuitive trade pattern. Despite increasing rates of protection on both raw and refined sugar separately, the individual tariff rates on raw and refined sugar were legislated in such a way that under the Hawley–Smoot tariff schedule the effective rate of protection on sugar refining shifted from a positive level of protection over foreign competitors to a negative rate of protection. This paper analyzes the effective protection on sugar refining with a new decomposition of the effective rate of protection. The results of this new decomposition are used to show that unlike the ad valorem equivalent rates on raw and refined sugar that prices were not as significant a factor on the rate of effective protection on sugar refining and that the legislated tariff schedule was the primary factor in its determination.

I. Introduction

"Cuba must always be peculiarly related to us in international politics. She must in international affairs be to a degree a part of our political system. In return she must have peculiar relations with us economically. She must be in a sense part of our economic system."

President Theodore Roosevelt, August 1902[1]

"I believe that few nations of differing languages and cultures have drawn so closely together during the last 50 years, freely and without duress, as have Cuba and the United States… Trade between the two nations has increased steadily in volume and importance… Although our two countries are separated by only ninety miles of water, and vary greatly in size and strength, they collaborate harmoniously on a basis of equal sovereignty and independence of action. This relationship provides living proof of the ability of nations great and small to live in peace and to enjoy the full benefits of commercial and cultural exchange."

President Harry S. Truman, April 19th, 1948[2]

During the early twentieth century, commercial trade between the United States and Cuba was significant for both countries, albeit more so for the island nation of Cuba. The majority of this trade was in the form of sugar products sent from Cuba to the United States, which were necessary to satiate American consumption of sugar during the interwar period, as over half of sugar consumed in the United States originated in Cuba. However, in 1930, with the onset of the Great Depression and the drastic change in trade policy embodied in the Hawley-Smoot Tariff

---

[1] Roosevelt, Theodore. *Compilation*, 56.
[2] Truman, Harry S. *Public Papers,* 81.

Act of 1930, trade between the two countries declined substantially. This shift away from Cuban sugar significantly altered the composition of the American and Cuban sugar industries.

In terms of the American economy, the shifts in the sugar industry were just one small part of major changes that followed from the new legislation. However, for the Cuban economy, the change was disastrous. Nevertheless, in the midst of declining trade between the U.S. and Cuba, especially in sugar products, refined sugar exports from Cuba grew robustly. At the same time, the overall American sugar industry was expanding under protection from foreign competitors. However, the sugar refining industry growth was divergent from the rest of the industry and shrunk over the same period.

The purpose of this paper is to investigate the changes in trade policy in order to clarify the causes for these divergent trends in raw and refined sugar production and bilateral trade. The analysis will proceed by determining the effective rate of protection on the process of sugar refining as well as decomposing the different rates of protection on sugar products by the primary factors that determine the level of protection.

II. Sugar

The word *sugar* refers to a group of simple carbohydrates that taste sweet to the tongue and are consumed by humans. Specifically, most table sugar is sucrose, a disaccharide sugar. The two primary sources of sucrose are sugar cane and sugar beets. Sugar cane is a tall grass that contains sugar-dense cane juice in its stalk, and sugar beets are cultivated plants whose roots store high concentrations of sucrose that is produced by photosynthesis[3]. Beet sugar is produced from the sucrose extracted from the roots of sugar beets and is processed on site into refined

[3] The Sugar Association. *Refining and Processing Sugar*.

(ready for consumption) sugar. Cane sugar is refined from the cane juice contained in the sugar cane stalk and is processed into an intermediate product, raw sugar, at a sugar mill on the same plantation as it is harvested. However, this processing only produces raw sugar, which is not considered fit for human consumption and must be subsequently shipped to a sugar refinery to be processed into a consumable product[4]. Once processed through the refinement stage, beet and cane sugar are indistinguishable and perfectly substitutable[5].

During the early twentieth century, consumption of sugar in the United States was growing quickly. On average, Americans consumed an annual average of 64 pounds of sugar per capita during the period from 1897–1900; however, their consumption increased to an annual average of 103 pounds per capita during the period from 1927–1930[6].

Unlike most tropical goods, which are exported in their crudest form to be processed and refined in the markets for which they are ultimately destined, sugar cane must be processed at the site of cultivation. This follows from the fact that once sugar cane is cut, its sucrose content, and therefore value, begins to diminish as the cane juice leaks from the severed stalks. During the interwar period in Cuba, the accepted amount of time from cutting of the sugar cane in the field to the start of processing at a central mill was less than 24 hours[7].

Different grades of raw sugar are differentiated by their polarization. Polarization is a measure of the sucrose content of a sugar product and is found by measuring the optical rotation of the polarized light that passes through a sugar solution. The degrees of polarization of a sugar product can be thought of as the percent of that solution which is sucrose, i.e. a measure of the purity of the sugar. Sugar that is ready for consumption, refined sugar, has been processed to the

---

[4] Dye, Alan. *Cuban Sugar in the Age of Mass Production*, 35.
[5] The Sugar Association. *Refining and Processing Sugar*.
[6] The United States Tariff Commission. *Sugar*, 6.
[7] Dye, Alan. *Cuban Sugar in the Age of Mass Production*, 94.

point of having a polarization of 100° whereas raw sugar most commonly has a polarization of 95° or 96°.

III. Sugar Trade

Overall, U.S.-Cuban commercial trade was significant for both countries during the first half of the twentieth century. In 1929, on the eve of both the business cycle shock of the Great Depression and the trade policy upheaval of the Hawley-Smoot Tariff, Cuba was the fifth largest exporter to the United States in terms of value of goods exported. U.S. imports of Cuban goods were worth $207 million and represented 5.23% of the total value of goods imported that year. Further, U.S. exports to Cuba were significant as well, totaling $129 million, which represented 2.59% of all U.S., exports in that same year.

From the Cuban perspective, these figures are even more significant. Indeed, Cuban exports to the United States represented 76.6% of total Cuban exports in 1929[8]. Sugar represented the majority of Cuban exports, and 77.99% of Cuban sugar exported that year was shipped to the United States. During earlier years in the 1920s and especially before the First World War, Cuba sent upwards of 90% of its total sugar production to the United States.
This sugar trade was also crucial for the United States because during the interwar period, the supply of sugar for American consumption was sourced from three different locations of production: domestic production in the continental U.S. (cane sugar, primarily in Louisiana, and beet sugar from western and Midwestern states), insular areas of the United States (i.e. Hawaii, Puerto Rico, the Philippines Islands, and to a far lesser extent the American Virgin Islands), and significant imports of raw sugar from Cuba. One can account for essentially the entire U.S.

---

[8] Boeckel, R.M. *Cuban-American relations.*

supply of sugar from 1922 to 1933 with these sources. Before 1930, about half of U.S. sugar consumption was supplied by imports from Cuba, with the rest split relatively evenly between the continental U.S. and the insular regions of the country. However, after 1930, the share of sugar consumption supplied by Cuban imports decreased by 50%, and the difference was made up for by growth in supplies from the United States' insular regions.

Figure 1. – U.S. and Cuban Sugar Production

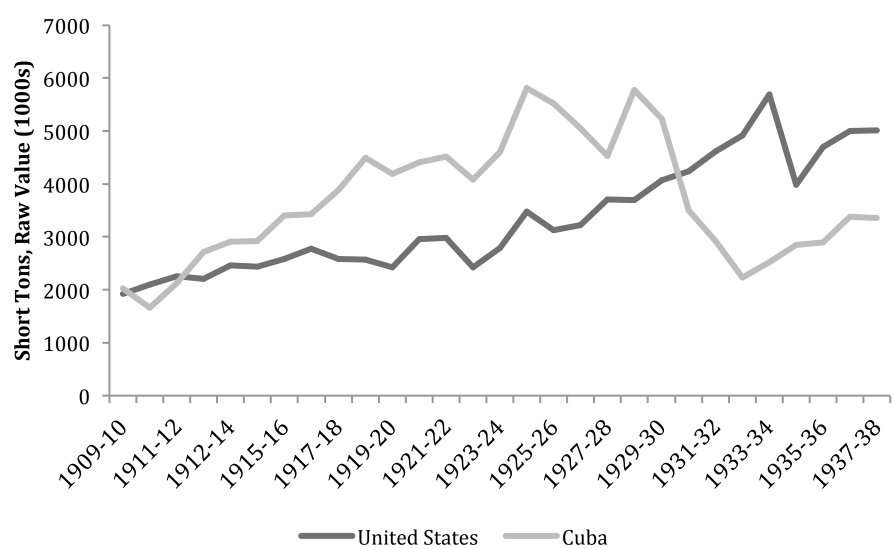
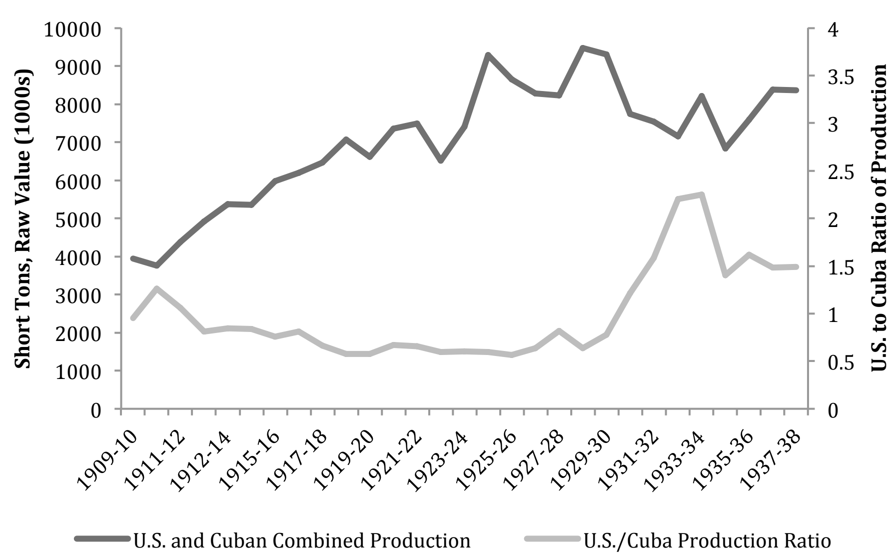


Figure 2. – U.S./Cuban Combined Production and Ratio



The shift in production is presented in Figure 1 and Figure 2, which show trends in Cuban and American sugar production, as well as the combined trend and the ratio between the two sources of sugar production. Sugar production in the continental U.S. in 1932 was primarily of beet sugar, which accounted for 89% of continental production. Louisiana cane sugar was the primary component of the remaining 11% of the continental supply[9].

IV. Tariffs

Trade barriers are impediments to trade between the origin of a product and its destination. Some trade barriers are natural, such as the cost of transporting an item across an ocean. Other barriers are artificially imposed by nations, such as tariffs, quotas, and costs associated with product standards. Specifically, a tariff is a tax imposed by a government on the act of importing a good into its territory. Depending on the size of the tariff relative to the price of the good, a legislated tariff can be prohibitive, i.e. so large that all imports of that good cease. However, sugar from Cuba was continually imported into the United States even as the rates changed, which implies that the tariffs on Cuban sugar were non-prohibitive. While a tariff can take a variety of forms, historically, the United States has primarily levied two kinds of tariffs on imports: specific and ad valorem (separately or in combination).

A specific tariff is a nominal tax; i.e., it is a tax denominated in domestic currency per physical unit imported. For example, taxes on sugar imports were most often in terms of cents per pound. On the other hand, an ad valorem tariff rate is set as a percentage of the value of an imported item. If a non-prohibitive tariff is imposed on a good then the domestic price, p^* , of

[9] The United States Tariff Commission. *Sugar*, 8.

that good can be expressed two ways in terms of the world price, p, and the type of tariff, τ, imposed (see equations 1 and 2).

(1) $$p^{*} = (1+\tau)(p) \quad \text{(ad valorem tariff)}$$

(2) $$p^{*} = p + \tau \quad \text{(specific tariff)}$$

For comparison between the two forms of import duties, a specific rate tariff can be expressed as its ad valorem equivalent duty: by taking the ratio of the specific duty and the unit price of the good, which gives the percentage of the good's unit value that the specific duty is equal to, referred to as the ad-valorem equivalent rate. Given the assumptions above, the ad valorem equivalent rate, *r*, can be consider the percentage difference between the domestic and world price for the good given the imposition of a tariff (see equation 3). Replacing the equations for the domestic price calculations in equations 1 and 2 into equation 3, the expression of the ad valorem equivalent rate for both a specific and an ad valorem tariff can be found (see equations 4 and 5).

(3) $$r = (p^{*} - p)/p$$

(4) $$r = \tau \quad \text{(ad valorem tariff)}$$

(5) $$r = \tau/p \quad \text{(specific tariff)}$$

It is clear from the above equations that differentiating between specific and ad valorem duties is crucial because the two kinds of tariffs, while immediately comparable in a static setting with ad valorem equivalent duties, will respond very differently to changing prices, both the overall level and relative value. This follows from the fact that the ad valorem equivalent rate of an ad valorem tariff is not dependent on the price whereas the ad valorem equivalent rate of a specific tariff is entirely dependent on the price given a static legislated τ. That is, given a change in the unit price of a good, an ad valorem tariff will maintain the same ad valorem equivalent rate by definition (see equation 6 and 7). However, if the price of a good were to increase, the ad valorem equivalent rate of a specific duty on that good would decrease, and vice versa. Further, the rate of this change is not constant for a given price change. In particular, as the price of an imported good approaches zero the rate of change tends towards infinity at an increasing rate of increase while the rate of change decreasingly approaches zero as the price approaches infinity.

(6) $$\frac{dr}{dp} = 0$$ (ad valorem tariff)

(7) $$\frac{dr}{dp} = -\frac{\tau}{p^2}$$ (specific tariff)

It follows that increasing prices will erode the protection afforded by a tariff as the rate of protection slowly approaches zero whereas decreasing prices will push the rate of protection increasingly towards infinity with every decrease in the price. Tables 1 and 2 provide a visualization of these effects for an exemplary scenario where a pound of sugar costs \$0.048 and that the ad valorem equivalent rate of protection is 25% in time period zero. In this scenario, the tariff could either be legislated as a 25% ad valorem tax or as a \$0.012 tax. If the price of a pound of sugar were to fall from \$0.048 to \$0.042 in time period one, the results would differ depending on the form of the tariff.

Table 1. – Specific Rate

Time Period	t_0	t_1
Price	\$0.048	\$0.042
Legislated Rate	\$0.012	\$0.012
Ad Valorem Equiv. Rate	25.0%	52.4%

Table 2. – Ad Valorem Rate		
Time Period	t_0	t_1
Price	$0.048	$0.042
Legislated Rate	25.0%	25.0%
Specific Equivalent Rate	$0.012	$0.011

Given that the rate of protection is dependent on the legislated rate, τ, and the price, p, it is useful to consider the possible causes for changes in the ad valorem equivalent rate. The above examples assumed a fixed τ and explored the results of price changes. However, in reality tariff rates are subject to change through the legislative process. The other causes of change in the rate of protection are related to different kinds of changes in prices. There are two sources of changes in the price of an imported good. First, there is the possibility that inflationary pressures change the overall price level, so that even if the price of a good is constant relative to other goods, the change in price level combined with the static specific tariff rate will change the relative price and the ad valorem equivalent rate of protection. Second, the price of the good itself, relative to all other goods can change with a different magnitude or direction than overall prices, which also alters the ad valorem equivalent rate of a static specific import duty. In contrast, a pure ad valorem tariff rate will not change relative to prices in percentage terms unless the percentage rate of the import duty as legislated is explicitly altered through a change in the tariff schedule.

Crucini (1994) outlines the following equation that decomposes the ad valorem equivalent rate of a tariff in a given year into these three components that influence the ad valorem equivalent rate: a legislative portion, an import price level portion, and a relative price portion (equation 8).

$$\tau_{jt}^{*} = \left[\tau_{js} + \frac{\omega_{js}}{P_{js-1}}\right] + \left[\frac{\omega_{js}}{P_{js-1}}\left(\frac{P_s}{P_t} - 1\right)\right] + \left[\frac{\omega_{js}}{P_{js-1}}\left(\frac{P_{js-1}}{P_{jt}} - \frac{P_s}{P_t}\right)\right] \equiv T_{js}^{L} + T_{jt}^{P} + T_{jt}^{RP} \quad (8)$$

In equation 8, $T_{js}^{L} + T_{jt}^{P} + T_{jt}^{RP}$ represent the legislative, price level, and relative price components of the actualized ad valorem tariff rate, τ_{jt}^{*} (with the index *j* representing the specific good and the index *t* represent the year), respectively. The legislative portion is further decomposed into two parts, the legislated ad valorem rate τ_{js} for the specific good *j* in the legislative period *s* and ad valorem equivalent rate of any specific tariff component ω_{js} for good *j* in legislative period *s* for the price of good *j* in the period it was set, *s-1*. The import price level component is defined as the product of the ratio of the ad valorem equivalent of any specific component in the legislative period *s-1* and the ratio of the price level at the legislated period and the current price level minus one. Finally, the relative price component is the product of the ad valorem equivalent rate of the specific portion of the tariff at the time of legislation and the difference between the ratio of the price at legislation to the current price of good *j* and the ratio of the import price index at the time of legislation to the current import price level index.

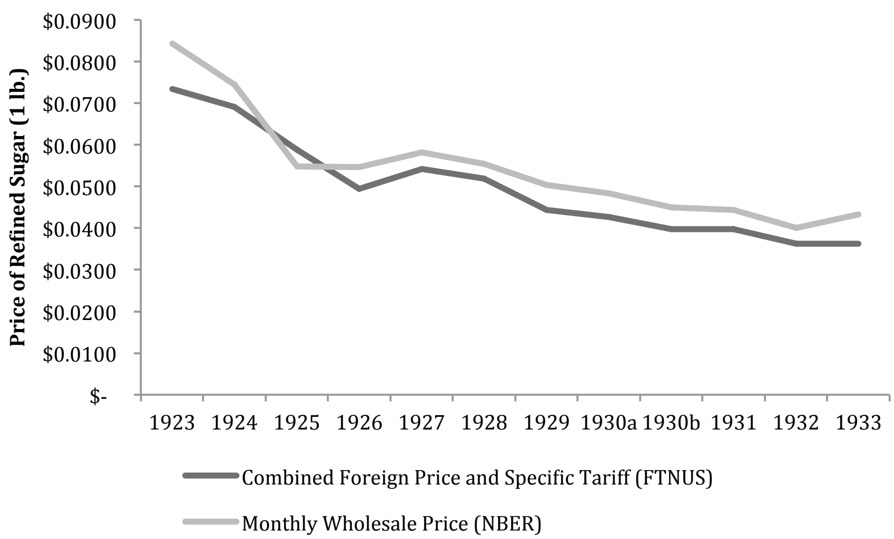
V. The Data

Data on tariff rates and import quantities was collected from the Foreign Trade and Navigation of United States (FTNUS) annual reports of the U.S. Department of Commerce from 1922 to 1933[10]. Each report includes a record of all of the goods imported into the United States in a given year. In particular, for each individual good there is an individual line item that reports the imports of that good for the year (if any were imported at all). Each line item contains four fields: the import duty as legislated in the tariff schedule, the quantity of the good imported in the given year, the total value of the imports for the year, the amount of import revenue collected

[10] These data were generously provided by Professor Mario J. Crucini and represent part of a larger archival exercise involving all U.S. line item imports.

over the year, and for goods not subject to pure ad-valorem tariffs, the average annual equivalent ad valorem duty of the tariff rate.

Figure 3. – Refined Sugar Price, Wholesale vs. Combined Foreign Price and Specific Tariff



From the data on quantity and value imported, the average annual unit value can be calculated. This unit value represents the foreign price that the import duty is levied on. When the U.S. domestic wholesale price of refined sugar (NBER data series m04030a) is compared to this computed price, it is clear that the imputed unit values of imports and wholesale prices are comparable in level and track each other in year-to-year changes (see Figure 3).

The data on sugar imports in FTNUS are delineated by degree of polarization. However, not every degree of polarization was imported in every year so information on price and AVE are not available for the years when certain varieties we not imported. As a practical matter, the majority of sugar imported spanned a handful of varieties that appear in every year of the dataset, most importantly 95°, 96°, 97°, 98° and 100° polarization sugar. The 95° and 96° varieties were the most common polarization of raw sugar imported for refinement into 100° (refined) sugar in the United States. It is evident that beyond 95° and 96° the importation of sugar from Cuba drops off dramatically (see Table 3). Therefore, the following analysis will report decompositions and analyses using 95° and 96° raw sugar as well as refined sugar (100°) imports as analysis of the lesser imported varieties found similar results. In terms of representativeness, when compared to total U.S. imports of sugar from Cuba, it is clear that these two varieties of raw sugar compose the vast majority in any given year (see Table 4).

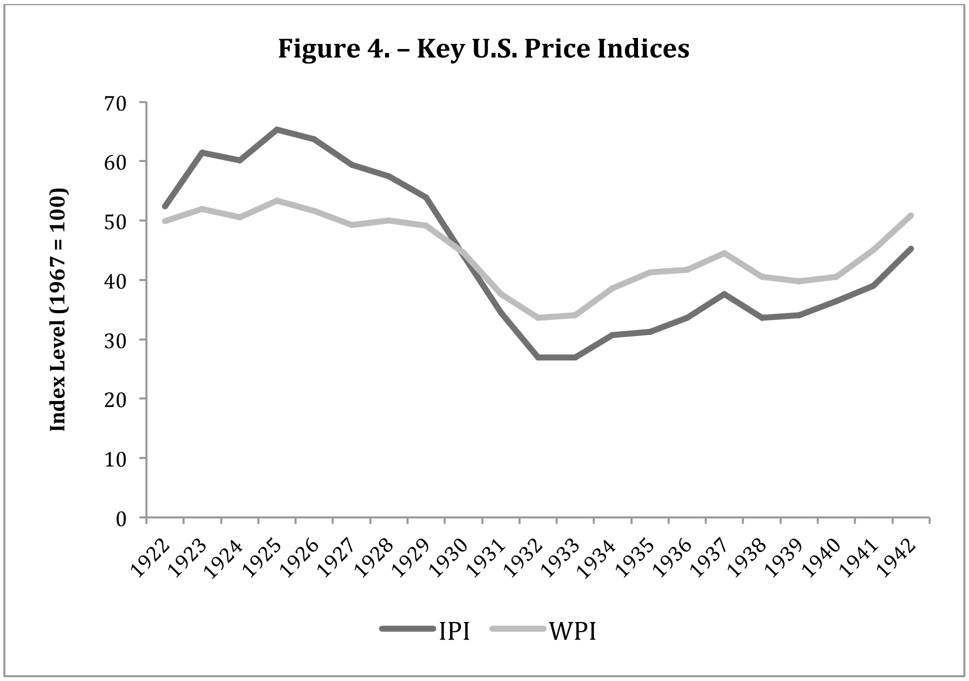
Table 3. – Quantity of Sugar Imported From Cuba by Degree of Polarization (1,000,000 lbs.)

Year	Degree of Polarization					Combined
	95°	96°	97°	98°	100°	
1923	2,515	4,171	55	14	29	6,783
1924	2,958	4,290	154	33	1	7,436
1925	2,791	4,825	123	41	3	7,782
1926	3,195	4,750	130	32	116	8,223
1927	3,048	3,819	227	59	177	7,331
1928	2,427	3,346	332	24	373	6,502
1929	2,619	3,742	391	13	512	7,277
1930a	1,011	1,572	798	56	303	3,740
1930b	830	1,183	52	6	207	2,277
1931	1,540	2,064	447	17	704	4,771
1932	807	1,468	373	64	841	3,553
1933	168	1,568	450	99	780	3,065

Table 4. – 95° and 96° Raw Sugar Compared to Total Sugar Imports 1,000,000 lbs.)

Year	Imports of 95° and 96° (from Cuba)	All Raw Sugar Imports (from Cuba)	All Sugar Imports (from Cuba)	Coverage of All Raw (from Cuba)	Coverage of All Sugar (from Cuba)
1923	6,686	6,755	6,783	98.98%	98.57%
1924	7,248	7,435	7,436	97.48%	97.47%
1925	7,615	7,780	7,782	97.88%	97.85%
1926	7,945	8,107	8,223	98.00%	96.62%
1927	6,868	7,154	7,331	96.00%	93.68%
1928	5,773	6,128	6,502	94.20%	88.79%
1929	6,361	6,765	7,277	94.02%	87.41%
1930a	2,583	3,437	3,740	75.16%	69.07%
1930b	2,012	2,070	2,277	97.22%	88.39%
1931	3,604	4,067	4,771	88.60%	75.53%
1932	2,275	2,712	3,553	83.89%	64.02%
1933	1,736	2,284	3,065	75.99%	56.64%

Further, as overall price level changes will be used in the following analysis, the broader relationship between import prices and wholesale prices is presented below in Figure 4, which compares domestic wholesale prices (Wholesale Price Index, i.e. WPI) and import prices (Import Price Index, i.e. IPI) over the sample period. These data on the import price index and the wholesale price index are available in *Historical Statistics of the United States: Colonial Times to 1970*.



Of primary importance for the following analysis is the large deflation of the price level with the onset of Great Depression, which is evident in both the index of wholesale (domestic) prices as well as import prices. However, while these indices make clear that import and domestic prices moved in the same direction during this period it is also evident that the magnitude of year-to-year changes was greater for import prices.

VI. Sugar Tariffs

In 1898, the U.S.-Cuban sugar trade began to increase in significance for both countries and major revisions to the American tariff schedule also became increasingly relevant. This follows from the fact in 1898, Cuba gained total independence from Spain with the end of the Spanish-American war and was therefore freed from its Spanish colonial trade restrictions[11].

Key revisions and legislation during this period include: the 1904 Reciprocity Agreement between Cuba and the United States, the Payne-Aldrich Tariff Act of 1909, the Underwood Tariff Act of 1913, the Emergency Tariff Act of 1921, the Fordney-McCumber Tariff Act of 1922, and the Hawley-Smoot Tariff of 1930. The table in Appendix A (Table A1) summarizes the tariff rates on imports of sugar over time by tariff schedule and key technical changes in the legislation during the period that are, in part, presented in the following paragraphs.

The Reciprocity Treaty of 1904 between the United States and Cuba, along with the ratification of new Cuban constitution that same year, marked the end of the American military occupation of the island. Politically, the treaty represented the benefits that Cuba gained from its new pseudo-imperial relations with the United States[12]. Of primary concern to the U.S.-Cuban sugar trade, the treaty provided for a 20% reduction of import duties on goods originating in Cuba.

The Payne-Aldrich Tariff of 1909 did not significantly change U.S. trade policy on sugar imports. During the decade preceding the revision, domestic production and refinement of sugar had grown under the umbrella of protection. Indeed, if the Philippines and Cuba are included, by 1907 over 90 percent of sugar consumption in the United States originated in the insular areas under American trade protection[13]. The 1909 tariff schedule revision allocated free importation of sugar from the Philippines up to 300,000 tons a year, which bolstered the Philippine sugar

[11] Dye, Alan. *Cuban Sugar in the Age of Mass Production*, 58.
[12] Ibid.
[13] Fisk, George M. *The Payne-Aldrich Tariff*.

industry immensely[14]. In the following decades, it would grow into a major supplier to the United States market.

The Underwood Tariff of 1913 broadly decreased domestic protection in the U.S. and sugar was no exception. However, it is important to note that these specific rates on sugar became an increasingly smaller percentage of the cost of sugar as the First World War produced strong inflationary pressures that eroded nominal protections, which spurred the calls for revisions under the new Republican administrations that came to power at the end of the war. The Emergency Tariff of 1921 was the first such upward revision to the tariff schedule that followed the First World War.

The Fordney-McCumber Tariff Act of 1922 broadened the aims of the Emergency Tariff in a comprehensive tariff schedule revision. Most of the industries that saw increased protection under the Emergency Tariff had these protective measures reinforced with further tariff hikes. Import duties on a pound of refined sugar were increased from 2.160 cents per pound to 2.390 and on a pound of 96° raw sugar from 2 cents a pound to 2.2060 cents per pound. Both the duty-free status of importation of sugar from the Philippines and the 20% reduction on import duty rates for Cuban goods remained active under this tariff schedule.

Finally, the Hawley-Smoot Tariff Act of 1930 represents the apex of American protectionist fervor. Agricultural agitation over the state of trade policy and campaign promises from the 1928 Republican platform brought the Fordney-McCumber schedule up for revision following the election. In June 1930, the Hawley-Smoot bill was enacted and broadly raised import duties to protect domestic industry[15]. This is exemplified by the rates on sugar, which increased from 2.390 cents per pound of refined sugar to 2.650 cents and from 2.2060 cents per

[14] Fisk, George M. *The Payne-Aldrich Tariff*.
[15] Irwin, Douglas. *Peddling Protectionism*.

pound of 96° raw sugar to 2.5 cents. However, the legislative changes were not the end of tariff increases in the early years of the Great Depression. Much like how the inflation during the First World War eroded the specific rates as outlined in the Underwood tariff schedule, deflation in the first few years of the Great Depression sent the already elevated specific tariff rates from the Hawley-Smoot schedule to extraordinary heights.

Given that under both the Fordney-McCumber and Hawley-Smoot tariff schedules the import duties on sugar imports were legislated as specific rates, i.e., in terms of a nominal value per unit, on different levels of polarization, the tariff rate can be expressed as a function of polarization. Under both schedules, a base rate in terms of cents per pound was set for raw sugar testing by the polariscope not above a polarization of 75°. Recall, the polarization of raw sugar is a measure of the amount of sucrose in a sugar solution versus water and other matter as measured by the polarization of light through the solution. From the base rate for sugar imports of 75°, the tariff rate was increased in a linear fashion for each additional degree of refinement.

While both the Fordney-McCumber and Hawley-Smoot tariff schedules legislate the import duties on tariffs in the same linear fashion, the Hawley-Smoot Tariff Act of 1930 increased the base rate from 1.24 cents per pound of 75° raw sugar to 1.7125 cents per pound. Significantly, the Hawley-Smoot tariff schedule reduced the rate of linear increase with each additional degree of polarization from .0460 cents per degree to .0375 cents per degree (see Figure 5). This reduced the percentage increase in the import duty with each associated with additional degree of refinement, especially so at the highest levels of refinement, which also were the most commonly imported.

Since the tariff legislation set the tariff rates on sugar in nominal terms, the true variation in the rate of protection year-to-year is not evident given the rate alone. The real variation is embodied in the ad valorem equivalent rates presented in Figure 6 on the different grades of raw sugar imports from Cuba during the period under the Fordney-McCumber and Hawley-Smoot tariff schedules.

Figure 5. – General and Cuban Tariff Schedules for Sugar Imports under Fordney-McCumber (1922) and Hawley-Smoot (1930) Legislation

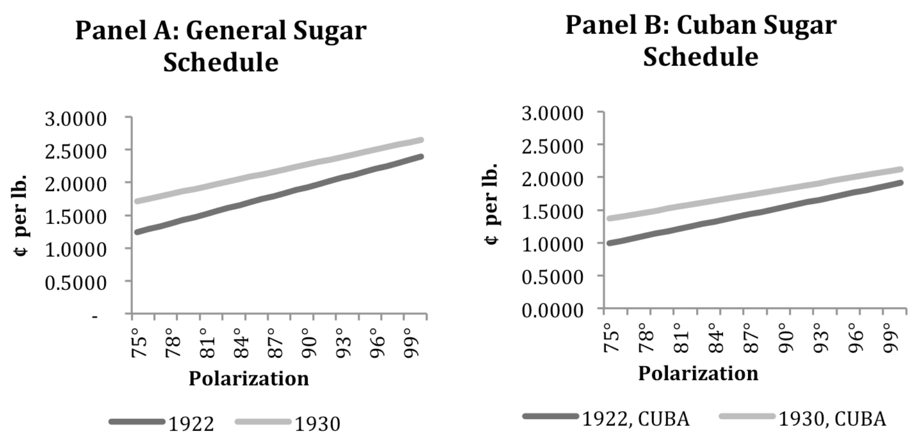
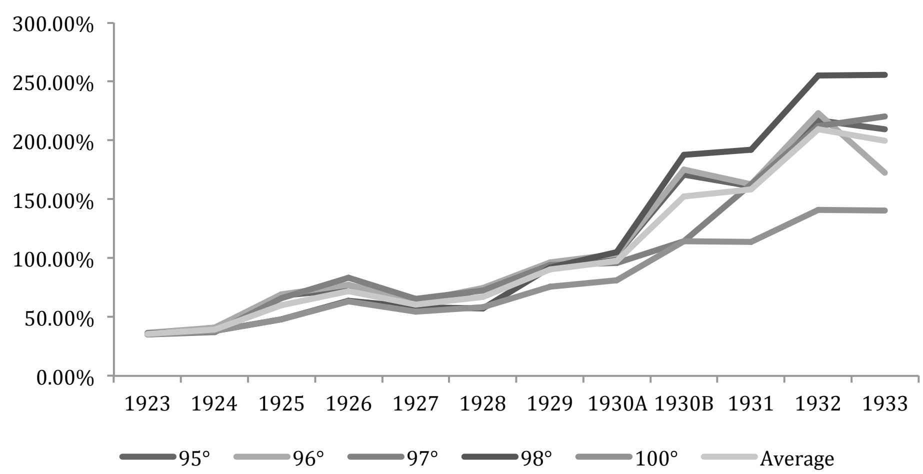


Figure 6. – Ad Valorem Equivalent Rates



Unlike the specific rates legislated in the tariff schedule, the ad valorem equivalent rates for these varieties varied widely over the decade surveyed, which indicates that there were significant price changes (both overall level and relative) that are not evident when simply accounting for the legislated specific rates. The decomposition of these realized ad valorem equivalent rates according to the Crucini (1994) decomposition are presented below (see Figure 7 and Table 5). The weighting by variety is accomplished by taking the total of the imports of 95° and 96° from the full sample years (1923-1933) and finding the ratio between the variety total and the total for both varieties of raw sugar from Cuba.

Figure 7. – Crucini Ad Valorem Equivalent Decomposition

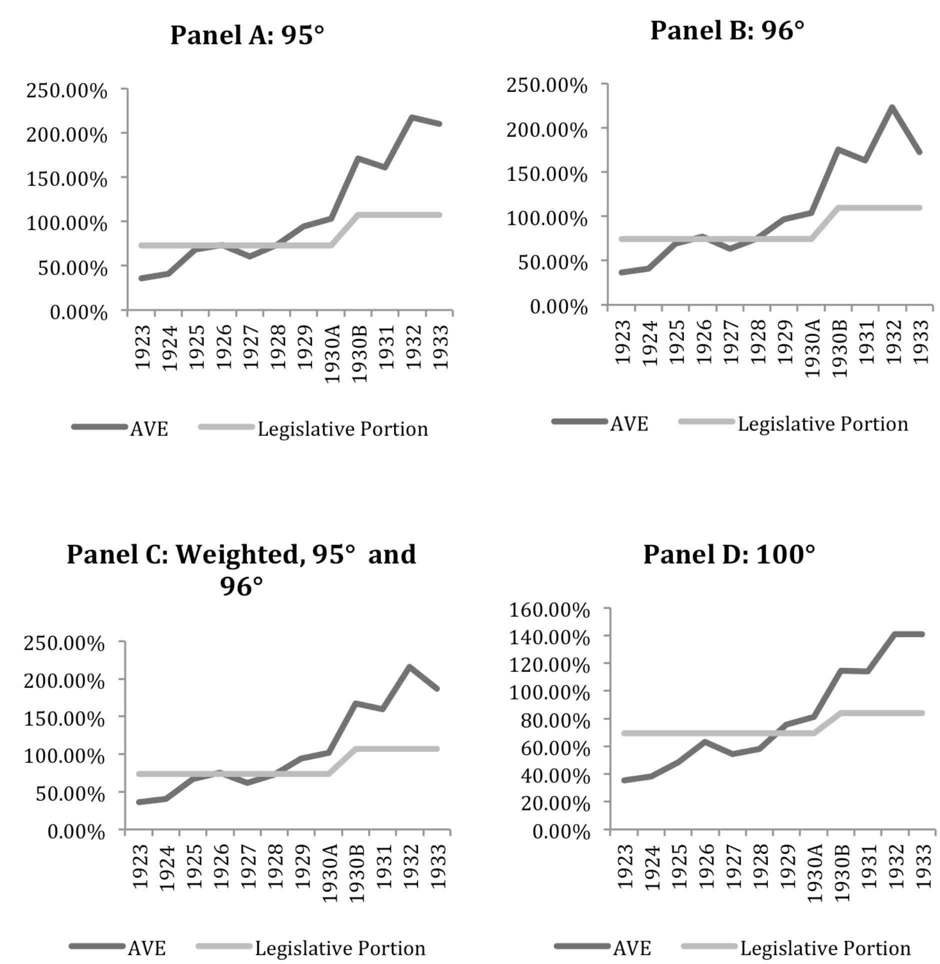


Table 5. – Crucini Three-Component Decomposition of AVE Tariff Rates on Cuban Sugar, Panel A: 95° polarization

Year	AVE	Legislative Portion	Import Price Movements	Relative Price	Combined	Error
1923	35.5%	72.9%	-10.7%	-26.7%	35.5%	0.0%
1924	41.1%	72.9%	-9.3%	-22.4%	41.1%	0.0%
1925	68.2%	72.9%	-14.4%	9.8%	68.2%	0.0%
1926	73.5%	72.9%	-12.9%	13.6%	73.5%	0.0%
1927	60.0%	72.9%	-8.6%	-4.3%	60.0%	0.0%
1928	73.3%	72.9%	-6.4%	6.8%	73.3%	0.0%
1929	94.3%	72.9%	-2.0%	23.4%	94.3%	0.0%
1930A	102.8%	72.9%	13.5%	16.4%	102.8%	0.0%
1930B	170.7%	107.5%	0.0%	63.2%	170.7%	0.0%
1931	161.0%	107.5%	30.2%	23.3%	161.0%	0.0%
1932	217.0%	107.5%	69.1%	40.3%	217.8%	0.0%
1933	209.6%	107.5%	69.1%	33.0%	209.6%	0.0%

Panel B: 96°

Year	AVE	Legislative Portion	Import Price Movements	Relative Price	Combined	Error
1923	36.5%	74.3%	-10.9%	-26.9%	36.5%	0.0%
1924	41.1%	74.3%	-9.5%	-23.6%	41.1%	0.0%
1925	69.1%	74.3%	-14.7%	9.5%	69.1%	0.0%
1926	77.2%	74.3%	-13.2%	16.1%	77.2%	0.0%
1927	63.4%	74.3%	-8.8%	-2.1%	63.4%	0.0%
1928	74.8%	74.3%	-6.5%	7.0%	74.8%	0.0%
1929	96.6%	74.3%	-2.1%	24.4%	96.6%	0.0%
1930A	103.6%	74.3%	13.8%	15.5%	103.6%	0.0%
1930B	175.2%	109.5%	0.0%	65.8%	175.2%	0.0%
1931	163.0%	109.5%	30.8%	22.6%	162.8%	0.2%
1932	223.0%	109.5%	70.4%	43.3%	223.1%	-0.1%
1933	172.6%	109.5%	70.4%	-7.2%	172.6%	0.0%

Panel C: Weighted by Variety (95° and 96°)

Year	AVE	Legislative Portion	Import Price Movements	Relative Price	Combined	Error
1923	33.9%	69.2%	-10.1%	-25.2%	33.9%	0.0%
1924	38.6%	69.2%	-8.9%	-21.7%	38.6%	0.0%
1925	64.5%	69.2%	-13.7%	9.0%	64.5%	0.0%
1926	71.1%	69.2%	-12.3%	14.2%	71.1%	0.0%
1927	58.3%	69.2%	-8.2%	-2.8%	58.3%	0.0%
1928	69.6%	69.2%	-6.0%	6.5%	69.6%	0.0%
1929	89.8%	69.2%	-1.9%	22.5%	89.8%	0.0%
1930A	96.9%	69.2%	12.8%	14.9%	96.9%	0.0%
1930B	162.8%	102.0%	0.0%	60.8%	162.8%	0.0%
1931	152.2%	102.0%	28.7%	21.5%	152.1%	0.1%
1932	207.0%	102.0%	65.6%	39.5%	207.1%	-0.1%
1933	175.6%	102.0%	65.6%	8.1%	175.6%	0.0%

Panel D: 100°

Year	AVE	Legislative Portion	Import Price Movements	Relative Price	Combined	Error
1923	35.2%	69.4%	-10.2%	-24.0%	35.2%	0.0%
1924	38.2%	69.4%	-8.9%	-22.3%	38.2%	0.0%
1925	48.2%	69.4%	-13.7%	-7.5%	48.2%	0.0%
1926	63.2%	69.4%	-12.3%	6.2%	63.2%	0.0%
1927	54.5%	69.4%	-8.2%	-6.7%	54.5%	0.0%
1928	58.2%	69.4%	-6.0%	-5.1%	58.2%	0.0%
1929	75.7%	69.4%	-1.9%	8.3%	75.7%	0.0%
1930A	81.2%	69.4%	12.9%	-1.0%	81.2%	0.0%
1930B	114.4%	83.9%	0.0%	30.3%	114.2%	0.0%
1931	114.0%	83.9%	23.6%	6.5%	114.0%	0.0%
1932	141.0%	83.9%	54.0%	2.9%	140.8%	0.2%
1933	140.6%	83.9%	54.0%	2.8%	140.6%	0.0%

The decomposition of the ad valorem equivalent rates on raw and refined sugar indicate that the price components, which were the primary factor driving the ad valorem equivalent rates higher throughout the period, were the most significant determining factor of the ad valorem equivalent rates during the period. For the different varieties of sugar imported the impact of the relative price of sugar was mixed from year-to-year, whereas the overall price level was a significant factor in holding the rates down in the 1920s and raising them higher in the 1930s.

VII. Production Structure

The process of refining sugar from its raw semi-crude form to granulated sugar that is ready for human consumption is technically very similar to the processing that takes sugar cane stalks and transforms them into raw sugar. Centrifuges, evaporation, and chemical processes are all used to extract from the raw sugar the pure sucrose that will be sold for consumption[16]. Like sugar processing, by the early twentieth century, sugar refining had grown into an industrialized high-throughput industry. Intricate machinery that minimized the need for human interaction and maximized the flow of inputs through the production process was used instead of the more traditional approaches that had been popular a century earlier[17].

A sugar refiner would purchase raw sugar in bulk, which depending on its purity would require more or less refinement and a greater or lesser quantity in order to produce a single pound of refined sugar. Technically, there are two forms of refined sugar, hard and soft. Hard refined sugar is completely separated from any molasses and clear, whereas soft sugar generally has some molasses still attached and is brown in color. However, both involve similar levels of

[16] The Sugar Association. *Refining and Processing Sugar*.
[17] Dye, Alan. *Cuban Sugar in the Age of Mass Production*, 58.

refinement from raw sugar. The primary inputs into this process were then, the capital embodied in the large factories and intricate machines that refined the sugar, the labor that was required to maintain and run the machinery, a source of energy by which to power the machinery, and the raw sugar that was to be refined. Data from the Census of Manufactures in 1929, 1931, and 1935 indicates that over 90% (an average and median of 93%) of the input costs for sugar cane refining in the United States were from the direct input of raw sugar, with the remaining 7% composed on wages and energy[18]. However, not all of the value-added throughout the refinement process represented the same kind of underlying relationships. Unlike the rest, the quantity of sugar required to produce one unit of refined sugar was a static physical relationship defined by a technical coefficient. Regardless of the price of raw sugar or other inputs, if a refiner produced one unit of refined sugar, hard or soft, it required a set amount of raw sugar. It follows that the production function of sugar refinement can be expressed as equation 9 and 10.

$$q_j = f(k, l, q_i, \psi_{ij}) \tag{9}$$

$$q_j = min\left(k^{\alpha} l^{1-\alpha}, \frac{1}{\psi_{ij}} q_i\right) \tag{10}$$

This production function defines the production of a quantity of refined sugar, q_j, as a relationship of three inputs and one relation: capital (*k*), labor (*l*), raw sugar (q_i), and the physical input-output relationship between raw sugar and refined sugar, the technical coefficient (ψ_{ij}). Here the simplest assumption is made about the value-added aspects of sugar refinement, a Cobb-Douglas relation, whereas the Leontief relationship is relevant for the relationship between physical units of raw sugar inputs and refined sugar outputs. This specification is supported by

[18] Crucini, Harrison, Reasner, Rodrigue, and Zeibarth (2016)

other investigations into the sugar refining industry[19] as well as documentation from the Tariff Commission (1934).

It follows that the cost function a unit of refined sugar, as determined by this production framework and cost minimization, is expressed in equations 11 to 13.

(11) $$c_j = f(r, w, p_i, \psi_{ij})$$

(12) $$c_j = \Omega * r^{\alpha} * w^{(1-\alpha)} + p_i * \psi_{ij}$$

(13) $$\Omega = \left[\frac{(1-\alpha)}{\alpha}\right]^{\alpha} + \left[\frac{\alpha}{(1-\alpha)}\right]^{(1-\alpha)}$$

A detailed exposition of the firm's minimization problem can be found in appendix B. This composite cost function explicitly expresses the relationship of the cost of sugar refining as a function of the rate of capital, *r*, the wage of labor, *w*, the price of the raw sugar input, *i,* and the technical coefficient of production ψ_{ij}. Again, like the production function from which it is derived, this cost function can be decomposed into two components: the Leontief technical relationship between input *i* and output *j* as well as the value added component defined by Cobb-Douglas relationship.

Table 6. – Raw-to-Refined Sugar Conversion Factors[20]

Polarization	Pound of Sugar (Raw Value Per Pound)	Pounds to Pound Refined Value
100°	1.07000	1.0000
99°	1.05250	1.0166
98°	1.03500	1.0338
97°	1.01750	1.0516
96°	1.00000	1.0700
95°	0.98250	1.0891
94°	0.96500	1.1088
93°	0.94750	1.1293
92°	0.93000	1.1505

[19] Genesove and Mullin. *Testing static oligopoly models* (1998).
[20] Chen and Chung-Chi. *Cane sugar handbook*, 435.

Note that the above production and cost functions are defined in terms of a single input and a single output. However, during the interwar period, a variety of inputs, distinguished by their degree of polarization, were utilized in the production of refined sugar. Each variety of raw sugar will have its own price and unique technical coefficient. These multiple inputs can be analyzed separately or combined by a weighted average by the quantity imported in a given year. The following table (Table 6) outlines the technical coefficients of the raw sugar inputs by polarization. For example, one pound of raw sugar measured by the polariscope to have a polarization of 96° will produced only 0.935 pounds of refined sugar, in this case, ψ_{ij} would equal 1.07 and $1/\psi_{ij}$ would equal 0.935.

VIII. Effective Protection

The effective rate of protection is a calculated ad valorem equivalent tariff rate that incorporates the impact of different tariffs on intermediate inputs and final goods. Essentially, the effective rate of protection can be thought of as equivalent to the ad valorem equivalent tariff rate on the value-added of production for a particular good given the tariff on the output and inputs and the optimal responses of input choice to the tariff schedule. The following analysis will decompose the effective rate of protection on the process of refining sugar in the United States, which is different from the ad valorem equivalent tariff rate on refined sugar because the inputs into the process of refining, raw sugar, are also taxed with import duties. Formally, the effective rate of protection can be expressed as in Anderson and Naya (1969) (see equation (14)):

$$e_j = \frac{v_j' - v_j}{v_j} \tag{14}$$

In the equation above: e_j is effective rate of protection for good *j*, v_j' is the value-added by the specific production process per unit under the protection of a tariff, and v_j is the same value-added under free-trade. However, given a historical dataset, such as that available in FTNUS, it is impossible to measure the value-added from the process of refining sugar in both a protected and free trade condition. Normally, this would be a significant issue as the measure v_j would not be the same in both scenarios. Indeed, in the free trade scenario the value-added is equation 15.

(15) $$v_j = p_j - p_i\psi_{ij}$$

In the above equation, p_j is the price of the final good *j*, p_i is the price of the intermediate good *i,* and ψ_{ij} is the necessary quantity of good *i* required to produce one unit of good *j*[21]. Whereas the protective scenario, the presence of tariffs, with ad valorem equivalent rates of t_i on the input good *i* and t_j on the output good *j*, will influence domestic prices and result in a different value-added, v_j' which is expressed in equation 16.

(16) $$v_j' = p_j(1 + t_j) - p_i(1 + t_i)\psi_{ij}$$

Notice here, it is assume the input quantity per unit of output has not changed in response to the change in the tariff schedule. In general, it is likely that the change in domestic prices will, in fact, result in an adjustment in the production process to a new equilibrium combination of inputs that give a new physical relationship between the input and output goods, such that $\psi_{ij}' \neq \psi_{ij}$[22]. This results in the following value-added where ψ_{ij} is replaced by the new ψ_{ij}' in equation 17.

(17) $$v_j'' = p_j(1 + t_j) - p_i(1 + t_i)\psi_{ij}'$$

[21] Anderson, James, and Seiji Naya. *Substitution and two concepts of effective rate of protection*.
[22] Ibid.

Clearly it is important to understand how input choices per unit of output change to determine both ψ'_{ij} and ψ_{ij} to measure the effective rate of protection correctly. This is evident in the following equations for the effective rate of protection; r_j under free trade conditions and r'_j under protected conditions, with the previous definitions of value-added substituted in for calculability[23] in equations 18 and 19.

(18)
$$r_j = t_j + \frac{(t_j - t_i)\left({}^{p_i}/_{p_j}\right)\psi_{ij}}{1-\left({}^{p_i}/_{p_j}\right)\psi_{ij}}$$

(19)
$$r'_j = t_j - \frac{(1+t_j)\left(\left({}^{p_i}/_{p_j}\right)\psi'_{ij} - \left({}^{p_i}/_{p_j}\right)\psi_{ij}\right)}{1-\left({}^{p_i}/_{p_j}\right)\psi_{ij}}$$

Notice that the difference between r_j and r'_j follows solely from the fact that $q'_{ij} \neq q_{ij}$. If instead $\psi'_{ij} = \psi_{ij}$, then $\left({}^{p_i}/_{p_j}\right)\psi'_{ij} = \left({}^{p_i}/_{p_j}\right)\psi_{ij}\left(\frac{1+t_i}{1+t_j}\right)$ and it would follow that $r_j = r'_j$ and therefore the effective rate of protection could be measured without bias from data that is exclusively from either free trade or protected conditions, such as the import data available from the Foreign Trade and Navigation of United States annual records.

The specification of the production structure presented in the previous section reveals that ψ_{ij} is a ratio that defines a Leontief production, i.e. fixed proportion, input-output relationship. In the case of sugar refinement, it is a physical relationship arising from the chemical composition of sugar solutions that defines the technical coefficient. This characteristic of the process of sugar refinement is crucial to the determination of the effective rate of protection. Due to its physical nature, this input-output relationship will not shift due to substitution with

[23] Anderson, James, and Seiji Naya. *Substitution and two concepts of effective rate of protection*.

changing prices. It follows that in the case of sugar refining that ψ'_{ij} is indeed equal to ψ_{ij}, which allows for an unbiased estimation of the effective rate of protection.

Estimating the effective rate of protection for sugar refining is particularly important given the legislative changes to the tariff schedule embodied in the Hawley-Smoot Tariff of 1930, which represented a shift in policy away from explicit effective protection of the sugar refining industry. It will be shown how this change in policy, the move from a positive to a negative effective rate of protection for sugar refining, significantly impacted the trade flows of sugar between the United States and Cuba as well as the configuration of production.

IX. Effective Rate of Protection, Determination and Decomposition

As explored in an earlier section, the Hawley-Smoot Tariff Act of 1930 increased the base level of the tariff on sugar imports by 13.33% and simultaneously decreased the increment with which the specific rate increased for each additional degree of polarization over 75°, which will be significant in determining the effective rate of protection. Given the fixed technical coefficients for sugar refinement, the determination of the effective rate of protection will require an adjustment to be made for these physical ratios. Without such an adjustment for the input-output ratio, the result is the tariff schedule as outlined in Figure 8. With adjustment for the technical coefficients, the Fordney-McCumber schedule, with its greater incremental increase for each degree of refinement remains upward sloping even with the adjustment, an indication of a positive effective rate of protection for sugar refinement, i.e. a greater tariff on the output of refining than the necessary amount of inputs (see Panel A of Figure 9). However, due to the legislated decrease in the increment of change with each additional degree of refinement, the Hawley-Smoot tariff schedule does not remain positively sloping with the technical coefficient adjustment (see Panel B of Figure 9). Instead, the adjusted tariff schedule is downward sloping, indicating a negative rate of effective protection as the import duties levied on the inputs of one unit of output are greater than those on the output itself.

Figure 8. – Fordney-McCumber and Hawley-Smoot Tariff Schedules without Adjustment for Technical Coefficients

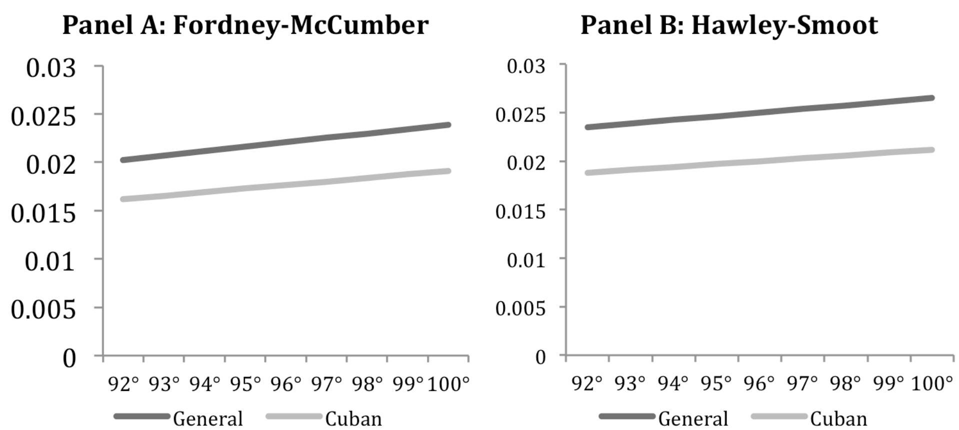
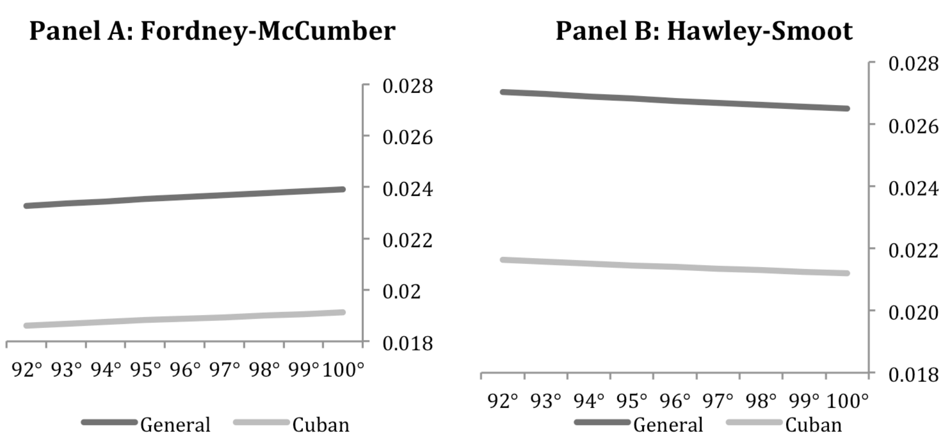


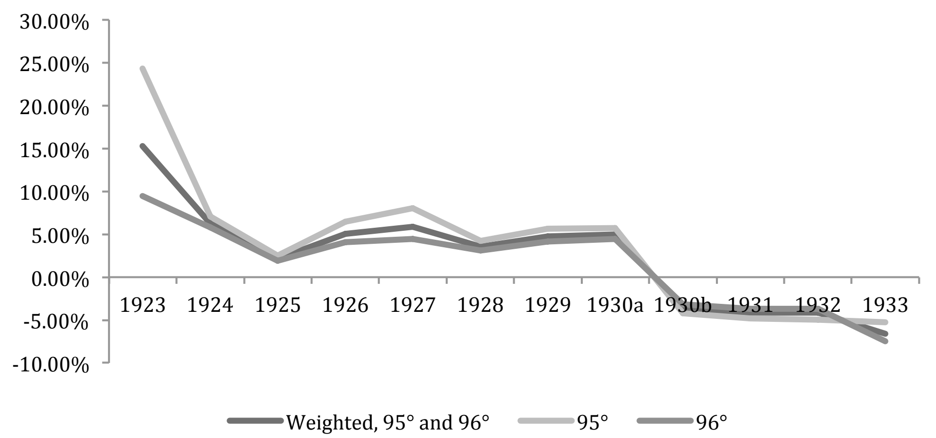
Figure 9. – Fordney-McCumber and Hawley-Smoot Tariff Schedules with Adjustment for Technical Coefficients



This shift in tariff policy was lobbied against by the American sugar refining industry as it put them at a competitive disadvantage to both foreign competitors, especially Cuban refiners, and beet sugar producers that refined their product at the site of cultivation[24]. In the figure below (see Figure 10), it is shown that the Hawley-Smoot tariff schedule drove the effective rate of protection on the American sugar refining industry into negative territory. After 1934, with the official cartelization of the American sugar market, the status of Cuban refiners became less advantageous in terms of the tariff schedule, which is evidenced by the FTNUS records.

Once calculated without bias, the effective rate of protection can decomposed in a similar manner to the ad valorem equivalent tariff rates three-component decomposition as outlined in Crucini (1994). This extension of the previous literature is accomplished through a reinterpretation of each of three components of the decomposition (a legislative component, an import price level component, and a relative price movement component) in order to reflect the same three influences impact on the effective rate of protection. This new decomposition is presented in the equation below (see Equation 20).

Figure 10. – Effective Protection By Degree (95°, 96°, Weighted)



24 American Sugar Refining Company. *Annual Report*, 7.

$$(20)\quad e_{jt}^{*} = \left[\frac{\omega_{js}-\omega_{is}\psi_{ij}}{\left((p_{js-1}+\omega_{js-1})-\left((p_{is-1}+\omega_{is-1})(\psi_{ij})\right)\right)}\right] +$$

$$\left[\frac{\omega_{js}-\omega_{is}\psi_{ij}}{\left((p_{js-1}+\omega_{js-1})-\left((p_{is-1}+\omega_{is-1})(\psi_{ij})\right)\right)}\left(\frac{P_s}{P_t}-1\right)\right] +$$

$$\left[\frac{\omega_{js}-\omega_{is}\psi_{ij}}{\left((p_{js-1}+\omega_{js-1})-\left((p_{is-1}+\omega_{is-1})(\psi_{ij})\right)\right)}\left(\frac{\left((p_{js-1}+\omega_{js-1})-(p_{is-1}+\omega_{is-1})(\psi_{ij})\right)}{\left((p_{js}+\omega_{js})-\left((p_{is}+\omega_{is})(\psi_{ij})\right)\right)}-\frac{P_s}{P_t}\right)\right]$$

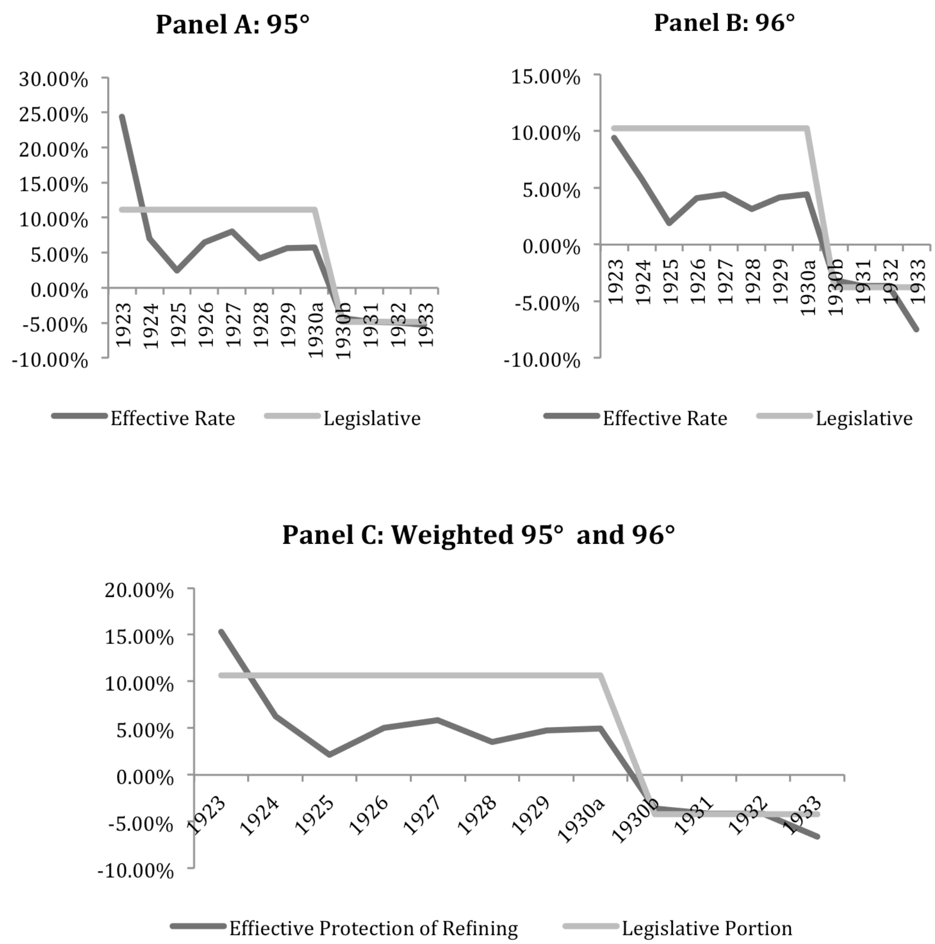
$$\equiv e_{js}^{L} + e_{jt}^{P} + e_{jt}^{RPD}$$

With this new decomposition, the legislated rate is calculated as the difference between the specific tariff rate on one unit of the output good and the specific tariff rate on the input good times the amount of the input needed to create one unit of output divided by the difference between the price in the previous legislative period of one unit the output good and the amount of input needed for one unit of output of the input good in the previous legislative period.

The import price component is expressed as the multiplication of the legislated component with the percent difference of the overall level of import prices in the given year compared to the first year of the current legislative period. Further, the relative price component, i.e. the movement of the price of the difference between the input and output good compared to movement of overall prices, is expressed by the multiplication of the legislated portion by the percent difference between the percent change in the relative price level and the overall price level compared to the levels in the first year of the legislated period.

Moreover, this new decomposition can be broken out by the degree of polarization and with a single combined decomposition where the different polarizations of raw sugar are weighted by import shares. In each of the decompositions it is clear that the Hawley-Smoot schedule represented a dramatic shift from the pre-1930 positive effective rate of protection to a negative effective rate of protection for the sugar refining industry (see Figure 11 and Table 8, Panel A and B).

Figure 11. –Effective Rate of Protection Decomposition



Unlike the ad valorem equivalent rates on imports of raw sugar, where the primary variation was the result of overall price changes, the primary mechanism of change in the effective rate of protection appears to be the legislative component. This result would follow from the fact that both refined and raw sugar prices moved with a similar magnitude and in a similar direction during the sample period, so the difference between the two did not change as drastically as the actual prices. This would be expected, given that 93% of the cost of refined sugar production is the raw sugar imports and the lack of substitutability that follows from the existence of fixed technical coefficients of production. However, the difference in the tariff rates on inputs and outputs shifted substantially, which were therefore the primary mechanism that determined variation under the Fordney-McCumber and Hawley-Smoot tariff schedules from 1922 to 1934.

The weighted decomposition suggests effective rate of protection for the refining industry was legislated so as to provide an effective rate of protection of 10.63% under the Fordney-McCumber schedule. The legislated portion was reduced by almost 15 percentage points (14.83) to negative 4.20 percentage points, a decrease of 138.83% with the introduction of the Hawley-Smoot tariff schedule in 1930. The decomposition of the effective rate of protection in Table 8 and Figure 11 shows that the two varieties of raw sugar that composed over 90% of all sugar imports, 95° and 96° polarization, exhibit fluctuations within the range expected from the fluctuations of the relative and overall price levels over the period (see Table 8, Panel C).

Table 8. – Three Component Decomposition of the Effective Rate of Protection on Sugar Refining by Polarization of Input

Panel A: 95° Polarization

Year	Effective Protection of Refining	Legislative Portion	Import Price Movements	Relative Difference Raw and Refined	Composite	Error
1923	24.4%	11.2%	-1.6%	14.8%	24.4%	0.0%
1924	7.0%	11.2%	-1.4%	-2.7%	7.0%	0.0%
1925	2.5%	11.2%	-2.2%	-6.45	2.5%	0.0%
1926	6.5%	11.2%	-2.0%	-2.7%	6.5%	0.0%
1927	8.1%	11.2%	-1.3%	-1.8%	8.1%	0.0%
1928	4.2%	11.2%	-1.0%	-6.0%	4.2%	0.0%
1929	5.7%	11.2%	-0.3%	-5.2%	5.7%	0.0%
1930a	5.8%	11.2%	2.1%	-7.5%	5.8%	0.0%
1930b	-4.3%	-4.9%	0.0%	0.6%	-4.3%	0.0%
1931	-4.8%	-4.9%	-1.4%	1.4%	-4.8%	0.0%
1932	-4.9%	-4.9%	-3.1%	3.1%	-4.9%	0.0%
1933	-5.3%	-4.9%	-3.1%	2.7%	-5.3%	0.0%

Panel B: 96°						
Year	Effective Protection of Refining	Legislative Portion	Import Price Movements	Relative Difference Raw and Refined	Composite	Error
1923	9.4%	10.3%	-1.5%	0.7%	9.4%	0.0%
1924	5.8%	10.3%	-1.3%	-3.2%	5.8%	0.0%
1925	1.9%	10.3%	-2.0%	-6.3%	1.9%	0.0%
1926	4.1%	10.3%	-1.8%	-4.4%	4.1%	0.0%
1927	4.4%	10.3%	-1.2%	-4.6%	4.4%	0.0%
1928	3.1%	10.3%	-0.9%	-6.3%	3.1%	0.0%
1929	4.1%	10.3%	-0.3%	-5.9%	4.1%	0.0%
1930a	4.5%	10.3%	1.9%	-7.7%	4.5%	0.0%
1930b	-3.2%	-3.8%	0.0%	0.6%	-3.2%	0.0%
1931	-3.7%	-3.8%	-1.1%	1.2%	-3.7%	0.0%
1932	-3.7%	-3.8%	-2.4%	2.5%	-3.7%	0.0%
1933	-7.5%	-3.8%	-2.4%	-1.3%	-7.5%	0.0%

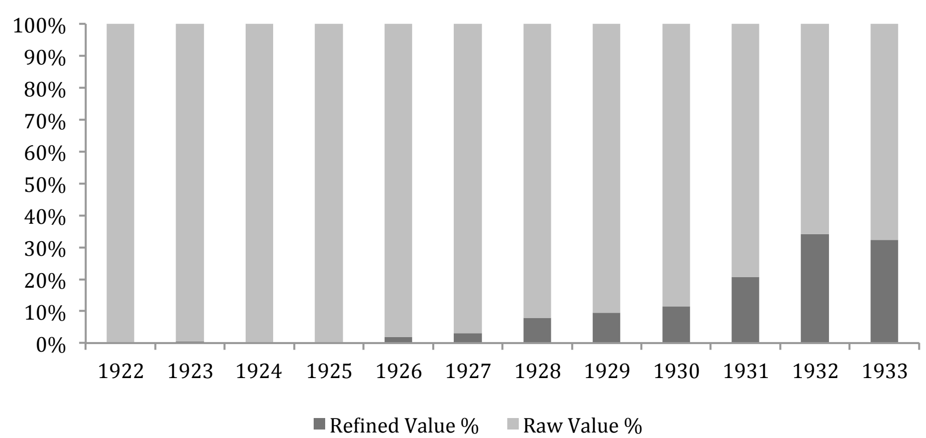
Panel C: Weighted 95° and 96°						
Year	Effective Protection of Refining	Legislative Portion	Import Price Movements	Relative Difference Raw and Refined	Composite	Error
1923	15.3%	10.6%	-1.6%	6.2%	15.3%	0.0%
1924	6.3%	10.6%	-1.4%	-3.0%	6.3%	0.0%
1925	2.1%	10.6%	-2.1%	-6.4%	2.1%	0.0%
1926	5.0%	10.6%	-1.9%	-3.7%	5.0%	0.0%
1927	5.9%	10.6%	-1.3%	-3.5%	5.9%	0.0%
1928	3.5%	10.6%	-0.9%	-6.2%	3.5%	0.0%
1929	4.7%	10.6%	-0.3%	-5.6%	4.7%	0.0%
1930a	5.0%	10.6%	2.0%	-7.6%	5.0%	0.0%
1930b	-3.6%	-4.2%	0.0%	0.6%	-3.6%	0.0%
1931	-4.1%	-4.2%	-1.2%	1.3%	-4.1%	0.0%
1932	-4.2%	-4.2%	-2.7%	2.8%	-4.2%	0.0%
1933	-6.6%	-4.2%	-2.7%	0.3%	-6.6%	0.0%

X. Empirical Results

Between 1929 and 1933, the peak and trough of the overall business cycle, real U.S. output fell by 29%. However, the growth trends in the quantity and value of the various components of the U.S. and Cuban sugar industries did not exhibit a similar contraction. Within the industry there were divergent growth trends for different sectors, some grew rapidly while others contracted.

The composition of the trade flow of sugar from the United States to Cuba shifted significantly between 1929 and 1933. In 1929, the vast majority of the sugar imported into the United States from Cuba was either 95° or 96°, two different varieties of raw sugar for input into the U.S. sugar refineries. Overall, the quantity of Cuban sugar imports had declined dramatically by 1933. In particular, this was driven by the Cuban raw sugar imports, which when each variety is combined, experienced a decline in quantity from 6,287 million pounds imported in 1929 to only 2,143 million pounds in 1933, i.e. a 66% decline. On the other hand, the overall decline in Cuban sugar imports was lessened by the quantity of refined sugar imported from Cuba, which increased from 512 million pounds in 1929 to 780 million pounds in 1933, a 52% increase in quantity imported over the same period.

Figure 12. – Composition of the Total Value of Imports of Cuban Sugar, Raw and Refined



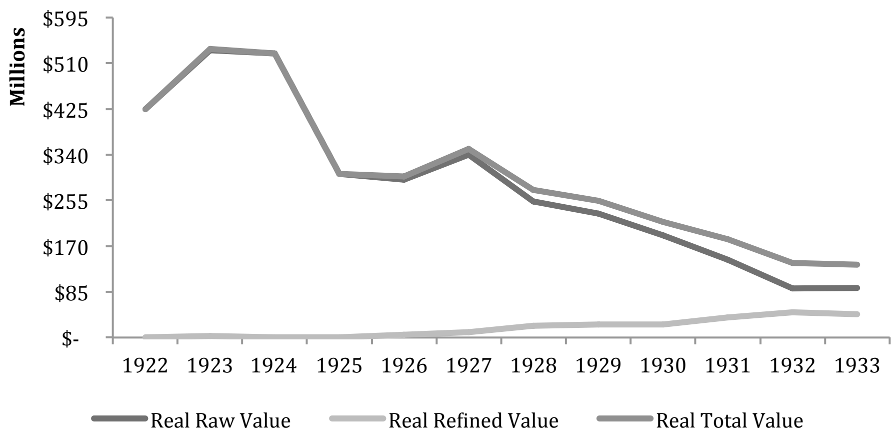
From the Cuban perspective, these shifts in the quantity of trade flows were significant. However, it is necessary to consider the U.S.–Cuban sugar trade in terms of the value of goods exchanged as well. Cuban exports to the United States represented 76.6% of total Cuban exports in 1929[25]. Sugar represented the majority of Cuban exports, and that same year 77.99% of Cuban sugar exported from the island was shipped to the United States. While the expansion of the Cuban refining industry began in the mid-1920s, its absolute growth accelerated with the passage of the Hawley-Smoot tariff schedule. As a portion of the total value of the imports of Cuban

[25] Boeckel, R.M. *Cuban-American relations.*

sugar, refined sugar grew from only 9% of the total in 1929 to 32% in 1933, the trough of the Great Depression (see Figure 12 and 13).

However, this break down of the total value of Cuban sugar imports does not indicate the dramatic decline in the value of Cuban raw sugar imports over the same period. Overall, the real value of American imports of sugar, raw and refined, from Cuba declined by twice as much as the overall level of American output, 47%. Given the distinct divergence between refined sugar imports from Cuba and raw sugar imports from Cuba, the following analysis will use the decompositions of both the effective rate of protection and the ad valorem equivalent rate of protection on refined and raw sugar imports from Cuba to clarify causes of the divergence.

Figure 13. – Value of Imports of Sugar from Cuba into the United States, Real Values (Deflated by IPI, 1967 = 1)

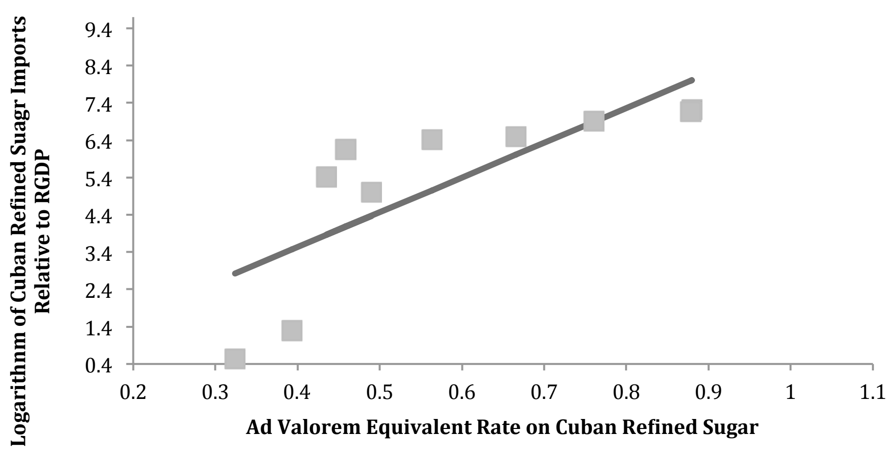


When considering the simple ad valorem equivalent rate of the tariff on Cuban refined sugar, there is a significant positive correlation between the tariff rate and quantity of imports of refined sugar relative to the overall level of output (as defined by real GDP). Without any further analysis, this would appear to imply that higher import duties were highly correlated with increased imports of refined sugar from Cuba (see Equation 21, Table 9, and Figure 14).

(21) $$log\left(Q_t^{ref}/RDGP_t\right) = \beta_0 + \beta_1 log\left(1 + AVE_t^{ref}\right) + \varepsilon$$

Table 9. – Log–Log Regression, Sugar Imports on the Ad Valorem Equivalent Rate							
Regression Statistics							
R	0.77858						
R Square	0.60619						
Adjusted R Square	0.55697						
S	1.6004						
Total number of observations	10.00						
$log(Q_t^{ref}/RDGP_t) = -0.1916 + 9.3203 * log(1 + AVE_t^{ref})$							
ANOVA							
	d.f.	*SS*	*MS*	*F*	*p-level*		
Regression	1.	31.54086	31.54086	12.31446	0.00797		
Residual	8.	20.49029	2.56129				
Total	9.	52.03116					
	Coefficients	*Standard Error*	*LCL*	*UCL*	*t Stat*	*p-level*	*H0 (5%) rejected?*
Intercept	-0.19161	1.63365	-3.95882	3.57559	-0.11729	0.90952	*No*
AVE	9.32027	2.65596	3.19563	15.44491	3.5092	0.00797	*Yes*
T (5%)	2.306						
LCL - Lower value of a reliable interval (LCL)							
UCL - Upper value of a reliable interval (UCL)							

Figure 14. – Predicted Cuban Refined Sugar Imports [AVE]

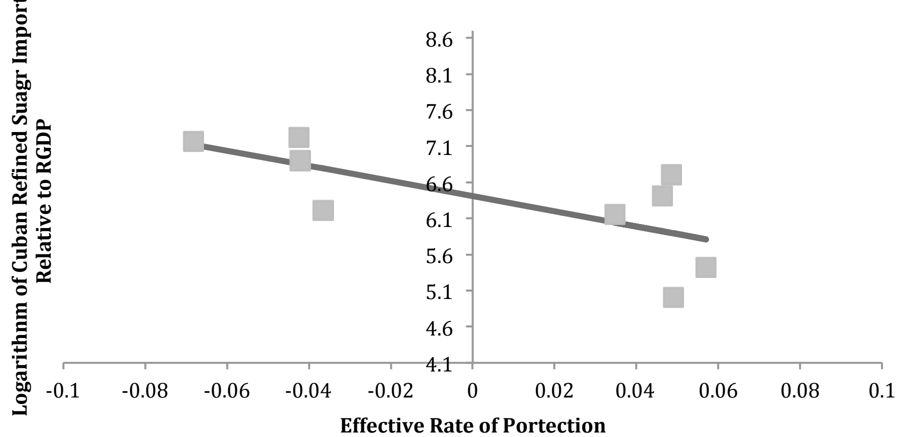


In contrast, when the correlation between the imports of Cuban refined sugar relative to overall output of the United States and the effective rate of protection on sugar refining is calculated, the correlation is significantly negative. It is now clear that even as the ad valorem equivalent rate on raw sugar increased with the Hawley-Smoot tariff legislation that the effective rate legislated shifted to a negative effective rate of protection, which incentivized the importation of refined sugar from Cuba over the less processed alternative raw sugar during the years that the Hawley-Smoot Tariff Act was in effect (see Equation 22, Table 10, and Figure 15)

(22) $$log\left(Q_t^{ref}/RDGP_t\right) = \beta_0 + \beta_1 log\left(1 + EFF_t^{ref}\right) + \varepsilon$$

Table 10. – Log–Log Regression, Refined Sugar Imports on Effective Rate of Protection							
Regression Statistics							
R	0.70444						
R Square	0.49623						
Adjusted R Square	0.42426						
S	0.57437						
Total number of observations	9.00						
$log\left(Q_t^{ref}/RDGP_t\right) = 6.4082 – 10.4846 * log\left(1 + EFF_t^{ref}\right)$							
ANOVA							
	d.f.	*SS*	*MS*	*F*	*p-level*		
Regression	1.	2.27471	2.27471	6.89523	0.03412		
Residual	7.	2.30928	0.3299				
Total	8.	4.58399					
	Coefficients	*Standard Error*	*LCL*	*UCL*	*t Stat*	*p-level*	*H0 (5%) rejected?*
Intercept	6.40821	0.19256	5.95289	6.86353	33.27985	0.	*Yes*
Effective	-10.48462	3.99281	-19.92611	-1.04314	-2.62588	0.03412	*Yes*
T (5%)	2.36462						
LCL - Lower value of a reliable interval (LCL)							
UCL - Upper value of a reliable interval (UCL)							

Figure 15. – Predicted Cuban Refined Sugar Imports [Effective]



Given the decompositions of both the ad valorem rate of protection and the effective rate of protection on imports of sugar from Cuba, these analyses can also reinterpreted to include the decomposed components to determine the relative impact of the various factors on the rates, i.e. which had the greatest effect on the level of imports relative to overall output. The following multiple linear regression that investigates the impact of the three decomposition components of the effective rate of protection on imports of refined sugar from Cuba is specified in equation 23.

$$(23)\quad log(Q_t^{ref}/RDGP_t) = \beta_0 + \beta_1 log(1 + EFF_t^{leg}) + \beta_2 log(1 + EFF_t^{p}) + \beta_3 log(1 + EFF_t^{rpd}) + \varepsilon_t$$

Table 11. – Log–Log Regression, Refined Sugar Imports on Effective Rate of Protection (Decomposed)

Regression Statistics							
R	0.75187						
R Square	0.5653						
Adjusted R Square	0.40229						
S	0.75698						
Total number of observations	12.00						
$log(Q_t^{ref}/RDGP_t)$ = 1.9508- 21.6756 * $log(1 + EFF_t^{leg})$ + 55.6158 * $log(1 + EFF_t^{p})$ - 10.4817 * $log(1 + EFF_t^{rpd})$							
ANOVA							
	d.f.	*SS*	*MS*	*F*	*p-level*		
Regression	3.	5.96147	1.98716	3.46786	0.07087		
Residual	8.	4.58416	0.57302				
Total	11.	10.54563					
	Coefficients	*Standard Error*	*LCL*	*UCL*	*t Stat*	*p-level*	*H0 (5%) rejected?*
Intercept	1.95082	0.33645	1.17496	2.72667	5.79825	0.00041	Yes
Eff Leg	-21.67565	9.10814	-42.67906	-0.67224	-2.37981	0.04456	Yes
Eff Imp	55.61585	26.94021	-6.50839	117.74008	2.06442	0.07286	No
Eff RPD	-10.4817	14.99253	-45.05454	24.09114	-0.69913	0.50429	No
T (5%)	2.306						
LCL - Lower value of a reliable interval (LCL)							
UCL - Upper value of a reliable interval (UCL)							

This analysis of the imports of refined sugar from Cuba on the decomposed effective rate of protection (see Table 11) returns results that follow intuitively from the original decomposition, the shift in the legislative component of the effective rate of protection is the significant factor influencing the increase in imports, as evidenced by a significant negative correlation, whereas the price components, which do not exhibit strong trends in either direction over the period, are not the significant determining factors.

A similar analysis of the impacts of the decomposed components of the ad valorem equivalent rate on raw sugar imports from Cuba delineates a different relationship with the rate of protection. Instead of the legislative component, the import price movement component of the ad valorem equivalent rate on raw sugar imports is the primary factor explaining the level of imports from Cuba, with a strong negative correlation. The equation for this multiple linear regression is specified as equation 24.

(24) $log(Q_t/RDGP_t) = \beta_0 + \beta_1 log(1 + AVE_t^{leg}) + \beta_2 log(1 + AVE_t^{p}) + \beta_3 log(1 + AVE_t^{rpd}) + \varepsilon_t$

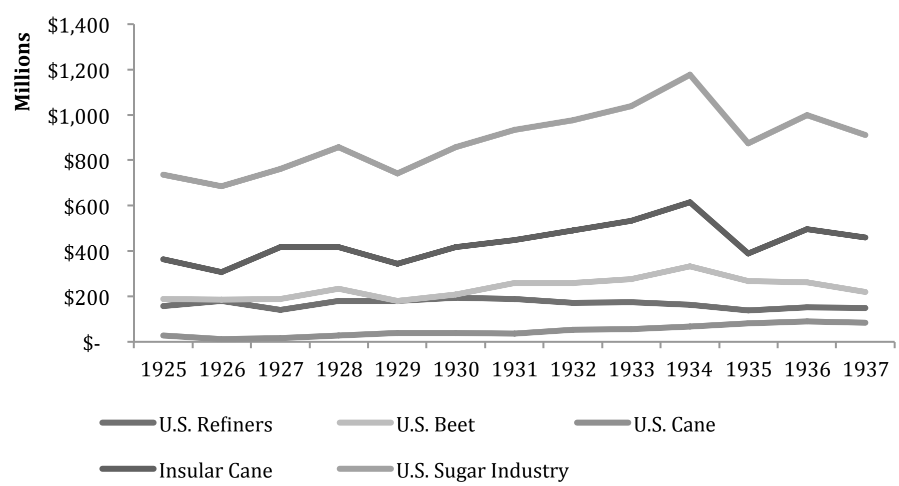
Table 12. Log–Log Regression, Sugar Imports on the Ad Valorem Equivalent Rate (Decomposed)

Regression Statistics							
R	0.98479						
R Square	0.9698						
Adjusted R Square	0.95686						
S	0.1004						
Total number of observations	11.00						
$log(Q_t/RDGP_t)$ = 9.2911 - 0.3875 * $log(1 + AVE_t^{leg})$- 1.5779 * $log(1 + AVE_t^{p})$ - 0.2959 * $log(1 + AVE_t^{rpd})$							
ANOVA							
	d.f.	*SS*	*MS*	*F*	*p-level*		
Regression	3.	2.26634	0.75545	74.9398	0.00001		
Residual	7.	0.07056	0.01008				
Total	10.	2.3369					
	Coefficients	*Standard Error*	*LCL*	*UCL*	*t Stat*	*p-level*	*H0 (5%) rejected?*
Intercept	9.29106	0.74811	7.52206	11.06006	12.41937	0.00001	*Yes*
Legislative Portion	-0.38751	1.2701	-3.39082	2.6158	-0.3051	0.76916	*No*
Import Price Movements	-1.57795	0.40543	-2.53665	-0.61925	-3.89199	0.00596	*Yes*
Relative Price	-0.29594	0.17856	-0.71816	0.12628	-1.65741	0.1414	*No*
T (5%)	2.36462						
LCL - Lower value of a reliable interval (LCL)							
UCL - Upper value of a reliable interval (UCL)							

Note, the relative price component is determined in relation to the overall price component and that the relation is not significant in the above regression analysis (see Table 12). This is likely caused by the fact that price of sugar generally moved in the same direction but at a greater magnitude than import prices, which already moved in the same direction but greater magnitude than wholesale prices (see Figure 4). Further, the lack of a significant relationship in the multiple linear regression of the legislated tariff rate on the quantity of imports might be surprising out of context. There is little doubt that the increased protectionism embodied in the Hawley-Smoot Tariff Act of 1930 decreased trade between the United States and other countries and that increased tariff rates, *ceteris paribus*, will increase the price of imports and lead to a decrease in quantity imported. However, it is important to note that the sample period only incorporates two different tariff schedules: the Fordney-McCumber and Hawley-Smoot schedules. Both of these tariff regimes imposed highly protectionist duties on the importation of raw sugar, indeed the increase in 1930 was more a change of the degree of intensity than a change in overall policy towards raw sugar imports. Further, the legislated increase captured in the decomposition is not a measure of the entire impact of the legislated tariff, in spite of how it is referred to. Indeed, the entire tariff on raw sugar, from which all three components of variation stem, follows from the legislation as drafted. The nature of the tariff on raw sugar as a specific rate was legislated in such a way to vary with prices changes; this was a legislated choice, albeit not under the umbrella of the legislative portion of the decomposition. It is true that conditional on the variation in the quantity of imports that followed from the change in the overall price level due to the specific rate nature of the import duties on sugar that the 'legislated' component of the decomposition does not appear significant, but the fact is that this does not imply that the legislated changes in tariff policy are insignificant in determining trade flows. Rather, in this case, it is simply that the legislative form the tariff on raw sugar took on and the relatively exogenous variation in the overall price level were the primary determinates of fluctuations in the quantity imported, not the specific increase at the moment of the establishment of the legislation in June 1930. It is important to note that there is analysis (Irwin 2014) that establishes that (to varying degrees) the legislated changes to the import duties on raw sugar in the early twentieth have led to significant and immediate shifts in prices and trade flows.

Trends in the American sugar industry reveal a different level of growth between the peak and trough of the business cycle in 1929 and 1933. Data on the gross income of the different components of the American sugar industry from *Sugar economics, statistics, and documents* (1938) provide insight into the potential for welfare gains and losses across groups within the United States from these shifts in trade flows and production Indeed, in nominal terms, the U.S. sugar industry, which includes American refiners, American beet sugar producers, and continental and insular American cane sugar producers, only saw a decline in gross income of 3.02%. Unlike the Cuba industry, the greatest declines were in the gross income of U.S. refiners and U.S. beet sugar producers and insular cane sugar growers experienced the greatest gains in the gross income. However, like the Cuban figures, it is necessary to adjust for the overall price level, in this case with the domestic wholesale price index and not the import price index, to determine the real changes in the income of the domestic industry.

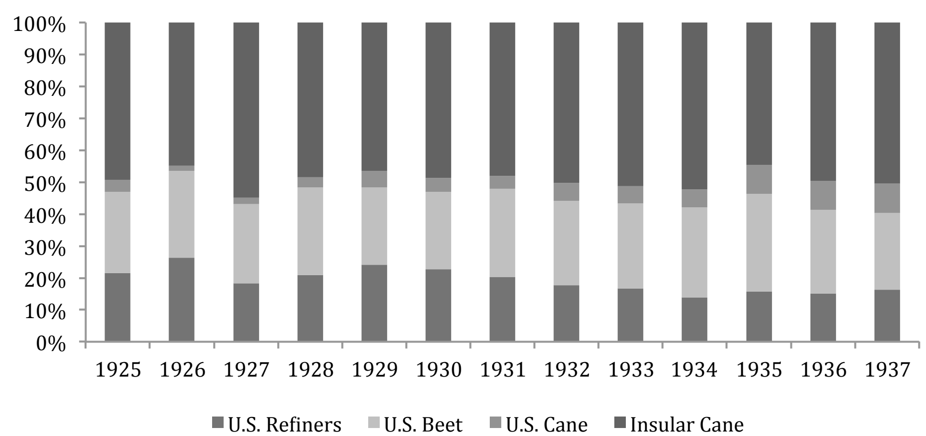
Figure 16. – Real U.S. Sugar Industry Gross Income by Year (1967 = 100)



When adjusted for the overall price level, as shown in Figure 16, it is revealed that the U.S. industry declined less significantly than the Cuban industry; rather, it grew substantially as Cuban sugar imports declined. Indeed, the gross income of the American sugar industry grew by 40.05% between 1929 and 1933. In real terms, the only component of the U.S. sugar industry that experienced a decline in income over the four-year period was the U.S. sugar refining industry which saw a decline in real gross income of 3.18%, which is still strong performance compared to overall output, even if it appears to weak compared to the other components of the U.S. sugar industry.

Figure 17 presents the same information in percentage terms, which highlights the change in the composition of the industry's gross income over the sample period. Indeed, in 1929, refining represented 24.18%, essentially a quarter, of the American sugar industry's gross income. However, by 1933, refining only represented 16.71% of the industry's total gross income, a 30.89% decline in contributions to the industry gross income (a 7.47 percentage point decline).

Figure 17. – Composition of U.S. Sugar Industry Gross Income by Year



XI. Conclusion

It is evident that U.S.-Cuban trade during the interwar period was a significant portion of each country's economy. In particular, a single commodity, sugar, comprised the majority of this trade flow to the United States, from which proceeds covered the importation of a variety of goods into Cuba. Further, it is clear that the trade policy of the larger United States impacted these trade relations substantially, as was the case with the switch from the Fordney-McCumber to the Hawley-Smoot tariff schedule. Rising ad valorem equivalent rates were associated with dramatic decreases in both the U.S.-Cuban sugar trade as well as Cuban production. Effective protection on the sugar refining industry shifted from a positive protective barrier to a disadvantageous negative trade policy. This led to increasing imports of refined sugar from Cuba at the same time that raw sugar imports were declining significantly. Simultaneously, beet sugar production, which requires no secondary refinement, was growing in the United States and American refiners shifted their inputs to more expensive and less efficient sources within the United States free trade zone, the continental U.S. and its insular regions.

With the possible opening of U.S.-Cuban trade relations in the near future[26], this analysis provides evidence of the significance of the U.S.-Cuban sugar trade during the interwar period as well as the devastating effects trade policy had on that relationship. The redistribution of wealth that resulted from significant shifting trade policy relating to sugar created sectors that gained substantially and others that were not as fortunate. The results from this policy change are a testament to the power of trade policy to alter markets and the importance of the careful exercise of such power.

[26] Chandler, Adam. *The Slow Shredding of the Cuban Embargo*.

XII. Works Cited

American Sugar Refining Company. *American Sugar Refining Company, Annual Report*. 1930.

Anderson, James, and Seiji Naya. "Substitution and two concepts of effective rate of protection." *The American Economic Review* (1969): 607-612.

Boeckel, R. M. Cuban-American relations. Editorial research reports 1930 (Vol. II). Washington, DC: CQ Press, 1930.

Chandler, Adam. *The Slow Shredding of the Cuban Embargo*. The Atlantic (September 18th, 2015). http://www.theatlantic.com/national/archive/2015/09/the-slow-shredding-of-the-cuban-embargo/406117/

Chen, James CP, and Chung-Chi Chou. *Cane sugar handbook: a manual for cane sugar manufacturers and their chemists*. No. Ed. 12. John Wiley and Sons, Inc., 1993.

Crucini, Mario J. "Sources of variation in real tariff rates: The United States, 1900-1940." *The American Economic Review* (1994): 732-743.

Dye, Alan. *Cuban Sugar in the Age of Mass Production: Technology and the Economics of the Sugar Central, 1899–1929*. Stanford, CA: Stanford University Press, 1998.

Fisk, George M. "The Payne-Aldrich Tariff." *Political Science Quarterly* (1910): 35-68.

Genesove, David, and Wallace P. Mullin. "Testing static oligopoly models: conduct and cost in the sugar industry, 1890-1914." The RAND Journal of Economics (1998): 355-377.

International Sugar Organization (ISO). *Memo(12)30, Suggested Changes to Statistical Rules*. November 22, 2012.

Irwin, Douglas A. *Peddling Protectionism: Smoot-Hawley and the Great Depression*. Princeton, NJ: Princeton University Press, 2011.

Irwin, Douglas A. *Tariff Incidence: Evidence from US Sugar Duties, 1890-1930*. No.

w20635. National Bureau of Economic Research, 2014.

Lynsky, Myer. *Sugar economics, statistics, and documents.* New York, NY: United States Cane Sugar Refiners' Association, 1938.

Roosevelt, Theodore. *A Compilation Of The Messages And Speeches Of Theodore Roosevelt, 1901-1905, Volume 1*. Washington, D.C.: Bureau of National Literature and Art, 1906.

The Sugar Association. *Refining and Processing Sugar*. http://www.sugar.org/images/docs/refining-and-processing-sugar.pdf

The United States Tariff Commission. *Sugar: Report of the United States Tariff Commission to the President of the United States*. Washington D.C.: Government Printing Office, 1934.

Truman, Harry S. *Public Papers of the Presidents of the United States: Harry S. Truman, 1948, Volume 4*. Washington, D.C.: United States Government Printing Office, 1966.

United States Cuban Sugar Council. *Sugar; Facts And Figures*. Washington, 1952.

XIII. Appendix A

Table A1. – U.S. Sugar Import Duties

Legislation	Effective	Duty (cents per pound)				Changes in Treatment of Offshore Regions
		Raw		Refined		
		Full Rate	Cuban Rate	Full Rate	Cuban Rate	
Hawaiian Reciprocity Treaty	May 31st, 1875	-	-	-	-	Sugar from Hawaii admitted free
Mongrel Tariff	March 3rd, 1883	2.2400	2.2400	3.5000	3.5000	
McKinley Tariff	October 1st, 1890	Free	Free	0.5000	0.5000	
Dingley Tariff	July 24th, 1897	1.6850	1.6850	1.9500	1.9500	
Foraker Act	May 1st 1900	1.6850	1.6850	1.9500	1.9500	85% preference on Puerto Rican sugar
Executive Proclamation	July 25th, 1901	1.6850	1.6850	1.9500	1.9500	Sugar from Puerto Rico admitted free
Tariff Act, 1902	March 8th, 1902	1.6850	1.6850	1.9500	1.9500	25% preference on Philippine sugar
Cuban Reciprocity Treaty	December 17th, 1903	1.6850	1.3480	1.9500	1.5600	20% preference on Cuban sugar
Payne-Aldrich Tariff	August 5th, 1909	1.6850	1.3480	1.9000	1.5200	Philippine sugar admitted free (up to 300,000 tons)
Underwood Tariff	March 1st, 1914	1.2560	1.0048	1.3600	1.0880	Sugar from the Philippines admitted free
Emergency Tariff	May 27th, 1921	2.0000	1.6000	2.1600	1.7280	
Fordney-McCumber Tariff	September 22nd 1922	2.2060	1.7648	2.3900	1.9120	
Hawley-Smoot Tariff	June 17th, 1930	2.5000	2.0000	2.6500	2.1200	
Proclamation by President Roosevelt	June 8th, 1934	1.8750	1.5000	1.9875	1.5900	
Cuban Trade Agreement	September 3rd, 1934	1.8750	0.9000	1.9875	0.9540	

XIV. Appendix B

Mixed (Fixed and Variable Input) Production Function:

$$q_j = min\left(k^{\alpha}l^{1-\alpha}, \frac{1}{\psi_{ij}}q_i\right)$$

Mixed (Fixed and Variable Input) Cost Function Derivation:

$$q_j = min\left(k^{\alpha}l^{1-\alpha}, \frac{1}{\psi_{ij}}q_i\right) = \begin{cases} k^{\alpha}l^{1-\alpha} & if\ k^{\alpha}l^{1-\alpha} \leq \frac{1}{\psi_{ij}}q_i \\ \frac{1}{\psi_{ij}}q_i & if\ \frac{1}{\psi_{ij}}q_i < k^{\alpha}l^{1-\alpha} \end{cases}$$

$$0 < \alpha < 1$$

if $k^{\alpha}l^{1-\alpha} \leq \frac{1}{\psi_{ij}}q_i$, then:

$$MP_k = \frac{\partial(min\left(k^{\alpha}l^{1-\alpha}, \frac{1}{\psi_{ij}}q_i\right))}{\partial k} = \alpha k^{(\alpha-1)}l^{(1-\alpha)}$$

$$MP_l = \frac{\partial(min\left(k^{\alpha}l^{1-\alpha}, \frac{1}{\psi_{ij}}q_i\right))}{\partial l} = k^{\alpha}(1-\alpha)l^{-\alpha}$$

it is clear that both marginal products are positive when n>0 and k>0

$$\frac{\partial MP_k}{\partial k} = \frac{\partial\left(\alpha k^{(\alpha-1)}l^{(1-\alpha)}\right)}{\partial k} = \alpha(\alpha-1)k^{(\alpha-2)}l^{(1-\alpha)}$$

$$\frac{\partial MP_l}{\partial l} = \frac{\partial(k^{\alpha}(1-\alpha)l^{-\alpha})}{\partial l} = k^{\alpha}(1-\alpha)\alpha l^{-\alpha-1}$$

it is clear that each second derivative is negative when n>0 and k>0

if $\frac{1}{\psi_{ij}}q_i < k^{\alpha}l^{1-\alpha}$, then:

$$MP_{q_i} = \frac{\partial(k^{\alpha}l^{1-\alpha} + \frac{1}{\psi_{ij}}q_i)}{\partial q_i} = \frac{1}{\psi_{ij}}$$

$$\frac{\partial MP_{q_i}}{\partial q_i} = \frac{\partial \psi_{ij}}{\partial q_i} = 0$$

it is clear that the marginal product is positive as it is a constant defined as such

if $k^{\alpha}l^{1-\alpha} \leq \frac{1}{\psi_{ij}}q_i$, then:

Let $q_j = q_j(l,k) = q_j{}^*$, where q^* is fixed. Then,

$$dq = \frac{dq(l,k)}{dk}dk + \frac{dq(l,k)}{dl}dl$$

$$0 = \frac{dq(l,k)}{dk}dk + \frac{dq(l,k)}{dl}dl$$

$$\frac{dq(l,k)}{dk}dk = -\frac{dq(l,k)}{dl}dl$$

$$-dk\frac{dq(l,k)}{dk} = \frac{dq(l,k)}{dl}dl$$

$$-\frac{dk}{dl} = \frac{\frac{dq(l,k)}{dl}}{\frac{dq(l,k)}{dk}}$$

$$-\frac{dk}{dl} = \frac{MP_l}{MP_k}$$

$$-\frac{dk}{dl} = MRTS = \frac{MP_l}{MP_k} = \frac{(1-\alpha)k^{\alpha}l^{-\alpha}}{\alpha k^{\alpha-1}l^{1-\alpha}} = \frac{(1-\alpha)}{\alpha} * \frac{k}{l}$$

if $\frac{1}{\psi_{ij}}q_i < k^{\alpha}l^{1-\alpha}$, then:
Let $q_j = q_j(q_i) = q_j{}^*$, where q^* is fixed. Then,

$$q_j{}^* = \frac{1}{\psi_{ij}}q_i$$

$$\psi_{ij}q_j{}^* = q_i{}^*$$

Cost Minimization:

if $k^{\alpha}l^{1-\alpha} \leq \frac{1}{\psi_{ij}}q_i$, then:

We know: $MRTS_{nl} = \frac{MP_l}{MP_k} = \frac{w}{r}$

So, $\frac{MP_l}{MP_k} = \frac{(1-\alpha)}{\alpha} * \frac{k}{l} = \frac{w}{r} \rightarrow k = \left[\frac{\alpha}{(1-\alpha)} * \frac{w}{r}\right] * l$

$$q_j{}^* = k^\alpha l^{1-\alpha} = [\frac{\alpha}{(1-\alpha)} * \frac{w}{r} * l]^\alpha * l^{1-\alpha} = \left[\frac{\alpha}{(1-\alpha)} * \frac{w}{r}\right]^\alpha * l^\alpha * l^{(1-\alpha)}$$

$$q_j{}^* = l * \left[\frac{\alpha}{(1-\alpha)} * \frac{w}{r}\right]^\alpha \Longrightarrow l^* = q^* * \left[\frac{(1-\alpha)}{\alpha} * \frac{r}{w}\right]^\alpha$$

$$\Rightarrow k^* = \left[\frac{\alpha}{(1-\alpha)} * \frac{w}{r}\right] * l^* = \left[\frac{\alpha}{(1-\alpha)} * \frac{w}{r}\right] * \left[\frac{(1-\alpha)}{\alpha} * \frac{r}{w}\right]^\alpha * q^* =$$

$$= \left[\frac{\alpha}{(1-\alpha)} * \frac{w}{r}\right] * \left[\frac{\alpha}{(1-\alpha)} * \frac{w}{r}\right]^{-\alpha} * q^* = \left[\frac{\alpha}{(1-\alpha)} * \frac{w}{r}\right]^{(1-\alpha)} * q^*$$

together,

$$k^* = \left[\frac{\alpha}{(1-\alpha)} * \frac{w}{r}\right]^{(1-\alpha)} * q_j{}^*$$

$$l^* = q_j{}^* * \left[\frac{(1-\alpha)}{\alpha} * \frac{r}{w}\right]^\alpha$$

if $\frac{1}{\psi_{ij}} q_i < k^\alpha l^{1-\alpha}$, then:

$$\psi_{ij} q_j{}^* = q_i{}^*$$

So, it follows that the cost function is:

$$c(q_j{}^*) = wl^* + rk^* + p_i q_i{}^*$$

$$c(q_j{}^*) = w * q_j{}^* * \left[\frac{(1-\alpha)}{\alpha} * \frac{r}{w}\right]^\alpha + r * \left[\frac{\alpha}{(1-\alpha)} * \frac{w}{r}\right]^{(1-\alpha)} * q_j{}^* + p_i q_i{}^*$$

$$\frac{c(q_j{}^*)}{q_j{}^*} = w * \left[\frac{(1-\alpha)}{\alpha} * \frac{r}{w}\right]^\alpha + r * \left[\frac{\alpha}{(1-\alpha)} * \frac{w}{r}\right]^{(1-\alpha)} + p_i \frac{q_i{}^*}{q_j{}^*}$$

$$c^{unit}(q_j{}^*) = w^{(1-\alpha)} * \left[\frac{(1-\alpha)}{\alpha} * r\right]^\alpha + r^\alpha * \left[\frac{\alpha}{(1-\alpha)} * w\right]^{(1-\alpha)} + p_i \psi_{ij}$$

$$c^{unit}(q_j{}^*) = w^{(1-\alpha)} * r^\alpha * \left[\frac{(1-\alpha)}{\alpha}\right]^\alpha + r^\alpha * w^{(1-\alpha)} * \left[\frac{\alpha}{(1-\alpha)}\right]^{(1-\alpha)} + p_i \psi_{ij}$$

$$c^{unit}(q_j{}^*) = w^{(1-\alpha)} * r^\alpha * \left[\left[\frac{(1-\alpha)}{\alpha}\right]^\alpha + \left[\frac{\alpha}{(1-\alpha)}\right]^{(1-\alpha)}\right] + p_i \psi_{ij}$$

$$\text{let,} \qquad \Omega = \left[\frac{(1-\alpha)}{\alpha}\right]^\alpha + \left[\frac{\alpha}{(1-\alpha)}\right]^{(1-\alpha)}$$

$$\Rightarrow c^{unit}(q_j{}^*) = \Omega * w^{(1-\alpha)} * r^\alpha + p_i \psi_{ij}$$