Senior Project
Department of Economics

"Welfare Effects in the Cotton Industry: A Multi-Market Analysis"

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Abstract

The MFA imposed quotas on cotton imports for nearly two decades. Then, the seven and a half year Uruguay Round instated a plan to liberalize trade in textiles and clothing. By 2005, all quotas were required to be removed on these items. The United States, a price maker when it comes to world cotton trade, was no exception to this rule. As by international economic theory, trade liberalization will impact prices on traded goods. As such, the supply and demand curves for textiles in the US were estimated seemingly unrelated regressions in an attempt to calculate the effects these changes in trade held on U.S. consumers and producers in terms of overall welfare. Bootstrapping was used to give statistical validity.

Introduction

The United States currently produces about 20% of the world supply of cotton. It is the second largest world producer of cotton next to China, and is the largest world exporter of the commodity (Womach, 2004). Seeing its significance in U.S. trade, changes in welfare effects of both consumers and producers in this industry greatly impact the U.S. economy. But what causes those changes? Trade liberalization can alter consumer or producer welfare by changing the price of cotton from the domestic price towards the world price. Changes in price affect the quantity supplied and demanded domestically (by basic supply and demand theory) as well as exports and imports, because consumers always choose the lowest price when deciding between two goods, all else considered equal. Therefore, the price of a domestically produced good versus the price of the good abroad will sway consumers' choices.

So why cotton specifically? Cotton is a good that previously had strict barriers to trade in the form of quotas that have been recently reduced. These "reductions" are more of a liberalization in trade. In the 1974 the Multi-Fiber Agreement (MFA) initialized a quota regime. This regime established rules for bilateral and unilateral quotas between countries. It was expanded several times throughout the next decade and a half to include more countries and rules for restriction. However, the 1986 Uruguay Round began making freer trade one of its goals. While the discussion of removal of the MFA was underway, no concrete plan was laid down to ensure the removal of quotas until 1994. The following year the Agreement on Textiles and Clothing (ATC) was signed as a plan with steps towards removing all quotas on textiles and clothing (that the MFA had instituted) by the year 2005.

Thus, a few things make cotton an interesting good to follow when studying welfare effects in the United States. The first is size of cotton as an export commodity. As was stated previously, a large amount of cotton is grown on U.S. soil. Secondly, the relatively recent liberalization of cotton trade also makes it interesting to measure welfare effects following a change in the price, because in theory trade liberalization will ultimately affect price.

The purpose of this paper is to determine producer and consumer welfare before, during, and after trade liberalization of textiles. Welfare measurements will be made from year to year, such that upon examination it should become apparent whether removal of quotas had any dramatic welfare effects or not, and if so in which direction they pointed (positive or negative).

Theory states that the welfare effects for producers and consumers should be opposite (for example if producer surplus goes down due to freed trade, consumer surplus should then go up), so that theory will be put to test empirically. The next question that follows is whose welfare was impacted greater by freed trade (the consumers' or producers') and then what the overall welfare effect was. In theory, freed trade means increased (positive) total welfare globally, but it does not necessarily mean increased overall total welfare for the United States specifically.

In short, this paper is looking to find the welfare effects of free trade on cotton textiles and cloth in the United States based on time-series data from 1980 to 2007. The hypothesis is that removal of quotas due to the ATC increased total welfare overall in the U.S. by increasing producer surplus in a greater amount than the consumer surplus forgone.

Literature Review

Much of the economic literature about free trade in cotton and textiles begins in the 1970's. This is due to the fact that in 1974 the Multi-Fiber Agreement (MFA) began, and many participating countries adopted quotas on cotton and cotton products, including the U.S. Over the next decade and a half MFAII, MFAIII, and MFAIV made the agreement more and more restrictive one by one, especially towards developing countries (Dadakas and Katranidis, 2009). Although the Uruguay Round in 1986 attempted to liberalize the textile trade markets (Dadakas and Katranidis, 2010), it wasn't until the Agreement on Textiles and Clothing (ATC), with its phase out plan to eliminate quotas by January 1, 2005, that trade liberalization really seemed to get moving. Interestingly, by the summer of 2005 Chinese exports to the EU and US were so great that both economies imposed new quotas on Chinese imports, for a less shocking shift towards free trade (Dadakas and Katranidis, 2009).

The multimarket analysis (to be used empirically in this paper) has been used by Dadakas and Katranidis (2010) to look at the supply and demand for cotton yarn, and it's effect on changes in consumer and producer welfare in Greece. They examined two time periods: 1974-1994 while the Multi-Fiber Agreement was in effect, and 1995-2000 as the Uruguay Round gradually made way for increasingly liberalized trade of T&C. The markets they used in their research included the initial cotton market, or the market for cotton seed; two intermediate markets, the market for cotton seed and the labor market for yarn, and finally the cotton yarn market. The market for cotton yarn is the primary market of interest in their research, as the other three markets build up to it in what they call a "vertically linked market setting" (Dadakas and Katranidis, 2010). They found a gradual decrease in producer welfare over the years after 1987 when the ATC was agreed upon. This decline was partially made up for by the gradual increase in consumer welfare overtime. Prior to that time, transfers were relatively high, though they demonstrated high volatility.

Dadakas and Katranidis were not the first to use a multi-market model however. A paper written by Brannlund and Kristrom (1996) describes the derivation of both this model, and a single market model. Although Brannlund and Kristrom use their single market model to look at welfare effects of a chlorine tax proposal in Sweden, as opposed to their multimarket model, they still used the multimarket analysis to measure changes in welfare. This was a key component of what Dadakas and Katranidis (2010) modeled, as well as what this paper intends to do. In their study, Brannlund and Kristrom examine the difference between the two models (single or multi-market), by conducting empirical experiments on data about a chlorine tax proposal in Sweden. The multiple markets that they use include markets for pulp and paper, sawmills, and forestry. They describe the difference between the two methods as "quite transparent." They say that the only difference is of course that the multimarket model takes into account repercussions from the additional markets. However, they also point out that it can consequentially also contain estimations from "bad" models, and contain distorted results or greater errors than it shows. They also derive a formula that represents the difference in deadweight loss between the single and multi-market models.

Other partial equilibrium models are frequently used in articles discussing the effects of trade liberalization on cotton. In 2007, Pan *et. al.* estimated the effects of removing all tariffs on cotton imports and subsidies on cotton production using one such model. They found that overall the world price would actually increase due to free trade, but places that currently have high tariffs on imported cotton would see price reductions due to the removal of trade barriers (conversely those states with low barriers to trade would see increased prices). Some prime examples of price increases given by Pan *et. al.* (2007) include China, Pakistan, India, the EU, Turkey, and Mexico. As well as prices, trade flows would also be greatly affected by removing subsidies and tariffs. The United States would be expected to see both its net exports and net production of cotton decrease. However, despite negative U.S. trends, the world trade would increase as countries such as Brazil and Australia, for example, would make up more of the exporting cotton market than they do now (Pan *et. al.* 2007).

Another study by some of the same authors (Pan *et. al.*, 2008) researched welfare effects of increasingly freed trade of cotton and textiles. This time, instead of estimating what would happen if all countries removed their established barriers to trade, they sought out to find the predicted welfare effects for the Dominican Republic-Central America-United States Free Trade (US-CAFTA-DR), which called for duty free and quota free trade between participating states. The agreement is between the United States and six economies in Central America and the Caribbean. These countries are Costa Rica, El Salvador, Guatemala, Honduras, Nicaragua, and the Dominican Republic (Pan *et. al.*, 2008).

Basic international economic theory was used to explain expected outcomes in welfare gains and losses between the countries of the trade agreement. In their empirical research, they found that the theory held true. In these southern regional nations (generally net importers of cotton), they found that producer surplus of cotton decreased due to decreases in cotton prices. The government revenues that came from tariffs were also decreased. However, consumers of cotton in these states benefitted from the decreased price of cotton (what had been the domestic price was now lowered to the free trade price). In the United States, free trade brings about increased prices for cotton. But since the U.S. was a net exporter, the government feels no loss, and producer surplus is much greater than consumer surplus. Pan et al (2008) found that net importers of cotton have a positive net welfare gain because increased consumer surplus is greater than decreased producer surplus.

There have been many studies about the welfare effects of relatively recent trade policies on specific economies. I want to take these studies one step further, by looking at the welfare effects of cotton and textile trade in the United States since the 1974 and up through 2009. I plan on looking at specific dates, before and after policy implications, to try and determine where consumer and producer surpluses changed most drastically.

Formulation of the Model

The main model is a Seemingly Unrelated Regression (SUR) borrowed from Dadakas and Katranidis. However, in an attempt to correct for endogeneity problems, a three stage least squares model was also used to estimate the regressions. They use a multimarket analysis (looking at four different markets for cotton yarn) and tie them all together by their correlated error terms. In this multimarket analysis, the regressions run are the supply and demand of cotton textiles (equation 1 and 4), the demand of cotton labor (equation 3), and the demand of cotton seed (equation 2). These regressions should be of the form:

$$Qst_t = \alpha_0 + \alpha_1 Pt_t + \alpha_2 Pc_t + \alpha_3 wage_t + \alpha_4 Qst_{t-1} + \varepsilon_t \quad (1)$$

$$Qdc_t = \beta_0 + \beta_1 Pt_t + \beta_2 Pc_t + \beta_3 wage_t + \beta_4 Qdc_{t-1t} + \varepsilon_t \quad (2)$$

$$Qdlabor_t = \gamma_0 + \gamma_1 Pt_t + \gamma_2 Pc_t + \gamma_3 wage_t + \gamma_4 Qdlab_{t-1} + \varepsilon \quad (3)$$

$$Qdt_t = \delta_0 + \delta_1 Pt_t + \delta_2 Psubray_t + \delta_3 Psubpoly_t + \delta_4 Psubwool_t + \delta_5 Qdt_{t-1} + \varepsilon \quad (4)$$

The theory behind the seemingly unrelated regressions is that the error terms should be correlated.

The main dependent variables of interest will be the quantity of cotton lint consumed by textile mills (Qdc), the labor market for laborers (Qdlabor), and the quantities of textiles produced and purchased (Qst and Qdt respectively). Price variables make up the majority of the independent variables. These include the price of cotton lint (Pc), the price of laborers (wage), the price of textiles (Pt), the price of substitutes for cotton fabric such as rayon, polyester, and wool (Psubray, Psubpoly, Psubwool). Many of these variables will be measured at both time t (year in question) and time t-1 (the lag time).

The price of textiles is expected to have a positive effect on the equation for the supply of textiles. Conversely, the price of cotton seed and the wage of laborers should have be inversely related to the quantity of textiles supplied, for they are input prices and demonstrate cost to the producers; a lower input price means that the producer will purchase more of it (and hence produce more himself). The demand for cotton seed should be negatively related to the price of cotton seed, but positively related to the price of textiles. The demand for labor, similarly, should be negatively related to the wages of laborers, but positively related to the price of textiles. Finally, the coefficients on the prices of cotton textile substitutes should be positive, while the price of cotton textiles should be negative in the equation for the demand for cotton textiles.

All of these equations are functions of the price of textiles. Interestingly enough, most are functions of the price of cotton seed and the wage of cotton laborers as well. This is due to the fact that the production of cotton textiles is the product of its two major inputs: cotton lint and labor (Dadakas and Katranidis, 2010).

The purpose of this study however is much more than determining the supply and demand for textiles in a multimarket set up. These equations are just pawns in a much bigger economic question: what are the overall welfare gains or losses from time period to time period? Thus it is equally important, if not more important to derive the formulation of the welfare analysis.

Beginning with producer welfare, it is first important to note that producers always work to maximize profits. Profits ($\prod$) are a function of how much the producer has sold at what price less the costs of production (in our case cotton seed and cotton labor). Thus, the profit maximizing function should look like:

$$\prod = Pt * Qst - Qdlabor * wages - Qdc * Pc \quad (5)$$

We know the Qst, Qdlabor, and Qdc to be individual functions of Pt, Pc, and wages. Thus equation (5) becomes:

$$\prod = Pt * Qst(Pt,Pc,Qstlag,wage,C_t) - Qdlabor(Pt,Pc,Qdlablag,wage,C_l) * wages - Qdc(Pt,Pc,Qdclag,wage,C_c) * Pc + \varepsilon_n \quad (6)$$

Where C_n is a catchall constant, that takes into account all the other input factors assumed in my model to be constant. ε_n represents the error term. Thus the profit function itself is a function of Pt, Pc, wages, and some C_n. To simplify matters, consider:

$$\prod (Pt, Pc, wage, C_n) \quad (7)$$

The producer surplus is represented by the geometric area under the supply curve up to the given equilibrium price. Thus, per calculus, an integral is used to find the area under a curve, and in this case we shall find the area under the profit curve as derived above.

$$PS = \int_{Pt0}^{Pt1} Qst(Pt, Pc, wage, Cn)dPt - \int_{w0}^{w1} Qdlabor(Pt, Pc, wage, Cn)dwage - \int_{Pc0}^{Pc1} Qdc(Pt, Pc, wage, Cn)dPc \quad (8)$$

These integrals should be calculated over the change in the relevant variable from some initial period (superscript 0) to a final period (superscript 1). Each is an integral of a quantity function in terms of its major dependent variable, and a price variable of either textiles, cotton seed, or labor. It is important to note that in world trade in the cotton industry, the United States takes on a large country assumption, where price changes in cotton lint will affect the price of cotton textiles.

The same model can also be derived as Dadakas and Katranidis derived it, by assuming the profits are a function of the price of the output and the prices of the inputs (equation 7). Then the change in profits will be the difference between the initial and final prices (for example, the price before and after freed trade).

$$\Delta\prod = \prod (Pt^0, Pc^0, wage^0, C_n) - \prod (Pt^1, Pc^1, wage^1, C_n) \quad (9)$$

This (9) can be expressed as the following line integral of the derivatives of the parts. Thus, via calculus, it can be written as the sum of the definite integrals:

$$\int_0^1 \frac{\partial \pi}{\partial Pt}(Pt, Pc, wage, Cn)dPt + \int_0^1 \frac{\partial \pi}{\partial Pc}(Pt, Pc, wage, Cn)dPc + \int_0^1 \frac{\partial \pi}{\partial wage}(Pt, Pc, wage, Cn)dwage + \int_0^1 \frac{\partial \pi}{\partial C}(Pt, Pc, wage, Cn)dC \quad (10)$$

Using the Envelope theorem and Hotelling's lemma (Morey, 2002):

$$\frac{\partial \pi}{\partial Pt} = Qst, \frac{\partial \pi}{\partial Pc} = -Qdc, \frac{\partial \pi}{\partial Pt} = -Qdlabor \quad (11)$$

And thus, we shall substitute (11) into (10). Also, it is important to realize that C_n is a constant. The derivative of a constant is zero and the integral of zero is still zero, so we end up with:

$$\Delta\prod = \int_{Pt0}^{Pt1} \text{Qst(Pt, Pc, wage, Cn) dPt} - \int_{Pt0}^{Pt1} \text{Qdlab(Pt, Pc, wage, Cn)dw} - \int_{Pt0}^{Pt1} \text{Qdc(Pt, Pc, wage, Cn)dPc} \quad (12)$$

Which is exactly like equation (8).

The change in consumer surplus can be thought of using similar logic, as it is the difference between the amount consumers would be willing to pay and the equilibrium amount that they actually paid. Therefore it is represented as the geometric area below the demand curve for textiles. This is depicted in figure 1. Note also that consumers have no "cost" functions and therefore the simple area is sufficient. Thus:

$$\text{CS} = \int_{Pt0}^{Pt1} \text{Qdt(Pt, Psubs, Cn)}dPt \quad (13)$$

Where Psubs refers to a vector representing all the prices of the substitutes for cotton textiles.

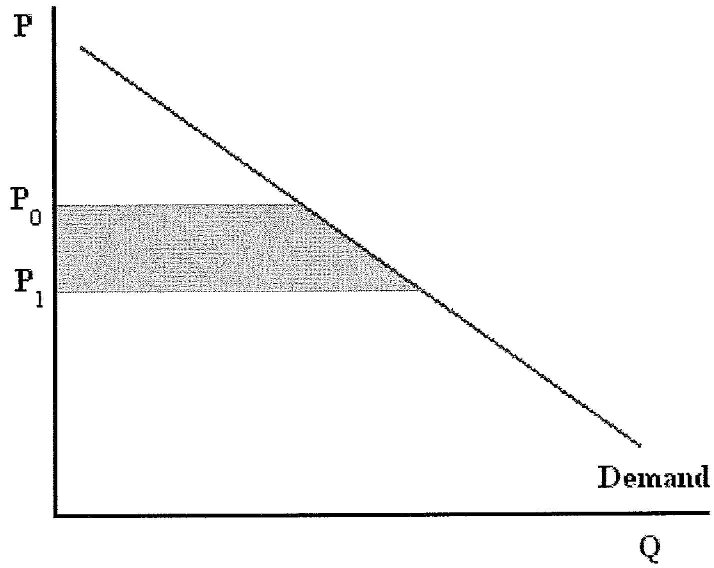

Figure 1

Data Sources and Description

The data used in my regressions comes mainly from the U.S. Department of Agriculture, and in particular, from the National Agricultural Statistics Service (NASS) branch, of the National Cotton Council. Data about the consumer price index was collected from the Bureau of Labor Statistics. Cotton data is measured in thousands of bales and converted to pounds (1 bale is equal to 500 pounds). Price data is measured as U.S. cents per pound, and wage data is the average U.S. dollars per hours for farm laborers. The wage data is taken nominally and then converted to real US dollars of base year 2000 for more accurate regression results, using CPI_{2000}=172.2.

Variables that are lagged will be denoted as the name of the variable with a lag suffix (for example, the lagged quantity demanded of textiles is Qdt_{t-1}). These variables match very closely to the ones that Dadakas and Katranidis examined, the only major difference being cotton textiles instead of yarn, and differing substitutes.

Variable	Mean	Std Dev	Minimum	Maximum
CPI	144.7158	36.17654	82.4	207.342
Price of Cotton Seeds	75.60343	27.54675	31.11462	156.1085
Price of Cotton Lint	89.27804	34.1012	40.06008	190.1514
Price of Polyester	91.1558	31.40838	53.40681	160.5495
Price of Rayon	123.6892	23.61977	84.46223	163.8647
Price of Wool	96.3805	45.88426	33	200.8757
Price of Cotton Textiles	89.82649	37.70096	40.01089	178.4694
Quantity of Cotton Demanded	7935022	2163633	4583813	11348690
Quantity of Labor Demanded	2279.68	1014.08	1003	4043.4
Quantity of Textiles Demanded	26.90786	7.544596	13.49	36.4
Quantity of Seeds Supplied	16341.39	3851.44	7771	23890
Quantity of Textiles Supplied	18.87107	4.620532	11.83	26.4
Wages	7.671052	0.531643	6.89463	8.507054
Year	1993.5	8.225975	1980	2007

Table 1

The SAS econometric program was used to run seemingly unrelated regressions and to bootstrap the results to give statistical significance. Bootstrapping is necessary because the time-series data goes from 1980 to 2007, and therefore only 27 observations are used. Table 1 displays the output from the proc means procedure, in which the sample mean, standard deviation, and maximum and minimum data points are present, while figure 1 represents the real prices of cotton and textiles, to show yearly price fluctuations.

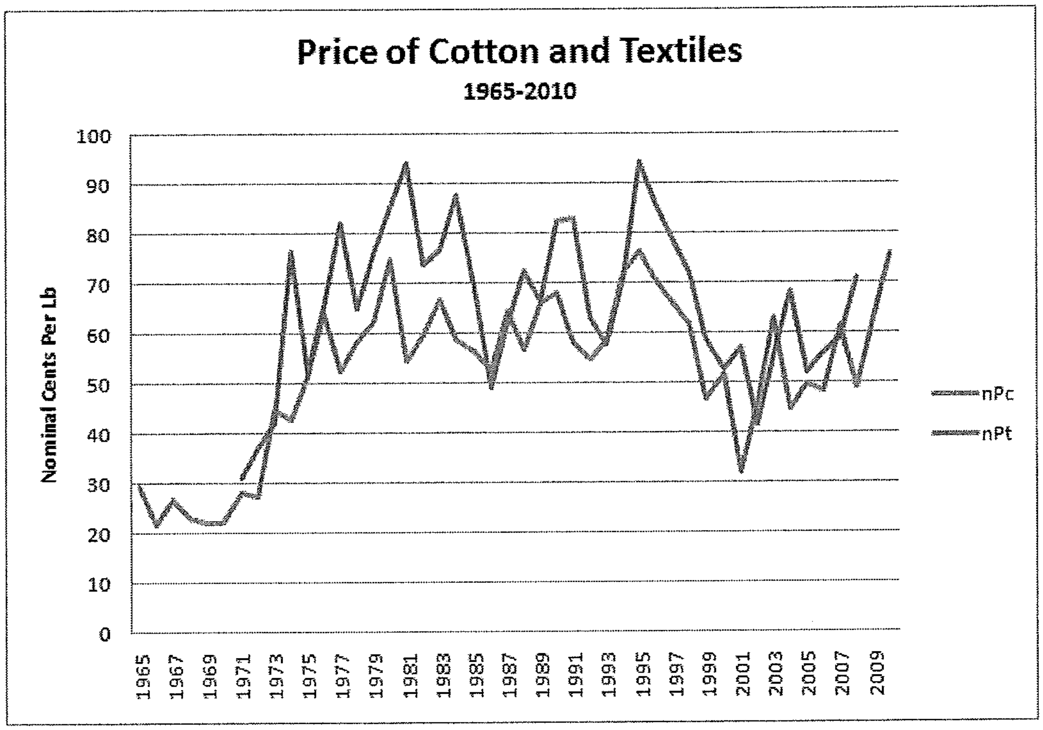

Figure 2

Model Estimation and Interpretation

Table 2 contains the results from the SUR regressions. The SAS statistical software was used to run the four regressions. The Stata program was used to find the bootstrapped OLS results. On the far right are the results of the Ordinary Least Squares regression for the demand for cotton textiles. Each cell of table 2 contains the parameter estimate, with the t-value below it in parenthesis to show statistical significance.

Neither three stage least squares, nor seemingly unrelated regressions were able to produce the desired results for the supply of cotton textiles, or for the demand of cotton lint. This is most likely because the data collected was time-series, and therefore time-series analysis is necessary to get accurate results. Macroeconomic data cannot be run using micro-econometrics. However, the demand for cotton textiles did have the expected signs with the exception of the price of polyester, which is peculiar since it is considered a substitute for cotton in this analysis. Perhaps polyester could also be considered a complement in the case of mixed fabrics.

	Supply of Textiles	**Demand for Cotton Seed**	**Demand for Labor**	**Demand for Textiles**	**Demand for Textiles OLS**
Constant	4.062896 (0.91)	-966683 (-1.30)	9551.127 (2.26)	7.885153 (2.96)	8.262493 (3.05)
Price of Textiles	-0.05218 (-2.91)	-0.09486 (-4.16)	0.811689 (1.67)	-0.06224 (-2.41)	-0.0539901 (-2.31)
Price of Cotton Seed	0.094863 (4.16)	28144.15 (2.31)	4.551338 (0.42)		
Cost of Labor	-0.81169 (-1.67)	4.551338 (0.42)	-1081.26 (-2.31)		
Price of Rayon				0.062403 (2.22)	0.0977592 (2.60)
Price of Polyester				-0.06109 (-1.19)	-0.1149789 (-1.56)
Price of Wool				0.006057 (0.49)	0.0153648 (0.57)
Lagged Demand of Textiles				0.801106 (13.01)	0.7488993 (10.89)
Lagged Supply of Textiles	1.008476 (20.08)				
Lagged Demand of Seed		0.911533 (16.26)			
Lagged Demand for Labor			0.280305 (-2.31)		
Mean R^2	0.9844				0.9724
Durbin-H Test					-1.0818

Table 2

To test for serial correlation problems, a Durbin-h test was performed. However, the results from this test were sufficiently insignificant as to conclude that autocorrelation is not a major issue in the model for the demand for textiles. A similar test would also be necessary for the other three equations had they more satisfactory results.

The welfare effects are summarized in table 3 below. The demand functions for labor and textiles showed the expected sign and are thus downward sloping as theory provides. However, because of the insignificance and impossible trend of the supply curve for cotton textiles, only the consumer surplus was calculated in this analysis. It was calculated based on the bootstrapped OLS regression results, which did not differ too drastically from their counterparts from the SUR. The following represents the change in consumer surplus from one year to the next in terms of millions of 2000 U.S. dollars. Although not every coefficient was statistically significant, every coefficient was still used to make the welfare calculations. This is because this empirical study is already inconclusive and therefore it should only be taken theoretically and the calculations were made for demonstration purposes only.

Year	%ΔPt	ΔCS	Year	%ΔPt	ΔCS
1980			1994	19.30222	-409.427
1981	-0.01005	0.275866	1995	29.88836	-760.596
1982	-26.2024	753.5815	1996	-11.8293	380.776
1983	0.694785	-14.9295	1997	-10.2371	294.9511
1984	9.609455	-228.155	1998	-9.55135	264.8524
1985	-23.8079	659.732	1999	-20.1839	529.527
1986	-30.4829	717.2353	2000	-13.2718	283.1502
1987	22.2722	-407.319	2001	5.335968	-99.5628
1988	11.79961	-291.363	2002	-28.0605	525.1706
1989	-12.3821	320.8622	2003	29.58264	-417.574
1990	17.7349	-426.533	2004	20.08722	-362.012
1991	-3.45589	95.94954	2005	-26.077	570.1175
1992	-26.1085	738.9243	2006	4.298372	-73.7647
1993	-11.2157	259.5987	2007	2.247903	-40.7813

Table 3

The welfare effects seem to jump in sign and size, perhaps a bit more abruptly than would have been anticipated. However, it is important to note that the trends between the percent changes in price and changes in consumer surplus were always opposite; when prices went down, consumer surplus went up. According to my model (which in this case is parallel to economic theory), consumers purchased more textiles as they became cheaper. Between the years 2004 and 2005 when quotas were supposed to be removed entirely on textiles and clothing, consumer surplus went up drastically. Perhaps producer surplus decreased simultaneously, however this study was too limited to be certain.

Conclusions and Limitations of the Study

The data set is a time series data set, beginning in 1980 and running all the way through 2007. As such, the data used gives the equilibrium points from year to year of supply and demand prices and quantities, and the true curves may be shaped differently. Perhaps to somewhat correct for this, the three stage least squares model would have been the more appropriate results to report. As was mentioned before, a time-series analysis would be required to give better estimations for the data used here. However, this study could be improved upon by changing the unit of observation to a state or country and taking panel data over a period of only a few years, and calculating changes in welfare globally. Panel data should be used in this analysis where time-series leaves some major flaws.

Many other limitations in this empirical model could have lead to the inconclusiveness of the results. There is always the possibility that important variables were omitted from every equation, for example, polyester, wool, and rayon are not cotton's only substitutes.

Also, it is important to note that labor data specific to the cotton industry does not properly exist (there is no comparable data collected about employment prior to 1990, and wage data does not exist specific to the cotton industry). Thus farming numbers are used in this empirical experiment, both in terms of employment and wages, as they should be akin to cotton farming numbers, fairly similar in value and rising and falling close to the same times. However, they are not exactly the same, and therefore do not explain changes in the cotton industry exactly.

Unfortunately, policy implications and suggestions should most likely not be formulated from the results of this paper, seeing as it does not appear to be the best model available.

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