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On the impact of US subsidies on world cotton prices: a meta-analysis approach.[♣]

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Résumé

Malgré l'abondante littérature traitant de l'impact des subventions sur le prix mondial du coton, il n'existe pas de consensus sur la quantification de cet impact. Le but de cet article est de contribuer à ces recherches par la mise en œuvre d'une méta-analyse. Cette méthode nous permet : (i) d'identifier les principales sources d'hétérogénéité entre les études de base, (ii) de donner certaines pistes pour améliorer la modélisation, (iii) de fournir une estimation fiable de l'effet de la suppression des subventions sur les cours mondiaux du coton. Basés sur l'estimation de différents modèles, nos résultats montrent que la suppression des subventions américaines entrainerait une augmentation des cours mondiaux d'environ 10%.

Mots-clés : Méta-analyse, Mixed Effect Size (MES), Coton, Subventions, Agriculture.

Classification au JEL : Q17, Q18, C82.

Abstract

Despite the vast literature dealing with the impact of the subsidies on world cotton prices, there is no consensus regarding the quantification of these effects. The aim of this paper is to contribute to this literature through the implementation of a meta-regression analysis. This methodology allows us to: (i) identify the main sources of heterogeneity between the primary studies, (ii) give some tracks to improve the modeling, (iii) provide a reliable quantification of the removal of subsidies on world cotton prices. Relying on the estimation of various models to derive robust results, our findings show that a withdrawal of US subsidies would increase the world cotton price by around 10%.

Keywords: Meta-Regression Analysis (MRA), Mixed Effect Sizes (MES), Cotton, Subsidies, Agriculture.

JEL Classification: Q17, Q18, C82.

[♣] This article is an extension of a former work (Guerreiro, 2009) where the econometric methods are improved and a special attention is paid to US subsidies.

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1. Introduction

During the 2003 Cancun summit, four Western and Central Africa countries addressed a resolution to WTO arguing that the large subsidies granted by the US and the EU to their cotton growers led to a collapse of world cotton prices. For a long time, Western and Central Africa is specialized in cotton production, and the ongoing fall of world prices (from 0.91$/lb in 1994/1995 to 0.42$/lb in 2001/2002) triggered a serious crisis in that sector inward the region.

From a theoretical viewpoint, the consequences of the subsidies are well known: the more the support is coupled to production and price, the more it is trade-distorting[1]; and the greater are the amounts, the greater are the distortions. The US and the EU are the main subsidizers in the world (Table 1). While in 2004/2005, the export cotton market was estimated at 8 billion dollars, the amount of US and EU subsidies reached 5.5 billion. Also, even if a revision of the Common Agricultural Policy (CAP) in 2004 led to more decoupled subsidies in the EU, most of the US subsidies are still counter-cyclical, as set in the Farm Bill and in the FSRI Act (2002).

Table 1. Amount of US and EU Subsidies between 2000 and 2008 (in Millions of Current Dollars).

	2000/01	2001/02	2002/03	2003/04	2004/05	2005/06	2006/07	2007/08
US support	NR	3706	3336	1722	4484	NR	3599	1185
European support	675	720	820	963	1060	NR	NR	NR

Note: NR: not reported. Sources: ICAC (website, 2008) and DG AGRI.

From an empirical perspective, the quantification of the impact of subsidies is more difficult and results are not clear-cut. It is however a key issue to quantify these effects for at least two reasons. First, it is of a great interest to assess the economic consequences of subsidies on some less advanced countries which are very dependent from cotton. Second, it is interesting to calculate the compensations for countries that have complained to WTO[2].

Our aim in this paper is to contribute to this literature by implementing a meta-analysis to the empirical findings regarding the impact of subsidies on world cotton prices. Derived from experimental sciences, the meta-analysis is "*a quantitative form of research synthesis that aims to extract useful generalizations from a large body of diverse literature*" (Longhi et al., 2005). In our view, this statistical method is not only able to set a fair quantification of the impacts of subsidies, but also to reveal the sources of heterogeneity between studies, which could, at least, give some suggestions to improve the modeling.

The rest of the paper is organized as follows. Section 2 presents the primary studies, the data and the methods used in our meta-regression. Section 3 is dedicated to our results. Section 4 summarizes our main findings and concludes the paper.

[1] See Araujo-Bonjean et al. (2007) among others.
[2] As Brazil in 2003.

2. Primary studies, data and methods

2.1. Presentation of the primary studies and their results

Our sample is made of twelve studies[3] that deal with the impact of subsidies on cotton prices (Table 2). While all these studies agree with the fact that subsidies have a depressive effect on cotton prices, the amplitude of the value of this effect is large, even within a same study. Indeed, as reported in Table 2, the mean effect size varies from 1.87% to 22%.

Table 2. Primary Studies and Effect Sizes.

Authors	Number of Effect Sizes	Subsidies	Time Period	Effect Sizes		
				Minimum	Maximum	Mean
Araujo-Bonjean et al. (2007)	26	USA, EU	2002/2003 and 2003/2004	0.39%	16.7%	3.81%
FAPRI (2005)	2	ALL	2001/2002	2.93%	11.4%	7.18%
Gillson et al. (2004)	4	USA, EU, CHINA	2001/2002	18%	28%	22%
Goreux (2003)	15	USA, EU, CHINA	1997/2002	5.2%	15.2%	10.32%
Plastina (2007)	6	USA, EU, OTHERS	2005/2006	0.7%	10.3%	3.43%
Pan et al. (2005)	2	USA	Simulation	0.45%	3.87%	2.1%
Pan et al. (2006)	9	USA	1999/2008	1.9%	2.05%	1.97%
Poonyth et al. (2004)	10	USA	1996/2000	2.3%	11.4%	6.18%
Reeves et al. (2002)	2	ALL	2000/2001	2.2%	2.3%	2.25%
Sumner (2003)	9	USA	1999/2008	7.74%	17.7%	11.58%
Sumner (2006)	10	USA	1999/2009	5.36%	19.74%	10.65%
Tockarick (2003)	3	ALL	2000/2001	0.8%	2.8%	1.87%
Whole	98	-	-	0.45%	28%	6.6%

These heterogeneous results may come from the existence of many differences between the studies. The aim of the meta-regression analysis (MRA) is to explicitly account for these differences and transform them into explanatory variables in order to quantify their impact on the effect sizes.

[3] Initially there were fifteen studies, but we remove: (i) Shepherd (2004) because we could not recover the supply and demand elasticities, (ii) Valderrama (2000) and Traoré (2005) because some key-data were missing.

2.2. Database

We present here all the variables that we have constructed. Note that some of them have been excluded from our regressions because of colinearity problems. We group the explanatory variables in six categories. Some of them are dummy variables (first part of Table 3); others are quantitative (second part of the table).

Table 3. Meta-Independent Variables.

Category	Variable	Feature	Frequency			
Cotton market modeling	STOCKS	1 if a study models cotton stocks.	57.1%			
	SUBSTITUTE	1 if a study models a substitute to cotton.	37.8%			
Data	ICACUSDA	1 if a study uses ICAC and USDA data.	75.6%			
	US	1 if a study tests removal of US subsidies.	41.3%			
	EU	1 if a study tests removal of EU subsidies.	15.3%			
	WORLD	1 if a study tests removal of world subsidies.	36.7%			
Type of subsidy distortions	DNR	1 if a study doesn't report the type of distortion.	14.4%			
Econometric model	P-E	1 if a study uses partial equilibrium models.	64.3%			
	EDM	1 if a study uses an equilibrium displacement model.	12.2%			
	OTHER	1 if a study uses another model than P-E and EDM.	23.5%			
			Mean	**Max**	**Min**	**SD**
Elasticity supply	ES	Weighted by exporting country.	0.70	2.4	0.05	0.46
	ESSUB	Weighted by subsidizer.	0.68	3	0.15	0.54
	ESNSUB	Weighted by non-subsidizer.	0.59	3.33	0.15	0.64
	ESCHINA	China's supply elasticity.	0.55	3.6	0.14	0.71
Elasticity demand	ED	Weighted by importing country.	-0.33	-0.05	-0.82	0.21
	EDSUB	Weighted by subsidizer.	-0.30	-0.05	-0.81	0.19
	EDNSUB	Weighted by non-subsidizer.	-0.25	-0.05	-0.75	0.14
	EDCHINA	China's demand elasticity.	-0.35	-0.05	-1	0.28
Cotton market modeling	PRICE	Reference price for the calibration of the econometric model.	0.58	0.692	0.418	0.06

One of the main limits of the MRA comes from the lack of information in some primary studies. In our case, due to data unavailability, we do not include an explanatory variable replicating the pass-through between world and domestic prices.

2.3. Econometric methods

According to Florax (2002), the two main issues when implementing a MRA are: (i) the heterogeneity among studies, and (ii) the dependence between studies.

- Heterogeneity

As displayed in Table 2, there are important disparities among studies regarding the values of the effect sizes. To implement a MRA, one has to determine if the differences between effect sizes are "true" heterogeneity (e.g. explainable by a set of explanatory variables), or only sampling errors which do not require particular regression techniques. The usual test to assess that problem is the homogeneity test of Cochran (1954)[4]. Unfortunately it requires the knowledge of the standard errors associated to the effect sizes, an information that is not provided by the studies that constitute our sample. Nevertheless, as Longhi et al. (2005) emphasize, the larger are the number of effect sizes, the higher is the probability that the homogeneity test decides heterogeneity, even if differences between effect-sizes are very small. Since we have 98 effect sizes, we think that our MRA is relevant. Nelson and Kennedy (2009) make a typology of the different kinds of heterogeneity and the way to model them. As they argue: "*it is not reasonable to expect that a meta-regression can explain all of the variation present in the data, either due to observables, or because the estimates are drawn from a distribution of population effects"*. On the whole and based on these arguments, we consider that heterogeneity is partially explainable and model it through relying on the Mixed Effect Sizes (MES) methodology. In what follows, we estimate the equation:

$$\gamma_{ij} = \alpha_0 + \beta_1 x_{1ij} + \beta_2 x_{2ij} + \ldots + \beta_1 x_{Kij} + u_i + \varepsilon_i \quad (1)$$

where:
- γ_{ij} are the effect sizes estimated by each study;
- α_0 is the mean between studies;
- $x_{1ij}, x_{2ij}, \ldots, x_{Kij}$ are the explanatory variables;
- u_i are the random-effects;
- ε_i is the sampling estimation error;
- i is the study index and j the study result index.

As seen in Table 2, our panels are unbalanced since the studies have not the same number of effect sizes. Thereby, our results are automatically heteroskedastic (Baltagi, 2008), affecting the estimations of the parameters' variance (Nelson and Kennedy, 2009).

- Dependence

Dependence between effect sizes arises for three main reasons (Nelson and Kennedy, 2009):
- they share some common observable features, such as data or modeling approaches;
- they share some common unobservable features, such as the pass-through between world and domestic prices;
- studies provide more than one effect size.

The first problem can be easily solved thanks to the explanatory variables we set in Table 3. The two others are much difficult to deal with and create multidimensional autocorrelation.

In order to correct our model from heteroskedasticity and cluster correlation, we use an extension of the Huber-White estimator consistent with within-cluster correlation in our random-effect regressions[5].

[4] See Chèze (2007) for more explanations on the Cochran's test.
[5] See Froot (1989) for a presentation of the estimator.

3. Models and results

Before proceeding to the estimations, we correct our effect size from outliers by applying the Hadi's method (Hadi 1992, 1994). We find that the last estimate of Sumner (2006) is an outlier. We thus drop this observation from our sample which is now composed by 97 observations.

3.1. Models

We estimate three models (Table 4). This allows us to investigate different ways to account for elasticities, and also to conduct a sensitivity analysis in order to test the robustness of our results.

Table 4: Meta Regressions.

Category	Variable	(1)	(2)	(3)
Cotton market modeling	STOCKS	0.038*** (0.015)	0.03* (0.016)	0.058*** (0.009)
	SUBSTITUTE	-0.023*** (0.011)	-0.022 (0.014)	-0.032*** (0.001)
	PRICE	-0.123** (0.061)	-0.122** (0.061)	-0.122** (0.061)
Data	ICACUSDA	0.049*** (0.001)	0.048*** (0.001)	0.042*** (0.007)
	EU	-0.051*** (0.008)	-0.051*** (0.008)	-0.053*** (0.007)
	WORLD	0.065*** (0.016)	0.068*** (0.015)	0.076*** (0.019)
Type of subsidy distortions	DNR	-0.053** (0.028)	-0.057** (0.03)	-0.056** (0.028)
Econometric model	EDM	0.03*** (0.008)	0.028*** (0.009)	0.03** (0.013)
	OTHER	dropped	dropped	dropped
Elasticity supply	ES	0.003 (0.005)	-	-
	ESSUB	-	dropped	-
	ESNSUB	-	dropped	-
	ESCHINA	-	-	0.011*** (0.002)
Elasticity demand	ED	0.061*** (0.016)	-	-
	EDSUB	-	0.03*** (0.005)	-
	EDNSUB	-	0.042*** (0.008)	-
	EDCHINA	-	-	0.088*** (0.01)
Intercept	C	0.1*** (0.038)	0.108*** (0.038)	0.103*** (0.036)
Random individual effects	U	0.087	0.062	0.026
R^2	WITHIN	0.41	0.41	0.41

	BETWEEN	0.72	0.67	0.77
	OVERALL	0.63	0.60	0.64
Breusch-Pagan test	p-value	0.011	0.005	0.037
Number of observations		97	97	97

***, **, and * respectively denote significance at 1%, 5%, and 10% level.

The Breusch-Pagan test is used to determine if the model is well specified (i.e. random individual effects are significantly different from 0), or if the Fixed Effect Sizes (FES) modeling would have been used. The p-values indicate that random individual effects are significant, meaning that our equations are well specified. Some variables (OTHER, ESSUB, and ESNSUB) have been dropped due to multicolinearity problems.

3.2. Results

Model (1) considers average price-elasticities of supply and demand. Model (2) tests the assumption made by Araujo-Bonjean et al. (2007) that increases in cotton price are higher in the following cases: (i) subsidizer countries present price-elasticites near |1|, and (ii) non-subsidizer countries present price-elasticities near 0. Finally, model (3) focuses on the price-elasticities of one of the most important country in cotton market, namely China.

Despite these differences, our results appear to be globally robust since coefficients and their significance are largely stable. They have a good overall explanatory power ($R^2 > 0.6$), even if they better explain inter study differences (with R^2 around 0.7) than intra study ($R^2 = 0.41$). Our key finding is that a withdrawal of US subsidies will increase the world cotton price by about 10%. Let us now pay a special attention to the explanatory variables effects.

- Cotton market modeling

This category is what Stanley and Jarrel (1989) calls "*the selected characteristics of the authors of the primary literature"*. The assumptions made by the authors on the cotton market to construct their modeling are not the same. The principal differences we set are the (non) inclusion of stocks, the (non) existence of a substitute to cotton, and the price of model calibration.
We try to control for the inclusion of stocks and the existence of a substitute by two dummy variables: STOCKS and SUBSTITUTE. Our findings show that they have antagonist effects. In (1), stocks modeling increases the effects of US subsidies removal by 3.8 points, whereas taking into account the existence of a substitute lower it by about 2.3 points. In (2), SUBSTITUTE is not significant anymore, and STOCKS is significant only at the 10% level. In (3), both STOCKS and SUBSTITUTE are significant (at the 1% significance level). The impact of eliminating the US subsidies on world cotton prices is increased by 5.8 points according to STOCKS, and lowered by 3.2 points regarding SUBSTITUTE.
PRICE is a quantitative variable accounting for discordances in price calibration. Most of the studies forecast the impacts of subsidies. In order to do so, the authors must previously forecast cotton prices to calibrate their models. These forecasted prices differ across studies. The effects are quite the same in all models. We notice that when the forecasted price increases by one dollar, world cotton prices decrease approximately by 0.123%. The higher are forecasted prices, the lower is the increase in world cotton prices.

- Data

The data may be an important source of differences between studies. It belongs to the "*specification variables"* category (Stanley and Jarrell, 1989). Our data category is composed by a single variable (ICACUSDA) and a family variable (US/EU/WORLD) where US is the omitted. ICACUSDA specifies the origin of data, and the family variable US/EU/WORLD models the subsidies amounts: subsidies level evolves according to the amounts granted by each country. Since this information was not provided by primary studies, we choose to classify subsidies by provenience.
ICACUSDA is significant at the 1% level in all the models and induces an increase of 4.9 points in (1), 4.8 points in (2), and 4.2 points in (3). EU and WORLD variables have the expected signs, and the coefficients are equivalent between the models. If only European subsidies are accounted for, the effects comparing to US subsidies withdrawal fall by 5.1 points in (1) and (2), and 5.3 points in (3). If world subsidies are accounted for, then effects are increased by 6.5 points in (1), 4.8 points in (2) and 7.6 points in (3).

- Type of subsidy distortions

As mentioned in Section 1, the more the subsidies are coupled to price or production, the greater are the distortions they induce in international trade, and then in world prices. However, several studies do not report the way they account for the distortions. This category aims to control that lack. Our models show that when the type of distortions induced by subsidies is not reported, the increase in world price is lowered by 5.3 points in (1), 5.7 points in (2), and 5.6 points in (3).

- Econometric model

As data or subsidy provenience, this category can be classified in *"specification variables"*. It is composed by a family variable where P-E is the omitted. Unfortunately, we could not include the explanatory variable OTHER in any model because of colinearity problems. Compared to E-P, EDM seems to have an increasing effect. Indeed, the impact of removing the US is increased by approximately 3 points when primary studies employ an equilibrium displacement model.

- Elasticities

Unlike PRICE, elasticities are quantitative variables. In model (1), the elasticity of supply is not significant. On the contrary, the demand elasticity is significant and has a positive sign. At first sight, this relation may appear wrong, but we have to remember that the values of the elasticity of demand are negative. It makes sense that an increase of 1% of the elasticity of demand (i.e. a decrease of the sensitivity of demand relating to the price) leads to an increase of world cotton price of 0.066%. In model (2), we could not test Araujo's assumption because of problems of colinearity. In model (3), China's supply and demand elasticities are significant. A one percent increase of China's supply elasticity (i.e. a rise of supply sensitivity relating to the price) leads to an appreciation of world cotton price of 0.011%, and a one percent increase in China's demand elasticity (i.e. a decrease of demand sensitivity relating to the price) leads to an appreciation of world cotton price of 0.088%.

The explanatory variables study indicates that the main sources of heterogeneity are found in (i) *"the selected characteristics of the authors of the primary studies"*, (ii) the data, and (iii) the values of supply and demand price elasticties.

4. Conclusion

The aim of this paper was to investigate the effects of US subsidies on world cotton prices. To this end, we rely on a meta-regression analysis, which allows us to quantify these impacts. Using various models to derive robust conclusions, our findings show that a withdrawal of US subsidies would increase the world cotton price by around 10%. There is however some heterogeneity across studies regarding the value of the effect sizes. Our results indicate that this heterogeneity comes from three main sources. The first one is the data: the amount of subventions set by the ICAC is higher than that announced by WTO, showing that, despite the juridical definition proposed by WTO[6], it is very difficult to classify the support. The second source comes from *"selected characteristics"*, and we think that future studies dealing with the impact of subsidies on cotton prices must account for the stocks modeling and the existence of a substitute. Finally, the last source relies on price-elasticity values, especially those of major actors.

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[6] The green, amber, and red boxes.

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