The Impact of United States Subsidies on World Cotton Price : Evidence from a Simultaneous Equations Model

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Abstract

This article investigates the impact of United States subsidies on world cotton price in a structural framework. It starts with a simultaneous equations model of world cotton market and focus on the reduced form afterwards. Using the ARDL bounds tests of Pesaran, Shin and Smith. (2001), no evidence of cointegration was found between the underlying variables. However, working in a classical framework, strong evidence of negative impact of subsidies on cotton price was found either in the short run or in the long run.

Keywords : United States, subsidies, cotton, ARDL models
JEL Codes: C32; Q17.

1 Introduction

With more than 4 billions of dollars granted to its cotton growers in 2004, the United States are the first country for the amount of the subsidies going to its cotton sector. These subsidies take different forms (direct payments, production subsidies, export subsidies, insurance subsidies...). The focus on this country subsidies might be viewed as relevant due to the fact that it is the second producer and the fisrt exporter of cotton in the world.

In a general context of declining cotton prices, the subsidies described above are very often accused by non governmental organizations (NGO) like OXFAM as well as some developing and emerging countries (Chad, Mali, Brazil...) to lower cotton prices. Many previous studies has attempted to asses the impact of United States support on world cotton price with a large range of modelling strategies. The modelling strategy adopted in those studies is partial equilibrium models (Goreux, 2003; Tockarick, 2003; Poonyth and al., 2004; Araujo Bonjean et *al.* (2006) or general equilibrium ones (Reeves et *al.*, 2001). Few authors has used econometric approach (Shepherd, 2004). The observed differences in previous studies is due to their different aims. Partial and general equilibrium models try to answer the question: what would have happened if all the subsidies were removed? In contrast, an econometric approach will answer the question of statistical significance and causality between subsidies and the cotton price. This approach is less data consuming (only the world market is considered instead of individual countries) and express in a sens a kind of global assesment. That is the reason why it is the modelling strategy adopted here.

The originality of this paper comparing to other papers that are present in the litterature lies first on its structural modelling framework. It considers first a world cotton market described in a simultaneous equation model which takes account supply, demand, stocks and competing products such as polyseter. The second point concerns the treatment of the reduced form in the new Autoregressive Distributed Lag (ARDL) modelling framework developped by Pesaran, Shin and Smith (2001).

The remaining of this paper is organized as follows : section 2 presents an overview of world cotton market while the next one discuss the model. In the fourth section, the results are provided and the final section concludes.

2 Overview of world cotton market

The world cotton market is dominated by two large countries: China and United States. The former is the first producer in the world with 6.7 millions of metric tons while the later is the first exporter with 3 millions of metric tons. The United States account for more than 35% of world exports so that they can be considered as price maker. Table 1 shown below illsutrates this fact and point out that , other countries like Uzbekistan, Australia or Brazil are also big actors in world cotton market. However, these countries are much more important than United States in terms of market shares and to our knowledge, they are not subsidizing their cotton sectors. In terms of consumption, the main consumers are located in Asia (essentialy in China and India) where the textile industry is situated. For both of these countries, the production, although substantial, is essentially for domestic use.

Table 1: world cotton market statistics: shares in percentage(2006)

	Production	**Exportations**	**Consumption**
USA	18.5	35.7	4.1
China	26.5	0.2	41.0
India	18.4	11.9	15.2
Ouzbekistan	4.6	12.3	0.6
Australia	0.9	5.8	0.05
Brazil	5.4	3.4	3.4
ROW	25.7	30.6	35.7

Source: National Cotton Council of America (2007)

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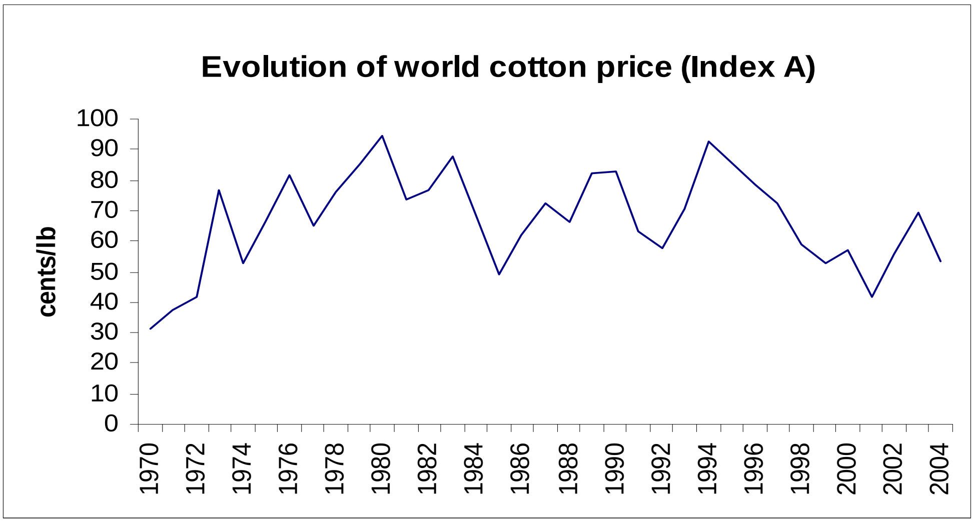
The evolution of world cotton price measured with A index of Cotlook -like many other commodities- presents large fluctuations in the last three decades . Nevertheless, we can notice a clear declining trend since 1994-1995 crop year with the lowest value of the last thirty years in 2001 (*45 cents/lb*). The price's decline in recent years is essentially due to the lower demand occured with the 1997 East Asian crisis and to the high level of Chinese Stocks (about 30% of world stocks). The competition of man made (or synthetic) fibers may also be mentionned, in particular the secular decline of polyester price. The remaining debate is whether or not the developped countries subsidies create or accentuate this trend.

Figure 1: Evolution of world cotton price



3 The model

As mentionned previously, there is a profuse litterature about the impact of United States or European Union subsidies on world cotton market. Most of these studies used partial equilibrium models or, rarely, general equilibrium models and econometric ones. Probably the best way to deal with this subject, if one adopt an econometric framework, is to work with a structural model. Structural models allow to consider all the driving forces on a specific market (supply, demand, stocks...) and equilibrium conditions. For that reason, we retain this modelling strategy here. We start with a structural model of world cotton market as described below:

$$\begin{cases} Q_t^s = \alpha_0 + \alpha_1 p_{t-1}^w + \alpha_2 Sb_{t-1} + \alpha_3 T + \varepsilon_t \\ Q_t^d = \beta_0 + \beta_1 p_t^w + \beta_2 GDP_t + \beta_3 Pol_t + v_t \\ Stk_t = \gamma_0 + \gamma_1 \left(p_t^w - p_{t-1}^w\right) + \gamma_3 Q_t^d + u_t \\ Q_t^d = Q_t^s + \Delta Stk_t \\ \Delta Stk_t = Stk_{t-1} - Stk_t \end{cases} :$$

The supply of cotton (Q_t^s) is a function of past prices (p_{t-1}^w) and United States subsidies (Sb_{t-1}) and a time trend (T) reflecting technical progress. The presence of past prices in stead of current ones reflects the naive expectations hypothesis. This hypothesis, although discutable, is very convenient because it permits identifying conditions (for the structural model) and it also make possible the estimation of long run parameters by instrumental variables methods[1]. Other factors that are important for supply equation (fixed factors or prices of competing products) could have been retained, but at this level of agregation, these factors can hardly be handled. The demand (Q_t^d)depends on the current price (p_t^w), the GDP of the OECD countries (GDP_t) which is a proxy of rich countries revenue. The last variable entering the demand equation is polyester (Pol_t), the main -synthetic fiber-competitor of cotton fiber. Polyester price has much fallen since early sixties and is a relevant determinant of cotton price (Baffes and Gohou, 2005). Stocks (Stk_t) are modelled in a traditional way in a transaction and a speculative part. Here it is assumed that the spread between current and lagged values of the price reflects the opportunity cost of handing stocks. Finaly, stocks adjust to ensure equilibrium between supply and demand.

Once a simultaneous equations model has been constructed, identification issues are crucial and have to be examinated. It appears that all the equations of the system satisfy the rank conditions[2]. But, as we are interested in the impact of subsidies on cotton price, we will work with the reduced form of the model wich is given by[3] :

[1] This issue will be discussed in subsection 4.3.

[2] The rank conditions are necessary and sufficient. Since we are not interested in the strucural parameters, we don't discuss about order conditions.

[3] The $\pi's$ are combinations of structural parameters and their exact formulation are available from the author upon request.

$$p_t^w = \pi_0 + \pi_1 p_{t-1}^w + \pi_2 p_{t-2}^w + \pi_3 Sb_{t-1} + \pi_4 T + \pi_5 Pol_t + \pi_6 Pol_{t-1} + \pi_7 GDP_t + \pi_8 GDP_{t-1} + \eta_t \quad (1)$$

This reduced form is an Autoregressive Distributed Lag (ARDL) model (2,0,1,1)[4]. In order to avoid misspecification problems (like omitted variables bias), the true lags order will be determined by an information criterium.

The main issue with equation (1) concerns the properties (particulary the stationarity ones) of the series which are present. One can use standard unit roots tests and adopt strategies like Engle and Granger (1987) two step method. But it is well known now that the pretesting procedure of series in order to determine their order of integration has many drawbacks like size distorsion and low power of unit root tests (Schwert, 1989; Cochrane, 1991; Blough, 1996). In the ARDL modelling framework, Pesaran and Shin (1997) and Pesaran, Shin and Smith (2001) have developped a new testing procedure which is more powerfull. These new tests, called "bounds tests" can be described as follows :

Suppose we have a general unconstrained error correction model of the following form between a serie y_t and a vector of explanatory variables x_t, with $w_t = (y_t, x_t)$:

$$\Delta y_t = \alpha_0 + \pi_{yy} y_{t-1} + \pi_{yx.x} x_{t-1} + \sum_{i=1}^{p-1} \beta_i \Delta w_{t-i} + \gamma' \Delta x_{t-1} + \lambda' z_t + \varepsilon_t \quad (2)$$

where z_t is a vector of determinist variables such as trends or dummies.

The null hypothesis of no cointegration between the variables is given by

$H_0^{\pi_{yy}} : \pi_{yy} = 0,\ H_0^{\pi_{yx.x}} : \pi_{yx.x} = 0'$

and $H_1^{\pi_{yy}} : \pi_{yy} \neq 0,\ H_1^{\pi_{yx}} : \pi_{yx.x} \neq 0$

i,e $H_0 = H_0^{\pi_{yy}} \cap H_0^{\pi_{yx.x}}$

$H_1 = H_1^{\pi_{yy}} \cup H_1^{\pi_{yx.x}}$

The testing procedure consists of computing the F-statistic under the null hypothesis and to compare it with critical values tabulated by Pesaran and al. (2001). These authors have tabulated two critical values bounds. The first one (the lower bound) assumes that all the regressors are I(0) and the second one (the upper bound) assumes that they are all I(1). If the computed F-statistic is above the upper bound, cointegration is not rejected; on the other hand if the statistic is below the lower bound, cointegration is rejected and inference can be made in

[4] Although the subsidies are lagged one period, the principle remain valid.

a classical framework. However, if the statistic fall within the bound, the test is inconclusive and further investigation is needed.

In order to extend the work by Banerjee, Dolado and Mestre (1998), they have developped a t-test version, based on the error correction term in (2) . The bounds testing procedure remain the same as for the F-test.

Applied to equation (1), these tests are given by:

$$\Delta p_t^w = c_0 + a_0 T + a_1 p_{t-1}^w + a_2 Sb_{t-2} + a_3 GDP_{t-1} + a_4 Pol_{t-1} + \sum_{i=1}^{p} b_i \left(\Delta p_{t-i}^w\right)$$
$$+ \sum_{i=0}^{p} \rho_i \left(\Delta Sb_{t-i}\right) + \sum_{i=0}^{p} \tau_i \left(\Delta GDP_{t-i}\right) + \sum_{i=0}^{p} \phi_i \left(\Delta Pol_{t-i}\right) + \eta_t \qquad (3)$$

for the F-test

$$\begin{cases} H_0 : a_1 = a_2 = a_3 = a_4 = 0 \\ H_1 : a_1 \neq 0,\ a_2 \neq 0,\ a_3 \neq 0,\ a_4 \neq 0 \end{cases}$$

and for the t-test:

$$\begin{cases} H_0 : a_1 = 0 \\ H_1 : a_1 \neq 0 \end{cases}$$

Using Schwarz information criterium, an order p=4 is retained for equation (1). The F and t-statistics are provided in the table below.

Table 2: Test statistics

Variables	**computed values**	**5% critical values**	
		$I(0)$	$I(1)$
$F\left(p_t^w / Sb_t, PIB_t, Pol_t, T\right)$	3.99	6,23	7,74
$t\left(p_t^w / Sb_t, PIB_t, Pol_t, T\right)$	-3,17	-3,41	-4,16

Both the calculated F and t-statistics lies outside the critical values bounds and below the lower bound, so we conclude that cointegration can be rejected and equation (1) can be handled in a classical framework without knowing the order of integration of the series.

4 Data and Results

4.1 Data

Before estimating (2), it is necessary to discuss the data set.

The main characteristic of the data set is that all the series are annual ones covering the period 1965-2004. This period can be viewed as relatively short, but although one can have monthly or quaterly data for cotton price for example, it is almost impossible to have such an information for the whole system.

The supply, demand, stocks and cotton price data as well as polyester price, come from the National Cotton Council of America database and from various issues of United States Department of Agricuture (USDA) "Cotton and Wool Yearbooks". This database provides more information than the FAO database wich only provides information about seed cotton. The subsidies are defined in a per unit basis (cents/pound) and are taken from the USDA Factsheets. The OECD GDP is taken from the World Development Indicators published by the World Bank.

4.2 Short run impacts

Following Pesaran, Shin and Smith (2001), equation (2) is estimated with appropriate and different lag orders to avoid mispecifications such as omitted variables biases. Using Schwarz information criterium again, we finaly estimate an ARDL (2,2,4,0) model which is given by[5]:

$$p_t^w = \pi_0 + \pi_1^p p_{t-1}^w + \pi_2^p p_{t-2}^w + \pi_3^s Sb_{t-1} + \pi_4^s Sb_{t-2} + \pi_5^g GDP_t + \pi_6^g GDP_{t-1} + \pi_7^g GDP_{t-2} + \pi_8^g GDP_{t-3} + \pi_9^g GDP_{t-4} + \pi_{10} Pol_t + \pi_{11} T + \mu_t \quad (4)$$

It is well known that equation (2) with all the lagged values of the variables, is the short run representation of the ARDL model and Table 3 below show the

[5] The $\pi's$ are combinations of structural parameters and their detailed formulations are available from the author.

results of its estimation, corrected for autocorelation[6]:

Table 3: Short run elasticities

Variables	Coefficients	t-statistics[7]
p^w_{t-1}	0.02	0.18
p^w_{t-2}	-0.36	-1.79*
sb_{t-1}	-0.06	-2.25**
sb_{t-2}	-0.04	-1.80*
GDP_t	5.02	2.27**
GDP_{t-1}	-5.65	-1.53
GDP_{t-2}	4.75	1.13
GDP_{t-3}	-1.37	-0.36
GDP_{t-4}	3.79	2.07**
Pol_t	0.54	2.95***
T	-0.19	-3.31***
π_0	-191.06	-3.17***
$\overline{R}^2$	0.80	

As one can reasonably expect, the short run impacts are usual. The subsidies have a negative and significant impact on cotton price. However the elasticities are relatively small (-0.06 and -0.04). In the demand side, GDP has a positive and significant impact on cotton price, much more important than subsidies. But, although some lagged GDP values are negative, they are not significant. The positive effect of polyester price on cotton traduces the substitution effect between the two fibers. An increase in polyester price result in a shift of demand in favor of cotton. Here again, the impact is more important than the elasticity of subsidies but less than the impact of GDP. Finally, a clear negative trend is identified in cotton price, reflecting the relative decline mentionned in the above subsection.

4.3 Long run impacts

The following subsection has illustrated the short run impact of subsidies on cotton price. It is straightforward to see that π^s_3 and π^s_4 are short run elasticities. In a traditionnaly ARDL modelling framework, the long run (or equilibrium) impact of subsidies on cotton price is given by :

[6]The long run issues will be discussed in the next subsection.

$$\theta = \frac{\pi_3^s + \pi_4^s}{1-\pi_1-\pi_2} \qquad (5)$$

To estimate this long run elasticity one can use the formula (5) above.But in order to get the standard error of the long run elasticity, it is neccessary to use either the so called "delta method" or Bewley (1979) transformation and Wickens and Breusch intrumental variables approach. For computationnaly convenience, the later approach is adopted here. To see how does this method work, let us suppose $\lambda = \frac{1}{1-\pi_1-\pi_2}$.

By substrating $\sum_{i=1}^{2} \pi_i^p p_t^w$ from both sides of (4) , rearanging the sb_t's and multiplying each side by λ, we get[8]:

$$\begin{aligned} p_t^w = & -\lambda\pi_1 \left(p_t^w - p_{t-1}^w\right) - \lambda\pi_2 \left(p_t^w - p_{t-2}^w\right) + \theta sb_{t-1} + \lambda\pi_4^s \left(Sb_{t-1} - Sb_{t-2}\right) \\ & +\lambda\pi_5^g GDP_t + \lambda\pi_6^g GDP_{t-1} + \lambda\pi_7^g GDP_{t-2} + \lambda\pi_8^g GDP_{t-3} + \lambda\pi_9^g GDP_{t-4} \\ & +\lambda\pi_{10} Pol_t + \lambda\pi_{11} T + \eta_t \qquad (6) \end{aligned}$$

The presence of p_t^w in the right hand side of (4) make its estimation by OLS impossible (endogeneity). So we have to use instrumental variables techniques. Breusch and Wickens has shown that the estimate of θ we get by applying 2SLS on (6) is exactly the same we will get by applying formula (5) provided that we use -exactly the same number of variables- the explanatory variables of (4) as instruments. The results of this approach are given in table 3 below.

Table 4: Long run elasticities

Variables	**Coefficients**	**t-statistics**
sb	-0.07	-2.61**
GDP	4.87	2.98***
Pol	0.40	2.76**

As in the short run, subsidies have a negative and significant impact on cotton price. However, the long run elasticity is smaller than the shorter run. So the impact tends to dampen throughout the time: a shock at a given period is not accumulated over time.

[8] See Bewley (1979) and Wickens and Breusch (1988) for any proof.

The coefficients of GDP and polyester remain positive and strongly significant. Again, GDP appears as the main driving force on the cotton market, 10 times greater than the coefficient of polyester and much more greater than the coefficient of subsidies. As a result, the main determinant of world cotton price seems to come from the demand side, not from the supply one.

5 Conclusion

The aim of this article was to asses the impact of United States cotton subsidies on world cotton price with a simultaneous equations model of world cotton market. A negative and significant impact of these subsidies on cotton price is founded in the short run as well as in the long run. Another result is that short run impacts are lower than long run ones.

The results also indicate that cotton price is much more responsive to demand forces (like GDP) rather than supply ones (subsidies). So the impact of subsidies although negative and significant, are not the main driving force in world cotton market.

All the conclusions made about the results are based on the naïve representation of expectations. It would be better to asses the robustness of this hypothesis by trying other assumptions like adaptative or rational expectations approach.

The study does not take into account European Union and Chinese subsidies. These subsidies may also have negative impacts on world cotton price. But it is not easy to have enough data for European Union countries (essentially Grece and Spain) since they joined the Union in the early eighties, and there is relatively few data on chinese support.

Finally, a detailed approach of US subsidies might be usefull. A decomposition of subsidies into decoupled and non decoupled parts could help understanding if the latter is effectively neutral.

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