WELFARE ANALYSIS IN A MULTI-MARKET FRAMEWORK: IMPLICATIONS OF THE CAP COTTON, MAIZE AND SUGAR BEET REGIME IN GREECE

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Abstract

This paper examines the welfare effects of the Common Agricultural Policy (CAP) cotton, maize and sugar beet regimes practiced in Greece after its 1981 entry into the European Union. These markets are considered as horizontally related because there are usually the same farmers that use the same areas to produce various combinations of the relevant products. We use bootstrap techniques to conduct a statistical analysis of the estimated welfare measurements. The welfare analysis indicates that the income amounts transferred to farmers rose significantly in the period between 1981 and 1992. The 1992 CAP reform slowed down this trend, and transfers have remained at an almost statistically constant level since 1992.

Key Words: *welfare analysis, Common Agricultural Policy, bootstrapping, Greek cotton, maize and sugar beet production*.

1. Introduction

In the EU cotton regime, market intervention operates through a target price that is set annually for cottonseed. Cotton ginners are able to pay the farmer's target price because they receive a deficiency payment equal to the difference between the target price and the world market price. In addition, since the crop year 1986-87, a mechanism of maximum guaranteed quantities (MGQ) coupled with a corresponsibility levy has been in place. The latter is applied whenever national cotton production exceeds the MGQ so as to limit budgetary outlays. Floor prices also are in place for maize, which are supported through a system of export subsidies and import levies. Although in 1992 a market policy reform was introduced, mainly aiming at lower producer prices supplemented by direct income payments, EU prices for maize are still above the world markets price level. Sugar beet floor prices are in order, supported through a system of national production quotas in sugar production. The Greek Sugar Corporation (G.S.C.) determines the desired quantity of sugar beet each year and the price at which it will buy the product. The G.S.C. then signs contracts with producers, specifying two parameters of mutual agreement: a) the area of the land to be used for sugar beet production; and b) the sugar beet price to be paid by G.S.C. Producers know that their production, however large or small, from the predetermined land area will be bought by G.S.C. at the specified price.

Cotton, maize and sugar beet production is a significant part of Greek farming. According to the latest available data (1997) cotton, maize and sugar beet covered 12.3%, 6% and 1% of the total agricultural area. The respective shares in the total value of the national agricultural production were 11.7%, 2.2% and 2.3%. The irrigation facilities and the wide use of chemicals that led to internationally notable high yields have also become the main factor in restricting future expansion in cotton seed, maize and sugar beet production. High production costs make Greek farmers uncompetitive in world markets. Therefore, the future development of both industries will be closely tied to the (high) levels of farmers' income protection. High levels of cotton price support have been realized in Greece mainly after the country's entrance into the EU. Until 1981, Greek cottonseed prices stayed close to world market prices. After 1981 they rose sharply, finally stabilizing at a level more than twice that in world markets. On the other hand, maize prices received by Greek farmers were higher than world prices before Greece joined the EU, and were raised further upon membership. This situation began to change after the 1992 CAP reform, which altered maize prices, moving them closer to the world market level. Finally, prices for sugar beet were lower than their international counterparts before 1981. This situation changed gradually after the entry in EU, and sugar beet prices became after the mid-80’s higher than the international ones.

The objective of this paper is to analyze the effects of cotton, maize and sugar beet policy regimes on farmers’ welfare. We consider these three products as potential choices for a substantial part of Greek farmers. The latter are economically and technically able to produce alternatively various levels of cotton, maize and/or sugar beet, mainly depending on the availability of land and on the prices expected for these products. The relevant markets are considered as horizontally related agricultural markets, since the same farmers use the same factors of production, mainly land and labor, in order to achieve the desired level of production. Further more, we test empirically the effects of the entry into the European Union on farmers’ welfare as well as the commonly expressed position that the 1992 C.A.P reform has hurt significantly farmers’ income in industries such as cotton, maize and sugar beet. Although cotton and sugar beet regime were not on the agenda of the 1992 reform, their production may have been affected by it, due to the existing interrelationships between the relevant markets.

The analysis is undertaken in a partial equilibrium framework, and the relevant welfare changes are perceived in terms of changes in producers' surplus. Our approach in evaluation CAP emphasizes the use of a more statistical analysis as suggested in Bullock et. al (1999). We use a bootstrap resampling technique in order to provide our welfare point estimates with a confidence interval. This enables us to formulate our research questions as statistical hypotheses and test them at various levels of statistical significance. We examine the welfare effects of the C.A.P cotton, maize and sugar beet regime on farmers' welfare compared to the welfare they would receive if a free trade regime were in order. We test the welfare effects of the C.A.P by dividing the whole period under consideration in four sub-periods. The firsts of them refers to the pre-EU regime (1976-1981), the second refers to the post-entry regime till the reform in the cotton policy in 1986 (1982-1986), the third to the following period till the 1992 C.A.P reform and the forth to the post-reform regime (1993-1997).

2. Theoretical Framework

In this paper we analyze the effects of simultaneous price changes on the welfare of a representative and profit maximizing farmer, who produces the above three products, under the assumption of given input prices, technology, institutional framework etc. We consider these three products as close substitutes in production, i.e. farmers have the technical and physical capability to produce cottonseed, maize and/or sugar beet, at various level of production, according to the expected prices, as they are determined in the context of the C.A.P.

Previous studies measuring the impacts of price changes on representative producers' welfare are usually evaluated under the assumption that all other output and input prices are constant (Babcock and Foster 1993, Otsuka and Hayami, 1985 and Wallace, 1962). Furthermore, factors such as technology, institutional framework, weather conditions etc. are also considered as given. Constant output prices of the other goods produced is an acceptable assumption as long as price and output of the product under consideration cannot affect prices and output of other products produced by the representative farmer and *vice versa*. This assumption can obviously not be accepted in cases of joint production, products that are substitutes in consumption etc. Input prices used in the relevant production process can also be considered as given, as long their prices cannot be affected from the level of production of the product under consideration. This is the case, for example, whenever the input quantities demanded are only a very small portion of the total input quantity produced. In our case the fact that, *first*, the prices of all three products, namely cotton seed, maize and sugar beet, are determined in the context of the C.A.P. and, *second,* that they are substitutes in production makes it necessary to consider the changes in their prices simultaneously.

Figure 1 presents the changes in producers' welfare in terms of changes in producers' surplus when producer prices are changing. The levels of output and prices of the relevant products are depicted by q and p, w is the input prices, and T refers to the level of technology. The subscripts c, m, and b correspond to the three products under consideration, namely cottonseed, maize and sugar beet. The upper scripts i and w refer to domestic, i.e. prices achieved under the C.A.P. regime, and world market prices, respectively. Finally 0 is set to indicate that the relevant variables are considered as constants.

According to the left panel of Figure 1, which refers to cotton supply q_c, a cotton price increase from p_c^w to p_c^i results in an increase in farmers welfare equal to $\Delta PS = p_c^w p_c^i AB$, under the assumption that the prices of maize and beets are equal to their international counterparts, p_m^w and p_b^w, respectively. In the case, however, that maize prices are set at their domestic level p_m^i, then the total change in producers' welfare is equal to the sum of $p_c^w p_c^i AB + p_m^w p_m^i KI$. Finally, if the sugar beets price is also considered at its domestic level p_b^i, then the total change in producers' welfare is equal to $\Delta PS = p_c^w p_c^i AB + p_m^w p_m^i KI + p_b^w p_b^i P\Sigma$. This result is the outcome of a certain path, which we assumed has been followed with respect to the changes in the prices of the three products under consideration. The path that we followed is a change in price of cotton, followed by a change in price of maize, and the last change was in the price of beets. However, the same result is obtained in the case of another path. If, for example, we assume that the change in prices was first in maize, then in cotton and finally in sugar beets, then the change in producers' welfare would be equal to $\Delta PS = p_m^w p_m^i \Gamma\Delta + p_c^w p_c^i \Theta\mathrm{H} + p_b^w p_b^i \mathrm{P}\Sigma$. This result has to be equal to the one obtained previously, which was equal to $\Delta PS = p_c^w p_c^i AB + p_m^w p_m^i KI + p_b^w p_b^i P\Sigma$ i.e. it has to be path independent in relation to the order that the changes in prices have taken place.

This problem can be set in mathematical terms in the following manner, departing from a profit function Π (Just et. al. 1982) of the representative farmer, which is equal to

$$\begin{aligned}\Pi\left(p_c, p_m, p_b, w^0, T^0\right) \equiv{}& p_c q_c\left(p_c, p_m, w^0, T^0\right) + p_m q_m\left(p_c, p_m, w^0, T^0\right) + \\ & p_b q_b\left(p_c, p_m, w^0, T^0\right) - w^0 x\end{aligned} \tag{1}$$

where Π are the profits and x the quantities of the inputs. All other symbols have been explained previously.

If we assume, that all three prices change from p^w to p^i, then the change in farmers' profits will be equal to:

$$\Delta\Pi = \Pi\left(p_c^i, p_m^i, p_b^i, w^0, T^0\right) - \Pi\left(p_c^w, p_m^w, p_b^w, w^0, T^0\right) \tag{2}$$

And respectively equal to the following line integral (Just et. al., 1982):

$$\int_L \left[\frac{\partial\Pi}{\partial p_c}(p_c, p_m, p_b, w, T)dp_c + \frac{\partial\Pi}{\partial p_m}(p_c, p_m, p_b, w, T)dp_m + \frac{\partial\Pi}{\partial p_b}(p_c, p_m, p_b, w, T)dp_b + \right. \\ \left. \frac{\partial\Pi}{\partial w}(p_c, p_m, p_b, w, T)dw + \frac{\partial\Pi}{\partial T}(p_c, p_m, p_b, w, T)dT \right] \tag{3}$$

where L a certain path of integration according to the order we assume that change in producer prices has taken place. Path L is defined with respect to the relevant supply and derived demand functions, as well as to the changes in output and input prices.

The above line integral is path independent in the case that the profit function Π has continuous partial derivatives. Under this assumption it equals the following definite integrals:

$$\Delta\Pi = \int_{p_c^w}^{p_c^i} \frac{\partial\Pi}{\partial p_c}\left(p_c, p_m^w, p_b^w, w^0, T^0\right)dp_c + \int_{p_m^w}^{p_m^i} \frac{\partial\Pi}{\partial p_m}\left(p_c^i, p_m, p_b^w, w^0, T^0\right)dp_m + \\ + \int_{p_b^w}^{p_b^i} \frac{\partial\Pi}{\partial p_b}\left(p_c^i, p_m^i, p_b, w^0, T^0\right)dp_b + \int_{w^0}^{w^1} \frac{\partial\Pi}{\partial w}\left(p_c^i, p_m^i, p_b^i, w, T^0\right)dw + \int_{T^0}^{T^1} \frac{\partial\Pi}{\partial T}\left(p_c^i, p_m^i, p_b^i, w^1, T\right)dT \tag{4}$$

Given, that input prices, technology and all other factors mentioned previously are considered as constant, i.e. $\mathrm{dw} \equiv \mathrm{dT} \equiv 0$, the last two terms are equal to zero. Furthermore, and according to the Hotelling's lemma:

$$\frac{\partial\Pi}{\partial p_c}\left(p_c, p_m^w, p_b^w, w^0, T^0\right) \text{ is the supply of cotton } q_c\left(p_c, p_m^w, p_b^w, w^0, T^0\right) \tag{5}$$

$$\frac{\partial\Pi}{\partial p_m}\left(p_c^i, p_m, p_b^w, w^0, T^0\right) \text{ is the supply of maize } q_m\left(p_c^i, p_m, p_b^w, w^0, T^0\right) \tag{6}$$

parametric assumptions (Efron, 1979). The mean value and the standard error of the bootstrap distribution is then used as an approximation or estimate of the mean value and the standard error of the relevant variable, in our case of the relevant welfare measures.

For purposes of illustration, let $\hat{\boldsymbol{\beta}}$ be the *SUR* estimate of the system of equations in (9)-(11) and $\hat{W} \equiv W(\hat{\boldsymbol{\beta}})$ be the corresponding welfare statistic from (8). The bootstrap procedure may be outlined as follows:

- *Step 1:* generate a "bootstrap sample" of size *N* by sampling the estimation data set randomly with replacement ;
- *Step 2:* compute the *SUR* estimate for this bootstrap sample $\boldsymbol{\beta}_r^*$ and obtain $W_r^* \equiv W(\boldsymbol{\beta}_r^*)$;
- *Step3:* repeat steps 1 and 2 *R* times to obtain *R* bootstrap estimates W_r^*, $r = 1, 2, \ldots, R$.

To construct bootstrap confidence intervals for $W \equiv W(\boldsymbol{\beta})$ we use the *percentile method* of Efron and Tibshirani (1993). The percentile-method (1-2*a*) equal-tail bootstrap confidence interval for the welfare measure $W(\boldsymbol{\beta})$ is given by :

$$\left(W_R^{*(\alpha)},\quad W_R^{*(1-\alpha)}\right) \tag{14}$$

where $W_R^{*(\alpha)}$ and $W_R^{*(1-\alpha)}$ are respectively the $\lfloor (R+1)\alpha \rfloor$th and $\lfloor (R+1)(1-\alpha) \rfloor$th ordered values of $\hat{W}_r^*$, $r = 1, \ldots, R$, where $\lfloor c \rfloor$ denotes the integer part of any real number *c*. Here *R* was set equal to a *1,000* bootstrap replications, while the original sample consists of $N = 27$ observations. As *R* increases the distribution of the normalized bootstrap *SUR* estimator $\boldsymbol{\beta}^*$ converges to the distribution of the normalized *SUR* estimator $\hat{\boldsymbol{\beta}}$, i.e., $\Pr\left(\sqrt{N}\left(\boldsymbol{\beta}^* - \hat{\boldsymbol{\beta}}\right) \le z\right) \to \Pr\left(\sqrt{N}\left(\hat{\boldsymbol{\beta}} - \boldsymbol{\beta}\right) \le z\right)$ in probability uniformly in *z*.

Since $W(\boldsymbol{\beta})$ is a smooth function of $\boldsymbol{\beta}$, it follows that the distribution of normalized bootstrap welfare measure W^* converges to the distribution of the normalized welfare measure $\hat{W}$, i.e., $\Pr\left(\sqrt{N}\left(W^* - \hat{W}\right) \le s\right) \to \Pr\left(\sqrt{N}\left(\hat{W} - W\right) \le s\right)$ in probability uniformly in *s*. In fact, the normalized *SUR* estimator $\sqrt{N}(\hat{\boldsymbol{\beta}} - \boldsymbol{\beta})$ is, under mild conditions, asymptotically normal (see Green, 1993), and since the welfare measure *W* considered here is a continuous and smooth function of $\boldsymbol{\beta}$, it is easy to show that the normalized statistic $\sqrt{N}(\hat{W} - W)$ is also asymptotically normal (see Amemiya, 1985). This observation justifies our choice of equal-tail confidence intervals for $W(\boldsymbol{\beta})$ and leads us to expect that the bootstrap will provide a better finite-sample approximation to the distribution of the test statistic than first-order asymptotic theory alternatives like the δ-method (see Beran 1988; and Hall 1986, 1992).

The results presented in Table 2 refer to bootstrap mean values that almost coincide with the estimations obtained from the original sample. The values in parentheses are standard errors, obtained through the resampling procedure. The results refer to the periods: 1976-1981 (the period directly before the Greek entry into the European Union), 1982-1996 (the first years after the entry, till the introduction of co-responsibility levies in cotton production in 1996), 1986-1992 (the following period till the 1992 C.A. P. reform) and finally the period that followed the reform, till 1997 (the last year for which data are available). Since standard error estimations are available, we formulated our research questions as statistical hypotheses and tested them at various levels of statistical significance. First, we tested the hypothesis that the changes in the average income transfers across periods were different against the null that they were the same. In a further step, we replicated the same statistical procedure to find out the statistical significance of the differences in the per ha transfers.

In Figure 3, box- and-whiskers plots are used so as to present the entire bootstrap distribution of the relevant welfare measures. Bootstrap confidence intervals can be easily read from these graphs.

The welfare measures along with their 90% bootstrap confidence intervals are presented in Figure 3, using box-and-whiskers plots. Box-and-whiskers plots (Tukey, 1977) provide a way of visualizing the entire distribution of a random variable. The bootstrap distribution of every welfare measure is represented by five values: $\left\{\hat{W}_R^{*(\alpha)} \mid \alpha = 0.05, 0.25, 0.50, 0.75, 0.95\right\}$, i.e., the 5, 25, 50, 75, and 95% quantiles of the bootstrap sample. The 25th and 75th quantiles define a “box” and the median (50th quantile) is represented by a line inside this box, while the extreme 5th and 95th quantiles trace out the “whiskers” of the plot. In each of the graphs in Figure 1, the horizontal axis marks the three sample periods singled-out for separate treatment in our analysis, while the vertical axis plots the welfare measure. The (bootstrap) median estimates of the relevant welfare measure are also reported along the vertical axis for easy reference. The mean estimates, as well as the estimates using the original sample, were in all cases indistinguishable from the reported median estimates and are therefore omitted here. This is due to the fact that all of the bootstrap distributions were, as expected (see discussion above), very normal-like. Finally, it is worth noting that the procedure of constructing these graphs is entirely non-parametric and consistent with the definition of percentile bootstrap confidence intervals given above.

CAP policies significantly affected farmers' income as indicted by upper part Table 2 and the left panel of Figure 3. Accordingly, during the last twenty years cotton, maize and sugar beets producers realized an uninterrupted increase in their average annual incomes. Directly after entry into the European Union, i.e. in the years between 1982-1986, the relevant annual transfers stood eight times higher than those of the period before the entry, 1976-1981. This difference is statistically significant at 1% level. The same situation continued in the second half of the 80's, with an amount equal to 35,424 mil. Greek drachmas on an average annual basis. These transfers doubled those of the previous period with the relevant difference being statistically different than zero at 1%. Finally, the average annual transfers after the 1992 C.A.P. reform amounting to 39,750 mil. Greek drs., were again higher than those of the average of the previous period, although the difference in these transfers between 1987-1992 and 1993-1997 was statistically different from zero only at the 10% level. Hence, one can argue, that there is no strong statistical evidence that the transfers realized to cotton-maize and sugar beets farmers were higher than those realized in the previous period. On the other hand, the hypothesis that the 1992 C.A.P. reform has led to income decreases for the relevant farmers can be clearly rejected.

The lower part of Table 2 as well as the right panel of Figure 3 present the estimated average annual transfers per ha of cultivated land. These estimates indicate that the entry into the European Union has positively affected the per ha transfers to cotton, maize and sugar beets producers. The differences among the relevant sub-periods were statistically significant at 1% level until the introduction of the 1992 C.A.P. reform. Comparing the estimates of the two sequential periods, 1987-1992 and 1993-1997, the difference between the estimated averages were statistically non different than zero.

5. Conclusions

This paper is based upon the hypothesis, that cotton, maize and sugar beets are substitutes in production in the sense that one considers them as three alternative choices for a main part of the Greek farmers. This hypothesis is very close to the reality of Greek farming, since the great majority of these farmers posses the technical and physical ability to allocate land, labor and capital available to them, according to expected prices, in cotton, maize and sugar beets production.

The impact of simultaneous price changes in producers' welfare can be presented in the form of a line integral with a certain path of integration. This line integral is path independent if we assume that farmers operate with a profit function that is continuous and differentiable in its domain. Hence, it can be transformed in a sum of definite integrals. According to Hotelling's lemma, one may easily demonstrate that the sum of these integrals gives the change in producers' economic *quasi* rents. The latter are obtained according to the estimated supply functions. In the analysis of these changes we used a bootstrap resampling technique, which provided standard errors and confidence intervals for our estimates. This enables us to formulate our research questions as statistical hypotheses and test them at various levels of statistical significance.

Our statistical analysis shows that the C.A.P cotton, maize and sugar beets price policy regimes significantly affect farmers' welfare. According to the obtained outcome, the main results of this study are: *first*, entry into the European Union and implementation of the C.A.P. led to an immediate and remarkable increase in annual transfers, which occurred in favor of cotton, maize and sugar beets producers. These transfers - calculated as average annual transfers in mil. of Greek Drachmas, as well as in Greek Drachmas per ha of cultivated land, each time at constant 1982 prices - were statistically different compared to those realized before the entry at any level of statistical significance, as usually used in applied economic analysis.

Second, the increase in farmers' quasi rents continued into the second half of the 80's. The realized transfers in this second period after the entry were greater than those of the first, the relevant difference between them was again statistically different from zero at the typically used levels of statistical significance. This statement holds for both, i.e. the average annual transfers in absolute terms as well as for the transfers realized per ha of cultivated land. It confirms that farmers received significant amounts for all periods across the 80's, which should, ceteris paribus, have remarkably affected their economic welfare.

Third, the 1992 C.A.P. reform seemingly stopped the increases in farmers' quasi rents of the previous decade. The realized transfers remained since then at a relatively constant average level. The respective amounts in absolute terms, i.e. annual averages, as well as in relative terms, i.e. annual averages per ha, are statistically different than in the pre-reform period. Thus, the position that C.A.P reform has led to income losses for farmers involved in cotton, maize and sugar beets production cannot be verified according to the obtained results. One may finally conclude, that C.A.P reform did not reduce farmers' welfare compared to that of the 80's, but rather has stopped the trend of the increases that were directly introduced, after entry into the European Union.

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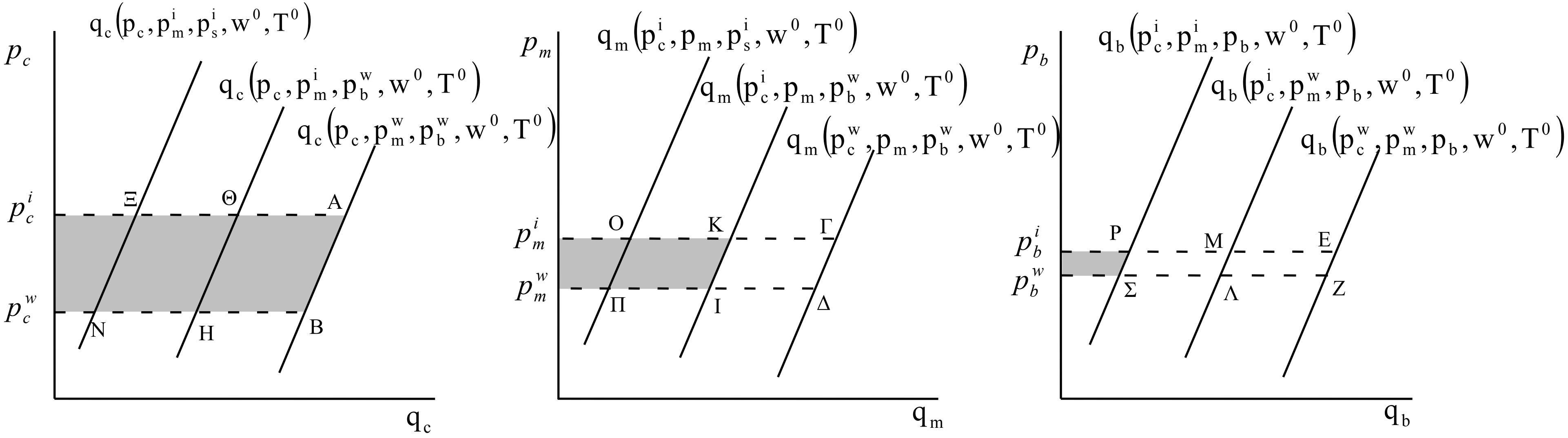
Figure 1: Effects of cotton, maize and sugar beet price changes on farmers welfare.


$q_c(p_c, p_m^i, p_s^i, w^0, T^0)$
$q_c(p_c, p_m^i, p_b^w, w^0, T^0)$
$q_c(p_c, p_m^w, p_b^w, w^0, T^0)$
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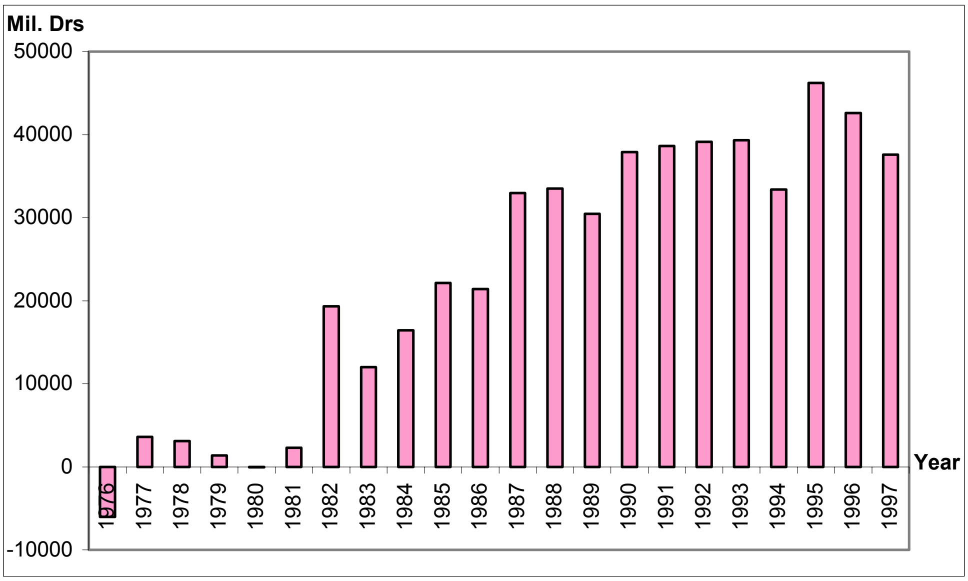
(Cotton supply) (Maize supply) (Sugar beet supply)

Table 1: Income transfers to farmers (ΔPS) per year, and per year and stremma, in 1982 prices.*

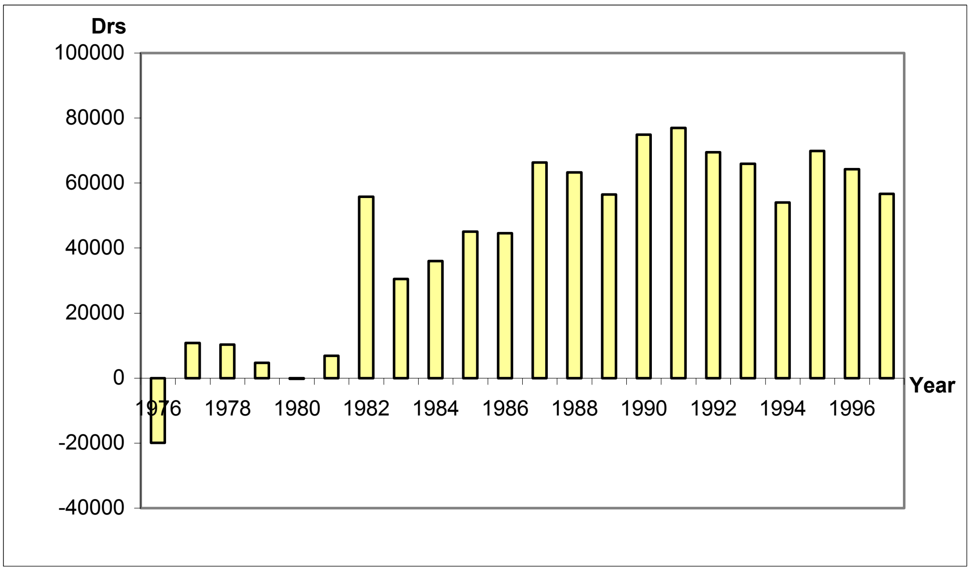
Year	ΔPS per year in mil. drs	ΔPS per year and stremma in drs	Year	ΔPS per year in mil. drs	ΔPS per year and stremma in drs
1976	-6,019	-19,952	1987	32,968	66,346
1977	3,595	10,847	1988	33,519	63,255
1978	3,095	10,276	1989	30,467	56,451
1979	1,355	4,731	1990	37,915	74,916
1980	-72	-221	1991	38,614	76,966
1981	2,307	6,859	1992	39,147	69,447
1982	19,311	55,812	1993	39,325	65,971
1983	12,017	30,455	1994	33,374	53,986
1984	16,450	35,973	1995	46,215	69,865
1985	22,121	45,034	1996	42,603	64,248
1986	21,423	44,612	1997	37,573	56,679

* 1 ha = 10 stremma

Figure 2: Income transfers to farmers (ΔPS) per year (a) and per year and stremma (b) in 1982 prices.



(a)



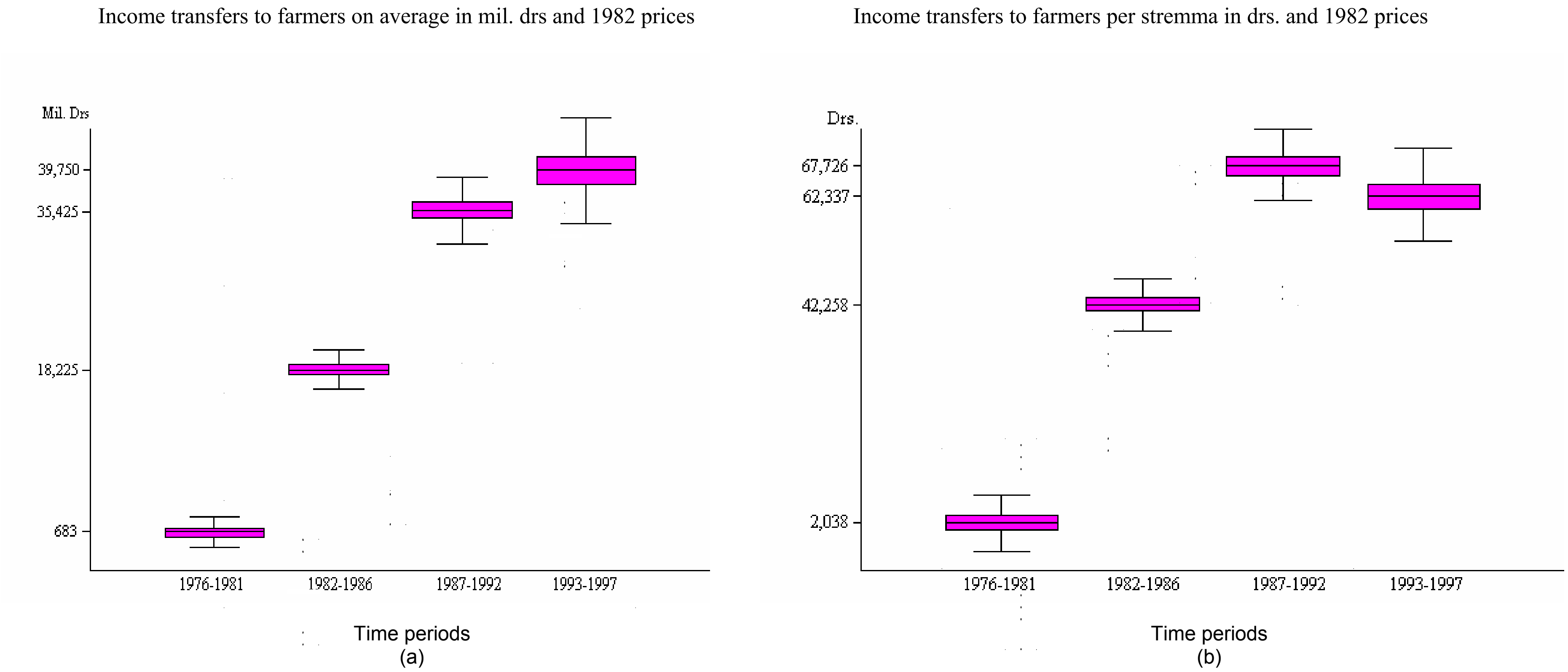
(b)

Table 2: Income transfers (ΔPS) to farmers on average per year, and per year and stremma, in 1982 prices.

	1976-1981	1982-1986	1997-1992	1993-1997
Income transfers on average per year (ΔPS per year) in mil. drs.	683.1 (657.8)*	18,225.5 (882.9)	35,424.6 (1,480.1)	39,749.6 (2,165.2)
Income transfers on average per year and stremma (ΔPS per year and stremma) in drs.	2,039 (2,010)	42,258 (2,107)	67,726 (2,752)	62,337 (3,377)

* prices in parentheses are standard errors.

Figure 3: Income transfers to farmers per year, and per year and stremma, in 1982 prices.


Income transfers to farmers on average in mil. drs and 1982 prices

Income transfers to farmers per stremma in drs. and 1982 prices

Appendix

Table 1: Estimated parameters of the supply functions

Variable	Cotton supply	Maize supply	Sugar beet supply
Constant	98.124	-901.870	949.825
	(140.47)*	(524.04)	(811.06)
P_c	2.626	-12.603	-5.058
	(2.03)	(3.90)	(7.44)
$P_{m, t-1}$	-12.603	88.228	-140.721
	(3.90)	(34.58)	(38.22)
$P_{b, t-1}$	-5.058	-140.721	921.739
	(7.44)	(38.22)	(220.11)
$Q_{c, t-1}$	0.929		
	(0.07)		
$Q_{m, t-1}$		0.930	
		(0.11)	
$Q_{b, t-1}$			0.449
			(0.12)
TIME		95.793	
		(27.49)	
$TIME^2$		-1.933	
		(0.61)	
n	27	27	27
$\overline{R}^2$	0.90	0.94	0.61

* prices in parentheses are standard errors.