International price transmission on soft wheat markets: which role for policy variables in cointegration relationships?

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Abstract— **This paper aims at considering policy regimes while studying international price transmission mechanisms. The focus is on the soft wheat market between the United States and the European Union in the years 1978-2003. EU domestic and border policies are expected to play a strong role; a theoretical framework is developed in which the basic idea is that the intervention price acts as a threshold above which the EU and the US price can interact. A composite variable, equal to the maximum between the intervention and the US price, is then introduced in a cointegration model and its relation with the EU price is studied. In addition to this, other models are estimated, in which the adjustment coefficients and the parameters of the cointegrating vector are allowed to vary according to the policy regime in place. All models yield consistent results. The EU price reaction to the long run relations suggests that the role of the US price can be understood only if policy regimes are adequately accounted for. To which extent the US price adjusts to disequilibria requires further research.**

Keywords— **International price transmission; Cointegration; Common Agricultural Policy.**

I. INTRODUCTION

In literature, price transmission mechanisms for agricultural commodities have received considerable attention. The use of price data only has often implied increasingly sophisticated techniques, but scarce attention for policy factors. In econometric models, in turn, the latter are explicitly added as regressors in the relevant equations, but often relying on simplistic hypothesis, like the exogeneity of the world price for the European Union (EU) in AGMEMOD [1].

This works aims at providing alternative schemes for the analysis of price transmission in international markets that account for policy regime changes. This paper focuses on soft wheat, a heavily traded commodity. The main exporters are Argentina, Australia, Canada, the United States (US) and the EU, that together in most years account for about 90% of world wheat exports [2]. Policy regimes play a significant role in soft wheat production and export shares [3]. The Common Agricultural Policy (CAP) is a case in point: during the 1980s the EU emerged as the second larger exporter, having previously been a net importer.

Thanks to the EU Common Market Organization (CMO) for soft wheat, from the late 1960s already, intervention mechanisms ensured that domestic prices never fell below the intervention price. Variable levies and export subsidies insulated the domestic market. The full functioning of the CMOs led to surpluses growth and budgetary costs escalation. In 1992, the MacSharry Reform implemented substantial cuts in intervention prices to re-align internal with world prices; farmers were compensated through direct subsidies per hectare; but the old variable levy and export subsidy structure kept on insulating EU markets. In 1999, the Agenda 2000 reform set a 15% reduction in two years of the intervention price for cereals, and the introduction of decoupled payments. These were strengthened by the Fischler Reform of 2003.

In agricultural trade politics, the most relevant event is the institution of the World Trade Organization in 1995, and the following implementation of the Uruguay Round Agreement on Agriculture. The limits on domestic support and export subsidies were never binding for EU wheat [4]. For market access it was agreed to convert all border measures into import duties, to be lowered in the following six years. However, the "intervention price plus 55%"[i] rule eliminated any real difference with the old variable levy system.

It is clear, then, that agricultural domestic and border policies cannot be disregarded while studying international price transmission for soft wheat. We here aim at explicitly considering their role.

II. ANALYTICAL FRAMEWORK

The study of price transmission mechanisms implies referring to some basic economic concepts [5]. In a nutshell, the Law of One Price (LOP) states that markets linked by trade and perfect arbitrage will have a unique price, when expressed in the same currency, net of transport costs. This concept is one of the building blocks of international trade theory but, nevertheless, most of the empirical tests are against it [5] [6]. Border and domestic policies are amongst the factors that prevent prices from convergence [7]; trade liberalization will improve price transmission.

Different econometric techniques have been used within this theoretical framework. Cointegration models assume that non-stationary variables will nonetheless be linked by a long-run relationship - in this case, the LOP itself. The following Vectorial Error Correction Model (VECM) holds between the prices:

$$\Delta \mathbf{p_t} = \boldsymbol{\alpha}\boldsymbol{\beta}' \mathbf{p_{t-1}} + \sum_{i=1}^{m} \boldsymbol{\Gamma}_i \Delta \mathbf{p_{t-i}} + \boldsymbol{\varepsilon_t} \quad (1)$$

where $\mathbf{p}_t$ is a (n x *1*) vector containing the n prices, $\boldsymbol{\alpha}$ is the (n x r) matrix of the adjustments parameters, $\boldsymbol{\beta}$ is the cointegration matrix (n x r; r is the cointegration rank), $\boldsymbol{\Gamma}$ is the (n x n) matrix accounting for short-run relations, and $\boldsymbol{\varepsilon}_t$ is the (n x *1*) vector of white noise errors. If we have n = 2 prices in logarithms, normalizing and rearranging terms, β_2/β_1 is the long-run price transmission elasticity, as in equations (2) and (3).

$$\boldsymbol{\beta}' \mathbf{p_{t-1}} = \beta_0 + \beta_1 p_{1,t-1} + \beta_2 p_{2,t-1} = z_{t-1} \approx I(0) \quad (2)$$

$$p_{1,t-1} = -\frac{\beta_0}{\beta_1} - \frac{\beta_2}{\beta_1} p_{2,t-1} + z_{t-1} \quad (3)$$

Despite the use of cointegration techniques has a number of shortcomings [6] [8] [9], they have been extensively used. Empirical evidence is mixed. Barassi and Ghoshray [10] test cointegration with structural change for US Soft Red Wheat, Hard Red Winter Wheat and EU wheat export prices. After the MacSharry Reform, which is the breakpoint, the EU price is cointegrated with the US Soft Red Wheat. Verga and Zuppiroli [11] find that EU soft wheat markets are strongly cointegrated amongst themselves but not with the US one. Thompson and Bohl [12] find that German soft wheat and US Dark Northern Spring prices are cointegrated. Thompson et al. [13] find evidence of integration amongst EU and US markets which increased after market liberalization reforms.

In this paper, we aim at testing the presence of co-movement of domestic EU prices with the world ones; policy regimes will need to be taken into account[ii]. On the import side, the EU price will be positively related to the world one only when the latter is above the entry price so that the variable levy goes to zero[iii]. On the export side, the EU price is positively related to the world one only when the latter is at least above the intervention price; otherwise, export refunds would provide a lower threshold for the EU price not to fall. The EU and the world price should then be positively related only when the latter is above both the intervention and the entry price. But this, actually, was almost never the case.

Alternatively, we could aim at verifying if there is co-movement between the EU and the world price also when the latter is below the entry price but above the intervention price. The intervention price acts as a lower "threshold", which allows to identify two different observable regimes. If the world price is below the intervention one, then the EU internal price is expected to follow the intervention one; if the world price is above the intervention price, the EU domestic price is expected to follow the behaviour of the world one.

III. EMPIRICAL EXERCISE

Wheat monthly prices for the US and France for the period 1978:12 to 2003:12 (301 observations) have been used. The French price (*swfr*, EUROSTAT data) is assumed to be representative of the EU one. US Gulf FOB Hard Red Wheat prices and freight rates (converted in euros with EUROSTAT bilateral exchange rates) to obtain EU CIF prices were used (*hrw*, International Grains Council). The US price is assumed to represent the world one. Intervention prices and their monthly seasonal adjustments (*pint*) were obtained from European Commission regulations. All prices have been used in logs.

First of all, we checked whether the LOP holds between *swfr* and *hrw* ($\mathbf{p_t}' = [swfr_t \; hrw_t]$ in equation (1)). Results of unit root tests overall confirmed that the series are I(1)[iv]. A cointegration analysis has been

performed[v]. The cointegration rank turned out to be zero.

To introduce policy regimes in the model, we create the "EU external reference price" (*wref*), a composite variable calculated as the maximum between the intervention price and the world (US) price. As explained in the previous paragraph, the intervention price acts as a lower threshold for the US price (which tends to be above it from the MacSharry Reform onwards, Figure 1). *wref* contains 162 times the intervention price over 301 months and is I(1), as well. The rank of the cointegration matrix between *swfr* and *wref* is one. The estimates of Model 1 (equation (1), where $\mathbf{p_t'} = [swfr_t \quad wref_t]$) are reported in Table 1. Adjustment coefficients are both significant and have the right sign. A 1 coefficient for transmission elasticity is not rejected (χ^2 =0.161; p-value 0.688).

We then observe a co-movement of EU and US prices under certain "policy regime" conditions. To further explore the theoretical framework which has been proposed, alternative models can be built. Model 2 can be interpreted as a cointegration threshold model in which the adjustment coefficients take different but non-zero values according to the observable regime to which the observations belong. In fact, we assume that the LOP holds between the EU price and the US price only when the latter is above the intervention price; otherwise, the LOP will hold between the intervention and the French price. Price reactions to long-run disequilibria are allowed to be different in either case. This is achieved through the creation of a regime dummy variable, reg_t. We then estimate the following model:

$$\mathbf{\Delta p_t} = \boldsymbol{\alpha}_1 reg_{t-1} z_{1,t-1} + \boldsymbol{\alpha}_2 (1 - reg_{t-1}) z_{2,t-1} + \sum_{i=1}^{n} \mathbf{\Delta p_{t-i}} + \boldsymbol{\varepsilon}_t \qquad (4)$$

where $z_{1,t-1} = (swfr_{t-1} - hrw_{t-1})$, $z_{2,t-1} = (swfr_{t-1} - pint_{t-1})$. If $hrw_{t1} > pint_{t-1}$, then $reg_{t-1} = 1$, and only $z_{1,t-1}$ is "active"; if $hrw_{t-1} < pint_{t-1}$, and then $reg_{t-1} = 0$, only $z_{2,t-1}$ is "active". Estimates of Model 2 are reported in Table 1. In the French equation, the adjustment coefficients have the right sign, though only the one to the LOP holding with the intervention price is significant. Moreover, $|\alpha_1| < |\alpha_2|$, i.e. the French price responds more quickly to the LOP holding with the intervention than with the US price. In the US equation, α_1 has the right sign but is not significant and α_2 has not even the right sign (the US price does not respond to the disequilibria from the LOP between the intervention and the French price).

In Model 3, we assume that regime changes don't affect the adjustment parameters, but the cointegration vector itself. The French price is still expected to be linked to either the intervention price or the US price according to which of them is higher; but the transmission elasticity is allowed to vary in the two cases.

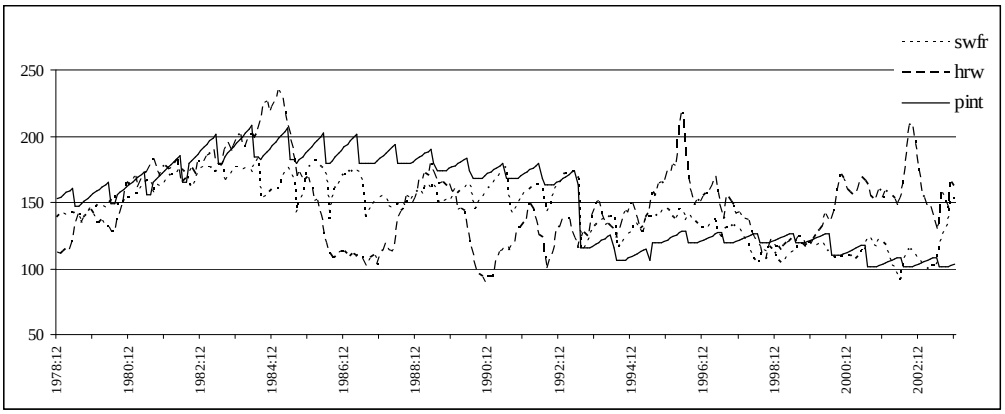

Fig. 1 Soft wheat French price, US Hard Red Wheat price, intervention price (EUR/t)

Table 1: Model estimates (* significant at 10%; ** significant at 5%; *** significant at 1%)

		Δswfr	Δhrw	Cointegration relation
Model 1	α_0	-0.093***	0.064**	$swfr_t$=- 0.397+1.054$wref_t$
Model 2	α_1	-0.013	0.022	LOP imposed
	α_2	-0.099***	-0.025	
Model 3	α_3	-0.073***	0.002	$swfr_t$ =1.400+ 0.707 $wref_t$ -0.022 reg_t $wref_t$
Model 4	α_4	-0.023	0.021	$swfr_t$ =1.400+ 0.707 $wref_t$ -0.022 reg_t $wref_t$
	α_5	-0.260***	-0.069	

The cointegrating vector of the VECM between the US and the French price is assumed to be

$$swfr_t - \beta_0 - \beta_1 wref_t - \beta_2 reg_t wref_t = z_t \quad (5)$$

If $hrw_t > pint_t$, and then $reg_t = 1$, we have

$$swfr_t = \beta_0 + (\beta_1 + \beta_2) hrw_t + z_t \quad (6)$$

and if $hrw_t < pint_t$, $reg_t = 0$, the relation is

$$swfr_t = \beta_0 + \beta_1 pint_t + z_t \quad (7)$$

As expected, the elasticity of transmission is lower with the US than with the intervention price (Table 1), but the difference doesn't seem of a big magnitude. Both adjustments coefficients (α_3) have the right sign, but the US one is not significant; this could depend on its weak exogeneity, but also on the fact that it does not react to the disequilibria between the French and the intervention price.

Finally, in Model 4, both adjustment coefficients and the cointegrating relationship were allowed to differ. We have

$$\Delta \mathbf{p_t} = \boldsymbol{\alpha}_4 * \mathbf{reg}_{t-1} * \mathbf{z}_{t-1} + \boldsymbol{\alpha}_5 * (1 - \mathbf{reg}_{t-1}) * \mathbf{z}_{t-1} + \sum_{i=1}^{n} \Delta \mathbf{p}_{t-i} + \boldsymbol{\varepsilon}_t \quad (8)$$

where z_t is calculated as in Model 3. If $reg_{t-1} = 1$, the adjustment coefficient to the LOP holding with the US price are given by α_4; if $reg_{t-1} = 0$, then the adjustment coefficients to the LOP holding with the intervention price are given by α_5. Adjustment coefficients of the US and the EU prices behave consistently with Model 2, though slightly higher in absolute value (Table 1).

Interestingly, for the French price, the adjustment coefficients of Model 1 and 3, in which the LOP holds between a combination of US and intervention prices, are in between those of Model 2 and 4, where they are allowed to vary according to which price the LOP holds with. This is valid also for Model 3 for the US price. Significant and consistent EU adjustment coefficients suggest that the role of the US price might be understood only in light of adequate consideration for policy regimes. US coefficients are instead significant only in Model 1. To which extent the US price is weakly exogenous (Model 3) or the cointegrating relationship is driven by the intervention price (Models 2, 4) requires further research.

IV. FINAL CONSIDERATIONS

This paper aims at considering policy regimes while studying international price transmission. The focus is on soft wheat, a highly traded commodity whose market has been heavily regulated by the CAP. French (EU) domestic prices and US (world) prices have been analyzed in the period 1978:12-2003:12.

The analysis has been performed within the general framework of cointegration analysis to test the LOP. The models presented, though over-simplified, are an attempt of combining policy and price data.

Firstly, the regime switch has been modelled through the creation of a composite variable, the maximum between the US and the intervention price. This series is cointegrated with the French price. This means that, basically after the MacSharry Reform, which reduced the intervention price allowing the US one to be much more often above it, US prices interacted more with EU domestic ones, even if the same border policies kept being in place.

This relationship has been further investigated. A threshold model has been estimated (Model 2), with different adjustments coefficients depending on the observable policy regime. The LOP has been imposed between the French and the higher between the US and the intervention price. The French price responds more quickly to the LOP with the intervention price; the response of the US price brings some interpretative problems. In Model 3, it is the price transmission elasticity which is allowed to change; the one between the French and the intervention price turns out to be stronger than the one with the US price. The US price performs as weakly exogenous. Finally, in Model 4,

both adjustment coefficients and the cointegrating vector parameters are allowed to vary. Results are consistent with the previous ones.

Unfortunately, more recent observations were not available for the French price. In the last months in particular, soaring food prices inflamed the debate (characterizing the last CAP reforms already) about the appropriateness of domestic support and border policies, and caused dramatic changes in commercial policy measures. Considering the evolving international context goes then beyond the use of more recent data, and represents an interesting possibility of developing the framework presented.

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[i] For the EU, the entry price of the main cereals was capped at 155% of the intervention price, if the sum of the duties would make it go above this threshold.

[ii] Instead, we expect the EU export prices and the world ones to be cointegrated, right because of EU export subsidies.

[iii] After 1995, this is true also if the sum of the world price plus tariff doesn't exceed the 155% of the intervention price. In practice, this has almost never been the case.

[iv] Unit root tests and econometric estimates are available from the author upon request.

[v] The optimum lag-length for the VAR has been chosen according to information criteria. Additional lags were included to remove autocorrelation. Monthly dummies were selected with specification tests. In Model 1, the Johansen and Juselius procedure has been followed (dummies were inserted outside the cointegration vector to account for export taxes).