Should private storage be subsidized to stabilize agricultural markets once price support schemes are removed? A General Equilibrium analysis applied to European reforms

The stabilization of European agricultural markets, which was one of the initial objectives of the Common Agricultural Policy (CAP), is today questioned. Indeed, successive reforms have progressively replaced the price support scheme, initially setup by the CAP, by a system of payments more and more decoupled from production and prices. While still supporting agricultural incomes, this evolution tends to reconnect European to international agricultural markets, and so to expose European agricultural producers to market fluctuations they did not face in the past. Regarding this increase of European farmers' exposure to market risks, more and more attention is being paid today to private risk managing instruments. Some of these instruments, including storage, already existed in the past but were not extensively used by agricultural producers, notably because of the existence of public price supports; althought, private storage behaviors, which derive from inter temporal arbitrages, can reduce price volatility and therefore stabilize markets (Makki, Tweeten, and Miranda, 1996).

One can presume that, with the removal of the public price support, private storage will be more and more used on agricultural markets and will mitigate the increase of market volatility induced by this removal. There is however some limits to the use of private storage as a risk managing instrument. Anderson (1992) notably shows that the markets' stabilization induced by stockholding behaviors is very sensitive to storage costs: a small decrease in storage costs can generate a huge decrease in price volatility. This raises the question as to whether there should be a public intervention on storage, either at the country level or, as proposed by von Braun and Torero (2009), at the world level. One way for governments to intervene on storage is to directly buy or sell stocks, so as to contain market prices within a band determined by a support price and a release price. This kind of mechanism has formerly been used by the European Union (EU) to keep agricultural prices above an intervention level and stabilize markets. However, according to Wright (2012), it is actually both theorically and practically unsustainable and expensive, and can even be destabilizing if it fails. Public stockholdings have actually proven to be very costly (Jha and Srinivasan, 1999). Furthermore, this mechanism generates a decrease of price volatility, which is a necessary condition for private storage to hold, and thus discourage private stockholdings (Glauber, Helmberger, and Miranda, 1989; Zant, 1997). In the United States (US) for instance, the removal, in 1996, of the public storage scheme in agricultural sectors led to an increase of the private storage activity and thus induced almost no changes in the volatility of agricultural prices (Lence and Hayes, 2002). Finally, these buffer stock mechanisms, which can have an impact on production decisions, turn out to be distortive and do not comply with the World Trade Organisation (WTO) rules. Another way for governments to intervene on private storage is to stimulate this activity by providing financial support to stockholders.

In their study, where they compare different market stabilization programs, Glauber, Helmberger, and Miranda (1989) conclude that subsidizing private storage is the most cost effective way to stabilize market prices because storage subsidies can easily adjust to stochastic phenomena. However Choi and Meyers (1989) question these results, arguing that they do not account for the (positive) impacts of storage subsidies on production decisions. The issue of the impact of such subsidies on speculative behaviors should also be considered. Indeed, it has often been mentioned that the behaviors of some non rational speculators could destabilized markets (Ravallion (1987), for instance). Femenia (2010), using a dynamic Computable General Equilibrium (CGE) framework shows that, even if they are not fully rational, speculative behaviors tend to bring some stability to agricultural markets, and thus contradicts this assumption. One can however wonder about the new behaviors a storage subsidy could induce. Taking into account all agents' behaviors, as can a CGE model do, to study the effect of storage subsidies thus seems important. Furthermore, as shown by Jha and Srinivasan (1999) greater price stability achieved through a government intervention does not necessarily imply greater welfare for economic agents: if the policy generates very high government costs the social welfare can decrease. Here again CGE models are the most appropriate tools to simulate these global welfare effects. Yet, whereas CGE frameworks are widely used to study the effects of agricultural policies, none of the aforementioned works dealing with private storage subsidies has been conducted using a CGE model. One of the main reasons is probably that, as pointed out by Wright and Williams (1988), studying the effects of market stabilization mechanisms requires a dynamic framework and, in the case of storage subsidies, the modeling of stockholding behaviors. Few CGE models display such characteristics. Among them is the inter temporal dynamic CGE model developed by Femenia and Gohin (2009) and Femenia (2010) which includes stockholding behaviors and can incorporate imperfect expectations.

Our main objective in this paper is to simulate the impacts of a subsidization of storage costs, aimed at stimulating private storage at the world level, on markets fluctuations following CAP reforms, and to study the welfare effects of this public intervention. To do so, we use the aforementioned dynamic CGE model. We simulate the effects of a radical reform: the complete removal of the CAP in arable crops sectors; we then study the impacts of a subsidization of wheat storage costs at the world level.

We find, as could be expected, that the CAP removal in arable crop sectors destabilizes European markets and tends to stabilize markets in the United States (US) and in the Rest of the World (RoW). Furthermore, the subsidization of private storage effectively boost the storage activity ; it generates welfare losses, but those are very limited compared to the world welfare gains arising from the CAP removal. However, the effects of this subsidy on market volatilities are contrasted: we find that some cases where crop markets are actually stabilized following the, but in other cases the opposite arises and markets are destabilized. To understand the factors influencing the signs of the effects of the subsidy on price fluctuations, we perform a logistic regression and show that those depend on the form of the agents' expectations, and on the some distributional characteristics of the productivity shocks arising in the crop sectors. Namely, the more past information is taken into account by economic agents to take their decision, and the more the productivity shocks are negatively auto correlated, the more the storage subsidy is efficient in stabilizing the markets.

In the next section we briefly recall the main features of the dynamic CGE model used. Then, we present the data used with a particular focus on the way the "standard" data have been modified to improve the modeling of the CAP instruments in arable crop sectors, we also present the policy scenarios that are simulated. The last section is devoted to the presentation of our main results. Finally we conclude.

1 The model

To be able to study the effect of storage subsidies on market volatility, while accounting for both the linkages between agents' inter temporal decisions and for the potential role of non rational behaviors (or, more precisely as will become clearer later, the potential role of imperfect expecations of economic agents), we use a dynamic CGE model developed by Femenia and Gohin (2009) and Femenia (2010). This model is based on the GTAP-AGR framework, which is a version of GTAP particularly adapted to the study of agricultural policies effects (Keeney and Hertel, 2005). The main distinctive features of this dynamic model, compared to the standard GTAP AGR static model, are as folllows.

1.1 Dynamics

As usual in dynamic CGE model, the accumulation of capital stocks is used as link between periods: sectoral capital stocks accrue from one period to another in each region: $K_{irt+1} = (1 - \delta_{ir}) K_{irt} + I_{irt}$, with K the capital stock, I the new investment and δ the depreciation rate of capital, the subsets i, r and t denoting respectively the sector, the region and the time period concerned. In addition to this usual linkage between periods, Femenia and Gohin (2009) give an inter temporal dynamic dimension to their model by introducing the inter temporal dimension of producers' investment and households' savings decisions:

To take his investment decision the producer seeks to maximize the present value of his firm (Devarajan and Go, 1998), which corresponds to the discounted value of all his expected future profits (capital income) minus his expected future investment costs:

$$\max \ \pi_{ir} = \sum_t \frac{1}{(1+r)^t} \left(wk_{irt} K_{irt} - PI_{irt} \left(1 + \frac{\psi}{2} \frac{I_{irt}}{K_{irt}} \right) I_{irt} \right)$$

$$s.t. \quad K_{irt+1} - K_{irt} = -\delta_{ir} K_{irt} + I_{irt}$$

With r the interest rate, wk the capital income, PI the price of investment and ψ an adjustment parameter: the term $\frac{\psi}{2}\frac{I_{irt}}{K_{irt}}$ represents the adjustment cost of capital (McKibbin and Wilcoxen, 1999). Solving this optimization problem leads to a condition determining the optimal investment in each sector and region:

$$
\begin{aligned}
& wk_{irt+1} + (1-\delta_{ir})\, PI_{irt+1}\left(\psi\tfrac{I_{irt+1}}{K_{irt+1}}+1\right) = \\
& (1+r)\, PI_{irt}\left(\psi\tfrac{I_{irt}}{K_{irt}}+1\right) - \tfrac{\psi}{2}PI_{rt+1}\left(\tfrac{I_{irt+1}}{K_{irt+1}}\right)^2
\end{aligned}
\tag{1}
$$

Then because, as we will detail later, producers have limited knowledge about output price, capital returns and interest rate in the far future, they are assumed to consider that the economy will reach a steady state at some future period. This "producer steady state" may never arise, because they periodically revise their plans, but this formulation allows to determine the optimal firms' investment plan at each period, and so their current investment.

Households also base their saving decisions on inter temporal arbitrages. Indeed they spend a part of the income they earn at one period to consume goods, which brings them some utility, and save the remaining part. The part of the income saved at one period will be used later to consume and thus represents a future utility. So, the representative household in each region seeks to maximize the value of its inter temporal utility, subject to an inter temporal budget constraint:

$$\max U_r = \sum_t \frac{1}{(1+\rho)^t} U_{rt}\left(Q_{rt}\right)$$

$$s.t. \quad \sum_t \frac{1}{(1+r)^t} E_{rt} = \sum_t \frac{1}{(1+r)^t} \left(P_{rt} Q_{rt} + S_{rt}\right)$$

With ρ a time preference parameter (households have a preference for immediate utility), Q the quantity consumed, P the composite consumer price, E the total income (including interest earned from foreign assets, factor returns, distributed profits and tax receipts) and savings. The first order condition of this program allows to determine the evolution of savings:

$$E_{rt} - S_{rt} = \left(\frac{1+\rho}{1+r}\right)\left(E_{rt+1} - S_{rt+1}\right) \tag{2}$$

As producers, households have limited knowledge about prices and incomes in the far future; they are thus also assumed to consider that the economy will reach a steady state at some future period. Once again, the steady state expected by households may never be reached but this condition, combined with Equation 2 allows to derive savings plan of households and thus current savings at each period.

These different characteristics of agents' inter temporal decisions, combined with a foreign debt accumulation period by period, are the main features of the model allowing the simulation of the dynamic evolution of markets.

1.2 Sources of market volatility

Two sources of price volatility on agricultural markets are identified in the economic literature (Butault and Le Mouël, 2004). On the one hand, many economists have argued that fluctuations on agricultural markets were essentially due to demand and supply shocks (Moschini and Hennessy, 2001): first, the time lag between production decisions of farmers and harvests induces a short-term rigidity of the agricultural supply, which can hardly adjust to market price changes; second, most agricultural products are staples and the demand for these goods is quite inelastic. Because of these two characteristics, agricultural markets are very sensitive to market shocks: a supply decrease due to an exogenous shock will result in a large price increase. Yet agricultural production is exposed to several epidemic and climatic risks and these exogenous shocks occur quite frequently, thus generating price fluctuations. On the other hand, the inter temporal dimension of decision processes implies that agents have to form expectations about the future path of economy at the time they take their decisions. Many studies dealing with uncertainty assume rational expectations (Williams and Wright (1991) for instance). However, processing and collecting information can be costly and it can in fact be more rational for economic agents to form imperfect expectations (Just and Rausser, 2002) and thus to potentially make expectation errors. As formalized by Ezekiel (1938) in his Cobweb theorem, these expectation errors can spread over time and induce endogenous fluctuations of market prices. Fluctuations on agricultural markets can therefore be first induced by exogenous stochastic shocks and then endogenously amplified and spread over time by the imperfect nature of economic agents' expectations. These two aspects of price volatility are introduced in the model as follows.

Firstly, the agricultural technology is represented in the model by a nested CES production function. The first nest combines production factors to create value added; the second one combines the aggregate factors with intermediate consumptions to produce output:

$$\begin{cases} VA_{irt} = \gamma_{ir} \left(a_{ir} K_{irt}^{\rho_{ir}} + b_{ir} L_{irt}^{\rho_{ir}} + c_{ir} T_{irt}^{\rho_{ir}} \right)^{\frac{1}{\rho_{ir}}} \\ Y_{irt} = \Phi_{ir} \left(\beta_{ir} VA_{irt}^{\theta_{ir}} + (1 - \beta_{ir}) \, IC_{irt}^{\theta_{ir}} \right)^{\frac{1}{\theta_{ir}}} \end{cases} \tag{3}$$

With VA the value added, L the labor factor, T the land factor, Y the quantity produced and IC the aggregate intermediate consumption. a, b, c and β are share parameters, ρ and θ determine respectively the degree of substitutability between capital, labor and land and between value added and intermediate consumption, finally γ and Φ are productivity parameters. Exogenous supply shocks are introduced through the productivity parameter Φ : Random disturbances ϵ are thus introduced such that $Y_{irt} = \Phi shock_{ir} \left(\beta_{ir} VA_{irt}^{\theta_{ir}} + (1 - \beta_{ir}) \, IC_{irt}^{\theta_{ir}} \right)^{\frac{1}{\theta_{ir}}}$, with $\Phi shock_{ir}$ the "shocked" productivity parameter: $\Phi shock_{ir} = \Phi_{ir} (1 + \varepsilon)$. We assume that $\varepsilon \sim N(0, \sigma_{\varepsilon})$ which implies that $\Phi shock_{ir}$ fluctuates around Φ_{ir} with a variance equal to $\sigma^2_{\Phi shock_{ir}} = \Phi^2_{ir} \sigma^2_{\varepsilon}$, meaning that the Φ_{ir} values calibrated from the initial data correspond to average expected values.

Secondly, assuming that farmers have the right information concerning their own productivity (that they know the distribution of the exogenous shocks affecting their production) seems quite obvious. On the other hand, their expectations about market prices are assumed to be imperfect, which introduces an endogenous source of volatility in the model. For that purpose we follow Femenia and Gohin (2009) and rely on Nerlove's work (Nerlove, 1958) who proposed a formalization of adaptive expectations based on past information. These expectations are such that agents take their past expectation errors into account to form their new expectations:

$$\hat{P}_{t+1} = \hat{P}_t + \alpha \left[P_t - \hat{P}_t \right] = \alpha P_t + (1 - \alpha) \hat{P}_t \tag{4}$$

$\hat{P}$ denotes expected prices and P observed market prices, α can be seen as a measure of the adjustment speed of expectations.

1.3 Modeling of storage

To introduce stockholding behaviors in the model, we follow Femenia (2010). Namely, one representative stockholder in each region holds stocks and can sell a part of these stocks or buy other stocks at current market price at each period.

The stockholder seeks to maximize his intertemporal profit which corresponds to the discounted sum of his sales minus his purchases and the storage costs. His program can thus be expressed as:

$$\begin{aligned}
&\max \sum_t \tfrac{1}{(1+r)^t} \sum_i \left(-\hat{P}_{irt} \Delta_{irt} - k_{rt} ST_{irt} \right) \\
&s/t \quad ST_{irt} = ST_{irt-1} + \Delta_{irt}
\end{aligned}$$

With ST_{irt} the quantity of good i stored in region r at period t, $k_r t$ the endogenous unitary storage cost in the region, and Δ_{irt} the variation of stock quantities ($\Delta_{irt} > 0$ implies that stocks are bought and $\Delta_{irt} < 0$ implies that stocks are sold during the period). Solving this optimisation program leads to the complementary conditions:

$$P_{irt} + k_{rt} \geq \frac{\hat{P}_{irt+1}}{(1+r)} \quad \perp \quad ST_{irt} \geq 0 \tag{5}$$

This equation is the standard relationship explaining stockholding behaviors (Williams and Wright, 1991): if the cost of buying goods at time t and storing them during one period is lower than the (discounted) price at which these goods can be sold at time $t+1$, stockholders buy goods thus increasing the current prices until an equality holds in the first condition of 5. On the contrary, if the cost of buying goods at time t and storing them during one period is higher than the price at which these goods can be sold at time $t+1$, stockholders sell their stocks thus lowering current market prices until the same equality is reached or until their stocks are null (an equality holds in the second condition of 5), in which case the market is in equilibrium even if an inequality holds. These considerations explain why stockholding behaviors come to mitigate market price volatility, and also why sudden price peaks can occur in case of null stocks.

Furthermore, storing a commodity generates costs paid by stockholders and made up, for instance, of the rent of grain silos and of the wages of workers who carry out stock handling. In order to determine these storage costs, a storage service sector is represented in the model. This sector uses labor and capital factors which are combined through a Constant Elasticity of Substitution (CES) function to produce a "storage service" good. Then, as for the other goods, the zero profit condition in this sector allows to endogenously determine the price of the storage service which corresponds to the unitary storage cost. Moreover, as capital stocks are subject to adjustment costs, the storage capacity does not adjust instantaneously to stockholders' demand which places an upper limit on this capacity even if no storage bound is explicitly imposed.

Finally, the market equilibrium conditions determining market prices includes beginning-of-period stocks on the supply side and end-of-period stocks on the demand side. Stocks buying and sales thus have an impact on equilibrium market prices.

1.4 Execution of the model

The model is solved iteratively, period by period, because economic agents readjust their decisions at each period, and in two steps for each period. This sequencing of the model resolution deserves some explanation.

As we already mentioned, consumers and producers base their decisions on expected future market prices, and, contrary to other agents, farmers do not observe market prices at time they take their production decisions. To take this specific feature of agricultural sectors into account the model is solved in two steps: in a first step agricultural production decisions are taken, based notably on farmers' expectations about market prices. At this time the prices of factors used for agricultural production adjust to ensure the equilibrium between farmers' demand and factor owners' supply. In a second step, agricultural quantities produced are sold, consumption, savings, investment and stockholdings decisions are taken, and prices of goods and factors allocated to non agricultural activities adjust so as to ensure the market equilibrium. If a productivity shock occurs after agricultural producers have decided how much to produce, then the quantities effectively produced are not equal to what farmers had expect. On the other hand, the other economic agents observe the market conditions and thus know current market prices at time they take their decisions. In the first step, determining agricultural production decisions, the model is thus solved by considering exogenous price expectations of producers, instead of endogenous market prices, and expected productivity values ($E\left[\Phi shock_{ir}\right] = \Phi_{ir}$). The outcome of this first step corresponds to what agricultural producers plan and thus determines the level of production factors they use. The real agricultural supply can then be computed using the production function (Equation 3) and the "real" productivity values ($\Phi shock_{irt}$). In the second step, the model is solved by considering the levels of agricultural factors and agricultural supply as exogenous. The outcome of the model corresponds to what effectively happens on markets, and notably determines the market prices, the levels of investment and the stock buying or selling. In the next period, the first step is re-executed by taking into account the new levels of stockholdings and capital stocks, resulting from the previous period decisions, and the new expectations of agricultural producers. The second step is re-executed by taking into account the new producers' plans and the new agricultural supply levels. And so on.

2 Description of data and simulation scenarios

Before to turning to our simulation results, we describe in this some specific characteristics of the data used to run these simulations, we also present how the European price support scheme has been introduced in the model, and then define the simulation scenarios.

2.1 Data

As already mentioned, the model we use is based on the GTAP AGR framework. We have already detailed the modifications made to the GTAP AGR model to introduce dynamic behaviors and to account for private storage. Yet, some other differences with the GTAP AGR framework deserve some explanations. These concern the GTAP database, the calibration of parameters and the modeling of CAP instruments. Before turning to the simulation results, we therefore describe these particular features of our framework. We also devote the last part of this second section to the definition of simulations.

To run our simulations, we use the 6th version of the GTAP database calibrated on 2001 economic flows and including tariffs, export subsidies and direct payments for the different region represented. These data are aggregated into 12 sectors, among which 7 are agricultural sectors, and 3 regions: the European Union (EU), the United States (US) and the Rest of the World (RoW).

As the GTAP database was initially aimed at being used in a static framework to simulate long term effects, we need to make some assumptions to calibrate the data for our dynamic model. Here again we follow Femenia (2010) and assume that the initial interest rate r, the time preference parameter ρ and the unit capital installation cost ψ are all equal to 5%. This, along with the assumption that the economy is initially in a steady state, allows the calibration of all dynamic parameters. Then, we reduce by half the supply price elasticities in agricultural sectors to account for the fact it harder for agricultural supply to adjusts in the short term than in the long term. Finally, the expectation adjustment parameter α is set to 0.05.

We introduce wheat stockholdings in the three regions. As the economy is assumed to be initially in a steady state, private stockholdings are initially nil. However, the CES form of the production function in the storage service sector does not allow for zero production. To overcome this issue we also assume that some precautionary wheat stocks, representing 10% of wheat production, are held by the public sector in the three regions. These precautionary stocks are constant over time and have thus no effect on price volatility.

2.2 Representation of the European price support scheme

Our main objective in this paper is to simulate the effects of a storage subsidy on the market volatility induced by the removal of the CAP instruments in arable crops sectors. To do so, we need first to simulate this volatility as accurately as possible. Yet, the EU price support scheme is badly represented in in the standard GTAP AGR model. Indeed, since the creation of the CAP, the EU has used variable export subsidies and variable levies to stabilize agricultural prices, in cereal sectors notably. Even if following the 1993 Uruguay Round Agreement on Agricultural (URAA) variable levies have been abolished, in 2001 variable export subsidies are still used to maintain agricultural prices above an intervention level. Furthermore, import tariffs are still closely related to export subsidies *via* the so called "“155%”" rule (van Meijl and van Tongeren, 2002) (roughly, a minimum import price is set at 155% of the intervention price). As a matter of fact, as underlined by Thompson, Gohout, and Herrmann (2002), the effects of these reforms on price instability are low. Yet, in the GTAP model EU export subsidies and import tariffs are represented as ad valorem instruments, and thus do not adjust to support domestic prices and insulate European from world markets as they do in reality. To account for the effects of these instruments on agricultural market volatility, we therefore change their modeling: we introduce both of them as endogenous variables in the arable crop sectors. Export subsidies adjust so as to maintain prices above an intervention level (set to the 2001 prices) and import tariffs adjust so as to maintain total imports and thus ensure domestic market protection from low-prices imports.

2.3 Definition of simulations

The simulations are conducted over 50 periods.

We first simulate a benchmark scenario in which there are no political changes. In that case markets volatility results from productivity shocks occurring each year in the wheat, oilseeds and other cereals sectors in all regions

(EU, US and RoW). These exogenous shocks can lead agricultural producers to make mistakes when they anticipate forthcoming prices, thus also generating an endogenous volatility of markets. For each region and each sector, the 50 stochastic exogenous shocks affecting agricultural productivity are generated according to normal distributions $N(0, 0.01)$ in the EU and the US, and $N(0, 0.02)$ in the RoW to reflect the potential highest yield variability in this large region, which includes some countries frequently facing extreme climatic events (Australia for instance). 3 regions $\times 3$ sectors $\times 50$ periods $=$ 450 shocks are thus generated. Moreover, to make sure that the results we obtain are not essentially due to some specificity of the generated samples, we run some Monte Carlo experiments and repeat the simulations using 100 different samples of 450 shocks.

In a second time, we use the same 100 shock samples and simulate the effects of a removal of the CAP instruments in the wheat, oilseeds and other cereals sectors. Namely, we remove the import tariffs, export subsidies and direct payments, and increase by 5% the land endowment in these sectors to reflect the removal of the set-aside policy linked to the direct payments. This policy reform is implemented gradually from the 3rd to the 6th periods. Indeed, it has been shown by Femenia and Gohin (2010) that, when agents have adaptive expectations, a gradual implementation of a radical reform, such as this one, is preferable to an immediate implementation, in terms of welfare effects. Comparing the results we obtain in this second step with those of the benchmark scenario, we are thus able to characterize the changes in arable crops markets volatility induced by the CAP reform.

Finally, in a third time, we simulate the effects of the same CAP reform along with a subsidization of starting at the end of the CAP reform (at the 6th period). This subsidy is implemented in the 3 regions through a subsidization of 20% of the production costs in the storage sector[1], which leads to a decrease of the storage costs.

3 Simulation results

We present here the results of the three sets of CGE simulations that have been conducted: the benchmark scenario, the CAP reform and the storage subsidization scenario. For some of the 100 samples of productivity shocks that have been used, one or more of the simulated scenarios lead to diverging dynamic systems. Even if many feedback effects represented in our CGE model decrease the occurrence of diverging cobwebs (Femenia and Gohin, 2009), they do not totally eliminate them. We have thus chosen to remove the "diverging" samples, which reduces to 83 the total number of samples used in our analysis.

3.1 Benchmark scenario

Table 1 reports the standard deviations of output, price and farm income in the EU, US and RoW crop sectors simulated in the benchmark case, that is to say when no changes in agricultural policies are implemented. The figures reported in the table are the mean values of the 83 standard deviations simulated with the different productivity shocks samples. In this benchmark

[1]Different rates of subsidy have been tested and the conclusions of the study remain the same

scenario, the market volatility is only due to exogenous shocks arising in all regions and to the expectation errors made by agents when they take their decisions. It appears that even if the volatility of exogenous disturbance is quite limited, with standard deviations equal to 0.01 in the EU and the US and to 0.02 in the RoW, the volatility of output can be slightly higher. This is so because of the imperfect expectations of agents; this endogenous source of output volatility comes in addition to, and is also sustained by, the exogenous shocks.

The standard deviations of prices are even higher in the RoW and the US, between 0.04 and 0.09 depending on the sectors. This is notably due to the inelasticity of the demand for agricultural products and the rigidity of their supply in the short run which makes prices very sensitive to supply changes (as formalized by the King's law). The price volatilities of wheat and other cereals are however much lower in the EU than in the other regions (0.02 instead of 0.08 for wheat and 0.00 instead of 0.07 or 0.04 for other cereals). These figures illustrate the price stabilizing role of the European price support scheme. On the contrary, in the oilseeds sector, which is much less protected in the EU, the standard deviations of prices are equal to 0.09 for all regions.

Then, in addition to the volatility of output and price, we have chosen to report in Table 1 the standard deviations of farm incomes. Indeed, even if most of the studies dealing with agricultural market risks focus on output and price fluctuations, what matters to farmers is the stability of their incomes. Yet, if prices and outputs are negatively correlated, price fluctuations can compensate output fluctuations and thus, in a sense, provide a form of income insurance for agricultural producers. With standard deviations of income ranging from 0.05 to 0.19, this is obviously not the case here.

3.2 CAP removal

Having described the main characteristics of the volatility on agricultural markets in the benchmark case, we now get interested in the effects of a complete CAP removal in the wheat, oilseeds and other cereals sectors on this volatility. However, before turning to this central issue in our paper, we describe the long term effects of this radical policy reform.

The mean effects of the CAP reform observed over the last 5 simulation periods are considered as long term effects. Their mean computed, over the 28 samples, are reported in Table 2.

The effects on output, price and farm income of the removal of CAP instruments in arable crops sectors are in accordance with those commonly found in the economic literature. Indeed, the suppression of tariffs, export subsidies and, above all, direct payments in the EU induces a decrease of production in the wheat (by 17.5%) and other cereals (by 13.2%) European sectors. The production drop is smaller (-7.6%) in the European oilseeds sector because direct payments are initially smaller in this sector and there is no tariffs nor export subsidies. This production decrease induces a price increase by 9.3% for wheat, 6.7% for oilseeds and 13.1% for other cereals. Overall, the price increases does not compensate the production decreases and EU farm incomes are negatively impacted by the reform: they decrease by 64.5% in the wheat sector, by 35.9% in the oilseeds sector and by 58.5% in the other cereals sector. In the US and the RoW the production increases in the 3 sectors to compensate the decrease of EU exports due to the removal of export subsidies and the decrease of production, and to satisfy the increase of EU imports due to the tariffs removal. Then, because of the world prices increase induced by the increase of imports and the decrease of exports from the EU, prices slightly rise in these regions (between 0.3% and 1.6%). The production and price increases lead to an increase of farm income in the US and the RoW.

Table 3 reports the welfare effects of the reform in the three regions. The figures reported in this table correspond to the discounted sum, over the 50 simulation periods, of the mean equivalent variations of household incomes in US$ million. The welfare effect in the EU is highly positive with a total effect over the 50 periods of around 33 US$ billions. This positive effect can be attributed to the suppression of some distorting impacts of the CAP. In the RoW, which is the main trading partner of the EU and thus the main beneficiary of the European export subsidies, the increase of crop prices induces a welfare loss which amounts to 10 US$ billions. In the US the additional value added in agricultural sectors comes to mitigate the price increases and allows the welfare losses in the US to be rather small (1 US$ billion over the 50 periods). Globally, the world welfare impact is positive.

As shown in Table 4, the effects of the CAP removal on price fluctuations in the EU are unambiguously positive: the mean standard deviation of the EU prices increase from 0.02 to 0.08 for wheat, from 0.09 to 0.10 for oilseeds and from 0.00 to 0.07 for other cereals. This is not surprising, since the public instruments protecting European markets from world price fluctuations have been removed. The increase of price volatility is besides much more important in the wheat and other cereals sectors than in the oilseeds sector which was less supported before the reform. Output fluctuations also increase. This can be explained by the endogenous dimension of the volatility represented in our model: the destabilization of prices induces a destabilization of agricultural producers' price expectation, and so a destabilization of their production. The EU farm incomes are thus also destabilized in the wheat and other cereal sectors, but not in the oilseeds sector where the standard deviation of income decreases from 0.19 to 0.14. In fact, the liberalization of EU markets tends to "reconnect" the oilseeds sector to the initially highly protected wheat and other cereal ones. The market fluctuations in the three sectors are thus closer after the reform than before, which benefits to the oilseeds sector. The same kind of mechanism explains why price volatility of wheat and other cereals are reduced in the RoW and the US after the CAP removal. The transfer of risk from protected markets to world markets has besides often been used as an argument in favor of a liberalization of agricultural markets (see Tyers and Anderson (1992) for instance). However, we must acknowledge that these reductions of price volatility are very limited, and that almost no reduction of output, neither farm income, fluctuations are observed. This is probably, once again, due to the endogenous source of market volatility represented in our model: following the reform expectation errors of European agents spread to foreign markets and come to increase the endogenous fluctuations on these markets. This last phenomenon partly compensates the decrease in volatility induced by the CAP removal.

By displaying the mean percentage of wheat held in stocks by period,

Table 5 provides an indication of the wheat storage activity in the three regions before and after the CAP reform. It appears that European wheat stockholdings in the EU increase after the reform: the stocks are nil in the benchmark, whereas on average they amount to 0.05% of the production at each period after the CAP reform. This can be explained by considering the price volatilities after the reform (Table 4). Indeed, as we have seen the CAP removal induces an increase of the standard deviations of EU prices in the wheat sector. Yet, the more prices fluctuate the more the private storage activity is stimulated. The opposite phenomenon arises in the RoW and in the US: the CAP removal induces a decrease of price fluctuations, which slows down the wheat storage activity in these regions (from 0.80% to 0.63% of wheat production stored at each period in the RoW and from 0.36% to 0.14% in the US).

3.3 Private storage subsidies

As we have seen, the volatility of crop markets increases in the EU following the CAP reform, which is not unexpected since the European price support is removed but can have negative economic impacts especially if market agents are risk averse. In the same time this volatility certainly decreases in the US and the RoW, but only slightly, and the storage activity decreases in these region. Since private storage is often referred to as risk managing instrument allowing to stabilize markets, one can presume that its subsidization at the world level will limit the destabilization of European crop markets and reinforce the stabilization of the RoW and US markets. This is what we evaluate now.

3.3.1 Simulation results

We use the CGE model to simulate the impacts of a 20% subsidization of production costs in the storage service sector implemented at the end of the CAP reform. This induces a decrease of wheat storage costs at the world level and stimulates private storage: the mean quantities of wheat stocks held by period are now represent on average 0.06% of the wheat production in the EU, 0.93% in the RoW and 0.23% in the US. This represents a significant increase, particularly in the RoW and the US.

The long term effects of this new reform are reported in Table 6. We can notice that the introduction of the storage subsidy has no effect on productions. On the other hand, the price increases are now higher than with the CAP removal alone, especially in the wheat sector: the price increases following the reform are now equal to 9.6% in the EU, 1.2% in the RoW and 1.7%, compared to 9.3%, 0.9% and 1.6% without the storage subsidy. These price increases can be explained by the additional demand of wheat coming from private stockholders.

Table 8 reports the welfare effects the private storage subsidy (these figures are computed by subtracting the welfare effects of the CAP removal alone to those of the CAP removal together with the storage subsidy). The three regions face welfare losses: they amount to 59 US$ millions for the EU, 233 US$ millions for the RoW and 20 US$ millions for the US, which represents a 312$US millions loss at the world level. This result is not very surprising regarding the increase in world wheat stocks which tends to decrease the quantities of goods available for consumption, and the increase of mean prices of wheat following this reform. However the magnitude of these welfare effects is very small compared to those of the CAP reform and the global welfare loss induced by this reform is more than offset by the gains arising from the removal of the European price support scheme.

From this point, since the setup of a private storage subsidy induces an increase of the storage activity and has a limited negative welfare impact compared to the positive impact of the CAP reform, this policy appears to be a good answer to the rise of market volatilies in the EU (and the very limited decrease of these volatilities in the US and the RoW). However, the results presented in Table 7 completely contradict this assumption. Indeed, the main argument in favor of a subsidization of private storage is that stockholding behaviors allow to stabilize agricultural markets. Yet, as reported in Table 7, the standard deviations of wheat productions, prices and farm incomes are higher here than before the introduction of the storage subsidy. In the RoW, for instance, the standard deviation of wheat production is more than 4% higher than without the subsidy and the standard deviation of price is more than 2 % higher. These differences are certainly small, but are in sharp contrast to what was expected from the subsidy.

In fact, a closer look at our results comes to qualify this surprising conclusion that, despite the fact that the setup of the wheat storage subsidy actually increases the amount of stocks held by period, it does not stabilize, and even to some extent destabilizes, crop markets. Table 9 the percentage of samples of productivity shocks (among the 83 samples we have kept in the analysis) where stand deviations of output, price and farm income actually increase. It interesting to note here that prices and farm incomes are actually destabilized in barely half of the samples and, in the case of wheat, that they can even be stabilized in the majority of the samples. The mean standard deviations reported in 4 and 7 are thus not sufficient to draw any conclusion on the effects of the subsidy on crop market volatilities: those effects vary and can be opposite from one sample to the other. It thus seems that some intrinsic characteristics of the random shock samples can influence the way the subsidization of private storage acts on market fluctuations. To study this question we perform a logistic regression based on additional CGE simulation results.

3.3.2 Characterization of the factors influencing the effects of the storage subsidization on market volatilities

As mentioned above, we suspect that some characteristics of the shock samples can explain the contrasted effects of the storage subsidy on market volatilities. To confirm this and find which distributional characteristics are the most influencial, we perform a logistic regression. The depending variable INC_i takes the value 1 if the price volatility increases with the storage subsidization, and 0 if it decreases, the observation i corresponding to one product (wheat, oilseeds or other cereals) and one region (EU, RoW or US) in one sample. We choose first to use the following distributional characteristics of the different samples as potential (continuous) explanatory variables: the mean M_i, the standard deviation St_i, the first order autocorrelation $AC1_i$, the second order autocorrelation $AC2_i$, the skewness Sk_i, and the kurtosis K_i. We also use some potential dummies explanatory variables characterizing the products ($WHEAT_i$ and $OILSEEDS_i$) and the regions (EU and ROW).

Furthermore, as shown by Femenia (2010), when agent's expectations are imperfect, the speed of adjustment of these expectations to new market information, which is represented by the α parameter in our case, has an impact on the markets stabilization induced by stockholding behaviors. We thus run some new CGE simulations, varying the value of the α parameter from 0.01 to 0.1 and add those new results to the dataset used for the logistic regression, which brings the total number of observations in this dataset to 2268[2]. We also add $ALPHA_i$, taking the values of the *alpha* parameter, to our potential explanatory variables, which brings their number to 11.

The Akaike information criterion is used to find the model fitting the best our data and so select the most relevant combination of explanatory variables to explain the volatility increase or decrease induced by the storage subsidy. Those variables are $ALPHA_i$, $AC1_i$, $WHEAT_i$ and $OILSEEDS_i$. The results of the logistic regression performed on these variables are presented in Table 10. Different elements come out of these results. First, the value of the α parameter has a positive impact on the probability of increasing the instability of crop markets by subsidizing private storage. This result is in line with the conclusions of Femenia (2010) who finds the more past information is taken into account by economic agents when they make their expectations, that is to say the slowler they react to market news (the lower α is)

[2]as it has been done for $\alpha = 0.05$, we only keep the samples where there is no divergence problem for all the values taken by α, which reduces to 21 the total number of samples kept: we thus have 21 samples $\times$ 12 values of α $\times$ 3 products *times* 3 regions = 2268 observations

the greater the probabilities that stockholding behaviors can reduce market volatility. Then, with negative coefficients associated with the $WHEAT_i$ and $OILSEEDS_i$ variables, it appears that the subsidy is more likely to have the expected effect of reducing price fluctuations in the wheat and, to a lesser extend, in the oilseed sectors than in the other cereal sectors. Since the storage takes place and is subsidized for wheat only, it is not surprising to get higher effects for that sector. Given the signs of these effects, one can expect that there is actually a high probability that the storage subsidy will stabilize the wheat and the oilseeds markets, but destabilize other cereal markets. The oilseeds sectors thus tend to also benefit from the subsidization of wheat storage, whereas it seems that this public support tends to transfer the market volatilities to the other cereals sector. Finally, the first order autocorrelation of productivity shocks plays a role in the way the subsidies affect the volatility of crop markets: the more the shocks are positively auto correlated, the more the subsidy is likely to lead to a destabilization of markets. In other words, the policy is more likely to have desired stabilization effects if the shocks tend to be alternately positive and negative (negative autocorrelation) than if a succession of positive shocks is followed by a succession of negative shocks or vice versa. The figures 1 and 2 allow to understand this mechanism: we have represented the evolution of the world wheat price and wheat stocks with and without storage subsidization, for a sample where we observe a 4% decrease of price volatility (the standard deviation of wheat decreases from 0.070 to 0.068) (Figure 1) and a sample where we observe a 36% increase of price volatility (the standard deviation of wheat increases from 0.102 to 0.138)

(Figure 2) following the reform[3]. The first order autocorrelation of productivity shocks is lower in the sample where the volatility decreases (-0.17) than in the one where the volatility increases (-0.10), which is in accordance with the result of our logistic regression. Actually, the evolution of the world wheat price and stocks represented on Figure 1 corresponds to what one would first expect from a subsidization of private storage: by looking to what happens between periods 36 and 41, we notice that the quantities of wheat stored are higher once storage is subsidized, which tends to limit the decrease of wheat price when a positive productivity shock occurs, as in period 36; then, when a negative shock occurs shortly afterwards, more stocks can be released on the market, which comes to mitigate the price increase induced by the low wheat production. The reduced wheat price volatility can even lead to less stocks buying, as in period 43. It is important to note here that the wheat price increases are shortly followed be wheat price decreases, which is due the negative first order autocorrelation of productivity shocks: positive and negative shocks arise almost alternatively. There is thus no prolonged period of very low or very huge prices. The story is different in the case of a higher autocorrelation of shocks, as presented on Figure 2. Indeed, rather long periods of low prices (as between periods 18 and 27 or between periods 31 and 41) can be observed, they are notably due to successions of positive productivity shocks (reflected by the relatively higher first order autocorrelation of these shocks) and are in a sense responsible for the destabilization induced by the storage subsidization. Here is the mechanism at work: positive productivity shocks generate relatively high outputs and low prices and

[3] the α parameter is equal to 0.05 for both figures

lead an increase of stock quantities. So, when several positive shocks arise successively, prices remain at a relatively low level for several periods, which leads to a decrease of agricultural producers' price expectations. Then, at the time a negative productivity finally occurs, as the quantities of wheat produced are even lower because of the low price expectations of wheat producers, if the quantities of wheat stored are not high enough to satisfy the demand, stocks are completely cleared and wheat prices highly increase. The subsidization of private storage increase the quantities of wheat stored and can thus postpone the time at which stocks are cleared but, in that case the expectations of producers become even lower than without the subsidy (since they have observed more periods of low prices), and the clearance of stocks generates even higher price spikes than without the subsidies. This is what arises between periods 31 and 36: without the subsidy, wheat stocks are null from period 38 and the price starts increasing from that period; but with the subsidy, the stocks of wheat remain positive and its price remains low for 3 more periods, which leads producer's price expectations to decrease compared to the case without the subsidy, so when stocks finally clear the price spike is much higher. To sum up, the less the productivity shocks are negatively auto correlated, the more the setup of the storage subsidy might scramble the market information send to market agents by generating (too) long periods of high stock levels, and so destabilize markets.

Conclusion

Our main objective in this article was to study the effects of a subsidization of private storage on the volatility of agricultural markets following the removal of CAP instruments in arable crop sectors. Indeed, in the current context of agricultural market liberalization, more and more attention is being paid to the need for a public intervention to stabilize these markets. Such an intervention could take the form of storage cost subsidies aimed at stimulating private storage at the world level. We have thus used a dynamic CGE model, taking into account the inter temporal dimension of economic agents' decisions, to study the impacts of a subsidy of wheat storage costs implemented in the RoW, both in terms of market stabilization and welfare effects. This model assumes that agents have imperfect expectations, which allows a representation of the endogenous source of market volatility. The exogenous source of volatility is also represented through the introduction of productivity shocks.

Our first results, concerning the effect of the removal of CAP instruments in the wheat, oilseeds and other cereals sectors, illustrate the effects of this reform on agricultural market fluctuations. Indeed, following the reform, the output, price and farm income volatilities increase in the EU, especially in the wheat and other cereals sectors where prices were highly supported (by variable tariffs and export subsidies) before the reform. On the contrary, the fluctuations on arable crop markets tend to decrease in the other regions (the US and the RoW). This comes from the suppression of the transfer of risk from EU to world markets initially induced by the EU price support mechanism. However this decrease of volatility observed on foreign markets is rather limited compared to the increase observed in the EU. The reform besides lead to a decrease of the storage activity in the US and the RoW. The subsidization of private storage thus seems appropriate, first to limit the destabilization of European crop markets, and second to reinforce the stabilization of the RoW and US markets after the CAP reform. We actually find that, for a limited cost, this policy allows to boost the storage activity in the 3 regions. However, its role as a market stabilizing instrument is more questionable. Indeed this subsidy tends, on average, to increase the volatility on agricultural markets. A closer look at the simulation results allows to qualify this unexpected conclusion. Two opposite cases can actually arise: for about one half of the samples of productivity shocks, the markets are effectively destabilized, but they are stabilized for the other half. To qualify these contrasting results, we perform a logistic regression and reveal three factors influencing the way the storage subsidy can act on market volatilities: the crop sector concerned (as storage takes place in the wheat sector only, it comes with no surprise that the stabilization is more likely in this sector), the form of agent's expectations and the first order autocorrelation of the productivity shocks: we find that the stabilization is more likely when agents slowly react to new market information, and when productivity shocks are negatively auto correlated. Actually, it is well known that the lower the stock levels, the stronger the reaction of market prices to small shocks (see Wright (2012) for instance), we show here is that this is all the more true as the drop in stocks arise after a prolonged period of high stock levels (as a negative productivity shock arise after a succession of positive shocks).

From the results of this study, it thus appears that there is a risk by subsidizing storage costs to stimulate the activity of private stockholders', to actually destabilize markets. Our results also bring to light to important elements on which further research is needed: the form of economic agents' expectation, and the distribution of productivity shocks in different regions of the world. We must also acknowledge that these results must be taken cautiously, since the potential risk aversions of economic agents have not been introduced in the model, yet this could change the outcomes of the model, and would certainly have important impacts on the effect of the (de)stabilization of markets induced by the political reforms simulated here. Furthermore, the subsidy we have chosen to represent here is rather basic: it consists in a fixed subsidy to production costs in the storage service sector. More elaborated ways to stimulate private storage at the world level, like subsidies adjusting to market conditions, should be considered before concluding that there are no incentives to publicly intervene in storage at the world level.

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Tables and Figures

Table 1. Mean Standard Deviations in the Benchmark

		EU	RoW	US
Output	Wheat	0.01	0.03	0.01
	Oilseeds	0.01	0.02	0.01
	Other Cereals	0.01	0.02	0.01
Price	Wheat	0.02	0.08	0.08
	Oilseeds	0.09	0.09	0.09
	Other Cereals	0.00	0.07	0.04
Farm Income	Wheat	0.08	0.10	0.06
	Oilseeds	0.19	0.11	0.14
	Other Cereals	0.04	0.09	0.05

Table 2. Long Term Effects of the CAP Reform (%age Changes Compared to the Benchmark)

		EU	RoW	US
Output	Wheat	-17.5	1.8	2.4
	Oilseeds	-7.6	0.6	0.3
	Other Cereals	-13.2	0.8	0.7
Price	Wheat	9.3	0.9	1.6
	Oilseeds	6.7	0.3	0.6
	Other Cereals	13.1	0.4	0.4
Farm Income	Wheat	-64.5	3.6	6.8
	Oilseeds	-35.9	1.1	1.4
	Other Cereals	-58.5	1.5	2.2

Table 3. Welfare Effects of the CAP Reform (Equivalent Variation in Income, 2001 US$ million)

EU	RoW	US	Total
33334	-10352	-1220	21763

Table 4. Mean Standard Deviations After the CAP Reform (Change in Standard Deviations Compared to the Benchmark)

		EU	RoW	US
Output	Wheat	0.05	0.03	0.02
		(+288.2%)	(+1.3%)	(+27.8%)
	Oilseeds	0.03	0.02	0.01
		(+127.1%)	(+1.2%)	(+2.5%)
	Other Cereals	0.04	0.02	0.01
		(+260.6%)	(+0.5%)	(+3.2%)
Price	Wheat	0.08	0.07	0.07
		(+322.3%)	(-3.1%)	(-6.0%)
	Oilseeds	0.10	0.09	0.09
		(+9.8%)	(+0.8%)	(+1.0%)
	Other Cereals	0.07	0.07	0.04
		(+198346.2%)	(-4.4%)	(-4.0%)
Farm Income	Wheat	0.15	0.10	0.06
		(+90.2%)	(-2.4%)	(+8.5%)
	Oilseeds	0.14	0.11	0.14
		(-26.7%)	(+1.5%)	(+1.5%)
	Other Cereals	0.13	0.08	0.05
		(+236.9%)	(-5.7%)	(-3.8%)

Table 5. Mean Wheat Stocks Held by Period (in %age of Wheat Production)

	EU	RoW	US
Benchmark	0.00	0.80	0.36
CAP reform	0.05	0.63	0.14
Storage subsidies	0.06	0.93	0.23

Table 6. Long Term Effects of the CAP Reform with Private Storage Subsidies (%age Changes Compared to the Benchmark)

		EU	RoW	US
Output	Wheat	-17.5	1.8	2.4
	Oilseeds	-7.6	0.6	0.3
	Other Cereals	-13.2	0.8	0.7
Price	Wheat	9.6	1.2	1.9
	Oilseeds	6.7	0.3	0.6
	Other Cereals	13.1	0.4	0.4
Farm Income	Wheat	-64.4	4.3	7.1
	Oilseeds	-35.9	1.1	1.4
	Other Cereals	-58.5	1.5	2.2

Table 7. Mean Standard Deviations After the CAP Reform and the Setup of the Private Storage Subsidies (Change in Standard Deviations Compared to the CAP Reform Alone)

		EU	RoW	US
Output	Wheat	0.05	0.03	0.02
		(+0.22%)	(+4.33%)	(+0.73%)
	Oilseeds	0.03	0.02	0.01
		(+0.01%)	(+0.02%)	(-0.01%)
	Other Cereals	0.04	0.02	0.01
		(+0.00%)	(+0.08%)	(+0.02%)
Price	Wheat	0.08	0.08	0.07
		(+2.35%)	(+2.48%)	(+2.46%)
	Oilseeds	0.10	0.09	0.09
		(+0.07%)	(+0.06%)	(+0.06%)
	Other Cereals	0.07	0.07	0.04
		(+0.01%)	(+0.05%)	(+0.04%)
Farm Income	Wheat	0.15	0.10	0.06
		(+0.41%)	(+3.01%)	(+1.61%)
	Oilseeds	0.14	0.11	0.14
		(+0.03%)	(+0.07%)	(+0.07%)
	Other Cereals	0.13	0.08	0.05
		(+0.00%)	(+0.04%)	(+0.03%)

Table 8. Welfare Effects of the Private Storage Subsidies (Equivalent Variation in Income, 2001 US$ million)

EU	RoW	US	Total
-59	-233	-20	-312

Table 9. Percentage of Samples Where the Volatility Increases Following the Setup of the Storage Subsidy

		EU	RoW	US
Output	Wheat	80	82	53
	Oilseeds	59	59	51
	Other Cereals	41	58	55
Price	Wheat	47	45	45
	Oilseeds	59	59	60
	Other Cereals	49	59	55
Farm Income	Wheat	46	55	36
	Oilseeds	58	57	58
	Other Cereals	52	57	57

Table 10. Results of the Logistic Regression

	Coefficient[a]	z-value
Intercept	-0.5000 ***	-4.586
$ALPHA$	7.6638 ***	4.872
$AC1$	0.5588 .	1.748
$OILSEEDS$	-0.4146 ***	-3.923
$WHEAT$	-0.8031 ***	-7.336
Log Likelihood	-1461.101 (df=5)	
AIC	2932.2	

[a]'.' and *** denote variables significant at respectively 10% and 1%

Figure 1. Wheat Market (Example of a Sample Where The Subsidy Induces a Stabilization of Markets)

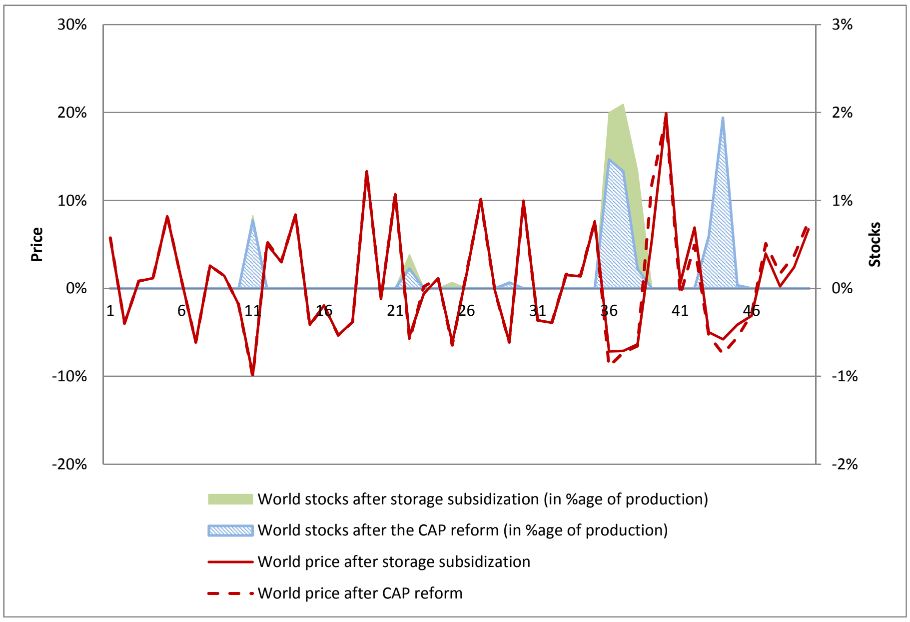

Figure 2. Wheat Market (Example of a Sample Where The Subsidy Induces a Destabilization of Markets)