ON THE OPTIMAL IMPLEMENTATION OF

AGRICULTURAL POLICY REFORMS

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Abstract:

Economic analyses of farm policies generally focus on the long run, steady state impacts while the transition dynamics are often overlooked. In this paper we develop a determinist dynamic computable general equilibrium analysis allowing agents to form imperfect versus pefect expectations. Using an illustrative CAP reform scenario, we simulate an abrupt versus a gradual implementation of this reform. Our results show that if economic agents are able to perfectly anticipate the impacts of the reform, then delaying its implementation is never optimal. On the other hand, if agents gradually learn from market developments, then we find some cases where a gradual implementation of this reform is welfare improving. Such gradual implementation allows minimizing adjustment costs.

Keywords: Dynamics, Transition, Farm Policies, Welfare

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Introduction

Agricultural policies in developed countries have undergone several reforms since their creation. These reforms have almost always been implemented gradually. This is notably the case of the Common Agricultural Policy (CAP) of the European Union (EU): the reduction of support prices begun in 1992 and was reinforced in 1999 and 2003 reforms while the decoupling of farm payments started in 2003 and was pursued with the 2008 Health Check.

This gradual implementation of agricultural policy reforms can first be explained by political considerations. Indeed these reforms are often difficult to agree upon due the opposition of stakeholder including farmers. A gradual reform generally benefits from a better acceptability. Secondly there might be a time lag between the implementation of a reform and agents' adaptation to the new policy because of adjustment costs. Hence reforming gradually may lessen these adjustment costs and may be economically justified. On the other hand, a too long implementation of a reform may ultimately become inefficient if the steady state benefits are postponed too far away and are thus heavily discounted. A quick implementation can also be motivated by other political considerations. Indeed a quick implementation at the beginning of a new administration confers some credibility to its elected members (Haggard and Webb, 1993). Furthermore this allows the new policy to be well embedded and benefits materialize before the end of the mandate and the new elections. Accordingly, governments face both economic and political trade-offs when deciding the implementation of a reform.

To our knowledge, few economic analyses focus on the transition dynamics and thus deal with this issue. Furthermore only a small part of the existing studies specifically addresses agricultural policy issues. Among these is the analysis of Yanagida et al. (1987) who argue that suppressing immediately agricultural price supports in the US is preferable to suppressing them gradually. The reason is that a gradual reform generates cyclical market movements. However this study is based on an econometric model focused on market impacts without any computation of economic welfare effects. On the contrary, using a dynamic Computable General Equilibrium (CGE) framework with static expectations for investment decisions, Levy and van Wijnbergen (1995) argue that a progressive liberalisation of Mexican agriculture is preferable to an immediate reform. Even if an immediate liberalisation induces larger economic gains, the authors prove that gradualism is not very costly while it allows mitigating the welfare losses for the group affected. The analysis of Adams et al. (2001) confirms this trade-off between smoothness and short run efficiency losses. These authors develop a dynamic CGE model on the Danish economy, with static versus perfect expectations, to analyse the implementation of a quota on pig production. They conclude that whether announcement (gradual) or surprise (abrupt) implementation is to be preferred depends on agents' attitude towards risks and how they discount the future. On the other hand, the position of Malakkelis (1998) on the optimal timing of a tariff reform for Australia is more definitive. He shows using a dynamic CGE model with perfect expectations that, even if both type of reforms lead to similar long term effects, reforming immediately is better than reforming gradually. The reason is that the economy adjusts more slowly when the reform is progressive: the earlier tariffs on capital goods are suppressed, the earlier allocation efficiency gains are realized. These different studies rely on different models, on different assumptions concerning agents' expectations and inter temporal decisions, and focus on different policy issues. Their results are thus hardly comparable. However their contrasting conclusions show that the issue of the optimal implementation of policy reforms is still open and that several factors can influence it.

In this article we focus on the role played by price and return expectations formed by economic agents. The basic intuition is the following: the more stakeholders are able to correctly anticipate the market effects of the reforms, the more the reforms can be implemented quickly. Adams et al. also express this intuition but do not formally test it. More generally different economic studies have already shown that these expectations can be crucial when evaluating policy reforms (Pereira and Shoven, 1988). In particular Ballard (1987) shows with a dynamic CGE model for the US economy characterized by many distortions, that the implementation of a consumption tax in the US in place of the income tax can generate lower welfare gains if agents perfectly anticipate the future than if they make adaptive expectations. The reason is that the taxation of consumption leads to an increase of capital stock, and if consumers have perfect foresight they expect the induced decrease of capital returns, leading them to reduce their savings before the reform. This, in turns, generates a welfare loss which does not occur if consumers do not anticipate the effect of the reform before its implementation. In the same vein, Thissen and Lensink (2001) ,using a dynamic CGE model for Egypt, find that a currency devaluation which is perfectly anticipated by economic agents has a negative effect on pre reform investments and production. These negative effects are absent with adaptive expectations. This issue of expectations is not specific to dynamic CGE analyses of macro-economic reforms. For instance, Scandizzo et al. (1983) develop a static partial equilibrium model calibrated on a stylised farm market. These authors find that the welfare gains of a price stabilisation reform are higher the more agents are naïve; as a matter of fact, most of the gains could be reaped if agents were better informed. This cost of naivety suggests that, if agents are not fully rational and adjust their expectations along with time, a gradual reform is preferable because it allows them to learn and improve their information progressively.

If the aforementioned studies provide some insights about the role played by expectations on the optimal implementation of reforms, none of them specifically addresses this issue. In that context, our main objective in this article is to investigate this overlooked issue. We obviously focus on farmers who potentially face major changes from agricultural reforms. In this respect, we develop a dynamic CGE model aimed at simulating the effects of agricultural policy reforms on farm markets and welfare. This dynamic model is developed using different expectations schemes, ranging from perfect foresight to pure naivety. Using this framework, we simulate the effects of a radical reform, namely the total suppression of the CAP in the EU arable crop sectors (cereals and oilseeds). This shock is implemented in one step or implemented gradually (over five years). Our simulation results show that if economic agents have perfect expectations, then delaying the implementation of reforms is never optimal. On the other hand, if agents gradually learn from market developments because of their imperfect expectations, then we find some cases where a progressive implementation of a radical reform is welfare improving while an abrupt implementation may generate significant welfare losses in the short run.

The next part of this article is devoted to a brief description of our dynamic CGE model with a special focus on the links between the form of expectations and the dynamic decisions of the model. The results of the simulations conducted under different assumptions concerning the implementation of the reform and the expectations of economic agents are then presented. We also perform sensitivity analysis of main results to our assumptions on the level of adjustment costs and on the imperfect nature of expectations. Finally we conclude.

1. Modelling frameworks

We develop two consistent dynamic CGE models. In the first version agents are assumed to have perfect expectations while the second one they are assumed to have adaptive expectations, the case of naïve and static expectations being particular cases. In a first subsection we present the main characteristics of the perfect expectation version. The necessary changes to the model to switch from the perfect to the adaptive expectations version are then described in a second subsection.

1.1. The version with perfect expectations

We start from the static version of the widely used Global Trade Analysis Project (GTAP) model. More precisely, our point of departure is the GTAP-AGR model which offers a detailed representation of the farm and food sectors (Keeney and Hertel, 2005). In this static CGE model, savings by household are a fixed proportion of domestic income. Then a world bank collects savings from all countries and allocates world saving to regional investments according to expected regional capital returns. These expected capital returns decline with investments according to an ad hoc log-log specification.

In our dynamic CGE models, we develop alternative specifications of these saving and investment dynamic decisions. They result from consistent micro-economic dynamic optimisation programs. Different expectation schemes by economic agents can be introduced in these programs.

1.1.1 Producers' behaviours

Producers' behaviours result from both intra and inter temporal decisions. At each time period producers maximise capital returns by combining primary factors (capital, labour, and land in the case of agricultural producers) and intermediate consumption through nested CES functions. Land and labour endowments in each region are assumed to be fixed, although they can be reallocated across agricultural sectors or across non agricultural sectors at each period. Capital, once installed in a sector, is assumed to be fixed in the current period. However this sectoral capital stock changes with firms' investment from one period to another, namely:

$$K_{i,r,t+1} = (1 - \delta_{i,r}).K_{i,r,t} + I_{i,r,t}$$

with $K_{i,r,t}$ the capital stock installed in region *r* and sector *i* in period *t*, $I_{i,r,t}$ the new investment made in period *t* and δ_{ir} the depreciation rate of capital. The optimal investment may be positive or negative. This optimal investment is precisely determined by the inter-temporal dimension of producers' decisions. Producers seek to maximize the present value of their firm (Devarajan and Go, 1998), which corresponds to the discounted value of their expected future profits (capital income) minus their expected future investment costs:

$$
\begin{aligned}
&\max \quad \pi_{i,r} = \sum_{t=1}^{\infty} \frac{1}{(1+r)^t} \left(wk_{i,r,t} K_{i,r,t} - PI_{i,r,t} I_{i,r,t} \left(1 + \frac{\varphi_{i,r}}{2} \frac{I_{i,r,t}}{K_{i,r,t}} \right) \right) \\
&s.t. \quad K_{i,r,t+1} = \left(1 - \delta_{i,r}\right).K_{i,r,t} + I_{i,r,t}
\end{aligned}
$$

With r the interest rate, $wk_{i,r,t}$ the expected capital unitary return, $PI_{i,r,t}$ the expected price of the investment good. The term $\frac{\varphi_{i,r}}{2} \frac{I_{i,r,t}}{K_{i,r,t}}$ represents the installation cost of capital with $\varphi_{i,r}$ a structural parameter (McKibbin and Wilcoxen, 1999). Solving this optimisation problem leads to a condition determining the optimal sectoral investment:

$$
\begin{aligned}
&wk_{i,r,t+1} + \left(1 - \delta_{i,r}\right) PI_{i,r,t+1} \left(\varphi_{i,r} \frac{I_{i,r,t+1}}{K_{i,r,t+1}} + 1 \right) \\
&= (1+r) PI_{i,r,t} \left(\varphi_{i,r} \frac{I_{i,r,t}}{K_{i,r,t}} + 1 \right) - \frac{\varphi_{i,r}}{2} PI_{i,r,t+1} \left(\frac{I_{i,r,t+1}}{K_{i,r,t+1}} \right)^2
\end{aligned}
\tag{1}
$$

To facilitate the economic interpretation of this implicit equation, let’s first assume that the installation cost parameter is null. The right hand side is then the marginal cost of investment in period t evaluated in period t+1. The left hand side is the marginal revenue of this investment: it equals the next period expected capital returns and the next period expected price of the (depreciated) investment good. When installation costs are positive, then the marginal cost and revenue of present investment are augmented by these costs. The last term of this equation takes into account that this installation cost decreases with the capital stock, hence investing today will decrease the installation cost of next-period investment.

This optimal investment decision depends on the expected prices of the investment good and the expected capital returns. The latter depend on the expected prices of outputs and the expected returns to other production factors. Accordingly if an agricultural policy scenario leads to some expected changes in output prices and capital returns, then farmers will react by modifying their investment decisions (and periodic production and input decisions as well). This will have subsequent impacts on future production and markets.

1.1.2 *Households' behaviours*

Households' decisions can also be decomposed between inter and intra temporal decisions. Households base their savings decisions on an inter-temporal trade-off: 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 represents a future utility. So, the representative household in each region seeks to maximize the value of its inter-temporal utility, which is assumed to be additively separable, subject to the constraint on wealth accumulation:

$$\begin{aligned}
&\max \quad U_r = \sum_{t=1}^{\infty} \frac{1}{(1+\rho)^t} U_{r,t}(Q_{r,t}) = \sum_{t=1}^{\infty} \frac{1}{(1+\rho)^t} \log(Q_{r,t}) \\
&s.t. \quad W_{r,t+1} = (1+r)W_{r,t} + E_{r,t} - PC_{r,t}.Q_{r,t}
\end{aligned}$$

With ρ a time preference parameter (households have a preference for immediate utility), Q_{rt} the composite quantity consumed, $PC_{r,t}$ the composite consumer price, $W_{r,t}$ the wealth of household (due to their ownerships of domestic and foreign capital assets), E_{rt} the sum of labor and land earnings. Periodic household savings are simply given by:

$$S_{r,t} = W_{r,t+1} - W_{r,t} = rW_{r,t} + E_{r,t} - PC_{r,t}.Q_{r,t}$$

The first order condition of this program determines the level of savings in each region:

$$rW_{r,t} + E_{r,t} - S_{r,t} = PC_{r,t}Q_{r,t} = \left(\frac{1+\rho}{1+r}\right)\left(rW_{r,t+1} + E_{r,t+1} - S_{r,t+1}\right) = \left(\frac{1+\rho}{1+r}\right)PC_{r,t+1}Q_{r,t+1} \qquad (2)$$

We again get an implicit equation determining the optimal evolution of consumption expenditure and savings in terms of expected consumer prices and expected incomes. Finally, the periodic income that is not saved is spent by the households to buy consumption goods so as to maximise their (Stone Geary) intra temporal utility.

1.1.3 *Equilibrium conditions*

Solving an infinite horizon dynamic CGE model with perfect expectations imposes the modeller to define steady state conditions at some future terminal period. The equations determining investment (equation 1) and saving (equation 2) relate current decisions to next period decisions in terms of expected prices, incomes and returns. As usual (see for instance, Diao and Somwaru, 2000), we assume that the markets reach a steady state at some period T;

from this period investment equals capital depreciation and the household real wealth does not grow:

$$I_{i,r,T} = \delta_{i,r} K_{i,r,T} \tag{3}$$

$$W_{r,T+1} = W_{r,T} \tag{4}$$

These two terminal conditions ensure that a country net debt is stable or, equivalently, that the country savings equals its investment at the steady state.

Finally we mention that computing dynamic welfare gains is not straightforward when perfect expectations are assumed. It can not be computed as the discounted sum of yearly welfare effects because there is an optimal transition path that depends on prevailing prices. The consistent decomposition of the total welfare effect between an inter-temporal and an intra-temporal welfare effect is described in appendix 1.

1.2. The version with adaptive expectations

In the perfect expectation version of the model described above, agents are assumed to know exactly the future market prices and factor returns. This assumption implies that agents have full information and are able to process it so as to perfectly anticipate the evolution of all markets. However, collecting and processing information can be costly, so it may be rational for agents to base their decision on an alternative form of expectations, different from the perfect ones (Just and Rausser, 2002). Furthermore the econometric estimations of farmers' expectations generally conclude they form at best quasi rational expectations, often adaptive expectations (Nerlove and Bessler, 2001). These alternative expectation schemes are taken into account in a second version of our model in which we assume that agents do not know perfectly future prices and factor returns. Instead they form some expectations, based on past observations, about them. We have chosen in that case to adopt an adaptive form of expectations, originally proposed by Nerlove (1958), which are such that:

$$\hat{P}_t = \hat{P}_{t-1} + \alpha\left[P_{t-1} - \hat{P}_{t-1}\right] = \alpha P_{t-1} + (1-\alpha)\hat{P}_{t-1},\ 0 < \alpha \leq 1 \tag{3}$$

Here $\hat{P}_t$ denotes the price expected for period t, and the α parameter can be seen as a measure of the speed of adjustment of expectations. In fact the lower α is, the slower expectations adjust to market changes. An extreme case of Nerlovian expectations arises when α equals 1: economic agents only consider the previous period to form their expectations. These are called naïve expectations. At the opposite, if this parameter equals zero, then agents have constant expectations: they do not change with previous market conditions. Considering adaptive instead of perfect expectations implies some changes to the model. These changes concern the execution of the model and equilibrium conditions.

1.2.1. Execution of the model

When economic agents have perfect expectations, the prices they expect to prevail for the next period are conform to the economic theory. It implies that at the first period consumers and producers base their decisions on future market prices as determined by the model. All the decisions are thus taken at the first period for all subsequent periods and do not need to be re adjusted in the future: the model is solved once for all period simultaneously. On the contrary, when agents have adaptive expectations, they re-adjust their decisions at each period; the model is thus solved iteratively, period by period as a temporary general equilibrium (Grandmont, 1977). This does not prevent that at each period agents make plans for several future periods to take their inter-temporal (investment and savings) decisions. More precisely, we assume that at each period, producers define an investment plan for several future periods with some price/return expectations. We furthermore assume that, due to their imperfect information, producers define this investment plan over a finite (rather than infinite) horizon. After some transition period, we assume that producers consider that their investments will be equal to their capital depreciation. Indeed this firm steady state condition may never appear because firms periodically revise their plans, but this formulation defines the current optimal investment plan for firms, including the current investment. Basically we face the same issue for households' dynamic decisions. They save today part of their income for future consumption without accurate knowledge of future prices and returns. We assume that their current saving decision is also determined by a dynamic program with a steady state condition stipulating that wealth no longer accumulates after some period. But the level of this terminal constraint changes every period.

Secondly some particularities of agricultural sectors need to be considered here. Indeed, contrary to some other agents who may observe current market prices at time they take their decisions, agricultural producers have to decide the quantities to produce and inputs to use before knowing the market price of their production; they thus base their production decisions on expectations. This distinctive feature of agricultural sectors does not have any impact on the execution of the model if farmers have perfect expectations, whereas it needs to be taken into account in the case of adaptive expectations. To do so, the model is solved in two steps at each period. In a first step agricultural production decisions are taken based on farmers' expectations about selling prices and given their capital stocks. In a second step the quantities produced are put on the markets, all decisions by other agents are taken and prices adjust so as to ensure the intra temporal equilibrium for the period.

1.2.2. Equilibrium conditions

Contrary to the perfect expectation case, here investment and savings decisions are taken independently. Accordingly nothing in the model guaranties the equality between global savings and global investments. To overcome this issue, we make endogenous the world interest rate which adjusts to ensure the equality between global world savings and investments at each period.

Furthermore, in a model where future prices are perfectly anticipated, an inter-temporal equilibrium prevails (Pereira and Shoven, 1988). On the other hand, in the case of imperfect expectations, decisions and future plans are readjusted at each period: even if agents expect a future steady state to be realized when they take their inter temporal decisions, this state steady might not effectively be reached. Consequently, we may have a succession of temporary short run equilibriums, instead of an inter-temporal equilibrium, without reaching a steady state (Grandmont, 1977).[1] It means for instance that at each period the gap between regional savings and investments can be financed by other regions through a foreign debt increase. In that case the steady state where capital stocks and foreign assets/debts are stable may never occur. Despite this issue, we can still compute welfare effects at each period. We follow Ballard (1987) by computing welfare on effective periodic consumptions, thus neglecting periodic savings.

2. Empirical framework

We use the GTAP database calibrated on the 2001 economic flows to run our policy simulations. As usual we reduce the dimension of the empirical model. These data are

[1] The other critical issue of existence of this suite of temporary general equilibrium points is discussed below

aggregated to 3 regions (the EU, the US and the Rest of the World (Row) and to 10 sectors, among which 7 are agricultural sectors.[2]

The calibration of most behavioural parameters is identical to the calibration in the static GTAP-AGR model. The main exception concerns the substitution elasticities used to calibrate the nested CES functions of arable crop production technologies. Indeed, the ex post supply price elasticities are rather high in the static GTAP-AGR model because this model aims to simulate the long term effects of policy reforms. On the other hand, our dynamic framework simulates a sequence of short term effects, and agricultural supply adjusts less to price changes in the short term. Moving from the static specification to dynamic specifications already reduces these short run supply responses because the capital stock is fixed in the short run. Nevertheless the resulting supply elasticities remain still too high compared to usual elasticities used in partial equilibrium analyses of agricultural policies (see table 1, panel a). In fact fixing the capital stock has a low impact on supply elasticities because the capital returns often represent low shares in total production costs. That's the reason why we reduce all substitution elasticities in arable crop technologies to 0.1. The resulting own price supply elasticities are reported in table 1, panel b.

(Insert table 1)

Furthermore additional parameters, compared to the static model, have to be calibrated in our dynamic models (see equations 1 and 2). For that purpose, we follow Devarajan and Go (1998) and assume that the initial 2001 data correspond to a steady state. We also assume that the initial interest rate, the time preference parameter, and the capital adjustment parameter are all equal to 5 per cent.

Finally, when we adopt imperfect expectations, we also need to assume the horizon of the firms' investment plans as well as the horizon of households' optimal sequence of savings. We tested for different horizons (from 3 years to 8 years) and did not find substantial impacts. So we adopt a 3 year horizon in both cases. We also need to determine the precise way expectations are formed. Here we face some resolution issues already encountered by

[2] These 10 sectors are: wheat, coarse grains, oilseeds, other crops, cattle, meat production, other food products, manufactured goods, services, trade and transport.

previous authors with non linear economic models (for instance, Hommes 1994). If expectations are close to be naïve, then the dynamic system quickly diverges as in the standard cobweb model. On the other hand, when these expectations are more stable because all past prices/returns are taken into account, then our dynamic system no longer diverges. We focus our analysis of simulation results on these non divergent cases. We start assuming that the α parameter equals 1/5 for all agents and for all decisions (periodic production/ multi period investment). Then a sensitivity analysis of the results on this crucial parameter will be offered.

3. Simulation results

We simulate the complete removal of the CAP instruments in the arable crop sectors (wheat, other cereals and oilseeds) in order to maximise the resulting economic impacts on these sectors. On the other hand we maintain CAP instruments in livestock sectors. This illustrative scenario also allows us to circumvent the question of how particular instruments operate at the margin in these arable crop sectors. Practically, we remove export subsidies, import tariffs and direct payments as they are modelled in the static GTAP-AGR framework (a subsidy to land use). As said above, our models are calibrated on 2001 figures using the GTAP database. A real policy analysis must start building a realistic baseline incorporating all policy changes already implemented or projected. Since 2001 the CAP has been reformed twice (in 2003 with the so-called Mid Term Review, in 2008 with the so-called Health Check) but these reforms mainly affect livestock sectors. So we make the simplest assumption to define the baseline: we assume that the year 2001 is a steady state and does replicate in all subsequent years.

We then consider two implementations of our illustrative CAP reform. In the first case, we assume that this reform is abruptly applied in 2013. In the second case, we assume a linear gradual implementation of this reform from 2013 to 2017. In other words, we implement each year a 20 per cent reduction of the pre-reform levels of policy instruments. In both cases, we assume that EU governments agree upon and announce this radical reform in 2011. We thus start simulating our model from 2011 when the policy reform is announced.

3.1. Impact on the steady state of a brutal implementation with perfect expectations

Before analysing transition dynamics and the optimal implementation of agricultural policy reforms, it is useful to understand the steady state impacts of this reform on farm markets.

Here we focus on the simplest case of a brutal implementation with perfect expectations by all economic agents.[3]

Table 2 reports the main steady state impacts of our reform. As expected the suppression of tariffs, export subsidies and, above all, direct payments in the EU induces a decrease of production of wheat (by 16.5 per cent) and other cereals (by 12.4 per cent). The production drop is smaller (by 6.3 per cent) in the European oilseeds sector because the share of direct payments in total revenues is initially smaller in this sector and there is no tariffs nor export subsidies.

(Insert table 2)

In these sectors, primary factor uses decrease as expected: land uses decrease more than capital. For instance the capital stock in the wheat sector decreases by 15.9 per cent and the land use by 22.2 per cent. So there is a small change in production technologies toward more input-intensive technologies because the land input subsidy is removed. The returns to land in arable crop sectors dramatically drop (by as much as 83 per cent in the wheat sector). Accordingly we observe a reallocation of land towards the "still protected" livestock sectors (land use for fodder production increases by 13.6 per cent). This does explain the slight increase in cattle production (by 0.3 per cent).

On the EU agricultural markets, we also obtain a significant reduction of EU exports of arable crops (by as much as 33.5 per cent for wheat). The removal of export subsidies partly explains these results. This reduction is however lower than the production drop, so we end up with higher EU real producer prices of arable crops (for instance by 7.1 per cent for wheat). Without surprise, the impact on US and RoW farm markets are in the opposite directions. For instance, their exports of arable crops increase (by 4.4 per cent for the US wheat, by 9.9 per cent for RoW wheat), their production expands as well. The increases are partly to the detriment of their livestock productions.

At the steady state obtained after 15 years of simulation, the yearly EU welfare increases from the CAP reform because some distorting impacts of this policy are suppressed. The discounted (to 2011) EU economic welfare increases by 580 million US$ in 2025. By

[3] The perfect expectation version of the model was first solved over 15 years, then over 16 years. Market and welfare results were robust to this choice of the terminal year.

contrast, the RoW suffers from welfare losses because this region is a net importer of arable crops and the world prices of these products increase (discounted loss of 255 millions US$ in 2025). Finally the US economy experiences a small welfare gains (by 20 million US dollar in 2025).

3.2. The transitory dynamics

Before discussing welfare effects, we first analyse the dynamics of the EU wheat market. The dynamics observed on other markets exhibit the same qualitative patterns. Figure 1 (2) reports the evolution of the European wheat price (production) for the different simulations. A first thing to note is that the long term effect, a 7.1% increase of wheat price is the same for all the simulations. The transition paths however are different: whereas prices rapidly converge to their steady state value in the perfect foresight setting, they fluctuate much more when expectations are adaptive, especially if the reform is abruptly implemented.

(Insert figures 1 and 2)

Let’s start with the perfect expectation results. Producers perfectly anticipate the effects of the reform. Once announced, they immediately adjust downwards their investment levels while other input decisions (land, fertilizer, pesticides, …) are already made. This reduction of first year (2011) investment is logically greater in the abrupt implementation than in the gradual implementation. Accordingly the EU wheat production in the second year (2012) already decreases even if the reform is effectively implemented from 2013 onwards. This reduction amounts to 1.4 per cent in the gradual implementation, up to 2.4 per cent in the abrupt implementation with respect to the no-reform benchmark. That’s the main reason why we also observe an increase of the EU wheat price in that second year (by 0.7 per cent in the gradual implementation, by 1.2 per cent in the brutal implementation).

The EU wheat producers continue to adjust downwards their investment in the second year (2012). They also modify their other input decisions (intermediate inputs, land and labor) because they perfectly anticipate the price/returns effects of the following years. In particular, they perfectly anticipate the major effects of the (partial/total) removal of direct payments in the third year. The EU wheat production declines by 5.9 per cent in the gradual implementation, up to 13.2 per cent in the brutal implementation. So there is a huge difference in that third year between the two implementations due to the greater modifications in the optimal combination of variable inputs with installed physical capital.

This process of adjustment quickly converges to the steady state with the abrupt implementation. It is more slowly with the gradual implementation because producers still benefit from (declining) CAP price supports and subsidies.

The transition dynamic is completely different with imperfect expectations by economic agents. Even if the reform is announced in 2011, agents do not adjust in the first years because they are backward looking. To justify this assumption, one possible interpretation is that agents believe that the reform is not credible and will not be applied.[4] Another possible interpretation is that agents are not able to figure out their relative competitiveness and the true characteristics of all markets. So they are initially passive and wait to learn from market developments. When the reform is effectively implemented (in 2013), the EU wheat producers significantly loss money (compared to the no reform benchmark) because they produce the same quantity of output but they now no longer benefits from former subsidy and price support levels. The EU wheat price declines by 1 per cent with the gradual implementation, by 4.6 per cent with the brutal implementation.

Because producers are backward looking and just experience negative income effects, they start adjusting their farming system. This adjustment is naturally more important with the abrupt implementation because their income losses (capital returns and land returns) are more significant. So they considerably revise their combination of variable inputs and also their investment. In fact it appears that they sell part of their capital when the reform is abruptly implemented. They only do not invest when the reform is gradually implemented. The main consequence is that the EU wheat production significantly drops in that third year when the reform is abruptly implemented. It decreases by 24.7 per cent leading to a subsequent huge price effect (by 23 per cent). By contrast, this production decreases by 7.2 per cent with the gradual implementation, leading to a more moderate price effect (4.7 per cent).

We observe that this process of adjustment converge rather rapidly to the steady state with the gradual implementation. On the other hand, the price and production patterns exhibit more pronounced variations with the abrupt implementation. It is worth mentioning that the production drops by as much as 31 per cent in 2016, three years after the completion of the

[4] Agreed reforms often include conditional clauses.

CAP reform. In other words, we observe on this wheat market that the series do not start converging to the steady state once the reform is completely implemented. The situation is opposite on the EU coarse grain market (not shown). Production and price effects on this market in the first year of reform are even more distant to their steady state levels. In the first year after the completion of the reform, we observe in this market a convergence towards the steady state levels. This initial convergence on the coarse grain market is to the detriment of the initial convergence on the wheat market.

Figure 3 represents the evolution of the welfare effects induced by the reform in the different simulation settings. It appears, first, that the long term European welfare gains are higher when expectations are adaptive, whatever the way the reform is implemented: they amount to about US$150 million, compared to US$100 million in the perfect expectations setting. The reason for these differences lies in the macroeconomic closure of the model. Indeed, in the adaptive version of the model the endogenous world interest rate allows European investments to be financed by other regions through an accumulation of the foreign debt. By contrast regional investments have to be entirely financed by regional savings, and foreign debts/assets have to be stable from the steady state period in the perfect foresight version. Long term European investments, capital stocks and capital income are thus higher in the adaptive expectation model, which in turns leads to higher disposable income for consumption and to higher European welfare gains.

(Insert figure 3)

If agents have perfect foresight the welfare effects are positive in all cases all along the transition path and slightly higher when the reform is implemented immediately because the gains are reaped earlier. It thus appears that in the case of perfect foresights an immediate reform is preferable to a gradual one. On the other hand, when expectations are adaptive the welfare gains are lower during the 10 first simulation periods, and, above all, the immediate implementation of the reform generates significant welfare losses (among US$1.2 billion) during the 8 first periods. These welfare losses first come from the adjustment costs associated with farmers' disinvestment. As explained above, the EU farmers strongly adjust downwards their capital stocks with the abrupt implementation in the first years following the reform. They thus pay significant des-installation costs. In the first year of the reform, they amount to 203 millions US$ (compared to 20 millions US$ with the gradual implementation) for the three arable crops sectors together. A second source of welfare effects is the foreign investment effect. The EU value of total investment decreases following the reform while the saving is rather stable. This leads to a small decrease of the world interest rate (by 0.06 per cent). This also implies that the EU economy partly finances foreign investments. We thus also observe significant different welfare effects in the other regions. For instance, the US economy in the second year of the reform (2014) experiences a higher welfare gain with the abrupt implementation (663 millions US$) compared to the gradual implementation (174 million US$). As expected the world welfare effects are initially lower with the brutal implementation because other regions also incur adjustment costs.

3.3. Sensitivity analysis

In this subsection we test the robustness of the short run welfare losses previously analysed in the case of an abrupt implementation with imperfect expectations.

Our first sensitivity analysis focuses on the imperfect expectations of farmers. So far we assume that agents slowly learn from market developments. This is reflected in the nerlovian parameter equal to one fifth. We now assume that farmers react more strongly to last price/return observations. This parameter is now set to one half. If we impose this parameter to all dynamic decisions, our dynamic system diverges. On the other hand, if we impose this parameter only to the variable input decisions while letting unchanged this parameter for investment decisions, then our dynamic system converges to a steady state. The figure 4 reports the effects of the EU welfare. We observe that our main result is quite robust: there are initially welfare losses. We also observe that the results oscillate much more before reaching the steady state. The welfare effects often turn from positive to negative and vice versa before stabilizing in the positive range. The intuition is the following: the more farmers strongly react to last price/return changes, the higher are the endogenous market fluctuations and adjustment costs.

(Insert figure 4)

Our second sensitivity analyses focuses on the crucial adjustment cost parameter (see equation 1). In the standard case, this parameter is such that installation costs represent 5 per cent of investment purchases. We now assume it to represent 2.5 per cent and 7.5 per cent of investment purchases. The impacts on EU welfare are provided in the figure 5. It appears that the initial welfare losses are even greater when these adjustment costs are low. This counter intuitive result can be explained as follows. When these adjustment costs are lower, then the farmers adjust their physical capital more strongly. For instance the EU wheat production decreases by as much as 42 per cent following the reform (compared to 31 per cent in the standard case). This also implies stronger adjustment in other sectors (like in the cattle production). In other words, the low adjustment costs favour stronger market fluctuations. Assuming higher adjustment costs have the symmetric effect. Initial welfare losses are more muted but still remain.

(Insert figure 5)

Conclusion

What is the best way to implement an agricultural policy reform? This issue is often overlooked in economic analysis of farm policies where the focus is on the long run, steady state impacts. In this paper we perform a determinist dynamic CGE analysis allowing agents to form imperfect versus perfect expectations. Using an illustrative CAP reform scenario, we simulate an abrupt versus a gradual implementation of this reform.

Our results show that if economic agents are able to perfectly anticipate the impacts of the reform, then delaying its implementation is never optimal. They start adjusting their production patterns once the reform is announced, so that the markets smoothly reach their steady states. On the other hand, if agents gradually learn from market developments, then we find some cases where a gradual implementation of this reform is welfare improving. By contrast an abrupt implementation generates initial losses due to significant adjustment costs. These initial losses are all the more important that agents, in particular farmers, strongly react to last price observations. Accordingly it may be optimal to gradually implement reforms so that agents smoothly learn from market developments.

Even if our modelling framework offers some improvements with respect to traditional models used to assess farm policies, some additional efforts are needed to address the impacts of some modelling assumptions. In particular we neglect in our dynamic framework the various sources of risks present in farm markets as well the risk aversion of farmers. It is however not clear whether this will challenge our main conclusion. Adding risks and/or uncertainty may further raise the economic optimality of gradual policy reforms so that agents are able to discern the effects of reform from the expression of risky events (Calvo Pardo, 2009).

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Table 1. Arable crop own price supply elasticities

a. With standard substitution elasticities

	Wheat	Other Cereals	Oilseeds
EU	2.868	2.819	2.417
US	0.939	1.259	1.004
RoW	2.330	2.235	1.380

b. With revised substitution elasticities

	Wheat	Other Cereals	Oilseeds
EU	0.677	0.663	0.592
US	0.275	0.340	0.290
RoW	0.664	0.627	0.423

Table 2. Steady state impacts of a brutal CAP reform on agricultural markets when perfect expectations are assumed (percentage changes with respect to the baseline)

	EU				*US*				*RoW*			
	Wheat	***Other Cereals***	***Oilseeds***	***Cattle***	***Wheat***	***Other Cereals***	***Oilseeds***	***Cattle***	***Wheat***	***Other Cereals***	***Oilseeds***	***Cattle***
Production	-16.5	-12.4	-6.3	0.3	2.5	0.7	0.4	-0.1	1.8	1.0	0.4	-0.1
Producer price	7.1	8.5	4.5	-0.8	1.3	0.5	0.5	0.2	0.6	0.4	0.3	0.1
Exports	-33.5	-31.1	-13.3	1.6	4.4	2.8	0.8	-0.7	9.9	8.9	2.5	-0.8
Land return	-83.0	-80.3	-70.5	-24.4	7.1	3.3	2.6	1.1	4.0	2.4	1.3	0.2
Land use	-22.2	-19.2	-10.6	13.6	1.9	0.4	0.2	-0.4	1.4	0.8	0.3	0.0
Capital stock	-15.9	-11.7	-5.9	2.3	2.6	0.8	0.4	-0.5	1.8	1.1	0.5	-0.2

Figure 1. Evolution of the European wheat price following the CAP reform (percentage change compared to the baseline)

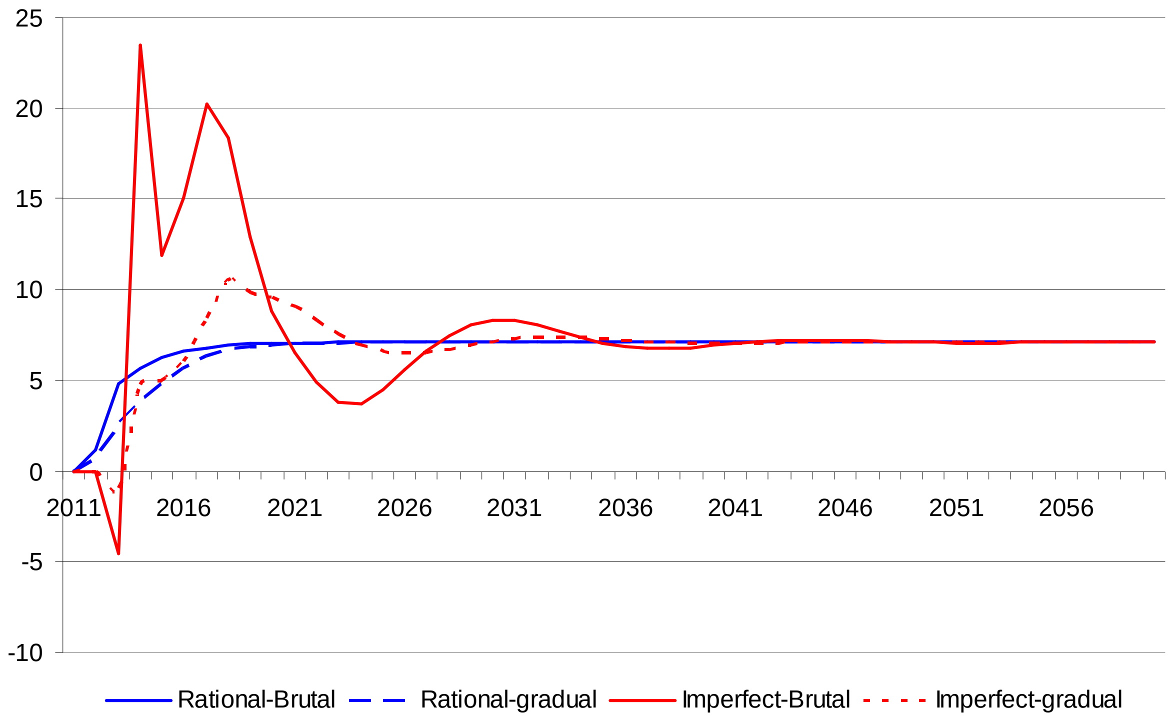


Figure 2. Evolution of the European wheat production following the CAP reform (percentage change compared to the baseline)

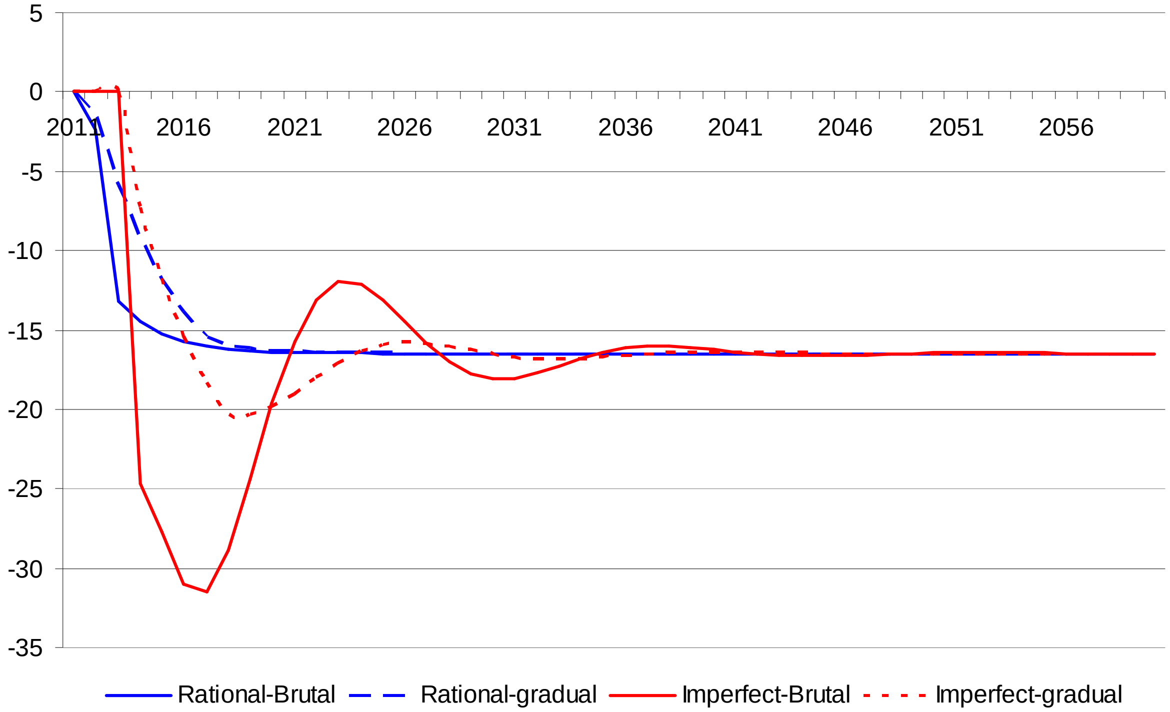


Figure 3. Evolution of the Equivalent Variation of income in the EU following the CAP reform (millions US dollars)

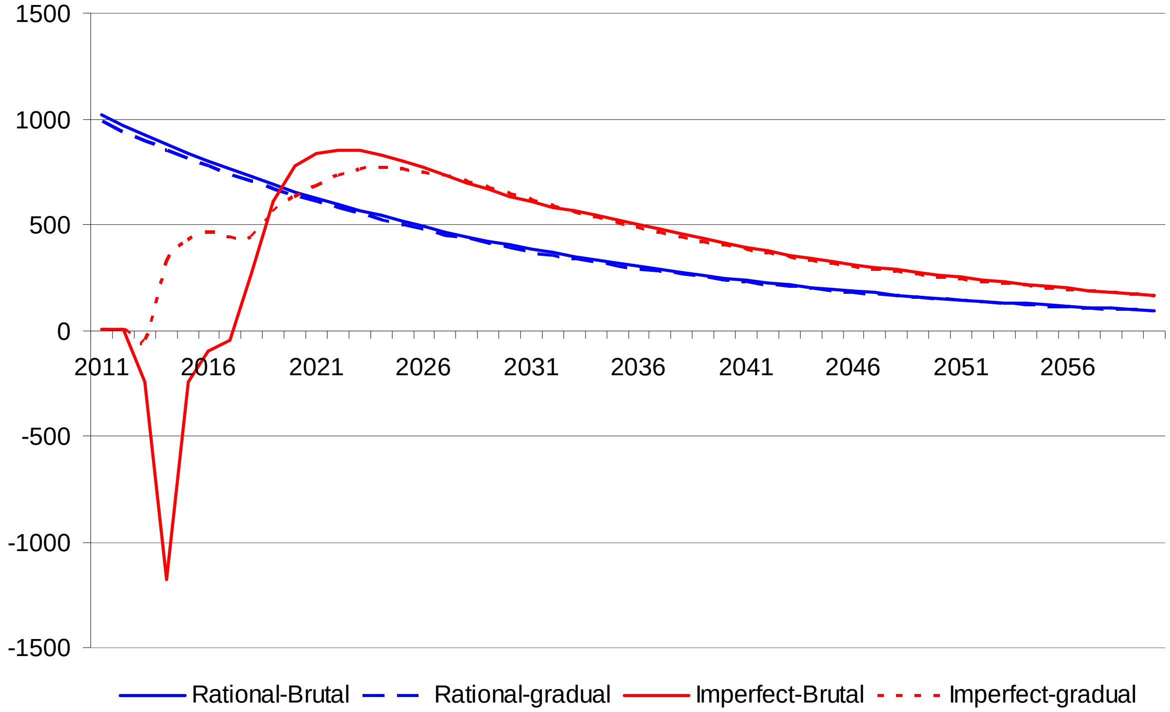


Figure 4. Sensitivity of EU welfare effects following a brutal CAP reform to the expectation scheme (million dollars)

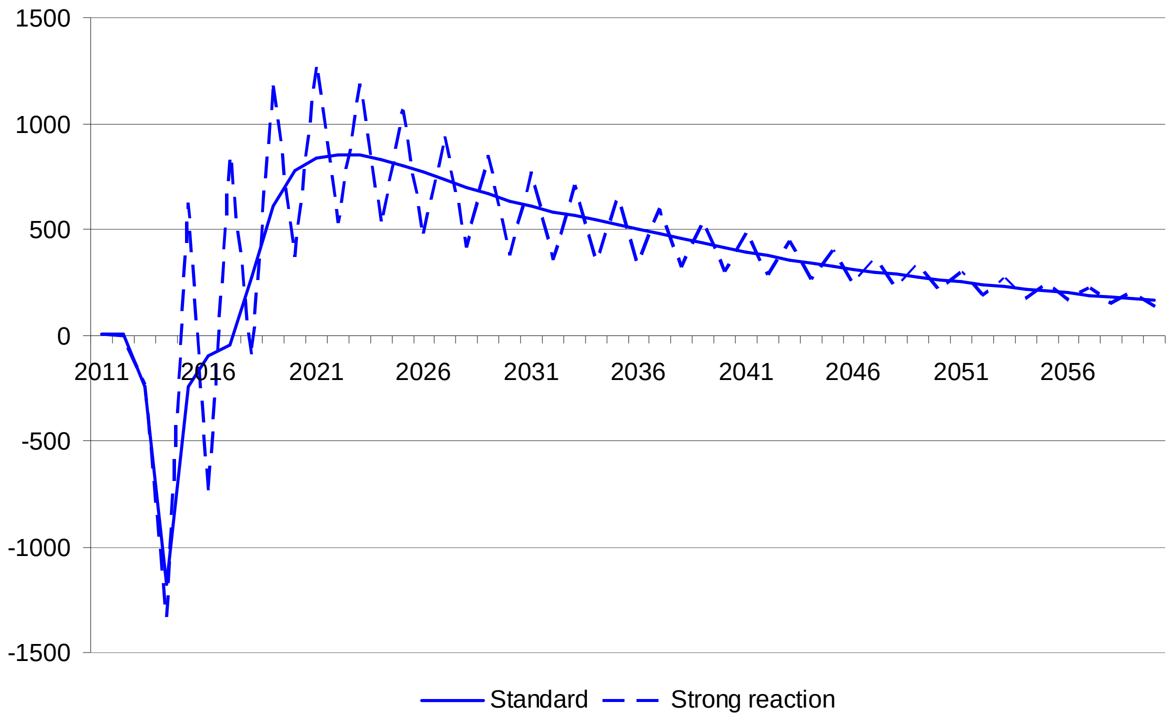
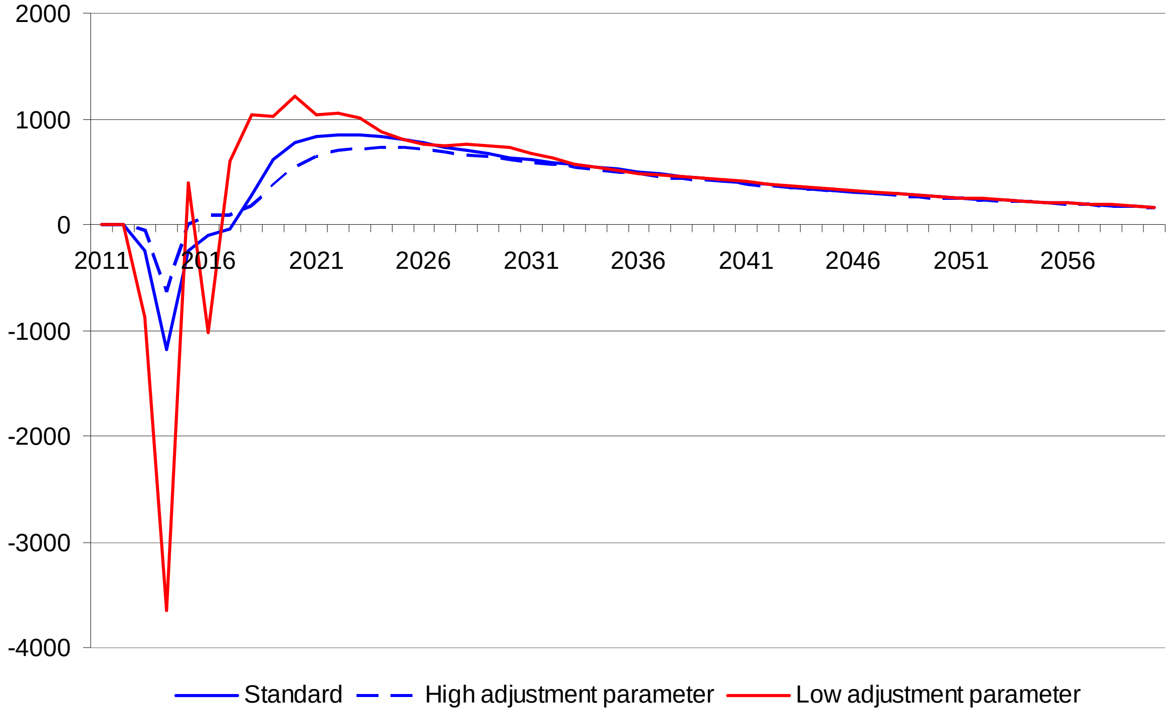


Figure 5. Sensitivity of EU welfare effects following a brutal CAP reform to the adjustment cost (million dollars)



Appendix. Computing dynamic welfare effects with perfect expectations

In static CGE models welfare effects of a policy reform are usually measured by the Equivalent Variations (EV). This indicator corresponds to the additional amount of income a household would be willing to pay to reach the post reform level of utility, at pre reform prices. Formally, it is given by:

$$EV = E\left(P^0, U^1\right) - E\left(P^0, U^0\right),$$

with $E(.)$ the household's consumption expenditure function, P^0 the pre reform prices and U^0 and U^1 the respectively pre and post utility levels.

In current existing dynamic CGE models, the equivalent variation is often computed globally, as in Diao and Somwaru (2000) for instance, in which the global welfare effect ζ corresponds to the share of additional pre reform consumption necessary to reach the post reform utility level[5]:

$$\sum_t \left(\frac{1}{1+\rho}\right)^t U\left(q^0\left(1+\zeta\right)\right) = \sum_t \left(\frac{1}{1+\rho}\right)^t U\left(q_t^1\right)$$

However this computation does not reveal the transition path in terms of welfare effects. One could be tempted to assume that the overall EV is equal to the discounted sum of the period specific equivalent variations:

$$EV = \sum_t \frac{1}{\left(1+r\right)^t} ev_t \text{ , with } ev_t = \left(e\left(p_t^0, u_t^1\right) - e\left(p_t^0, u_t^0\right)\right).$$

This formulation, for instance used in the Linkage model (van der Mensbrugghe, 2005), gives one path of welfare effects. However the discounted sum of within period equivalent variations does not necessarily equal the overall equivalent variation. Indeed, Keen (1990) demonstrates that:

$$E\left(P^0, U^1\right) = \sum_t e^t\left(p^0{}_t, H^t\left(p^0{}_t, E_U\left(P^0, U^1\right)\right)\right)$$

with $H^t\left(p_t, E_U\left(P, U\right)\right)$ the optimal part of U allocated to period t, when the prices in period t are equal to p_t and the overall price of utility is equal to $E_U\left(P, U\right)$.

5 Here we assume that the economy to be in steady state before the shock, $q_t^0 = q^0, \forall t$.

Let $u^{1b}{}_{t}$ denotes the part of U^1 allocated to period t when prices are equal to their pre-shock levels. It is defined by:

$$u^{1b}{}_{t} = H^t\left(p^0{}_t, E_U\left(P^0, U^1\right)\right) \neq H^t\left(p^1{}_t, E_U\left(P^1, U^1\right)\right) = u^1{}_t$$

As a matter of fact:

$$EV = E\left(P^0, U^1\right) - E\left(P^0, U^0\right) = \sum_t \frac{1}{(1+r)^t}\left(e^t\left(p^0{}_t, u^{1b}{}_t\right) - e^t\left(p^0{}_t, u^0{}_t\right)\right)$$

$$EV = \sum_t \frac{1}{(1+r)^t}\left(e^t\left(p^0{}_t, u^{1b}{}_t\right) - e^t\left(p^0{}_t, u^1{}_t\right) + e^t\left(p^0{}_t, u^1{}_t\right) - e^t\left(p^0{}_t, u^0{}_t\right)\right)$$

$$EV = \sum_t \frac{1}{(1+r)^t} ev_t + \sum_t \frac{1}{(1+r)^t}\pi_t \neq \sum_t \frac{1}{(1+r)^t} ev_t$$

Here π_t denotes the inter-temporal equivalent variations and represents the price the household is willing to pay to re allocate their utility across periods. Both inter temporal (π_t) and intra temporal (ev_t) equivalent variations thus have to be taken into account to study the path of welfare gains or losses along with time. So, in order to get the transition path of welfare effects, we rely on Keen's work to find an expression of the ev_t and π_t in our model.

More precisely we need to compute $e^t\left(p^0{}_{rt}, u^1{}_{rt}\right)$ and $e^t\left(p^0{}_{rt}, u^{1b}{}_{rt}\right)$ to be able to compute ev_t and π_t. $e^t\left(p^0{}_{rt}, u^1{}_{rt}\right)$ represents the minimum amount a household would be willing to pay to reach the utility $u^1{}_{rt}$ at price $p^0{}_{rt}$ in period t. This expenditure is computed with simulated post reform consumption values and the parameters of the intra temporal Stone Geary utility functions.

Regarding $e^t\left(p^0{}_{rt}, u^{1b}{}_{rt}\right)$, $u^{1b}{}_{rt}$ is the optimal part of U^1 allocated to period t at price $p^0{}_{rt}$. This is the solution of the following optimisation program:

$$\min \quad U_r = \sum_{t=1}^{\infty} \frac{1}{(1+r)^t} e_{r,t}\left(p^0_{r,t}, u^{1b}_{r,t}\right)$$

$$s.t. \quad U^1_r = \sum_{t=1}^{\infty} \frac{1}{(1+\rho)^t} \log\left(u^{1b}_{r,t}\right)$$

Because pre reform prices are constant (steady state conditions), we obtain:

$$u_{r,t}^{1b} = e^{\frac{U_r^1}{\sum_{s=1}^{\infty}\frac{1}{(1+\rho)^s}}}$$