Endogenous risk and long run effects of liberalisation in a global analysis framework

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Abstract

In a classical Walrassian framework of smoothly functioning markets and comparative static analysis, the beneficial effects of trade liberalisation are well known. In the real world, production decisions develop along time. They are fringed with uncertainty, and subject to unfulfilled expectations. Depending upon demand elasticity, such phenomena lead to converging or diverging cobwebs. Yet, even if demand is inelastic, diverging cobwebs are rarely observed, because there exist also many return strings which call systems back in the vicinity of (unstable) equilibrium. Among the latter, as already noticed by Knut Wicksell in the 1930's, attitudes toward risk and investment functions play a large role. In effect, introducing such mechanisms into a dynamic market equilibrium leads to "chaotic motion", a now well documented mathematical being, with very specific characteristics.

In this context, market price fluctuations no longer occur because of the "hand of God", from completely external sources, such as climatic events. They are endogenous, generated by the market itself. While external risk is subject to the "law of large number", thus allowing for the benefit of risk pooling through insurance mechanisms, endogenous is not. In particular, any effort to lower individual decision maker exposition to risk affects the values of the key model parameters, such as supply elasticity, thus changing the risk regime itself. Now, while many studies (especially by Hertel et al) have been undertaken in order to elicit the consequences of external risk for the magnitude and distribution of the trade liberalisation benefits, the endogenous risk case has generally been benignly ignored by the world research community. The present paper aims at filling this gap.

To this end, a GTAP model along that line is developed, with and without agricultural liberalisation. It is shown that, after a while, the tendency to divergence is smoothed out by risk considerations. Yet, because of a greater price uncertainty, over 60 years, long run world growth is significantly affected by liberalisation. Increased price volatility plays the role of a negative technical progress, which offset the benefits from a more efficient use of comparative advantage. Distributional effects are discussed, both between regions and within. Results suggest that liberalisation is not likely to reduce poverty, quite the contrary, because rich are less risk averse than poor, and thus, can accumulate more reinsvestible benefits. However, richest nations do not benefit in the whole, because of the investment slowing down mechanism outlined above.

Efforts have been done to test the model, taking opportunity of its dynamic character, which allows for the comparison between "predicted" and "actual" series. Although results in this respect can still be very much improved, price regimes from this model are compared with a few actual long run observed series, and found to be similar. The paper briefly discuss the difficulty of such comparisons, which, because of the "sensitivity to initial condition", cannot be reduced to the simple point per point measurement of the discrepancy between "predicted" and "observed". Series must be characterized by global indices, such as moments or Fourrier spectrums.

Most of these results very much contradict common wisdom. This is why they are interesting. More research is thus needed to specify the deep sources of this outcome and their political significance.

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Introduction : From the Walrassian to the Wicksellian framework

Although enormous recent progresses have been made in data collection and computing, from an analytical point of view, the general equilibrium models presently in use are conceptually and economically still very similar to the original concept developed by Léon Walras more than one century ago (Walras, 1874). Yet, just as economic theory as a whole, they do have much larger potential than the strict Walrassian framework, so genial and in advance on his time as it might have been.

A white stone in post Walrassian analysis is certainly the works by Knut Wicksell (1898) (see Blanchard, 2001) who introduced the idea of cumulative processes and disequilibria, stressing the importance of expectations, and opening the way for the Keynesian analysis. Can Wicksell's ideas in these matter be introduced into a CGE model, just as was the case with Walras's ? The present paper is an attempt in that direction.

In effect, the three key points in Wicksell analysis are that :

a) A small departure from equilibrium may trigger a "cumulative process", by which the system move continuously away from "optimum", either shrinking or expanding indefinitely (in value if not in "real" terms).
b) There are nevertheless limits to this process, because a too large discrepancy between expectation and reality is not sustainable. Although he suggested several mechanisms by which these limits can materialize, one particularly interesting is the fact that banks might be "afraid" of loans expanding continuously.
c) Adjustments occur through "unfulfilled expectations" and "involuntary" savings in stocks, with the famous distinction operated between the *ex ante* and the *ex post* equilibriums.

Nowadays, the above considerations are the basic ingredients of dynamic chaotic models. We shall thus first recall the theory regarding such models, presently at the exact opposite of the general equilibrium analysis mainstream. We shall then show why may such theory be nevertheless relevant, especially when agricultural trade liberalisation is under examination. We shall present the results of an empirical model built along that line. And we shall end with practical policy implications of such an approach, as well as with questions regarding the validity of alternative models.

I - The theory of chaotic markets

A) The essence of chaotic motion

From a mathematical point of view, a chaotic motion is just a specific kind of solution for a dynamic differential equation. Everybody knows that a differential equation $f(\ddot{x},\dot{x},x,t)=0$, (where $\ddot{x}$ and $\dot{x}$ stand for the second and first derivative of x(t) with respect to time t) may have "exploding" solutions (that is, x(t) growths indefinitely with time), or solutions converging to a limit, or "periodic" solutions, $x= f[\sin(2\pi\omega t)]$, implying that x(t) comes out to be equal to itself at regular intervals. Yet, these patterns do not exhaust possibilities. There is also a possibility that x(t) is never periodic, while not growing to infinity, nor reaching a limit. This situation is called a "chaotic solution" to the dynamic equation. In general, it is not possible to express a chaotic motion algebraically which does not means that it does not exist[4].

What is perhaps more counterintuitive is that the same dynamic equation may lead to different regimes, depending upon the value of specific parameters (references ?). Thus, the mere specification of a theoretical model is not sufficient to warrant a qualitative solution: an order of magnitude must be specified for the parameters. Even so, in the parameter space, the domain for which solutions are chaotic may not be a standard "volume" clearly delimited by lines or planes or hyper planes the equations of which could be sought for. Most of the time, such domains are "fractals", that are complicated geometric figures. For these reasons, chaotic motion rarely can be the subject of purely analytical treatment. Practical modelling and experiences are necessary.

Yet, there are constancies in potentially chaogenic situations. An essential condition for chaos is that at least one equilibrium point be instable (or "repelling", or "a well"). Otherwise, if the equilibrium is an attractor, of course, trajectories have a tendency to converge toward that point (it is then "attracting", or "a sink") . But a repelling equilibrium point is not sufficient to generate a chaotic dynamics. Another condition is that when they are far away, trajectories are attracted back toward equilibrium. Otherwise, if any point of the phase space is repelling, trajectories move away to infinity. If these two conditions (locally unstable equilibrium point *and* a "return spring" moving back toward it) are fulfilled, one of the natural outcomes is a periodic motion, as with a frictionless pendulum, but chaos can occur as well.

B) How can chaos occur in markets.

Can such situations occur in markets ? The basic reference on this issue is certainly Ezekiel (1938) , with it famous "cobweb theorem". It shows that with "naïve expectations", a market equilibrium point may be repelling, if demand is rigid.

Indeed, with naïve expectations, assuming linear supply and demand curves (or "linearized") p_t and q_t standing for time t quantity and price, and t being discrete, then :

(1) $$p_t = \frac{\alpha}{a} p_{t-1} + \frac{a\beta - b}{a}$$

with (α,β) being the demand curve slope and intercept, and (a,b), the supply curve slope and intercept. If $\left|\frac{\alpha}{a}\right| \geq 1$, then there is no limit for p_t which growths to infinity (by alternate values, since α is normally negative) as time passes.

Yet, the cobweb model is clearly insufficient, since nobody never saw any price growing to infinity (especially minus infinity). Thus something must be calling back the system toward equilibrium when it comes to stay too far away. Many such devices can be imagined, but the simplest is probably provided by risk considerations, as already noticed by Wicksell when he was seeking exactly the same kind of mechanism to prevent that business cycle reach infinity. Boussard (1996) suggested to introduce risk considerations into the cobweb model. Let us suppose that producers maximize the profit certainty equivalent (in Von Neuman sense) , given expected price $\hat{p}_t$, expected price variance $\hat{\sigma}_t^2$ and a,b,α,β as above. Then, A

[4] After all, it is not possible to express e^x or Log(x) algebraically, which does not prevent these functions to be familiar to economists.

being the producer absolute risk aversion, the expected price assumed constant $\widetilde{p}$, and the variance expectation being "naïve", thus $\hat{\sigma}_t^2=(\hat{p}_{t-1}-p_{t-1})^2$. On the other hand, let us assume that the supply curve is identical to marginal cost, the producer optimality condition is :

(2) $$\hat{p}_t-\hat{\sigma}_t^e q_t=aq_t+b$$

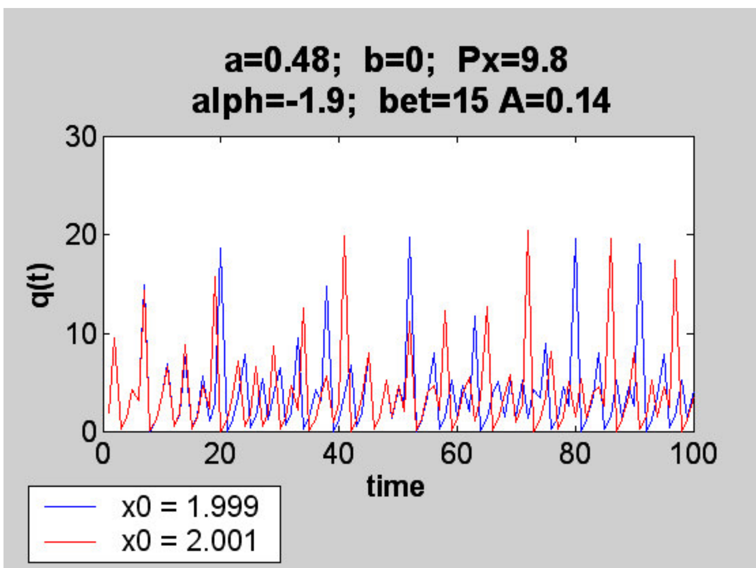
Introducing these changes into the traditional cobweb model, one get the following expression for $q_t = f(q_{t-1})$:

(1bis) $$q_t=\frac{\widetilde{p}-b}{a+A(\widetilde{p}-\alpha q_{t-1}-\beta)^2}$$

This is a very intricate formula, despite the model simplicity . Now, for some parameter values, it produces even more complicated outcomes, as plotted on figure 1 .

Figure 1 : Constant mean expectation risky cobweb

There is nothing random in this graph... The red and blue curves are with the same parameters, and start at about the same point. They part one from each other, just as two exponential do.



Other "return springs" can be imagined. Especially, the capital stock, which acts as a memory in any economic system, can be involved in such mechanisms. As far as capital is underemployed, the supply curve may be elastic. It becomes extremely rigid as soon the capital stock is fully employed, if new machines cannot be purchased at once. Again, this kind of situation is likely to drive back markets toward equilibrium, even if the latter are instable.

Thus, as soon as:

i - expectations may not be exactly fulfilled, and,

ii the equilibrium point is instable in the sense defined above, a market may not necessarily converge. Instead, it may rock up and down, both in quantity and in price. Because such dynamic is sensitive to initial conditions, it is then unpredictable, even if not submitted to any random contingency (but for the initial conditions).

C) Widening the scope : risk into general equilibrium models

What has just been said, with one product, one producer and one consumer, is probably even more relevant for real world markets, with many commodities and multiple equilibriums. Especially, in the multidimensional case, two specially preoccupying problems arise.

a) In a multidimensional system, an equilibrium point may not be instable in all directions. Most of the time, it stands as a "saddle point", with one (or more) direction(s) looking like an attracting sink, and one (or more) other direction(s) like a well. However, in such a case, as soon as the trajectory of the whole system comes close to the equilibrium, it is pushed away in the repelling direction. Thus, even if a subsystem may look stable, the simple consideration of the unstable portion of the whole may make necessary reconsidering this conclusion[5] In practice, a genuinely stable market, for instance a luxury good, with a large demand elasticity, may very well be "polluted" by a food commodity market, the instability of which derives from the corresponding demand inelasticity.

b) As far as two such chaotic systems are isolated one from each other, they may look "complementary", in the sense that a peak in one of them may correspond to a hollow in the other. In such a case, it is very tempting to stabilise markets by merging the two in one. Actually, this reasoning is the core of a very strong argument for trade, without comparative advantages (Bale and Lutz, 1979). It would be perfectly valid if the source of instability were to be found into completely exogenous circumstances, such as climatic events. But this is not true anymore here, with the endogenous instability under discussion. On the contrary, there may be a very perverse effect of merging two previously isolated chaotic markets: instead of fluctuating independently one of each other, they may then fluctuate "in phase", just as two radio sets correctly tuned.

The question which arises at this point is then: all that is purely theoretical. What about real markets ? This is the question we tried to look at, by building up a model which presents most of the characteristics of a Computable General Equilibrium (CGE) model, except that, instead of assuming equilibrium is reached every time without problems, we systematically allow for situations with a lag between the decisions to produce and the decision to consume, in the spirit of the cobweb model. Yet, unlike the cobweb model, we also systematically provide a set of reasonable "return springs", in the spirit described above, thus ensuring that the system, instead of moving away *at infinitum*, will be kept within a "pipe". As we will se, risk play an important role in defining this "pipe".

[5] A very famous anecdote in this respect is the « three body problem » partially solved by Poincaré at the end of the 19th century: Considering a system in R^2 with one sun, one planet and one asteroid, he concluded to stability and regular elliptic orbits. In R^3, there is the possibility of an unstable situation, with the asteroid rocking between incomplete orbits around the planet and around the sun. Eventually, such situations were actually observed.

II - A general disequilibrium model

A)- Time and risk in CGE's

The notion of equilibrium is essentially static: early CGE's were considered as a picture of a long run permanent situation, "after all adjustments have been made". Yet, the existence of capital makes this situation unrealistic: if savings exist, it must increase capital stock. Thus, very quickly, most GGE's were given a time dimension. Two possibilities exist in this respect:

i- One is to translate the standard multiperiod theoretical Arrow-Debreu model into a computable model, just adding a time subscript to all prices and quantities, as done by such authors as Devaradjan (1995). A main advantage of this approach is that savings is then perfectly consistent with the neoclassical theory of savings, even in presence of risk(which, in this case, may become one of the determinant of the dicount rate[6]). Conceptually, it is not very difficult. Practically, even with the most powerful computers, this is a hard task.

ii- Another possibility is to set up a "recursive model", that is a model which is solved for equilibrium each "year", the "year t stock of capital" being related with "year t-1" through savings and depreciation. A difficulty here is with the fact that savings may not be "optimal", although that a vague reference to a strange mix of Keynes and Friedman allows most authors to define it as a constant fraction of income. Even so, a difficulty still exists, because each year, the new capital must be allocated to one or another sector. The question then arise of the nature of capital, "putty-putty", "clay-clay", and so on…. Most of the time, CGE's authors assume that old capital is specific for each sector of the economy (thus, a combine harvester cannot be used to produce electricity) while new capital is allocated between sectors thanks to a profit driven investment function.

The recursive approach is often viewed as a proxy for the "better, but more difficult" multiperiod approach[7]. Yet, it might have its own justification, precisely if risk and imperfect foresight are considered.

In effect, the risk considerations present in the theoretical approaches quoted above is quite different from what we had in mind in the first section of this paper. The neoclassical risk is exogenous. It originates in "the hand of God". No links exist between agents behaviour and the risk mangnitude. It does not mean that agents cannot choose their risk exposition levels – on the contrary, most of the models intricacies are consequences of the ways such choices are made. But these behavioural assumptions have no consequences upon the risk generation mechanism itself.

On the contrary, the risk described above is the consequence, not of exogenous shocks, but of expectations errors. Nothing, in the model, is random. Risk and instability are purely endogenous, and produced by the market itself, under some circumstances depending on the parameters values. Thus, errors must be present, which contradicts the "rational expectation hypothesis". We shall see that leaving the rational expectation hypothesis out, rather than an

[6] Of course, the number of writers on this point is much too large for that we can quote any of them. Yet, let us mention Hertzler (1997), as one outstanding recent contribution on this intricate question of the relation between discount and interest rates and risk aversion, as well as the basic references, the two papers, one by Grandmond and one by Radner *in* Hildenbrand and Sonnenschein(1991). .

[7] This point was central in Day's analysis of farmers decision making. It led him to become a pioneer in chaotic dynamic studies. See Day(1963, 1982)

departure from, might be a progress toward realism. In this context, a recursive scheme, normally subject to errors, is just a logical consequence of a realistic approach of the world.

But if we consider the "recursive logic" at least as a promising approach, we should not restrict it to the only problem of capital. In particular, one of the specificity of CGE's model should then be questioned: the simultaneity between supply and demand decision. In effect, in a "standard" CGE, at any point of time, given factors, producers and consumers plans are driven by equilibrium price. This is a consequence of the "rational expectation" assumption[8]. But of course, such an assumption is highly discussible. If we admit the possibility of expectation errors in capital decisions, then why should we not assume that they matter also in some producers behaviour, especially when a significant delay exists between the decision to produce and the decision to sell..

This, of course, implies a dramatic reappraisal of the basic philosophy of CGE models. It will not be easily accepted by everybody. Yet, this approach stay along the general development line of these tools toward more realistic models. In this new framework, simultaneous equations will not serve in computing a full equilibrium between production and consumption, but only between consumption and supply. The supply itself will be generated on the basis of expected, instead of equilibrium prices– exactly as it does in the one commodity cobweb model. Of course, with the possibility of erroneous expectation, introducing risk is quite natural, even in the absence of exogenous shocks (which does not mean the latter do not exist). This is the essence of the Knut Wicksell message, a message which was seized up by Keynes later on, and unjustly forgotten since[9].

B) Practical implementation : equilibrium equations

The practical implementation of the principles set out above is not difficult, and does not require any more data nor computational skill than standard CGE model.

In effect, reduced to skeleton, a standard recursive[10] CGE can be described with the following equations:

(1) $$F_j(\ldots x_{ijt}..) = \sum_h z_{hjt} + \sum_{i\in I,J} x_{jit} + \sum_h v_{hjt}, \qquad j\in J \qquad \text{(supply equates demand)}$$

(2) $$\phi_{jt} = p_{jt} F_j(\ldots x_{ij}..) - \sum_{i\in J} p_{it} x_{ijt} - \sum_{i\in I} \pi_{it} x_{ijt}, \qquad j\in J; \quad \text{(producer's utility)}$$

(3) $$\sum_j x_{ijt} = \sum_h e_{hit} \qquad \forall i\in I \qquad \text{(factors availability)}$$

(4) $$u_{ht} = U(\ldots z_{hjt}.., s_{ht}), \qquad h\in H; \quad \text{(consumer's utility)}$$

(5) $$\sum_j p_{jt} z_{hjt} = \sum_{i\in I} e_{iht} \pi_{it} + s_{h,t} \qquad h\in H \qquad \text{(consumer's budget constraint)}$$

[8] Or rather, of a somewhat naïve version of the rational expectation assumption. Of course, nobody can deny the relevance of assuming decision makers are rational in processing the information available to them at a specific time. But assuming rationality does not imply information is perfectly relevant, and cannot generate errors or "surprise".

[9] At this point, that is why, one should therefore speak of disequilibrium rather on equilibrium models.

[10] "Recursive" here means that plans $x_{t\square}$ made at time t for time □ depend on observed past values x_{t-1}. However, $x_{t\square}$ may be eventually revised, in such a way that $x_{t+1,1}$ may be different from $x_{t,2}$. Thus, in this framework, a model may be both recursive and multiperiodic, although the planning horizon is only one in all applications below.

(6) $$\sum_h s_{ht} = \sum_h \sum_j p_{jt}\, v_{hjt} \qquad h \in H \quad \text{(value for savings)}$$

(7) $$e_{hit} = e_{hit-1}(1 - \delta_{hi}) + G(..v_{hjt}\dots) \qquad h \in H,\ i \in I \quad \text{(recurrence equation)}$$

With the sets I for factors , J for commodity, H for institution, t for time; F_j (.) a production function, U_{ht} (.) the utility function of consumer h, and G(.) the investment function which transforms inputs into factors – mainly capital, but manpower as well; z_{hjt} the final consumption of commodity j by consumer h; x_{ij} the quantity of commodity or factor i used as input for commodity j ; v_{kjt} the demand of commodity j by consumer k for investment , e_{hi} , the quantity of factor I belonging to institution h ; ϕ_{jt} , the profit of industry j ; s_{ht} the savings by institution h , δ_{hi} a depreciation rate; p_{jt} for commodity prices, π_{it} for factors prices.

The model is solved by writing the first-order conditions for producer's and consumer's optima, that are the derivatives with respect to x_{ijt} of equation (2) subject to (3), and the derivatives with respect to z_{hjt} and s_{ht} of equation (4) subject to (5). It is to be noticed that, here, the only intertemporal equation is (7), which, applied to capital, is the basic dynamical equation. Our Wicksellian ID^3 model is derived from these equations, with the following modifications:

a). A lag between production and consumption decisions:

First, a lag is introduced between the production and the consumption decisions. Equation (1) must be rewritten as:

(1bis) $$F_j(\dots x_{ijt-1}..) = \sum_h z_{hjt} + \sum_{i \in I,J} x_{jit-1} + \sum_h v_{hjt}, \qquad j \in J$$

Thus, the market equilibrium occurs by the confrontation of last year (given) production, and current consumption. But this means that production decisions must not be taken on the basis of equilibrium prices. Rather, expected prices $\hat{p}_{jt}$ must be used. Hence equation (2) is modified:

(2bis) $$\phi_{jt} = \hat{p}_{jt}\ F_j(\dots x_{ij}..) - \sum_{i \in J} p_{it}\, x_{ijt} - \sum_{i \in I} \pi_{it}\, x_{ijt} \qquad j \forall \in J\ ;$$

In addition, an expectation function $E_m(.)$ must be defined to determine $\hat{p}_{jt}$.

It is clear that different expectation schemes can (and should) be envisaged. In the runs presented in this paper, a Nerlovian adaptative expectations scheme with a 5% revision coefficient has been chosen[11]:

$$\hat{p}_{jt} = \hat{p}_{jt-1} + 0.05*(p_{jt-1} - \hat{p}_{jt-1})$$

Notice that actual equilibrium prices are used for inputs, so that expectations are important only for next year production. At the same time, since incomes are distributed immediately, incomes for year t depend heavily on expectations for year t+1, which implies that firms may suffer losses or profit gains. They hence bear risks : this is the last and most important aspect of the model. In fact, risk plays a key role in two different ways: in the producer's utility function (2bis), and in the recurrence equation (7).

b) A risk sensitive producer utility function

[11] In most of the previous model runs as well as in Boussard (1996), $\hat{p}_{jt} = \tilde{p}$, expectations were made constant

In the producer's utility function, following the remarks above, it was deemed relevant to introduce some sort of risk premium. Although there are a variety of possibilities in this respect, the simpler Markowitz utility function was opted for. Thus, (2ter) replaces (2bis):

$$\text{(2ter)} \qquad \phi_{jt} = \hat{p}_{jt}\ F_j(\dots x_{ij}..) - \sum_{i\in J} p_{it}\, x_{ijt} - \sum_{i\in I} \pi_{it}\, x_{ijt} - 2A_{jt}\, \hat{\sigma}^2_{jt}\, F^2_{jt}(\dots x_{ij}..)$$

where $\hat{\sigma}^2_{jt}$ is the expected variance of p_{jt}, and A_{jt} some risk aversion coefficient.

Of course, this implies an expectation function $E_v(.)$ is defined for variance. With naïve expectations, E_m,, it seems logical to take $\hat{\sigma}^2_{jt} = (\hat{p}_{jt-1} - p_{jt-1})^2$, although more complicated expectation schemes could be envisaged. The order of magnitude of A_{jt} (the absolute risk aversion coefficient) is important. It should be commensurable with 1/w, where w is the average wealth of the decision-maker. This remark opens the way for introducing wealth and wealth distribution (in addition to income) considerations into CGE's – and this not the least interest of this approach.

Of course, data regarding wealth are not common place. Those made use of used in our model have been the subject of rough guesses. The problem here is the calibration of the model, which should reproduce the SAM matrix at the starting point of the simulation. It has been done by adjusting coefficients in a "maximum likelihood " logic, although, of course, no formal use of any statistical instrument has been made.

c) Profits distributed as capital income

Finally, the last term of equation (2ter), $2A_{jt}\, \hat{\sigma}^2_{jt}\, F^2_{jt}(\dots x_{ij}..)$, is an expected profit. It should be distributed one way or another. We decided to distribute it just as the income from capital, on the (fragile[12]) ground that profit is the reward for taking risk, and that profit accrue in general to capital holders.

C) Practical implementation : recurrence equations

(2ter) is not the only equation for which risk matters. As far as growth and accumulation are concerned, equation (7) and the function $G(..v_{hjt}\dots)$ are of the utmost importance. In the first CGE version, function G was straightforward: changes in total labor force were driven by demography, while capital was easily shifted from one sector to another, so that it was "naturally" invested in the most productive places. Yet, such assumptions imply that a nuclear power plant can be used to harvest grain, or that a bus driver can be employed immediately as a teacher in mathematics. It not very realistic. Many models have been set up with sector-specific labor force and capital. The difficulty, in that case, is that neither capital nor labor are obviously stuck with any sector for ever. Some flexibility must be added.

In the present model, no special care has been taken for labor : it shifts freely within groups of sectors (agriculture, manufactures, etc..). In addition, the total labor force is driven by simple demographic considerations. By contrast, an original submodel has been developed for capital. The old capital is fixed by sector, just decaying at a constant rate. But the "new" capital owned by each institution is allocated between sectors according to a Markowitz (1970) mean/variance portfolio selection model. Let be :

[12] Without quoting the whole enormous literature pertaining to distribution theory and the sociology of labor, it is well known that workers may benefit from the profits of a successful firm, especially if the latter enjoys some monopoly power, and even if this kind of advantage is vanishing nowadays under the pressure of competition.

k_{jt} : capital of branch j, time t

S_t : total saving period t

$\hat{\pi}_{jt}$: expected profitability of capital in branch j

$\hat{V}(\pi_{jt})$: expected variance of π_{jt}

A_k : risk aversion parameter for investor k

Pk_{jt} : price of the capital good for branch j

$\hat{P}k_{jt}$: expected value of P_{kjt}

I_{jt} : capital good bought for branch j, time t

Then, I_{jt} is chosen by investors through the maximization of :

(8) $$\sum_j \hat{\pi}_{jt} Pk_{jt} I_{jt} - A_k \hat{V}(\pi_{jt}) I_{jt}^2$$

subject to :

(9) $$\sum_j Pk_{jt} I_{jt} \leq S_t$$

with a naïve expectation scheme :

(10) $$\hat{\pi}_{jt} = \pi_{jt-1}$$

(11) $$\hat{P}k_{jt} = Pk_{jt-1}$$

(12) $$\hat{V}(\pi_{jt}) = (\hat{\pi}_{jt-1} - \hat{\pi}_{jt-2})^2$$

In addition, since $\hat{P}k_{jt} \neq Pk_{jt}$, some saving may last or be created on time t. It is then credited to or subtracted from saving year t+1.

The capital available for each branch j is updated in the recursive loop over time:

(13) $kj_{t+1} = kj_t (1-\delta) + I_{jt}$

Although exchange rate variability has not been taken into account, such a model could be easily extended to cope with this important source of volatility.

d) Data and other settings

The Gtap data base (version 5) has been used to represent the world through 13 regions, 5 production factors and 17 sectors, including 8 for agricultural production and 4 for agri-business (see Table 1).

Two types of households are considered , splitting the population around the income median, and defining middle-low income and middle-high income group, in order to be able to include equity considerations when analyzing the results.

Production is described by embedded CES production functions. At the first level, aggregate added value and aggregate variable inputs are considered. These are disaggregated at the second level, where two other CES are used, one for the five production factor and another for inputs. Parameters are taken from the GTAP data base[13].

Demand is a linear expenditure system, estimated by using GTAP income elasticities as well as consumption and price levels.

[13] Detailed equations of the model can be found in Boussard et al. (2002).

Exchange rates are exogenous. Investment is determined by savings and foreign capital flows, calculated to balance the external trade. Government budget is balanced through public consumption adjustment. The two versions of the model are dynamic, using temporary equilibria. Because of uncertainty on agricultural prices, the expected profitability of agricultural activity, which determines resources allocation to the various agricultural activities, may differ from the real ones, calculated one year later. Therefore, at least one production factor has returns distributed with the same lag, so as to allow the adjustment between expected and real results. Capital returns are calculated ex-post, in order to allow this adjustment.

Armington assumption of imperfect substitutes of products from different countries holds. Parameters as well as transport costs are taken from the GTAP data base.

Table 1: GTAP database desegregation for ID3 model

Regions	Sectors	Production factors
European Union	Wheat	Unskilled labour
United States	Others grains	Skilled labour
Australia – New Zealand	Livestock	Land
PECO	Other animal production	Natural Resources
Mercosur	Milk	Capital
Others Latin American Countries	Oilseeds	
Developed Asia	Sugar	
Southeast Asia	Other Crops	
South Asia	Forestry	
China	Meat Processing	
Sub-Saharan Africa	Milk Processing	
Northern Africa – Middle East	Sugar Processing	
Rest of the World	Others Food Industries	
	Wood	
	Other Manufacturing	
	Energy	
	Services	

2.3. Agricultural Policies

A last original feature of the model concerns agricultural policies in the European Union and United States, especially market price support policies as there are those that should be dismantled with trade liberalization. In earlier version, the true policies had been replaced by Price Support Equivalent (PSE) from OECD, as it is commonly found in the literature. However, such simplification becomes hardly acceptable, once one assumes that imperfect information and risk matter in producers behaviour. Indeed, one of the main advantages of guaranteed price through public storage in Europe or intervention price in United States is that such policies erase price fluctuations and risk for agricultural producers concerned. As it has been shown above, risk and price fluctuations matter a lot in the supply functions in the imperfect information version, so that removing such policies can not only be considered as the removal of a simple producers subsidy.

For guaranteed prices in Europe, the equation for producer supply remains (2) where output price, p_{jt} is now the domestic market price, at least equal to the guaranteed price. In order to achieve this level for domestic market price be, the government storing the excess of supply. A stock, $stor_{jt}$ is thus added to Equation (1 bis) :

$$(1ter) \qquad F_j(\ldots x_{ijt-1}\ldots) = \sum_h z_{hjt} + \sum_{i\in I,J} x_{jit-1} + \sum_h v_{hjt} + store_{jt}, \qquad j\in J$$

and an equation is added to determine the stock level, considering pg_{jt}, the corresponding guaranteed price for j product :

$$(14) \qquad p_{jt} \geq pg_{jt}$$

We assumed here that public stock can be sold on the market one year later. The difference between the market price and the guaranteed price is a new expenditure in government budget.

For intervention policy in the United States, the scheme is different since such policy is more similar to a producer subsidy that does not affect domestic consumers, contrary to the European case. Thus (1 bis) stays the same, but equation (2) becomes, with $inter_{jt}$ the level of intervention :

$$(2quar) \qquad \phi_{jt} = (p_{jt} + inter_{jt})\ F_j(\ldots x_{ij}\ldots) - \sum_{i\in J} p_{it}\, x_{ijt} - \sum_{i\in I} \pi_{it}\, x_{ijt} \quad j \forall\in J\ ;$$

and another equation is also added to determine the intervention level, considering $pinterv_{jt}$, the intervention price set each year by the US government :

$$(15) \qquad p_{jt} + inter_j \geq pinterv_{jt}$$

Again, a new expenditure is thus added in US public budget to take account for this policy cost .

e) Sustainability and computing considerations

Solutions from this set of equations are time series of prices, quantities and incomes. In principle, the whole series of Social Account Matrices for each regions, together with a trade flow matrix should be produced over an unspecified length of time. In the case of a perfect neoclassical model (along the line developed by Devarajan and Go 1995), unless technology does not allow for growth, the only limit to the number of "years" to be considered is the size of computers memories. In effect, in this case, yearly solutions should converge toward either a Von Neumann "turnpike" growth path (if *all* factors are variable) or a limit solution (if some ultimate fixed factor – such as manpower or natural resources – does exist) .

As soon as expectations are not perfect, there is a possibility for the system being locked into a trap, without feasible solutions: for instance, under investment creates a situation where even capital renewal is not possible. This is true of most standard models, with perfect foresight for capital and productive resources allocations, but "inconsistent" savings. Yet, most of the time, such models do not result in total infeasibility, because savings affects only a small share of total demand, thus leaving room for adaptations. In the case of the present model, prices may be very much inconsistent, especially those of agricultural and, more generally, low demand elasticity products. Therefore, computational problems are to be expected. In effect, most of model runs stop after a few "years", because GAMS/PATH does not find any solution from the current starting point (and although a feasible solution may still exist). We nevertheless present here some of the "longer lasting" solution we could find – solutions which, for fortuitous reasons (mainly, apparently secondary parameters values), could be operated over 60 years. There are at least two reasons for that:

a) many years are necessary for that the effects of most of the above described mechanisms can be observable[14].

b) A statistical analysis of results – necessary for validation purpose – requires a "large" number of observations.

Thus, series presented here are only instrumental in validating the intuitions at the origin of the model, and checking essential mechanisms of market imperfection have been captured. Of course, they do not imply any idea of predicting the future for 60 years ahead.

III – Results, political consequences and validation

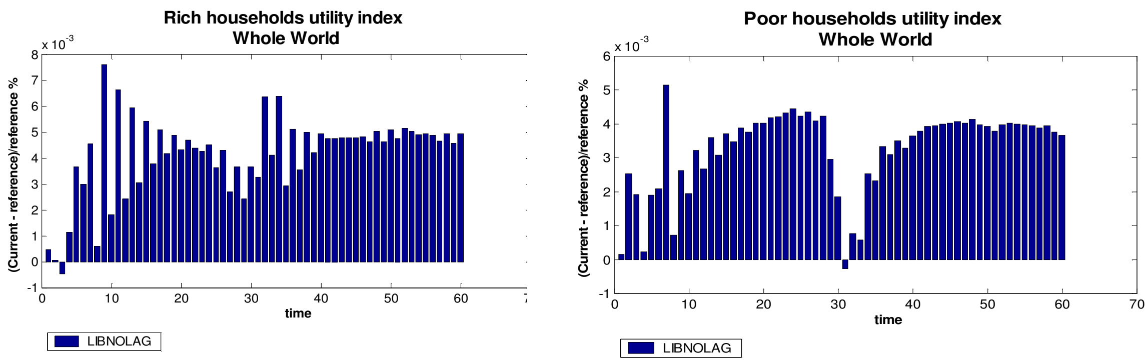
A) – Will trade liberalization increase welfare ?

The main result is that very strange conclusions can be derived from a model along that line. As for most of presently existing world CGE's models, the model outlined above has been used to assess the consequence of agricultural trade liberalization. While most existing models conclude that liberalization will increase global welfare by an amount which, although modest (a few percent) in terms percentage over existing welfare, represent nevertheless a very large number of billion dollars, the ID3 model presented here is much more cautious.

In effect, two versions of the model have been run: one is the standard general equilibrium model, with rational expectations and no risk. The second is the disequilibrium model described above. Data are the same, as well as the general setting (see Boussard, Gerard *et al*.,2001)

[14] For instance, in a standard model, EU and US subsidies to agricultural exports increase welfare in food importing countries, by providing urban poor with cheap food. Yet, this is short sighed a view: the major perverse effect of such subsidies are that, because agricultural prices are depressed in the importing countries, the latter are unable to develop any food producing industry by themselves, whatever their comparative advantage for such production. In that case, for the beneficial effect of removing subsidies to be apparent in the importing counties, it is necessary to wait until the beneficial effect of investment can be observed. Now, in the present framework, this will require that entrepreneurs be reasonably sure that the subsidy policy is removed for long, and that they can gather the necessary resources to significantly increase domestic food production: it may necessitate several years for these conditions to be fulfilled.

Figure 2
Standard model liberalization effects on rich and poor:
Difference between " liberalization" and "reference" , in % of reference

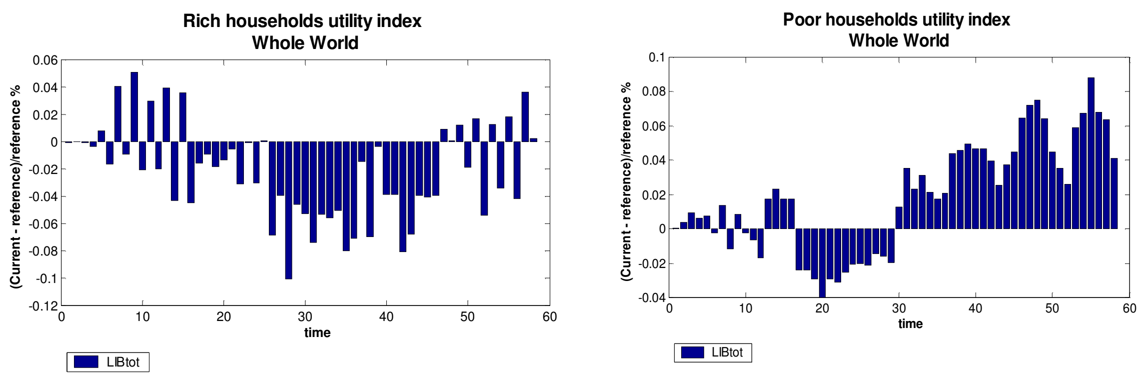


The standard equilibrium model produces the same results as many similar models presented in this or a preceding conference (figure 2) : liberalization[15] increases the growth rate, and is globally beneficial. For various reasons, benefits[16] accrue to the poor as well as to the rich: Because food imports are now deprived of subsidies, urban poor – especially in food importing developing countries – are harmed by a rise in food prices. But rises in agricultural prices benefits rural poor. In the whole, the increase of efficiency, and the exploitation of comparative advantage benefits every body, at least at the beginning of the process.

As time progresses, benefit gradually vanish, and virtually disappear after about 30 years. This is surprising: a purely rational growth model should display a certain "sensitivity to initial conditions", precluding the possibility of two trajectories merging together after having been remote for a while. This is because even with "rational expectations" this model is not "pure growth": expectations (and risk, as seen above) play a role in deciding savings allocation to capital growth. As a consequence, mistaken investments can occur, leading the growth path toward a quasi chaotic trajectory. Yet, the consequences of such errors are small, because the better efficiency of the whole system allows for recovery. Thus, after the "thirty year crisis", liberalization benefits come back again.

[15] Here, "liberalization" means removing all export and import taxes and subsidies, as defined in the GTAP database.
[16] These effects are measured in terms of "utility" – that is, in practice, with a linear expenditure system, as the amount of expenses in excess of the minimum level . Utility is assumed to be additive across households – obviously, somewhat heroic an assumption. Unfortunately, very few easily computed welfare indexes are available. This one is frequently made use of in the literature. It is fully consistent with the very logic of models, as soon as the LES consumption function is assumed ruling consumption decisions. If certainly not the best, it is at least not the worse.

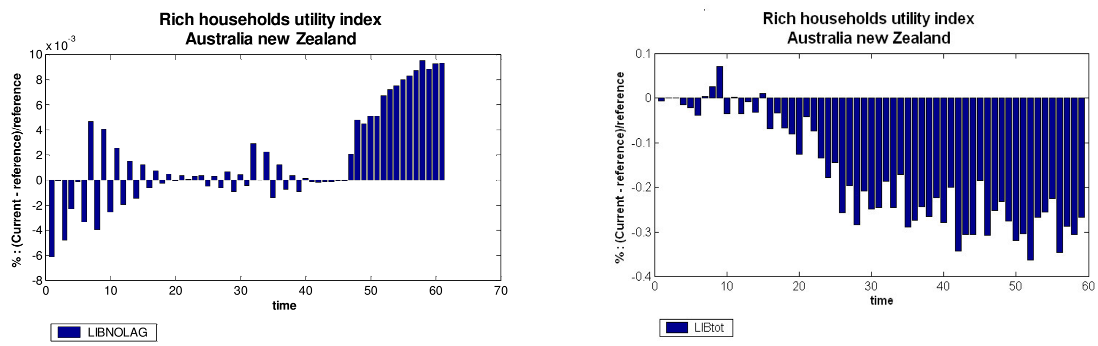
Figure 3
Recursive model liberalization effects on rich and poor
Difference between " liberalization" and "reference" , in % of reference



In the case of the ID3 "recursive model" (figure 3), similar phenomena do occur. For that reason, liberalization is far from being completely negative, and may produce a few benefits. Yet, the latter are even smaller than with the standard model. Worse, in some occasions, benefits are frankly negative, and such situations can last for long. In the whole, within this framework, liberalization seems more beneficial for the poor than for the rich, although only after a very long time. On the other hand, losses materialize earlier to the poor, while the rich may benefit a little at least for some years at the beginning.

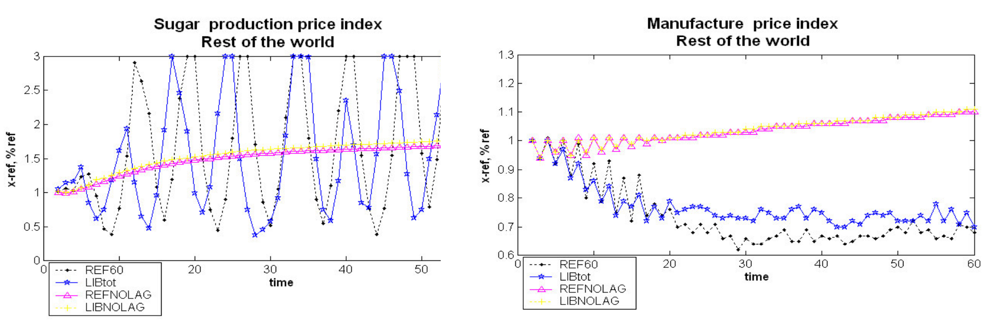
The world level summation masks discrepancies between regions and countries. It is striking to look at the different conclusions to be derived from the model for the same region, with or without perfect forecasts. Figure 4 illustrates this statement in the case of Australia/new Zealand : on the ground of a cursory inspection of the left part of figure 4, a naïve analyst would have concluded that liberalisation, in these countries, will, at the beginning, be rather detrimental to rich people, and slightly beneficial after a very long time. But if the right side of the same drawing shows the same kind of "starting" scenario – effects are even stronger, because the scale is not the same on the two graphs, (observe the maximum y scale is 0.1% on the left side graph, which is divided by 1E-3, and amount to 10% on the right side graph) followed after a few years by a very strong decrease of utility, up to –30%. Similar figures can be found in abundance in the whole set of graphs derived from this study.

Figure 4 : Autralia-New Zealand
Evaluation of rich households utility index, according to type of model
Standard model ID3 model



The reasons for these surprising results are of course those developed above: because markets do not operate properly, especially in the case of rigid demand function, they transmit scrambled information to producers. As a consequence, the latter take decisions which are finally even worse than those – certainly not optimal – derived from government interventions and more or less inefficient agricultural policies. Figures 5 illustrate this statement.

Figure 5
Prices of sugar and manufactures with four scenarios
LIBNOLAG and LIBtot are liberalisation with and without perfect information.
REFnolag and REF60 are corresponding reference runs
Sugar **Manufactures**



We see from Figure 5 (relative to "sugar" and "manufactures" in the "rest of the world', but similar graphs could have been drawn for almost all countries and commodities) that prices are much more volatile in the ID3 model results than with the corresponding standard simulations. Again scales are not the same in both graphs: on the right panel, price indexes vary from 0. to 3 – which is rather realistic for the free sugar market- , while they vary from 0.8 to 1.3 only in the case of "manufactures". It reflects the much larger price demand elasticity in the case of manufactures as compared with sugar. Yet, sugar (and other agricultural commodities) volatility is somehow contagious, since, otherwise, given a large demand elasticity, manufacture prices should converge toward equilibrium in the ID3 as they do in the standard model.

B) Is this credible ?

At this stage, the question which arises is that of the credibility of the analysis underlying the ID3 model. Is this model telling a fairy tale, or something looking like reality ? It is difficult to answer. However, some clues can be found in the statistical properties of the series – especially price series – derived from both models.

Early econometricians used to check models by computing some sort of distance – often, the sum of squared differences - between "actual" and "predicted" series. It would not work here, for many reasons: first, we do not have many observations of situations "with" and "without" such or such policy – whatever "liberal" or not. Second, if we admit the idea that price series are either random walk or chaotic motion, they are subject to "sensitivity to initial conditions", which means that only a very modest help can be expected from any classical statistical test. Rather than a direct test of the model, therefore, we shall try to determine to what extent the "general shape" of the series produced by ID3 (or by the alternative "rational expectation model") resemble or not to the general shape of price series that can be observed in reality - especially for agricultural commodities.

To that end we compare the dynamic properties of simulated prices with properties observed on real series. Among the indicators available, we particularly look for those describing the volatility patterns of prices, e.g. the risk that price changes might inflict to market operators. We derive from the literature three main properties : agricultural prices are non normal - their distribution is fat-tailed and middle-peaked, they exhibit a unit root (in nominal terms) which makes them non stationary, and lastly, they display nonlinearities, either in a stochastic (conditional heteroskedasticity or "Arch" effect) or deterministic form (chaos)[17]. The table 1 summarises the properties set and the statistical tests associated. The standard deviation value of log price changes has been added to provide direct comparison of instability between products among different scenarios. Because of data constraints, tests and measures of chaos (BDS test, Grassberger and Procaccia attractor's dimension) are omitted : they would not provide robust results on series whose length is 60.

We proceed in three steps : In the first step, indicators value is assessed on real market prices of a representative set of commodities. Test values confirm the three main properties described above (annex 1). Then we assess the simulated price properties provided by the rational expectation (viz. with no time lag) version of the model, with and without liberalisation. We restrict to the agricultural product of the rest of the world (ROW), for it being likely to be much less affected by domestic policy changes over the long run (liberalisation is partly achieved now). Last, we duplicate the previous step on the prices generated by the recursive model version with risk.

Results can be summarised as follows (details are provided in annex 2):

Result 1 : prices are much more instable when generated by the model with time lag and risk than with the rational expectation model without lag. Be it measured through the coefficient of variation (CV) of nominal prices or with the standard deviation of the log difference of

[17] Among the vast literature body, one can refer to Ayouz, Daviron, Voituriez (2003) for a survey of price properties and their implication on policies.

prices, all the agricultural products considered are more volatile with risk, milk excepted in one scenario. Volatility ratio between the two versions of the model vary from 50 to 4 among products when measured with the standard deviation of the log difference of prices, and from 5 to 0.5 when measured with the CV of nominal prices.

Table 1 : dynamic properties, indicators and tests

Properties set	**Indicator and/or test**
Distribution	1. Standard deviation 2. Kurtosis 3. Skewness 4. Doornik-Hansen Normality test
Stationarity	5. Unit Root Augmented Dickey-Fuller test
Nonlinearity	6. Arch test (correlation test for second moment)

Result 2 : instability on real market series are closer to the instability generated by the model with time lag and risk than to the rational expectation model (for the few products on which direct comparison can be made).

Result 3 : the liberalisation scenario generates higher volatility for all the products on the rational expectation version of the model, whereas volatility increases for some products (wheat, miscellaneous crops, animals other than beef) and decreases for the others in the version with time lag and risk. This is a particularly striking result, which underlines the argument described above according to which merging markets through free trade can either magnify prices changes (peaks and drops are synchronised) or smooth them (peaks compensate for drops and vanish altogether).

Result 4 : though uneven and imperfect especially regarding the unit root hypothesis (always rejected on simulated prices, which is not the case on real market series), simulated prices display some key properties of real market prices, namely non normality and nonlinearity.

Result 5 : distribution properties remain not fully convincing yet. They are along with the "lack of unit root problem" the major shortcoming of our simulations. Especially in the version with time and risk, price changes behave too often like a roller-coaster, making the distribution too far from the unimodal, Gaussian-like price changes distribution we observe on real data. Extreme highs and lows succeed without a random-walk-like path in between. This might be a consequence of the lack of storage in the agricultural sector, which is often use as a smoothing variable in farming and processing activities. This provides some fruitful hypothesis for further modelling research on trade liberalisation and risk.

CONCLUSION : FROM WICKSELL TO KEYNES

Thus, instead of a Walrassian general *equilibrium* model, following a line of though initiated by Knut Wicksell at the beginning of the 20th century, a general *disequilibrium* model has just been outlined. Because it relies on unfulfilled expectations, and since unexpected events are the main source of risk, behaviour under risk play a major role in the determination of solutions.

The latter are time series reflecting the succession of market equilibriums deriving from *ex post* adjustment of many *ex ante* plans not necessarily compatible one with each other. Although they are far from being completely similar to "real" (historical) observed commodity time series, they look more likes real price series than those derived from a standard equilibrium model based on the same patterns, the same data, and the same general modelling approach. In effect, the major weakness of CGE modelling is the difficulty of validation. Here, we provides some clues in this respect, so imperfect might they be.

In any case, this model suffers for obvious shortcomings : labour supply is fixed, all the difficulties linked to the functioning of international money markets have been neglected, rates of exchanges are fixed – all such simplifications reduce the validity of our conclusions. In addition, in such a context, nothing guarantee the system is sustainable: for instance, underinvestment when expectations are not favourable may jeopardize the existence of feasible solutions in subsequent years. In effect, such system crash were frequently observed in the course of our researches. Yet, it must be stressed that these simplifications are also present – and to a much larger extent – in "standard" models, so that prudence with respect to policy conclusions should apply also to the latter.

Indeed, political implications of using this new kind of model are much different from what they are with standard models. The disequilibrium approach allows for evaluating the impact of such policies as price regulation and market intervention, which are by construction "bad" (at least inefficient) when considered through a standard model, while they may have positive consequences in the new framework. Actually, instead of creating inefficiencies, by decreasing the "quantity of risk" (if such a word can be employed!) present in the economy, these policies may bring realty closer to the ideal efficient solution, at least when properly designed, and if markets are not functioning as smoothly as required for the validity of the standard equilibrium approach.

This is the very essence of Keynes's message (Shackle, 1965): while risk cannot (for logical reasons) be totally removed from economic life, too much risk can deprive markets from significance, by making "right" expectations impossible. Inefficient situations, ignored by the classical and neoclassical theories simply because they neglect risk, can then arise, and must be corrected by suitable policies.

Yet, Keynesian policy recommendations have been oversimplified, at the point of a caricature. Most politicians, from a hasty lecture of epigones, consider the only practical Keynes's conclusion to be that "deficit spending is good", and that "market intervention is desirable". Of course, this is not true – at least, not always-, and the failure of such simple and naïve recipes was to be expected.

General Equilibrium Models have in general been developed in reaction to such failures, under the necessity of introducing more rigour into the spirit of policies. Their role has certainly been important in making national and international policies more realistic and more rational, by emphasizing the interdependence between activities and social classes, as well as pointing out the benefits from comparative advantages and stressing the impossibility of consuming more than what is produced. A Walrassian framework was then the most natural setting for delivering the message.

This is not a reason to forget the progresses made in economic analysis after Walras. Here, starting from the Wicksell's criticisms against Walras, we come down with recommendations which may look more or less similar with old fashioned Keynesian policies. It must be clear that we do advocate coming back to the notorious policy errors of the 60's, based on a wrong interpretation of advanced economic research. But we are anxious to take opportunity of modern data gathering and computing facilities to translate the mid 20th century modern research into numerical applied and well founded recommendations.

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Annex 1 : Market prices properties

Distribution					Unit root	Nonlinearity
Series	**1. Std Dev**	**2. Kurt.**	**3. Skewness**	**4. Normality test**	**5. ADF Test**	**6. Arch(1) Test**
Cocoa fut.	0.02	3.21	0.51	Rejected 1%	-2.25	2.7627*
Coffee fut.	0.02	10.57	0.66	Rejected 1%	-2.18	30.7769***
Rape fut.	0.01	15.82	-1.59	Rejected 1%	-1.85	11.18***
CPO fut.	0.02	22.39	-1.09	Rejected 1%	-2.1	113.6586***
CPO spot	0.06	10.59	0.72	Rejected 1%	1.27	45.877***
Sugar fut.	0.02	20.76	-1.5	Rejected 1%	-0.88	17.8949***
Sugar spot	0.08	9.49	0.76	Rejected 1%	-3.64***	44.577***
Wheat spot	0.22	0.30	0.19	Rejected 1%	-3.41**	10.219***
Corn fut.	0.021	10.68	1.14	Rejected 1%	-2.23	51.01***
Soya fut.	0.031	77.27	-4.96	Rejected 1%	-2.48	4.4707**

Series	Freq.	Beginning	End	Source
Cacao Futures	Daily	04/01/89	28/04/00	New York Board of Trade
Coffee Futures	Daily	04/01/89	28/04/00	New York Board of Trade
Rape futures	Daily	28/10/94	28/12/00	Paris Matif http://www.matif.fr
Crude palm oil Futures	Daily	06/12/80	23/10/00	Kuala Lumpur Commodity Exchange
Sugar Futures	Daily	04/01/93	28/12/00	Tokyo Grain Exchange, http://www.tge.or.jp
Corn Futures	Daily	04/01/93	28/12/00	Tokyo Grain Exchange, http://www.tge.or.jp
Soya Futures	Daily	04/01/93	28/12/00	Tokyo Grain Exchange, http://www.tge.or.jp
Sugar spot	Monthly	01/1800	01/2001	Piketty M-G, Boussard J-M (2002)
Crude palm oil spot	Monthly	01/1800	12/1999	Voituriez T (2001)
Wheat	Yearly	1841	1998	Globalfindata

*** : 1% rejected
** : 5% rejected
* : 10% rejected
The null hypothesis for the ADF Test is Unit root
The null hypothesis for the Arch(1) test is no conditional heteroskedasticity (no nonlinearity)

Annex 2 : Simulated prices properties

Table 1 : Reference scenario (no liberalisation)

Distribution					Unit root	Nonlinearity
Series	1. Std Dev	2. Kurt.	3. Skewness	4. Normality test	5. ADF Test	6. Arch(1) Test
Wheat RE	0.011	3.15062	1.65839	Rejected 1%	-4.8246***	10.844601***
Wheat TAR	0.47	-1.17207	-0.11821	Rejected 10%	-7.8767***	1.987138
Ocereals RE	0.011	0.92687	0.82323	Rejected 5%	-10.1391***	40.348478***
Ocereals TAR	0.54	-1.53245	-0.01004	Rejected 1%	-5.2044***	2.302249
Oilseed RE	0.011	2.00364	1.10679	Rejected 1%	3.1759	18.420199***
Oilseed TAR	0.44	-1.28683	-0.17893	Rejected 5%	-4.6829***	0.704923
Sugar RE	0.011	0.90380	1.24110	Rejected 1%	-11.3584***	41.147930***
Sugar TAR	0.40	-0.86146	-0.36250	Rejected 10%	-8.0986***	0.048527
Misc Crops RE	0.011	2.83128	1.31684	Rejected 1%	-4.0431***	4.393129**
Misc Crops TAR	0.41	-1.09422	-0.38648	Rejected 1%	-3.5895***	1.510240
Livestock RE	0.01	0.66891	1.13229	Rejected 1%	-4.1412***	38.673291***
Livestock TAR	0.41	-0.78016	-0.14457	Not rejected	-9.7527***	0.298539
Oanimals RE	0.009	0.85618	0.52016	Not rejected	-9.0635***	42.158289***
Oanimals TAR	0.22	-0.13409	-0.28403	Not rejected	-4.0587***	4.635249**
Milk RE	0.01	1.24759	0.82483	Rejected 5%	-8.7111***	30.729430***
Milk TAR	0.07	1.09146	-0.17830	Rejected 10%	-3.3545**	15.596255***

Table 2 : Free trade scenario (liberalisation)

Distribution					Unit root	Nonlinearity
Series	1. Std Dev	2. Kurt.	3. Skewness	4. Normality test	5. ADF Test	6. Arch(1) Test
Wheat RE	0.011	2.15337	1.16841	Rejected 1%	-7.7156***	30.762077***
Wheat TAR	0.50	-1.34796	-0.13263	Rejected 5%	-6.1668***	3.662205*
Ocereals RE	0.011	1.76943	1.14328	Rejected 1%	-12.4271***	25.789475***
Ocereals TAR	0.47	-1.23682	-0.05309	Rejected 5%	-8.9624***	0.013449
Oilseed RE	0.011	0.98872	0.92417	Rejected 5%	-13.2805***	48.580209***
Oilseed TAR	0.38	-0.66346	-0.25808	Not rejected	-11.2454***	2.343058
Sugar RE	0.013	6.65441	1.95847	Rejected 1%	-0.6103	8.236344***
Sugar TAR	0.39	-1.03572	-0.14937	Not rejected	-8.7661***	0.487905
Misc Crops RE	0.011	1.76921	1.16606	Rejected 1%	-13.8710***	18.920601***
Misc Crops TAR	0.40	-0.96160	-0.31373	Rejected 10%	-6.4177***	5.041562**
Livestock RE	0.011	1.47754	1.01938	Rejected 1%	-8.9559***	34.758472***
Livestock TAR	0.40	-0.68242	-0.05154	Not rejected	-9.0390***	1.786045
Oanimals RE	0.01	1.16029	0.71173	Rejected 10%	-7.3532***	36.187740***
Oanimals TAR	0.25	-0.23060	-0.24164	Not rejected	-10.8004***	3.105052*
Milk RE	0.011	0.97133	0.83139	Rejected 5%	-3.3656**	42.100673***
Milk TAR	0.047	-0.45743	-0.32003	Not rejected	-3.8739***	0.345885

"RE" stands for the Rational Expectation (no time lag, no risk) version of the model
"TAR" stands for the version with Time And Risk
Products are derived from GTAP 5 : Wheat, Other cereals (Ocereals), Oilseed, Sugar, Other crops (Misc Crops), Livestock, Other animals (Oanimals) and Milk.
*** : 1% rejected
** : 5% rejected
* : 10% rejected
The null hypothesis for the ADF Test is Unit root
The null hypothesis for the Arch(1) test is no conditional heteroskedasticity (no nonlinearity)