Future scenarios of the modernized agriculture and a Sraffian framework for the "return of techniques" scenario

Antonio Sortino, Margherita Chang Ting Fa, Livio Clemente Piccinini

University of Udine, Department of Biology and Agro-Industrial Economy, Udine, Italy - antonio.sortino@uniud.it

Abstract: *Rural areas in Europe are characterized by several agricultural models and paths. We can schematically oppose the modernized and the traditional agriculture. The first is characterized by agricultural techniques of production pervaded by industrial (or modernized) elements and values. It is based on the most fertile soils of the European rural areas. The modernized agriculture has also reached elevated levels of productivity but it lacks in socio-environmental terms (i.e. biodiversity losses).The traditional agriculture, instead, has his base on the less favoured areas and it is an unintentional keeper of traditional and virtuous techniques and elements (i.e. crop rotation and local genetic resources). It is such because it does not accept exogenous elements (i.e. mountainous agriculture where mechanization is applied with low efficiency/effectiveness) and it has therefore remained excluded from the processes of industrialization. The weak point of traditional agriculture, which has caused its decline, is the economic inefficiency. It is however an unknowing producer of positive externalities (i.e. safe food, local genetic resources, landscape).*
In our paper we try to assess the hypothesis of the return of traditional elements and techniques in the modernized agriculture. In order to analyze the problem, we shall introduce the theoretical framework of the "re-switching of techniques" from the neo-ricardian theory (Sraffa 1960). Sraffa, within the "re-switching" framework, pointed out that a low-capital-intensive technique may be competitive both at a relatively low and high rate of profit. Finally, after we have shown two examples of economic models of "re-switching of techniques", we shall build an example of "re-switching" for the short period and an original example with multiple-switching points.

Keywords: *re-switching of techniques, modernized agriculture, traditional agriculture, sustainable development.*

Crisis and future scenarios of the modernized agriculture

"In America the machine is invading all branches of farm production, from the making of butter to the weeding of wheat. Why, because the American, free and lazy, would prefer a thousand deaths to the bovine life of the French peasant. Plowing, so painful and so crippling to the laborer in our glorious France, is in the American West an agreeable open-air pastime, which he practices in a sitting posture, smoking his pipe nonchalantly."
Paul Lafargue, La Droit à la Paresse, 1880

As is commonly known, economic development has determined a sequence of different societies: the rural one before, the industrial one later and the post-modern one today. Those different societies were modified according to the dominant economic sector (in temporal order: agricultural, industrial and tertiary sectors). The social transformations, produced by the passage from a dominant sector to another one, do not concern only production and exchange relations but the whole society: personal relationships, languages, shared values, aesthetics, *etc.* The centrality of an economic sector is therefore evident in its ability to transform and to make itself similar to its surroundings (Sortino & Chang 2007). When the modernization of the whole society took place, the agricultural sector, although fundamentally different from the industrial one, gradually managed to assimilate its principal resources and values. The agricultural modernization model is based on characteristics that belong to the industrial sector: concentration, intensification and specialization (Arnalte *et al.* 2006). At the same time, the agricultural sector has substantially become dependent on modern inputs, external elements and industrial values.

The processes of modernization have not been uniformly distributed among all the agricultural areas and some types of agriculture have remained excluded from modernization. That is because the traditional types of agriculture do not accept exogenous/industrial elements (*i.e.* mountainous agriculture where mechanization is applied with low efficiency/effectiveness).

We can schematically identify two types of agriculture: the modernized and the traditional agriculture. The first one is characterized by agricultural techniques of production pervaded by industrial (or modernized) elements and values. It is based on the most fertile soils of the European rural areas. The modernized agriculture has also reached elevated levels of productivity but it lacks in socio-environmental terms (*i.e.* biodiversity losses). Types of farms, both modernized and traditional, are extremely diversified and they are characterized from several "local styles of farming" (van der Ploeg 1992). The typologies of "styles of farming" depend on, in our opinion, in different combinations of three elements: a) the technological level ("*product oriented"* farms); b) the high integrations with national or global markets ("*market oriented" farms*); c) the attitude to follow the public policies to catch greater government supports ("*policymakers oriented" farms*).

Modernized "local styles of farming" are characterized by an elevated technological level and by a strong integration with domestic and international markets. The modernized farms result also strongly *policymakers oriented.* This is shown, for example, by the interest of such farms for corn and other grain crops that are hardly supported by the CAP.

In the Fig. 1 is schematized, in a three-dimensional graph, the local style of farming for the two types of agriculture. Modernized farms cover a cloud of points around the point B (Fig. 1) where the level of both technology and market integration is high and there is a great attitude to follow the policymaker choices.

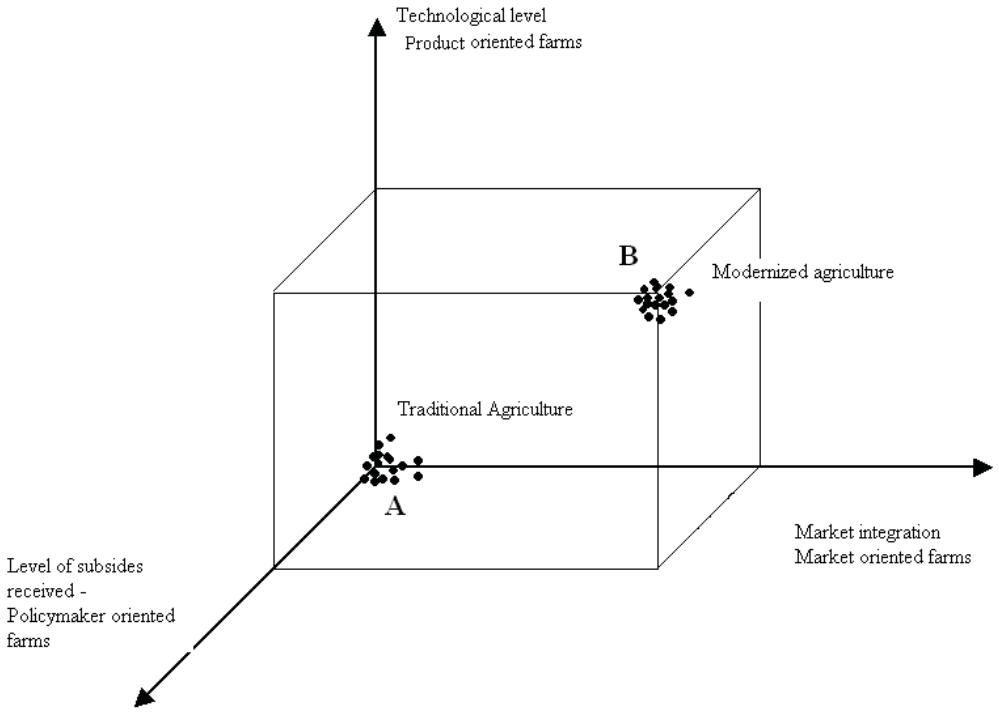

Figure 1. Traditional and modernized styles of farming

Traditional "styles of farming", instead, cover a cloud of points around the point A. For an example of this type of agriculture we can analyze the extraordinary case of self-consumption farms. In Italy, according with the last agricultural census, there are 1 million of self-consumption farms on the total one of the 2.5 million of farms (Massoli 2004). This type of style of farming is characterized by a limited access to the domestic markets and by a very low level of technology. Their decisions are

rarely policymaker oriented. The position of such farms in the Fig. 1 is presumably closed to the point A.

The evaluation of the positive aspects of the modernization of the agricultural sector is a fairly controversial one. We cannot disregard that it has resolved, at least in Europe and in the United States, the thousand year-old problem of the lack of food and the reality of famines. Moreover, the modernization of the agricultural sector has also created a huge agricultural *surplus.*

However, during the last decades the limits of such an agriculture clearly exploded and the modernization model of agriculture has therefore met a crisis point. It produces, in fact, negative externalities, *i.e.* pollution or biodiversity losses. At the same time, modernized agriculture does not assure food safety. This has been proven by a succession of food crisis in the last 20 years (*i.e.* bovine spongiform encephalopathy). It is evident that farmers, in view of the CAP distortions, produce more than required by citizens. The overproduction could be destroyed (with a further waste of energy) or undersold on the international market with unfair dumping policies.

The modernized agriculture, despite its overproduction and negative externalities, is particularly supported by EU and US agricultural policies. It is well known that in EU more than ¾ of CAP support goes to the biggest 10% of significant beneficiaries of subsidy recipients. In US the distribution model is even more distorted: 40% of farmers receive any subsidy. Within this group, the richest 5% get over half. The Gini coefficient[1] for government support shows that EU and US subsidy distribution is more unequal than income distribution in the world's most unequal countries, calling into question the idea that subsidies play an important social welfare role (UNDP 2005). The CAP support of European citizens has therefore been reduced since they pay twice the agricultural support: as contributors and as consumers (CAP causes the increase of consumption prices). Last but not least, modernized agriculture is in crisis in view of the so-called *agricultural squeeze* (compression of the agricultural profits) connected essentially to the structural increase of the variable costs and in particular to energetic input costs. As a result, the agricultural modernization model is in crisis and there will be an in-depth change in the agricultural sector.

For this reason we hypothesize three future scenarios for modernized agriculture and we shall connect them to one of the definitions of sustainable development which are present in the economic literature (Tab. 1). The definition we choose foresees a level of both strong sustainability (eco-centered development) and weak sustainability (techno-centered development), as well as endless intermediary levels. Each level is defined by different assumptions as to the replaceability level between the natural capital and the artificial material and immaterial capital (Turner *et al.* 1996 p. 75, Sortino 2007).

A) The first future scenario concerns the "continuing modernization". Agriculture which is already modernized, through the further incorporation of innovative material and immaterial capital (i.e. new technologies, GMO and scientific knowledge), crosses over to a system which is based on a further specialization and an intensification of agricultural processes. Such a scenario is strongly supported by the agricultural *lobbies* and particularly by the agro-industry system. The agro-industry system is a very involved one. In fact, it receives low-cost commodities from farmers and it sells them the innovative technology (Van der Ploeg 2006). This scenario does not contemplate the reduction of externalities. This could guarantee the increase in technical efficiency and the economic growth of the agricultural sector. The problem though is that rural development is absent.

B) The second future scenario concerns the "balanced modernization". It is characterized by the prosecution of the modernization processes. This is emphasized by the introduction of innovative technology which is useful in order to decrease the negative externalities and to transform them into resources. Such a scenario fits into the paradigm of the weak sustainable development (or techno-centered development). The most evident example is the case of *biogas* production from animal wastes. It consists of the conversion of externalities (animal wastes) into an energetic resource.

C) The last scenario which has been hypothesized is mostly discussed in this paper. We have called it the "return of techniques". It implicates the conversion towards the sustainability of the productive activities in agriculture through the return of virtuous elements, techniques and knowledge of the tradition. The traditional elements are suitably readapted to the new productive context (Sortino & Chang 2007). In the next paragraphs we analyze in depth this scenario. We believe that it is the most

[1] The Gini coefficient is a measure of statistical dispersion used as a measure of inequality of wealth (or income) distribution.

appropriate to represent the (European) model of multifunctional agriculture, which should be based on both production (*i.e.* safe food or landscape) and reproduction (of fertility or biodiversity).

The causes that force modernized agriculture to return to the past are linked to the elements of crisis that we have already discussed (agricultural squeeze, pollution, overproductions). In any case, other factors do exist, in particular the change of food consumption models. Last but not least, the CAP reform is another cause that forces modernized agriculture to accept past techniques, through the financial resource relocation towards the second pillar (rural policies). We shall study more in details these causes in the next paragraph.

The "return of techniques" scenario could be inserted in a theoretical context of strong sustainable development (or eco-centered development) which is connected to production de-growth. Obviously, the quantitative de-growth is not always linked with worse economic performances. In fact, products from *tradition* generally have, in post-industrial economies, more elevated prices. Therefore, within this context of rural development that is without quantitative growth the term "post-productivism" is the perfect synonym of "post-industrial".

Table 1. Future scenarios of modernized agriculture

Future of modernized agriculture	Sustainability of development
Continuing modernization	Economic growth without rural development
Balanced modernization	Techno-centered development
Return of techniques	Eco-centered development, quantitative de-growth

For a clearer presentation we have considered the three future scenarios of modernized agriculture as though they were clearly distinguished. Realistically speaking, we can find types of agriculture where modern unsustainable elements, modern sustainable elements and virtuous elements of the past are contemporarily present but with a different intensity that above-all characterizes a background tendency for rural development.

Causes of return of traditional techniques

In this paragraph, unless otherwise indicated, we have used data related to Italian agriculture. The most surprising case of "return of techniques" we found is the reduction of chemical input. The adoption of a plant protection strategy and the introduction and use of new and low innovative molecular dosages has in fact brought a gradual reduction of pesticides and above-all of fungicides and herbicides (-27% from the period 1990-2005). A lot of attention has also been given by farmers to the use of phytosanitary (INEA 2006). With respect to the preceding year, a fall (-11%) in 2005 was determined in the use of nitrogen, phosphorus and potassium-based fertilizers. The cause can perhaps be found in the elevated purchase costs of mineral and organic-mineral fertilizers together with the change in cultural system that has resulted in a reduction of sown acreage of cereals as a consequence of the application of new EU agrarian policies. According to us, there are mainly three principal causes that *force* modernized agriculture to return to the traditional techniques of process and product. Such causes concern: A) the market (the demand and supply of food goods); B) the governance and, last but not least, C) the trend of the costs related to modern inputs.

A) The increase in the incidence of quality food products on the demand (consumptions) and supply. At higher levels of *per capita* income, which can now be found in post-industrial countries, such quality consumption in fact can be found in a greater hierarchical level within the demand structure. But we cannot disregard other two causes that have influenced the new food consumption models in the post-industrial countries: 1) the increase in education level; 2) the precautionary principle adopted by consumers because of the food crisis during the last decades.

Within this context, we observe the tendency to emphasize a return to products from the "past" through an adaptation in terms of the certified quality of geographical origin or genuineness and salubriousness of the products themselves. Some examples can be found in *GMO-free* or organic products, or in raw materials which are derived from autochtonous or abandoned varieties such as "*Farro*" (*Triticum turgidum dicoccum, T. spelta*) (Miceli *et al.* 2000). Some of these products recall a more remarkable return to a "past" which has been deemed to be virtuous whereas other products are merely the result of a marketing strategy. In this last case we list products of the big-scale agro-industries which entice the consumer into thinking about an idyllic vision of the rural world even if they

apply modern productive methods (Fig. 2). Anyhow, the genuine return to traditional products can face several obstacles in particular *vis-à-vis* the health legislation. This does not always take into account traditional products in the furrow of food safety in the (post) modern sense of the word.

Figure 2. Return of techniques as marketing strategy

B) Changes which have occurred within the CAP. Since its origins, EU agricultural policies have historically tried to direct the agricultural sector towards a technological expansion and also towards a total modernization. This policy caused an over-production of some basic agricultural products and an increase of negative externalities. The first timid steps of the EU agricultural policies towards the environmental sustainability of productive processes started at the beginning of the 90s in the last century following specific agro-environmental measures (the reg. EEC 2078/92 gave monetary incentives for the return to past elements, such as the reintroduction of domestic breeds under threat of extinction or the restoration of hedges, wood spot and dry walls, *etc.*). The attempt to encourage virtuosity continues to this day through the "politics of rural development" which have been financed by the second pillar of the CAP and which uses a strategy of development in favour of rural territories. The "politics of rural development" are matched with the “politics of cohesion" (Piomponi *et al* 2006). The politics of cohesion deal with rural territories but are based in a non-agricultural context (*i.e.* interventions in favour of transportation or environment) or in a local development context (*i.e.* the integrated territorial programs) (Piomponi *et al.* 2006). These policies draw inspiration from the so-called "Lisbon strategy" (2000) which was then confirmed by Goteborg (2001) and from the "medium-term revision" of the CAP (2005). They are both in the implementation phase for the 2007-13 period. Financing for uncoupled or coupled aid to production should be gradually reduced after 2013 and reutilized in the form of benefits for rural development. We will therefore notice a passage of resources from the first to the second pillar of EU policies.

C) The increase in the cost of modern productive factors. This has caused the so-called *agricultural squeeze* phenomenon (the compression of agricultural profits). This phenomenon consists in the reduction of the difference between the value of production and the production costs (Arnalte *et al.* 2006, van der Ploeg 2006). This is also caused by the increase of energetic costs which has progressively augmented commencing with the 1973-75 oil crisis of the last century. In the 1991-2005 period a strong compression of the profits was created in Italian agriculture as the index number of output prices went from 100 (1991) to 111.8 (2005) whereas input prices reached 139.5 in 2005. The profitability loss of Italian agriculture has suffered an acceleration in the last five-year period (2001-2005) with respect to the preceding decade (1991-2000). The range between the index numbers related to the output and the input has been respectively 14 and 20 points in favour of inputs (Ciaccia *et al.* 2006).

According to our thesis, the joint action of these three causes is determining the partial conversion towards the sustainability of the productive activities of modernized agriculture through the return of techniques which were once considered to be obsolete.

Return of traditional techniques: searching for an economic framework

The attempt to frame the return of techniques within economic science has allowed us to analyze three examples which are present in the economic literature and which derive from the framework of "*re-switching of techniques*" (Sraffa 1960). We believe that this framework has an important heuristic potential in explaining the processes of re-conversion of modernized agriculture through the return to sustainable elements of the past. Such a *framework* originates from the challenge of Sraffa to disprove the validity of the marginalist approach in the explanation of some anomalous phenomenon regarding capital and production (Marzano 1975).

Sraffa pointed out (Fig. 3) that a production technique may be competitive both at a relatively low and high rate of profit, but may be dominated by another technique for intermediary rates of profit. It is not reasonable, as the marginalist economists affirm, that any change of technique as the rate of profit falls will be in favor of the more capital-intensive (or mechanized) one (Roncaglia 2003).

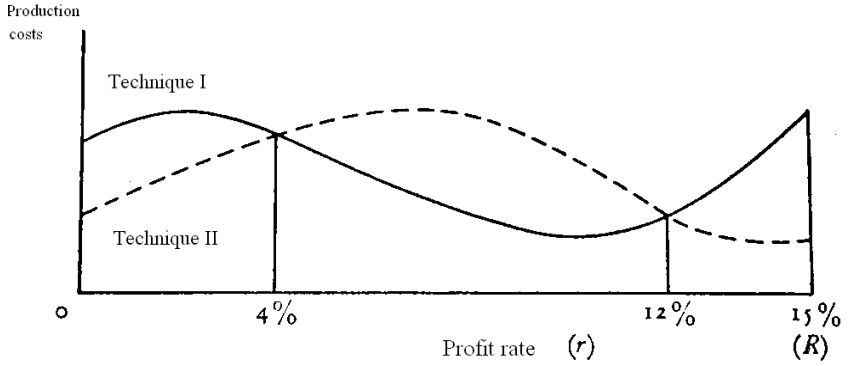

Figure 3. Re-switching of techniques

Sraffa finally demonstrates that more mechanized techniques follow less mechanized techniques (and vice versa) in an unforeseeable way and without any relationship with the rate of profit. Even if in one of the switching point between the two techniques the system follows the marginalist theory, it is sure that in the other switching point the system will move in the opposite way (Roncaglia 2003). Sraffa specifies then that in some cases could be several points of re-switching of techniques. We will show the case of multiple switching in the final part of this paragraph.

In accord with the Sraffian model we can hypothesize that, at least theoretically, the traditional techniques can return to be convenient in the modernized agriculture for the expectation to get bigger profits. Such affinity is evident in the figure 3; we could in fact hypothesize that within a low level of capital productivity -it is the case of the traditional context- (*r<4*%) a traditional technique (i.e. crop rotation) is convenient. The traditional technique is also convenient at higher level of capital productivity (*r>12*%); while in correspondence of intermediary levels of capital productivity (4%<r <12%) the modern technique is more convenient. This is quite connected by the reality, for example practices of organic/sustainable agriculture may be convenient both in less favored agricultural contexts (mountainous areas etc.) and in potentially more favored contexts. Traditional techniques that return in the modernized agriculture are, however, adapted in the new (and modern) productive context. The organic agriculture in the less favored areas will be, for example, often informal and not always certified. The organic agriculture in the modernized areas gets, instead, strong inputs from the tertiary sector for the services of certification and *marketing.*

The following examples of "re-switching" intend to show the coherence of the Sraffian framework and that, at least theoretically, it is possible that traditional techniques can once again be found to be convenient in modernized agriculture for the expectation of obtaining higher profits. The first example of the re-switching of techniques (figure 4) was proposed by Samuelson (Samuelson 1966). He hypothesizes two different investments in order to produce the same product. The first investment produces 18 units of product in the first period, 0 units in the second period and 54 units in the third period. The second investment produces 63 units in the second period and 0 units in the first and in the third period. As can be deduced from figure 4, the first investment (continuous line) is more convenient up to *i=0.5*, the second investment (dotted line) subsequently becomes more convenient. From *i=1* the first investment again becomes preferable.

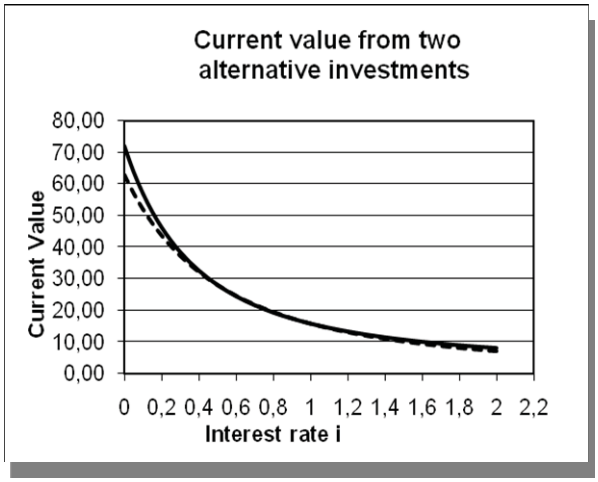

Figure 4. Samuelson's example

This example is not very realistic if we consider the length of the period which is equal to one year. The interest rates when the techniques switch (50% and 100%) appear, in fact, not realistic during the short period. Samuelson's example is consistent if we adopt a longer temporal horizon, i.e. a ten or twenty-year period.

An example of the re-switching of techniques during a short period is present in literature: Ricossa's example (Ricossa 1982). Ricossa considers (Fig. 5a) two different flows of income, indifferently positive or negative for three years (first year: 6, -10 and 0 and second year: -25/3, 100 and -500/3). He does not consider a generic period as Samuelson did. The interest rates when the techniques switch, as noted by Ricossa, correspond to 1+*i*=200% and 1+*i*=600%. During the short period, such interest rates appear to be unrealistic. The Ricossa's example is furthermore incorrect as we have shown in the figure 5b.

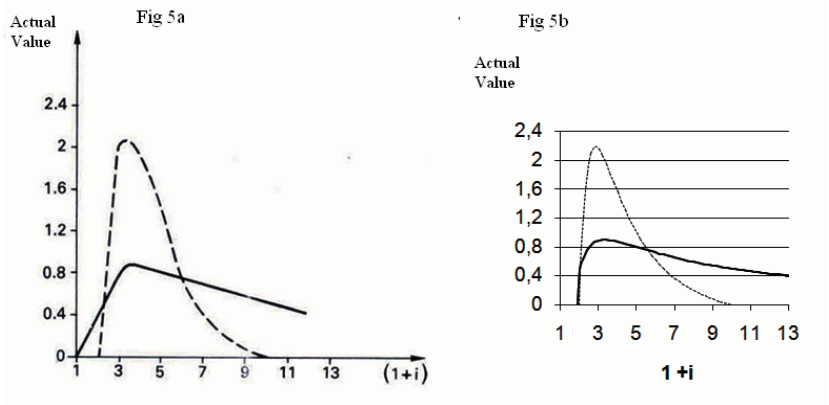

Fig. 5a. Ricossa's example; Fig. 5b. Ricossa's correct example

It is however possible to construct examples that are meaningful also in the short period, as Piccinini's example shows us: we consider two alternative investments for three periods (years). The two production functions have a common *plafond* with values R_1, R_2, R_3 with the differential outputs U_1, U_2, U_3; V_1, V_2, V_3 which have been added. The first outputs are therefore: $R_1+ U_1$ (first year), $R_2+ U_2$ (second year), $R_3+ U_3$ (third year); the second outputs are instead: $R_1+ V_1$ (first year), $R_2+ V_2$ (second year), $R_3+ V_3$ (third year). The example is built with $U_1>0$, $U_2=0$; $U_3>0$ and $V_1=0$, $V_2>0$; $V_3=0$. For every parameter $\varepsilon>0$ we can determine U_1, V_2 and U_3 so that the inversion of the techniques happens when the interest rate is 100ε and $3*100\varepsilon$. We mean that the first project is more convenient for *i* between 0 and 100ε the second for *i* between 100ε and 300ε, and the first one once again for *i* greater than 300ε. We can see the following in Piccinini's example:

$$(1) \qquad \begin{cases} U_1=1 \\ V_2=2+4\varepsilon \\ U_3=1+4\varepsilon+3\varepsilon^2 \end{cases}$$

If $\varepsilon=0.05$ we have: $U_1=1$; $V_2=2.2$; $U_3=1.2075$ and the interest rates when the techniques switch are equal to 5% and 15%. Taking $R_1=R_3=0$; $R_2=0.9$ we will find that the first investment produces 1 units in the first period, 0.9 units in the second period and 1.2075 units in the third period. The second investment produces 3.1 units in the second period and 0 units in the first one and in the third period. As one can deduce from Fig. 6a, we have built the curve of relative actual value (Investment 2/ investment 1). When the relative actual value is equal to 1, it will be the point where techniques switch. It is clear that in this case the switch-points are equal to *i*=5% and *i*=15%. The first investment in fact is more convenient up to nearly *i*=5% and it becomes preferable after *i*=15%.

Fig 6a

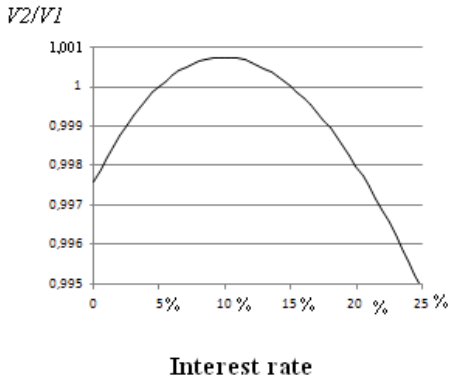

Fig 6b

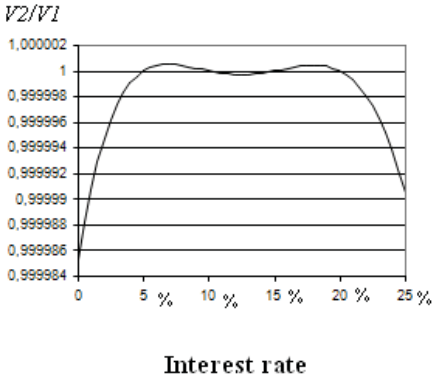

Figure 6a Piccinini's example of re-switching for the short period;
Fig. 6b Piccinini's example of multiple re-switching

As we have introduced, it is possible to create examples of multiple re-switching of techniques. We consider two alternative investments for five periods (years) The mechanism is identical to the one we have seen in the preceding paragraph with the only difference that once fixed an $\varepsilon>0$ the inversion of the techniques happens when the interest rates are equal to 100ε, $2*100\ \varepsilon$, $3*100\ \varepsilon$ and $4*100\varepsilon$. We mean that the first project is more convenient for *i* between 0 and 100ε, for *i* between $200\ \varepsilon$ and 300ε and for values of *i* grater than 400ε.

We can see the following in Piccinini's example:

$$(2) \qquad \begin{cases} U_1=1 \\ U_3 = 6 + 30\varepsilon + 35\varepsilon^2 \\ U_5 = 1 + 10\varepsilon + 35\varepsilon^2 + 50\varepsilon^3 + 24\varepsilon^4 \\ V_2 = 4 + 10\varepsilon \\ V_4 = 4 + 30\varepsilon + 70\varepsilon^2 + 50\varepsilon^3 \end{cases}$$

We consider $U_2=U_4=V1=V_3=V_5=0$. If $\varepsilon=0.05$ we have: $U_1=1$; $U_3=7.5875$; $U_5=1.5939$; $V_2=4.5$; $V_4=5.68125$ and the rates when techniques switch will be: 5%, 15%, 20% and 25% (FIG 6b). If we take $R_1=R_2=R_3=R_4=R_5=0$ we will find that the first investment produces in the 5 years: 1; 0; 7.5875; 0; 1.5939; while the second investment produces in the 5 years: 0; 4.5; 0; 5.68125; 0.

Some concluding remarks for the debate

The industrialization of the agricultural sector has resolved, at least in Europe and in the United States, the thousand year-old problem of the lack of food. Unfortunately, during the last years the limits of such agriculture clearly exploded. The modernized agriculture, in fact, produces negative externalities and it does not assure food safety.

With our work we have hypothesized three future scenarios for modernized agriculture. We have studied in particular the one that foresees the conversion to sustainability through the return of traditional techniques. Generally speaking, our opinion is that the “continuing modernization” and the “balanced modernization” future scenarios may not have a long term economic and environmental sustainability. The return of traditional techniques may help the modernized agriculture to find the "lost virtuosity" and the environmental sustainability.

In order to analyze the problem, we have introduced the Sraffian framework of the “re-switching of techniques”. Finally we have built an original and new model of “re-switching” for the short period and a model with multiple switching points.

The principal conclusions of our study are the following: a) the Sraffian model of the re-switching of techniques is based on a coherent and logical theoretical structure. B) Samuelson’s example (long period) and Piccinini’s examples for the short period and for the case of multiple re-switching have realistic values and are in line with real investment choices. C) Finally, we have demonstrated that, at least theoretically, traditional and sustainable techniques could be convenient in a context of both low and high profit level. The crisis elements of modernized agriculture, the new agricultural policies and the new consumption models, that have been hereby discussed, could provoke re-distribution effects of profits which are capable of encouraging the return of traditional techniques.

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