ASSESSING PROFITABILITY IN RICE CULTIVATION USING THE POLICY ANALYSIS MATRIX AND PROFIT-EFFICIENT DATA [*]

Authors: *Andrés J. Picazo-Tadeo* [a]
Ernest Reig [a, b]
Vicent Estruch [c]

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(a) Universidad de Valencia. Departamento de Economía Aplicada II. Facultad de Economía. Avda. dels Tarongers, s/n. 46022 Valencia. Spain.

(b) Instituto Valenciano de Investigaciones Económicas. Guardia Civil, 22, 2, 1.º. 46020 Valencia. Spain.

(c) Universidad Politécnica de Valencia. Departamento de Economía y Ciencias Sociales. Escuela Superior de Ingenieros Agrónomos. Camino de Vera, s/n. 46022 Valencia. Spain.

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ABSTRACT

This paper assesses the profitability of rice farming in the *Albufera*, a protected wetland site located in Eastern Spain, under the post-2003 *Common Agricultural Policy* (*CAP*) policy scenario. The interest in analysing this agricultural system derives from its ability to produce positive externalities that can be regarded as public goods. The methodology combines the *Policy Analysis Matrix* (*PAM*) approach and *Data Envelopment Analysis* (*DEA*) techniques. Two policy matrices are computed using, respectively, observed and profit-maximising data on costs and revenues. Findings from observed data point to a lack of profitability, even when public support granted by the *CAP* to rice growers is considered, thus jeopardising the public goods provided by this agricultural system. The policy matrix with profit-efficient data shows that farmers could make positive profits, both at private and social prices. Our conclusion is that in order to maintain the non-marketable functions of rice farming in the *Albufera*, greater efforts should be done to extend the implementation of best practices among rice growers.

Key words: Rice farming, multifunctionality, public goods, European Common Agricultural Policy, profit efficiency, Policy Analysis Matrix, Data Envelopment Analysis.

JEL classification: Q12, Q18, C61, D61.

1. INTRODUCTION

The *Common Agricultural Policy* (*CAP*) of the European Union is currently evolving under the combined pressure of internal requirements for change and the need to adjust in advance to the provisions of future international trade agreements. The *Uruguay Round* of the *GATT* (1986-94) paved the way for an improvement in the access of third countries' exporters to the internal European market, and a further move in the direction of trade liberalisation is currently envisaged, as a likely outcome of the *Doha Round* negotiations. Partial or total decoupling of agricultural support from current production levels has been the answer of European policy-makers to the criticisms raised by foreign competitors concerning the so-called *trade-distortion effects* of the *CAP*.

For the European authorities, the political problem of supporting farmers' incomes in an increasingly open economic environment has been further compounded by the need to take on board the impact of trade liberalisation on non-commodity outputs of European agriculture. There is a growing recognition that, beyond its primary function of supplying food and fibre, agriculture generates positive externalities that can be treated as public goods, providing environmental benefits, like the contribution to the sustainable management of renewable natural resources and the preservation of bio-diversity. As they are all non-marketable goods, its provision will primarily depend on the intervention of public authorities. These new concerns are frequently summarised under the heading of *multifunctional agriculture* and have become an integral part of the *European model of agriculture* (European Commission 1999, 2000).

The problem is that *multifunctionality* risks to remain too vague as a concept, plagued with opposed *normative* and *positive* interpretations. The recognition of the multiple functions displayed by farming, and of its joint production of commercial and non-marketable public goods may be the key to a new understanding of the role of agriculture in European societies. But *multifunctionality* can only gain scientific substance if referred to empirical evidence, based on site-specific interrelationships between farming activities and non-commercial functions. Our wish with this paper is to contribute to this kind of approach by focusing our attention on a crop that is important for the survival and recreation of wetlands in Europe, and describing the conditions required for its economic viability. In particular, we perform a profitability analysis of rice farming in the *Albufera Natural Park*, located in the Eastern Spanish region of Valencia, in order to assess its possibilities of survival in the new policy context that characterises the *CAP*'s *Mid-Term Review*.

Rice farming provides an interesting case of a crop that plays an important ecological role and where the European Union has assumed the need to provide more room for imports from developing countries. Rice cultivation in Mediterranean wetlands represents a system of land management that, besides helping to shape highly valued traditional landscapes, performs an important non-marketable function linked to the protection of biodiversity and the environment. The *Albufera Natural Park* is a protected wetland area that is representative of the sort of rice fields that were mentioned as a source of positive environmental externalities in the review of the Spanish literature on agricultural multifunctionality, commissioned by the *OECD* (Tió and Atance, 2001). In addition, the concern for the ecological consequences of the abandonment of farming has led us to focus on this protected area, where for technical and ecological reasons no alternative crops exist.

In this paper, we take a step beyond conventional profitability analysis: instead of adopting a purely static viewpoint based on what farmers are currently doing, we introduce the perspective of what they *could* do in order to rise to the challenge posed by international competition. Rice farmers will have to adjust in the coming years to a less protective policy environment, by using their productive assets more efficiently and cutting costs, thereby improving their chances of survival in the face of strong import competition. Hence, we draw a clear distinction between *observed* and *efficient* farmers' behaviour, leading respectively to *observed* and *efficient* outcomes.

Usually, the analysis of farming systems has attempted to assess farms' viability by dealing with actual farmers' behaviour, implicitly assuming that all farmers behave efficiently. But, one could legitimately ask: what happens if the *current* farming practices of some individual farmers are inefficient when compared with *best* practices under present available technologies? and also: are all farmers using the optimal input-mix according to current input prices?

The answer to these questions has important economic policy implications. The impact of agricultural policies on farmers' incomes might be widely different under observed and efficient behaviours. Likewise, the assessment of private and social profitability for a particular farming system can change substantially after major input adjustment decisions have been adopted in response to the diffusion of best management procedures. Profits obtained after all those adjustments have taken place could provide a useful benchmark for current production practices, showing whether or not enough room exists for an improvement of farms' financial situation.

Our methodological approach is based on the use of *Policy Analysis Matrix* (*PAM*) to compute private and social profitability of rice farming under *observed* and *efficient* conditions. The estimates of the *efficient* levels of input use, income, costs and profits are computed using *Data Envelopment Analysis* (*DEA*). *Efficient*[1] conditions are *virtual* for most of the farms, representing the input-output

[1] In this paper *efficiency* is used with two different meanings. One, as in the present paragraph, refers to the adjustment of firms' input and output vectors to achieve maximum profits, for a set of prices, fixed factors and the current state of the technology. It is used in connection with *DEA* computations. The other, used in connection with *Policy Analysis Matrix*, refers to a social benchmark for the calculation of costs and revenues based on the adoption of international prices and the removal of the effects of subsidisation and taxation.

coefficients for labour, capital and other inputs that would prevail *if* farms were operated efficiently, i.e. with all farmers doing what the best farmers do.

The rest of the paper is organised as follows. Section 2 briefly describes the *Albufera*'s rice farming system and outlines the payment system for rice cultivation established by the reformed *CAP*. Sections 3 and 4 are devoted to describing the data and to computing profit-maximising productive plans, respectively. The *PAMs* under both observed and efficient scenarios are computed in section 5. Section 6 discusses the results and a final section concludes.

2. THE COMMON AGRICULTURAL POLICY SUPPORT TO THE *ALBUFERA* RICE FARMING

Rice farming in the Iberian Peninsula plays an essential role in the provision of public goods related to the environment and the protection of bio-diversity. The Spanish rice fields act as seasonal aquatic ecosystems, given that they are flooded during Summer, a season in which the Mediterranean wetland areas undergo drought conditions, and also during part of Winter, for ecological reasons. It has been estimated that at least 25 bird species of European conservationist concern use the rice fields in Spain to either pass the Winter, or as a place to rest and feed during their migrations (Fasola and Ruiz, 1997).

The *Albufera* and its vicinity was declared a *Nature Reserve* by the Valencian Regional Government in 1986 and a *Ramsar* site[2] in 1990. The semi-urban character of the *Park* is a circumstance which enhances its value as a natural resort of great recreational interest. Flooded rice fields around the Albufera lake provide the predominant regional feeding area for some bird species like ducks, common cranes and egrets, because the eutrophication of the waters of the Albufera prevents the lake itself from supplying enough food to cover birds' needs. The rice fields of the Albufera are also important in regulating the water cycle and detecting the problems that affect it, as well as in the treatment, by natural decantation, of polluted waters.

Since the *CAP* reform of 1992, rice farmers have benefited from a support system based on three elements: commercial protection and export subsidies, public intervention purchases, and direct aid per hectare. Nonetheless, the *Uruguay Round Agricultural Agreement* established restrictions on the use of export subsidies, and opened a future of free import access to European domestic

[2] The *Convention on Wetlands of International Importance especially as Waterfowl Habitat*, signed in 1971 in the Iranian city of Ramsar, is an intergovernmental treaty for the conservation and wise use of wetlands, primarily oriented to provide habitat for waterbirds, but increasingly concerned with biodiversity conservation in general.

markets, in accordance with the *Everything But Arms Initiative*, adopted in favour of less developed countries. In year 2003, following the *Mid-Term Review* of the European *CAP*, policy tools changed, and a decoupled system of payments was introduced (*Council Regulation (EC) 1782/2003*).

The effects of the aforementioned support instruments on the private profitability of rice farms are supplemented by the environmental payments being applied in cultivation areas included in the *Ramsar* list, as is the case of the *Albufera* of Valencia. These payments compensate for the restrictions on the use of specific farming techniques, imposed for the sake of ecosystem protection. The agro-environmental program, '*Protection of the Flora and Fauna in Coastline Wetland Sites: the Albufera of Valencia*', which established compensation payments for farmers, was approved in 1995. Since 1995, several programs with an environmental purpose have targeted this area (Estruch and Vallés, 2001).

3. THE DATA

The empirical analysis we carry out is based on a dataset corresponding to a sample of 131 single crop rice farms located in the *Albufera* area. The data were collected from a comprehensive survey made by the authors with support from the *Spanish Ministry of Science and Technology*, and correspond to the year 2004. Our dataset provides data for one output and six inputs. Output is measured in kilograms of rice production. The only fixed input is cultivated land, measured in hectares. Variable inputs are: labour (measured in working days), in addition to capital, fertilisers, seeds, herbicides and fungicides, all of them measured in €. *Table 1* reports a sample description for the data.

Table 1

SAMPLE DESCRIPTION

Variable	Description	Units	Quantities		Price (€ per unit)
			Mean	Standard deviation	
Output	Rice	Kilograms	34,712	62,208	0.24
Fixed input	Cultivated land	Hectares	4.2	7.6	721
Variable inputs	Labour	Working days	66.4	91.6	36.30
	Capital	€	2,969	5,447	1
	Fertilisers	€	477	905	1
	Seeds	€	584	1,074	1
	Herbicides	€	686	1,333	1
	Fungicides	€	276	603	1

Labour input includes both family labour, embracing the farmer's and his family's on-farm labour, and hired labour. Input capital includes the cost of use of both farm-owned and rented machinery and equipment. Labour is taken to be a variable factor of production because part-time farming has long been recognised as a structural characteristic of Valencian agriculture (Arnalte and Estruch, 2000). The region's highly diversified economic structure allows for alternative jobs in services or manufacturing industries in the same areas where rice farms are located. Likewise, many productive tasks are outsourced in the sense that they are carried out by external labour teams and rented machinery.

Concerning prices, the price of rice has been established as 0.24 € per kilogram, and it is assumed to be the same for all farms in the sample. The reason for this choice is that all farms produce similar varieties of rice, which is sold in the local market with no differences in price. Family-owned labour has been priced using the wage earned by salaried workers on rice farms, as a conventional opportunity cost. In the same way, in order to compute the aggregate expenditure on capital services, the price of own capital services has been equated to the cost of hired machinery. Likewise, it is assumed that the price of labour and capital is the same for all farms, because the markets for both production factors are local markets with no observed difference of prices. Finally, since fertilisers, seeds, herbicides and fungicides have all been measured by the total expenditure, their price has been conventionally set to one.

Calculation of *PAM* matrices also involves the prices paid for the services of fixed production factors. In our case, the private rent of land has been established according to the most common quotations for transactions in the local farmland rent market, currently around 721 € per hectare. Prices of output and inputs are displayed in *Table 1*.

4. COMPUTATION OF PROFIT MAXIMISING PRODUCTIVE PLANS WITH DATA ENVELOPMENT ANALYSIS

Microeconomic theory considers productive processes as the result of profit-optimising behaviour. Nonetheless, not all firms' managers are successful in achieving this goal, and profit frontiers representing best practices need to be computed. Benchmarking productive activity and computation of technological frontiers offers a suitable framework for evaluating firms' relative performance and working out productive plans that maximise firms' profits.

Here, *Data Envelopment Analysis* (*DEA*) is used to compute productive plans that maximise short-run profit for given input and output prices. *DEA* techniques were introduced by Charnes *et al.* (1978); Reig-Martínez and Picazo-Tadeo (2004) highlight their usefulness for analysing farming systems. In essence, these techniques evaluate the performance of peer units by constructing a surface over the data that allows the observed behaviour of a decision-making unit to be compared with best observed practices (see Cooper *et al.*, 2004 for further details).

The production theory underlying the framework of efficiency analysis posits the existence of a technology of reference that provides a complete description of all technologically feasible relationships between inputs (variable *x*) and outputs (variable *y*). Formally, the *technology* is:

$$T \quad [(x,y): x \text{ can produce } y]= \qquad (1)$$

It is assumed that the technology satisfies the usual axioms, initially proposed by Shephard (1970) (see also Grosskopf, 1986). These properties include the possibility of inaction, no free lunch, free disposability of inputs, implying that the same level of outputs can be always produced using higher quantities of inputs, and strong disposability of outputs, meaning that lower quantities of outputs can be produced at no cost using the same inputs. Furthermore, we assume that x_v and x_f represent the vectors of variable and fixed inputs, respectively.

Based on this characterisation of the technology, and assuming that prices of both variable inputs and outputs are known and given by the vectors *r* and *p*, respectively, the *short-run profit function* can be formulated as:

$$\begin{aligned} &\text{Profit}(r,p,x_f) = \text{Max}_{x_v,y}(ry - px_v) = \\ &\text{subject to}\,(x_v,y) \in T(x_f) \quad = \end{aligned} \qquad (2)$$

where $T(x_f)$ is the *short-run technology* representing all technologically feasible productive plans for a given endowment of fixed inputs.

Using *DEA* techniques, computation of the productive plan that maximises short-run profit for farm *k'* requires the comparison of its actual observed output and input data with those of the farms showing best observed practices, i.e., profit-efficient farms. Formalising, the profit maximising combination of variable inputs and output of farm *k'* arises from the following program:

$$\begin{aligned} &\text{Profit}\left(r,p,x_f^{k'}\right) = \text{Max}_{x_v^{k'},y^{k'},z^{k'}}\left(ry^{k'} - \sum_{v=1}^{6} p_v x_v^{k'}\right) = \\ &\text{subject to:} \\ &\qquad y^{k'} \le \sum_{k=1}^{131} z^k y^k && \text{(i)} \\ &\qquad x_f^{k'} \quad \sum_{k=1}^{131} z^k x_f^k \quad f \quad 1 && \text{(ii)} \\ &\qquad x_v^{k'} \ge \sum_{k=1}^{131} z^k x_v^k \quad v \quad 1,\dots,6 && \text{(iii)} \\ &\qquad z^k \ge 0 \qquad k \quad 1,\dots,131 && \text{(iv)} \\ &\qquad \sum_{k=1}^{131} z^k \quad 1 && \text{(v)} \end{aligned} \qquad (3)$$

y^k, x_f^k and x_v^k being the observations of output and both fixed and variable inputs of farm *k*, respectively. Besides, z^k represents the weighting of each farm *k* in the composition of the technological frontier. Finally, variable returns to scale have been imposed (see Banker *et al.*, 1984 for details).

As previously noted, output is measured by rice production; in addition we have considered that the only fixed input is land, while the six variable inputs are fungicides, herbicides, fertilisers, seeds, labour and capital. The solution to program (3) for each farm in the sample provides the productive plan, i.e. the combination of variable inputs and output, which maximises its short-run profit, for given prices of output and variable inputs, the restrictions imposed by the available technology, and a given endowment of land, as fixed input. On average, achieving profit-efficiency involves a reduction in the use of capital, fungicides, herbicides, and, mainly, labour (*Table 2*). Conversely, the use of fertilisers and seeds slightly increases when moving from observed to efficient productive plans. Finally, yields by hectare also increase slightly.

Table 2

OBSERVED AND SHORT-RUN PROFIT-MAXIMISING PRODUCTIVE PLANS
(averages per ha.)

Variable	Units	Observed	Profit-maximising	Variation (%)
Output				
Rice	Kilograms	8,229	9,118	10.8
Variable inputs				
Labour	Working days	23.7	11.5	-51.5
Capital	€	715	615	-14.0
Fertilisers	€	118	123	4.2
Seeds	€	138	139	0.7
Herbicides	€	154	111	-27.9
Fungicides	€	65	61	-6.2

The calculation of the short-run profit function also allows to work out an *overall efficiency indicator*, that compares current observable profit levels with profits that could be achieved after a profit-maximising adjustment of both variable inputs and output. This measure of profit-efficiency can be computed from the following relationship (Färe *et al.*, 1994):

$$\text{Profit}(r,p,x_f)=\frac{ry}{\text{Efficiency}_g(x,y,p,r)}-\text{Efficiency}_g(x,y,p,r)\cdot px_v \qquad (4)$$

where $Efficiency_g\,(x,y,p,r)$ is the so-called *graph measure of overall efficiency*, and $Profit\,(r,p,x_f)$ is the short-run profit computed through expression (3).

The average overall efficiency for the whole sample is equal to 0.826 (*Table 3*), with only eight farms behaving efficiently (*Figure 1*). On average, revenue should be increased by 13 per cent and costs cut by 22 per cent in order to achieve overall profit efficiency. In addition, cost reductions are, as noted, particularly important for the labour and capital. These results reveal that substantial chance to improve the financial situation of many farms exists. Improving managerial efficiency would, undoubtedly, facilitate these growers to remain in operation, thus helping to preserve the non-marketable function of the *Albufera* rice farming system, and its provision of environmental public goods.

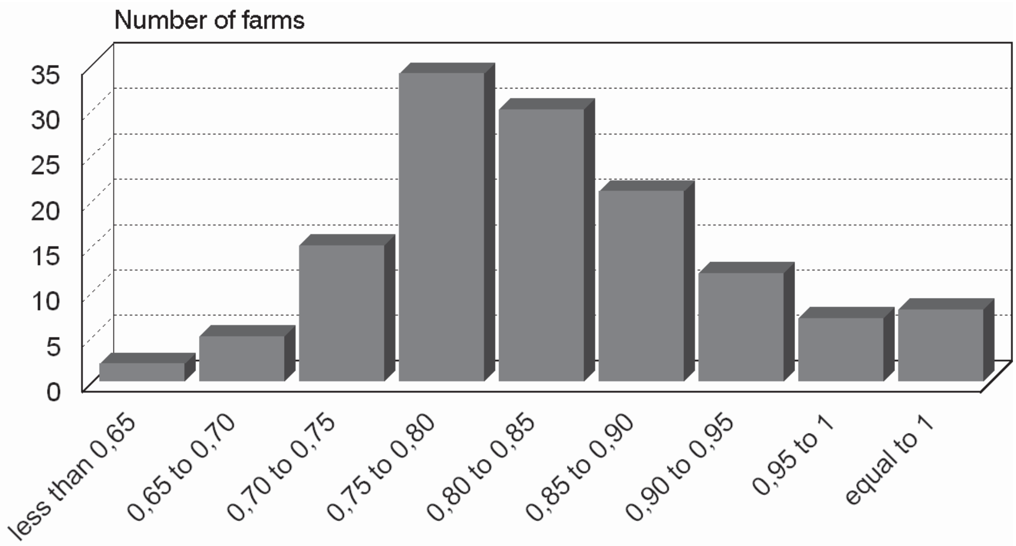
Table 3

ESTIMATES OF OVERALL PROFIT-EFFICIENCY

	Average	Standard deviation	Maximum	Minimum
Profit-efficiency	0.826	0.090	1.000	0.471

Figure 1

HISTOGRAM OF THE COMPUTED OVERALL PROFIT-EFFICIENCY SCORES



5. CONSTRUCTION OF THE POLICY ANALYSIS MATRIX FOR RICE CULTIVATION IN THE *ALBUFERA NATURAL PARK*

5.1. The Policy Analysis Matrix: theoretical aspects

The *Policy Analysis Matrix* (*PAM*) is a tool for quantitative policy analysis pioneered by Monke and Pearson (1989) which embodies many insights from international trade theory and cost-benefit analysis. The *PAM* is the representation of two basic identities. The first identity defines profitability as the difference between income and costs (rows), whereas the second measures the effects of the differences in incomes, costs and profits arising from distorting policies and market failures (columns). In this way, the matrix allows us to compute the effects on income, costs and profits, of a particular policy or the adoption of a new technology. *Table 4* shows a simplified *PAM*.

Table 4

A SIMPLIFIED POLICY ANALYSIS MATRIX

	Income	Costs		Profits
		Tradable inputs	Domestic factors	
Private prices	A	B	C	D
Social prices	E	F	G	H
Effects of both the domestic divergences and the efficiency-restoring policies	I	J	K	L

The rows of the matrix respectively represent:

- the *private profitability* from farming production (D = A – B – C).
- the *social profitability* (H = E – F – G).
- the divergences between private and social valuations of revenues, costs and profits. They represent a net balance from the application of a combination of policies that create economic distortions (trade protection, price support, exchange rate misalignment, among others), market failures, and correcting policies that aim to restore efficiency conditions.

The columns of the matrix show income and profits, as well as the breakdown of costs into two components, tradable inputs and domestic production factors. The so-called *intermediate inputs*, like fertilizers or pesticides, must also be decomposed into elements of the tradable inputs type, and into domestic factors.

The main purpose of constructing a *PAM* is to capture the differences between private and social profitability. Nonetheless, the latter, i.e. social profitability, is to be strictly understood in conventional efficiency terms, e.g. adopting international prices as a benchmark in the valuation of tradable goods, and therefore without encompassing other possible social objectives, such as the redistribution of income, food security or environmental protection. Some particular conventions are adopted for pricing outputs and inputs, in order to calculate social profitability. For those outputs (E) and inputs (F) which are internationally traded, world prices (*c.i.f.* for imports and *f.o.b.* for exports) set up appropriate social values, whereas the valuation of domestic factors (G) corresponds to their opportunity cost, i.e. to the net income lost by not putting those factors to their best alternative use.

Differences between private and social valuations do not only affect tradable inputs and outputs. The valuation of domestic factors is also affected when the government taxes or subsidises land, capital or labour, or when their pricing is being affected by market failures. Whereas labour and capital are normally treated as variables, land is usually considered as a quasi-fixed factor in agriculture.

The *PAM* permits the construction of different ratios, which are useful to discover whether a farming system enjoys a comparative advantage *vis-à-vis* the international market. The following three have been calculated in this paper:

(i) Private Cost Ratio:

$$PCR \quad \frac{C}{(A-B)=} \qquad (5)$$

This is the quotient between the cost of the domestic factors, valued at private prices, and the value added, which is also calculated at private prices. The system will be competitive while the quotient is lower than or equal to unity.

(ii) Domestic Resource Cost Ratio:

$$DCR \quad \frac{G}{(E-F)=} \qquad (6)$$

This is the quotient between domestic factors' costs valued at social prices and the value added, also computed at social prices. An agricultural system enjoys a comparative advantage if its *DRC* ratio is less than unity, indicating that the economy is saving foreign exchange by means of domestic production.

(iii) Subsidy Ratio to Producers:

$$SRP \quad \frac{L}{E} \quad \frac{(D-H)}{E} \qquad (7)$$

This ratio measures the net transfer to the farming system as a proportion of the total social income generated, allowing the analyst to discover to what extent the economic policy is subsidizing the system. A high *SRP* points to a lack of competitiveness, as the system's financial viability tends to depend on political decisions.

Since the seminal work by Monke and Pearson (1989), the *PAM* approach has been widely used. It has been applied to studying the profitability of maize cultivation in Portugal, before this country joined the European Community (Fox *et al.*, 1990), and also in different developing countries (Pearson *et al.*, 1995, Nelson and Panggabean, 1991, Adesina and Coulibaly, 1998, Yao, 1997, Fang and Beghin, 2000). The possibility of incorporating environmental considerations into the *PAM* has opened new perspectives for the analysis of farming in areas of high ecological value (Kydd *et al.*, 1997, Pearson *et al.*, 2003).

In this paper, we use the *PAM* methodology in order to learn about the possibilities of maintaining rice cultivation in the *Albufera Natural Park*, under the post-2003 *CAP* support system. As noted in the introduction, we build two different matrices. The first one is based on the observed values for inputs and outputs, revenues, costs and profits. The second matrix, which we call *efficient*, is computed using values of these variables adjusted to their respective profit-efficient levels.

5.2. Computation of the conventional *PAM*

A *PAM* was initially constructed on the basis of the techniques and costs observed in the existing agricultural practices (*Table 5*). Yields and input/output coefficients were obtained from our dataset, and pricing conventions corresponding to the *private prices* row of the matrix have already been described in section three. The social prices were obtained from the international prices (*c.i.f.* prices for imports) for paddy rice and for tradable inputs. Taking international prices as an efficiency benchmark follows a recommended practice, even in the presence of international market distortions (Monke and Pearson, 1989, Pearson *et al*. 2003).

Table 5

POLICY ANALYSIS MATRIX COMPUTED UNDER OBSERVED PRODUCTIVE PLANS. (€/ha.)

		Income	Costs									Profits
			Tradable inputs					Domestic factors				
			Fungicides	Herbicides	Fertilizers	Seeds	Others [a]	Labour	Capital	Land	Others [b]	
Private prices	Output value	1,975	44	105	80	31	69	962	911	721	235	-309
	Agroenvironmental subsidies	398										
	CMO subsidies	476										
Social prices	Output value	1.728	24	86	66	27	51	943	889	0	235	-592

(a) Cost of the energy used in the drying process of rice.

(b) Other fixed costs: costs of water management, real estate taxes and harvest insurance.

Land rent at social prices was made equal to zero, given the impossibility of growing alternative crops on the land presently dedicated to rice fields within the protection perimeter of the *Albufera*, both for legal reasons derived from the *Natural Park* regulations and for physical reasons connected to the seasonal flooding of the cultivation plots. Should abandonment be the alternative to rice growing (a plausible assumption under local conditions) the land's rent must be valued at zero cost for society in terms of efficiency.

The *Input-Output Tables* for the Valencian Region (Institut Valencià d'Estadística, 1995) have been used for breaking down the intermediate input costs into their tradable and domestic factors components. The *Value Added Tax* has also been discounted from the private prices of the tradable goods, as has the European Union's *External Tariff Rate*, in order to obtain *social prices.*

Only slight differences remain between the valuations at private prices and at social of the tradable inputs once tax effects have been eliminated, given the low or nil tariff rate applied to these goods. Larger differences have only been found for certain fungicides due to market price segmentation applied by multinational chemical companies. As for the output (the *paddy* rice), the differences between domestic farm prices and *international prices* are significant, and they reflect the protection that the *CAP* grants to European growers. We have estimated an international, or *social*, price of 0.21 €/kg, which includes a cost of 0.04 €/kg corresponding to unloading the rice at the port of Valencia and transporting it to warehouses. The domestic price for the grower has been set, as noted in section 3, at 0.24 €/kg.

We have completed the analysis by incorporating the new support mechanisms for rice production, which are coming into force in the European Union during 2005-06 (*Regulations 1785/2003* and *1782/2003*), after the *Mid-Term Review* of the *CAP*. The intervention price has been reduced and a coupled subsidy of 476.25 € per hectare sown of rice will be paid to Spanish growers. A decoupled subsidy of 647.70 € per hectare will also be granted as a *Single Farm Payment* to those farmers who had previously received the rice *CMO* subsidy under the old *Regulation* during the years 2000, 2001 and 2002. We have included in the computation of revenue per hectare at private prices the coupled subsidy, but not the decoupled one, because it does not include any obligation on farmers to grow rice.

Agro-environmental payments, amounting to 397.63 € per hectare, have also been included in the computation of farmers' revenues at private prices. They represent a compensation for the costs incurred by farmers by adopting environmentally-friendly cultivation techniques.

5.3. Recalculating the *PAM* with profit-efficient data

Computation of profit-maximising productive plans with *DEA* has allowed us to construct a *virtual* average farm that we term *efficient* (*Table 6*). This farm obtains higher revenue than the average observed farm, because yields per hectare are increased by almost 11 per cent. The efficient farm also has lower costs than the average farm in our sample, because inputs are more economically managed (see again *Table 2*). The main savings arise from a reduction of 52 per cent in labour costs. We hypothesise that a substitution of outsourced labour for family labour allows a more efficient use of the workforce[3]. Revenue increases and cost-cutting results in a remarkable improvement in rice farms' financial situation.

Table 6

POLICY ANALYSIS MATRIX COMPUTED UNDER PROFIT-EFFICIENT PRODUCTIVE PLANS. (€/ha.)

		Income	Costs									Profits
			Tradable inputs					Domestic factors				
			Fungicides	Herbicides	Fertilizers	Seeds	Others (a)	Labour	Capital	Land	Others (b)	
Private prices	Output value	2.188	41	75	84	32	76	511	813	721	235	473
	Agroenvironmental subsidies	398										
	CMO subsidies	476										
Social prices	Output value	1.915	23	62	68	27	57	493	792	0	235	158

(a) These costs are slightly higher than in the *PAM* for observed production plans, because efficient production implies higher yields per hectare, which in turn imply higher drying costs.
(b) These fixed costs do not change from those of the observed production plans.

Figures of revenue and costs of the *virtual* efficient farm are used to build a new *PAM*. After some minor adjustments, like increasing the drying costs to reflect the increase in yields per hectare, we proceed to compute the *PAM*'s cells by using the same pricing conventions and decomposition into tradable and non-tradable intermediate inputs as in constructing the conventional *PAM*. We also make the same provisions to reflect the impact on private revenues of policy measures, arising from the regulation of the rice *CMO* and from farmers' participation in the Environmental Program '*Protection of the Flora and Fauna in Coastline Wetland Sites: the Albufera of Valencia*'.

[3] Picazo-Tadeo and Reig-Martínez (2006) find empirical evidence supporting the existence of a relationship between outsourcing and efficiency in citrus farming.

6. RESULTS AND DISCUSSION

Our first finding comes from the conventional *PAM* and shows that in the *Albufera* rice farming is a non-profitable agricultural system. The lack of social profitability is even more noteworthy than farmers' private losses. Lack of policy support shows up in output valuation, which goes down, and in the elimination of subsidies. Costs are also lower at social prices, but not enough to compensate for the income loss. The main item with a different valuation at social and private prices is land, because the social opportunity cost of the land rent is zero, as was previously justified.

The computation of the *PCR* and the *DCR* expound the basic weaknesses of this farming system (*Table* 7). The remuneration of the domestic factors per hectare exceeds the value added per hectare by 12 per cent, when computed at private prices, and by 40 per cent when computed at social prices. Rice farming in the *Albufera of Valencia* lacks any comparative advantage *vis-à-vis* the international market, in purely economic terms. The *SRP* amounts to 16 per cent. The increase in private revenues over social revenues, as a consequence of trade protection, market regulations and environmental payments, represents the main way of operating social transfers to rice farmers.

Table 7

PRIVATE AND SOCIAL PROFITABILITY INDICATORS FOR RICE CULTIVATION IN THE *ALBUFERA* OF VALENCIA.

Indicator	Including land rent in domestic costs (a)		Including land rent in profits (b)	
	***PAM* on observed data**	***PAM* on profit-efficient data**	***PAM* on observed data**	***PAM* on profit-efficient data**
PCR	1.12	0.83	0.84	0.57
DCR (c)	1.40	0.91	1.40	0.91
SRP	0.16	0.16	0.58	0.54

(a) Including the private valuation of land rent in cells C and G. A value equal to zero at social prices has been assumed for the land rent.

(b) Including land rent in cells D and H.

(c) Corresponds to the scenario of the reform of the CMO for rice in the *Mid-Term Review*.

Turning now to the *PAM* constructed using profit-efficient productive plans, we can observe that some impressive changes have taken place. Now profits are being made, both at private and social prices. Private revenue goes up by 7.4 per cent and social revenue by 11 per cent. Private costs diminish by 18 per cent and social costs by 24 per cent. The main savings correspond to the reduction in the use of herbicides and, particularly, to a sharp decrease in the use of labour. The expenditures linked to the use of capital are also reduced when farms adopt the best cultivation practices of profit-efficient farms. Bridging the gap between current inefficient management practices and the efficient ones takes the average farm from a net loss of 309 € per hectare to a net profit of 473 € per hectare. Negative economic returns at social prices also turn to profits. Furthermore, under our *efficient* scenario, both the *PCR* and the *DCR* remain below unity, pointing to the ability of this rice farming system to create value for the growers and also to add to national income at social prices (see again *Table* 7).

There is thus a sharp contrast between profitability under observed conditions and under efficient ones. Under observed (non-efficient) conditions, only if the land rent were not included in the domestic factor costs and added to profits would farmers obtain positive returns. The amalgamation of pure entrepreneurial profits and the remuneration of land, allows those farmers that cultivate their own land to resist short-term competitive pressures to adjust to a higher farm size or to abandon farming. But in the long term it seems clear that the opportunity costs of all farm assets need to be considered in order to evaluate the economic alternatives that farmers have to face.

7. SUMMARY AND CONCLUDING REMARKS

In this paper we have analysed the private and social profitability of a rice farming system located in the *Albufera Natural Park*, a Mediterranean Spanish protected wetland site of great ecological value. The analysis has been conducted under the *CAP*'s post-2003 policy environment. On the one hand, a *PAM* based on observed data has been constructed. The results show that the average farm makes losses, both at private and social prices, when the opportunity costs of all domestic factors involved in rice production are taken into account. In the long run the survival of this system is clearly compromised because of its lack of international competitiveness, an outcome that could seriously endanger the preservation of a highly regarded semi-natural landscape and of a wealth of biodiversity.

On the other hand, we have tried to ascertain whether pursuing a strategy of efficiency-augmenting managerial changes, based on the dissemination of the performance of the best practice farms in our sample, could take us to a substantially better scenario. With this purpose, we have used *DEA* to calculate the productive plans that allow individual farms to become profit-efficient. An *efficient PAM* has been built on the basis of this information, yielding new estimates of private and social profitability. Now, farms are able to make positive profits and the society also obtains a net welfare gain from the resources allocated to rice production. So, an increase in the efficiency of rice growing may allow its financial viability and guarantee the preservation of its role in providing environmental public goods.

It could be argued, with regard to the lack of social profitability of rice farms with observed data, that *social profitability* is too narrowly defined in the *PAM* context. The *PAM* methodology could be enlarged by including in the *social* row of the matrix the valuation of the public goods (landscape and biodiversity among them) jointly produced with the private or commercial output. A trade-off could then arise between negative economic returns and the production of non-commercial, i.e. *multifunctional*, outputs. We have not pursued this line of thinking. The lack of relevant empirical information that could be used for widening the scope of social efficiency, prevents us from providing a sound justification of private and social losses grounded in society's quest for non-commodity outputs from agriculture. Instead, we have explored the analytical possibilities offered by computing a *virtual PAM*, assuming profit maximisation on the part of farmers. This has served us to assess whether a way out exists from the current financial difficulties experienced by rice growers, which could allow the maintenance of valuable non-commercial functions currently performed by this farming system. Our findings point to a very positive outcome, both in terms of private and social profits, after farmers adopt the best practices of efficient farms.

Finally, we would like to highlight a couple of conclusions of our research. On the one hand, we believe that our results lead to a noteworthy conclusion of economic policy. In order to preserve the non-marketable function of the Albufera rice system linked to the protection of biodiversity and the environment, greater efforts need to be made by local and regional authorities to spread the adoption of best practices among rice farmers, helping them to improve their profit efficiency and financial viability. On the other hand, it vindicates the potential of the *Policy Analysis Matrix* to yield fruitful information about particular farming systems. Furthermore, the usefulness of this methodological approach may be substantially enhanced if the analyst can simulate the profitability of the system *after* all sorts of efficiency-improving changes have been adopted by farmers.

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SÍNTESIS

PRINCIPALES IMPLICACIONES DE POLÍTICA ECONÓMICA

Existe un reconocimiento creciente de que, conjuntamente con su función primaria de producir alimentos y fibra, la agricultura genera externalidades positivas –protección del medioambiente o preservación de la biodiversidad, entre ellas– que pueden ser consideradas como *bienes públicos*. Se trata de bienes que no se comercializan en el mercado y cuya oferta ha de decidirse, en consecuencia, a través de los mecanismos propios de la *Hacienda Pública*.

En esta investigación se evalúa la rentabilidad del cultivo del arroz en el *Parque Natural de la Albufera* de Valencia, bajo el sistema de apoyo establecido por la *Política Agraria Común* tras su reforma del año 2003. El interés en analizar este sistema agrícola reside en la importancia de las externalidades medioambientales generadas por las explotaciones arroceras y la necesidad de preservarlas, así como por la exigencia de reforma de la *Política Agraria Común* para adaptarse a una tendencia general hacia la liberalización del comercio internacional, que, previsiblemente, implicará una reducción de las ayudas públicas al sector.

Con este propósito, se utiliza una aproximación metodológica basada en el cálculo de *Matrices de Análisis de Políticas*. Este instrumento permite evaluar el impacto sobre los ingresos, gastos y rentabilidad de las explotaciones, de las políticas públicas de apoyo al sector, así como de otras políticas que distorsionen el funcionamiento de los mercados. Esta valoración puede realizarse en términos estrictamente privados o, también, sociales, esto es, desde la perspectiva del conjunto de la sociedad. En primer lugar, se calcula una matriz de políticas *convencional* utilizando datos observados sobre ingresos y gastos. Adicionalmente, se construye una matriz *eficiente* calculada usando datos correspondientes a los planes productivos que maximizarían el beneficio de las explotaciones arroceras, obtenidos a partir de técnicas de *Análisis de la Envolvente de Datos* y programación matemática. El interés de este planteamiento reside en el hecho de que la evaluación de la rentabilidad privada y social de este sistema agrario, así como el impacto de las políticas de apoyo a los ingresos de los agricultores, podría ser considerablemente diferente bajo ambos escenarios, observado y eficiente.

Los resultados obtenidos a partir del análisis de la matriz convencional revelan una importante carencia de rentabilidad del cultivo del arroz, incluso cuando se incluyen en las fuentes de ingresos de los productores las ayudas concedidas por la *Política Agraria Común*. En consecuencia, la supervivencia de este sistema agrario se encuentra comprometida, circunstancia que podría poner en peligro los bienes públicos generados conjuntamente con la producción de arroz. Contrariamente, cuando la matriz de políticas se construye con los planes productivos eficientes que maximizarían el beneficio, la explotación media es capaz de generar un beneficio privado, a la vez que la sociedad también obtiene ganancias netas de los recursos asignados a mantener la producción de arroz. Consecuentemente, una mejora en la gestión empresarial de las explotaciones garantizaría su viabilidad financiera, preservando así la provisión de los bienes públicos generados por este sistema agrario en el *Parque Nacional de la Albufera*.

Los resultados obtenidos en esta investigación conducen a una recomendación relevante de política económica. Al margen de los mecanismos de apoyo a la producción de arroz establecidos por la actual *Política Agraria Común*, para preservar la función no comercial de las explotaciones arroceras en el *Parque Nacional de la Albufera*, vinculada a la producción de bienes públicos como la conservación del medioambiente y la biodiversidad, es necesario potenciar el uso de las mejores prácticas productivas.

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