The policy analysis matrix with profit-efficient data: evaluating profitability in rice cultivation

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Abstract

This paper combines policy analysis matrix and data envelopment analysis techniques to model the analysis of profitability from farming. Policy analysis matrices are computed for a sample of rice growers located in the wetland of the *Albufera* (Eastern Spain) under observed conventional and profit-efficient farming conditions. While conventional analysis points to a lack of profitability, farmers are shown to make positive profits at private and social prices when data reflecting efficiency adjustments are used in the analysis. The main conclusion is that the usefulness of the policy analysis matrix might be substantially enhanced by simulating profitability after efficiency-improving managerial decisions have been adopted.

Additional key words: *Albufera* Natural Park, data envelopment analysis, European common agricultural policy, multifunctionality.

Resumen

La matriz de análisis de políticas con datos eficientes: evaluación de la rentabilidad del cultivo del arroz

Este trabajo combina la matriz de análisis de políticas y las técnicas de análisis envolvente de datos para modelizar el análisis de la rentabilidad de la agricultura. Se calculan matrices de análisis de políticas para una muestra de cultivadores de arroz ubicados en el marjal de la Albufera (Este de España) con datos observados y datos eficientes resultantes de un proceso de maximización de beneficios. Mientras el análisis convencional apunta a una falta de rentabilidad, cuando se introducen en el análisis datos que reflejan un comportamiento eficiente los agricultores obtienen beneficios, tanto a precios privados como sociales. La principal conclusión es que la utilidad de la matriz de análisis de políticas puede reforzarse sustancialmente simulando la rentabilidad que se obtendría después de la adopción de decisiones de gestión orientadas a mejorar la eficiencia.

Palabras clave adicionales: análisis envolvente de datos, multifuncionalidad, Parque Natural de la *Albufera,* política agrícola común.

Introduction

This paper evaluates the private and social profitability of farming systems by combining the use of two different tools: the policy analysis matrix (PAM) and data envelopment analysis (DEA). Since the seminal work by Monke and Pearson (1989), the PAM has been widely employed to compute market-driven and social profits for a variety of farming systems under different technological and institutional scenarios. Here, it is

Abbreviations used: CAP (common agricultural policy), c.i.f. (cost, insurance and freight), CMO (Common Market Organisation), DEA (data envelopment analysis), DRCR (domestic resource cost ratio), EU (European Union), f.o.b. (free on board), OECD (Organisation for Economic Cooperation and Development), PAM (policy analysis matrix), PCR (private cost ratio), SRP (subsidy ratio to producers).

shown that important additional insights might be obtained if the farmers' efficient behaviour is considered, in addition to their observed behaviour.

This methodological approach is applied to rice farming in the Albufera Natural Park, a coastal wetland with great ecological value and located in the Eastern Spanish region of Valencia. This empirical application responds to the concern over whether or not those European farming systems that can be deemed multi-functional, because of the important environmental functions performed, will be able to survive in the policy context of the post-2003 common agricultural policy (CAP).

The CAP of the European Union (EU) is currently evolving under the combined pressure of internal requirements for change and the need to adjust in advance to future international trade agreements. The Uruguay Round of the GATT (1986-94) paved the way for an improvement in the access of third country 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 (Swinbank, 2005). 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 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 the non-commodity outputs of European agriculture. There is a growing recognition that, beyond its primary function of supplying food and fibre, agriculture can provide environmental benefits and contribute to the sustainable management of renewable natural resources, as well as to the preservation of biodiversity, and the maintenance of the economic viability of less favoured rural areas. These new concerns are frequently summarised under the heading of multifunctional agriculture and have become an integral part of the European model of agriculture (EC, 1999, 2000). The research concerning the multifunctional character of agriculture is no longer restricted to international trade policy. A recent book included a variety of papers on different aspects of the multifunctionality of agriculture, focusing on the Spanish case (Gómez-Limón and Barreiro, 2007), while Spanish research on multifunctionality is reviewed in Reig (2006). Furthermore, starting with a basic piece of analysis by the OECD (2001), a variety of analytical tools to be used in the modelling of multifunctionality have been discussed in the last few years (Randall, 2002; Buysse *et al.*, 2007) and some of them, mainly concerned with assessing social preferences, have been put to use in Spain (Gómez-Limón and Atance, 2004; Kallas *et al.*, 2007).

Rice (*Oryza sativa* L.) farming provides an interesting case of a multifunctional crop that performs an important ecological role and where the EU 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).

The private and social profitability of rice farming is assessed, as previously noted, using the PAM. In addition, this paper goes one step beyond conventional profitability analysis: instead of adopting a purely static viewpoint based on what farmers are currently doing, the perspective of what they could do in order to rise to the challenge posed by international competition is introduced. 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, a clear distinction between observed and efficient farming behaviour is drawn, leading respectively to observed and efficient outcomes. The estimates of the efficient levels of input use, income, costs and profits are computed using DEA. Efficient[1] conditions are

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[1] In this paper *efficiency* is used with two different meanings. One, as in the present paragraph, refers to the adjustment of farms' input and output vectors to achieve maximum profits, for a set of prices, fixed factors and the current state of technology. It is used in connection with DEA computations. The other, used in connection with the PAM, 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.

potential for most of the farms and represent the productive plans that would prevail if farms were optimally operated, in terms of profit-efficiency.

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 would happen if the current farming practices of some individual farmers were inefficient when compared to best practices under presently available technologies?

The answer to this question has important economic policy implications. The impact of agricultural policies on farmers' income 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 could provide a useful benchmark for current production practices, showing whether enough room exists for an improvement in farms' financial situation.

Data and sample: the Albufera Natural Park

The Albufera Natural Park is a coastal wetland complex located nearby the Metropolitan Area of the city of Valencia (Eastern Spain). It protects 21,120 ha of wetlands and was declared a Natural Reserve by the Valencia Regional Government in 1986 and a *Ramsar* site[2] in 1990. The Albufera is a fresh water coastal lagoon, fringed by rice fields that cover a surface area of 14,350 ha.

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. Flooded rice fields around the lake provide the predominant regional feeding area for bird species such as 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. It has been estimated that at least twenty five bird species of European conservationist concern use the rice fields in Eastern Spain during the winter, or as a place to rest and feed during their migrations (Fasola and Ruiz, 1997).

The dataset used in this paper corresponds to a sample of 131 single crop rice farms located in the Albufera Natural Park. The data were collected from a comprehensive survey carried out by the authors with support from the Spanish Ministry of Science and Technology, and correspond to the year 2004. The dataset provides data for one output and seven inputs. Output is measured in kilograms of rice production. The only fixed input is cultivated land, measured in hectares. Variable inputs are: labour (working days), in addition to capital, fertilisers, seeds, herbicides and fungicides, all of which are measured in euros. Table 1 presents a sample description for the data.

Labour input includes both family labour, embracing the farmer's and his family's on-farm labour, and hired

Table 1. Sample description

Variable	Description	Units	Quantities		Price (€ per unit)
			Mean	**Standard deviation**	
Output	Rice	kg	34,712	62,208	0.24
Fixed input	Cultivated land	ha	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

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[2] The *Convention on Wetlands of International Importance especially as Waterfowl Habitat*, signed in 1971 in the Iranian city of Ramsar.

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.

The price of rice has been established at 0.24 € kg⁻¹, and 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 price differentiation. 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 differences in price. Finally, as fertilisers, seeds, herbicides and fungicides have all been measured by total expenditure, their price has been conventionally set to one[3].

The calculation of PAM matrices also involves the prices paid for the services of fixed production factors. The private rent of land has been established according to the most common quote for transactions in the local farmland rent market, which is currently around 721 € ha⁻¹. Input and output prices are displayed in Table 1.

Computation of profit-maximising productive plans with DEA

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 the computation of technological frontiers offer a suitable framework for evaluating firms' relative performance and designing productive plans that maximise firms' profits.

In agriculture, it has been occasionally argued that some farmers would not actually follow a profit maximising strategy, but rather a strategy aimed at maximising a utility function that does not necessarily match the profit function (Gómez-Limón *et al.*, 2004). In order to test for this possibility, rice growers interviewed in our survey were asked to manifest their degree of agreement with the following assertion: «*the most important target for a farm is to maximise profit*». Possible responses ranked from 1 (total agreement) to 5 (total disagreement), 3 being the neutral answer. Based on this scale of responses, nearly 80% of farmers declared their agreement or total agreement with this statement. Thus, we can assume that rice growers in the Albufera tend to follow a profit maximising strategy and then evaluate their relative performance.

Here, 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), while 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; also Alvarez-Pinilla, 2001).

Computing the productive plan that maximises short-run profit for farm *k'* requires its actual observed output and input data to be compared to those of the farms showing best observed practices, i.e. profit-efficient farms[4]. Formalising, the profit maximising combination of variable inputs and output of farm *k'* arises from the following program:

$$\text{Profit}\left(r, p, x_f^{k'}\right) = Max_{x_v^{k'}, y^{k'}, z^{k'}} \left(r y^{k'} - \sum_{v=1}^{6} p_v x_v^{k'}\right) \quad [1]$$

subject to:

$$y^{k'} \leq \sum_{k=1}^{131} z^k y^k \qquad (i)$$

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[3] Private prices include *VAT*. A lack of information prevents us from consider whether a net tax or a subsidy is being implied by the current tax system for farm operators.

[4] *DEA* is a deterministic approach to efficiency measurement that attributes all departures from a profit-efficiency status to managerial inefficiencies. Nonetheless, it should be noted that in practice these departures might also obey to any unmeasured or uncontrolled factors related to profit maximisation, such as the effect of luck, be it good or bad.

Table 2. Observed and short-run profit-maximising productive plans (averages per ha)

Variable	Units	Observed	Profit-maximising	Variation (%)
Output				
Rice	kg	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

$$x_f^{k'} = \sum_{k=1}^{131} z^k x_f^k \quad f=1 \qquad (ii)$$

$$x_v^{k'} \geq \sum_{k=1}^{131} z^k x_v^k \quad v=1,...,6 \qquad (iii)$$

$$z^k \geq 0 \qquad k=1,...,131 \qquad (iv)$$

$$\sum_{k=1}^{131} z^k = 1 \qquad (v)$$

y^k, x_f^k and x_v^k being the observations of output and both fixed and variable inputs of farm k, respectively. Furthermore, r and p_v are the output and variable input prices respectively, while 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 noted, it has been considered that the only fixed input is land, while the six variable inputs are fungicides, herbicides, fertilisers, seeds, labour and capital. The computation of program [1] for each rice farm in the sample shows that achieving profit-efficiency involves, on average, 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.

Construction of the PAM for rice cultivation in the Albufera Natural Park

The policy analysis matrix: theoretical aspects

The 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 of a particular policy or the adoption of a new technology on income, costs and profits. Table 3 shows a simplified PAM.

The rows of the matrix respectively represent: i) private profitability from farming production ($D = A - B - C$); ii) social profitability ($H = E - F - G$); iii) divergences between private and social valuations of revenue, costs and profits. They represent a net balance from the

Table 3. 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 efficiency-restoring policies	I	J	K	L

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 a breakdown of costs into two components, tradable inputs and domestic production factors. The so-called intermediate inputs, like fertilisers 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 allows different ratios to be constructed, 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:

$$PCR = \frac{C}{(A-B)} \qquad [2]$$

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 if the quotient is lower than or equal to unity.

(ii)   Domestic Resource Cost Ratio:

$$DRCR = \frac{G}{(E-F)} \qquad [3]$$

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

(iii)   Subsidy Ratio to Producers:

$$SRP = \frac{L}{E} = \frac{(D-H)}{E} \qquad [4]$$

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 economic policy is subsidising 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 various developing countries (Nelson and Panggabean, 1991; Pearson *et al.,* 1995; Yao, 1997; Adesina and Coulibaly, 1998; 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). The results of PAM analysis are always contingent to a specific set of output and input prices and input/output technical coefficients, but matrices can be updated to incorporate both technological and price changes.

In this paper, the PAM methodology is employed in order to learn about the possibilities of maintaining rice cultivation in the Albufera Natural Park. As previously noted, two different matrices are built. The first is based on the observed values for inputs and outputs, revenue, costs and profits. The second matrix, which is termed efficient, is computed using the values of these variables adjusted to their respective profit-efficient levels. A fundamental assumption here is that improving farm efficiency does not negatively impact the production of environmental services in this particular ecosystem. Because the Albufera Park's and environmental legislation forbids agricultural practices that are judged

damaging to the environment, this appears to be a reasonable assumption.

Computation of the conventional PAM matrix

A matrix was initially constructed on the basis of the techniques and costs observed in existing agricultural practices. Yields and input/output coefficients were obtained from the dataset and pricing conventions corresponding to the private prices row of the matrix which have already been described. Social prices were obtained from 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).

Land rent at social prices is set equal to zero, given the impossibility of growing alternative crops on the land presently devoted 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. It is true that recreational activities or fishing could be carried out in this area, but not in the rice farmed plots. The Albufera lagoon, located in the centre of the Natural Park, is where such activities (tourism, professional fishing) are currently, and in the foreseeable future, taking place.

The *input-output tables* for the Valencian Region (Instituto Valenciano de Estadística, 1995) have been used to break down intermediate input costs into their tradable and domestic factor components. Value added tax has also been separated from the private prices of the tradable goods, as has the EU's external tariff rate, in order to obtain social prices.

Only slight differences remain between the valuations at private and social prices 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 of paddy rice, the differences between domestic farm prices and international prices are significant and reflect the protection that the CAP grants to European growers. It has been considered an international or social price of 0.21 € kg^{-1}, which includes a cost of 0.04 € 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 «Data and sample: the Albufera Natural Park», at 0.24 € kg^{-1}.

The analysis has been completed by incorporating the support mechanisms for rice production, which came into force in the EU during 2005-06 (Regulations 1785/2003 and 1782/2003; OJ, 2003a,b), after the *Mid-Term Review* of the CAP. According to this legislation, rice farmers in the Albufera Natural Park are currently granted a coupled subsidy of 476.25 € ha^{-1}, in addition to a decoupled subsidy of 647.70 € ha^{-1} as a single payment. The effects of these support instruments on private profitability are supplemented by the agri-environmental payments being applied in cultivation areas included in the Ramsar list. These payments represent a compensation for the costs incurred by adopting environmentally-friendly cultivation techniques and amount to 397.63 € ha^{-1} for rice farmers in the Albufera Natural Park. Both agri-environmental payments and coupled subsidies have been included in the computation of revenue per hectare at private prices, but not the decoupled subsidies, as they do not include any obligation on farmers to grow rice. Table 4 shows the conventional PAM.

Recalculating the PAM matrix with profit-efficient data

Computing profit-maximising productive plans with DEA has allowed us to construct a virtual and representative farm that is termed efficient. This farm obtains higher revenue than the average observed farm, because yields per hectare are increased by almost 11%. The efficient farm also has lower costs than the average farm in the sample, because inputs are more economically managed (see Table 2). The main savings stem from a 52% reduction in labour costs[5]. Revenue increases and

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[5] A further hypothesis here is that substituting outsourced labour for family labour allows a more efficient use of the workforce (Picazo-Tadeo and Reig-Martínez, 2006, find empirical evidence supporting the existence of a relationship between outsourcing and efficiency in citrus farming).

Table 4. Policy analysis matrix computed under oberved productive plans (€ ha⁻¹)

	Income	Costs										Profits
		Tradable inputs					Domestic factors					
		Fungi-cides	Herbi-cides	Ferti-lizers	Seeds	Others[a]	Labour	Capital	Land	Others[b]		
Private prices												
Output value	1,975	44	105	80	31	69	962	911	721	235		–309
Agri-environmental payments	398											
Coupled 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 process of drying rice. [b] Other fixed costs: costs of water management, real estate taxes and harvest insurance.

cost-cutting results in a remarkable improvement in rice farms' financial situation.

The revenue and cost figures of the efficient farm are used to build a new PAM. After some minor adjustments, such as increasing drying costs to reflect the increase in yields per hectare, the cells of this PAM have been computed by using the same pricing conventions and decomposition into tradable and non-tradable intermediate inputs as in constructing the conventional PAM. In addition, the same provisions have been made to reflect how private revenues are affected by policy measures arising from the agri-environmental payments and the coupled subsidies granted by the EU to rice farmers in the Albufera Natural Park. The private and social profitability of rice farming computed under productive plans that maximise profits are shown in Table 5.

Results and Discussion

The first finding comes from conventional PAM analysis and shows that rice farming in the Albufera was a non-profitable agricultural system, according to the conditions prevailing in 2004, in the aftermath of the *Mid-Term* CAP reform. The lack of social profitability is even more noteworthy than farmers' private losses. Lack of policy support shows up in output valuation, which drops, and in the elimination of subsidies. Costs are also lower at social prices, but not enough to

Table 5. Policy analysis matrix computed under profit-efficient productive plans (€ ha⁻¹)

	Income	Costs										Profits
		Tradable inputs					Domestic factors					
		Fungi-cides	Herbi-cides	Ferti-lizers	Seeds	Others[a]	Labour	Capital	Land	Others[b]		
Private prices												
Output value	2,188	41	75	84	32	76	511	813	721	235		473
Agri-environmental payments	398											
Coupled 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.

Table 6. 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
Private cost ratio	1.12	0.83	0.84	0.57
Domestic resource cost ratio[c]	1.40	0.91	1.40	0.91
Subsidy ratio to producers	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 Common Market Organisation (CMO) for rice in the Mid-Term Review.

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 explained previously.

The computation of the *PCR* and the *DRCR* expound the basic weaknesses of this farming system (Table 6). The remuneration of the domestic factors per hectare exceeds the value added per hectare by 12%, when computed at private prices, and by 40% 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%. The increase in private revenue over social revenue, as a consequence of trade protection, market regulations and environmental payments, represents the main way of operating social transfers to rice farmers.

Turning now to the PAM constructed using profit-efficient productive plans, some impressive changes have taken place. Now profits are being made, both at private and social prices. Private revenue goes up by 7.4% and social revenue by 11%. Private costs diminish by 18% and social costs by 24%. 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 efficient ones takes the average farm from a net loss of 309 € ha⁻¹ to a net profit of 473 € ha⁻¹. Negative economic returns at social prices also turn to profits. Furthermore, under the efficient scenario both the *PCR* and the *DRCR* 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 6).

There is thus a sharp contrast between profitability under observed and efficient conditions. 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 greater 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.

Concluding remarks

This paper performs a modelling exercise on the private and social profitability of a rice farming system located in the Albufera Natural Park, a protected wetland site of great ecological value located in the Spanish Mediterranean coast. In doing so, the policy analysis matrix and techniques of efficiency analysis based on data envelopment analysis are combined. 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 the 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 both a highly regarded semi-natural landscape and also a wealth of biodiversity.

On the other hand, it has been ascertained whether pursuing a strategy of efficiency-augmenting managerial changes, based on the dissemination of the performance of the best practice farms in the sample, could take us to a substantially better scenario. With this purpose, DEA is used 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 make this activity financially viable and guarantee the preservation of its multifunctionality. Also, PAM-based policy advice concerning the impact of distorting and efficiency-restoring policies on the profitability of rice growing is distinctively different under observed and profit-maximising scenarios.

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, because it does not include a direct appraisal of the worth of the positive environmental externalities that stem from rice cultivation. The PAM methodology could be extended by including the valuation of the public goods (landscape and biodiversity among them) jointly produced with the private or commercial output in the social row of the matrix. A trade-off could then arise between negative economic returns and the production of non-commercial, i.e. multifunctional, outputs. However, this line of thinking has not been pursued in this paper.

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 on society's quest for non-commodity outputs from agriculture. But differences between private and social profits per hectare can be used to establish a lower threshold for the valuation of the annual supply of public good services jointly produced with rice output. Then, the computed figure can be compared with an independent estimate, e.g. contingent valuation, of the value of those services to the public[6].

Instead of pursuing a line of analysis that concentrates on the construction of an environmental PAM, the possibilities offered by computing a virtual PAM, assuming profit maximisation on behalf of farmers, is explored. This helps to assess whether there is a way out of the current financial difficulties rice growers are experiencing that could allow the valuable non-commercial functions currently performed by this farming system to be maintained. The 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, it is worth highlighting a couple of the conclusions of this research. On the one 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. On the other hand, the results of this research lead to a noteworthy conclusion in terms 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, local and regional authorities need to make a greater effort to spread the adoption of best practices among rice farmers, helping them to improve their profit efficiency and financial viability.

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[6] See a valuation of an individual's willingness to pay to visit the Albufera Natural Park for recreation purposes in Del Saz and Suárez (1998).

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