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Optimal taxation with joint production of agriculture and rural amenities[1]

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Abstract

We show that, when there is *joint production* of an agricultural good and rural amenities, the first-best allocation of resources can be implemented with a tax on the agricultural good and some subsidies on the production factors (land and labor). The use of a subsidy on the agricultural good can only be explained by the desire of the policymaker to redistribute income from the consumers to the farmers.

1 Introduction

It is increasingly recognized that agriculture, as well as supplying food and fiber, generates externalities, both positive and negative (Hodge (2000), Harvey (2003), Abler (2003)).[1] The present paper focuses exclusively on positive externalities. These can be classified in at least four categories (Swinbank (2001)): (*i*) conservation of biological diversity, meaning the numbers species and individuals of flora and fauna; (*ii*) maintenance of farmed landscapes, including cultivated and semi-natural habitats and landscapes features, such as terracing; (*iii*) preservation of cultural features, including historical remains on farmland and land uses of cultural significance; and (*iv*) protection against disasters, whether natural or induced (exacerbated) by human intervention, such as flooding, fire, avalanche, and severe erosion caused by wind or water. We will henceforth use the generic term *rural amenities* to refer to all the positive externalities associated with agricultural production.

The role of agriculture as a provider of rural amenities, jointly produced with commodity outputs, is captured by the term "multifunctionality". A formal definition is given in the report from OECD "Multifunctionality: Towards an Analytical Framework" (p. 13). The key elements of multifunctionality are: (*i*) the existence of multiple commodity and non-commodity outputs that are jointly produced by agriculture, and (*ii*) the fact that some of the non-commodity outputs exhibit the characteristics of externalities or public goods, with the result that markets for these goods do not exist or function poorly.

These two points are at the core of the WTO debate between two groups of

[1] A typical example of a negative externality is pollution.

countries. Countries with high levels of support (especially Japan and the European Union) argue that farm subsidies are the efficient way to elicit the public goods that are by-products of farm output. At the other extreme, the United States and members of the Cairns group question whether the public good values are truly significant, and claim that so-called environmental safeguards are just trade-distorting protectionism in disguise (Swinbank (2001)).

The market incompleteness or at best underprovision that characterize rural amenities makes public intervention inescapable. However one might envisage that these non-commodity outputs could be produced outside the agricultural sector, avoiding the production and trade distortions so undesirable in the eyes of the WTO. Clearly, however, there are *economies of scope* in the provision of agricultural products and rural amenities, and for this reason, it is efficient to produce both outputs jointly (Le Cotty and Voituriez (2003)).

As soon as the positive externalities associated with agriculture are recognized, and moreover, that it is less costly to generate these rural amenities through agricultural production rather than separately, the efficient response by the public authority is bound to distort output relative to the level that would be produced without intervention, and hence violate WTO recommendations (Blandford and Boisvert (2002), Peterson, Boisvert and de Gorter (2002)). Specifically, The Uruguay Round agreement on agriculture identifies a class of subsidies, the so-called "green box" measures, that are permissible forms of support, since they are considered to have no or minimally distorting effects on production or trade. Annex 2 of the Agreement on Agriculture specifies that a green-box measure must satisfy two basic criteria: (a) "(it) shall be provided through a publicly-funded government programme not involving transfers from consumers; and, (b) (it) shall not have the effect of

providing price support to producers". According to Blandford et al. (2003), "payments that are part of clearly defined environmental or conservation programs that are linked to production methods are permissible, provided that these are limited to extra costs or loss of income caused by compliance. It is also permissible to use payments to remove land from production. What seems to be problematic is the use of payments that encourage production of a particular commodity, even if the positive externality or public good depends upon such production. [...] The restriction on the linkage between payments and production is understandable if one assumes that any level of production in excess of that under free trade prices represents a distortion. It is less convincing if missing markets imply that the level of production under free trade would itself be distorted". Blandford and Boisvert (2002) add: "We would argue that when agriculture produces positive externalities or public goods, the issue should not be viewed as one of providing 'subsidies' to producers, but rather of providing the remuneration necessary to bring forth a socially optimal supply. The term "subsidy" has often been interpreted in a pejorative manner and used as a proxy for 'distortion"'.

We share these points of view and, in this paper, push the analysis further by exploring the nature of socially optimal policies when agriculture generates rural amenities. Related papers are Lankoski and Ollikainen (2003, 2005) and Peterson et al. (2003). While the first authors have a quite different approach, our study is closely related to the one by Peterson et al.[2]

We consider a model that fulfills the two conditions above for a multifunctional agricultural sector: there is no market for rural amenities and there

[2]Our work can be viewed as an optimal taxation exercise, and as such can be related to Sandmo (1975), who studies the optimal commodity tax schedule when there are some consumption externalities. He is however not concerned about the joint production issue.

is joint production. Following Boisvert (2001), joint production occurs when: (*i*) there are technical interdependencies in the production process; and (*ii*) outputs are produced from a non-allocable input; or (*iii*) outputs compete for an (allocable) input that is fixed at the firm level. When the interlinkage between the outputs is caused by technical interdependencies in the production processes, production of either output depends not only on the amount of the factor allocated to this output, but also on the level of the other output. The classic example of a technical interdependency is the joint production of honeybees and fruit trees, where the trees depend on insect fertilization but also provide feed for the bees. Alternatively, product interrelationships can arise from the use of *non-allocable inputs* in the production of multiple outputs, that is, where multiple outputs are obtained from the same input. Classical examples are production of mutton and wool obtained from feeding sheep, and oil and meal from crushing soybeans. In these cases, outputs are produced in fixed proportions. In the context of the multi-functionality debate, a canonical example is the production of meat and landscape by grazing cows on pasture. In such a case, output proportions are not fixed; rather, the proportions in which the different outputs are produced are sensitive to changes in relative prices. A third kind of product interrelationship arises when the factor used in the production of one output can be distinguished from the amount of the same factor used in the production of the others, but the total amount of the factor available to the enterprise is fixed (allocable fixed factor). An example would be a farm producing several commodities from a fixed land base.

In our model, joint production originates from a non-allocable input, which is typically land. Leathers (1991) has shown that the presence of non-allocable inputs engenders some *economies of scope*: the cost of producing m prod-

ucts jointly is less than the cost of producing the products separately. As mentioned above, it is for this reason that it may be socially justifiable to distort the production of the agricultural good. In the absence of such a cost "advantage", it would be preferable not to distort agricultural production and to produce the desired level of rural amenities separately.

In our model, land enters in both the production of the agricultural good A and of rural amenities R. There is a second, non-land, input, interpreted for convenience as labor, that is perfectly allocable: labor used in the production of A does not contribute to the production of R. While consumers would choose to purchase R at a positive price if it were available, there is no market for rural amenities. As a consequence, the provision of rural amenities in the *laissez-faire* allocation is sub-optimal.

We investigate whether in the context of this model, a social-welfare maximizing policy-maker is able to restore *first-best* optimality. Social welfare is defined as a weighted sum of the consumer surplus and producer profit. The weights are interpreted as the political power of these two groups of agents. We show that when the policymaker assigns equal weight to both groups, he chooses a policy that implements the first-best optimum. This policy consists of a *tax* on the agricultural good and subsidies on both inputs (land and labor). When the policymaker places different weights on the two groups, there is a *redistributive motive* that distorts away his choice from the first-best. We show that in order to redistribute income from the consumers towards the farmers, the policy maker may implement a subsidy on the agricultural output. Our general conclusion is that the historically observed high subsidy rates on agricultural goods, and the associated high levels of production of these goods, can be explained as the result of a desire to redistribute income

towards the farmers.

2 Agents of the economy

In the exposition that follows, we distinguish between *producer prices*, denoted by subscripted P's, and *market prices*, denoted by subscripted p's. Any difference between P_i and p_i will be due to a subsidy $s_i > 0$ or tax $s_i < 0$ on input or output i, payable to, or by, producers. The net tax burden is borne by consumers. We denote by $\boldsymbol{P}$, $\boldsymbol{p}$ and $\boldsymbol{s}$, respectively, the vectors of producer prices, market prices and subsidies.

2.1 The production sector

2.1.1 Production functions

Two outputs, an agricultural good A and a non-commodity output R (rural amenities) are produced using two inputs, land n and labor l. Land results in the joint production of both A and R; it is said to be non-*allocable*. On the other hand, we assume that labor is perfectly allocable across the two outputs; labor allocated to the production of good i is denoted l_i. The production function for good i is denoted $F_i(n, l_i)$. It is assumed to be strictly concave in land and labor. We denote by y_A and y_R the production levels of the agricultural output and rural amenities respectively:

$$\begin{aligned} y_A &= F_A(n, l_A) \\ y_R &= F_R(n, l_R). \end{aligned}$$

2.1.2 Profit maximization

Producers choose inputs and outputs levels so as to maximize profits, Π, given the producer prices that they face. Their maximization program is:

$$\max_{n,l_A,l_R} \Pi(\boldsymbol{P}) \quad \equiv \quad P_A F_A(n, l_A) + \phi^P(F_R(n, l_R)) - P_n n - P_l(l_A + l_R), \quad (1)$$

Farmers assign some value $\phi^P(y_R)$ to rural amenities, with $\phi'^P(.) > 0$ and $\phi''^P(.) < 0$, which enhance their working environment. This value may be arbitrarily small. However it has to be positive: as will become clearer below, it ensures that farmers allocate some labor to the production of rural amenities.

We assume that there is no market for rural amenities. The absence of a market for rural amenities is to be expected, given the pure public good nature of rural amenities. To see that amenities are both non-excludable and non-rival, consider for example an aesthetically pleasing agricultural landscape: it is hard to think of a way of excluding people from consuming this good; moreover, at least when consumption levels are sufficiently low that crowding is not a factor, one individual's consumption of the landscape does not detract from another's experience of it. Note that even in the absence of a market some amenities are provided, to meet the private demands of farmers; this level of provision, however, is clearly insufficient to fully satisfy public demand.

The first-order necessary conditions for a solution to the maximization pro-

gram (1) are:

$$\phi'^{P}(y_R)\frac{\partial F_R}{\partial n} + P_A\frac{\partial F_A}{\partial n} - P_n = 0 \quad (2a)$$

$$P_A\frac{\partial F_A}{\partial l_A} - P_l = 0 \quad (2b)$$

$$\phi'^{P}(y_R)\frac{\partial F_R}{\partial l_R} - P_l = 0. \quad (2c)$$

These three conditions allow us to determine the quantity of factors, l_A, l_R and n, chosen by the producer for given prices P_l, P_n and P_A. The corresponding output levels are given by the production functions. The *laissez-faire* equilibrium is obtained from these conditions, with the P's set equal to the corresponding p's.

2.2 Consumers

The framework of analysis is *partial equilibrium*. Accordingly, the consumers have a quasi-linear utility function that depends on three goods: the numeraire c, the agricultural good c_A and rural amenities R. Letting I denote their (exogenous) income and T the tax level, the consumer's utility maximization program is:

$$\begin{aligned} \max_{c,c_A} U(c, c_A, y_R) &\equiv c + u(c_A) + \phi^C(y_R) \\ \text{s.t. } c &= I - T - p_A c_A, \end{aligned} \quad (3)$$

where $u'(\cdot), \phi'^{C}(\cdot) > 0$, $u''(\cdot), \phi''^{C}(\cdot) < 0$ and p_A is the consumer price of the agricultural good. Demand for the agricultural goods is determined by the first-order condition for (3) with respect to c_A:

$$p_A = u'(c_A) \Leftrightarrow c_A = u'^{-1}(p_A). \quad (4)$$

Substituting (4) into the utility function, we obtain the indirect utility function $V(p_A, \Omega; R)$ where $\Omega \equiv I - T$ is after-tax income:

$$V(p_A, \Omega; y_R) = \Omega - p_A c_A(p_A) + u(c_A(p_A)) + \phi^C(y_R). \tag{5}$$

Note that $\phi^C(y_R)$ represents the *aggregate* benefit from rural amenities, rather than the private benefit of a single consumer. From an individual's perspective, we assume that the marginal cost required to produce more amenities (starting from the *laissez-faire*) dominates the marginal benefit. Therefore individual consumers do not find it worthwhile to solicit rural amenities directly from farmers, i.e., to create a market in effect.

2.3 Market equilibrium

We consider a *small open economy*. This implies that the consumer price of the agricultural good, p_A, is fixed at the world level and that the demand for this good, c_A, needs not coincide with production, y_A.

Concerning the factors markets, we assume that the supply curves are completely elastic and thus that the factor prices are fixed. This is of course a very demanding assumption, especially as far as land is concerned. But it allows us to abstract from any effect of public policy on factors prices and as such constitutes a useful benchmark. Furthermore, another reason for making such an assumption is that factors suppliers are absent of the model. Therefore, any analysis of the effect of public policy on factors prices would necessarily have to be incomplete.

3 The first-best

When consumers' utility is quasi-linear, the first-best Pareto optima are obtained by maximizing the sum of consumers' utility and profit when the producer prices are equal to the market prices:

$$\begin{aligned}
&\max_{n,l_A,l_R} V\left(p_A,\Omega;R\right)+\Pi\left(\boldsymbol{P}\right)= \\
&I-p_Ac_A(p_A)+u(c_A(p_A))+\phi^C(F_R(n,l_R)) \\
&+p_AF_A(n,l_A)+\phi^P(F_R(n,l_R))-p_nn-p_l(l_A+l_R) \\
\Leftrightarrow\quad &\max_{n,l_A,l_R}\phi^C(F_R(n,l_R))+p_AF_A(n,l_A)+\phi^P(F_R(n,l_R))-p_nn-p_l(l_A+l_R).
\end{aligned}$$

The associated first-order conditions are:

$$(\phi'^C(y_R)+\phi'^P(y_R))\frac{\partial F_R}{\partial n}+p_A\frac{\partial F_A}{\partial n}-p_n = 0 \tag{6a}$$

$$p_A\frac{\partial F_A}{\partial l_A}-p_l = 0 \tag{6b}$$

$$(\phi'^C(y_R)+\phi'^P(y_R))\frac{\partial F_R}{\partial l_R}-p_l = 0. \tag{6c}$$

Since the F_i's are strictly concave, there is a unique triple, $(n^{\text{fb}}, l_A^{\text{fb}}, l_R^{\text{fb}})$, which satisfies (6). The set of Pareto optimal allocations can be obtained by reallocating the total surplus generated by this solution between consumers and producers.

Let us compare this first-best allocation with the *laissez-faire*. In the laissez-faire equilibrium, too few rural amenities are produced, as their benefits to consumers are not internalized by producers. It follows that the first-best will involve more labor devoted to R and more land. This in turn implies that the marginal productivity of labor used in the production of A ($\partial F_A/\partial l_A$) will be increased and as a consequence more labor devoted to A will be hired.

Therefore, the first-best will entail a larger production of rural amenities *and* of the agricultural good.

4 Public intervention

The instruments available to the policymakers are taxes and subsidies to producers, s_A, s_R, s_l, s_n on A, R, l and n respectively. (Negative values for the s's represent taxes.) Producer subsidies are financed through taxes levied on consumers, while producer taxes are retroceded to consumers. The relationship between producer and market prices is now given by:

$$\begin{aligned} P_A &= p_A + s_A \\ P_l &= p_l - s_l \\ P_n &= p_n - s_n \end{aligned}$$

and the total tax burden on consumers is

$$T = s_A y_A + s_R y_R + s_l(l_A + l_R) + s_n n. \tag{7}$$

For given $\lambda \in [0,1]$, the government's goal is to choose the subsidy vector $\boldsymbol{s}$ that maximizes a weighted sum of the consumers' and the producers' payoff functions:

$$\max_{\boldsymbol{s}} SW \equiv \lambda V\left(p_A, \Omega; R\right) + (1-\lambda)\Pi\left(\boldsymbol{P}\right), \tag{8}$$

the weights λ and $1-\lambda$ can be interpreted as measures of the political power of consumers and producers respectively.

4.1 Implementation of the first-best with a subsidy on rural amenities and lump-sum transfers

When a subsidy on rural amenities and lump-sum transfers are available, the first-best can be achieved by the simultaneous use of these two instruments. To see this, we re-write the first-order conditions (2a)-(2c) with the different tax instruments appearing explicitly:

$$(\phi'^P(y_R) + s_R)\frac{\partial F_R}{\partial n} + (p_A + s_A)\frac{\partial F_A}{\partial n} - (p_n - s_n) = 0 \quad (9a)$$

$$(p_A + s_A)\frac{\partial F_A}{\partial l_A} - (p_l - s_l) = 0 \quad (9b)$$

$$(\phi'^P(y_R) + s_R)\frac{\partial F_R}{\partial l_R} - (p_l - s_l) = 0. \quad (9c)$$

Comparing these conditions with (6a)-(6c), it is clear that by setting $s_R = \phi'^C(y_R^{\text{fb}})$ and $s_A = s_l = s_n = 0$, we obtain an equation system identical to (6), and can thus implement the first-best allocation of resources. Moreover, using lump-sum transfers, the government can implement *any* redistribution of total surplus between consumers and producers, and hence can implement the entire set of Pareto optimal allocations. Thus, the solution to (8) for any $\lambda \in [0, 1]$ consists in using a subsidy on rural amenities and lump-sum transfers.

This result is not surprising. Rural amenities generate positive externalities to the consumers, that the market is unable to internalize. Setting the subsidy at the marginal externality level, $\phi'^C(y_R^{\text{fb}})$, acts like a Pigouvian correction and allows to achieve an efficient allocation of resources. Lump-sum taxes and transfers then serve at redistributing total surplus, without creating any distortion.

This solution is however of little practical interest. First, for most kinds

of rural amenities, there is no natural unit of measurement, and hence no natural way to define a per-unit subsidy. As an extreme example, it is obviously impractical to reward farmers based on the number of units of pleasing countryside they provide! While it is conceivable to make a payment to farmers in exchange for some good environmental practices (cross-compliance), a per-unit subsidy is unrealistic. Second, even though lump-sum transfers are feasible, they have always faced considerable resistance by farmers and have been considered as a useful policy instrument in agricultural policy only recently. Historically, the support to farmers have consisted in distorting price support measures rather than direct payments, the problem with these transfers being that they are easily observable to the general public and as such are considered as "weak" political instruments. Elected representatives prefer to use disguised transfers, such as output subsidies, less visible to the taxpayers and consequently less politically costly (see Coate and Morris (1995) for a theoretical investigation of this argument).

For these two reasons, we believe it most relevant for the current debate over the agricultural policy to understand the efficiency and redistributive implications of taxes/subsidies on goods and factors, when lump-sum transfers are ruled out. We pursue this analysis in the next section.

4.2 Optimal taxes when the subsidy on rural amenities and lump-sum transfers are ruled out

We saw in the previous section that the entire set of first-best Pareto optima can be implemented with a subsidy on rural amenities and lump-sum taxes/transfers. The subsidy is used to generate a maximum total surplus and the lump-sum instruments serve to redistribute this surplus between

producers and consumers. Thus the issues of allocative efficiency and redistribution can be addressed separately.

When lump-sum transfers are ruled out, the issues of equity and income redistribution cannot be separated anymore and a trade-off emerges, except in the special case where $\lambda = 1/2$.

4.2.1 $\lambda = 1/2$

When $\lambda = 1/2$, the government cares equally for both groups in the population and is thus indifferent with respect to the repartition of income. Therefore only efficiency considerations play a role. We characterize in the next proposition the optimal tax mix.

Proposition 1 *Let*

$$\gamma = 1 - \frac{\phi'^P(y_R^{fb})}{\phi'^P(y_R^{fb}) + \phi'^C(y_R^{fb})}.$$

When $\lambda = 1/2$, the optimal tax mix is the following

$$s_A^{fb} = -\gamma p_A \tag{10a}$$

$$s_l^{fb} = \gamma p_l \tag{10b}$$

$$s_n^{fb} = \gamma p_n \tag{10c}$$

This tax system implements the first-best allocation of resources.

To see that this subsidy system is optimal, note that we can multiply both sides of the equation system (6) by $1 - \gamma = \phi'^P(y_R^{\text{fb}})/(\phi'^P(y_R^{\text{fb}}) + \phi'^C(y_R^{\text{fb}}))$ to

obtain

$$\begin{aligned}
\phi'^{P}(y_R^{\text{fb}})\frac{\partial F_R}{\partial n} + (1-\gamma)p_A\frac{\partial F_R}{\partial n} - (1-\gamma)p_n &= 0 \\
(1-\gamma)p_A\frac{\partial F_A}{\partial l_A} - (1-\gamma)p_l &= 0 \\
\phi'^{P}(y_R^{\text{fb}})\frac{\partial F_R}{\partial l_R} - (1-\gamma)p_l &= 0.
\end{aligned}$$

Observing that $(1-\gamma)p_A = p_A + s_A^{\text{fb}}$ and $(1-\gamma)p_i = p_i - s_i^{\text{fb}}$, for $i = l, n$, it is clear that the system (6) is satisfied if and only if (2) is satisfied (with s_R set to 0). In words, this means that profit-maximizing farmers choose the first-best vector of inputs $(n^{\text{fb}}, l_A^{\text{fb}}, l_R^{\text{fb}})$ when confronted to subsidies $(s_A^{\text{fb}}, s_l^{\text{fb}}, s_n^{\text{fb}})$. Hence, the tax system $(s_A^{\text{fb}}, s_n^{\text{fb}}, s_l^{\text{fb}})$ also implements the unique first-best allocation of resources. That is, to achieve this first-best, one needs to tax the agricultural good and subsidize the two inputs.

The intuition for this result is as follows. The *laissez-faire* allocation, implemented by (p_A, p_n, p_l) is sub-optimal because too few rural amenities are produced. In order to increase their production, labor should be subsidized so as to increase the quantity of labor used for rural amenities (see (9c) with $s_R = 0$ and (6c)). To keep relative input prices that producers face in line with relative market input prices, land should be subsidized as well. But if both input prices were subsidized, while the output price of A remained constant, a super-optimal amount of A would be produced. Hence A should be taxed so that the ratio of the labor price to output price remains the same as in the *laissez-faire*.

4.2.2 $\lambda \neq 1/2$

When λ differs from $1/2$, the government is not indifferent anymore with respect to the repartition of income.[3] He thus trades-off the efficiency and redistributive effects of the different subsidies. In order to better understand this trade-off, it is useful to re-write the social welfare function, given in (8), in the following way:

$$\begin{aligned} SW &= \lambda V\left(p_A, \Omega; R\right) + (1-\lambda)\Pi\left(\boldsymbol{P}\right) \\ &= \lambda(\Omega - p_A c_A(p_A) + u(c_A(p_A)) + \phi^C(y_R)) \\ &\quad +(1-\lambda)((p_A + s_A)y_A + \phi^P(y_R) - (p_n - s_n)n - (p_l - s_l)(l_A + l_R)) \\ &= (1-2\lambda)T + \lambda(I - p_A c_A(p_A) + u(c_A(p_A)) + \phi^C(y_R)) \\ &\quad +(1-\lambda)(p_A y_A + \phi^P(y_R) - p_n n - p_l(l_A + l_R)). \end{aligned}$$

As I and p_A do not depend on the various taxes/subsidies, maximizing this function is equivalent to maximize:

$$(1-2\lambda)T + \lambda\phi^C(y_R) + (1-\lambda)(p_A y_A + \phi^P(y_R) - p_n n - p_l(l_A + l_R)).$$

This formulation allows us to separate the redistributive motive, represented by the term $RM \equiv (1-2\lambda)T$, from the efficiency motive, $EM \equiv \lambda\phi^C(y_R) + (1-\lambda)(p_A y_A + \phi^P(y_R) - p_n n - p_l(l_A + l_R))$. As the government wants to maximize the sum of these two functions, the solution adopted will be a compromise between the tax system that is the most efficient (i.e., that maximizes EM) and the one that redistributes the most (i.e., that maximizes RM). We study below these two programs.

[3] For $\lambda < 1/2$, the farmers have a social weight greater than the consumers and thus the government wants to transfer income from the consumers toward the farmers. For $\lambda > 1/2$, it is the opposite.

Optimal allocative subsidies The quantity of the factors needed to maximize the function EM satisfy the first-order conditions:

$$\begin{aligned}(\lambda\phi'^C(y_R) + (1-\lambda)\phi'^P(y_R))\frac{\partial F_R}{\partial n} + (1-\lambda)p_A\frac{\partial F_A}{\partial n} - (1-\lambda)p_n &= 0\\ p_A\frac{\partial F_A}{\partial l_A} - p_l &= 0\\ (\lambda\phi'^C(y_R) + (1-\lambda)\phi'^P(y_R))\frac{\partial F_R}{\partial l_R} - (1-\lambda)p_l &= 0.\end{aligned}$$

Following a reasoning similar to proposition 1, it can be shown that there exist subsidies s_A, s_n and s_l that implement this solution. These subsidies are:

$$\begin{aligned}s_A &= -\beta p_A\\ s_l &= \beta p_l\\ s_n &= \beta p_n,\end{aligned}$$

where

$$\beta = 1 - \frac{\phi'^P(y_R)}{\phi'^P(y_R) + (\lambda/(1-\lambda))\phi'^C(y_R)}.$$

It thus appears that, *if the planner were only concerned with the allocative effect of the subsidies, he would choose to tax the output and subsidize the inputs*. Observe that when the government is only concerned about the farmers ($\lambda = 0$), all the subsidies are set to 0, which corresponds to the *laissez-faire*. The intuition is clear. If the well-being of the consumers is not taken into account, there is no market failure anymore as the positive externalities of rural amenities on the consumers do not matter. Therefore, all the prices should be maintained at their *laissez-faire* level.

Optimal redistributive subsidies We now isolate the redistribution effect. Optimal subsidies from the redistributive point of view solve:

$$\max_{s_A, s_n, s_l} (1 - 2\lambda) (s_A A + s_n n + s_l l) .$$

Obviously this function is increasing with the subsidies if and only if $\lambda < 1/2$. Raising any of the subsidy allows to transfer income from the consumers to the farmers. Conversely, a decrease in the subsidies benefit the consumers, who end up paying less taxes.

The second-best policy The optimal second-best policy strikes a balance between the efficiency and the redistributive motives. The lesson from the previous sections is clear. If the government were only concerned about the allocative role of the subsidies, he would choose to tax the output and subsidize the inputs. The only reason why he may want to implement a subsidy on the agricultural comes from his desire to redistribute income from the consumers to the farmers. Consider for example the case $\lambda = 0$. We know that the efficient subsidies are 0 in this case. The optimal second best policy then consists in subsidizing both the output and the inputs. This is done for redistributive reasons only, so as to transfer income from the consumers to the farmers.

5 Conclusion

We have provided an analysis of the optimal tax/subsidy scheme when one production factor jointly produces an agricultural good and rural amenities. Our main finding is that efficiency calls for some taxation of the output

altogether with some subsidization of the inputs. The only reason why a government maximizing a weighted sum of the consumers' utility and of the farmers' profit may want to subsidize the output lies in his desire to redistribute income from the farmers to the consumers. This analysis thus sheds light on the pervasive use of distorting price support measures that have been so widely use in agricultural policy for many years.

This work rests on a set of specific assumptions that we would like to relax in future research. First, we have considered fixed input and output prices. Some additional insights may be gained by generalizing this model to endogenous prices, with public intervention affecting input and output prices. Second, we have abstracted from any negative externality generated by agriculture, such as pollution, which has of course very important implications for agricultural policy in general, and in particular for the determination of the set of optimal taxes and subsidies. Finally, our model is specific in the sense that one input (labor) is perfectly allocable while the other (land) is not allocable at all. This implies a correspondance between the number of inputs and the number of tax instruments that explains why it is possible to implement the first-best allocation of resources in the absence of a subsidy on rural amenities. With an arbitrary number of non-allocable inputs, this result may not hold true anymore. A proper treatment of this general case is however outside the scope of this paper and should be addressed in future work.

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