Promoting multifunctionality while minimizing trade distortion effects : the relative merits of traditional policy instruments

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Promoting multifunctionality while minimizing trade distortion effects: the relative merits of traditional policy instruments

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Abstract:

In relation to the growing debate around multifunctionality, this paper attempts to classify alternative measures of agricultural income support according to their ability in achieving three policy objectives (supporting agricultural income, promoting positive externalities and reducing negative ones) as well as to their induced trade distortion effects. Four income support programs are considered: a production-linked payment program, a land-based payment program and two decoupled payment programs. Their effectiveness as regards to the three policy objectives and their relatives induce trade distortion effects are examined on an equal cost/support basis through a conceptual framework that allows for free entry in the sector and the land price to adjust endogenously. Analytical results show clearly that no program uniformly dominates others. They also allow to identify the key parameters that have a substantial bearing on the relative merits of these programs.

Keywords: Multifunctionality, trade distortion, agricultural policy, internal support, WTO.

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1. Introduction

Although there is still considerable confusion within WTO (World Trade Organisation) Member States about what is really meant by the term multifunctionality, all countries agree that agricultural production provides food and non-food outputs. Some non-food outputs are not valued by market transactions and hence can be under produced relative to what society may desire. Multifunctionality proponents claim then that production-linked payments are necessary to obtain socially desired non-food benefits because of jointness relationships between agricultural production and non-food benefits. They argue that countries should have more flexibility in the domestic policy design relative to what is currently provided by the provisions of the URAA (Uruguay Round Agreement on Agriculture) green box. On the other hand, multifunctionality opponents argue that the green box provides sufficient flexibility to address non-food benefits, i.e., non-trade concerns, with the least distortions on trade. For these countries, mainly the United States (US) and the Cairns Group (CG), multifunctionality is not a sufficient basis for continuing to pursue production-linked policies, i.e., trade distorting policies according to the URAA classification of support policies. In their view, non-food benefits are better addressed through specific instruments directly linked to public goods and/or positive externalities.[2]

As noted by Bohman et al. (1999), the WTO does not make judgements about countries' agricultural policy objectives under the condition that policy instruments implemented to realize these objectives have no, or at most minimal, trade distortion effects or effects on production (Annex 2 of the URAA).

In this paper and in very general terms, we attempt to classify alternative "traditional" programs of agricultural income support according to their ability in achieving "traditional" goals of agricultural policies and to their induced trade distortion effects. Four income support programs (or instruments) are retained: a production-linked payment program, a land-based payment program and two decoupled payment programs, with or without the requirement to maintain land in agricultural use. Three agricultural policy goals are considered: supporting agricultural income, promoting positive exter-

[2] For a more complete discussion on this opposition, see Lankoski and Miettinen (2000). See also Paarlberg et al. (2000).

nalities and/or public goods provision and correcting negative externalities (pollution).[3] However, as the WTO discipline requires domestic policy programs to have no, or at most minimal, trade distortion effects or effects on production, the WTO rule of "the minimal induced trade distortion" is considered as a fourth "policy objective".

We develop a conceptual framework that allows for evaluating the impact of the four aforementioned programs on endogenous and various target variables. The model is an equilibrium displacement model with three equilibrium equations. The first one is the equilibrium condition in the agricultural output market, with aggregate supply equal to total demand (i.e., domestic demand and exports). The second one is the equilibrium condition in the land market, with aggregate supply equal to aggregate demand, both accounting for trade of land between farmers (Leathers, 1992). The third one is the entry/exit condition permitting the number of firms to be endogenously determined within the model. Hence, the model's endogenous variables are the agricultural output price, the land price and the number of farmers. Knowing the effects of each considered program on these endogenous variables, the model also allows to determine their respective effects on various target variables such as the agricultural income, variable input (mainly fertilizers and pesticides) quantities used per hectare, yields per hectare and agricultural output exports.

One may notice that our analysis is not concerned with efficient or optimal policies. It is interested in examining the extent to which the four retained programs achieve the objectives of income support, positive externality promotion and negative externality reduction, while determining the trade distortions arising from the use of these instruments. For that purpose, the impacts of each program regarding the four considered policy objectives are assessed through four target variables or "policy indicators".[4]

The ability of each program to achieve the policy objective of supporting agricultural income is evaluated through its respective impact on individual farmers' profit. The effect of the four considered programs on agricultural commodity exports is retained as a measure of their induced trade distortion effects. The policy objective of

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[3] We do not consider the issue of price and/or income stabilization as we use a static analysis framework without risk and uncertainty.

[4] Obviously, linking one policy objective to one synthetic indicator rests on rather restrictive assumptions. Hence, it must be kept in mind all along the paper that retained indicators are imperfect. They represent a simple but restrictive mean to evaluate the extent to which one program achieves one policy objective.

promoting the provision of non-food and non-market benefits is simply related to the number of farmers. In fact, following Hueth (2000), we assume that (most) non-food or non-market benefits are directly linked to the number of (high marginal cost) farmers. This is of course a very restrictive assumption. However it allows us to simply represent the multi-product nature of non-food benefits by considering that the society perceives a connection "between the existence of relatively high-cost farm operations and the preservation or sustainability of rural communities" (Hueth, 2000, p. 22). Finally, the policy objective of reducing negative externalities is directly linked to the use of variable inputs per hectare or to yields per hectare. In other words, we assume that negative externalities arise from an "excessive" use of variable inputs (mainly fertilizers and pesticides), so that decreasing this use contributes to reduce negative externalities.

The paper is organised as follows. Section 2 presents the analytical framework. In section 3, comparative static results are derived and the effects of the four alternative income support programs on endogenous variables as well as on policy objectives related target variables are analysed. In section 4, these effects are compared on an equal cost/support basis that makes possible to classify policy instruments according to their ability to achieve the four considered agricultural policy objectives. Section 5 concludes.

2. Analytical framework

A potential agricultural producer n has an initial endowment in land equal to li_n. He faces perfectly elastic supplies for all factors of production, including land, and takes their prices as given. However the agricultural industry experiences a rising supply curve for land. It is thus an increasing-cost industry (Hughes, 1980). Land can be acquired/let through rental only. The buying/selling price of land is assumed to be adequately approximated by the discounted sum of future rental values so that a prediction about the direction of the rental price is equivalent to a prediction about the direction of the buying/selling price (Leathers, 1992).

There are N potential agricultural producers and N is large. In order to simplify presentation and analysis, we assume that they have the same production function.

Agricultural producer behavior

The profit-maximizing program of a potential agricultural producer n may be defined as (the index n is omitted):

$$(1) \quad \begin{aligned} &\max_{y,x,l} \,(p+sp)y - wx - r(l-li) + tl + mo + mno \quad s.t. \quad y = f(x,l,nf) \\ &\equiv \pi(p+sp, w, r-t, nf) + rli + mo + mno \end{aligned}$$

where y denotes the agricultural output, x an aggregate variable input, l the amount of land used for production and nf the family labor. The price of output is p, the production subsidy is sp, the price of the variable input is w, the rental price of land is r, the land subsidy is t, the decoupled subsidy with mandatory production is mo and the decoupled subsidy without mandatory production is mno. The production function $y = f(x,l,nf)$ is assumed well defined for all non-negative variable input, land and family labor quantities. It is everywhere twice-continuously differentiable, non-negative, non-decreasing and concave. Program (1) defines a profit function $\pi(p+sp, w, r-t, nf)$ which is well defined for all positive prices, everywhere twice-continuously differentiable, non-negative, increasing, linearly homogeneous and convex in prices, increasing and concave in family labor (Diewert, 1974). In program (1), $r(l-li)$ represents the cost of renting additional land at price r per unit (in that case, $r(l-li) \geq 0$) or the earnings from leasing part or all of initial land endowment, also at price r per unit (in that case, $r(l-li) \leq 0$).

Output supply, land demand and variable input demand equations are obtained by applying Hotelling's lemma, i.e.,

$$(2) \quad \partial\pi(p+sp, w, r-t, nf)/\partial p = \pi_p(p+sp, w, r-t, nf) = y(p+sp, w, r-t, nf)$$

$$(3a) \quad -\partial\pi(p+sp, w, r-t, nf)/\partial r = -\pi_r(p+sp, w, r-t, nf) = l(p+sp, w, r-t, nf)$$

$$(3b) \quad -\partial\pi(p+sp, w, r-t, nf)/\partial w = -\pi_w(p+sp, w, r-t, nf) = x(p+sp, w, r-t, nf)$$

The individual supply function for the agricultural commodity is an increasing function of the output price, the production subsidy and the land subsidy. It is decreasing in the variable input price and the rental price of land, and it does not depend on decoupled subsidies with or without mandatory production (equation 2). The individual derived demand function for land is an increasing function of the output price, the production subsidy and the land subsidy. It is decreasing in the rental price of land, and it does not depend on decoupled subsidies with or without mandatory production. Impacts of changes in the variable input price on land demand depend on (Marshallian) substitution and complementarity relationships between production factors x and l (equation 3a).

System equilibrium equations

The model involves three equilibrium equations. The first one is the equilibrium condition in the output market. It requires the aggregate supply of the agricultural commodity to equal the aggregate demand (i.e., domestic demand and exports). The second one is the equilibrium condition in the land market, which implies that there is zero excess supply in this market. The third equilibrium equation corresponds to the entry-exit condition.

The equilibrium equation in the agricultural commodity market may be written as:

$$(4) \quad \sum_{K} y(p+sp, w, r-t, nf) = K.\pi_{p}(p+sp, w, r-t, nf) = DD(p) + DE(p)$$

where K is the number of producers who effectively produce, $DD(p)$ is the domestic aggregate demand function and $DE(p)$ is the export aggregate demand function.

The equilibrium equation in the land market may be written as:

$$(5) \quad \sum_{N} li + Sl(r, ls) = K.l(p+sp, w, r-t, nf) + Dl(r, ld)$$

Land supply is the sum of initial endowments in land of the N potential farmers, plus an upward-sloping function $Sl(r, ls)$ which corresponds to land supplied by land owners who are not potential farmers ($Sl_r \geq 0$). Land demand is the sum of derived demands for land by the K farmers who decide to enter and produce the agricultural commodity, plus a downward-sloping function $Dl(r, ld)$ which corresponds to land demanded by land users who are not potential farmers ($Dl_r \leq 0$). Parameters ls and ld are function shifters.

The last equilibrium equation corresponds to the entry-exit condition. A potential farmer will choose not to enter if he can earn more money by leasing out all his land endowment and holding the best possible alternative in terms of wages (PA), i.e., if:

$$(6)\ \pi(p+sp,w,r-t,nf)+rli+mo+mno \leq PA+rli+mno$$

As a result, a potential farmer with initial endowment li will be indifferent between farming and not farming if:

$$(7)\ \pi(p+sp,w,r-t,nf)+mo = PA$$

From (7), one notes that the entry-exit decision does not depend on the initial land endowment li. However this latter has a proportional impact, for a given land rental price, on total profit a farmer can earn by entering and producing (see program 1). One also notes that the entry-exit decision does not depend on the decoupled subsidy without mandatory production (mno), but on the decoupled subsidy with mandatory production (mo). At this stage, it is useful to explain the working of both types of decoupled subsidies. Without loss of generality, let us assume that the initial situation corresponds to a no support regime with Ki farmers who produce. Let us now assume that the government seeks to support farmers' incomes by means of a decoupled subsidy without mandatory production. Equation (6) implies that the latter is granted to the Ki farmers only, even if some of them decide to go out and not to produce in the new situation, but not to new entrants. Let us now assume that the income support instrument is a decoupled subsidy with mandatory production. Equation (6) shows then that the latter is granted to any farmer who decides to produce in this new regime, but not to farmers who produced in the initial situation and now prefer to go out and lease out all their land endowment. These assumptions allow us to write the entry and exit conditions in only one equation, i.e., equation (7).

The solution of equations (4), (5) and (7) gives the equilibrium price of the agricultural commodity p, the equilibrium rental price of land r, and the equilibrium number of farms, K, composing the industry. The analysis of farm programs proceeds then by totally differentiating (4), (5) and (7), and solving the resulting system.

The four considered alternative/complementary income support instruments are the decoupled subsidy without mandatory production *mno*, the decoupled subsidy with mandatory production *mo*, the land subsidy *t*, and the production subsidy *sp*. These four instruments are primarily designed to support farmers' incomes, but they do have impacts as regards to other policy objectives. Then, we assume that the government seeks to achieve four different policy objectives: to maintain/increase the individual earnings of persons engaged in agriculture (policy objective n° 1), to maintain/increase the provision of positive externalities and/or public goods (policy objective n° 2), to reduce the negative environmental consequences of an excessive use of potentially polluting inputs (policy objective n° 3) and to minimise the trade distortion induced by domestic programs (policy objective n° 4).

As previously underlined, the ability of each income support program to achieve each of the four aforementioned policy objectives is evaluated through four target variables. The target variable associated with policy objective n° 1 is the individual total profit of farmers (denoted *PRO*). We consider that a program inducing an increase (a decrease) in the individual total profit of farmers contributes positively (negatively) to the policy objective of supporting agricultural income. The target variable associated with policy objective n° 4 is the agricultural commodity exports (denoted *X*). We consider that a program resulting in an increase (decrease) in agricultural exports goes against (favours) the policy objective of preserving the compatibility of domestic programs with WTO rules. The target variable associated with policy objective n° 3 is individual yields per hectare (denoted *in* for individual intensification).[5] We admit that a program inducing a decrease (an increase) in yields per hectare contributes positively (negatively) to the policy objective of reducing negative externalities arising from intensification of agricultural production. Finally, the target variable associated with policy objective n° 2 is the number of farmers. The preservation of a "large" number of relatively small family-style farms is generally viewed as more effective to the sustainability and well-being of rural communities than a "small" number of relatively large farms (European Commission, 1999; Hueth, 2000). In a more general but cumbersome framework where potential farmers have different abilities (a higher ability corre-

[5] Yields have been retained instead of the aggregate variable input use per hectare because the comparative static results are far easier to derive for yields per hectare than for the variable input quantity used per hectare.

sponding to lower marginal costs), any increase in the number of farms/farmers means that relatively high-cost farmers choose to enter and produce (Leathers, 1992; Guyomard et al., 2000). One can reasonably assume that the society derives non-market benefits from the production of these relatively high-cost farmers by valuing their production beyond its market value (Hueth, 2000). Under this assumption, the policy objective of an increased number of farms/farmers may be viewed as a reduced form of a more general policy objective, i.e., ensuring the fulfillment of the positive multifunctional role of agriculture. Since the same conclusions are derived from both the "general" model (farmers with different abilities) and the "simplified" model used in this paper (farmers with identical abilities), one can interpret any increase in the number of farms/farmers as an increased supply of public goods/positive externalities produced by agriculture.

3. Impacts of alternative agricultural income support programs

We directly derive the comparative static effects of the four considered policy instruments on the price of the agricultural output, the rental price of land and the number of farms/farmers. Then, using these comparative static results, we may obtain the effects of policy instruments on farmers' total profit (from (1)), on yields per hectare (from (2) and (3a)) and on exports (from the export aggregate demand function $DE(p)$). Details of calculations are provided in Appendix.

The decoupled subsidy without mandatory production

Since the decoupled subsidy without mandatory production (mno) does not enter the three equilibrium equations (4), (5) and (7), it has no impact on the system but producers' incomes. In particular, it has no impact on the number of farmers, the intensification level (yields per hectare) and the volume of agricultural commodity exports.

The decoupled subsidy with mandatory production

The effects of a decoupled subsidy with mandatory production (mo) on the endogenous and target variables are given by:

(8) $\det M.(dp/dmo) = -K\pi_{rr}\pi_p(1-\varepsilon_y^l) - (Sl_r - Dl_r)\pi_p$

(9) $\det M.(dr/dmo) = K\pi_{pp}(-\pi_r)(1-\varepsilon_l^y) - (DD_p + DE_p)(-\pi_r)$

(10) $\det M.(dK/dmo) = K^2(\pi_{pp}\pi_{rr} - \pi_{pr}^2) + K\pi_{pp}(Sl_r - Dl_r) - (DD_p + DE_p)(K\pi_{rr} + Sl_r - Dl_r) > 0$

(11) $dPRO/dmo = \pi_p.(dp/dmo) + \pi_r.(dr/dmo) + li.(dr/dmo) + 1 = li.(dr/dmo)$

(12) $\det M.(dy/dmo) = -K(\pi_{pp}\pi_{rr} - \pi_{pr}\pi_{rp})\pi_p - \pi_{pp}(Sl_r - Dl_r)\pi_p + \pi_{pr}(-DD_p - DE_p)(-\pi_r) < 0$

(13) $\det M.(dl/dmo) = -K(\pi_{pp}\pi_{rr} - \pi_{rp}\pi_{pr})(-\pi_r) + \pi_{rp}(Sl_r - Dl_r)\pi_p - \pi_{rr}(-DD_p - DE_p)(-\pi_r) < 0$

(14) $l^2.\det M.(din/dmo) = (Sl_r - Dl_r)(-\pi_p)\pi_{pp}(-\pi_r)(1-\varepsilon_l^y) + (-DD_p - DE_p)(-\pi_r)\pi_{rr}\pi_p(1-\varepsilon_y^l)$

(15) $dX/dt = DE_p.(dp/dmo)$

where $\varepsilon_y^l = \partial \log y(p+sp, w, l, nf)/\partial \log l$ is the restricted Marshallian supply elasticity of output y with respect to land quantity l, while $\varepsilon_l^y = \partial \log l(y, w, r-t, nf)/\partial \log y$ is the restricted Hicksian derived demand elasticity of land l with respect to output level y.

Hence, the decoupled subsidy with mandatory production has only three unambiguous effects: a positive effect on the number of farms/farmers (equation 10), a negative effect on the farmers' output supply (equation 12) and a negative effect on the farmers' land demand (equation 13). The impacts of the decoupled subsidy with mandatory production on all other variables are indeterminate and depend closely on the levels of ε_y^l and ε_l^y relative to one.

The effect of the decoupled subsidy with mandatory production on the price of the agricultural commodity (equation 8) is unambiguously negative when the restricted Marshallian supply elasticity of output with respect to land quantity (ε_y^l) is lower than unity. When this elasticity is strictly greater than one, the effect can become positive if the positive impact of the first right-hand side term of (8) outweighs the negative impact of the second right-hand side term of (8). The effect on the rental price of land (equation 9) is unambiguously positive when the restricted Hicksian derived demand elasticity of land with respect to output level (ε_l^y) is lower than unity. When this elasticity is strictly greater than one, the effect can become negative if the negative impact of the first right-hand side term of (9) outweighs the positive impact of the second right-hand side term of (9). On may notice that convexity in prices of the profit function defined by program (1) implies that the product of elasticities $\varepsilon_y^l.\varepsilon_l^y$ is always smaller than one. It follows that the decoupled subsidy with mandatory production cannot simultaneously increase the output price and decrease the land price.[6]

The impact of the decoupled subsidy with mandatory production on total profit *PRO* (equation 11) is proportional to the initial land endowment of the farmer. It is positive (respectively, negative) when the rental price of land increases (respectively, decreases).

The decoupled subsidy with mandatory production will unambiguously reduce the farmer's output supply (equation 12) and the farmer's land demand (equation 13), but its effect on intensification (yields per hectare) is indeterminate (equation 14). It will be positive when $\varepsilon_l^y \geq 1$ and $\varepsilon_y^l \leq 1$, negative when $\varepsilon_l^y \leq 1$ and $\varepsilon_y^l \geq 1$, and indeterminate when $\varepsilon_l^y \leq 1$ and $\varepsilon_y^l \leq 1$.

The impact of the decoupled subsidy with mandatory production on agricultural commodity exports (equation 15) is indeterminate. It is positive (respectively, negative) when the price of the agricultural commodity decreases (respectively, increases).

The main results of the comparative static analysis are summarized in Table 1 (for the four income support instruments). As regards the four policy objectives considered in this paper, the only unambiguous effect of the decoupled subsidy with mandatory production is to increase the number of farms/farmers. Hence, one may conclude that the decoupled subsidy with mandatory production contributes positively to policy objective n° 2 (positive externality provision). For the three other policy objectives, the effects cannot be predicted with theory alone. The total profit of a farmer can decrease (a necessary, but not sufficient, condition for this being that the restricted Hicksian derived demand elasticity of land with respect to output is strictly greater than one), and agricultural commodity exports can decrease as well (a necessary, but not sufficient, condition for this being that the restricted Marshallian supply elasticity of output with respect to land is strictly greater than one). The impact of the decoupled subsidy with mandatory production on yields per hectare is indeterminate, depending on orders of magnitude relative to one of the two aforementioned elasticities.

The ambiguous effects of the decoupled subsidy with mandatory production may be explained as follows. All other things being equal, the decoupled subsidy favors the entry of new producers into farming, creating subsequently excess supply in the output

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[6] If the output price increases, then the land price increases too. And if the land price decreases, then the output price decreases too.

market and excess demand in the land market. A new equilibrium of our economy may be obtained through either an output price decrease and an increase in the rental price of land ($\varepsilon_y^l \leq 1$ and $\varepsilon_l^y \leq 1$), an output price increase compensated by a higher increase in the rental price of land ($\varepsilon_y^l > 1$ and $\varepsilon_l^y \leq 1$), or an output price decrease sufficient to cope with a decrease in the rental price of land ($\varepsilon_y^l \leq 1$ and $\varepsilon_l^y > 1$). These price adjustments obviously reduce the incentives for potential producers to enter the sector, but never outweigh the initial positive effect of the decoupled subsidy on the number of farmers.

[Insert Table 1]

The land subsidy

The effects of a land subsidy (t) on the endogenous and target variables are similarly derived from the total differentiation of equations (4), (5) and (7). We obtain:

(16) $\det M.(dp/dt) = -(Sl_r - Dl_r)\pi_p(-\pi_r) < 0$

(17) $\det M.(dr/dt) = K[\pi_{rr}\pi_p^2 + \pi_{pp}(-\pi_r)^2 + 2\pi_{pr}\pi_p(-\pi_r)] - (DD_p + DE_p)(-\pi_r)^2 > 0$

(18) $\det M.(dK/dt) = (Sl_r - Dl_r)[K\pi_{pp}(-\pi_r)(1-\varepsilon_l^y) - (DD_p + DE_p)(-\pi_r)]$

(19) $l^2.\det M.(din/dt) = -(Sl_r - Dl_r)\pi_p[\pi_{rr}\pi_p^2 + \pi_{pp}(-\pi_r)^2 + 2\pi_{pr}\pi_p(-\pi_r)] < 0$

(20) $dPRO/dt = li.(dr/dt) > 0$

(21) $dX/dt = DE_p.(dp/dt) > 0$

Thus, the land subsidy will unambiguously decrease the output price (equation 16), increase the rental price of land (equation 17), decrease yields per hectare (equation 19), increase the total profit of a farmer (equation 20) and increase the exports of the agricultural commodity (equation 21). However, its effect on the number of farms/farmers is indeterminate (equation 18). When the restricted Hicksian derived demand elasticity of land with respect to output is lower than one, the effect of the land subsidy is to increase the number of farmers. When this elasticity is greater than one, the effect is ambiguous and can become negative if the negative impact of the first right-hand side term of the square brackets in (18) outweighs the positive impact of the second right-hand side term of the square brackets in (18).

Hence, regarding the four considered policy objectives, one may conclude that the land subsidy contributes positively to policy objectives n° 1 (agricultural income support) and n° 3 (negative externality reduction), but at the expense of increasing trade distortion effects (policy objective n° 4). Its contribution to policy objective n° 2 (positive externality provision) is ambiguous. It may be positive or negative, depending closely on the level of ε_l^y relative to one.

Some further results can be wrung out of equations (16) to (21) when $Sl_r = Dl_r = 0$. Using the developed expression of $\det M$ provided in Appendix, we obtain:

(22) $dp / dt = 0$

(23) $dr / dt = 1$

(24) $dK / dt = 0$

(25) $din / dt = 0$

(26) $dPRO / dt = li$

(27) $dX / dt = 0$

Hence, in the particular case where the land supply and demand coming from the rest of the economy correspond to fixed amounts, the only non-zero effects of the land subsidy are to raise the rental price of land by the same amount (equation 23) and to increase the total profit of a farmer proportionally to his initial endowment in land (equation 26). Equations (24), (25) and (27) show that, in this particular case, the land subsidy has no impact on the number of farms/farmers (equation 24), neither on the exports of the agricultural commodity (equation 27).

This last result suggests that a land subsidy may be considered as a decoupled income support instrument, provided that there are restrictions on eligible land (and hence, payments) through the use on an aggregate base area.[7] In other words, this result shows that a policy instrument that does not fully conform to all green box eligibility

[7] Of course, this result is contingent to the model used, i.e., a static framework without risk and uncertainty and considering only one aggregate output.

criteria (as defined in points 1 and 6 for income support measures in Annex 2 of the URAA) may nevertheless has minimal distortion effects on trade.[8]

From a European Union (EU) perspective, the situation depicted in the above particular case corresponds to the current situation in the Common Market Organisation (CMO) for cereals, oilseeds and protein crops (hereafter COP crops), if we consider COP crops as one aggregate only. Therefore, from a WTO negotiation point of view, the EU could rightfully argue that the area payments in force in the EU COP sector have (at least at the aggregate level) minimal trade distortion effects (so could be considered as decoupled), although they do not fully conform to URAA decoupling criteria.[9]

The production subsidy

The effects of a production subsidy (sp) on the endogenous and target variables may be written as:

(28) $\det M.(dp/dsp) = -K[\pi_{rr}\pi_p^2 + \pi_{pp}(-\pi_r)^2 + 2\pi_{pr}\pi_p(-\pi_r)] - (Sl_r - Dl_r)\pi_p^2 < 0$

(29) $\det M.(dr/dsp) = (-DD_p - DE_p)\pi_p(-\pi_r) > 0$

(30) $\det M.(dK/dsp) = (-DD_p - DE_p)[(Sl_r - Dl_r)\pi_p + K\pi_{rr}\pi_p(1-\varepsilon_y^l)]$

(31) $l^2.\det M.(din/dsp) = (-DD_p - DE_p)(-\pi_r)[\pi_{rr}\pi_p^2 + \pi_{pp}(-\pi_r)^2 + 2\pi_{pr}\pi_p(-\pi_r)] > 0$

(32) $\det M.(dPRO/dsp) = li.(dr/dsp) > 0$

(33) $\det M.(dX/dsp) = DE_p.(dp/dsp) > 0$

Then, our analytical framework leads to find common results regarding the effects of a production subsidy. It unambiguously decreases the output price (equation

[8] The land subsidy considered in this paper does not conform to criterion (iv) and (v) of point 6 of Annex 2, i.e., respectively, the payment will not be related to or based on the factors of production employed and no production shall be required to receive the payment.

[9] Obviously, this does not mean that the current EU area payments to COP crops have no effect on the domestic aggregated supply of COP crops with respect to a free market situation. This would be the case only if the current EU base area for COP crops is not larger than the total area which would be devoted to COP crops in a non interventionist regime. The URAA however does not, at least explicitly, strictly constrain to take the free trade situation as the reference situation. For a discussion on the eligibility to the green box of EU compensatory payments granted in both the COP and the beef sectors, see for example Gohin and Guyomard (2000).

28), increases the rental price of land (equation 29), increases the intensification level (equation 31), increases the total profit of a farmer (equation 32) and increases the exports of the agricultural commodity (equation 33).

The only ambiguous effect of the production subsidy relates to the number of farmers. Equation (30) shows that the production subsidy will unambiguously increase the number of farmers when the restricted Marshallian supply elasticity of output with respect to land is lower than one. When this elasticity is greater than one, the impact is indeterminate and can become negative when the positive effect of the first right-hand side term of the square brackets in (30) is outweighed by the negative effect of the second right-hand side term of the square brackets in (30).

One may notice that when both the domestic demand *DD* and the foreign demand *DE* are price inelastic, the impacts of the production subsidy on the rental price of land, the number of farmers, the intensification level and the total profit of a farmer are small.

Finally, as regards to the four considered policy objectives, one may conclude that the production subsidy contributes positively to policy objective n° 1 (agricultural income support), but at the expense of increasing trade distortion effects (policy objective n° 4). It contributes negatively to policy objective n° 3 (negative externality reduction) while its contribution to policy objective n° 2 (positive externality provision) is ambiguous. It may be positive or negative, depending closely on the level of ε_y^l relative to one.

Previously presented comparative static results indicate whether, or under which conditions, each income support program contributes positively or negatively to the four considered agricultural policy objectives. However they do not allow to classify these support programs according to their relative ability to achieve these policy objectives. Such a classification becomes possible if the effects of each program on policy objectives related target variables are compared on an equal cost/support basis.

4. Equal cost/support comparison of alternative agricultural income support programs

In this section, we assume that the initial situation corresponds to the free trade equilibrium.[10] In other words we consider that the four income support programs are initially not in force. Such an assumption makes the analysis easier. Furthermore it implies that the comparison of the effects of instruments on an equal budget cost basis is equivalent to a comparison on an equal total agricultural income support basis.

Secondly, we consider only three of the four previous agricultural income support programs: the decoupled subsidy with mandatory production (*mo*), the land subsidy (*t*) and the production subsidy (*sp*). As the only non-zero effect of the decoupled subsidy without mandatory production (*mno*) is to raise, by the same amount, the farmers' individual profit, results of the comparison analysis with other instruments are quite obvious.

In a first step, we determine the differences between effects induced by each pair of instruments for the three endogenous variables and the four policy objectives related variables, for a constant budget cost/income support. Then, we examine the signs of these differences. Results of this first step are reported in Table 2. In a second step, the three programs are classified according to their relative ability to achieve the four considered agricultural policy objectives. Results of this second step are synthesized in Table 3.

Comparison of the effects of alternative agricultural income support programs

The differences between the effects induced by each pair of programs for endogenous and target variables are provided in Table 2.

[Insert Table 2]

As previously shown, when a program has an ambiguous effect on a variable, the sign of this effect is always closely related to the order of magnitude relative to one of, either ε_y^l (the restricted Marshallian supply elasticity of output with respect to land

[10] In the previous sections, we did not specify the status of the initial market situation because derived comparative static results are valid whether the initial situation corresponds to the free trade equilibrium or not.

quantity), ε_l^y (the restricted Hicksian derived demand elasticity of land with respect to output level), or both. It is thus, not surprising that when the difference between the effects induced by each pair of instruments on one variable is ambiguous, its sign depends always directly on the level of one or both these elasticities relative to one.

The decoupled subsidy with mandatory production (mo) vs the land subsidy (t)

Panel 2.a. shows that, for an equal budget cost, the decoupled subsidy with mandatory production leads unambiguously to a greater increase in the number of farms/farmers than the land subsidy. For all other considered variables, the signs of the differences between the impacts of both instruments depend exclusively on the level of the restricted Marshallian supply elasticity of output with respect to land quantity (ε_y^l) relative to one.

If this elasticity is lower than unity, then the decoupled subsidy with mandatory production leads to a higher decrease (in absolute terms) in the price of the agricultural output than the one induced by the land subsidy. In that case, the decoupled subsidy with mandatory production leads to a greater positive trade distortion effect than the land subsidy. In the opposite case (i.e., $\varepsilon_y^l > 1$), the positive trade distortion effect induced by the land subsidy is always greater than the trade distortion resulting from the application of the decoupled subsidy.[11]

Similar results may be derived for the rental price of land and the farmers' individual profit. When the restricted Marshallian elasticity ε_y^l is lower than one, the increases in the rental price of land and then in the farmers' individual profit generated by the land subsidy outperform those obtained with the decoupled subsidy.[12] In the oppo-

[11] When $\varepsilon_y^l > 1$, the decoupled subsidy with mandatory production may lead either to a decrease or an increase in the price of the agricultural output. In case of a decrease, this latter will be lower (in absolute terms) than the one induced by the land subsidy. Hence, agricultural commodity exports will raise more with the land subsidy than with the decoupled subsidy. In case of an increase, exports of the agricultural commodity will decrease with the decoupled subsidy while raising with the land subsidy. Therefore, in both cases, the positive trade distortion effect resulting from the land subsidy application will be higher than the trade distortion effect (positive or negative) induced by the decoupled subsidy.

[12] Let's remind that the change in the rental price of land and, consequently, in the farmers' individual profit resulting from the application of the decoupled subsidy may be positive or negative. It is positive if

site case (i.e., $\varepsilon_y^l > 1$), the implementation of the decoupled subsidy leads to higher increases in both the rental price of land and the farmers' individual profit than the land subsidy.[13]

Finally, once again, similar conclusions arise when comparing the effects of both instruments on yields per hectare. When the restricted Marshallian elasticity ε_y^l is lower than one, the decrease in the level of intensification resulting from the implementation of the land subsidy outperforms the one observed with the decoupled subsidy. In the opposite case (i.e., $\varepsilon_y^l > 1$), the decoupled subsidy leads to a decrease in the level of intensification, decrease which is higher (in absolute terms) than the one induced by the land subsidy.

The decoupled subsidy with mandatory production (mo) vs the production subsidy (sp)

As in the previous case, Panel 2.b. indicates that, for an equal budget cost, the decoupled subsidy with mandatory production leads unambiguously to a greater increase in the number of farms/farmers than the land subsidy. However, for all other considered variables, the signs of the differences between the impacts of both instruments now depend exclusively on the level of the restricted Hicksian derived demand elasticity of land with respect to output quantity (ε_l^y) relative to one.

The following results apply when this elasticity is greater than unity. The decoupled subsidy necessarily leads to a decrease in the price of the agricultural output, decrease which is greater (in absolute terms) than the one induced by the production subsidy. Therefore, the decoupled subsidy generates a positive trade distortion effect that is higher than the one induced by the production subsidy. The increase in the rental price of land and then in the farmers' individual profit generated by the production subsidy is always greater than the change observed in both variables (which may be positive or

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the restricted Hicksian derived demand elasticity of land with respect to output level (ε_l^y) is lower than one, and negative otherwise.

[13] Let's remind that $\varepsilon_y^l \varepsilon_l^y$ is always smaller than one. Therefore, when ε_y^l is greater than one, ε_l^y is necessarily lower than one. In other words, when $\varepsilon_y^l > 1$, the decoupled subsidy leads necessarily to increase the rental price of land and, consequently, the farmers' individual profit. And these increases are greater than the ones induced by the land subsidy.

negative) with the decoupled subsidy. Finally, the decoupled subsidy induces an increase in the level of intensification, increase which is greater than the one resulting from the production subsidy implementation.

One observes opposite results when the restricted Hicksian elasticity ε_l^y is lower than one.

The land subsidy (t) vs the production subsidy (sp)

As shown in the previous section, the land subsidy and the production subsidy both lead unambiguously to a decrease in the price of the agricultural output. However, Panel 2.c. suggests that, for an equal budget cost, the land subsidy induces a lower output price reduction (in absolute terms) than the production subsidy. Therefore, on an equal cost/support basis, the positive trade distortion effect generated by the land subsidy is always lower than the one resulting from the production subsidy.

In the same way, it has been shown in section 3 that both instruments raise the rental price of land and, consequently, the farmers' individual profit. However, on an equal cost/support basis, the increase observed in both variables is always greater with the land subsidy than with the production subsidy.

The comparison of the impacts of the land and the production subsidies on the level of intensification is quite obvious since the former induces a decrease in yields per hectare while the latter makes this indicator to increase.

Finally, Panel 2.c. reveals that, contrary to the two previous pairs of instruments, the only ambiguous result regarding the comparison, on an equal cost/support basis, of the impacts of the land and the production subsidies relates to their relative effects on the number of farms/farmers. When the restricted Hicksian elasticity ε_l^y is lower than one while the restricted Marshallian elasticity ε_y^l is greater than one, then the increase in the number of farms/farmers induced by the land subsidy is always higher than the change observed in the same variable with the production subsidy (change which may be positive or negative). One observed the opposite situation when the restricted Hicksian elasticity ε_l^y is greater than one while the restricted Marshallian elasticity ε_y^l is lower than one. When both elasticities are lower than one, both instruments make the number of farms/ farmers to increase. But the sign of the difference between their relative impacts remains ambiguous.

Classification of the alternative income support programs according to their ability to achieve the four policy objectives

Based on the results reported in Table 2, we are in a good position to classify the programs with respect to their ability to achieve policy objectives. Table 3 reports the obtained classification, for each of the three possible sets of conditions, with grade 1 for the most effective program and grade 3 for the worst effective one. Hence, on an equal cost/support basis, the following results arise:

i) for all possible sets of conditions on the levels relative to one of the Marshallian and Hicksian elasticities, ε_y^l and ε_l^y, the decoupled subsidy with mandatory production (*mo*) is the most effective instrument as regards to policy objective n° 2, i.e., under our hypotheses, for promoting the provision of positive externalities and/or public goods;

ii) when $\varepsilon_y^l > 1$ and $\varepsilon_l^y \leq 1$, the decoupled subsidy (*mo*) is the most effective instrument as regards to the four policy objectives. In order words, this decoupled subsidy program is the most effective instrument for simultaneously supporting agricultural income, promoting positive externalities and reducing negative externalities, while generating minimal distortion effects on trade;

iii) for the two other sets of conditions (i.e., $\varepsilon_y^l \leq 1$ and $\varepsilon_l^y \leq 1$ or $\varepsilon_y^l \leq 1$ and $\varepsilon_l^y > 1$), the decoupled subsidy is never the most effective instrument as regards to policy objectives n° 1, 3 and 4. It is always dominated by, at least, the land subsidy;

iv) when $\varepsilon_y^l \leq 1$ and $\varepsilon_l^y \leq 1$ or $\varepsilon_y^l \leq 1$ and $\varepsilon_l^y > 1$, the land subsidy (t) is the most effective program as regards to policy objectives n° 1, 3 and 4. In other words, the land subsidy is more effective than other instruments in supporting agricultural income and reducing negative externalities, while inducing minimal trade distortion effects;

v) whatever the possible set of conditions on the levels relative to one of the Marshallian and Hicksian elasticities, ε_y^l and ε_l^y, the production subsidy (*sp*) is never the most effective instrument as regards to the four considered policy objectives. When $\varepsilon_y^l > 1$ and $\varepsilon_l^y \leq 1$, it ranks last for all policy objectives. When $\varepsilon_y^l \leq 1$ and $\varepsilon_l^y \leq 1$, it ranks last for all policy objectives, but n° 2 (where the ranking between the land and the production subsidies is indeterminate). When $\varepsilon_y^l \leq 1$ and $\varepsilon_l^y > 1$, the production subsidy dominates the decoupled subsidy for all policy objectives, but n° 2.

From a policy perspective, our theoretical framework allows us to state that, on an equal cost/support basis, and except specific conditions, no program uniformly dominates others for achieving simultaneously the four considered policy objectives.[14] In other words and in accordance with the "targeting rule", no instrument does allow to achieve effectively simultaneously several policy objectives. Thus, a government considering a specific instrument necessarily faces trade-off between objectives. In the same vein, a government pursuing different policy objectives may be well-advised to mobilize various policy instruments.

From a WTO negotiation perspective, our production subsidy program would certainly be qualified as a amber box measure while both other instruments would likely be considered as green or blue box measures. Our theoretical framework then suggests that amber-box measures are not likely to be the most effective instruments in promoting multifunctionality, provided the definition of this notion in this paper. By way of consequence, promoting multifunctionality does not appear as an undeniable justification for claiming the continuation of amber box measures in future WTO negotiations. On the other hand, determining which green or blue box measure promotes most effectively multifunctionality while minimizing trade distortion effects is not a trivial matter. This depends on conditions that cannot be predicted by theory alone. To this regards, our results put emphasis on the key role of both the restricted Marshallian supply elasticity of output with respect to land quantity and Hicksian derived demand elasticity of land with respect to output quantity.

5. Conclusion

This paper develops a theoretical framework in order to analyze the ability of traditional programs of agricultural income support in achieving potentially conflicting/complementary policy objectives. This framework, which allows for free entry into the agricultural sector and land price endogeneity, show that attempts to evaluate the relative merits of various agricultural policies should take into account the impacts that these policies have on both individual producers (impact at the individual margin) and the number of producers (impact at the collective margin). For some instruments and some policy goals, impacts may be contrary to intuition or to results derived from a model with a fixed number of firms and/or an exogenous price of farmland. Moreover,

[14] Specific conditions corresponds here to the case where $\varepsilon_y^l > 1$ and $\varepsilon_l^y \leq 1$. Indeed in that case, the decoupled subsidy with mandatory production dominates both other instruments as regards to the four considered policy objectives.

this framework allows to identify the two key parameters that have a substantial bearing on the relative effectiveness of various instruments. The next step on the research agenda will obviously be the empirical evaluation of these crucial parameters.

Many research directions represent important avenues for further study. For instance, the model is very stylized with only one output, and one single and crude indicator for negative externalities as well as for positive externalities. This is valuable for conceptual understanding of the importance of entry-exit decisions and land market characteristics, but specific policy problems should be analyzed for particular agricultural industries with more carefully specified technologies and indicators.

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Table 1. The comparative static analysis of alternative income support policies

	Impact of a decoupled subsidy without mandatory production (*mno*) on	
Total profit of a farmer	+	
Number of farms/farmers	0	
Intensification level	0	
Agricultural output exports	0	
	Impact of a decoupled subsidy with mandatory production (*mo*) on	
Total profit of a farmer	Ambiguous: + when $\varepsilon_l^y \leq 1$; +/- when $\varepsilon_l^y \geq 1$	
Number of farms/farmers	+	
Intensification level	Ambiguous: + when $\varepsilon_l^y \geq 1$ and $\varepsilon_y^l \leq 1$; - when $\varepsilon_l^y \leq 1$ and $\varepsilon_y^l \geq 1$; +/- when $\varepsilon_l^y \leq 1$ and $\varepsilon_y^l \leq 1$	
Agricultural output exports	Ambiguous: + when $\varepsilon_y^l \leq 1$; +/- when $\varepsilon_y^l \geq 1$	
	Impact of a land subsidy (*t*) on	
	General case	**Particular case ($Sl_r = Dl_r = 0$)**
Total profit of a farmer	+	+
Number of farms/farmers	Ambiguous: + when $\varepsilon_l^y \leq 1$; +/- when $\varepsilon_l^y \geq 1$	0
Intensification level	-	0
Agricultural output exports	+	0
	Impact of a production subsidy (*sp*)	
Total profit of a farmer	+	
Number of farms/farmers	Ambiguous: + when $\varepsilon_y^l \leq 1$; +/- when $\varepsilon_y^l \geq 1$	
Intensification level	+	
Agricultural output exports	+	

Note: $\varepsilon_y^l = \partial \log y(p+sp, w, l, nf) / \partial \log l$, and $\varepsilon_l^y = \partial \log l(y, w, r-t, nf) / \partial \log y$.

Table 2. Equal cost/support comparison of the effects of each pair of instruments on the various endogenous and target variables

Panel 2.a. *mo* vs *t*

Differences between effects induced by pairs of instruments	Signs
$\left.\frac{dp}{dmo}\right\vert_c - \left.\frac{dp}{dt}\right\vert_c = -K.\frac{\pi_{rr}\pi_p.(1-\varepsilon_y^l)}{\det M}$	- if $\varepsilon_y^l \le 1$ + if $\varepsilon_y^l > 1$
$\left.\frac{dr}{dmo}\right\vert_c - \left.\frac{dr}{dt}\right\vert_c = (K.\frac{\pi_p^2\pi_{rr}}{\pi_r}).\frac{(1-\varepsilon_y^l)}{\det M}$	- if $\varepsilon_y^l \le 1$ + if $\varepsilon_y^l > 1$
$\left.\frac{dK}{dmo}\right\vert_c - \left.\frac{dK}{dt}\right\vert_c = \frac{K^2(\pi_{pp}\pi_{rr} - \pi_{pr}^2)}{\det M} + \frac{K(Sl_r - Dl_r)\pi_p\pi_{pr}}{\pi_r \det M} - \frac{K\pi_{rr}(DD_p + DE_p)}{\det M}$	+
$\left.\frac{din}{dmo}\right\vert_c - \left.\frac{din}{dt}\right\vert_c = \pi_{rr}\pi_p(1-\varepsilon_y^l)\frac{-\pi_r^2(DD_p + DE_p) + \pi_p^2(Sl_r - Dl_r)}{\det M.K(-\pi_r).l^2}$	+ if $\varepsilon_y^l \le 1$ - if $\varepsilon_y^l > 1$
$\left.\frac{dPRO}{dmo}\right\vert_c - \left.\frac{dPRO}{dt}\right\vert_c = li.(\left.\frac{dr}{dmo}\right\vert_c - \left.\frac{dr}{dt}\right\vert_c)$	- if $\varepsilon_y^l \le 1$ + if $\varepsilon_y^l > 1$
$\left.\frac{dX}{dmo}\right\vert_c - \left.\frac{dX}{dt}\right\vert_c = DE_p.(\left.\frac{dp}{dmo}\right\vert_c - \left.\frac{dp}{dt}\right\vert_c)$	+ if $\varepsilon_y^l \le 1$ - if $\varepsilon_y^l > 1$

Panel 2.b. *mo* vs *sp*

Differences between effects induced by pairs of instruments	Signs
$\left.\frac{dp}{dmo}\right\vert_c - \left.\frac{dp}{dsp}\right\vert_c = K.\frac{\pi_{pp}.\pi_r^2.(1-\varepsilon_l^y)}{\pi_p.\det M}$	+ if $\varepsilon_l^y \le 1$ - if $\varepsilon_l^y > 1$
$\left.\frac{dr}{dmo}\right\vert_c - \left.\frac{dr}{dsp}\right\vert_c = -K.\frac{\pi_{pp}.\pi_r(1-\varepsilon_l^y)}{\det M}$	+ if $\varepsilon_l^y \le 1$ - if $\varepsilon_l^y > 1$
$\left.\frac{dK}{dmo}\right\vert_c - \left.\frac{dK}{dsp}\right\vert_c = \frac{K^2(\pi_{pp}\pi_{rr} - \pi_{pr}^2)}{\det M} + \frac{K(Sl_r - Dl_r)\pi_{pp}}{\det M} - \frac{K\pi_{pr}\pi_r(DD_p + DE_p)}{\pi_p \det M}$	+
$\left.\frac{din}{dmo}\right\vert_c - \left.\frac{din}{dsp}\right\vert_c = (1-\varepsilon_l^y).\pi_{pp}.\pi_r.\frac{-\pi_r^2/\pi_p.(DD_p + DE_p) + \pi_p.(Sl_r - Dl_r)}{\det M.l^2}$	- if $\varepsilon_l^y \le 1$ + if $\varepsilon_l^y > 1$
$\left.\frac{dPRO}{dmo}\right\vert_c - \left.\frac{dPRO}{dsp}\right\vert_c = li.(\left.\frac{dr}{dmo}\right\vert_c - \left.\frac{dr}{dsp}\right\vert_c)$	+ if $\varepsilon_l^y \le 1$ - if $\varepsilon_l^y > 1$
$\left.\frac{dX}{dmo}\right\vert_c - \left.\frac{dX}{dsp}\right\vert_c = DE_p.(\left.\frac{dp}{dmo}\right\vert_c - \left.\frac{dp}{dsp}\right\vert_c)$	- if $\varepsilon_l^y \le 1$ + if $\varepsilon_l^y > 1$

Panel 2.c. *t* vs *sp*

Differences between effects induced by pairs of instruments	Signs
$\left.\frac{dp}{dt}\right\|_C - \left.\frac{dp}{dsp}\right\|_C = K.\frac{\pi_{pp}.\pi_r^2 + \pi_{rr}.\pi_p^2 - 2\pi_p\pi_r\pi_{pr}}{\pi_p.\det M}$	+
$\left.\frac{dr}{dt}\right\|_C - \left.\frac{dr}{dsp}\right\|_C = -K.\frac{\pi_{pp}.\pi_r^2 + \pi_{rr}.\pi_p^2 - 2\pi_p\pi_r\pi_{pr}}{\pi_r.\det M}$	+
$\left.\frac{dK}{dt}\right\|_C - \left.\frac{dK}{dsp}\right\|_C = \frac{K(Sl_r - Dl_r)\pi_{pp}\left(1-\varepsilon_l^y\right)}{\det M} + \frac{K(DD_p + DE_p)\pi_{rr}\left(1-\varepsilon_y^l\right)}{\det M}$	+ if $\varepsilon_l^y \leq 1$ and $\varepsilon_y^l > 1$ - if $\varepsilon_l^y > 1$ and $\varepsilon_y^l \leq 1$ Indeterminate otherwise
$\left.\frac{din}{dt}\right\|_C - \left.\frac{din}{dsp}\right\|_C = \frac{\left((Sl_r - Dl_r)\pi_p^2 - (DD_p + DE_p)\pi_r^2\right)\left(\pi_{rr}\pi_p^2 + \pi_{pp}\pi_r^2 - 2\pi_p\pi_r\pi_{pr}\right)}{\pi_p\pi_r l^2 \det M}$	-
$\left.\frac{dPRO}{dt}\right\|_C - \left.\frac{dPRO}{dsp}\right\|_C = li.(\left.\frac{dr}{dt}\right\|_C - \left.\frac{dr}{dsp}\right\|_C)$	+
$\left.\frac{dX}{dt}\right\|_C - \left.\frac{dX}{dsp}\right\|_C = DE_p.(\left.\frac{dp}{dt}\right\|_C - \left.\frac{dp}{dsp}\right\|_C)$	-

Table 3. Ranking of equal cost/support instruments according to the four policy objectives

Policy objectives:	Decoupled subsidy *mo*	Land subsidy *t*	Production subsidy *sp*
Income support:			
$\varepsilon_y^l \leq 1$ and $\varepsilon_l^y \leq 1$	2	1	3
$\varepsilon_y^l \leq 1$ and $\varepsilon_l^y > 1$	3	1	2
$\varepsilon_y^l > 1$ and $\varepsilon_l^y \leq 1$	1	2	3
Provision of positive externalities:			
$\varepsilon_y^l \leq 1$ and $\varepsilon_l^y \leq 1$	1	?	?
$\varepsilon_y^l \leq 1$ and $\varepsilon_l^y > 1$	1	3	2
$\varepsilon_y^l > 1$ and $\varepsilon_l^y \leq 1$	1	2	3
Reduction of negative externalities:			
$\varepsilon_y^l \leq 1$ and $\varepsilon_l^y \leq 1$	2	1	3
$\varepsilon_y^l \leq 1$ and $\varepsilon_l^y > 1$	3	1	2
$\varepsilon_y^l > 1$ and $\varepsilon_l^y \leq 1$	1	2	3
Minimizing trade distortion:			
$\varepsilon_y^l \leq 1$ and $\varepsilon_l^y \leq 1$	2	1	3
$\varepsilon_y^l \leq 1$ and $\varepsilon_l^y > 1$	3	1	2
$\varepsilon_y^l > 1$ and $\varepsilon_l^y \leq 1$	1	2	3

Appendix

Details of calculations

Total differentiation of equations (4), (5) and (7) gives:

$$\text{(S1)}\quad \begin{bmatrix} K\pi_{pp} - DD_p - DE_p & K\pi_{pr} & \pi_p \\ K\pi_{rp} & K\pi_{rr} + SI_r - DI_r & \pi_r \\ -\pi_p & -\pi_r & 0 \end{bmatrix} \begin{bmatrix} dp \\ dr \\ dK \end{bmatrix} = \begin{bmatrix} -K\pi_{pp}.dsp - K\pi_{pw}.dw + K\pi_{pr}.dt \\ -K\pi_{rp}.dsp - K\pi_{rw}.dw + K\pi_{rr}.dt - d(\sum_N li) \\ \pi_p.dsp + \pi_w.dw - \pi_r.dt + dmo - dPA \end{bmatrix}$$

or, in more compact notation,

$$\text{(S2)}\quad M.\begin{bmatrix} dp \\ dr \\ dK \end{bmatrix} = \begin{bmatrix} -K\pi_{pp}.dsp - K\pi_{pw}.dw + K\pi_{pr}.dt \\ -K\pi_{rp}.dsp - K\pi_{rw}.dw + K\pi_{rr}.dt - d(\sum_N li) \\ \pi_p.dsp + \pi_w.dw - \pi_r.dt + dmo - dPA \end{bmatrix}$$

The determinant of M, *detM*, is positive since it can be written as:

$$\text{(a1)}\quad \det M = K[\pi_{rr}\pi_p^2 + \pi_{pp}(-\pi_r)^2 + 2\pi_{pr}\pi_p(-\pi_r)] + (-DD_p - DE_p)(-\pi_r)^2 + (SI_r - DI_r)\pi_p^2 > 0$$

We now illustrate how the analysis proceeds on the example of the decoupled subsidy with mandatory production. From (S2) we immediately obtain:

$$\text{(S3)}\quad \begin{bmatrix} dp \\ dr \\ dK \end{bmatrix} = M^{-1}.\begin{bmatrix} 0 \\ 0 \\ dmo \end{bmatrix},$$

with

$$M^{-1} = (1/\det M).\begin{bmatrix} \pi_r^2 & -\pi_r\pi_p & K\pi_{pr}\pi_r - \pi_p(K\pi_{rr} + Sl_r - Dl_r) \\ -\pi_r\pi_p & \pi_p^2 & -\pi_r(K\pi_{pp} - DD_p - DE_p) + K\pi_{pr}\pi_p \\ -K\pi_{pr}\pi_r + \pi_p(K\pi_{rr} + Sl_r - Dl_r) & \pi_r(K\pi_{pp} - DD_p - DE_p) - K\pi_p\pi_{pr} & (K\pi_{pp} - DD_p - DE_p)(K\pi_{rr} + Sl_r - Dl_r) - (K\pi_{pr})^2 \end{bmatrix}$$

Hence:

(a2) $\det M.(dp/dmo) = K\pi_{pr}\pi_r - (K\pi_{rr} + Sl_r - Dl_r)\pi_p$

(a3) $\det M.(dr/dmo) = -(K\pi_{pp} - DD_p - DE_p)\pi_r + K\pi_{rp}\pi_p$

(a4) $\det M.(dK/dmo) = (K\pi_{pp} - DD_p - DE_p)(K\pi_{rr} + Sl_r - Dl_r) - K^2\pi_{pr}^2$

These three equations may equivalently be written as:

(a5) $\det M.(dp/dmo) = -K\pi_{rr}\pi_p[1 + \dfrac{\pi_{pr}(-\pi_r)}{\pi_{rr}\pi_p}] - (Sl_r - Dl_r)\pi_p = -K\pi_{rr}\pi_p(1 - \varepsilon_y^l) - (Sl_r - Dl_r)\pi_p$

(a6) $\det M.(dr/dmo) = K\pi_{pp}(-\pi_r)[1 + \dfrac{\pi_{rp}\pi_p}{\pi_{pp}(-\pi_r)}] - (DD_p + DE_p)(-\pi_r) = K\pi_{pp}(-\pi_r)(1 - \varepsilon_l^y) - (DD_p + DE_p)(-\pi_r)$

(a7) $\det M.(dK/dmo) = K^2(\pi_{pp}\pi_{rr} - \pi_{pr}^2) + K\pi_{pp}(Sl_r - Dl_r) - (DD_p + DE_p)(K\pi_{rr} + Sl_r - Dl_r) > 0$

The impact of mo on y and l may be written as, respectively:

(a8)
$$\begin{aligned} dy/dmo &= \pi_{pp}.(dp/dmo) + \pi_{pr}.(dr/dmo) \\ &= (1/\det M)[\pi_{pp}[K\pi_{pr}\pi_r - (K\pi_{rr} + Sl_r - Dl_r)\pi_p] + \pi_{pr}[-(K\pi_{pp} - DD_p - DE_p)\pi_r + K\pi_{rp}\pi_p]] \\ &= (1/\det M)[-K(\pi_{pp}\pi_{rr} - \pi_{pr}\pi_{rp})\pi_p - \pi_{pp}(Sl_r - Dl_r)\pi_p + \pi_{pr}(-DD_p - DE_p)(-\pi_r)] < 0 \end{aligned}$$

$$
\begin{aligned}
dl/dmo &= -\pi_{rp}.(dp/dmo) - \pi_{rr}.(dr/dmo) \\
\text{(a9)} \quad &= (1/\det M)[-\pi_{rp}[K\pi_{pr}\pi_r - (K\pi_{rr} + Sl_r - Dl_r)\pi_p] - \pi_{rr}[-(K\pi_{pp} - DD_p - DE_p)\pi_r + K\pi_{rp}\pi_p]] \\
&= (1/\det M)[-K(\pi_{pp}\pi_{rr} - \pi_{rp}\pi_{pr})(-\pi_r) + \pi_{rp}(Sl_r - Dl_r)\pi_p - \pi_{rr}(-DD_p - DE_p)(-\pi_r)] < 0
\end{aligned}
$$

From (a8) and (a9), we readily derive the impact of mo on intensification in (yields per hectare):

$$
\begin{aligned}
l^2.(din/dmo) &= (dy/dmo).l - (dl/dmo).y \\
\text{(a10)} \quad &= (1/\det M)[(Sl_r - Dl_r)(-\pi_p)[\pi_{pp}(-\pi_r) + \pi_{rp}\pi_p] + (-DD_p - DE_p)(-\pi_r)[\pi_{pr}(-\pi_r) + \pi_{rr}\pi_p]] \\
&= (1/\det M)[(Sl_r - Dl_r)(-\pi_p)\pi_{pp}(-\pi_r)(1 - \varepsilon_l^y) + (-DD_p - DE_p)(-\pi_r)\pi_{rr}\pi_p(1 - \varepsilon_y^l)]
\end{aligned}
$$