Meeting multiple policy objectives under GHG emission reduction targets

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Motivation for the Presentation

- Efforts continue to reach agreement on global commitments for reductions in GHG emissions.
- Future agreements will likely involve agriculture, which has been exempted from most national initiatives to reduce carbon emissions.
- Countries pursue a range of environmental objectives for agriculture--promotion positive externalities or public goods (e.g., wildlife habitat, water supply management, landscape amenities) &reduction of negative externalities, such as soil erosion or water pollution.
- The aim of reducing GHG emissions may have to be balanced against other environmental objectives.
- Policies will have to be designed to address multiple environmental outcomes.

Objectives of the Paper

- we examine this problem by considering an appropriate model of an agricultural sector to:
  - examine policy choices to increase the positive domestic environmental contribution of agriculture, while reducing its negative contribution.
  - examine implications for achieving domestic environmental objectives of the imposition of an internationally determined GHG emission reduction requirement on agriculture.
  - we do not include any other objectives, such as a redistribution of income from consumers to farmers

Outline of the Presentation

- **Describe the Model—differentiate between commodity and non-commodity outputs & highlighti causes for jointness in production**
- **Develop optimal taxes and subsidies on inputs equivalent to the Pigouvian solution in which externalities are taxed or subsidized at their social values assigned *at the national level***
- **Contrast this policy with one where a GHG emissions reduction is *imposed by an international agreement*, & for the possibility that the target may not be consistent with national environmental policy goals.**
- **Discuss Policy Design Issues**

Model: The Production Functions

Agriculture

$$Y = Y(L_y, K_y, K_a)$$

$$G = G(L_y, K_y) : \text{GHG}$$

$$N = (L_y, K_y): \text{N.Pollution}$$

$$A = A(L_y, K_a, K_y): \text{Amenities}$$

Forestry

$$F = F(L_f, K_f)$$

$$S = S\left(F(L_f, K_f)\right): \text{Sequester C}$$

Inputs

L_y and K_y are land & other inputs in agriculture

K_a other inputs in amenity production

L_f and K_f are land & other inputs in forestry

Model: Other Components

- **Fixed market prices for agricultural and agro-forestry outputs of P_y and P_f**
- **Fixed quantity of land, $L^* = L_y + L_f$**
- **Supplies of the distinct composite non-land inputs, (K_y, K_a, and K_f) are unconstrained and their market prices (P_{ky}, P_{ka}, and P_{kf})**
- **Marginal social values of GHG emissions, carbon sequestration, nutrient pollution, and landscape amenities are reflected through a set of fixed prices denoted by P_g, P_s, P_n, and P_a**

The Farmer's Problem

$$\max_{L_y,K_y,L_f,K_f,K_a} P_y Y(L_y, K_y, K_a) + P_f F(L_f, K_f)$$
$$+ P_g G(L_y, K_y)$$
$$+ P_n N(L_y, K_y) + P_a A(L_y, K_a, K_y)$$
$$+ P_s S\left(F(L_f, K_f)\right)$$
$$- (P_{ky} K_y + P_{ka} K_a + P_{kf} K_f)$$
$$+ \mu[L^* - L_y - L_f]$$

The First-Order Conditions

$$P_y Y_{Ly} + [P_g G_{Ly} + P_n N_{Ly} + P_a A_{Ly}] = \mu$$

$$P_y Y_{Ky} + \left[P_a A_{Ky} + P_g G_{Ky} + P_n N_{Ky}\right] = P_{ky}$$

$$P_a A_{Ka} + \left\{\left[P_y Y_{Ka}\right]\right\} = P_{ka}$$

$$P_f F_{Lf} + [P_s S' F_{Lf}] = \mu$$

$$P_f F_{Kf} + [P_s S' F_{Kf}] = P_{kf}$$

$$L^* - L_y - L_f = 0$$

Optimal Input Allocation

Optimal level of non-allocable input in Ag. Prod:

input shadow or market price = the sum of the marginal value products of the input in the production of the agricultural commodity and public goods (GHG pollution, & amenities)

Optimal level of non-allocable input in Ag-Forest:

input shadow price or market price = equals the sum of the marginal value products of the inputs in the production of the agro-forestry commodity and the public good (carbon sequestration)

Welfare Maximization (1)

$$\max \int_{P_y(Ly,Ky)}^{\infty} x\left(\widetilde{P_y}\right) d\widetilde{P}_y + P_y\left(L_y, K_y\right) Y\left(L_y, K_y, K_a\right) + P_f F\left(L_f, K_f\right) - D_g\left[G\left(L_y, K_y\right)\right] - D_n\left[N\left(L_y, K_y\right)\right] + B_a\left[A\left(L_y, K_a, K_y\right)\right] + B_s\left[S\left(F\left(L_f, K_f\right)\right)\right] - \left[\left(P_{ky}K_y + P_{ka}K_a + P_{kf}K_f\right)\right] + \mu\left[L^* - L_y - L_f\right]$$

Welfare Maximization (2)

$x(\widetilde{P_y})$ domestic demand agricultural output

$$Y = x(P_y) + x^*(P_y)$$

$D_g(\cdot)$ domestic social damage function- GHG E.

$D_n(\cdot)$ domestic social damage function nutrient P.

$B_a(\cdot)$ domestic social benefit function landscape A.

$B_s(\cdot)$ domestic social benefit function C sequestration

First-Order Conditions Welfare Maximization

$$x^*(P_y)\frac{\partial P_y}{\partial L_y} + P_y Y_{Ly} - D'_g(\cdot)G_{Ly} - D'_n(\cdot)N_{Ly} + B'_a(\cdot)A_{Ly} = \mu,$$

$$x^*(P_y)\frac{\partial P_y}{\partial K_y} + P_y Y_{Ky} - D'_g(\cdot)G_{Ky} - D'_n(\cdot)N_{Ky} + B'_a(\cdot)A_{Ky} = P_{ky}$$

$$B'_a(\cdot)A_{Ka} + P_y Y_{Ka} = P_{ka},$$

$$P_f F_{Lf} + B'_s(\cdot)S' F_{Lf} = \mu,$$

$$P_f F_{Kf} + B'_s(\cdot)S' F_{Kf} = P_{Kf}.$$

Difficult to implement Pigouvian solution when amenities, GHG emissions & nutrient pollution are unobservable, not measurable in a traditional way, or measurable only at substantial cost.

Welfare Maximum Input Taxes and Subsidies Small Country (1)

$$\max_{L_y, K_y, L_f, K_f} P_y Y\left(L_y, K_y, K_a\right) + P_f F\left(L_f, K_f\right) - (P_{Ky} + t_{Ky})\left(K_y\right) - (P_{Kf} + t_{Kf})(K_f) - (P_{Ka} + t_{Ka})(K_a) + s_{Ly}(L_y) + s_{Lf}(L_f) + (\mu)\left[L^* - L_y - L_f\right]$$

- **Non-commodity outputs can neither be priced nor regulated directly.**
- **Practical policies act on observable outputs and inputs.**
- **Optimal taxes and subsidies on inputs equivalent to the Pigouvian solution: externalities are taxed or subsidized at their social values assigned *at the national level***

Welfare Maximum Input Taxes and Subsidies Small Country (2)

$$P_y Y_{Ly} = \mu - s_{Ly},$$

$$P_y Y_{Ky} = P_{ky} + t_{Ky},$$

$$-P_{Ka} - t_{Ka} = 0,$$

$$P_f F_{Lf} = \mu - s_{Lf},$$

$$P_f F_{Kf} = P_{kf} + t_{Kf}$$

For Social Welfare Max. we require taxes and subsidies to be consistent with the first-order conditions for a Welfare Max. After appropriate substitutions we have:

Welfare Maximum Input Taxes and Subsidies Small Country (3)

- $s_{Ly} = B'_a(\cdot)A_{Ly} - D'_g(\cdot)G_{Ly} - D'_n(\cdot)N_{Ly},$
- $t_{Ky} = D'_g(\cdot)G_{Ky} + D'_n(\cdot)N_{Ky} + B'_a(\cdot)A_{Ky},$
- $t_{Ka} = -B'_a(\cdot)A_{Ka} - P_y Y_{Ka},$
- $s_{Lf} = B'_s(\cdot)S'F_{Lf},$ [Positive Subsidy]
- $t_{Kf} = -B'_s(\cdot)S'F_{Kf}.$ [Negative Tax]

Welfare Maximum International Limit on GHG Emissions (1)

$$\max \int_{P_y(Ly,Ky)}^{\infty} x(\widetilde{P_y})d\widetilde{P}_y + P_y(L_y,K_y)Y(L_y,K_y,K_a)$$
$$+ P_fF(L_f,K_f) - D_g[G(L_y,K_y)] - D_n[N(L_y,K_y)]$$
$$+ B_a[A(L_y,K_a,K_y)] + B_s\left[S\left(F(L_f,K_f)\right)\right]$$
$$- [(P_{ky}K_y + P_{ka}K_a + P_{kf}K_f)] + \mu[L^* - L_y - L_f]$$
$$+ \gamma\left[GHG^* - G(L_y,K_y) + \theta S\left(F(L_f,K_f)\right)\right]$$

Welfare Maximum International Limit on GHG Emissions Small Country (2)

- $s_{Ly} = B'_a(\cdot)A_{Ly} - D'_g(\cdot)G_{Ly} - D'_n(\cdot)N_{Ly} - \gamma G_{Ly}$,
- $t_{Ky} = D'_g(\cdot)G_{Ky} + D'_n(\cdot)N_{Ky} + B'_a A_{Ky} + \gamma G_{Ky}$,
- $t_{Ka} = -B'_a(\cdot)A_{Ka} - P_y Y_{Ka}$,
- $s_{Lf} = B'_s(\cdot)S' F_{Lf} + \gamma\theta S' F_{Lf}$,
- $t_{Kf} = -B'_s(\cdot)S' F_{Kf} - \gamma\theta S' F_{Kf}$.

Implications of the International GHG Emissions Limit

- **Domestic welfare maximizing taxes and subsidies on inputs now depend the "shadow price" of the GHG constraint, if GHG^* were increased, domestic social welfare would increase by an amount γ. If $\gamma > 0$**
- **added taxes on land and non-land inputs in agriculture = γ *X* marginal input contributions to GHG emissions**
- **Added subsidies to land and non-land inputs in forestry = γ *X* marginal input contribution to discounted carbon sequestration**

Two Cases for Policy: $\gamma = 0$ and $\gamma > 0$.

- Case 1 $\gamma = 0$-- internationally-agreed GHG constraint is not binding on the agricultural sector so subsidies and taxes on inputs to maximize domestic social welfare lead to GHG reductions in excess of global target
- Maybe due to preferential treatment of agriculture at expense of other sectors—potential problem because emissions from ag. high relative to GDP contribution—what about “fair share”
- Countries in the northern hemisphere may actually gain from higher global temperatures through increased productivity in agriculture and globally mandated reduction in GHG emissions may well reduce domestic welfare

Two Cases for Policy: $\gamma = 0$ and $\gamma > 0$.

- Case: 2 $\gamma > 0$ national social value assigned to the domestic damage due to GHG emissions is at odds with the global social value of the damage implicit in the command and control target level
- From domestic view, the global target level of reductions assigned to the country is too high
- Domestic agro-environmental policy objectives may be constrained by international obligations.
- The international GHG constraint might dictate land to go out of agriculture & into agro-forestry--limiting the supply of amenities associated with agriculture, but could reduce negative externalities of agriculture such as pollution of water supplies

Implications for Program Design

- Practical way to achieve multiple environmental objectives, including GHG mitigation in agriculture is to focus land use & the inputs applied to that land.
- Negative externalities can be reduced & positive externalities and public goods can be increased.
- Taxes on inputs is politically unacceptable
- More likely alternative is one based on payment for environmental services (PES) which is to "…translate external, non-market values of the environment into real financial incentives for local actors to provide such services"

Implications for Program Design

- Through PES producers can be rewarded for positive externalities and public goods as well as the reduction of negative externalities.
- Implementation of a PES requires that positive and negative environmental contributions be clearly identified and that payments be directed to achieving the maximum social benefit.
- An example from the US is the Conservation Reserve Program (CRP)

Implications for Program Design

- CRP, introduced in the 1985 Farm Bill, is a voluntary program that pays agricultural landowners an annual rental payment and cost-sharing assistance to establish long-term, resource conserving practices on eligible land.
- Contracts lasting from 10 to 15 years typically involve planting and maintaining covers to control soil erosion, improve water and air quality, and enhance wildlife habitat.
- The aim of the program is to change existing land use to increase supply of environmental services.

Implications for Program Design

- CRP involves competitive bidding. Farmers offer eligible acreage for enrollment in the program and specify the rental payment they will accept.
- Applications ranked using an Environmental Benefits Index (EBI) whose score is based on the eligible acreage's environmental characteristics.
- EBI reflects a judgment of which land attributes & practices applied would generate the highest environmental benefits, relative to costs.

Implications for Program Design

- 400 is maximum possible point score (excluding score for costs)
- 240 are unambiguously allocated to negative externalities of crop production (lower water and air quality and increased soil erosion),
- 110 are unambiguously allocated to promoting the supply of public goods (wildlife habitat and carbon sequestration).
- 50 points (enduring benefits) apply to increasing the probability of securing continued reduction in externalities and an enhanced supply of public goods beyond program enrollment period

Implications for Program Design

- Weightings, both total points to a characteristic (wildlife habitat, vs. water quality) & allocation of points within characteristics (aspects of wildlife habitat or water quality) reflect a preference set.
- Characteristics rated based on scientific judgments, but science may offer limited guidance as to weights—some preferences based on thresholds and others continuous
- Marginal trade-offs among characteristics are impossible for the discontinuous rating.
- Interpretation of marginal valuations among factors with continuous ratings not straightforward due to differences in metrics.

Program Design-Advantages of Indexed PES

- Explicit relative weights placed on environmental factors valued by policymakers.
- Factors are known to producers in advance, to help judge the value of program participation.
- Competitive bids give taxpayers best value to improve environmental quality – bids in line with private costs of meeting contract requirements may be below social costs or benefits involved.

Program Design-Disadvantages of Indexed PES

- **Index construction(factors included, measurement & point allocation) may not produce most desirable or efficient outcome.**
- **May be learning by doing or implicit collusion among producers such that bids tend to converge to maximum rate policymakers can offer.**
- **Use of index may involve relatively high transactions costs of bid preparation, evaluation by policymakers, & monitoring compliance.**

Adapting EBI approach to climate change mitigation in Norway

- Many elements of framework to target payments to achieve a range of environmental objectives, including climate change mitigation objectives, already in place
- Regional (county) level priorities center on the protection of the cultural landscape (e.g., maintenance of grazing systems to preserve open space) & pollution prevention.
- Local authorities can prioritize the use of resources provided by central government both in terms of the balance between the two principal objectives & the spatial allocation of funds

Adapting EBI approach to climate change mitigation in Norway

- **<u>Stylized Program Design</u>**
- **As in our model, assume target has been established for reducing GHG emissions in agriculture & that carbon sequestration is used to help meet that goal.**
- **Then farmers will be offered a payment to encourage them to divert land from agricultural production to agro-forestry in addition to payments for achieving other environmental objectives.**

Adapting EBI approach to climate change mitigation in Norway

- **Nature of the Payments**
- **Diversion payment might cover establishment costs for forest plantings and compensation for net income foregone over the life of the planting, either through fixed annual payments or a lump sum based on a discounted stream of future income.**
- **If cost were the only consideration diversion payments would be targeted to regions where the opportunity costs of agro-forestry are low and where the sequestration potential from forestry is high**

Adapting EBI approach to climate change mitigation in Norway

- **Nature of the Payments**
- With multiple environmental objectives, the determination of how to allocate diversion payments based on the use an EBI would seem to be more appropriate since GHG mitigation would have to be balanced against these in selecting which land parcels to include in the diversion program.
- A application of an EBI for Norway would need to be focused at an appropriate geographical scale, which is facilitated by current county-based approach used for agri-environmental programs.

Adapting EBI approach to climate change mitigation in Norway

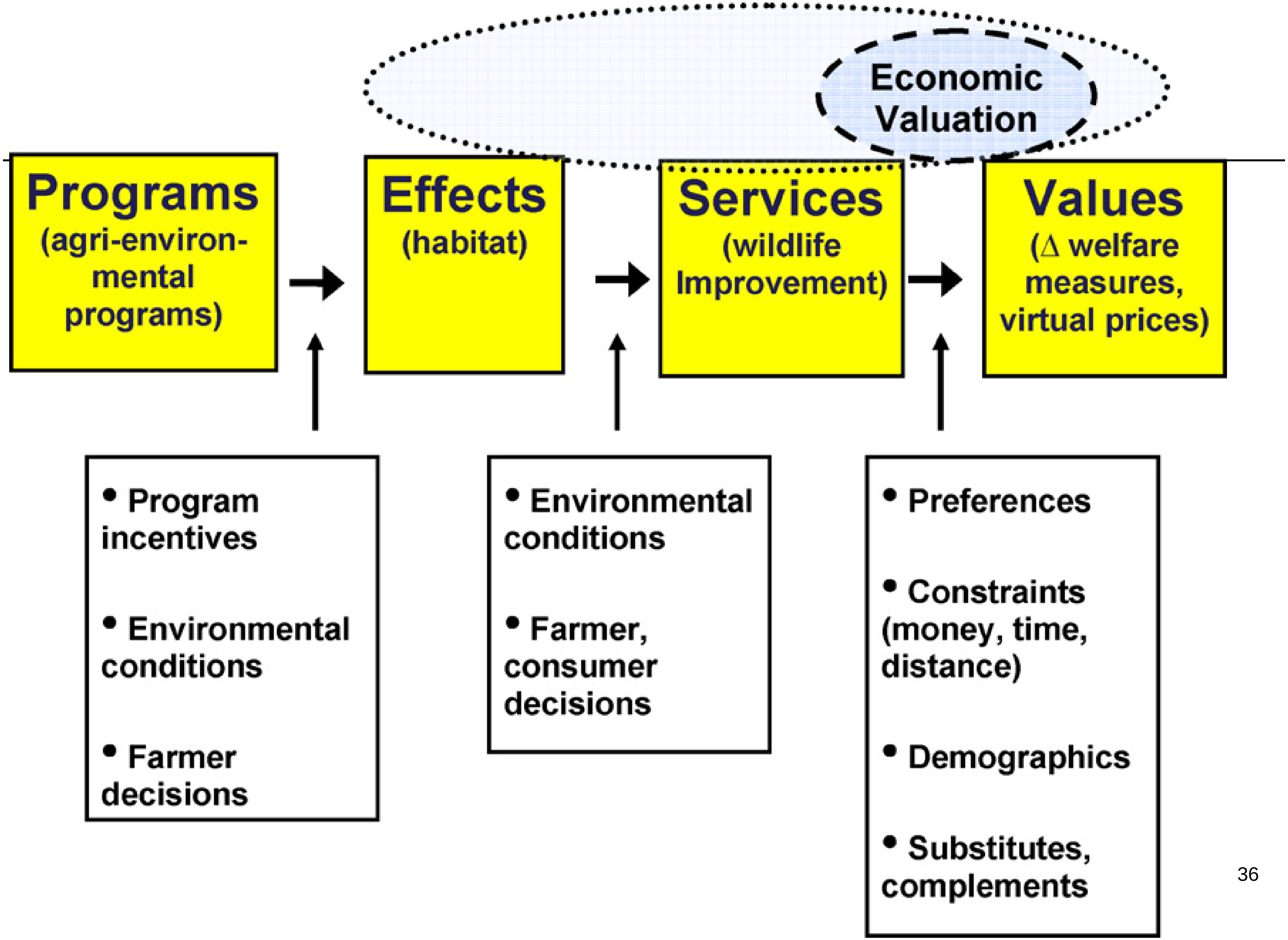
- **Nature of the Payments**
- Compared with the CRP's EBI, the public good component in Norway would have to be expanded beyond the enhancement of wildlife habitat to include other aspects of landscape amenities, but these are also already reflected at the local level in Norwegian agri-environmental program.
- Currently in the CRP's EBI, little weight is given to carbon sequestration, but that would be much more important in Norway.

Adapting EBI approach to climate change mitigation in Norway

- **The major function of the EBI might be to provide transparency in the determination of payments to particular parcels of land that are brought under environmental programs that have multiple objectives.**
- **<u>But constructing an EBI is no easy task</u>**

The Valuation Issue for Multifunctional Agriculture

- The task, familiar but nevertheless challenging to economists, of valuing non-commodity services is only the final step in the process of valuing policies and programs. This process involves several intervening steps—linking policies and programs to effects, linking effects to changes in services, and valuing those changes in services.
- A. Randall / Agriculture, Ecosystems and Environment 120 (2007) 21–30 23


Economic Valuation
Programs
(agri-environ-mental programs)
Effects
(habitat)
Services
(wildlife Improvement)
Values
(Δ welfare measures, virtual prices)
• Program incentives
• Environmental conditions
• Farmer decisions
• Environmental conditions
• Farmer, consumer decisions
• Preferences
• Constraints (money, time, distance)
• Demographics
• Substitutes, complements