Government Policies and their Effects on Resource Use in the U.S. Grain and Oilseed Sectors

by

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Abstract

Three Policies widely used by governments around the world--market price supports, direct payments, and input subsidies--are analyzed for their implications for resource use and effectiveness in transferring income to growers. Results indicate that direct payments are the most effective while input subsidies are least effective in transferring income to farmers. All policies result in expanded input use with input subsidies having the largest effect while direct payments have the least impact.

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More than a decade ago, the OECD Secretariat and USDA's Economic Research Service initiated the measurement of producer and consumer subsidy equivalents (PSEs/CSEs) and the modeling of the trade impacts of various policies (Ballenger, 1988; Cahill and Legg, 1990; OECD, 1987; Roningen and Dixit, 1989, 1991). These modeling exercises used PSEs/CSEs (as aggregate commodity price wedges) to proxy the policy regime without any consideration to the mix of policy instruments in existence.

In recent years, governments have adjusted their policy instruments for providing support, relying less on market price support and more on direct payments and other forms of support. To what degree have the changes in policy mix impacted various indicator variables important to policy makers, such as taxpayer and consumer costs, producer income, resource use, and trade? This paper describes the analytical framework within which, using the information on support levels provided by the PSE, we can examine such questions.

The Modeling Framework

The modeling framework used in this analysis is an intermediate-run static, partial equilibrium, net-trade model, and factor markets are modeled explicitly. The model is an adaptation of the partial equilibrium farm sector model described by Gardner (1987). A single-product CES production function is used to represent the technology of food grains, feed grains, and oilseeds production. All markets are assumed competitive, equilibrium in factor markets assumes autarky, while outputs are traded internationally and the rest of the world is represented through export demand equations

Production equations

Production of each of the three outputs is a function of nine inputs. Production technology is represented by a Constant Elasticity Substitution *(CES)* technology.

$$\textbf{(1)} \qquad Qs_i = \gamma_i[\Sigma_j \ \delta_{ij} \ X_{ij}^{-\rho_i}]^{-1/\rho_i} \quad ,$$

i= wheat, 2: feed grains, 3: oilseeds
j=1: other purchased inputs, 2: fertilizer, 3: chemicals, 4: hired labor, 5: irrigation, 6: energy, 7: capital, 8: insurance, 9: nonpurchased inputs

where Qs_i is output of commodity *i*, X_{ij} is the quantity of input *j* used in the production of commodity *i* indexed over *j*, γ_i is the efficiency parameter ($\gamma_i > 0$), δ_{ij} is the distribution parameter of input *j* for commodity *i*, ($\sum_j \delta_j = 1$) and ρ_i is the substitution parameter for commodity *i* with *(-1<*ρ_i*)*.

Commodity demand equations

Demand for each commodity is assumed to be a multiplicative function of the consumer price of all commodities, and is represented by constant elasticity functions. Commodities are linked in these equations through cross-price elasticities of demand. Therefore, substitution among commodities is allowed for consumers. Each demand equation contains a set of demand shifters, such as the level and distribution of disposable income, representing all exogenous variables affecting demand but excluded from the analysis. The value of the demand shifters is embodied in the base year, and since the policies examined are not expected to affect the value of these shifters, only the impact of changes in prices is modeled.

$$\textbf{(2)} \quad Qd_i = \mu_i \prod_k \left(Pc_k^{\lambda_{ik}} \right) \quad ,$$

where Qd_i is quantity demanded of commodity *i*, μ_i is the demand constant for commodity *i*, Pc_k is the price consumers pay for commodity *k*, and λ_{ik} are the own- and cross-price elasticities of the i^{th} commodity. Exports *(*Qx_i*)* of each commodity is the difference between the quantity produced and domestic consumption of commodity *i*.

Factor demand equations

Factor demand is derived from the marginal revenue product *(MRP)* equation for factor *j* used in the production of commodity *i* under profit maximization assumptions. The derived

factor demand equations are functions of output price, input price, the elasticity of substitution, the efficiency parameter, the distribution parameter, and output level.

$$\textbf{(3)} \quad X_{ij}^{d} = Qs_i[(\frac{\delta_{ij}}{\gamma_i^{\rho_i}})^{\sigma_i} (\frac{Wd_j}{Pq_i})^{-\sigma_i}] \quad ,$$

where X_{ij}^{d} is demand for input *j* in production of output *i*, Wd_j is the price the producer pays for input *j*, and Pq_i is the price producers receive for commodity *i*. Total demand for factor *j* (X_j^d) equals the aggregate of the demand for input *j* used in wheat, feed grains and oilseed production.

Factor supply equations

Supply of each input is assumed to be a simple function of its price, and is represented by constant elasticity functional form.

$$\textbf{(4)} \quad X_j^S = a_j (Ws_j)^{\zeta_j} \quad ,$$

where X_j^s is the total quantity of factor *j* supplied, a_j is the constant of factor *j* , Ws_j is the market price that suppliers of factor *j* receive, and ζ_j is the supply elasticity of factor *j* in the sector. In equilibrium, the total quantity of factor *j* supplied, X_j^s, equals the quantity demanded of the factor.

Price and policy linkage equations

The policy structure of the model is embedded in equations linking domestic (producer) price to world price. Policies are captured through links to prices. For this exercise, we include only three of the five categories of agricultural policies considered in the PSE calculations: market price support *(mps)*, income support (direct) payments *(dp)*, and input subsidies *(isub)*.

World price Pw_i for commodity *i* is a function of U.S. exports. The equation is represented by a constant elasticity function:

$$\textbf{(5)} \quad Pw_i = \phi_i \prod_j Qx_j^{\xi_{ij}} \quad ,$$

where Qx_j is the quantity of commodity *j* exported (which is endogenously determined in the model) and ξ_{ij} is the export price flexibility of commodity *i* with respect to exports of commodity *j*. The price flexibility of export demand summarizes in one parameter the reactions of both exporting and importing countries to a change in export quantity by the United States.

Producer price (Pq_i) is a function of world price and the per-unit *mps* rate. (Marketing margins are not modeled explicitly, but assuming they do not change as a result of the various experiments, the results are not materially affected). If the world price is lower than the producer price (positive *mps*), then producers are effectively being subsidized. A negative transfer can occur when policies keep internal prices below world prices (e.g., export tax).

$$\textbf{(6)} \quad Pq_i = Pw_i + mps \quad .$$

Consumer price (Pc_i) is also derived from the world price for commodity *i*. Market price support, consumer subsidies, and other subsidies may affect consumer price. A positive *mps* indicates an implicit tax where consumers pay higher prices, either because of a price floor or the existence of export subsidies. In addition, the consumer price may include direct subsidies *(Csub)* derived from demand enhancing programs. Consumer subsidies reduce the price of consumption.

$$\textbf{(7)} \quad Pc_i = Pw_i + mps - Csub \quad .$$

Input prices are determined domestically. For purchased inputs, the price the providers of input *j* receive, W_j^s, may differ from the price farmers pay, W_j^d, if input subsidies, *isub*, are provided. Input subsidies, therefore, expand the use of the input beyond the profit maximization level in the absence of subsidies. Input subsidies can be generic (available to all inputs) or input-specific, and they create a wedge between the price that suppliers receive and the price that producers pay.

$$\textbf{(8)} \quad W_j^s = W_j^d + isub_j \quad .$$

The nonpurchased, or farmer-owned, input represents the bundle of land, fixed capital, and producers' own-labor, and it is modeled similarly to purchased inputs--its demand is derived from the profit maximization conditions and there is a representative supply schedule reflecting the opportunity cost of providing additional units of the input. A major distinction is that the nonpurchased input is commodity-specific and its supply is much less elastic, reflecting the relative fixity of this factor in agriculture--relative to purchased inputs, larger price increases are needed to induce an additional unit of supply. In addition, the input subsidies discussed above, *isub*, are not available to nonpurchased inputs; rather, we assume that direct payments, *dp*, induce agricultural producers to supply more of the nonpurchased bundle relative to the profit maximization level. In this sense, direct payments act as other subsidies, and create a wedge between the price (opportunity cost) of staying in farming and market returns from farming.

$$\textbf{(9)} \quad W_i^{s,\,fo} = W_i^{d,\,fo} + dp \quad ,$$

where $W_i^{s,fo}$ represents the opportunity cost of reducing own-labor or land use in crop *i*, and $W_i^{d,fo}$ represents market returns. This differs across the commodities, reflecting that returns differ across crops, in contrast to factor price of purchased inputs. Direct payments can be generic (available to all producers) or crop-specific, and as modeled, act to increase the supply of the nonpurchased bundle above the amount that would otherwise be provided.

Equilibrium in the model is attained through market clearing conditions for each of the outputs and inputs. Equilibrium for the output markets reflects links to world markets through exports, while equilibrium in the factor markets assumes autarky. These markets are all in equilibrium through market clearing conditions used to enforce the equality of supply and demand in both commodity and factor markets.

Calibration and Policy Scenarios

The model is calibrated to represent the market and policy conditions for 1995, the last year of the Food, Agriculture, Conservation, and Trade Act of 1990 (FACTA 90). The PSE/CSE data base

from the OECD with some modifications are used as an indicator of taxpayer and consumer transfers to agriculture in 1995, and to generate the wedges in various prices in the model. Many of the parameters in the model were generated by the OECD's AGLINK model, and the rest gleaned from the literature[1].

Three policy instruments; 1) market price support, 2) direct payments, and 3) input subsidies, are examined for their effects on output, consumption, trade, resource use, and welfare (consumer and producer). In addition, an income transfer efficiency index is computed to indicate the relative effectiveness of the policies to deliver income to farmers.

A total of five policy scenarios are examined--two types of market price support; a) targeted for wheat, and b) available to all three commodities; two types of input subsidies, a) targeted for only those inputs that were subsidized during 1995, and b) available to all purchased inputs; and one direct payment which is not targeted.

Starting with 1995 support levels, we assume the additional infusion of $100 million of support, i.e., an increase in the value of the PSE by $100 million sequentially as market price support, direct payments, or input subsidies. Total support is converted into a per-unit subsidy, and results are reported as changes in income, welfare, resource use, production, or exports due to an additional $1 of support. We allow endogenously determined supports to adjust as needed to ensure that exactly $100 million of additional support is provided, but the total PSE at the end of the experiment may be above the initial $100-million because base-year policies continue.

Results

The first counter-factual experiment is to examine the effects of increasing expenditures on a targeted export subsidy program (like the Export Enhancement Program) for wheat. Increasing **market price support** by $1.00 causes producer and domestic consumer prices to increase $.09/ton, but leaves the price of coarse grains and oilseeds unchanged. Higher wheat price expands input demand stimulating wheat production while the higher prices contract domestic consumption, leading to larger wheat exports. Added input demand leads to higher input prices, higher costs, and a fall in input demand by coarse grain and oilseed producers. However, the

[1] Data and parameters used are available from author upon request.

added demand by wheat producers more than compensates, leading to a net increase (except for irrigation water) in input demand (table 1). Production of coarse grains and oilseeds declines due to higher costs, but domestic consumption expands as consumers substitute away from higher price wheat, leading to a fall in exports (table 2). The effect of the policy is to lower welfare, especially of wheat consumers as total consumer surplus is estimated to fall by about $0.31. In addition, taxpayer costs (in the form of additional export subsidies) increase about $0.53. The beneficiaries of the subsidy are the suppliers of the purchased inputs, whose aggregate producer surplus increases $0.23; and foreign consumers, especially of wheat, whose consumer surplus increases $0.21. Farm households also benefit from the subsidy, as aggregate income increases $0.35. However, this is somewhat misleading because the sole beneficiaries are wheat producers whose income expands $0.48 while returns to coarse grain and oilseed producers fall.

Increasing **market price support** by $1 (not targeted to a specific commodity) causes domestic producer and consumer price of each output to increase by about $0.01/ton. Increased output price expands demand for factors of production and stimulates production while domestic consumption contracts, causing exports to increase and world prices to decline by about $0.02/ton. The fall in consumption and increase in consumer prices leads to a drop in consumer surplus, estimated for all three crops to be about $0.31, with consumers of feed grains suffering the largest decline in surplus. The additional cost to taxpayers is $0.27, lower than the previous scenario due to lower export subsidies. The beneficiaries of the subsidy are the suppliers of the purchased inputs, whose aggregate producer surplus increases $0.17; farm households, whose income increases $0.24; and foreign consumers of these commodities, whose consumer surplus increases about $0.15. Providing a general rather than targeted market price support, lowers total taxpayer and consumer cost to $.58 from $.85; lowers benefits to presumably unintended beneficiaries, foreign consumers and suppliers of purchased inputs; and although the increase in aggregate farm household income is lower, gains accrue to each group of producers, not just producers of the targeted commodity.

Increased support in the form of **direct payments**, as may be expected, has smaller impacts on production and consumption than does market price support. Direct payments, as modeled, are available to all producers and mimic deficiency payments in that market prices are

not affected but producers have to remain in agriculture to receive them. These payments lead to an expansion in the supply of farm-owned inputs by increasing returns. The additional supply expands production, lowers output prices, and expands domestic consumption and exports (the magnitude of changes are smaller than for market price support). Additional consumption and lower prices increase domestic consumer welfare by about $0.14, with more than half of the benefits accruing to feed grain consumers. This form of support is more expensive to taxpayers; the taxpayer and consumer costs of direct payments increase by $0.86. But, if the objective of supports is to transfer income to farm households while minimizing transfers to overseas consumers and input suppliers, direct payments are much better instrument than market price support. A $1 increase in direct payments results in a 67-cent increase in farm household income, but only a 2-cent increase in producer surplus of input suppliers and a 5-cent increase in consumer surplus of overseas consumers.

During 1995, U.S. programs subsidized use of irrigation water, capital, and insurance. The **targeted input subsidy** assumes that only these three inputs are subsidized. An additional $1.00 input subsidy lowers the cost of using these inputs, expands production of each output, and increases demand for all inputs, with the demand of the targeted inputs expanding the most. The additional production lowers prices and increase domestic consumption and exports, leading to lower world prices. This policy has a relatively hefty cost to taxpayers, but consumers gain as their surplus increases about $0.43, leading to total taxpayer and consumer costs which is lower than targeted *mps* or *dp*. Foreign consumers also benefit as their consumer surplus increases $0.16. As one would expect, increasing input subsidies leads to increasing returns for input suppliers, as their producer surplus expands $0.26, with the providers of the subsidized inputs reaping the majority of the benefits. Striking is the relatively small pass-through to farmers as farm household income increases only $0.09.

The results are not materially different when the input subsidy is not targeted to any input. Additional **general input subsidies** reduce input prices and expand demand for inputs. Changes in demand for inputs however, is not skewed as was the case in the previous scenario. Consumer benefit the most with this instrument as consumer surplus increases $0.47, and the combined taxpayer and consumer cost is the lowest. Foreign consumers once again benefit as their

consumer surplus increases. Total returns to providers of inputs is very similar to above, but the distribution of benefits among the provides is more widespread and not concentrated as in the targeted case. It seems that input subsidies, whether targeted or not, are equally ineffective in transferring income to farmers; their income increases only $0.09.

Summary and Conclusions

Several observations are apparent from the results. First, a $1 increase in transfer payments to the farm sector through any of the components of agricultural policy leads to a lesser change in domestic farm income. The rest of the monetary transfer accrues either to other agents in domestic markets, foreign consumers/producers, or deadweight losses (inefficient use of resources). Additionally, increased support, even when made available to all participants, has different impacts, largely because changes in transfers to the US farm sector lead not only to changes in the level of support but also to changes in supply and demand. These supply and demand changes differ in magnitude and direction, allowing for a different allocation of resources in the factor and commodity markets.

Second, among the policies examined, direct payments expand farm household income the most. A dollar of support transferred through direct payments increases farm income by 67 cents. Transfer efficiency--the ratio of the change in farm household income to the change in total consumer and taxpayer costs--captures how effectively a given output subsidy transfers income to farm households. Transfer efficiency of direct payments is 78 percent, by far the highest among the policies considered, while input subsidies are the least efficient in transferring income to farmers. The transfer efficiency of targeted input subsidies is 15 percent, while the transfer efficiency of market price supports is 40 percent. This suggests that policy shifts towards direct payments are beneficial to farmers. In addition, we modelled direct payments as providing incentives for farm households to expand the use of their land and labor. To the extent that the flexibility contracts are completely decoupled, transfer efficiency should be even higher with the new program. Direct payments also reduce transfer leakages to input suppliers and foreign consumers.

Third, the increased transfer efficiency of direct payments comes with relatively high taxpayer costs, while domestic consumers incur most of the costs of market price supports. The

most consumer-friendly policy is also least beneficial to farmers--input subsidies. When taxpayer and consumer costs are combined, direct payments have the highest cost per $1 of support, while input subsidies are the least costly. In short, $1 of additional support has very different impacts depending on how it is transferred, and very little of the transfer may make it to the intended beneficiaries.

Fourth, the trade distortion of additional support, measured by increased exports, is mitigated through direct payments, while targeted market price supports are most distorting. For example, an additional $1 in targeted market price support results in additional wheat exports that are 36 times greater than additional exports with the same level of support through direct payments. Additional exports and lower world prices that result from more support benefit foreign consumers of US grains and oilseeds. Direct payments minimize the transfer to foreign consumers, while foreign consumers of US grains and oilseeds benefit the most from US input subsidies. In fact, input subsidies are better at transferring welfare to foreign consumers ($0.17), than to domestic farmers ($0.09).

Fifth, policies have differential effects on resource utilization in agriculture. Input subsidies are not only ineffective in transferring income to farmers, they also tend to exacerbate pollution potential of agriculture by increasing demand for fertilizers, chemicals, and fossil fuels; inputs with potential to increase pollution. Direct payments are more environmentally benign because they tend to minimize changes in output and input use.

Table 1. Changes in input use from $1 increase in support as either market price support, direct payments, or input subsidies.

	Market price Support		Direct payments		Input subsidies
	Wheat	General	General	Targeted	General
Other purchased inputs (units)	0.220	0.132	0.014	0.044	0.210
Irrigation	-0.001	0.002	0.001	0.025	0.210
Fertilizer	0.082	0.068	0.005	0.013	0.089
Chemicals	0.007	0.035	0.004	0.013	0.058
Energy	0.033	0.023	0.002	0.006	0.035
Hired labor	0.015	0.011	0.001	0.004	0.018
Capital	0.034	0.028	0.003	0.188	0.048
Insurance	0.055	0.026	0.003	0.180	0.046

Table 2. Impacts of $1 increase in support as either market price support, direct payments, or input subsidies.

		Market price Support		Direct payments	Input subsidies	
		Wheat	General	General	Targeted	General
Change in production (Tons)	Food grains	0.500	0.030	0.020	0.066	0.064
	Feed grains	-0.148	0.233	0.053	0.127	0.213
	Oilseeds	-0.057	0.008	0.024	0.088	0.060
Change in consumption (Tons)	Food grains	-0.078	-0.007	0.004	0.013	0.014
	Feed grains	0.215	-0.021	0.006	0.016	0.019
	Oilseeds	0.013	-0.006	0.004	0.015	0.013
Change in exports (Tons)	Food grains	0.578	0.038	0.016	0.053	0.050
	Feed grains	-0.363	0.254	0.048	0.111	0.194
	Oilseeds	-0.070	0.015	0.019	0.073	0.047
Change in CS ($)	Food grains	-0.278	-0.038	0.020	0.062	0.068
	Feed grains	-0.044	-0.220	0.077	0.216	0.276
	Oilseeds	0.008	-0.051	0.043	0.147	0.122
	Total	-0.314	-0.309	0.141	0.425	0.465
Change in TPC ($)	Total	0.532	0.272	1.001	1.009	1.010
Change in TPC+CS ($)	Total	-0.846	-0.581	-0.861	-0.584	-0.544
Change in ISS ($)	Total	0.228	0.166	0.018	0.265	0.262
Change in FHI ($)	Total	0.347	0.239	0.671	0.090	0.091
Change in PSE ($)	Total	1.038	1.026	1.002	1.010	1.010
Change in FCS ($)	Food grains	0.214	0.058	0.019	0.057	0.062
	Feed grains	-0.007	0.052	0.013	0.037	0.048
	Oilseeds	0.004	0.038	0.020	0.069	0.057
	Total	0.210	0.148	0.052	0.163	0.167

TPC=Taxpayer costs CS=consumer surplus ISS= input supplier surplus FHI=farm household income FCS=foreign consumer surplus

References

Ballenger, N. "PSE what they are and their role in trade negotiations?" *Choices* 3:36-37, 1988.

Cahill, C and W. Legg, *Estimation of Agricultural Assistance Using Producer and Consumer Subsidy Equivalents, Theory and Practice*. OECD Economic Studies (special issue 13) 1990.

Gardner, B. *The Economics of Agricultural Policies*, New York: Macmillan, 1987.

Organization for Economic Co-operation and Development. *National Policies and Agricultural Trade*. Paris, France 1987.

_____. *Trade, Employment and Income Effects of Farm Support: A Framework for Analysis and an Application to Mexico*. COM/AGR/APM/TD/WP(96)66. Paris, 1996

_____. *Assessing Trade and Welfare Effects of Agricultural Policy Changes: (Update on Developing an Analytical Framework)*. COM/AGR/APM/TD/WP(97)3. Paris, 1997.

Roningen, Vernon and Praveen Dixit. "Economic Implications of Agricultural Policy Reforms in Industrial Market Economies". USDA/ERS Staff Report No. AGES 89-36. 1989.

_____. *How Level is the Playing Field: An Economic Analysis of Agricultural Policy Reforms in Industrial Market Economies*. USDA/ERS Foreign Agricultural Economic Report No. 239. 1991.