Where Does All the Money Go? Measuring Effects of Agricultural Policy Transfers on Farm Income (Wyatt Thompson, University of Missouri at Columbia, Organizer)

Efficiency of Income Transfers to Farmers through Public Agricultural Research: Theory and Evidence from the United States

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Studies of the efficiency of redistribution through agricultural commodity markets have focused on transfers made using domestic policy instruments, such as subsidies and quotas, and trade protection instruments, such as import tariffs and export subsidies. These instruments transfer income to producers from domestic consumers or domestic taxpayers (and occasionally to or from foreigners). My own recent estimates (Alston 2007) indicate that for every dollar of U.S. government spending on farm subsidies, farmers (in their capacity as both landowners and suppliers of other farming inputs such as labor and managerial inputs) receive about 50 cents, landlords who rent land to farmers receive about 25 cents, domestic and foreign consumers receive about 20 cents, and 5 cents are wasted. Additional amounts are wasted collecting taxes to finance the spending and in administering the policies—perhaps another 20 cents per dollar. If the purpose is to transfer income to farmers, the mechanism is very inefficient. Expenditure on farm programs of $20 billion per year (with an opportunity cost of, say, $24 billion) in typical recent years yielded benefits of about $10 billion to farmers, such that the average transfer efficiency ($10 billion divided by $24 billion) was less than 42%.

In contrast, agricultural research involves a "deadweight gain" rather than a loss. Recent estimates by Alston, Andersen, James, and Pardey (AAJP) (2009) indicate that U.S. federal and state government expenditure on agricultural research and extension generates benefit–cost ratios of at least 10:1 and more likely much higher. A benefit–cost ratio of 10:1 implies that public expenditure of $2 billion on agricultural R&D would generate benefits of $20 billion. The farmer's share of these national social benefits depends on details of elasticities, agricultural commodity policies, and the nature of the research-induced technical change, which together determine the distribution of research benefits. If farmers were to receive 50% of the total benefits (as from farm program subsidies), then the average transfer efficiency would be 420% ($10 billion divided by $2.4 billion, allowing for the social opportunity costs of government spending)—in other words it takes only $2 billion of taxpayer expenditure on agricultural R&D to achieve the same farmer benefit as $20 billion spent on farm commodity subsidies, and in the process society earns a net benefit. In what follows, I elaborate on this contrast between the net welfare impacts and transfer efficiency of subsidies versus agricultural R&D and then consider possible explanations for the persistent underspending on agricultural R&D and overspending on subsidies.

Size and Distribution of Welfare Impacts of Farm Commodity Programs

Alston (2007) reports estimates of the price, quantity, and welfare effects from a hypothetical elimination of all subsidies applied to U.S.

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farm program crops in 2005. Such an analysis of the joint elimination of the full set of subsidy policies is necessary if we wish to understand the impacts of farm program policies as a whole. The resulting estimates differ from those implied by piecemeal analysis of the elimination of policies applied to individual commodities, leaving other subsidies in place. I use the estimates from Alston (2007) who provides details of the models, assumptions, and support for particular parameter values. A brief summary of the approach is presented here.

The first step was to derive an estimate of the fully coupled subsidy equivalent of the different types of subsidies, using an approach suggested by Sumner (2005). The concept here is that any subsidy amount can be partitioned into two elements: a fully decoupled payment and a fully coupled subsidy equivalent. Different weights (fractions between 0 and 1) apply to different types of subsidy instruments reflecting the extent to which they are coupled to production. Multiplying a given subsidy by its weight yields a measure of the fully coupled equivalent in terms of the incentive effects; subtracting this amount from the total leaves a measure of the equivalent fully decoupled residual.

Table 1 shows details of government subsidy payments to program crops in 2005, crop by crop and in total. Subsidies to producers of program crops included \$5.25 billion in the form of direct payments (DP), \$4.82 billion in the form of countercyclical payments (CCP), and \$6.44 billion in the form of loan program payments (LPP—including loan deficiency payments, marketing loan gains, and certificate exchange gains), together totaling \$16.5 billion. In 2005, production of program crops had a value of about \$58 billion, such that the payments were equal to 28.6% of the value of production nationally. In addition to the total subsidy (TS_1) equal to the simple sum of program payments, the table includes a weighted sum of payments (TS_2), given by applying the weights (0.4, 0.5, and 1.0—see Sumner (2005) and Alston (2007) for justification of the particular values) to the respective elements of payments (DP, CCP, and LPP): $TS_2 = 0.4 * DP + 0.5 * CCP + LPP$. Weighted and unweighted subsidy amounts are expressed relative to the value of production in the last two columns. The entries in the final column, $100 * TS_2/V$, represent the percentage fully coupled subsidy equivalent of the payments for the commodities in the table. The last entry in that column represents the average rate of fully coupled output subsidy equivalent: 19.0%.

The second step was to apply this estimate of the fully coupled equivalent subsidy rate in a two-factor model of the U.S. program crop sector as a whole (as used by Floyd 1965), with parameters representing program crops as a whole produced using land and a composite of all other inputs (output demand elasticity, $\eta = 1.0$; elasticity of substitution between land and other inputs, $\sigma = 0.1$; elasticity of supply of land for the production of program crops, $\varepsilon_1 = 0.2$; elasticity of supply of "other" inputs used to

Table 1. Commodity Program Payments and Subsidy Rates in Crop-Year 2005

Program Crop	Crop Value (V)	Subsidy Payments[a] (\$*millions*)					Subsidy Rate ($\tau_i = 100 * TS_i/V$) (*Percent*)	
		DP	CCP	LPP	TS_1	TS_2	τ_1	τ_2
Corn	21,041	2,109	2,948	4,600	9,657	6,918	45.9	32.9
Soybeans	16,928	598	0	19	617	258	3.6	1.5
Upland cotton	5,204	611	1,376	371	2,358	1,303	45.3	25.0
Wheat	7,140	1,136	0	1,036	2,172	1,490	30.4	20.9
Rice	1,789	425	87	130	642	344	35.9	19.2
Other[b]	5,696	375	414	288	1,077	645	18.9	11.3
Total[c]	57,798	5,254	4,824	6,444	16,522	10,958	28.6	19.0

Source: Alston (2007).

[a] DP = direct payments; CCP = countercyclical payments; LPP = "loan program payments," which includes loan deficiency payments, marketing loan gains, and certificate exchange gains. TS_1 is the simple sum, and TS_2 is the weighted sum, where each weight represents an estimate of the equivalent rate of output subsidy per dollar of payment: $TS_1 = DP + CCP + LPP$ and $TS_2 = (0.4 * DP) + (0.5 * CCP) + (1.0 * LPP)$.

[b] Other includes other program crops: feed grains (barley, oats, grain sorghum), peanuts, oilseeds (sunflower seed oil, other minor oilseeds, canola, rapeseed, mustard seed, safflower seed, crambe, sesame), lentils, chickpeas, dry edible peas, wool, mohair.

[c] The total crop value figure includes the U.S. value of production data for food grains, feed crops, cotton, and oil crops, as reported by USDA.

produce program crops, $\varepsilon_2 = 1.0$; cost share of land, $s_1 = 0.20$—see Alston (2007) for evidence and arguments supporting the particular values). These parameters together imply an elasticity of supply of program crops in aggregate of $\varepsilon = 0.62$. Applying the subsidy rate of 19%, the implied effect of eliminating the programs would be a reduction in the production of program crops by 7.3%. These estimates treat the Conservation Reserve Program (CRP) as a separate policy. If the CRP were to be eliminated along with crop subsidies, the net effects on output would be smaller compared with eliminating the subsidies alone but still negative—an output reduction of around 5%. The corresponding estimates from the Australian Bureau of Agricultural and Resource Economics (ABARE) (McDonald et al. 2006) multimarket simulation model ranged from 2.9 to 13.9% for the crops considered here but were only 2.9 and 3.8% for soybeans and maize (which together represent two-thirds of the value of production). The implications are similar: the total output effects of elimination of subsidies would be modest, even for the most subsidized crops.

The direct net benefit (deadweight loss avoided) is correspondingly small. As shown by Alston (2007, Appendix E), the deadweight loss from distortions in the production and consumption resulting from an output subsidy, expressed as a fraction of the subsidy expenditure, is proportional to the percentage subsidy-induced change in production. Using the same parameters in the two-factor model and allowing for the role of international trade, the proportion to be applied to the percentage increase in the production is in the range of 0.5–1.0. Thus, if elimination of subsidies at an average rate of 19% (in incentive effect) would yield a 7.3% decrease in production (i.e., leaving the CRP in place), it would yield net gains to society in the range of 3.6–7.3% of the amount of effective subsidy expenditure of $10.96 billion in 2005 (that is, in the range of $400 million to $800 million, 2–5% of the actual subsidy expenditure of $16.52 billion). If the CRP is seen as a concomitant of the farm subsidies, the benefits from eliminating the distortions caused by the subsidy expenditures would be even smaller—perhaps, about two-thirds of these amounts. The total deadweight loss is much bigger if we allow for any significant deadweight losses associated with general taxation to raise the government revenues to finance subsidies (i.e., a social opportunity cost of government revenues significantly greater than $1.00 per dollar spent—say $1.20 per dollar). Including these additional deadweight losses as incurred on the full subsidy expenditure of $16.52 billion, the total deadweight loss is about $4 billion.

The same basic information was used to compute the distribution of the welfare impacts. First, the difference between the total subsidy amount for any crop (TS_1) and the fully coupled equivalent (TS_2) is given by $TS_3 = TS_1 - TS_2 = 0.6 * DP + 0.5 * CCP$, which represents the amount of the total subsidy that can be treated as a pure decoupled payment that goes to land. Having partitioned the total subsidies into an element that can be treated as a fully coupled output subsidy (TS_2) and a residual that can be treated as a fully decoupled payment (TS_3), we can analyze the impacts on landowners. The total benefits to landowners are equal to the benefits from the fully decoupled element (TS_3) plus the amount going to land from the fully coupled element ($\mu\ TS_2$, where μ is the share going to land): $TS_4 = TS_3 + \mu TS_2$. Given the parameters in the two-factor model, the implied value for μ is 30.0%, and $TS_4 = 0.72 * DP + 0.65 * CCP + 0.30 * LPP$. Taking this approach, the total of $16.52 billion is equivalent to a decoupled transfer of $5.56 billion, 100% of which accrues to land, combined with a pure output subsidy of $10.96 billion, 30% of which accrues to land.

After allowance for deadweight losses of about $0.5 billion, the overall incidence is therefore about $8.5 billion on land (roughly half of which is owned by the farmers who use it and half by landlords who rent to farmers) and about $7.5 billion on suppliers of non-land inputs and consumers (of which consumers get about 38%). In other words and in round figures, for every dollar spent on subsidies, about 20 cents accrue as a benefit to consumers, 50 cents accrue as a benefit to landowners, and 25 cents accrue as a benefit to farmers per se, such that the total "producer" benefit is about 75 cents per dollar and the total "farmer" benefit is about 50 cents per dollar of subsidy expenditure. A modest amount (say 5 cents) is wasted as a deadweight loss from distortions in the commodity market, which increases to 25 cents if the social opportunity cost of government spending in commodity programs is $1.20 per dollar.

Size and Distribution of Welfare Impacts of Agricultural Research Investments

Unlike farm program subsidies, which impose a net burden on the economy, public agricultural R&D yields a net benefit. Alston, Chan-Kang, Marra, Pardey, and Wyatt (ACMPW) (2000) conducted a meta-analysis of 292 studies reporting estimates of returns to agricultural R&D. A predominant and persistent finding across the studies was that the rate of return was quite large. After dropping some outliers and incomplete observations, ACMPW conducted regression analysis using a sample of 1,128 estimates of rates of return to agricultural R&D with a mean of 65%, a mode of 28%, and a median of 42% per annum. The main mass of the distribution of internal rates of return reported in the literature is between 20 and 60% per annum. ACMPW concluded that the evidence suggests agricultural R&D has paid off handsomely for society, but they raised a number of concerns about the methods used in the studies that were likely to have led to upward biases in the estimates.

In a study of effects of public U.S. agricultural R&D (1890–2002) on agricultural productivity (1949–2002) using state-level data, AAJP (2009) paid careful attention to modeling the research lag distribution and the state-to-state spillovers of research impacts, and the other types of methodological issues raised by ACMPW (2000). They found support for relatively long research lags (an overall lag length of 50 years with a peak impact at 24 years), with a very substantial share of a state's productivity growth attributable to research conducted by other states and the federal government. The results from the authors' preferred model show that marginal investments in agricultural research and extension by the 48 contiguous U.S. states generated national benefits ranging from \$10 to \$70 per dollar, and averaging \$32 per dollar across the states, and \$18 per dollar for USDA intramural research. These benefit–cost ratios are consistent with internal rates of return at the lower end of the range in the literature as reviewed by ACMPW. Specifically the corresponding AAJP estimates of national "social" rates of return averaged 23% per annum (ranging from 15% to 29%) across the states for state-specific research, with 19% per annum for USDA intramural research.

Their estimates of payoffs may be subject to upward bias from measurement error, but AAJP took pains to eliminate potential sources of error, and their estimates of benefit–cost ratios (or their counterpart internal rates of return) are lower than the vast majority of the previously published estimates. Moreover, these are *marginal* measures that will understate the average benefit–cost ratio if public agricultural research is characterized by diminishing returns. Consequently, a figure of 20:1 is a conservatively small estimate of the *average* benefit–cost ratio for the total public investment in agricultural R&D, implied by the AAJP estimates, which we can apply to the expenditure by the USDA on agricultural R&D. In what follows, I use an even more conservative estimate of the average benefit–cost ratio: 10:1.

The U.S. government invests about \$2.6 billion per year in agricultural R&D through the USDA, including intramural research conducted in USDA labs (\$1.2 billion in 2006), support for research conducted in State Agricultural Experiment Stations (\$1.0 billion in 2006), and extension (\$0.4 billion in 2006). With an average benefit–cost ratio of 10:1, these expenditures will generate national benefits over the first half of the 20th century with a discounted present value of \$26 billion in 2006. To evaluate transfer efficiency, we have to determine the share of those benefits going to producers versus consumers and, for some questions, the share of the producer benefit going to farmers versus landlords. To obtain measures of these distributive shares that are comparable to those presented for farm program subsidies, it is desirable to use a consistent set of modeling assumptions. Here, I present a model of research benefits that is consistent with the model used to estimate the incidence of farm program subsidies presented in the previous section and use it to interpret the distribution of benefits from public R&D.

In figure 1, D_0 represents the demand for U.S. agricultural output and S_0 represents the supply. This supply function nests linear and constant elasticity models as special cases and has the virtue of imposing a positive shutdown price while permitting supply to be inelastic at the equilibrium (see Lynam and Jones 1984; Pachico, Lynam, and Jones 1987). Suppose a research-induced technical change causes supply to shift down in parallel to S_1 and, as a result, the quantity produced and consumed increases from Q_0 to Q_1 and price falls from P_0 to P_1. The total benefits from the research-induced supply shift are equal to the area between the two supply curves, behind the demand curve, and this is equal to area $(B + C + E + F + G)$. Of that total, the consumer benefit is equal to area $(A + B + F)$ and the producer benefit is equal to area $(C + G)$, given the assumption of a vertically parallel supply shift, which means area $(A) =$ area (E). These shares of the total benefits are

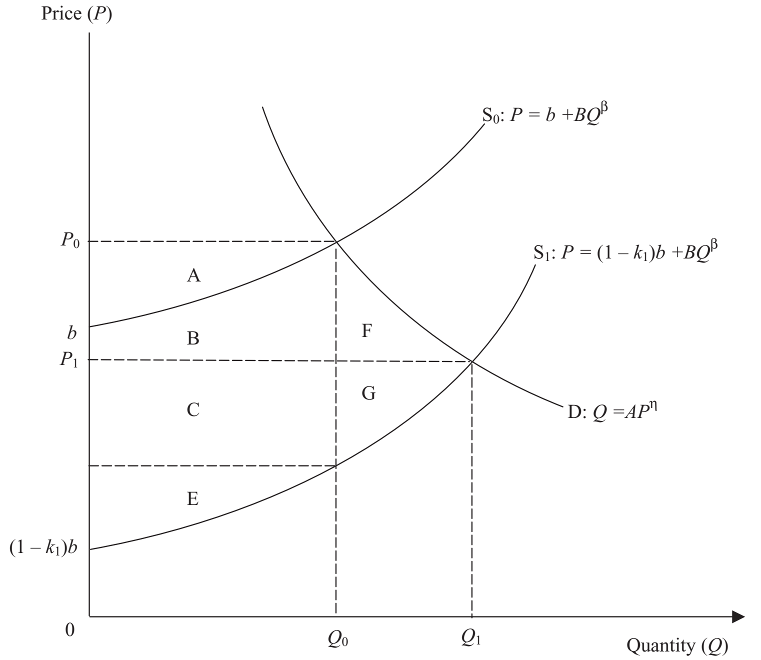

Figure 1. Price, quantity, and welfare effects of agricultural R&D

distributed according to the elasticities of supply (ε) and demand (η, representing the absolute value), where the producer share is approximately $\eta/(\eta + \varepsilon)$ and the consumer share is approximately $\varepsilon/(\eta + \varepsilon)$. In the two-factor model of program crops, the elasticity of demand for the aggregate farm output is $\eta = 1.0$, and the implied elasticity of supply is $\varepsilon = 0.62$. Thus, the consumer share is 38% (0.62/1.62) of the total research benefit, and the producer share is 62% (1.00/1.62)—compared with producers getting 75% of benefits from program crop subsidies because they are partially decoupled with 100% of decoupled payments accruing to landowners. If the purpose of federal support for agricultural R&D is to transfer income to producers, the policy is very efficient. Expenditure of \$2.6 billion yields producer benefits of \$16.1 billion (0.62 × \$26 billion), a transfer efficiency of 620% (517% if the expenditure has an opportunity cost of \$2.6 billion × 1.2 = \$3.1 billion).

Taken at face value, these estimates suggest that agricultural R&D is much more efficient than farm commodity programs as a mechanism for transferring income from taxpayers to agricultural producers. Compared with agricultural R&D, it costs 10–12 times as much to achieve a given producer benefit using subsidies. Moreover, the subsidy imposes a deadweight loss while the R&D yields a deadweight gain. Nevertheless, producer groups seem to be much more interested in subsidies than R&D (for instance, consider the positions taken by various farm commodity groups during the discussions of the 2007 Farm Bill), and the U.S. government continues to spend in the range of \$10 on farm subsidies for every dollar it spends on agricultural R&D.

Puzzling Persistence of Underinvestment in Agricultural R&D

How can we account for this seeming paradox? One possibility is that producer groups or policymakers (or both) may be skeptical about the measures of research benefits. Another is that some other aspect of the benefits may be relevant to the choice between policies—such as the distribution of the producer benefits among different groups of producers and over time. We explore some of these possibilities next.

Many estimates of rates of return to research seem implausibly large, and in some cases there are reasonable grounds for suspicion that the estimates may have been biased up as a reflection of choices made by the analyst (see ACMPW 2000). The fact that some estimates are distorted may have led to diminished confidence in the overall body of evidence. In addition, as discussed by Alston, Norton, and Pardey (1995), some modeling choices have important implications for the findings, and certain key choices are usually made without a strong empirical basis. For instance, the assumed nature of the research-induced supply shift is crucial. Producers necessarily benefit from a vertically parallel research-induced supply shift, but with a pivotal supply shift, the total benefits would be half as large as for a parallel shift, and producers may lose if demand is sufficiently inelastic (though certain farm program policies may counter this effect by making the effective demand facing farmers more elastic).

The model depicted in figure 1 can be represented as follows:

(1) $P = (1 - k_1)b + (1 - k_2)BQ^{\beta}$ (supply)

(2) $Q = AP^{\eta}$ (demand).

Although it cannot be solved analytically for the equilibrium price and quantity, this model can be solved numerically given particular values of parameters. Table 2 shows the resulting estimates of producer benefits as a share of total benefits for three different kinds of 1% shifts down of the supply function: (a) vertically "parallel" ($k_1 = 0.01$, $k_2 = 0$); (b) "pivotal" (or multiplicative in the quantity direction, $k_1 = 0$, $k_2 = 0.01$); and (c) "proportional" (or multiplicative in the price direction, $k_1 = k_2 = 0.01$)—essentially combining a parallel shift and a pivotal shift. The range of parameters imply values for the elasticity of supply at the initial equilibrium ranging from 0.33 to 2.00, bracketing the value of 0.62 implied by the assumptions of the two-factor model. These are combined with demand elasticities from 0.5 to 4.0, bracketing the value of 1.0 from the two-factor model as well as a more likely value of 1.5 for the elasticity of demand for U.S. program crops as a whole (see Alston 2007, Appendix B).

With a linear model, producers lose from a pivotal supply shift either if demand is inelastic or if demand is elastic but less elastic than supply. Somewhat similar results are found here for the nonlinear model. Producers do not benefit from a pivotal shift unless demand is elastic and much more elastic than supply. In contrast, with a parallel research-induced supply shift, even if demand is inelastic, producers

Table 2. Producer Shares (Percentage) of Research Benefits and Their Determinants

Supply Function Parameters			Demand Elasticity (Absolute Value)				
β	*b*	Elasticity (ε)	0.5	1.0	1.5	2.0	4.0
Parameter Values			*Producer Shares of Benefits (Percent)*				
Pivotal Supply Shift—$k_1 = 0.00$, $k_2 = 0.01$							
4.00	0.25	0.33	−100	−25	9	29	62
4.00	0.50	0.50	−150	−67	−25	0	44
4.00	0.75	1.00	−234	−150	−100	−67	0
2.00	0.25	0.67	−71	−20	8	25	57
2.00	0.50	1.00	−100	−50	−20	0	40
2.00	0.75	2.00	−140	−100	−72	−50	0
Proportional Supply Shift—$k_1 = 0.01$, $k_2 = 0.01$							
4.00	0.25	0.33	0	37	55	64	81
4.00	0.50	0.50	17	44	58	67	82
4.00	0.75	1.00	17	38	50	59	75
2.00	0.25	0.67	−14	20	38	50	71
2.00	0.50	1.00	0	25	40	50	70
2.00	0.75	2.00	4	20	32	40	60
Parallel Supply Shift—$k_1 = 0.01$, $k_2 = 0.00$							
4.00	0.25	0.33	60	75	82	86	92
4.00	0.50	0.50	50	67	75	80	89
4.00	0.75	1.00	34	50	60	67	80
2.00	0.25	0.67	43	60	69	75	86
2.00	0.50	1.00	33	50	60	67	80
2.00	0.75	2.00	20	34	43	50	67

Note: Entries in this table are measures of producer benefits as a percentage of the total benefits from the supply shift. The parameter *b* represents the shutdown price as a fraction of the initial price, and the parameter β is the exponent of the quantity in the price-dependent supply response function, such that a larger value of β tends to imply a smaller supply elasticity, as does a smaller value of *b*.

gain a substantial share of the benefits, especially if supply is relatively inelastic. And with a proportional shift, while the producer's share of benefits is smaller than that for a parallel shift, it is still in the range of 30–60% of total benefits given the more likely values for the supply and demand elasticities. The possibility of losses to producers is often discounted on the grounds either that demand is relatively elastic or that a parallel research-induced supply shift is relatively likely (or that the pivotal shift seems comparatively unlikely), but concrete empirical evidence on that issue has been elusive to date. Thus, even when we can be assured of benefits to the nation, some uncertainty remains about the distribution of benefits between producers and consumers.

Another issue is distribution of producer benefits among producers. Even if we can be assured that producers collectively would benefit, those who do not adopt the new technology will not gain and may even be made worse off (if the adoption by others leads to price reductions); so, individual producers or groups of producers may be uncertain about their benefits from a given research investment because of uncertainty over what technology may be developed and who will adopt it and when. Similarly, the factor bias of technological change, which is unlikely to be known in advance of the research investment, may mean that landowners benefit at the expense of suppliers of farm labor, including farm operators, or vice versa.

Timing issues are important, too, as a potential source of uncertainty about who may benefit from today's investments in research. The lags between investing in agricultural research and reaping benefits are very long—recent results from AAJP (2009) suggest lags as long as 10–15 years before important benefits begin to be realized, with streams of benefits extending for 40 years and more after the initial investment. Their measures of benefit–cost ratios account for the timing of the flows of benefits and account for impatience through the application of an appropriate social rate of time preference—a real discount rate of 3% per annum. But politicians and some farmers may not be quite so patient, especially given the unavoidable and inherent uncertainty about the size of research benefits. We cannot be certain about who will benefit from agricultural research, when, and by how much, and even *ex post*, it is hard to demonstrate unequivocally the size of benefits and the pattern among beneficiaries. In contrast, farm program benefits are comparatively certain, tangible, visible, and immediate.

Conclusion

Farm program subsidies involve relatively clear patterns of benefits with moderate deadweight losses, but if the same funds were invested alternatively in agricultural R&D, producers would receive much larger benefits, and society as a whole would obtain a large net gain. However, agricultural R&D apparently is not seen as an effective or efficient instrument for redistributing income from taxpayers to agricultural interests, probably because of two related characteristics of the benefits. First, we have to wait a long and indefinite time for research benefits. Second, we are uncertain about the size of the total research benefits (to be received at some unknown time in the future), the distribution of the total benefits between consumers and producers, and the distribution of producer benefits among farmers, landowners, and others, which depends on the factor bias of the new technology, who will adopt it, and when.

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