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Introduction

Governments around the world use a wide variety of policy tools to intervene in the agricultural sector. These policies directly or indirectly influence the production incentives and consumption patterns of various agricultural commodities. In last decade there has been an increasing interest in the political economy of agricultural protection. The topic that has received the most attention is the paradox of developing countries typically taxing and industrialized countries commonly subsidizing their agricultural sector. Most of the work in the area of political economy of agricultural protection (PEAP) has focused on the consequences of farm programs. A growing number of studies have recently attempted to explain the causes of farm programs as well. These studies have become more analytically realistic than earlier simple, descriptive attempts to examine policy mechanisms. A recent development is the treatment of policy intervention as endogenous rather than exogenous, within a public choice framework. In this new line of political economy literature, the policy is seen as an outcome of the interaction of rational policy-makers and trade-sensitive economic groups (Moore, 1990; Petit, 1993 and 1991).

This study investigates the prominent determinants of agricultural protection across industrialized and developing countries. The methodology we use improves upon earlier work in this direction in a number of ways. Since an accurate measurement of the actual level of intervention is a prerequisite for the effectiveness of the investigation, a comprehensive comparative analysis of different measurement concepts and their coverage of effects under a variety of policy scenarios becomes an important exercise. The aim of the study is to use a measurement concept that includes the effects of a wide range of policies, and that is suitable for analyzing the extent of government intervention across countries. Table 1 lists various measurement concepts used in the PEAP literature. Table 2 provides the policy-wise coverage of some of these measurement concepts. It is evident from the tables that the producer subsidy equivalents (PSEs) provide by far the widest coverage of effects of different policy instruments as compared with the concepts commonly used in the literature such as nominal rates of protection (NRP) and nominal protection coefficients (NPC).

Table 1. Comparison of alternative agricultural protection measurement concepts

Measurement Concept[a]	*Acronym*	*Definition*[b]
Nominal Protection Coefficient	*NPC*	P_d / P_w
Nominal Rate of Protection	*NRP*	$Q\,(P_d - P_w) / Q \cdot P_w$
Nominal Rate of Protection for Consumers	*NRPC*	$-\,Q_c\,(P_c - P_w) / Q_c \cdot P_w$
Nominal Rate of Assistance	*NRA*	$Q\,\{(P_d + \omega) - P_w\} / Q \cdot P_w$
Effective Rate of Protection	*ERP*	$(VA_d - VA_w) / VA_w$
Effective Rate of Assistance	*ERA*	$\{(VA_d + \delta) - VA_w\} / VA_w$
Direct Nominal Protection Rate	NPR_D	$\{(P_d - C) - (P_w - C')\} / (P_w - C')$
Indirect Nominal Protection Rate	NPR_I	$\{(P^*_{NA} \cdot E_o) / (P_{NA} \cdot E^*)\} - 1$
Total Nominal Protection Rate	NPR_T	$[\{(P_d - C) / P_{NA}\} - \{(P_w - C') / P^*_{NA}\}(E^*/E_o)] / \{(P_w - C') / P^*_{NA}\}(E^*/E_o)$
Producer Subsidy Equivalent	*PSE*	$\{Q(P_d - P_w) + D + I - L\} / \{Q \cdot P_d + D - L\}$
Producer Subsidy Equivalent, Trade Distortion Variant	PSE_{TD}	$\{Q(P_p - P_w) + D + I - L\} / \{Q \cdot P_p + D - L\}$
Consumer Subsidy Equivalents	*CSE*	$-\,\{Q_c(P_c - P_w) + D_c\} / (Q_c \cdot P_c)$
Trade Distortion by Support	*TDS*	$Q \cdot \varepsilon_s \cdot S_m - Q_c \cdot \varepsilon_d \cdot S_m + Q \cdot \varepsilon_s \cdot S_p - Q_c \cdot \varepsilon_d \cdot S_c + Q \cdot \varepsilon_s \cdot S_m - SSO$
Aggregate Measure of Support, GATT	AMS_G	$Q_t\,(P_{p,t} - P_{w,avg})$

a The measurement concepts refer to the protection levels for a single agricultural commodity. However, these can easily be aggregated to reflect overall protection to the agricultural sector. Percentage values can be derived by multiplying the each measure by 100, except the *TDS* and *AMS*.

b The variables used are defined as: P_d: Domestic Producer Price; P_w: World price (measured in domestic currency); Q: Domestic production; ω: Set of other subsidies/tax on output (including deficiency payments); C: Adjustment for differences in quality, storage, transportation, handling costs and other margins; C': Adjustment for differences in quality, storage, transportation, handling costs and other margins measured under competitive conditions; P_{NA}: Price index of non-agricultural sector; P^*_{NA}: Price index of non-agricultural sector in the absence of trade distortions; E_o: Nominal official exchange rate; E^*: Equilibrium exchange rate in the absence of intervention; VA_d: Value Added per unit of output at domestic prices; VA_w: Value Added per unit of output at world prices (measured in domestic currency); δ: Assistance on all outputs and inputs; D: Direct transfers to agricultural producers; I: Indirect transfers (budgetary-financed support) to agricultural producers; L: Agricultural producer levies; P_p: The "Policy", "Incentive" or "Shadow" price of the commodity that would keep the output the same as the current policies if all policies were removed; ε_s and ε_d: Own-price supply and demand (negative) elasticities, respectively; S_m: Market support ratios; S_p and S_c: Direct income support rates for producers and consumers, respectively; Q_c: Quantity consumed; SSO: Set-aside offset resulting from direct payments to producers; Q_t: Output produced in time period t; $P_{p,t}$: The "Policy" Price of the commodity in period t; $P_{w,avg}$: Fixed reference price based on the years 1986-88, generally the average f.o.b. unit value for the commodity in a net exporting country and the average c.i.f. unit value for the commodity in a net importing country in the base period, measured in domestic currency; P_c: The consumer price of the commodity; and D_c: Budgetary-financed assistance to consumers.

Sources: Bray, C., T. Josling and J. Cherlow (1992); Cahill, C and W. Legg (1990); Krueger, A. O., M. Schiff, A. Valdés (1991); Roningen, V. O. and P. M. Dixit (1991); Schwartz, N. E. and S. Parker (1988); and Josling, T. and S. Tangermann (1989).

Table 2. Policy effects captured by alternative protection measurement concepts

Policy measure[a]	*Producer*								*Consumer*	
	NPC	*NRP*	*NRA*	*NPR_D*	*NPR_I*	*NPR_T*	*ERP*	*PSE*	*NRPC*	*CSE*
Market Price Support										
Border Measures	x	x	x	x		x	x	x	x	x
Domestic Price Support	x	x	x	x		x	x	x	x	x
Market Board & State Trading	x	x	x	x		x	x	x	x	x
Other Output Price Policies	x	x	x	x		x	x	x	x	x
Direct Payments										
Deficiency Payments			x				b	x		
Disaster Payments								x		
Crop Insurance								x		
Producer Levies		x	x	x		x	x	x		
Income Stabilization Funds								x		
Input Assistance Policies										
Primary Input Policies							x	x		
Intermediate Input Policies							x	x		
Marketing Assistance										
Advisory and Inspection								x		
Transportation								x		
Infrastructure Assistance										
Research and Extension								x		
Land Improvement								x		
Irrigation								x		
Economy-wide Policies										
State and National Policies					x	x		c		
Taxation and Other Policies					x	x		d		
Consumer Assistance Policies										
Consumer Price Policies									x	x
Consumer Food Donations										x
Other Consumer Subsidies										x

a Border Measures also include the effects of tariffs, quotas, variable levies, export subsidies. Other output policies may include price premium, two-tiered pricing systems and price stabilization schemes. Primary inputs may include purchased inputs such as fuel, fertilizer, chemicals and disease control measures. Examples of an intermediate input subsidies would include feed subsidies on meat production. The estimates of *CSEs* as calculated by OECD (1991) have explicitly assumed the equivalence of producer and consumer prices and have used the farmgate or producer prices in their calculations of *CSEs*. However, since it is observed that, at times, the producer and consumer prices may differ significantly, it is more appropriate to recognize the differences in the two and use the observed consumer prices in the estimation of *CSEs*. Other consumer subsidies include both direct and indirect transfers to consumers. It may be noted that USDA, ERS calculations of *CSEs* (1990) do not make any distinctions between these direct and indirect transfers.

b The *ERP* calculations include the deficiency payments in case where such payments directly affect the input prices or the production of output.

c State and national policies include programs administered by state, provincial or national governments which tax or subsidize agricultural producers, such as state programs in the U.S., provincial programs in Canada and national programs in the E.C. The USDA (1990) calculations of *PSEs* include the effects of these policies in case of the U.S. and Canada only.

d Other economy-wide policies such as taxation and exchange rate policies have an important but indirect impact on agricultural returns.

Therefore, in order to gauge the level of government involvement in agriculture, the PSE estimates are obtained from OECD (1991) and USDA (1993 and 1990). The study covers 31 industrialized and developing countries for the period from 1979 to 1990. Moreover, since all protection levels are determined on a commodity basis, a product-specific approach is employed to study the protectionistic patterns in the wheat sector. In order to ascertain the effects of explanatory variables on the probability that the protection levels will be positive, the Probit and Logit estimation procedure are used. The results regarding the marginal effects of explanatory variables as well as their mean elasticities are also provided.

The Empirical Model

The producer subsidy equivalents (PSE) is transformed to form a discrete choice model. In this case, the normal ordinary least squares estimation will not yield efficient results and the Probit or Logit estimation techniques may be used based on the assumptions about the distribution function. The estimated coefficients from Probit or Logit models cannot be interpreted as in the earlier models. The coefficients need to be modified to obtain the estimate of the effect that the independent variable will have on the probability of the dependent variable taking a specific value.

Consider a model, y = b' x + m, where y may be unobservable. Instead, the data may be available whether a particular observation of y falls in one category (y > 0) or the other (y £ 0). The Probit analysis may be used to solve the problem of how to obtain the efficient coefficient estimates. Let z represent a binary variable with a value of one if y > 0, and zero otherwise. In this case, the probabilities that z takes a value of one or zero may be defined as:

Pi = Pr (y > 0) = F (b' x), and

(1 - Pi) = Pr (y £ 0) = 1- F (b' x),

where, F (•) is the normal cumulative distribution function of the error terms associated with the normal density function f (b' x). Then, the likelihood function for this case may be defined as:

$$L(\beta, x, z) = \prod_{i=1}^{n_1} \Pr\,[z_i = 1] \cdot \prod_{i=n_1+1}^{N} \Pr\,[z_i = 0],$$

where n = 1, ... , n1 , n1+1, ... , N, are the observations, with first n_1 observations taking the value of one and the rest are zero. Alternatively, in terms of the distribution function,

$$L(\beta, x, z) = \prod_{i=1}^{n_1} F_\mu(\beta' x) \cdot \prod_{i=n_1+1}^{n} [1 - F_\mu(\beta' x)].$$

The maximum likelihood estimation (MLE) technique can be used to obtain the best, linear, unbiased estimates (BLUE) for the coefficients, β, by solving

$$\frac{\partial L(\cdot)}{\partial \beta} = \sum_{i=1}^{n} \left[\frac{z_i - F(\cdot)}{F(\cdot)[1-F(\cdot)]} \right] \cdot f(\beta' x) = 0.$$

Moreover, since z may only take values one or zero, the variance of error terms may be assumed as unity. However, the coefficient estimates in this case do not represent the marginal effects on the probability of the dependent variable taking a value of one. To obtain the estimates of the effects of independent variables on this probability, the estimated coefficients need to be transformed by taking the product of the estimated coefficient and the probability density function, $\hat{\beta} \cdot f(\hat{\beta}' x)$. The resulting effect on the probability of the dependent variable taking a value of one of a unit change in the i^{th} explanatory variable may, then, be calculated as follows:

$$\frac{\partial \hat{P}_i}{\partial x_i} = \frac{\partial F(\cdot)}{\partial x_i} = \hat{\beta}_i \frac{1}{\sqrt{2\pi}} e^{-\frac{1}{2}(\hat{\beta}_i x_i)^2}.$$

The usual t-statistics can now be used to test a hypothesis about the statistical significance of a single variable. The likelihood ratio test statistic, with a χ^2 distribution, can be used in the case of a joint hypothesis about more than one variable. A derivative of the Probit model is the Logit model, which is based on the logistic cumulative distribution function. The logistic function closely approximates the distribution function of a normal variable. However, the coefficient estimates from Probit and Logit models are generally not significantly different as shown below.

To identify factors that affect the political positions of consumers and producers and the likelihood of producers being subsidized, a Probit model is estimated. The data on PSEs are grouped according to whether the protection is positive or negative. That is, the dependent variable, PSEwheat , was transformed such that z =1 if PSEwheat > 0, and z =0 otherwise. In order to compare the results of Probit estimation with those provided by the linear probability and the Logit models, the same model was estimated using the Probit, OLS and Logit estimation techniques.

Results and Discussion

The comparative results from the three approaches are provided in Table 3. The results from the linear probability model show significant impact of the Engel coefficient, income elasticity of demand, factor ratio and the previous year's world price on the probability that the farmers in that year would receive subsidies. All these coefficients have the expected negative sign, indicating that a unit increase in these variables decreases the probability of farmers being subsidized. The results of the Probit and Logit models are not very different from the linear probability model. All the coefficients on the Probit model are consistent with the theory and validate earlier results. The Cragg-Uhler R^2 coefficient is 0.71 and the model predicted the correct outcome 86.7 percent of the time. However, the numerical implications of the models yield a different interpretation of the estimated coefficients. Further, when the individual coefficients are considered, it is the relative magnitude that matters and not the absolute size of the coefficients.

Table 3. Comparison of linear probability, Probit and Logit predictions: Probability of agricultural producers receiving subsidies

	Linear Probability Model		*Probit Model*		*Logit Model*	
Independent Variable	*Estimated Coefficient*	*t-Statistic*	*Estimated Coefficient*	*t-Statistic*	*Estimated Coefficient*	*t-Statistic*
Engel Coefficient	-0.009*	-3.45	-0.033**	-2.06	-0.057**	-2.05
Labor Force in Industry	0.006	1.38	0.045	1.46	0.082	1.48
Income Elasticity (η)	-0.556*	-3.91	-3.276*	-3.12	-5.831*	-3.04
Factor Ratio	-0.087*	-3.51	-0.606*	-3.79	-1.148*	-3.79
World Price (Lagged)	-0.001*	-2.97	-0.006*	2.7	-0.01*	-2.7
Intercept	1.148*	5.42	2.92**	2.23	5.237**	2.21
Cragg -Uhler R^2	0.54		0.71		0.71	
Likelihood Ratio			126.94 at 5 d.f.		126.05 at 5 d.f.	
Percent of Correct Predictions			86.67		86.11	

Note: In case of the Linear Probability Model, the coefficient of determination is the Adjusted R2.

*, ** Statistically significant at 1% and 5% level, respectively.

For example, in the Probit and Logit models, the coefficient on the income elasticity is about 100 times that on the Engel coefficient. The incomes elasticity coefficient in the linear probability model is only 62 times as large as the Engel coefficient. However, as discussed, the estimates provided by the linear probability estimation technique are inefficient, and, therefore, the Probit model is superior.

As mentioned above, the estimated coefficients in the Probit as well as the Logit model do not represent marginal effects on the probability of the producer protection being greater than zero. These coefficients indicate a movement along the cumulative distribution function for a unit change in the explanatory variable. The Probit coefficients indicate the direction of change in the probability of PSEwheat being positive, but not necessarily a measure of the magnitude of the change. These coefficients have to be transformed to be interpreted as the marginal effects and are given in Table 4.

The marginal probabilities in the Probit model vary according to the original level of probability, while in the OLS model the marginal probabilities are constant. The results in Table 4 are calculated at the mean values of the independent variables. The mean values used in the transformation, along with their standard deviations, are provided in Table 5.

The coefficients indicate the effect of a one-unit change in the independent variable, *ceteris paribus*, on the probability of producers being subsidized. Both the Probit and Logit models provide similar estimates for the elasticities. For example, the Probit model predicts that a one percent increase in the Engel coefficient will decrease the probability of producer subsidies by 0.303 percent. A comparison of these results shows that the Probit and Logit models also yield significantly similar coefficient estimates. For example, the models yield the same predictions for the effect of a unit increase in the Engel coefficient or the previous year's world wheat price on the probability of farmers receiving subsidies. A one unit increase in the factor ratio would decrease their probability of being subsidized by 0.214 in the Probit model and 0.246 in the Logit model..

Table 4. Marginal effect coefficients and elasticities of positive protection levels predicted by the Probit and Logit models

	Probit Model		*Logit Model*	
Independent Variable	*Marginal Coefficient*	*Elasticity at Mean*	*Marginal Coefficient*	*Elasticity at Mean*
Engel Coefficient	-0.012	-0.303	-0.012	-0.252
Labor Force in Industry	0.016	0.382	0.018	0.336
Income Elasticity (η)	-1.157	-0.255	-1.25	-0.218
Factor Ratio	-0.214	-0.18	-0.246	-0.163
World Price (Lagged)	-0.002	-0.241	-0.002	-0.208
Intercept	1.033		1.122	

Table 5. Means and standard deviations of selected explanatory variables

Independent Variable	*Mean*	*Std. Deviation*
Engel Coefficient	30.567	15.172
Labor Force in Industry	28.028	8.9706
Income Elasticity (η)	0.256	0.288
Factor Ratio	0.977	1.107
World Price (Lagged)	138.08	76.978
Growth Rate of Agricultural Labor Force	-2.004	1.103
Gross National Product	337,230	803,880
Price Elasticity- Demand (ε)	-0.401	0.209
Price Elasticity- Supply (ε_{sp})	0.625	0.29

Probit estimates for some alternative model specifications with some additional variables are also performed and the results are reported in Table 6, along with the mean elasticities.[1] The marginal coefficients are reported for model (1) only. In models (1) and (3), the gross national product (GNP) was a significant additional variable that affects the probability of producer protection. The elasticity of the GNP and the Engel coefficient at their mean values are the most significant among the variables considered. In the case of Engel coefficients, which range between 11 and 61 percent across the sample, a one percent increase is expected to decrease the

1 Since the cumulative distribution function is assumed to be standard normal, and Logit results are not different from the Probit model, the table reports only the results for the Probit estimation.

Table 6. Probit estimates to explain the probability of positive producer protection levels

	Probit Models						
	(1)			*(2)*		*(3)*	
Independent Variable	*Estimated Coefficient*	Elasticity at Mean	*Marginal Coefficient*	*Estimated Coefficient*	Elasticity at Mean	*Estimated Coefficient*	Elasticity at Mean
Engel Coefficient	-0.043** (-2.28)	-0.082	-0.016	-0.039** (-2.44)	-0.378	-0.045** (-2.5)	-0.091
Labor Force in Industry	0.04 (1.27)	0.069	0.015	-	-	0.041 (1.33)	0.076
Income Elasticity (η)	-2.404** (-2.0)	-0.038	-0.905	-3.634* (-3.56)	-0.296	-2.35** (-2.23)	-0.039
Factor Ratio	-0.577* (-3.61)	-0.035	-0.223	-0.641* (-4.05)	-0.199	-0.566* (-3.59)	-0.036
World Price (Lagged)	-0.005** (-2.36)	-0.044	-0.002	-0.005* (-2.68)	-0.244	-0.005** (-2.43)	-0.048
Growth Rate of Agricultural Labor Force	-	-	-	-0.175 (-0.78)	-0.111	-	-
Gross National Product	0.000004*** (1.88)	0.083	0.000001	-	-	0.000004** (2.1)	0.086
Price Elasticity- Demand (ε)	-0.027 (-0.023)	-0.0007	-0.043	-	-	-	-
Price Elasticity- Supply (ε_{sp})	0.259 (0.43)	0.01	0.081	-	-	-	-
Intercept	2.529*** (1.73)	-	-	4.08* (4.32)	-	2.72** (2.04)	-
Cragg -Uhler R^2	0.73			0.71		0.73	
Likelihood Ratio	132.18 at 8 d.f.			125.29 at 5 d.f.		132.0 at 5 d.f.	
Percent of Correct Predictions	87.78			86.11		86.67	

probability of positive protection levels by 0.02. The income elasticity of demand has the largest effect on this probability. A one-unit increase in income elasticity of wheat is expected to decrease the probability of wheat farmers being subsidized by about 0.91.

The Cragg-Uhler R^2 for these models ranges between 0.71 and 0.73 and the models predicted the correct outcome about 87 percent of the time. These results highlight the impact of each explanatory variable on the probability that the domestic producers would receive positive protection. The results validate the findings reported earlier. All the independent variables have the correct sign with most of them highly statistically significant. The results of the empirical analysis provide a significant contribution to the understanding of agricultural protectionistic policies across industrialized and developing countries.

Summary

A product-specific approach is employed to study the protectionistic patterns across 31 industrialized and developing countries. The study uses a comprehensive and flexible measure of protection, namely producer subsidy equivalents (PSEs), to ascertain the level of government involvement in agriculture. Results of the Probit estimation indicate that some important factors influencing the probability of agricultural producers receiving protection include, among others, the share of food in household income, share of agriculture in national labor force, income and price and income elasticities.

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