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MEASURING PROTECTION IN AGRICULTURE:  
THE PRODUCER SUBSIDY EQUIVALENT REVISITED

by

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**MEASURING PROTECTION IN AGRICULTURE:**  
**THE PRODUCER SUBSIDY EQUIVALENT REVISITED**

**ABSTRACT**

In the 1980s, the Producer Subsidy Equivalent (PSE) became the dominant measure of protection in applied studies of international agricultural trade. This paper analyzes potential biases in the ratio form of the PSE introduced by using actual domestic prices rather than social opportunity costs in the denominator. It is shown that doing so introduces a consistent under-estimation of the effects of trade restrictions and other price-support policies, relative to deficiency payments and other income-support policies. It is found that under plausible conditions this bias leads the PSE to rank protection levels across countries or crops incorrectly. In a sample of 250 activities across 33 countries, such errors were found to occur in 5% of crop comparisons and 8% of country comparisons, including a number of politically sensitive cases. An improved formula would therefore provide significantly more accurate results than the conventional PSE, with no additional data or more restrictive assumptions.

## INTRODUCTION

A fundamental concern of applied economists is measuring how government policies affect economic incentives. The need for new measures has been particularly pressing in the Uruguay Round of GATT negotiations, as negotiators attempt to reach beyond previous tariff reduction agreements to reduce previously unregulated non-tariff interventions, particularly in agriculture. Such negotiations are hampered in part by the difficulty of knowing how quotas, deficiency payments, land set-asides, and other such policies affect production, trade and welfare. Their impact depends on a variety of interactions in the economy, which can be described only with a relatively complex model. Such models are constantly being improved, and at any one time it is difficult for economists or government officials to agree on the specification and parameters of one "true" model.

To establish common ground in national and international policy negotiations, it is helpful to have some simple measurement tool on which all sides can agree. Such a measure might be less accurate than a fully-specified economic model, but it is easier to understand and use as a basis for negotiation. In recent years the most prominent candidate for this role has been the Producer Subsidy Equivalent (PSE), a measure used informally in GATT negotiations and actually written into legislation for the Canada-U.S. Free Trade Area (Bredahl 1990, p. 4).

The PSE was developed by Josling in the early 1970s (Josling 1973), and is defined generally as "the level of producer subsidy that would be necessary to replace the array of actual farm policies employed in a particular country in order to leave farm income unchanged. It can be thought of as the 'cash' value of policy transfers occasioned by price and non-price policies" (Josling and Tangermann 1989, p. 346). In this way, the PSE provides an aggregate tariff-equivalent measure of many different interventions.

To make comparisons across crops and countries, some unit-free indicator is needed; the most common is the "percentage" PSE, or the total PSE divided by farmers' current revenue. This ratio is intuitively appealing, as it is based on farmers' actual receipts rather than some hypothetical opportunity cost. The percentage PSE thus appears to be a simple accounting measure, and not the output of an economic model based on behavioral assumptions and "what-if" scenarios. Josling (1990) emphasizes this point, writing that "the definition of a PSE is not based on knowledge about the no-policy situation", although he admits that "to add up the effects of various instruments it is indeed useful to calculate the effects of each (relative to its absence) and add them up." (Josling 1990, p. 6).

In the 1980s, the percentage PSE quickly became the dominant empirical measure of policy effects in agriculture. Initial estimates by the FAO (1975) were followed by large-scale USDA (1988) and OECD (1991) studies, both of which are updated periodically and are considered authoritative in the press (e.g. Carr 1992). The PSE

has also attracted some critics, who generally focus on the problem of aggregating support from different types of interventions. For example, Hertel (1989a, 1989b) demonstrates how the mix of support instruments influences their aggregate effect; de Gorter and Harvey (1990) and Roningen and Dixit (1991) propose alternative measures, focusing specifically on how interventions affect welfare or trade. In each case, the improved measure requires introducing an equilibrium model of how quantities would change in response to new government policies. This allows more precise measurement, but could not be used as a basis for policy negotiations without agreement on the structure and parameters of the model being used.

In this paper, we assume that it is precisely the absence of an equilibrium adjustment model that has made the PSE so popular. We accept as given the limitations of the data and of the "subsidy equivalent" concept itself. Instead we focus on the index-number properties of the ratio used to compare subsidy-equivalents across crops and countries, to determine the appropriate denominator. This line of research follows Peters (1989), who suggests that placing current revenue in the denominator of the PSE introduces a number of "quirks and ambiguities" into the measure, all of which "could be avoided by nothing more fundamental than a change of base" (p. 209).

Changing the denominator of the PSE to farmers' revenue at border prices (or, more broadly, national opportunity costs) instead of market prices would produce an indicator like the "Subsidy Ratio to Producers" (SRP) introduced in a different context by Monke and Pearson (1989). The OECD has recently begun calculating an SRP-type measure as an alternative to the PSE (OECD 1993); they term it the "Nominal Assistance Coefficient" (NAC). Official OECD estimates of the NAC are expected to be included in the forthcoming OECD report on "Agricultural Policies, Markets and Trade: Monitoring and Outlook 1993."

OECD analysts have long noted the possibility of changing the denominator of the PSE (e.g. Cahill and Legg 1989/90, p. 16), but they make no judgment as to whether one denominator might be preferable to another. Here, we show that using domestic market prices causes the conventional PSE to understate the effects of product trade policies, relative to domestic or input-market interventions. We show that the SRP/NAC eliminates this bias, changing both the absolute magnitude and the relative levels of measured protection for a number of important crops and countries. In each case, both the PSE and the SRP use identical data, and are equally subject to errors in those data -- but the formula itself is shown to have a substantial independent effect on measurement accuracy.

## **THE PSE AND ALTERNATIVE MEASURES**

Josling's percentage PSE is an adaptation of the far older Nominal Protection Coefficient (NPC), which shows how much government policies raise or lower a product's current market price ( $P$ ) relative to the product's social opportunity cost ( $P^*$ ), usually taken to be the product's import or export value:

$$(1) NPC = P/P^*$$

The NPC concept (and the use of trade values as reference prices), dates back at least to Book IV of The Wealth of Nations, in which Adam Smith assessed the effects of England's Corn Laws by comparing the domestic price of wheat with import costs.

To aggregate the effects of both product and input market policies, the oldest measure is the Effective Protection Coefficient (EPC). The EPC shows how much government policies raise or lower value added (VA) -- returns to labor, land and capital -- earned in producing a good: its product price (P) minus per-unit input costs (I), or the sum of all input prices ( $P_i$ ) weighted by their input/output coefficients ( $\alpha_i$ ):

$$(2) EPC = VA/VA^* = (P-I)/(P^*-I^*) = (P-\sum_i \alpha_i P_i)/(P^*-\sum_i \alpha_i P_i^*)$$

The EPC was introduced by Barber (1955), and has been widely used since the mid-1960s -- but in the context of highly protected activities the denominator ( $VA^*$ ) becomes small or even negative, and the EPC becomes unstable and hard to interpret.

Josling's PSE was introduced in part to overcome the instability of the EPC, by focusing directly on the net effect of government policies. In terms of prices, the percentage PSE is:

$$(3) PSE = (\Delta P - \Delta I)/P = [(P-P^*) - (\sum_i \alpha_i P_i - \sum_i \alpha_i P_i^*)]/P$$

where  $\Delta P$  and  $\Delta I$  are the net effects of policies on product price and input costs, respectively. Depending on the context,  $\Delta I$  may be defined either narrowly or broadly, "to accord with what is politically agreeable" (Josling and Tangermann 1989, p. 346). The narrowest PSEs would include only tradable inputs (like the EPC), whereas a broader PSE could include factor payments (such as deficiency payments).

The PSE's simplicity and flexibility makes it useful in a wide range of discussions, but it is also a weakness: by using fixed input-output coefficients ( $\alpha_i$ ), the PSE abstracts from any variation in marginal productivity or substitution effects, and by measuring each reference price ( $P^*$ ) individually, the PSE abstracts from any general-equilibrium or cross-price effects. Thus the PSE serves as a kind of index number, indicating the aggregate tariff-equivalent of a set of policies with no allowance for economic adjustment. Such an index does not always measure how policy affects quantities produced, consumed and traded, but doing so would require an equilibrium adjustment model -- and it is precisely where such models are not available that the PSE is needed.

The absence of an economic adjustment model introduces some error into the PSE, but that error is inevitable. In contrast, the choice of denominator introduces a

consistent bias that can readily be removed. To demonstrate this, we must first decompose the PSE's denominator into the product's border price ( $P^*$ ) and tariff-equivalent effect of policy ( $\Delta P$ ) (equation 3') and compare this with the definition of the SRP (equation 4):

$$(3') \text{ PSE} = (\Delta P - \Delta I) / (P^* + \Delta P)$$

$$(4) \text{ SRP} = (\Delta P - \Delta I) / (P^*)$$

The juxtaposition of equations (3') and (4) highlights the fact that product-price effects ( $\Delta P$ ) appear twice in the PSE formula (equation 3'), once in the numerator and once in the denominator, whereas they appear only once in the SRP. In this sense  $\Delta P$  is "double-counted" in the PSE, and the SRP formula simply removes this double-counting. The data and assumptions in the two formulas are identical: since  $\Delta P$  is defined as the difference between  $P$  and  $P^*$  (equation 3), there is no information in the SRP that is not in the PSE.

Given that the informational content is the same, does changing the formula matter? The PSE and SRP are both index numbers, without cardinal meaning. Their absolute level may be of interest to politicians and journalists, but has little economic importance. For this reason, economists have paid little attention to the choice of denominator, and have focused instead on making the numerator of the PSE comparable across different crops and countries.

Now that extensive databases of PSE results are available, however, it is clear that the share of taxes or subsidies given through trade restrictions and other product price policies ( $\Delta P$ ), as opposed to deficiency payments and other policies ( $\Delta I$ ), varies widely. As a result, including  $\Delta P$  (but not  $\Delta I$ ) in the denominator of the PSE could not only affect the measured level of protection, but could also cause the relative rankings of two PSEs to be reversed. In such cases the PSE would falsely suggest that one activity is more (or less) subsidized than another, when in fact the opposite is true. Similarly, over time the PSE could falsely suggest that protection levels are constant or falling, when in fact they are rising -- simply because intervention is shifting from product prices ( $\Delta P$ ) to other mechanisms ( $\Delta I$ ).

The conditions under which the PSE could give incorrect rankings (relative to the unbiased SRP) can be found algebraically. When comparing activities "a" and "b", a ranking reversal is defined as:

$$(5) \text{ PSE}_a > \text{PSE}_b \text{ and } \text{SRP}_a < \text{SRP}_b$$

As long as  $PSE_b$  and  $SRP_b$  are both positive, equation (5) is equivalent to:

$$(5') PSE_a/PSE_b > 1 > SRP_a/SRP_b$$

Substituting in equations (1) and (2), we obtain:

$$(5'') P_b/P_a > (\Delta P_b + \Delta I_b)/(\Delta P_a + \Delta I_a) > P_b^*/P_a^*$$

In other words, the PSE ranking will be incorrect relative to the SRP ranking when the ratio of market prices exceeds the ratio of total transfers, which in turn exceeds the ratio of undistorted reference prices. More intuitively, PSE ranking errors occur when one activity ("b") relies relatively heavily on product-price supports (the first inequality), and has a relatively high overall level of support (the second inequality).

A more intuitive proof of the possibility of ranking errors from the PSE relative to the SRP can be given graphically, if we reduce the problem to two dimensions. Assuming that scale effects are minimal, this can be done by normalizing all activities to a common level of revenue ( $P^*$ ). Figure 1 shows all such normalized activities, in terms of their mix of product-price support ( $\Delta P$ ) and input-cost subsidy ( $\Delta I$ ). The sets of activities sharing a given level of PSE and SRP (say,  $PSE_a$  and  $SRP_a$ ) are given by solving equations (3) and (4) for  $\Delta P$  in terms of  $\Delta I$ :

$$(6) \Delta P = - [(PSE_a/(PSE_a-1))] \cdot P^* + [1/(PSE_a-1)] \cdot \Delta I$$

$$(7) \Delta P = [SRP_a] \cdot P^* - \Delta I$$

The set of activities which share  $PSE_a$  form a line of slope  $[1/(PSE_a-1)]$ , while activities which share  $SRP_a$  form a line of slope minus one. Only when the PSE is zero (and hence the SRP is also zero) do these lines coincide. Ranking errors occur whenever activity "a", for example, is compared with another activity in the shaded areas between the lines. Activities such as "b" receive relatively more product-price supports whose effects are underestimated by the PSE, so that  $PSE_b < PSE_a$  but  $SRP_b > SRP_a$ . The reverse would be true with activity "c". In either case, the PSE gives an incorrect ranking relative to the SRP.



## EMPIRICAL RESULTS

How important is the potential bias in the PSE? The frequency with which double-counting causes ranking errors can best be assessed by comparing PSE results with SRPs calculated from the same data, over a large sample of observations. For this study, preliminary data from the USDA are used, covering the principal crops in each of 33 countries, for the 1983 through 1989 crop years.<sup>1</sup>

The USDA data are estimates of how much each type of policy affects product prices and production costs for each crop in each country. These are then

aggregated into PSEs as in equation (3). Analogous SRPs were obtained by subtracting from the denominator of the PSE all policies that directly affect product prices ( $\Delta P$  in equation 3). This removes the double-counting bias, by converting the denominator into a country-specific estimate of each product's opportunity cost ( $P^*$ ).

Policies classed as affecting product prices ( $\Delta P$ ) were trade interventions such as import quotas, variable levies, export enhancements, marketing board losses or profits, and the effects of state trading controls. Domestic policies such as deficiency payments or credit programs were classed as payments to factors, affecting production costs ( $\Delta I$ ) but not price. This distinction holds exactly for goods which are fully traded onto a large world market, so that shifts in domestic supply or demand do not move prices; in other cases it is only approximately correct, as changes in production costs also affect prices.<sup>2</sup>

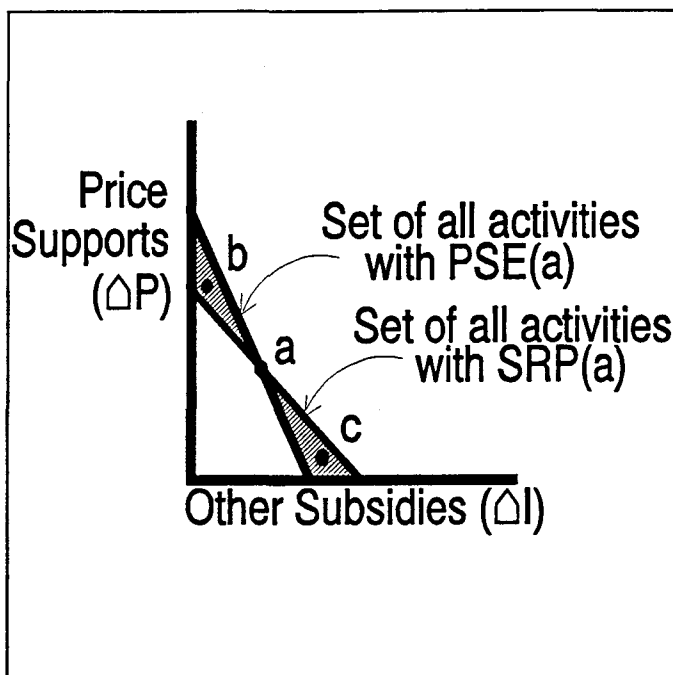


Figure 1.

1. These data have been collected as part of an ongoing project to update and extend the results published in USDA (1988); they are not official USDA estimates. Copies of the data files may be obtained from the author, or directly from the Economic Research Service of USDA.

2. A more refined distinction between product-price and input-cost effects would require a more realistic model, specifying supply and demand functions for each trading partner. To obtain approximate results without such models, it is necessary to  
(continued...)

Because PSEs (and SRPs) can fluctuate considerably from one year to the next, the analysis here considers only the 1983-89 period average PSE level.<sup>3</sup> There are a total of 250 period-average PSEs in the sample, distributed across the 33 countries. The resulting number of distinct activity pairs to be compared is  $250 \times 249/2 = 31,125$ . Spreadsheet macros were used to determine that of these 31,125 possible pairs, a total of 1,572 were ranked differently by the PSE than by the SRP, for an error rate of just over 5%. Although many of these errors are of little practical significance<sup>4</sup>, some do have important policy implications.

For national policy formation, the most important measurements concern the incidence of policy across crops within the given country. Selected examples are given in Table 1. In the U.S., for example, analysts using the PSE would argue that wheat production was more protected than barley production during this period, whereas the SRP shows the opposite to have been true. Such a result could influence any effort to equalize or otherwise adjust support levels across crops within the United States. A similar error arises within Mexico when comparing soybeans and corn. An example in a country where agriculture is taxed rather than subsidized is given for India.

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2(...continued)

make the simplifying assumption that output is fully traded at constant prices. But if more realistic models were available, results could be derived directly from them and PSEs/SRPs would not be necessary.

3. The average year-to-year coefficient of variation (standard deviation divided by mean) for the PSEs in this sample was 33%. The SRPs, in contrast, were a much more stable measure over time, with an average coefficient of variation of only 19%.

4. An example of an insignificant ranking error arises between Jamaican pimentos and Nigerian cocoa. These two crops enter completely different markets, so their PSEs are unlikely to be compared in any policy setting.

**TABLE 1. SELECTED NATIONAL PSE AND SRP COMPARISONS, 1983-89**

		PSE	SRP
United States	Barley	36.3%	79.2%
	Wheat	41.4%	70.4%
Mexico	Soybeans	56.5%	87.9%
	Corn	59.2%	61.7%
India	Corn	-43.3%	-13.7%
	Sorghum	-27.2%	-19.7%

Source: Calculated from preliminary USDA file data.

For international trade, the most important measurement issues concern how policies in different countries affect a given crop. Three of the most potentially important errors in such comparisons are shown in Table 2. For example, analysts using the PSE to study the US-Mexico grain trade would find greater subsidies for wheat production in Mexico than in the U.S., whereas the SRP shows the opposite to have been true. A similar result occurs in the dairy market when comparing the European Community with Canada, and in the sheepmeat market when comparing the EC with New Zealand.

**TABLE 2. SELECTED INTERNATIONAL PSE & SRP COMPARISONS, '83-89**

		PSE	SRP
Wheat	United States	41.4%	70.4%
	Mexico	43.3%	53.2%
Milk	EC-12	71.2%	249.1%
	Canada	114.0%	134.9%
Mutton/Lamb	EC-12	54.2%	118.9%
	New Zealand	71.5%	71.5%

Source: Calculated from preliminary USDA file data.

In some contexts, analysts might want to compare average support levels across countries. Such comparisons could show which country gives more protection to agriculture in general, taking account of each country's unique crop mix. For this study, national-average PSEs and SRPs were calculated by weighting each crop by its total value (price times quantity) to producers in that country. With 33 countries,

there are 528 distinct country comparisons ( $33 \times 32/2$ ). Of the 528 possible pairs, 41 (7.8%) were ranked differently by the PSE than by the SRP. A complete table of these results, including a matrix showing all ranking reversals, is given in the appendix; some of the more significant examples are given in Table 3. In each case, the PSE underestimates aggregate intervention levels in countries that rely heavily on trade interventions, relative to countries which use more domestic interventions and have more open borders.

**TABLE 3. SELECTED AGGREGATE PSE & SRP COMPARISONS, 1983-89**

	PSE	SRP
Taiwan	24.0%	45.7%
United States	25.6%	42.1%
EC-12	45.3%	103.1%
Canada	46.7%	54.6%
Thailand	8.2%	36.0%
Indonesia	18.9%	30.3%

Source: Calculated from preliminary USDA file data.

## CONCLUSIONS

The results presented here show that there is a systematic bias in the PSE measure, and that this bias can cause the PSE to give misleading results in a significant number of cases. Bias in the PSE is caused by placing market prices rather than reference prices in the denominator, which makes the PSE intuitively easy to understand but counts product price supports in both the numerator and denominator. Counting price policy twice leads the PSE to understate the effects of that type of policy, and can cause relative PSE rankings to be incorrect when comparing one crop or country with another. An improved measure can be obtained without additional data by dividing the components of the PSE into product-price and input-cost effects, and subtracting product-price effects from the denominator to obtain an estimate of reference-cost values. This removes the bias, giving more accurate results. In a USDA sample of 250 products over 33 countries for the 1983-89 period, the improved measure gave better rankings in 5% of individual-crop comparisons, and 8% of aggregate national comparisons. The cases of ranking reversal include a number of comparisons which could be of significance in domestic or international policy negotiations, highlighting the importance of using the improved measure wherever possible.

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APPENDIX: TABLE OF NATIONAL AVERAGE SRP/PSE ESTIMATES AND MATRIX OF RANKING ERRORS, 1983-89 PERIOD

	SRP	PSE	EC-12 Chile	Yugo. Taiwan	Czech. Thail.	Indon. USSR	S.Afr. Hungary	Kenya Egypt	Colombia Nigeria	Pakistan Jamaica
Japan	593.4	74.5	.	.	.	.	.	.	.	.
South Korea	230.2	73.4	.	.	.	.	.	.	.	.
Venezuela	157.6	63.8	.	.	.	.	.	.	.	.
EC-12	103.1	45.3	.	.	.	.	.	.	.	.
Chile	72.8	18.5	+	.	.	.	.	.	.	.
Yugoslavia	60.4	28.8	+	(-)	.	.	.	.	.	.
Canada	54.6	46.7	(-)	(-)	(-)	.	.	.	.	.
Poland	47.2	26.5	+	(-)	+	.	.	.	.	.
Mexico	46.5	26.2	+	(-)	+	.	.	.	.	.
Taiwan	45.7	24.0	+	(-)	+	.	.	.	.	.
United States	42.1	25.6	+	(-)	+	(-)	.	.	.	.
Czechoslovakia	37.1	10.6	+	+	+	+	.	.	.	.
Thailand	36.0	8.2	+	+	+	+	.	.	.	.
Indonesia	30.3	18.9	+	(-)	+	(-)	(-)	.	.	.
USSR	29.8	17.1	+	+	+	+	(-)	(-)	.	.
South Africa	26.2	14.8	+	+	+	+	(-)	(-)	.	.
New Zealand	22.9	22.7	+	(-)	+	(-)	(-)	(-)	(-)	.
Hungary	20.9	11.6	+	+	+	+	+	+	.	.
Bangladesh	20.8	14.4	+	+	+	+	+	+	(-)	.
Kenya	13.5	5.3	+	+	+	+	+	+	+	.
Egypt	12.6	-9.2	+	+	+	+	+	+	+	.
Colombia	8.5	-27.3	+	+	+	+	+	+	+	.
Australia	7.5	5.8	+	+	+	+	+	+	(-)	(-)
Turkey	5.1	2.1	+	+	+	+	+	+	(-)	(-)
India	1.6	-0.6	+	+	+	+	+	+	(-)	(-)
Morocco	0.9	-0.9	+	+	+	+	+	+	(-)	(-)
Nigeria	-3.5	-21.1	+	+	+	+	+	+	+	(-)
Argentina	-7.3	-10.4	+	+	+	+	+	+	+	(-)
Pakistan	-13.2	-37.0	+	+	+	+	+	+	+	+
China	-17.5	-31.5	+	+	+	+	+	+	+	(-)
Jamaica	-20.8	-59.3	+	+	+	+	+	+	+	+
Zimbabwe	-21.0	-37.9	+	+	+	+	+	+	+	+
Algeria	-33.8	-114.6	+	+	+	+	+	+	+	+

NOTES: SRP and PSE results are averages across all crops, weighted by value to producers, for the 1983-89 crop years. Crop coverage varies by country and year.

Countries are ranked by SRP level.

In the matrix, "+" indicates that the PSE and SRP give the same ranking when comparing the two countries; "(-)" indicates a ranking error, and "." shows duplicate pairs.

SOURCE: Calculated from preliminary USDA file data.

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