Producer Support Estimate Effects in Terms of Commodity Production – An Empirical Investigation

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Abstract: - The agriculture sector has steadily enjoyed government support for a relatively long period, especially in developed economies. Considerations relate to strategic behavior of countries' leadership, in that ensuring food security is essential to avoid dependence on other countries for food supply. However, recent decades' objectives have been focused on farmers' income stability as well as on the environmental impacts of agriculture. While there is a consensus on the depressing effects on consumers' and taxpayers' welfare, the discussions on the public policy impacts on the agricultural outcome are of a wider range. Empirical studies at the farm level doubt the positive effect of farm support on their technical efficiency. This paper provides an analysis of the role of Producer Support Estimate (PSE) as a source of assistance on a commodity basis in a group of OECD and other big agricultural traders. With a special focus on the *Producer Single Commodity Transfer* (PSCT) effect on the countries' commodity production levels, the general finding is that the government intervention in specific commodities investigated here may not be efficient.

Key-Words: - Producer Single Commodity Transfer (PSCT), Producer Support Estimate (PSE), Agriculture, Farmers, Government support, Agricultural commodities, Agricultural production Function.

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1 Introduction

The agriculture sector has steadily enjoyed government support for a relatively long period, especially in developed economies. Considerations relate to the strategic behavior of countries' leadership, in that ensuring food security is essential to avoid dependence on other countries for food supply. However, recent decades' objectives have been focused on farmers' income stability as well as on the environmental impacts of agriculture. While there is a consensus on the depressing effects on consumers' and taxpayers' welfare, the discussion on the public policy impacts on the agricultural outcome are of a wider range. Empirical studies at the farm level doubt the positive effect of farm support on their technical efficiency. Whilst the impact of agricultural support policies on farms' economic performance in terms of production levels, although an interesting issue for policymakers, remains less clear.

There are different pathways through which farms are affected by government intervention in the sector, and according to [1], two of them are fundamental. In an optimistic spectrum, subsidies provide incentives to farmers through innovation and better organization of their production processes. From a more pessimistic point of view, subsidies make farmers less eager to efficiently use their resources, allowing them to operate below the production frontier. However, government interventions involve not only direct subsidies and payments to agriculture producers. Broadly, "agricultural support is defined as the annual monetary value of gross transfers to agriculture from consumers and taxpayers, arising from governments' policies that support agriculture, regardless of their objectives and their economic impacts", [2].

This paper provides an analysis of the role of Producer Support Estimate (PSE) as a source of assistance on a commodity basis in a group of OECD and other big agricultural traders. More specifically, the focus will be on the *Producer Single Commodity Transfer* (PSCT) effect on the countries' commodity production levels. The PSCT tool falls under the Producer Support Estimate (PSE), which is an instrument of the support to producers' policy. Considering components of PSE and PSCT which include support and payments based on commodity outputs and input use, one would theoretically suggest that the effect of the measure and its components are positive to commodities output level. Existing literature on the matter provides essentially empirical hints on the direction of policy impacts mostly at the farm level, while implying complex theoretical impact pathways. In this paper, it is argued that PSCT has an impact on the total product level of specific commodities when estimated for a mix of developed and emerging economies for a period of about 20 to 30 years, although the direction might not be as positive as it could be expected. This analysis contributes to the knowledge of agriculture related support policies by investigating on the efficiency of such policies, in terms of the production level impacted. Most of the existing literature elaborates on the effect on prices, while less is explored on how much support policies encourage farmers to produce more.

This paper is organized in five sections. The second one describes the supporting policy measure concepts, along with a critical analysis of the calculations and interpretation of the estimates of interest that fall under the PSE category. The third section surveys existing empirical literature that evaluates the role of support policies and also the possible changes in their regimes on the farmers' performance. The methodology for estimation of the PSCT component of PSE on commodity-specific production in an aggregate level through a production function approach that will follow in this paper is also introduced. Section four provides the data description and explains the empirical results. Section five concludes and provides modest policy implications.

2 Problem Formulation Producer Support Policies - a Critical Analysis of Measures of Estimates

The value-added share of the agriculture sector to the GDP has continuously decreased in many countries. During the last decades, the decline has been faster in the less developed economies where the sector had previously comprised a relatively larger share. In developed OECD countries the agricultural sector contribution to the economy is currently about 2 percent, with Chile, and Mexico at less than 4 percent, and Turkey and New Zealand around 6 percent, see Figure 2 (Appendix). Regarding government expenditure in the sector, the trend has been relatively stable. Some emerging economies and a few developed ones attribute no more than 2 percent of the government expenditures to the sector. A mix of OECD and BRICS countries go as high as more than 5 percent (for example India and Switzerland, see Figure 3 (Appendix). However, these figures do not entirely reveal the intervention in the agricultural sector.

Besides export subsidies which normally violate GATT rules (notably by the US and the European Union), quota restrictions and (Japan's import ban on rice) supply management, as well as other domestic support entitlements have been subjecting of Uruguay and Doha rounds, as part of endeavor negotiations to reduce domestic support. An upper limit on each country's Total Aggregate Measure of Support (AMS) was disciplined under the WTO Agreement on Agriculture with the Uruguay Round as early as of January 1995. The monetary value of such support, excluding permitted exemptions, [3], are qualified as *Amber box* policies, in that they distort trade. Measures to support prices such as *market price support* (MPS) are included here, as well as other subsidies directly related to production quantities. If the support also requires farmers to limit production and it would normally be in the *amber box*, it would be placed in the *blue box*.

Green box policies cannot be linked to current production or prices and any direct payments to producers provided by a government program cannot involve transfers from consumers (only from taxpayers), [4]. Whilst *green box* programs cannot support domestic prices, a positive effect on the total level of production however could be maintained. Along with the progression of the WTO framework on Agricultural Agreement, OECD indicators were developed to monitor and evaluate performance in agricultural policy. The purpose would be to establish a common base for policy dialogue among countries as well as provide economic data to assess the effectiveness and efficiency of policies, [5].

One of the main indicators OECD calculates as a measure of agricultural assistance policy is the Producer Support Estimate (PSE), a successor term to substitute for the Producer Subsidy Equivalent. The change was to reflect the fact that the indicator is measuring transfers and not the 'subsidy equivalent' of the support provided. An investigation of the estimation of such assistance by [6], explores the five categories of agricultural policy measures to be included in the OECD calculations of PSEs: (i) *Market Price Support* (MPS) which is a measure to affect producer and consumer prices; (ii) *Direct Payments* which indicate measures that transfer money directly to producers without raising prices to consumers; (iii) *Reduction in Input Costs* that involve measures which lower input costs (capital or other inputs); (iv) *General Services* which indicate for money not directly received by producers but that contribute in the long term reduction of costs; (v) *Other* indirect support such as taxation concessions and other subnational/subregional subsidies.

A component of PSE, the *Producer Single Commodity Transfer* (PSCT) represents the “annual monetary value of gross transfers from consumers and taxpayers to agricultural producers, measured at the farm gate level, arising from policies linked to the production of a single commodity such that the producer must produce the designated commodity to receive the transfer”, [2]. As such, the national (aggregate) PSCT is the sum of all transfers arising from policies that have been attributed to single commodities, as the following equation (1) shows:

$$\text{Producer SCT}_c = \text{MPS}_c + \Sigma\ \text{BOT}_{sc} \quad (1)$$

where the Σ BOT represents the national aggregate budgetary and other transfers to producers from policies that have been labeled as based on a single commodity (*SC*). Because the empirical analysis in this paper will be performed on this measure (PSCT), there is a rationale to provide some detailed explanation of its components, which incorporate payments related to the four PSE components (ranked below as categorized by OECD):

A1. MPS – transfers from consumers and taxpayers to agricultural producers arising from policy measures that create a gap between domestic market prices and border prices of a specific agricultural commodity, measured at the farm gate level.

A2. Payments based on output – transfers from taxpayers to agricultural producers from policy measures based on the current output of a specific agricultural commodity.

B. Payments based on input use: *B1. Variable input use* – transfers reducing the on-farm cost of a specific variable input or a mix of variable inputs; *B2. Fixed capital formation* – transfers reducing the on-farm investment cost of farm building, equipment, plantations, irrigation, drainage, and soil improvements; *B3. On-farm services* – transfers reducing the cost of technical, accounting, commercial, sanitary, and phytosanitary assistance, and training provided to individual farmers.

C2. Payments based on current production required, single commodity (for example crop insurance payments) including transfers through policy measures based on area/animal numbers;

D. Payments based on non-current Area/Animal numbers/Receipts/Income (A/An/R/I), production required: are transfers from taxpayers to agricultural producers arising from policy measures based on non-current (historical or fixed) A/An/R/I with current production of any commodity required.

The OECD calculates and publishes a country-specific database of PSE measures and the PSCT coefficient, which is a percentage of the total sum of the above transfers to the gross receipts for individual commodities. The latter would be the sum value of commodity production plus the Producer Single Commodity Transfers. A general overview of the PSE database shows that support for agriculture has experienced a general decline in aggregate terms across the OECD members and some of the emerging economies after the 1990s. According to [7], targeted production activities such as rice, maize, beef, pork, and dairy are assisted to a more concentrated degree, with around 75 percent of the total single commodity support captured in these five types of commodities (based on 2015 support levels).

Whilst the PSE was developed as an agricultural policy reform measure, its consideration as a measure of trade distortion rather than simply policy support has generated some criticism on the estimate, [8], [9], [10], [11], [12], [13]. Other criticisms arise with the algebraic form of calculation (similar to the PSCT, but different in the components) which presented in [6], is as follows:

$$\text{Total PSE (TPSE)} = Q_p (P_d - P_w) + D - L + B \quad (2)$$

Total unit PSE = $TPSE / Q_p$
Percentage PSE = 100 ($TPSE$) / [Q_p (P_d)+D-L] (at domestic prices)

where the level of production is Q_p, the domestic market price is P_d, the world price is P_w, direct payments are D, levies on producers are L and all other budgetary-financed support is B.

As can be observed from the above formulations, the PSE is based on a comparison of world market prices with the domestic ones, and most criticisms relate specifically to that difference, [14], [15], [16], [17]. The world price could be depressed by the very existence of support to the production level through the PSE and hence the calculated measure could overestimate the amount of support provided. Moreover, a variation in the world price could be reflected in the PSE value even when there is no explicit change in domestic agricultural policy. Furthermore, there are concerns regarding the exchange rate (fluctuations and not equilibrium rate usage) in the comparison of the world to domestic prices in the PSE calculations.

Another criticism argued by [17], is that aggregation of the measures related to *real market price support* and the *decoupled direct income support* is not reasonable in the composition of the PSE. However, [18], claims that the income support policies that are assumed to be decoupled are not such, as they directly affect commodities, due to wealth and insurance effects. Many income support programs are explicitly set up to insure against risk in the first place, thus suggesting that the programs tend to exist in the markets where the insurance effect may be largest.

Despite the above criticism, establishing a set of subsidy-free equilibrium world prices as a benchmark for calculating subsidies would hardly command agreement among policymakers, as it would anyway require a model using the PSE as calculated by the OECD, [19]. Overall, there is a general agreement in the corresponding literature that the evaluation of a collection of agricultural policies in the OECD and other countries lacked a coherent and comparative method until the PSE was developed. Basic PSE (and its components) have become rather popular as a policy measure in various empirical investigations that highlight the effect of government intervention on individual farm performance. The following section develops a brief investigation into the regard.

3 A Production Function Approach of the PSCT Effects

This section provides indications of the methodology used in this paper to estimate the effects of PSCT as a policy measure on the total commodity level of production. Given the latter, it is argued that a production function would be more appropriate for the empirical investigation.

3.1 Empirical Literature Review on Support Impacts

Referring to the components of the PSCT as presented in section two, it can be argued that agricultural subsidies have a direct product effect through the relative support differentials between commodities. The increase in subsidies affects the relative prices and hence may lead to an output substitution. Moreover, subsidies affect production costs associated with commodities, relieving the overhead burden to producers. In theory, MPS provides incentives for output expansion and input-use intensification and will result in farmers modifying their management practices and output mix even with a fixed payment rate, [20].

Furthermore, agricultural subsidies could affect the structure of agricultural production, influencing the size of production units, as identified in [21], in the case of the US. Vertical integration of production and economies of scale may induce a higher level of overall output. In addition, domestic support tends to reduce producer flexibility in crop selection. It could even be that support to agriculture, if concentrated more across a few specific commodities, could make farmers focus on the production of only or mostly those highly supported crops especially if the triggers for support payments are based on much higher expected production per acre.

Empirical literature that estimates the effect of policy supports provides mostly nonpositive effects of their measure on the individual farmers' performance. As argued by [22], agricultural subsidies tend to have a technology "lock-in" effect, which means that they can prevent technological changes by supporting specific inputs or technologies. Direct payments based on output or variable input use were also found to be highly inefficient, [10], for four crops (wheat, rice, coarse grains, and oilseeds). They further argue that the support measures causing the greatest distortion to production (and trade) are also the least efficient in providing income benefits to farm households.

[20], summarises that trade-based MPS measures can generate a negative effect on productivity; coupled output support generally produces a negative effect on technical efficiency and productivity. The rationale is that the existence of supply control measures might severely constrain the output-increasing effect of higher support payments. However, in the long term, there may be a positive bias towards commodities which have high levels of MPS over time, for development or productivity-improving innovations. He also acknowledges the direct incentive to increase production when assuming the environmental effects of the A1 and A2 components of the PSE (which are also part of PSCT).

Whilst empirical models that employ support measures have been mostly used to estimate technical efficiency, trade distortions, and environment impacts at the farm level, [1], [10], [23], [24], the empirical literature built on agriculture aggregate data makes almost no use of the above-discussed measures. There is limited evidence on how agricultural production function is affected by policy intervention. [25], estimate the agricultural productivity's responsiveness to the price interventions, being these negative. In a set of 18 countries' pooled data, they suggest that agricultural productivity would have increased.

Overall, it could be that the *multifunctionality* concept of the agricultural sector, [26], [27] and hence the multidimension (or even absence of well-defined) objectives of agricultural policy as argued by [28], produce various (contradictory) performance effects of the support policies. The following section contributes with a discussion on how the support policies could be estimated to impact agricultural production function.

3.2 Methodology - Agricultural Production Function Approach

In this paper, a general production function is assumed, so that agricultural production is a function of a given set of inputs Y_{jt} = f (X_{jt}). The subscripts stand for country j and time t representing country specific unobserved heterogeneity in the model. Agriculture production implies the use of multiple inputs. The possibility of continuous adjustment between inputs as relative factor prices and factors availability change should be accounted for in the agricultural production function through a flexible functional form. This gives a reason for considering the translog production function for empirical estimation, as identified below in equation (3).

Besides the traditional inputs, [29], employ a set of state variables as constraints on inputs or policy constraints on producers' behavior (such as quotas) which are assumed to contribute to the heterogeneity of the technology in a panel data analysis of 30 countries' agricultural production functions. Although their data are wide and balanced for 29 years, the relatively high degree of aggregation and the use of a set of institution variables that are not necessarily closely related to the agricultural sector (political rights, civil liberties) along with the use relative prices to another economic sector as another state instrument raises concerns on the usage of the instrument.

As in [30], agricultural production function estimates, the agricultural inputs considered here are labor, machinery, fertilizer, and land and the number of cow equivalent livestock units. The empirical literature in the field acknowledges also the possible effect of intermediate production factors. For example, [31], suggests the direct agriculture credit amount has a positive and statistically significant impact on Indian agriculture output and its effect is immediate. Since the most interest in this paper's analysis is on the impact of government support on agriculture, the PSCT measure introduced in section 2 is accounted for as a state variable that can affect the agricultural production level.

As anticipated above, the inter-country agricultural production function for estimation is specified in the following translog form:

$$lnQ_{jt} = a_j + \sum_{i=1}^{4} \beta_{ijt} lnX_{ijt} + \gamma s_{jt} + u_{jt} \qquad (3)$$

Where Q is the commodity-specific level of output of 3 types of crops in a group of countries for the years during which the PSCT indicator is available. The independent variables X_{ijt} indicate the inputs i (labor, machinery, fertilizer, land, and cow inventories) of agricultural output, for each country j in each year t; and the s variable represents the PSCT measure value. In equation (3), β_{jt} represents the coefficient for the independent variables, i.e. the effect of each on the level of production, γ is the coefficient for the PSCT variable and u is the error term. The panel data availability allows for the outcomes investigated to employ estimation methods that deal with potential heterogeneity bias, [32]. Moreover, as [33] observes, by "combining times series of cross-sectional observations, panel data give more informative data, more variability, less collinearity among variables, more degrees of freedom and more efficiency" (p. 637).

As two designed approaches for the panel data investigation, the fixed and random effects methods simulate unmeasured time-invariant factors as country-specific intercepts. The intercept varies for each country but still, the slope coefficients are assumed constant across countries in the fixed effect model (FEM), meaning the country-specific intercepts are treated as fixed effects to be estimated, equivalent to including dummy variables for the N-1 number of countries. On the other side, instead of treating the intercept as fixed and assuming that it is a random variable with a mean value of a, the intercept value for one country can be expressed as:

$a_j = a + \varepsilon_j$ $\quad\quad$ $j = 1, 2, \ldots, N$ countries.

Equation (3) would be re-written as follows:

$$lnQ_{jt} = a + \sum_{i=1}^{4} \beta_{ijt} lnX_{ijt} + \gamma s_{jt} + \varepsilon_j + u_{jt} \quad (4)$$

The component error term in (4) has the expected mean value of zero, and variance equals (2+u2); both error terms are assumed to have normal distribution, [34]. Note that the latter equation expresses the random effect model (REM) and equation (3) stands for the fixed effect model, with the error terms representing the between-country error (ε_{jt}) and within-country error (u_{jt}). Because the interest here is to investigate the causes of agricultural production changes within each country, the fixed effect method could be considered more appropriate, especially as the data indicate some unobserved heterogeneity between countries under investigation. However, it is argued that when there are reasons to believe that differences across entities have some influence on the dependent variable, the random effects should be estimated. This is also the case when time-invariant variables are used as explanatory ones. In this analysis, a dummy to control whether the country belongs to a developed grouping or not will also be used, to count for the heterogeneity in the production function which could arise due to the level of countries' general economic development.

To empirically decide between fixed or random effects, a Hausman test is run where the null hypothesis is that the preferred model is random effects versus the alternative fixed effects, i.e. that the unique errors ε_{jt} and the regressors are uncorrelated. If ε_{jt} and the independent variables are correlated, the FEM may be appropriate, [34]. Results indicating the choice of the model are presented in section 4.2.

By studying the repeated cross-section of observations, the panel data are well suited to capture the dynamics in the effects investigated. Given the nature of production, it is assumed that commodity production of a given year is dependent on the inputs used the previous year, given also the almost yearly production process of most agricultural commodities (crops). Hence, the independent input variables have one year lag. On the other side, government interventions are thought to affect the production level of the current output year, for which reason the support indicator PSCT in the percentage of the same year as the output measure is introduced as an independent variable.

Inputs are certainly expected to positively affect the commodity-specific production level. The square input variables used as explanatory variables would be indicative of the convexity of the production function about the proper input and trends of input-related productivity. Interaction effects of inputs are also considered, respectively only interactive terms of area harvested to each of the other inputs in the case of wheat, maize, and soybean, and the cow inventories interaction terms with sector employment and pasture. The rationale is that area harvested for the crops and cow inventories are observed for the commodity-specific production, whereas other input variables, labor, machineries, fertilizers and pasture are observed for the entire agricultural sector and are not commodity specific.

It could be argued that price also affects farmers' decision on product. For example, [25] and [31], use price as an instrument in the choice of inputs in the agriculture production functions. Here instead it is assumed that the lagged price of the commodity could capture farmers' expectations related to the value of their product and is endogenous to the commodity product level. A supposition is that the price itself depends on the market price support (MPS) as well as on the balance of trade of the specific commodity, which are used as instruments in a panel endogenous model specification, as explained at the end of section 4.2. The following section informs about the data used and the estimated empirical results.

4. Empirical Estimates of PSCT Impact on Production

4.1 Data

The countries considered in the empirical analysis were chosen based on the extent to which they are actors in the global agriculture arena and to a certain extent the data availability. They compound an unbalanced panel. The crops regarded as the most important worldwide, both in terms of production and consumption value are cereals and oilseeds. Among these, wheat and maize are deemed as most essential from the former category, and soybean from the latter.

Table 2 (Appendix) presents all the countries and years under study for each of the commodities. Altogether, they contributed around 65 percent of the wheat production in 2019, the share dropped from about 85 percent in the early 1990s. The list of countries that produce Maize contributes about 80 percent of world production, and those listed for the Soybean analysis account for about 60 percent of the world soybean production. Australia, although a big producer, is not included in the crops' analysis since the economy has liberalized the crop market and provides no support under the measures described in section 2.

Data are retrieved from the OECD Agricultural Policy Monitoring and Evaluation (AGME) Reference Tables – single commodity indicators for a group of mixed OECD and emerging economies. For most of the countries, the data are available for the period 1986-2018 and others only after 1990-1992 or 1995. The database provides details on the indicators of interest that is Percentage Producer Single Commodity Transfer, measured as the ratio of the total sum of the components A1, A2, B, C2, and D described earlier in section 2 over the farmers' gross revenue, expressed in percentage. Given that the monetary indicators are influenced by the size and structure of the country's agricultural sector, as well as the country's rate of inflation, percentage indicators allow for comparisons of support levels between countries, assess the level of support provided within a country to different commodities and could also be used in comparative analysis empirical estimates.

An advantage of the AGME tables is that they can be exploited to analyze the composition of support, e.g. to identify and calculate the presence and shares of total support to estimate whether the transfers come from consumers or taxpayers. In this context, it has been possible in this study to identify the *Market Price Support* as transfers from consumers and taxpayers to agricultural producers (which are not based on output). The tables also provide data on the total level or production in thousands of tones, value of production and producer price (at the farm gate), transfers to producers from consumers and taxpayers as well as other measures that quantify producer and consumer support estimates, all commodity specific. OECD database also provides detailed information on the area harvested for all the kinds of crops, pastureland in thousands of hectares, and cow inventory in case of beef and veal meat in thousands of tones. Production data for each of the commodities is also provided in thousands of tones.

Whilst a range of data related to agriculture sector inputs are available in the OECD databases, there are gaps in tables which would create a lot of missing values and a lack of opportunity for more efficient estimates. Hence, another database is considered to retrieve information on inputs: the United States Department of Agriculture (USDA) Economic Research Service with a full series of input level data. However, these (as well as those input related provided by OECD) are sector aggregate data and one should be careful in incorporating them into commodity specific empirical estimates and interpreting result coefficients.

Inputs provided by the USDA database are divided into six categories: farm labor, agricultural land, two forms of capital inputs (farm machinery and livestock), and two types of intermediate inputs (inorganic fertilizers and animal feed). Farm labor is the total number of adults who are economically active in agriculture, reported by thousands of participants. Farm machinery is the total metric horse-power of major farm equipment in use. It is the aggregation of the number of 4-wheel riding tractors, 2-wheel pedestrian tractors, power harvester-threshers, and milking machines, expressed in "40-CV tractors-equivalents" per 100 sq. km of arable land. Fertiliser is the sum of nitrogen, potash, and phosphate content of various fertilizers consumed, measured in thousand metric tons.

Descriptive statistics on the dependent and independent variables in the absolute value are given in Table 3 (Appendix). Because the PSCT indicator takes not only positive but also negative values when the sector is taxed (resulting in negative policy transfers), the summary statistics, as well as empirical estimations, are presented for the whole sample as well as for the subsample for which the indicator does not take negative values (is either 0 or positive). In Table 3 (Appendix), the subsamples are represented by a smaller number of observations for each of the commodities. As can be observed, there are discrepancies between the countries observed in terms of all the variables, which are certainly related to their different size regarding population and geographical area and hence employment in the sector and area harvested. There are differences also in terms of machinery and fertilisers used. For example, for wheat production, the minimum values for all the variables (except for fertilizers which is South Africa and PSCT) are for Israel, and the biggest stands for either China or India. The lowest (negative) value of PSCT percentage is for Argentina and the largest for Japan.

Figure 1 (Appendix) presents the trend of the percentage PSCT indicator in the countries under investigation for wheat commodities. Other commodities (maize and soybean) trends of PSCT are shown in Figure 4 and Figure 5 (Appendix).

As can be observed, a few countries such as Argentina and Kazakhstan, but also India, Russia, and Ukraine have experienced negative values of the support measure, meaning that farmers were effectively “taxed” by government policies.

Japan, Norway, and Switzerland wheat farmers have enjoyed higher support, although that has been reduced. The same is observed for Korean soybean growers. It can also be observed from the graphs of PSCT indicators that India, Russia, and Ukraine farm policies have followed a very changing trend from positive to negative support and vice versa. Referring to other countries, the trends are in line with what [35] also confirms, that overall producer support as a share of gross farm receipts during 1995-2015 has been larger in Japan, than in EU, Turkey, US, and Russia, followed by China and Indonesia. It has been particularly increasing in some Asian countries, for example in Viet Nam, the Philippines and China for maize see Figure 4 (Appendix), Korea for the soybean in Figure 5 (Appendix), and as Figure 1 (Appendix) shows for wheat in China after 2005. On the other hand, the 2014–20 Common Agricultural Policy in the EU has provided greater flexibility for countries to use certain trade-distorting instruments compared to the previous CAP with coupled aid started to grow again, for which reason Norway and Switzerland are shown to have relatively high PSCT indicators. Empirical estimation results of the support measure on the commodity-specific level of production are explained in the following section.

4.2 Empirical Estimates of PSCT Impact on Production

Regressions following the form of equations (3) and (4) introduced in section 3.2 are run for each panel data set of commodities: wheat, maize, and soybean in Stata 13. Table 1 (Appendix) shows coefficient estimators of the random effect model for crops after the Hausman test of model choice supposition is performed. Countries heterogeneity effect is taken into account by employing the dummy variable *OECD* or *Developed Country*. Due to issues with heteroscedasticity that usually arise with panel data estimations, coefficients are obtained using heteroskedasticity-robust standard errors. On the whole, the Wald chi-square and Probability chi-square of model significance indicate relatively strong overall significant explanatory power of the regressors used.

Different specifications are used in considering the whole sample of countries shown in Table 2 (Appendix) and then subsamples of countries reporting nonnegative values of the PSCT percentage. These are called model specifications 1 and 2. More is investigated in observing the behaviour of output for another (smaller) subsample of observations after removing also the cases when market price support is present (components A1 and A2), calling that specification 3. This is done with the rationale of exploring if and how payments are made to producers based on input use and products (that fall under categories B, C2, and D of classification explained in section 2), without allowing for the presence of market price support, affect product level. The number of the column in Table 1 (Appendix) of estimated coefficients for each commodity indicates the specification model used. In prior estimations, the relation between the dependent variable and the regressors is observed through two-way scatter graphs. For wheat production, these are shown in Appendix. The relationships observed are those expected, production is positively related to lagged amount of inputs. The relationship with the most variable of interest, the PSCT percentage shown in the last three graphs, is less clear. However, the general perception arising is that the relationship is not positive.

Because under specifications 2 and 3 all the aggregate input coefficients are not significant, and since these are indeed not commodity specific, it is deemed rational to drop them from the equation and run the regressions maintaining area harvested and its interaction term with the aggregate inputs. The degrees of freedom would also increase as the aggregate input variables are dropped off with the diminution of sample sizes (in the second and more in the third specification) accounting for more efficient estimation.

As can be observed from Table 1 (Appendix) of coefficient results, the land input is significant for Maize and Soybean, showing a concave relationship between production level and with area harvested. That indicates that there is a decreasing marginal productivity of the area harvested, which could be due to the use of marginal land as the crop area (for these two commodities) increases. On the contrary, the relation between output and fertilizers observed is indicative of increased marginal productivity of their usage (negative coefficient of the input and positive to the square of input).

The impact of Employment and Machinery inputs is less clear. However, interactive terms of area harvested with each of the aggregate level inputs are indicative of a non-significant or negative relationship of output with the interaction of land with employment and machinery (when coefficients show to be significant). Reminding that these are agricultural sector aggregate input levels, it could be that intensity of labor and technology in limited cropland areas make these inputs less efficient. The interactive term of area harvested with fertilizers is still significantly positive, indicating that the intense use of this input positively affects commodity products. This finding is in line with what [36] highlights, that agricultural fertilizer use is one of the important land management practices that has substantially increased crop yield and soil fertility over the past century.

Contrary to expectations, dummy variables of OECD countries show a negative sign for wheat and a positive for soybean. It could be that wheat, being a necessary commodity, does not make the OECD countries more advantageous in producing more at given levels of inputs. However, considering soybean and alternative uses of this commodity (mostly for animal feed and recently also biodiesel), the positive coefficient result shows that OECD countries have the advantage of significantly producing more than other countries at a given level of other regressors.

Considering the variable of most interest for this study, the PSCT indicator shows a negative sign which is significant in all specifications for Maize, but only in the second and/or third specifications for Wheat and Soybean. However, the effect was shown to be relatively small. It could be generalized from the results that the PSCT coefficient is almost neutral to the commodity product level when all the commodity samples are taken into consideration, meaning that negative support, neutrality, and also positive support being taken into account. It could be expected that the effect would have been significantly positive given the wide range of policy alternatives, especially when transitioning from negative to positive support to producers.

Empirical estimation coefficients point to a significant negative effect, although relatively small of the support indicator when observations of transfers from producers are dropped off (specification 2), also when the MPS effect is omitted (specification 3). The latter means that although there is no market price support, other support policies on production are not necessarily associated with higher overall commodity product levels. These results could raise doubts about the efficiency of the payments made to farmers, at least for the commodities under analysis in this study.

To thoroughly investigate the role of government support to farmers, regressions were run with the dependent variable being the value of the product at the farm gate (available from the OECD database). The coefficient estimator of PSCT is either not significant or negatively related to the regressand (although results are not shown in this paper). Results could raise doubts also about the lack of positive effect of farmers' support on their gross revenues.

Alternative estimation specification (to investigate the role of support policies for farmers in this paper) uses the lagged price (at the farmer gate) of commodity as an endogenous explanatory variable to the commodity product level. As argued at the end of section 3.2, the rationale is to capture farmers' expectations related to the value of their product. For this reason, it is assumed that the Trade Balance ratio and MPS value of a year before the production would be well-suited instruments to the lagged price farmers receive at the gate farm. Results for Maize are not presented here.

It could be argued that the effect of price on production level might be ambiguous, as the price could as well reflect input costs. However, empirical estimation findings here imply that there is a positive effect of the lagged price on the product level for maize. Results on the effect of the PSCT indicator on output hold the same as before, with a negative significant coefficient. However, the effects of the previous year trade balance and market price support on the same year's price are not the same for the two commodities. The impact of trade balance on price, being relatively small, is more disputable. Comparative advantages of countries in producing these commodities should be accounted for in providing behavioral explanations of price dependency on the balance of trade. Moreover, caution in interpreting related results arise as it would be necessary to observe the relationship of price to the trade balance indicator of a previous period (i.e.: a year-lagged price with two years lagged trade balance ratio).

5 Conclusion

Being subject to lobbying and pressure from interest groups, the agricultural sector has for long been under various degrees of government support, especially in developed economies. There are however countries where the sector is taxed, with the outcome of a negative support to the sector. This paper aims to provide a thorough understanding of the Price Support Estimate as a composite tool for government intervention in the agricultural sector. It is exploited that the Organization for Economic Cooperation and Development has developed indicators that are provided in its database of Agricultural Policy Monitoring and Evaluation and which give useful instruments in comparing countries' degree of support. To the most interest of this paper analysis, the Producer Support Estimate (PSE) is elaborated.

It is explained that there are controversies in using the PSE and its component Producer Single Commodity Transfer (PSCT) in empirical analysis as a factor impacting farmers' product, efficiency, and income receipts. However, being a universal indicator of the support policies for a wide range of countries for a long time span, this research work provides a challenge in investigating the effect of PSCT measures on the product level of a few chosen commodities. Production function methodology for panel data is considered the right approach in estimating the elasticity coefficients of inputs, controlling for the coefficients of inputs, and controlling for the effect of the government intervention.

Overall, the empirical findings comply with the economics theory on the role of inputs on agricultural production, with coefficients showing different behavior of the input marginal productivity. Fertilizers are found to have the most significant positive effect. It should be noted however that input observations relate to the aggregate sector rather than commodity-specific production, besides the area harvested for the crops. Moreover, regression estimations indicate that developed and/or OECD countries do not always succeed in producing more than other counterparties, ceteris paribus.

Regarding the role of government support in commodity specific production for the crops chosen, estimated coefficient results do not support any positive effect. These findings may be assumed to support those found earlier at the farm level (and cited in section 3) that, different from what would have been theoretically expected, producer support does not contribute to increased production. Doubts could be further raised on the efficiency of the policy support, at least on those that are linked with the Producer Single Commodity Transfer. It should be noted however that more needs to be investigated, especially on the role of specific instruments (as represented by components of PSCT indicator) to allow for the accumulation of more knowledge on the efficiency of money transfers to farm producers. Further improvements and alternatives of methods of empirical investigation and input data could provide even more insightful findings in future study analysis.

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APPENDIX

Table 1. Coefficient estimations of commodity-specific production functions

Commodity	Wheat			Maize			Soybean		
Regressors	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)
PSCT-percentage	-0.0004	-0.004**	0.002	-0.002***	-0.005***	-0.005***	-0.00004	-0.001	-0.003***
	(0.0007)	(0.002)	0.003	0.0001	0.001	0.0007	0.001	0.001	0.001
Area	0.2	0.09	-0.09	0.76	0.62**	0.08	1.9***	0.84***	0.93***
	(0.27)	(0.29)	1.08	0.41	0.29	0.25	0.22	0.1	0.15
Area Square	0.02	0.005	0.05	-0.07	-0.04*	-0.05**	0.01	-0.02***	0.02
	(0.02)	(0.02)	0.07	0.05	0.02	0.02	0.006	0.006	0.02
Employment Lag				-1.23***			0.14		
				0.33			0.12		
Machinery Lag				0.06			0.92		
				0.91			0.67		
Fertiliser Lag				-1.6***			-5.17***		
				0.5			0.64		
Employment Sqr				0.006			-0.02		
				0.03			0.01		
Machinery Square				-0.04			-0.02		
				0.05			0.03		
Fertilizer Square				0.08**			0.19***		
				0.04			0.03		
Area×Employment	-0.03***	-0.03***	-0.02	0.08**	-0.05***	-0.05**	0.001	-0.02***	-0.02***
	0.007	0.006	0.01	0.04	0.01	0.02	0.01	0.003	0.004
Area × Machinery	-0.01**	0.003	-0.04	0.1	0.01	0.02	-0.06***	-0.004	0.002
	0.005	0.007	0.02**	0.09	0.01	0.02	0.02	0.003	0.004
Area × Fertiliser	0.04***	0.05***	0.06	-0.04	0.07***	0.09***	-0.01	0.04***	-0.001
	0.005	0.01	0.01	0.08	0.011	0.02	0.03	0.009	0.02
OECD	-0.91***	-0.68*	0.14	-0.07	-0.12	-0.08	0.29***	-0.07	1.36***
	0.34	0.36	0.28	0.25	0.26	0.46	0.09	0.08	0.46
Constant	4.85***	3.84***	4.9	18.35***	1.2	2.1***	28.77***	0.33	
	0.99	1.13	4.06	5.1	1.04	0.78	4.37	0.48	
sigma_u	0.58	0.58	0.41	0.478	0.383	0.343		0	0
sigma_e	0.22	0.21	0.17	0.197	0.179	0.168		0.12	0.115
rho	0.88	0.89	0.86	0.85	0.82	0.807		0	0
Observations	395	305	102	404	313	162	201	153	90
groups	16	16	10	17	17	13	8	7	4

*Note: Standard errors are in parentheses. Coefficients are significant at 10, 5, and 1% of the level of significance if *, ** and ***. Variables with the notation "Lag" at the end indicate that they are lagged by one year period. All the other input variables are also of natural logarithm.*

Table 2. List of countries and years under investigation for each commodity

Country	Wheat	Maize	Soybean
Argentina	1997-2017	1997-2017	1997-2017
Brazil	1995-2017	1995-2017	
Canada	1990-2017	1987-2017	1990-2017
Chile		1995-2017	
China	1995-2017	1995-2017	1995-2017
Colombia		1995-2017	
India	2000-2017	2000-2017	2000-2017
Israel	1995-2017		
Japan	1990-2017		1990-2017
Kazakhstan	1995-2017	1995-2017	
Korea			1990-2017
Mexico	1991-2017	1991-2017	1991-2017
Norway	1990-2017		
Philippines		2000-2017	
Russia	1995-2017	1995-2017	
South Africa	1995-2017	1995-2017	
Switzerland	1990-2017	1990-2017	
Turkey	1990-2017	1990-2017	
Ukraine	1995-2017	1995-2017	
USA	1990-2017	1987-2017	1990-2017
Viet Nam		2000-2017	

Table 3. Descriptive statistics

Variable	Wheat: number of observations 395				Wheat: number of observations 305			
	Mean	Std.Dev.	Min	Max	Mean	Std.Dev.	Min	Max
Product	23677.93	31930.95	29	134334	19609.94	30509.34	29	134334
Area harvested	8366.12	9907.55	40	31788	6692	88389	40	31788
Employment	31180.77	83713	37	362496	20916.32	65912.58	37	357911
Machinery	1467043	2239897	21444.9	12300000	1493644	2296395	21444.9	12300000
Fertilizers	6254641	11100000	13000	49800000	5924103	10600000	45200	49800000
PSCT Perc	13.81	30.79	-98.56	85.34	24.71	23.6	0	85.34
Variable	**Maize: number of observations 404**				**Maize: number of observations 313**			
	Mean	**Std.Dev.**	**Min**	**Max**	**Mean**	**Std.Dev.**	**Min**	**Max**
Product	39537.86	79089.49	90.7	384780.5	46140.68	86095.38	90.7	384780.5
Area harvested	6618.8	10263.25	15.32	44968	7541.45	11096.22	15.32	44968
Employment	32174.11	82465.53	139	362496	29482	80707.96	139	362496
Machinery	1335522	2225926	21056.1	12300000	1398250	2325318	21056.06	12300000
Fertilizers	6373566	11000000	13000	49800000	6800572	11400000	13000	49800000
PSCT Perc	6.62	25.28	-99.43	67.09	16.17	16.21	15.32	67.09
Variable	**Soybean: number of observations 201**				**Soybean: number of observations 153**			
	Mean	**Std.Dev.**	**Min**	**Max**	**Mean**	**Std.Dev.**	**Min**	**Max**
Product	18282.44	28456.66	56.07	120075	14320.96	28826.85	75.45	120075
Area harvested	7578.44	10076.31	45.56	36219.49	5720	10179.24	45.56	36219.49
Employment	57463.89	111229.4	286	362496	44770.88	102111.3	286	362496
Machinery	2537316	2716680	250017	12300000	2450519	2699398	250016.5	12300000
Fertilizers	10600000	13900000	475000	49800000	9583378	14000000	475000	49800000
PSCT Perc	14.39	35.35	-73.47	90.43	26.14	30.32	0	90.43

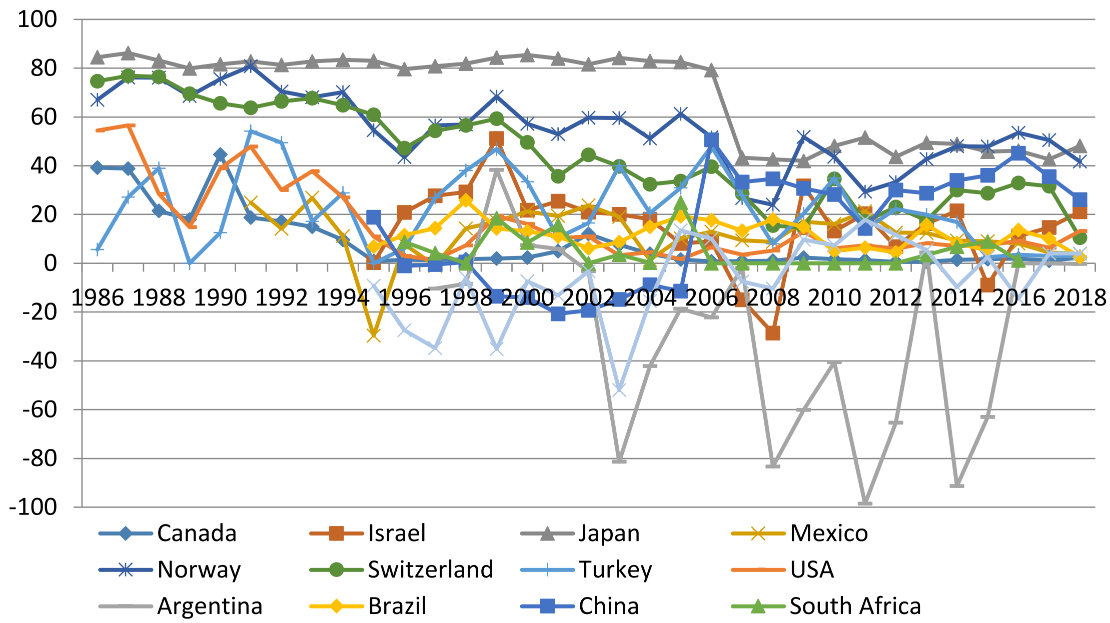

Fig. 1: PSCT percentage indicator for wheat commodity in selected countries, [2]

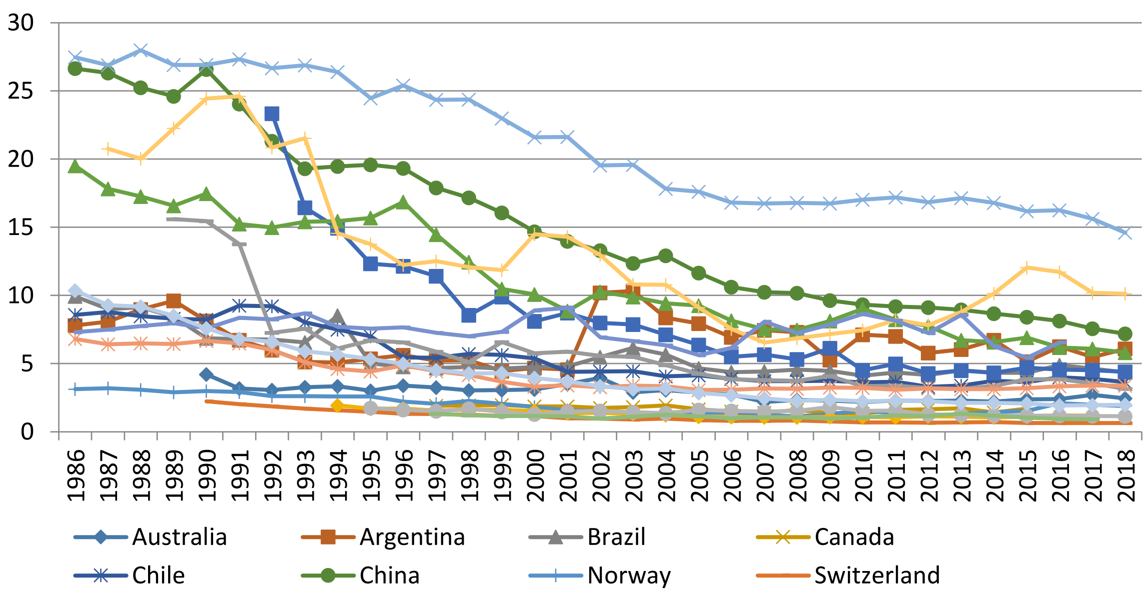

Fig. 2: Agriculture, forestry, and fishing, value added as a percentage of GDP

Source: [37]

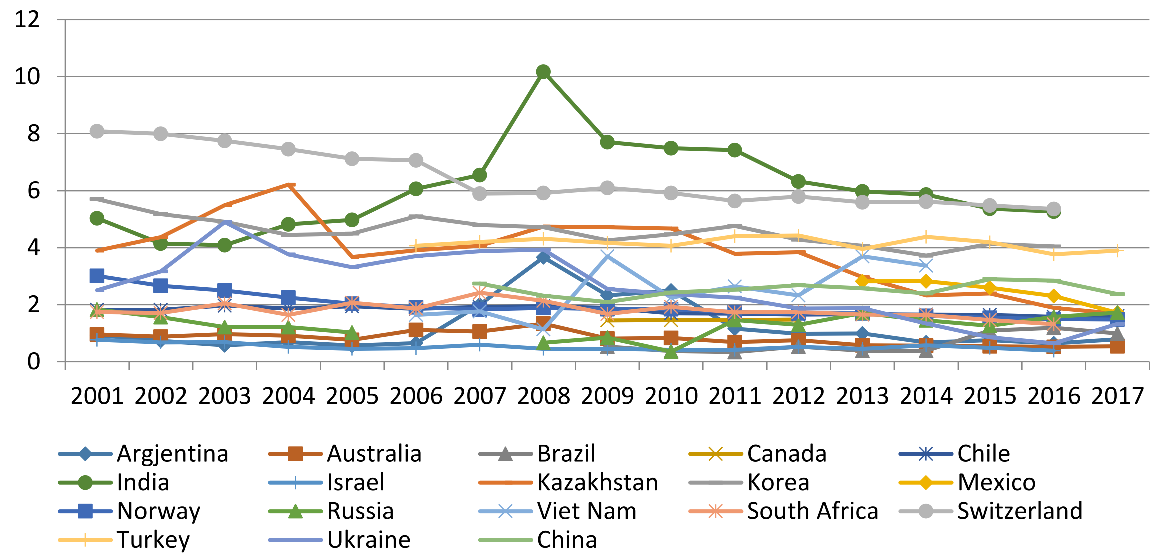

Fig. 3: Expenditures on Agriculture, Forestry, Fishing and hunting (AFF) share of Total Outlays in Central Government, LCU current prices, [38]

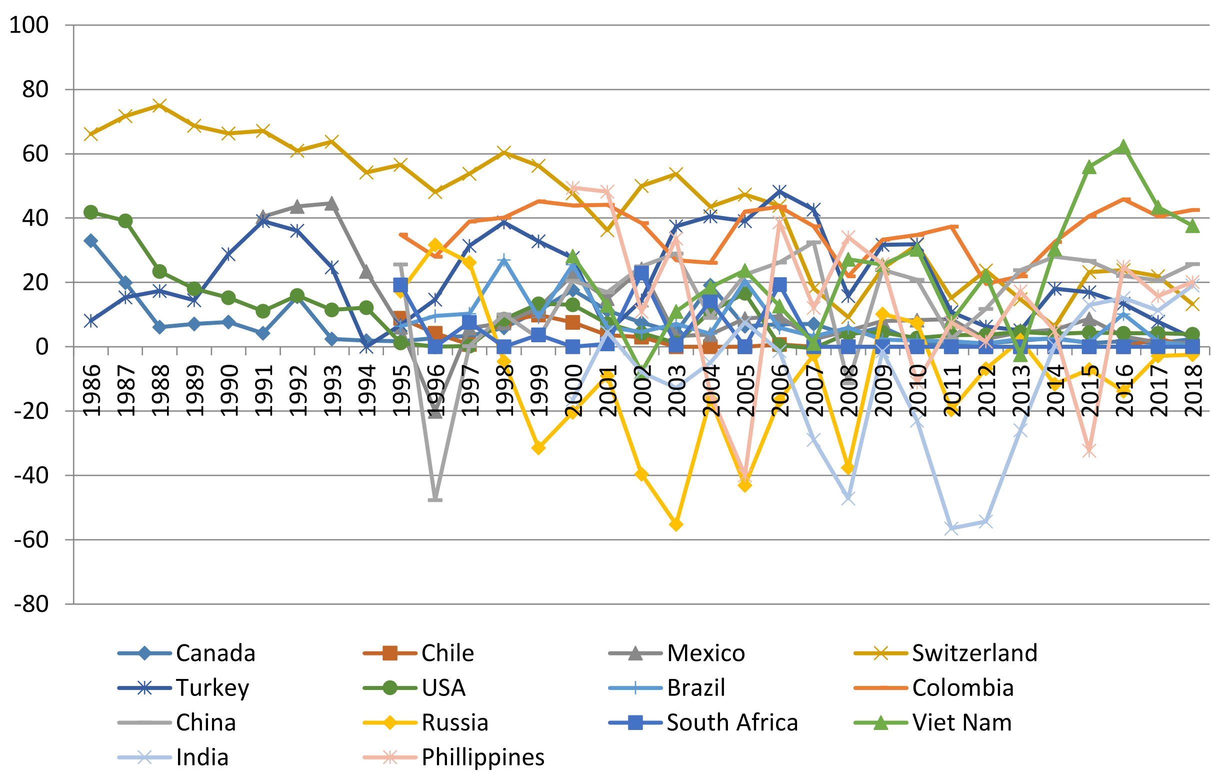

Fig. 4: PSCT percentage indicator for maize commodity in selected countries, [2]

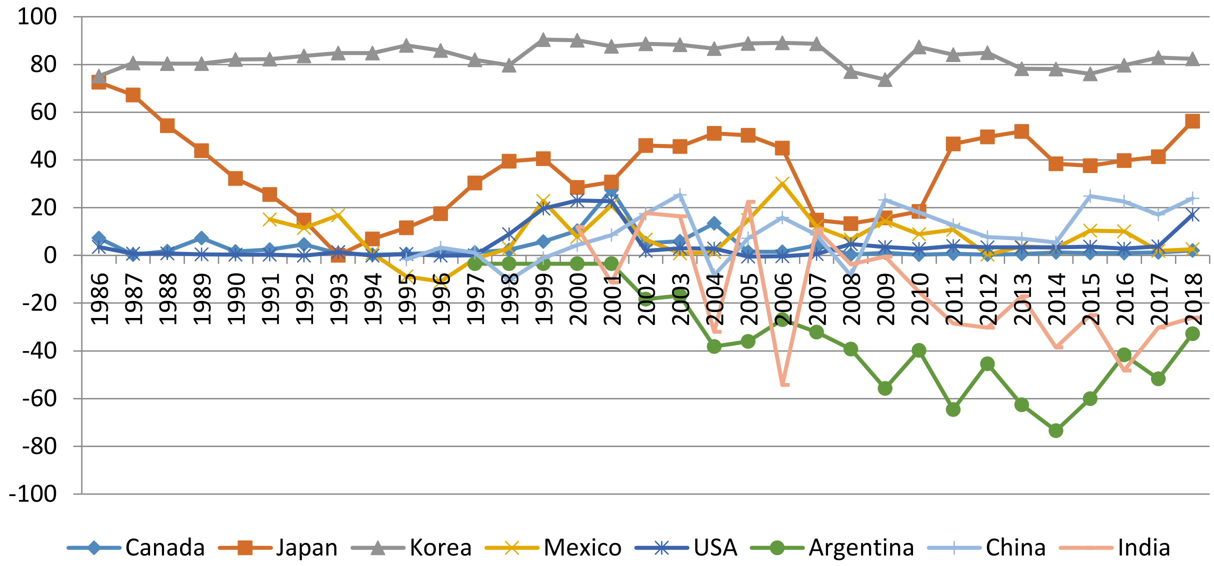

Fig. 5: PSCT percentage indicator for soybean commodity in selected countries, [2]

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