An Alternative Approach to USDA NASS Subcomponent Price Indexes

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Abstract

This paper assesses methodologies to construct elementary price relative estimators used in constructing the United States Department of Agriculture's National Agricultural Statistics Service (USDA NASS) Prices Received Subcomponent Indexes. This paper evaluates alternative index formulas in conjunction with agricultural commodity characteristics which may provide an improved conceptual and empirical methodology for the USDA NASS Prices Received index program than the currently used modified weighted Dutot estimator. The implications of changing to a different price relative estimator are discussed. The price relative estimator comparisons are presented using the axiomatic approach and an empirical analysis. The evaluation of the alternative methodologies is presented using empirical research.

Key Words: USDA NASS Price Received Indexes; Price Relative Estimators

1. Introduction

The United States Department of Agriculture's National Agricultural Statistics Service (USDA NASS) Prices Received and Prices Paid Index Series are constructed and published monthly. These price indexes provide a measure of change in the general price level of farm products sold and farm inputs purchased by agricultural producers. The percentage change of a particular aggregate price index from the base reference period to the current period represents the general level of price change for a particular group of commodities. Permanent legislation mandates use of the Prices Received and Prices Paid Index Series in formulating farm policy.[1]

The mission of USDA NASS in its price program is to provide relevant, timely, accurate, and useful statistics for use in evaluating the economic condition of the U.S. agricultural economy. In support of this mission, USDA NASS periodically obtains external reviews of core programs. In 2008, USDA NASS solicited the Council on Food, Agriculture & Resource Economics (C-FARE) to assemble a panel of expert social scientists from academia, government, and the private sector to conduct an "independent, comprehensive, and objective review" of the agricultural price program (C-FARE, 2009). Based on the C-FARE review, USDA NASS concluded that the current price index methodology needed improvement to implement a more current price index methodology consistent with other governmental statistical agencies

This paper examines alternative methodologies for building USDA NASS Prices Received Subcomponent Indexes while adhering to farm program requirements. The common methods used to calculate elementary price indexes are discussed followed by an analysis of different price index methods and assumptions.

This paper provides the results of empirical research on price relative estimators compared with a Fisher price index baseline standard using NASS commodity data. Three subcomponent group indexes, feed grain, food grain and oilseed, are constructed and analyzed when applying commodity price and quantity data.

[1] The methodology behind the USDA NASS price indexes is described in more detail in USDA NASS (2011), USDA NASS (2014b), and USDA NASS (2015a).

2. Background

The USDA NASS price index data provide key agricultural economic indicators used in many federal government programs and are required by legislation (USDA NASS, 2011). USDA NASS computes the price indexes under the provisions of the Agricultural Adjustment Act of 1938, as amended by the Agricultural Acts of 1948, 1949, 1954, and 1956 (U.S. Government, 1938, 1948, 1949, 1954, 1956). A summary of agricultural legislation and farm bill programs pertaining to price indexes dating back to 1933 is found in the 2011 Price Program documentation (USDA NASS, 2011). The price data provide a link between agricultural production and distribution and are part of the gross domestic product (BEA, 2009).

The primary issue related to the legislation and USDA NASS requirements is how USDA NASS prices and price indexes should be calculated. The major provisions of the amended Act relating to the construction of economic statistics retained as an aid in establishing farm policy are as follows:

> "(1) (A) The 'parity price' for any agricultural commodity, as of any date, shall be determined by multiplying the adjusted base price of such commodity as of such date by the parity index as of such date.(B) The 'adjusted base price' of any agricultural commodity, as of any date, shall be (i) the average of the prices received by farmers for such commodity, at such time as the Secretary may select during each year of the ten-year period ending on the 31st of December last before such date, or during each marketing season beginning in such period if the Secretary determines use of a calendar year basis to be impracticable, divided by (ii) the ratio of the general level of prices received by farmers for agricultural commodities during the period January 1910 to December 1914, inclusive."

In addition, the Agricultural Adjustment Act of 1938 as amended by the Agricultural Adjustment Acts of 1948, 1949, 1954, and 1956 define a "parity index" as

> "The ratio of (i) the general level of prices for articles and services that farmers buy, interest on farm indebtedness secured by farm real estate, and taxes on farm real estate, for the calendar month ending last before such date to (ii) the general level of such prices, rates, and taxes during the period January 1910 to December 1914, inclusive."

The Agricultural Adjustment Act of 1948 further states that the Secretary of Agriculture has responsibility for the construction of the price indexes:

> "The prices and indices provided for herein, and the data used in computing them, shall be determined by the Secretary, whose determination shall be final." [2]

This language has generally been interpreted to mean that USDA NASS, as a representative of the Secretary of Agriculture, has discretion in building price indexes that provide an accurate description of the relationship between the general levels of prices producers receive for farm products and the general level of prices producers pay for production inputs.

USDA NASS price indexes are not intended to be welfare indexes similar to cost-of-living indexes or exact price indexes as defined by Diewert (1976) and others. USDA NASS price indexes are constructed to provide a measure of price relationships and the general level of price change for agricultural products sold and the cost of farm inputs purchased. The indexes do not measure farm income, producer total purchasing power, or producer welfare.

As will be shown in more detail in the following sections, the basic form of the elementary USDA NASS Prices Received Index is as follows:

[2] The *Federal Code of Regulations* defines "Secretary" to mean Secretary of Agriculture.

$$I_{2011=100}^{2014}(\overline{\boldsymbol{P}}_R, \boldsymbol{P}_t|\boldsymbol{Q}_B) = \left(\sum_{j=1}^{J} \frac{p_{jt}}{\bar{p}_{jR}} \overline{w}_{j,R,B(t)}\right) \times 100 \tag{1}$$

where p_{jt} is the price for commodity j in period t,[3] $\bar{p}_{jR}$ is the average price for commodity j in the base reference period (R), $\overline{w}_{jR,B(t)}$ is the base weight period (B) weight for the price relative for commodity j in period t.

3. Methods to Calculate Price Indexes

A number of methods to calculate price indexes have been proposed since the first documented price indexes were developed in the 17th Century. Two of the simplest indexes in common use today are the *Laspeyres Price Index* and the *Paasche Price Index*. Letting p_{jt} denote the price for commodity j in period t, $w_{js,v}$ is the marketing weight for commodity j based on prices in period s and quantities in period v (typically calculated as $w_{js,v} = p_{js}q_{jv}/\sum_{k=1}^{J} p_{ks}q_{kv}$), q_{jv} is the quantity of commodity j sold in period v, and J is the number of commodities in the index, the Laspeyres Price Index is

$$I^{Laspeyres}(\boldsymbol{p}_R, \boldsymbol{p}_t|\boldsymbol{q}_R) = \left(\sum_{j=1}^{J} \frac{p_{jt}}{p_{jR}} w_{jR,R}\right) \times 100 \tag{2}$$

whereas the Paasche Price Index is written as:

$$I^{Paasche}(\boldsymbol{p}_R, \boldsymbol{p}_t|\boldsymbol{q}_t) = \left(\sum_{j=1}^{J} \frac{p_{jt}}{p_{jR}} w_{jR,t}\right) \times 100 \tag{3}$$

As shown in (2) and (3), the difference between the two indexes is the period from which weights are based. The Laspeyres Price Index weights the price relative for each commodity j (p_{jt}/p_{jR}) by the base reference period quantities, while the Paasche Price Index weights the price relative for each commodity j by the current period quantities.

Four of the most common price index axioms proposed in the Axiomatic Approach are:

- *Axiom 1 (Proportionality Test)*. Proportional prices lead to a proportional price index number.
  $I(\boldsymbol{p}_R, \lambda\boldsymbol{p}_R) = \lambda \times 100, \forall\lambda \in R$
- *Axiom 2 (Change in Units Test)*. Changes in pricing units of measurement do not matter.
  $I(\boldsymbol{\alpha p}_R . \boldsymbol{\alpha p}_t) = I(\boldsymbol{p}_R, \boldsymbol{p}_t)\ \forall\boldsymbol{\alpha} \in R_+^J$
- *Axiom 3 (Reciprocity Test)*. Switching the base period price for the current period price and vice versa yields a reciprocal index number.
  $I(\boldsymbol{p}_t, \boldsymbol{p}_R) = 1/I(\boldsymbol{p}_R, \boldsymbol{p}_t)$
- *Axiom 4 (Transitivity Test)*. The price index satisfies transitivity.
  $I(\boldsymbol{p}_R, \boldsymbol{p}_1)I(\boldsymbol{p}_1, \boldsymbol{p}_2) = I(\boldsymbol{p}_R, \boldsymbol{p}_2) \times 100$

It is very rarely the case that there is only one price for each commodity in any given period, in which case some estimators must be used for the price relative. Weighted versions of the three main estimators proposed in the literature are:

[3] The notation period t represents the period in which prices are being compared to the base reference period.

- *Weighted Dutot Price Relative Estimator.*

$$\hat{R}_{jt}^{Dutot} = \frac{\left(1/\sum_{i=1}^{N_j} m_{ijt}\right)\sum_{i=1}^{N_j} m_{ijt}p_{ijt}}{\left(1/\sum_{i=1}^{N_j} m_{ijR}\right)\sum_{i=1}^{N_j} m_{ijR}p_{ijR}} \tag{4}$$

- *Weighted Carli Price Relative Estimator.*

$$\hat{R}_{jt}^{Carli} = \left(1/\sum_{i=1}^{N_j} m_{ijt}\right)\sum_{i=1}^{N_j} m_{ijt}\frac{p_{ijt}}{p_{ijR}} \tag{5}$$

- *Weighted Jevons Price Relative Estimator.*

$$\hat{R}_{jt}^{Jevons} = exp\left(\left(\frac{1}{\sum_{i=1}^{N_j} \bar{m}_{ijt}}\right)\sum_{i=1}^{N_j} m_{ijt}\, log\left(\frac{p_{ijt}}{p_{ijR}}\right)\right) \tag{6}$$

where N_j is the number of price observations for commodity j, p_{ijv} is price observation i for commodity j in period v, and m_{ijv} is sampling weight i for commodity j in period v.
As an example, consider price data for a commodity as in Table 3.1 below. (The commodity can be thought of as a general grain commodity having numerous varieties, classes, grades, and price levels.) Using these prices, the estimate for the price relative under the Weighted Dutot Price Relative Estimator is **1.57** (= $[0.5(2) + 0.3(3) + 0.2(7)]/[0.5(1) + 0.3(2) + 0.2(5)]$), while the estimate for the price relative under the Weighted Carli Price Relative Estimator is **1.73** (= $0.5(2/1) + 0.3(3/2) + 0.2(7/5)$) and the estimate for the price relative under the Weighted Jevons Price Relative Estimator is **1.71** (= $\exp\left(0.5\, log(2/1) + 0.3\, log(3/2) + 0.2\, log(7/5)\right)$).

Table 3.1: Example Price Data for Price Relative Estimates

	Grain Buyer 1	**Grain Buyer 2**	**Grain Buyer 3**
Previous Price ($/bu.)	1	2	5
Current Price ($/bu.)	2	3	7
Sampling Weight	0.5	0.3	0.2

One reason for using either the Weighted Carli Price Relative Estimator or the Weighted Jevons Price Relative Estimator is that, unlike the Weighted Dutot Price Relative Estimator, neither is influenced by items with abnormally high or low degrees of price levels.

Proposition 1. *The Weighted Dutot Price Relative Estimator is influenced by the relative size of price observations. Neither the Weighted Carli Price Relative Estimator nor the Weighted Jevons Price Relative Estimator are influenced by the relative size of price observations.*

Intuition[4]: The Weighted Dutot Price Relative Estimator equals the weighted average price in the current period divided by the weighted average base price. As a result, both the level of the prices and the rate of change of the prices may influence the price index. The Weighted Carli Price Relative and the Weighted Jevons Price Relative Estimators divide each current period price by its corresponding base period price

[4] A complete proof will be provided upon request.

before being weighted, resulting in only the rate of the price change. The price level or magnitude compared to other prices for the commodity is irrelevant.

Proposition 1 has important implications for use in calculating price indexes for agricultural products. Because some types of commodities in agricultural price indexes can be vastly different, using a Weighted Dutot Price Relative Estimator would not be optimal. This is especially true, for example, in commodities that have a significant proportion of organic sales,[5] where organic variety prices are significantly higher than other variety prices.[6]

C-FARE (2009) provides further justification for not using the Weighted Dutot Price Relative Estimator that relates to how the price relative estimator behaves when grain-buyer prices relatives do not change but sampling weights do change. A generalization of the C-FARE result is provided in Proposition 3 below.

Proposition 2. *The Weighted Dutot Price Relative Estimator is influenced by the relative size of sampling weights when price relatives for all observations change at the same rate. Neither the Weighted Carli Price Relative Estimator nor the Weighted Jevons Price Relative Estimator are influenced by the relative size of sampling weights when price relatives for all observations change at the same rate.*

Intuition: As before, the Weighted Carli Price Relative and the Weighted Jevons Price Relative Estimators divide each current period price by its corresponding base period price before being weighted, resulting in only the rate of the price change. When the rates of price changes for each observation are the same, the result is only the shared rate of price change.

Another reason for preferring the Weighted Carli Price Relative Estimator and the Weighted Jevons Price Relative Estimator over the Weighted Dutot Price Relative Estimator is that if a grain buyer that reports a significantly higher (or lower) price gets rotated out of the sample, then the Weighted Dutot Price Relative Estimator can yield unattractive results. Consider a sample rotation scenario as in Table 3.2 below. In this scenario, Grain Buyer 3, which has a higher price than the other two grain buyers in the base reference period is rotated out of the sample in the current period and replaced with another grain buyer paying relatively lower prices.

In this circumstance, assuming no explicit imputation methods are used, the Weighted Dutot Price Relative Estimator would yield an elementary price index number of 67. The Weighted Carli Price Relative Estimator and Weighted Jevons Price Relative Estimator, on the other hand, would both yield elementary price index numbers of 100, which is likely a better estimate in this scenario due to the fact that prices paid by grain buyers tend to move together.

Table 3.2: Example Sample Rotation Scenario

	Grain Buyer 1	**Grain Buyer 2**	**Grain Buyer 3***	**Grain Buyer 4***	**Avg.**
Previous Price ($/bu.)	1	3	5	---	3
Current Price ($/bu.)	1	3	---	2	2
Item Weight	1	1	1	1	---

* Grain Buyer 3 rotates out of the sample, while Grain Buyer 4 rotates into the sample in the current period.

[5] As of 2011, for example, the percentage organic production acreage of major fruits and vegetables such as carrots (14%), lettuce (12%), apples (5%), and grapes (4%) were relatively high, while the percentage organic production of major field crops such as corn (0.3%), soybeans (0.2%), wheat (0.6%), and oats (2.5%) were relatively low (USDA ERS, 2014).

[6] Prices for organic grain, for example, are generally two to three times higher than prices for other grain variety prices.

In deciding on whether to choose between the Weighted Carli Price Relative Estimator and the Weighted Jevons Price Relative Estimator, a potentially important concern is the ranking of the different estimators for a given set of prices and weights. As shown in Proposition 4, for any given set of positive prices and positive sampling weights the Weighted Carli Price Relative Estimator estimate is always higher than (or at least as high as) the Weighted Jevons Price Relative Estimator estimate.

Proposition 3. *For any given set of positive prices and positive sampling weights, the Weighted Carli Price Relative Estimator estimate is weakly greater than the Weighted Jevons Price Relative Estimator estimate.*

Intuition: The result follows from the fact that the logarithm is a concave function so that the logarithm of the sum is weakly greater than the sum of the logarithms. The desired result immediately follows because if this inequality holds then the inequality formed by taking the exponential of both sides of the inequality must also hold.

Another matter of interest in comparing the Weighted Carli Price Relative Estimator to the Weighted Jevons Price Relative Estimator is that the elementary price index formed by the Carli Price Relative Estimator does not adhere to Axioms 3 – 4 (Reciprocity Test and Transitivity Test), whereas the elementary price index formed by the Jevons Price Relative Estimator does. This provides another reason for preferring the Jevons Price Relative Estimator over the Carli Price Relative Estimator.

Proposition 4. *The Weighted Carli Price Relative Estimator Elementary Price Index adheres to Axioms 1 – 2 (Proportionality Test and Change in Units Test) but does not adhere to Axioms 3 – 4 (Reciprocity Test and Transitivity Test). The Weighted Jevons Price Relative Estimator Elementary Price Index adheres to Axioms 1 – 4.*

Intuition: The results for the Weighted Carli Price Relative Estimator Elementary Price Index are a direct implication of the definition of the Weighted Carli Price Relative Estimator. Because it is a sum of price relatives, it will not generally allow for reciprocity or transitivity. The results for Weighted Jevons Price Relative Estimator Elementary Price Index are a direct implication of the definition of the Weighted Jevons Price Relative Estimator. Because it is a product of price relatives, it satisfies reciprocity and transitivity.

Based on the aforementioned discussion, the axiomatic approach suggests the Weighted Jevons Price Relative Estimator as the preferable estimator when weighted by fixed weights. This price relative estimator adheres to the established price index axioms, while also being uninfluenced by the relative size of the price observations used to estimate the price relative estimates.

4. Empirical Evaluation of Subcomponent Price Indexes

This discussion examines evaluating the elementary prices received index estimators for the grains and oilseed at the national level. This empirical approach has been discussed by Gábor (2014) to evaluate and measure price index bias among elementary index estimators.

This empirical analysis includes an evaluation of both the aggregation of elementary price indexes at the commodity level and at the commodity subcomponent index level. The ultimate application is to construct the commodity subcomponent price indexes using commodity indexes based on price relatives rather than average price. NASS does not publish commodity indexes. The three commodity subcomponent indexes evaluated are the food grain, feed grain, and oilseed index groups. Because of data limitations and the relatively small value of sales for many less relevant crop commodities, only selected commodities are included in the subcomponent indexes. The food grain index consists of wheat and rice. The feed grain index includes corn, barley, and sorghum. The oilseed index is constructed from soybeans, peanut and sunflower commodities.

The available NASS data are a major consideration in the evaluation of index estimators and price indexes. Unlike many other data series, NASS conducts a monthly stratified probability survey for all field crops, including corn, barley, oats, sorghum, soybeans, sunflower, wheat, and more. The population and sampling units are known grain buyers purchasing directly from producers. The survey variables collected monthly include the total value of purchases and the total quantity purchased during the previous month.

Some crops (USDA NASS, 2011) consist of multiple classes or types with different characteristics and uses. Wheat, for instance, consists of three sub-classes; spring, winter and durum. A price is an aggregation of the sub-class unit prices. The Carli Index is used to construct overall commodity indexes for commodities consisting of sub-classes, such as wheat. Since the most recent price index base period is the year 2011, this evaluation covers the time period between 2011 and 2014.

Also at the commodity level, the characteristics of homogenous grains, such as corn and soybeans, make it possible to aggregate elementary price indexes with the quantity weights instead of the value weights. All price indexes were constructed as a direct index, which implies the price relative ratios were calculated as the current month prices divided by their respective base price. No imputation was performed. All zero value price relative ratios were excluded. The zero values included missing reports and new sample units rotating into the survey. In the case of missing reports, it is possible that no grains were purchased for the reporting month. The analysis and handling of zero values is left for future research.

Another major consideration about the NASS monthly survey program is that the sampling scheme maximizes sample rotation to reduce respondent burden. While this sampling scheme is appropriate for statistical sampling, the effects may be negative for price relative data which requires consistent elementary reports over time. This has implications for which commodity subcomponent price indexes are selected. Corn and soybeans account for 95 percent of the feed grain and oilseed subcomponent index while wheat accounts for about 82 percent of the food grain index. The relative importance of other grains such as sorghum, barley, oats, rice, peanuts, and sunflowers, is less prominent in their corresponding subcomponent indexes.

With the available commodity price and quantity data, a superlative ideal Fisher index can be constructed at the elementary level as a standard baseline measure for 2011 through 2014. The Fisher price index is preferred by economic theory when price and quantity data are available. As stated in Diewert (1995): "*Thus if price and quantity information is available at the elementary level, it seems preferable to use the Fisher ideal price index to aggregate the basic level price quotes rather than the Laspeyres, Paasche or geometric indexes …"* The Fisher index built in this period is viewed as a baseline standard and better represents a truer general level of price change. The elementary index bias is the empirical measure of standard error and average mean to evaluate alternative indexes. The alternative elementary price indexes proposed in this research are the Carli, Dutot, and Jevons.

The price received sub-component indexes are an aggregation of the elementary commodity indexes. The definition of the arithmetic mean group price index becomes:

$$I_{(P_{(R,t)}|\overline{w}_s)} = \sum_j P^j_{(R,t)} * \overline{w}^j_s \tag{7}$$

The definition of the geometric mean subcomponent price index is:

$$I_{(P_{(R,t)}|\overline{w}_s)} = \prod_j \left(P^j_{(R,t)}\right)^{\overline{w}^j_s} \tag{8}$$

Where:

- $P^j_{(R,t)}$ is elementary index of commodity j in period t,
- $\overline{w}^j_s$ is the five-year average weight of period s for commodity j,
- Base reference R represents Jan. 2011.

The weights used for the subcomponent indexes are a five-year average of agricultural cash receipt data. These weights are consistent with the construction of the current prices received index. To reduce the impact weights have on the monthly change, commodity subcomponent indexes are constructed using annual cash receipt data as weights. Weights for the Laspeyres price index are defined as year 2011. Weights for the

Paasche price index as well as the Carli, Dutot, and Jevons elementary indexes represent the correspondent years, 2011 through 2014.

The elementary index bias is defined as the difference between the price change measured by the elementary index and the ideal Fisher index. The average absolute mean value of the difference provides a measure of any elementary index bias from the Fisher index. The advantage of this empirical approach is that the index estimators can be evaluated directly with the Fisher index. The disadvantage is that a large amount of reported data are excluded because of sample rotation and the need to obtain base reference prices and quantities required to build the Laspeyres and Paasche indexes. Crops with lower quantities and frequencies, such as barley and oats, result in inconclusive measurements.

The comparative results of the index methodology with the ideal Fisher index are shown in the four tables, 4.1 through 4.4 (see Appendix). The methodology implemented uses current quantity weights (Table 4.1) and representing the commodities marketed in the current time period. The unweighted statistics (Table 4.2) indicate the price indexes when quantity data are not available. Base weights represent the base period quantities structure. These weights are fixed. The index change then will reflect the price change.

The three measures of comparison are the mean, standard deviation, and the product of the square root of the absolute value of the mean times the standard deviation. Results might be inconclusive when the smaller value of either the mean or the standard deviation contradict each other. For example, barley and rice have the smallest average mean and standard deviation with the Jevons index, while oats, peanuts, soybeans, and wheat have the smallest average mean with the Dutot index and the smallest standard deviation with the Jevons index (Table 4.1). Since this evaluation shows an inconsistent result, a third value is used for assessment, the product of the square root of the absolute value of the mean times the standard deviation.

The average mean and standard deviation of index bias using current weights compared to the Fisher index are much smaller than those of an unweighted elementary index (Table 4.1 and Table 4.2). The average mean and standard deviation for corn are 0.25 and 0.55 for a weighted Carli index. The average mean and standard deviation corn are 0.54 and 2.05 for an unweighted Carli index. The average mean and the standard deviation for soybeans are 0.60 and 0.73 for a weighted Carli index. The average mean and standard deviation are 1.11 and 1.07 for an unweighted Carli index. The average mean and the standard deviation for wheat are 0.24 and 1.95 for a weighted Carli index. On the other hand, wheat mean and standard deviation values for an unweighted Carli index are s 2.14 and 2.27, respectively In Tables 4.1 and 4.2, both average mean and standard deviation are smaller when elementary indexes are built using current quantity weights than without weights. There is a significant difference in the average means and standard deviations for barley, which is a crop of lower relative significance. The average mean for barley is 1.57 with weights and -11.13 without weights while the standard deviation is2.74 with weights and 14.89 without weights for Carli index. All other indexes have similar results as barley. The impact of weights are not only on the values of average mean and standard deviation, but also on the selection of the elementary index itself. Using the smallest value of mean as an example, the Dutot index estimator has the smallest average mean when using current weights for corn, soybeans, and wheat, without weights the Carli index estimator shows smaller average means for corn, soybeans, and wheat.

The product of the square root of the absolute value of the mean and standard deviation for oats, peanuts, soybeans, and wheat, are also smallest using the Dutot index. Tables 4.1, 4.2, and 4.3 show that the product of the square root of the absolute value of the mean and standard deviation is consist with the value of average mean.

A weighted Jevons price index, which is preferred using the axiomatic approach, also performs well for sorghum, barley, oats, wheat, rice, and sunflowers when built using the base period quantity weights (Table 4.3).

Corn, soybeans, and peanuts, have the smallest average mean value using the Dutot index and base weights. No commodity performs well using the Carli index and base weights. As a result of the quantity weights changing from fixed to variable, the values of the average mean among elementary indexes also change (Tables 4.1 and 4.3). Sorghum has the smallest average mean using the Carli index. Corn, oats, soybeans, wheat, and peanuts have the smallest average mean using the Dutot index. Only three commodities, barley, rice, and sunflower have the smallest average mean using the Jevons index.

When considering the Dutot index, which is defined as a ratio of average prices, the index performs well when built using current weights. The Dutot index estimator also performs well when the index is built using base weights or no weights. In this case, there is no quantity change and the Dutot index reflects only a change price. The Dutot index estimator becomes a problem when the index is built using variable weights or current monthly weights. In this case, the measure change represents both a change in price and quantity. The difference becomes how to obtain the average price. A weighted average price in the Dutot index is directly calculated from the sample data. An average price in NASS's current index is an estimate set by statisticians based on survey and available administrative data. Since there is potential bias for a weighted average price, a weighted Dutot index estimator may not provide the best NASS grains and oilseed price index.

The comparison of the Carli and Jevons estimators, using current weights for the commodities is shown in Table 4.1. The Jevons index performs better for barley, oats, rice, peanuts, and sunflowers. Corn, sorghum, soybeans, and wheat are best using the Carli index. The Jevons index provides the best estimate for five of the nine commodities. When looking at the commodities based on relative importance, corn, wheat, and soybeans are significant contributors to their respective subcomponent index. The estimator providing the closest index to the ideal Fisher baseline standard should provide the best NASS index.

The results of the subcomponent index comparisons is relatively straight forward as presented in Table 4.4. All three commodity subcomponent indexes have the smallest value of average mean for the Carli index when not considering the Dutot index.

5. Conclusions

This paper presents a thorough analysis to evaluate alternative grains and oilseed index formulation to revise the current methodology used in the construction of NASS indexes. The analysis evaluated the weighted Jevons price relative estimator and the weighted Carli price relative estimator in comparison with the current price methodology utilized by NASS. Overall, the Carli index estimator provides the best results for the NASS index based on empirical research. The Jevons index estimator provides a better index when aggregation is based on fixed weights, which isn't supported by the current survey methodology. The Dutot index also provides a sound index using variable weights. However, the Dutot index defined as a ratio of average prices may produce an index bias as suggested in the C-FARE recommendations. The empirical research shows a slight upward bias in the NASS index compared to the alternative estimators evaluated. In summary, the Carli price index estimator provides the best index when constructed using current quantity weights.

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Appendix

Table 4.1 Statistics of current weights crops elementary index compared to Fisher index (2011 – 2015)

Commodity	Index	Mean	Standard Deviation	Square root (ABS(Mean)*Standard Deviation)
Corn	**Carli**	-0.252	0.548	0.372
	Dutot	-0.078	0.734	0.239
	Jevons	-0.708	0.551	0.625
Sorghum	**Carli**	0.123	3.023	0.610
	Dutot	0.455	3.935	1.338
	Jevons	-0.215	3.066	0.812
Barley	**Carli**	1.573	2.741	2.076
	Dutot	1.285	2.967	1.953
	Jevons	-0.334	2.317	0.880
Oats	**Carli**	2.220	3.097	2.622
	Dutot	-0.658	4.762	1.770
	Jevons	1.492	2.935	2.093
Soybeans	**Carli**	-0.600	0.731	0.662
	Dutot	0.509	0.765	0.624
	Jevons	-0.901	0.672	0.778
Wheat	**Carli**	0.238	1.947	0.681
	Dutot	0.106	1.756	0.431
	Jevons	-1.201	1.739	1.445
Rice	**Carli**	0.682	1.081	0.859
	Dutot	-3.866	3.700	3.782
	Jevons	-0.064	0.999	0.253
Peanuts	**Carli**	4.961	4.658	4.807
	Dutot	0.777	5.181	2.006
	Jevons	3.053	3.892	3.447
Sunflower	**Carli**	0.991	2.458	1.561
	Dutot	-2.139	6.820	3.819
	Jevons	-0.121	2.593	0.560

Table 4.2 Statistics of no weights Crops Elementary Index Compared to Fisher Index (2011 – 2015)

Commodity	Index	Mean	Standard Deviation	Square root (ABS(Mean)*Standard Deviation)
Corn	Carli	-0.537	2.051	1.049
	Dutot	-1.293	2.130	1.660
	Jevons	-1.115	2.062	1.516
Sorghum	Carli	0.365	2.637	0.981
	Dutot	0.056	2.549	0.378
	Jevons	-0.013	2.559	0.182
Barley	Carli	-11.130	14.856	12.859
	Dutot	-11.906	14.046	12.932
	Jevons	-14.723	16.445	15.560
Oats	Carli	4.669	3.543	4.067
	Dutot	3.324	3.261	3.292
	Jevons	3.732	3.394	3.559
Soybeans	Carli	-1.108	1.066	1.087
	Dutot	-1.616	1.085	1.324
	Jevons	-1.460	1.082	1.257
Wheat	Carli	-2.133	2.266	2.198
	Dutot	-3.850	2.315	2.985
	Jevons	-3.991	2.660	3.258
Rice	Carlie	0.368	2.729	1.002
	Dutot	-2.798	3.618	3.182
	Jevons	-1.219	2.376	1.702
Peanuts	Carli	5.063	9.188	6.820
	Dutot	2.534	7.129	4.250
	Jevons	0.623	8.540	2.307
Sunflower	Carli	2.276	5.503	3.539
	Dutot	1.328	4.489	2.442
	Jevons	0.561	4.389	1.569

Table 4.3 Statistics of base weights crops elementary index compared to Fisher index (2011 – 2015)

Commodity	Index	Mean	Standard Deviation	Square root (ABS(Mean)*Standard Deviation)
Corn	Carli	1.180	0.601	0.842
	Dutot	0.551	0.687	0.615
	Jevons	0.704	0.600	0.650
Sorghum	Carli	0.646	3.280	1.456
	Dutot	0.546	3.243	1.331
	Jevons	0.450	3.247	1.209
Barley	Carli	2.695	2.844	2.768
	Dutot	2.754	2.941	2.846
	Jevons	0.921	2.745	1.590
Oats	Carli	-0.731	2.707	1.407
	Dutot	-1.529	2.704	2.033
	Jevons	-1.336	2.646	1.880
Soybeans	Carli	1.219	0.639	0.883
	Dutot	0.676	0.659	0.667
	Jevons	0.854	0.652	0.746
Wheat	Carli	2.565	1.896	2.205
	Dutot	1.526	1.854	1.682
	Jevons	1.225	1.756	1.467
Rice	Carlie	0.874	1.062	0.963
	Dutot	-1.038	2.223	1.519
	Jevons	0.029	1.149	0.183
Peanuts	Carli	-1.136	3.390	1.962
	Dutot	-0.955	3.596	1.853
	Jevons	-3.350	4.306	3.798
Sunflower	Carli	1.242	3.181	1.988
	Dutot	0.967	2.963	1.693
	Jevons	0.020	2.573	0.227

Table 4.4 Statistics of Subcomponent Price Index Compared to Fisher Index (2011 - 2014)

Subcomponent	Index	Mean	Standard Deviation	Square root (ABS(Mean)*Standard Deviation)
Feed Grain	Carli	-0.168	0.625	0.324
	Dutot	-0.005	0.796	0.063
	Jevons	-0.777	0.613	0.690
	Laspeyres	1.162	0.674	0.885
	Paasche	-1.147	0.66	0.870
Food Grain	Carli	-0.052	1.364	0.266
	Dutot	-1.005	1.505	1.230
	Jevons	-1.100	1.341	1.215
	Laspeyres	1.842	1.464	1.642
	Paasche	-1.794	1.389	1.579
Oilseed	Carli	-0.447	0.746	0.577
	Dutot	0.494	0.860	0.652
	Jevons	-0.898	0.714	0.801
	Laspeyres	1.188	0.666	0.889
	Paasche	-1.172	0.655	0.876