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Avoiding Anomalies of GDP in Constant Prices by Conversion to Chained Prices

Accentuating Shifts in Philippine Economic Transformation

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Abstract

Changing the base year (1985) of Philippine GDP in constant prices could change the *growth rate* and the *shares* of components even when there is *no* change in the volume of production, implying that the changes in growth rate and shares are *anomalous* (i.e., no real basis). This possibility weakens GDP in constant prices as basis for valuing our economy's production and analyzing its growth performance. This paper demonstrates that conversion to chained prices avoids the above anomalies and also shows *smaller and shrinking* agriculture and industry sectors and *enlarging* services sector that is now *over 50 percent* of the Philippine economy than are shown by valuation in constant 1985 prices. In both contributions to level and growth of GDP, chained prices *accentuate* more than constant 1985 prices the declining importance of agriculture and industry and the rising importance of services in Philippine economic transformation.

Keywords: Real GDP; Constant prices; Chained prices; Fisher index

JEL classification: C43

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1. Introduction and Summary of Findings

The framework for GDP in constant prices is analytically shaky as a basis for growth and shares analyses. The changes in the GDP growth rate and shares of components (e.g., industries) when the base year alone is changed are anomalous because they could happen

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without a change in the volume of production. Hence, these growth rates and shares are vulnerable to "cheating" and, thus, lack integrity because they can be changed as one desires by choosing the base year. Furthermore, GDP growth and industry shares comparisons across countries that measure GDP in constant prices are invalid unless the base years are the same. Even in the latter case, the comparisons are tenuous because base-year dependence means that the conclusions lack generality. Furthermore, constant price valuations assume constant relative prices and, thus, ignore the real effects of relative price changes over time on the evolution of industries or economic sectors. Consequently, shares in constant prices paint a distorted picture of economic transformation. In contrast, the invariance of the growth rates and shares of GDP in chained prices with respect to the base year means that base year manipulations are inconsequential for growth and shares analyses.

As a vehicle for comparing the above measures of *real* GDP, in constant prices or in chained prices, this paper examines the effects of a change in the base year *alone*, i.e., no change in the economy's volume of production, on the GDP growth rate and shares of components. This criterion is critical because a change in the growth rate and shares in this case means that the real GDP in question is failing its intended purpose of measuring only quantity changes. [Henceforth, to avoid redundancy, GDP means "real GDP" unless otherwise stated.]

A change in the base year is equivalent to a change in the units of valuation and, thus, necessarily changes the level of GDP either in constant or chained prices. However, in theory, a change in the base year alone should not change the growth rate of GDP.[1] Unfortunately, GDP in constant prices has a fixed base year that when changed leads inevitably to a change in the growth rate because the condition for it to remain the same─which is the proportionality of prices between the two base years─is surely violated in practice. The change in the growth rate in this case is anomalous because it happens without a change in the volume of production. Moreover, because the GDP growth rate and shares of components are tied together, there are also anomalous changes in shares in constant prices. In contrast, the growth rate and shares in chained prices will not change with the base year changing alone. The implication is that the above anomalies are avoidable by GDP conversion to chained prices.

[1] The logical basis may be explained by analogy between GDP and a car. GDP is a *flow* and, thus, is like a car in *motion*. The level of GDP corresponds to the distance travelled by the car as the growth rate of GDP corresponds to the speed of the car. In this case, a change in the base year alone is like changing the unit of distance from, say, miles to kilometers. Therefore, a base year change should not change the GDP growth rate in the same way that a change in the unit of distance does not change the (physical) speed of the car.

For example, the 2002 growth rate of Philippine GDP in constant prices falls from 3.1 percent to 2.8 percent if the 1985 base year is changed to 1995 while everything else remains the same. In contrast, the 2002 growth rate of GDP in chained prices remains 2.8 percent whatever is the base year. As an example of the change in shares in constant prices, the 2007 share of trade falls from 17.1 percent to 15.4 percent when the base year is changed from 1985 to 1995. In contrast, the 2007 share of trade in chained prices remains 14.7 percent regardless of the base year.

However, changing the base year of GDP in constant prices could lead to legitimate changes in growth rates and shares of components when rebasing involves further adjustments to base year prices necessitated by a number of factors, for example, accounting for the disappearance of old commodities or appearance of new ones. But it follows from the preceding discussion that these legitimate and anomalous changes inevitably come together. Therefore, the changes in growth rates from rebasing of our GDP in constant prices (Domingo, 1992; Virola, Domingo, and Ilarina, 2001) are partly anomalous.

In light of the above, this paper proposes conversion of Philippine GDP in constant prices to chained prices for analytical and empirical reasons.[2] Analytically, the conversion avoids the above anomalies. Empirically, it reveals a more illuminating picture of our economic transformation hitherto hidden by valuation in constant 1985 prices.

Conversion to chained prices reveals smaller and shrinking agriculture and industry sectors and enlarging services sector that is now over 50 percent of the Philippine economy than have been shown by valuation in constant 1985 prices.[3] During 2002-2007, based on average shares of GDP <u>level</u>, agriculture accounted for 19.3 percent in constant 1985 prices but a *smaller* 14.5 percent in chained prices; industry, 33.0 percent (constant 1985) but a *smaller* 31.7 percent (chained); and services, 47.7 percent (constant 1985) but a *larger* 53.8 percent (chained). In parallel fashion, based on average shares of contributions to GDP

[2] This proposal is in the spirit of Resolution No. 4 (February 14, 2007) by the NSCB that created a *Special Committee to Review the Philippine Statistical System* (chaired by Dr. Vicente Valdepeñas, Jr.) one of whose major tasks was to evaluate "international best practices on statistical systems that could possibly be adopted in the Philippines." Also, NSCB has been looking for "alternative methodologies such as the use of a chain index" (Virola, *et. al*., 2001).

In his *Closing Remarks* listed in the references, Valdepeñas, Jr. (2008) emphasized that initiatives towards Philippine GDP conversion from constant prices to chained prices─consistent with the recommendations in the UN 1993 System of National Accounts─are long overdue. He stated that "… the time has come for the Philippine statistical community to exercise initiatives at raising the level of our understanding of chained indexes. … hopefully, we will have a greater understanding of chained indexes and their ability to tell a more accurate story of economic growth and development in the Philippines."

[3] *Agriculture* covers agriculture, fishery, and forestry; *industry* includes mining, quarrying, manufacturing, construction, electricity, gas, and water; and *services* comprise transport, communication, storage, trade, finance, ownership of dwellings, real estate, private services, and government services.

growth, agriculture contributed 14.3 percent in constant 1985 prices but a *smaller* 10.8 percent in chained prices; industry, 26.1 percent (constant 1985) but a *smaller* 24.2 percent (chained); and services, 59.6 percent (constant 1985) but a *larger* 65.0 percent (chained). Thus, it appears that chained prices accentuate more than constant 1985 prices the declining importance of agriculture and industry and the rising importance of services in Philippine economic transformation.

However, conversion to chained prices does not imply abandoning components in constant prices. The focus on growth of quantities requires "physical" quantities that are difficult to define across product categories above the commodity level.[4] However, components in constant prices fill the need for absent or unavailable physical quantities because these components grow at the same rate as their counterpart physical quantities. For this reason, compilation of components in constant prices needs to be continued because these components are necessary *data inputs* for calculating GDP in chained prices. But this paper objects to the present practice of measuring real GDP simply as the sum of components in constant prices because this GDP could yield anomalous results and, thus, is questionable as basis for valuation of the economy's production and analysis of its growth performance.

The rest of this paper is organized as follows. Section 2 presents an index number framework that reveals analytically the problems of GDP in constant prices and shows their solutions by conversion to chained prices. Section 3 uses Philippine GDP data in current prices and constant 1985 prices to empirically illustrate the above problems and their solutions. The illustrations serve to concretize the economic rationality, feasibility, and ease of converting our GDP to chained prices. Moreover, they paint a new illuminating picture of Philippine economic transformation hitherto hidden by valuations in constant 1985 prices. Section 4 puts together the preceding analyses to show that GDP in constant prices is objectionable for the *failure* of the underlying fixed-base quantity and price indexes to perform their purpose, which is to completely separate quantity and price changes. Thus, this paper recommends GDP in chained prices precisely for the success of the underlying quantity and price indexes in performing this purpose. Section 5 concludes this paper.

2. A Sketch of an Index Number Framework for GDP

The above problems with GDP in constant prices have long been known but the desirability of conversion, though established in principle, depended on the actual severity of

[4] This issue is elucidated in the Appendix of this paper.

the problems in practice. In the case of the US, for example, the onset of the information technology revolution in the late 1980s induced a switch to GDP in chained dollars because constant dollar pricing would have incorrectly measured the impacts of information technology in the national income and product accounts. To illustrate the severity of the problem in hindsight, Whelan (2002) estimated for example that the 1998 growth rate of US GDP in constant dollars was 4.5 percent using 1995 as the base year but will rise to 6.5 percent using 1990 prices, then to 18.8 percent in 1980 prices, and stunningly to 37.4 percent in 1970 prices. This implies that in measuring US GDP in constant dollars, older fixed base years would tend to overestimate the importance of information technology products especially because their prices have dramatically fallen in more recent years. Hence, beginning in the mid-1990s, the US converted GDP to chained dollars (Landefeld and Parker, 1997; Seskin and Parker, 1998; Moulton and Seskin, 1999).[5] In light of US experience and in view of the desirable theoretical properties of the underlying GDP indexes and their practicalities, the framework for US GDP in chained prices (dollars) is proposed by this paper for adoption to convert Philippine GDP to chained prices (pesos).

2.1 *GDP in Constant Prices*

GDP in constant prices may be computed either by multiplication (*inflation*) of a fixed-base Laspeyres quantity index by GDP in the base year or by division (*deflation*) of GDP in current prices by a fixed-base Paasche price index (Balk, 2004a). Either way, the result is the same. The NSCB follows the deflation method in computing GDP level in constant prices

[5] About the earliest appearance of US GDP in chained dollars may be found in the official publication of the US Bureau of Economic Analysis, *Survey of Current Business*, November/December 1995. The conversion of US GDP from constant to chained dollars is consistent with the recommendations in the United Nations 1993 System of National Accounts (1993 SNA) to implement chained volume measures (CVM). More recently, most Member States of the European Union (2007) have made a changeover to CVM in their quarterly and annual national accounts.

Virola (2008) enumerated the following countries as having implemented the 1993 SNA: US (1996), Australia (1998), Denmark (1999), Canada (2001), United Kingdom (2003), Japan (2004), and Hong Kong (2007). However, a check of his references revealed that the index formulas underlying CVM are not uniform. For instance, the US (see the references above) and Canada (Chevalier, 2003) have implemented the chained Fisher index while Australia (Aspden, 2000) and the United Kingdom (Robjohns, 2007) have implemented the chained Laspeyres index. In the case of Japan (Maruyama, 2005), annually chain-linked Laspeyres volume index and quarterly chain-linked Fisher volume index measures have been implemented. Hong Kong (Census and Statistics Department, 2007) has adopted *annually re-weighted chain linking approach* but the underlying index formula is not specified.

Virola also noted that no developing country has so far implemented CVM but stated that the Philippines started "migration" to the 1993 SNA by "pilot adoption" in 1997 through technical assistance by the Asian Development Bank and the Philippine-Australian Government Facility Project, 2001-2003. Among the specific activities of NSCB under the 1993 SNA implementation plan is "exploring the use of CVM" that sad to say has so far not culminated in CVM implementation in official practice. So, the exploration continues and it is hoped that this paper will be part of NSCB's exploration.

(National Economic Development Authority, 1987; Domingo, 1992; Virola, *et. al*., 2001). These two methods are described below.

2.1.1 *Inflation of a Fixed-Base Laspeyres Quantity Index*

In concept, a quantity index permits comparison of any two quantity bundles each comprising *N* goods, allowing for the possibility that one bundle has more of some goods and less of the others than the other bundle. To be able to say that one bundle is larger or smaller than the other, each bundle needs to be collapsed into a single value. This is usually done by multiplying each quantity by the corresponding price and then summing them up and this sum is the single value desired. If the prices and quantities are of the same year, the results are like GDP in current prices that incorporate both "changes in prices" and "changes in quantities." However, a quantity index is intended to capture only changes in quantities and, therefore, changes in prices should be netted out. The usual way to do this is to value the quantity bundles being compared by the *same* prices. In this case, the values reflect only "changes in quantities" and these values are used to construct the quantity index.

By formula, a quantity index is a ratio of the value of the "newer" quantity bundle to the value of the "older" bundle where the values are obtained using the same prices. The Laspeyres quantity index with a fixed base year is a special case where any bundle is compared to the bundle of the base year and the *fixed* base year holds prices *constant*. For example, let there be three years: the base year b and two other adjoining years s and t, $t = s + 1$, and $i = 1, 2, \cdots, N$ commodities. In the base year, prices are p_{ib} and quantities are q_{ib}. The quantities in years s and t are q_{is} and q_{it}. In this case, the fixed-base Laspeyres (denoted by the superscript *L*) quantity indexes are, by definition,

$$Q_{bb}^{L} = \frac{\sum_{i}^{N} p_{ib} q_{ib}}{\sum_{i}^{N} p_{ib} q_{ib}} = 1 \quad ; \quad Q_{bt}^{L} = \frac{\sum_{i}^{N} p_{ib} q_{it}}{\sum_{i}^{N} p_{ib} q_{ib}} \quad ; \quad Q_{bs}^{L} = \frac{\sum_{i}^{N} p_{ib} q_{is}}{\sum_{i}^{N} p_{ib} q_{ib}} . \tag{1}$$

Notice from (1) that the index in the base year equals 1, i.e., $Q_{bb}^{L} = 1$, because this compares the base year bundle to itself. In other years, the index may differ from 1. Suppose that $Q_{bt}^{L} = 1.05$. Since the valuations are in year b prices, this means that the "overall" quantity in year t (numerator), which is $\sum_{i}^{N} p_{ib} q_{it}$, is 105 percent of the overall quantity in year b (denominator), which is $\sum_{i}^{N} p_{ib} q_{ib}$. Thus, if the prices and quantities encompass all final goods and services in the economy, then the overall quantity in year t becomes the economy's GDP in constant prices, denoted below by Y_{t}^{L}, that can be obtained by multiplying together Q_{bt}^{L} and $\sum_{i}^{N} p_{ib} q_{ib}$.

To generalize the preceding discussion, let,

$Y_t^L =$ Year t GDP in constant year b prices ;

Q_{bt}^L= Laspeyres GDP quantity index linking year t to a fixed base year b ;

$\sum_i^N p_{ib} q_{ib} =$ GDP in the base year b .

Combining the above with (1), it follows that for any year t or s,

$$Y_t^L = Q_{bt}^L \times \sum_i^N p_{ib} q_{ib} = \sum_i^N p_{ib} q_{it} \quad ; \quad Y_s^L = Q_{bs}^L \times \sum_i^N p_{ib} q_{ib} = \sum_i^N p_{ib} q_{is} \; . \quad (2)$$

The result in (2) shows that GDP in constant prices may be obtained by multiplying (inflating) the relative change in overall quantities, as measured by the fixed-base Laspeyres quantity index, by the base year GDP acting as the scalar.

An appealing property of (2) in practice is that the procedure can be *replicated* to any arbitrary number of subaggregates (e.g., industries or sectors) and still obtain the same aggregate GDP. Suffice it for illustration that there are two mutually exclusive subgroups *X* and *Z*. In this case, GDP in the base year and GDP in constant prices in year t are split into,

$$\sum_i^N p_{ib} q_{ib} = \sum_{x \in X} p_{xb} q_{xb} + \sum_{z \in Z} p_{zb} q_{zb} \; ; \quad (3)$$

$$\sum_i^N p_{ib} q_{it} = \sum_{x \in X} p_{xb} q_{xt} + \sum_{z \in Z} p_{zb} q_{zt} \; . \quad (4)$$

The corresponding fixed-base subgroup Laspeyres quantity indexes are, by definition,

$$Q_{bt}^{LX} = \frac{\sum_{x \in X} p_{xb} q_{xt}}{\sum_{x \in X} p_{xb} q_{xb}} \quad ; \quad Q_{bt}^{LZ} = \frac{\sum_{z \in Z} p_{zb} q_{zt}}{\sum_{z \in Z} p_{zb} q_{zb}} \; . \quad (5)$$

Applying the procedure in (2) to (3), (4), and (5) yields,

$$Y_t^L = Q_{bt}^{LX} \times \sum_{x \in X} p_{xb} q_{xb} + Q_{bt}^{LZ} \times \sum_{z \in Z} p_{zb} q_{zb} = \sum_i^N p_{ib} q_{it} \; . \quad (6)$$

The result in (6) illustrates the *additivity* property of constant price components from the fact that the above Laspeyres quantity index is consistent in aggregation.[6]

2.1.2 *Deflation by a Fixed-Base Paasche Price Index*

GDP in current prices is given by prices and quantities in the same year, e.g., t or s,

$$\sum_i^N p_{it} q_{it} \quad ; \quad \sum_i^N p_{is} q_{is} \; . \quad (7)$$

[6] The term "consistent in aggregation" is due to Vartia (1976). An underlying index has this property if the value being calculated (e.g., GDP) in say, two stages as in the above example, necessarily equals the value calculated in a single stage, as shown by (6). The number of stages could be any arbitrary number greater or equal to two. By this definition, Diewert (1978) showed that the Fisher index presented later in this paper is only "approximately" consistent in aggregation.

GDP in constant prices may also be obtained by dividing or deflating (7) by a Paasche (denoted by the superscript *P*) price index with a fixed base. This index is, by definition,

$$P_{bt}^{P} = \frac{\sum_i^N p_{it} q_{it}}{\sum_i^N p_{ib} q_{it}} \quad ; \quad P_{bs}^{P} = \frac{\sum_i^N p_{is} q_{is}}{\sum_i^N p_{ib} q_{is}} \,. \tag{8}$$

Dividing (7) by (8) correspondingly yields exactly the same GDP in constant prices in (2),

$$Y_t^L = \frac{\sum_i^N p_{it} q_{it}}{P_{bt}^P} = \sum\nolimits_i^N p_{ib} q_{it} \quad ; \quad Y_s^L = \frac{\sum_i^N p_{is} q_{is}}{P_{bs}^P} = \sum\nolimits_i^N p_{ib} q_{is} \,. \tag{9}$$

Like the fixed-base Laspeyres quantity index, the fixed-base Paasche price index is also consistent in aggregation. This means that (7) can be split into subgroups similar to (3) and the corresponding subgroup deflators similar to (5) can be constructed from (8). In this case, summing up the deflated subgroups yields exactly the same GDP in constant prices in (6). This is the procedure followed by NSCB to compute GDP in constant prices.[7]

2.1.3 *Effects of Changing the Base year on GDP in Constant Prices*

A change in the base year will change the level of GDP in constant prices in (2) or (9) because the scalar value of base year GDP will change. But whatever its scalar value, base year GDP cancels out of growth rate and shares calculations. Therefore, the GDP growth rate and shares of components are expected *not* to change with the base year because the base year is chosen simply to determine the unit of valuation.

But contrary to expectations, it is possible for the GDP growth rate and shares of components in constant prices to change when a different fixed base year is chosen. To see these changes analytically, consider the GDP growth rate from year *s* to *t* in (2) or (9) and its decomposition into the growth contributions of components given by,

$$\frac{Y_t^L}{Y_s^L} - 1 = \frac{\sum_i^N p_{ib} q_{it}}{\sum_i^N p_{ib} q_{is}} - 1 = \sum\nolimits_i^N g_{it}^L \quad ; \quad g_{it}^L = \left(\frac{p_{ib} q_{is}}{\sum_i^N p_{ib} q_{is}}\right)\left(\frac{q_{it}}{q_{is}} - 1\right) . \tag{10}$$

In (10), g_{it}^L is the growth contribution of component *i*.

If the base year is changed from *b* to *c*, the growth rate in (10) will change if the prices in years *b* and *c* are not proportional to each other. That is,

$$\frac{\sum_i^N p_{ib} q_{it}}{\sum_i^N p_{ib} q_{is}} - 1 \neq \frac{\sum_i^N p_{ic} q_{it}}{\sum_i^N p_{ic} q_{is}} - 1 \quad , \quad \text{if} \quad \frac{p_{ib}}{p_{ic}} \neq k \,, \ \text{all } i \,. \tag{11}$$

[7] This property of consistency in aggregation permits additivity of GDP components in constant prices obtained by "double deflation," which is implemented when feasible to compute real gross value added of Philippine industries (National Economic Development Authority, 1987; Virola, *et. al.*, 2001) which equals output deflated by its own deflator less the inputs deflated by their own deflators.

Since the price proportionality condition is surely violated in reality, the change in the growth rate in (11) is inevitable.

To understand the problem implied by the inequalities in (11), consider again (9). Because the quantity bundles in years *s* and *t* are valued in the same base year prices p_{ib}, the relative change in GDP in constant prices, the ratio of Y_t^L to Y_s^L in (9), supposedly measures aggregate "volume" or overall "quantity" changes *net* of price effects. However, the inequalities in (11) imply that the value of this ratio changes when new base year prices p_{ic} are used. This change is anomalous because all along the quantity bundles in years *s* and *t* are the *same* as before. The implication is that the relative change of GDP in constant prices does not completely net out price effects and, hence, is a dubious measure of aggregate volume or overall quantity changes.

Moreover, the change in the growth rate in (11) necessarily implies that the shares of components in constant prices will change, which is also anomalous for the same reason. This follows because (11) yields,

$$\sum_i^N \left(\frac{p_{ib}q_{is}}{\sum_i^N p_{ib}q_{is}}\right)\frac{q_{it}}{q_{is}} \neq \sum_i^N \left(\frac{p_{ic}q_{is}}{\sum_i^N p_{ic}q_{is}}\right)\frac{q_{it}}{q_{is}}\,. \tag{12}$$

In turn, the above inequality implies that,

$$\frac{p_{ib}q_{is}}{\sum_i^N p_{ib}q_{is}} \neq \frac{p_{ic}q_{is}}{\sum_i^N p_{ic}q_{is}} \quad \text{for some } i\,. \tag{13}$$

The inequality in (13) means that a change in the fixed base year from *b* to *c* will change a component's share in the same year *s* if in (11) the price ratio k does not hold for all i. As a result, this component's growth contribution in (10) will also change.

The above anomalies of changing growth rates and shares in constant prices can be avoided by conversion of GDP to chained prices as shown in the following analysis.

2.2 *GDP in Chained Prices*

In a chain index framework, a chain-type index J_t is linked to a quantity index that uses prices and quantities in the adjoining periods *s* and *t* by,

$$J_t = J_s \times Q_{st}^F \quad ; \quad J_b = 1 \ \ , \ \ b = \text{base year}\,. \tag{14}$$

Since *s* follows *t*, i.e., $t = s + 1$, J_t in (14) is devised where $J_b = 1$ because Q_{st}^F may not equal the conventional value of 1 in the base year *b*. In the US GDP chain index framework—proposed by this paper for implementation to Philippine GDP—Q_{st}^F is the Fisher

(1922) quantity index, denoted by the superscript *F*, defined below. This index has well-known desirable theoretical properties and is widely used in practice.[8]

In similar fashion to the case of constant prices in (2), the *level* of GDP in chained prices, denoted below by Y_t^F, equals the chain-type index in (14) multiplied by GDP in the base year,

$$Y_t^F = J_t \times \sum_i^N p_{ib} q_{ib} = J_s \times Q_{st}^F \times \sum_i^N p_{ib} q_{ib} \quad ; \quad J_b = 1. \tag{15}$$

By definition, Q_{st}^F is the geometric mean of the Laspeyres quantity index (Q_{st}^L) and the Paasche quantity index (Q_{st}^P),

$$Q_{st}^F = (Q_{st}^L \times Q_{st}^P)^{\frac{1}{2}} \quad ; \quad Q_{st}^L = \frac{\sum_i^N p_{is} q_{it}}{\sum_i^N p_{is} q_{is}} \quad ; \quad Q_{st}^P = \frac{\sum_i^N p_{it} q_{it}}{\sum_i^N p_{it} q_{is}}\,. \tag{16}$$

Notice that the Laspeyres quantity index values the quantity bundles in years *s* and *t* using the prices of the "older" bundle in *s* while the Paasche quantity index values these bundles using the prices of the "newer" bundle in *t*. These quantity indexes use as weights the prices from year to year so that prices are "chained" and, thus, (15) measures GDP in chained prices.

2.2.1 *Effects of Changing the Base year on GDP in Chained Prices*

In concept, GDP in chained prices is also an aggregate "volume" or overall "quantity" measure denominated in base year prices. The relative change or the ratio of this GDP between any two years should only measure "volume" or "quantity" changes because the base year GDP cancels out of the ratio. This may be seen by expanding (14). This yields,

$$J_2 = J_1 \times Q_{12}^F \quad ; \quad J_3 = J_2 \times Q_{23}^F = J_1 \times Q_{12}^F \times Q_{23}^F\,. \tag{17}$$

Moreover, (15) implies,

$$\frac{Y_2^F}{Y_1^F} = \frac{J_2}{J_1} = Q_{12}^F \quad ; \quad \frac{Y_3^F}{Y_1^F} = \frac{J_3}{J_1} = Q_{12}^F \times Q_{23}^F\,. \tag{18}$$

Combining (17) and (18) yields the general result that,

$$\frac{Y_T^F}{Y_1^F} = \frac{J_T}{J_1} = Q_{12}^F \times Q_{23}^F \times \cdots \times Q_{(T-1)T}^F\,. \tag{19}$$

These show that the relative change from year 1 to any year forward up to *T* in (19) equals the products of the year to year Fisher quantity indexes starting from year 1 to *T*.

[8] The indexes underlying the US chained dollar framework are the superlative Fisher price and quantity indexes. Diewert (1976, 1978) defined an index as "superlative" if it is *exact* for an aggregator function (e.g., a utility or production function) that is *flexible*, i.e., capable of providing a second-order differential approximation to an arbitrary twice differentiable linearly homogeneous function. The Fisher index is the exact index for the homogeneous form of the flexible quadratic aggregator function.

That the ratios in (18) and (19) are *unaffected* by a change in the base year, it is sufficient to show that the Fisher quantity index in (16) is free of base year prices earlier denoted by p_{ib} or p_{ic} . This is shown below.

2.2.2 *Data for GDP in Chained Prices*

The data for computing GDP in chained prices are the same as those for computing the Fisher index in (16). For this purpose, data on components of GDP in current prices and in constant prices for years *s* and *t* are necessary and sufficient. These data are given by,

$$(p_{is}q_{is}, p_{it}q_{it}) \quad ; \quad (p_{ib}q_{is}, p_{ib}q_{it}) \,. \tag{20}$$

The computation requires the first set of data in current prices in (20). It also requires the cross-products of prices and quantities from different years, $(p_{is}q_{it}, p_{it}q_{is})$, that can be obtained from (20) by,

$$\frac{p_{is}q_{is}}{p_{ib}q_{is}} = \frac{p_{is}}{p_{ib}} \quad ; \quad \frac{p_{is}}{p_{ib}} \times p_{ib}q_{it} = p_{is}q_{it} \quad ; \quad \frac{p_{it}q_{it}}{p_{ib}q_{it}} = \frac{p_{it}}{p_{ib}} \quad ; \quad \frac{p_{it}}{p_{ib}} \times p_{ib}q_{is} = p_{it}q_{is} \,. \tag{21}$$

Moreover, these data yield the price and quantity ratios that are also needed later,

$$\frac{p_{it}q_{it}}{p_{ib}q_{it}} \Big/ \frac{p_{is}q_{is}}{p_{ib}q_{is}} = \frac{p_{it}}{p_{is}} \quad ; \quad \frac{p_{ib}q_{it}}{p_{ib}q_{is}} = \frac{q_{it}}{q_{is}} \,. \tag{22}$$

The results in (21) and (22) show that base year prices cancel out in computing the Fisher quantity index so that this index does not change with the base year. Therefore, the relative change of GDP in chained prices in (18) equals the "unchanged" Fisher quantity index and, thus, implies that this relative change measures only "quantity" changes.

2.2.3 *Additive Formulas for GDP in Chained Prices*

The formula for calculating the overall *level* of GDP in chained prices was earlier given by (15). To facilitate the implementation of this formula in more detail—in terms of determining component contributions to the level and growth rate of GDP in chained prices as well as the real shares of components that satisfy additivity—it would be useful to employ the *additive* decomposition of the Fisher quantity index (van IJzeren, 1952; Dumagan, 2002; Balk, 2004b).

The additive decomposition of the Fisher quantity index involves also the Fisher price index (P_{st}^F), the geometric mean of the Laspeyres (P_{st}^L), and Paasche (P_{st}^P) price indexes. These are,

$$P_{st}^F = (P_{st}^L \times P_{st}^P)^{\frac{1}{2}} \quad ; \quad P_{st}^L = \frac{\sum_i^N q_{is}p_{it}}{\sum_i^N q_{is}p_{is}} \quad ; \quad P_{st}^P = \frac{\sum_i^N q_{it}p_{it}}{\sum_i^N q_{it}p_{is}} \,. \tag{23}$$

Dumagan (2002) showed, using (16) and (23), that the additive decomposition of the Fisher index is,[9]

$$Q_{st}^F = (Q_{st}^L \times Q_{st}^P)^{\frac{1}{2}} = \sum_i^N w_{is}^F \left(\frac{q_{it}}{q_{is}}\right) \;\; ; \;\; w_{is}^F = \left(\frac{P_{st}^F}{P_{st}^L + P_{st}^F}\right) w_{is}^L + \left(\frac{P_{st}^L}{P_{st}^L + P_{st}^F}\right) w_{is}^P \,. \quad (24)$$

$$w_{is}^L = \frac{p_{is} q_{is}}{\sum_i p_{is} q_{is}} \;\; ; \;\; w_{is}^P = \frac{p_{it} q_{is}}{\sum_i p_{it} q_{is}} \;\; ; \;\; \sum_i^N w_{is}^F = \sum_i^N w_{is}^L = \sum_i^N w_{is}^P = 1 \,. \quad (25)$$

From (15), (16), (24) and (25), the growth rate of GDP in chained prices becomes a sum,

$$\frac{Y_t^F}{Y_s^F} - 1 = Q_{st}^F - 1 = \sum_i^N g_{it}^F \quad ; \quad g_{it}^F = w_{is}^F \left(\frac{q_{it}}{q_{is}} - 1\right). \quad (26)$$

In (26), g_{it}^F is the additive growth contribution of component i. Moreover, (26) implies that the level of GDP in chained prices also becomes a sum,

$$Y_t^F = \sum_i^N y_{it}^F \quad ; \quad y_{it}^F = Y_s^F w_{is}^F \left(\frac{q_{it}}{q_{is}}\right) . \quad (27)$$

In (27, y_{it}^F is the additive level contribution of component i. Hence, the real shares sum to 1 (or 100 percent) and each share is given by,

$$\frac{y_{it}^F}{Y_t^F} = \frac{Y_s^F}{Y_t^F} w_{is}^F \left(\frac{q_{it}}{q_{is}}\right) = \frac{w_{is}^F}{Q_{st}^F} \left(\frac{q_{it}}{q_{is}}\right) \quad ; \quad \sum_i^N \frac{y_{it}^F}{Y_t^F} = 1 \,. \quad (28)$$

It is important to note that the constant base year prices cancel out in all calculations of (23) to (28). Therefore, the growth rate, growth contributions, and shares of components of GDP in chained prices do not change with the base year.

It may be noted that the basic formulas for US GDP in chained dollars are the same as (14), (15), and (16) (Landefeld and Parker, 1997; Seskin and Parker, 1998; Moulton and Seskin, 1999).[10] Moreover, the decomposition formula of US GDP growth into the contributions of components is the same as (26) as shown by Dumagan (2000, 2002).

However, the US decomposition of the level of GDP in chained prices and calculation of real shares do not follow the additive procedures in (27) and (28) and, hence, lead to *non-additivity* (Ehemann, Katz, and Moulton, 2002; Whelan, 2002). To resolve this non-additivity problem─which is common to chain linking procedures─Dumagan (2008b)

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[9] Balk (2004b) surveyed the *additive* and *multiplicative* decompositions of the Fisher index. He pointed out that van IJzeren (1952) was the first to derive a satisfactory additive decomposition, "unfortunately in an article in a rather obscure publication series of what is now called Statistics Netherlands." Thus, Balk noted that van IJzeren's decomposition escaped wider attention in the statistical community, leading to independent rediscoveries by Dumagan (2002) and by Reinsdorf, Diewert, and Ehemann (2002).

[10] While the additive decomposition of the Fisher index has been applied to the national income accounts of the US (see the above references) and to those of the Philippines in this paper, the multiplicative decomposition of this index has been applied to total factor productivity analysis, for example, in US agriculture (Dumagan and Ball, 2008a).

derived and proposed (27) and (28) above for the case of GDP based on the chain-type Fisher index.

3. Empirical Results

In light of (20), (21), and (22), data on Philippine GDP in current prices (Table 1) and GDP in constant 1985 prices (Table 2) are necessary and sufficient to compute GDP in chained prices. Each entry in Table 1 is interpreted as $p_{it}q_{it}$ while each one in Table 2 is interpreted as $p_{ib}q_{it}$ where $b = 1985$.

Table 1. Gross Domestic Product (GDP) in Current Prices

	2002	2003	2004	2005	2006	2007
			(Billions)			
Philippines	3,959.6	4,316.4	4,871.6	5,444.0	6,032.8	6,648.2
Agriculture and Fishery	595.6	629.7	730.7	774.1	848.0	932.3
Forestry	1.8	2.3	3.5	4.3	4.8	4.1
Mining and Quarrying	33.5	43.6	52.9	63.6	75.6	108.2
Manufacturing	915.2	1,004.0	1,122.9	1,264.7	1,381.2	1,463.8
Construction	185.7	194.1	212.8	210.2	240.2	304.6
Electricity, Gas, and Water	124.1	137.2	155.8	196.7	216.1	230.8
Transport, Communication, and Storage	276.9	313.2	367.4	413.9	446.2	478.4
Trade	556.3	602.8	681.7	776.9	877.5	981.1
Finance	170.5	186.0	215.7	263.4	311.4	362.0
Ownership of Dwellings and Real Estate	252.9	270.1	292.2	320.4	350.7	374.0
Private Services	484.9	556.5	653.3	742.0	830.2	936.9
Government Services	362.3	377.1	382.7	413.9	451.0	472.2

Source: National Statistical Coordination Board. GDP data from 1983 to 2007 were used in all calculations but due to space limitations the results before 2002 were omitted in all tables in this paper. However, all the results are available from the author upon request.

Table 2. GDP in Constant 1985 Prices

	2002	2003	2004	2005	2006	2007
			(Billions)			
Philippines	1,033.0	1,085.1	1,154.3	1,211.5	1,276.9	1,368.6
Agriculture and Fishery	206.5	214.4	225.1	229.6	238.0	249.9
Forestry	0.7	0.9	1.3	1.4	1.5	1.3
Mining and Quarrying	15.3	17.9	18.3	20.0	18.8	23.7
Manufacturing	252.6	263.3	278.6	293.3	306.8	317.2
Construction	46.7	47.1	48.7	45.9	50.3	61.9
Electricity, Gas, and Water	34.2	35.3	36.8	37.7	40.1	42.7
Transport, Communication, and Storage	80.8	87.7	97.6	104.8	111.4	120.7
Trade	170.8	180.5	192.7	203.6	216.0	233.8
Finance	48.9	51.8	56.9	64.6	71.9	81.3
Ownership of Dwellings and Real Estate	48.9	51.0	53.7	56.5	59.7	63.2
Private Services	78.0	84.4	93.4	100.4	107.3	116.4
Government Services	49.6	51.0	51.2	53.8	55.1	56.5

Source: National Statistical Coordination Board.

Tables 1 and 2 yield in Table 3 the ratios for each industry of $p_{it}q_{it}$ to $p_{ib}q_{it}$ or the implicit deflators $p_{it}q_{it}/p_{ib}q_{it} = p_{it}/\ p_{ib}$, i.e., current prices relative to 1985 prices. [11]

Table 3. Current Prices Relative to 1985 Prices

	2002	2003	2004	2005	2006	2007	Average
Philippines	(Ratios: Entries in Table 1 Divided by Entries in Table 2)						
Agriculture and Fishery	2.88	2.94	3.25	3.37	3.56	3.73	3.29
Forestry	2.60	2.62	2.62	3.08	3.27	3.13	2.88
Mining and Quarrying	2.19	2.44	2.89	3.18	4.02	4.57	3.21
Manufacturing	3.62	3.81	4.03	4.31	4.50	4.61	4.15
Construction	3.98	4.12	4.37	4.58	4.78	4.92	4.46
Electricity, Gas, and Water	3.63	3.89	4.24	5.22	5.39	5.40	4.63
Transport, Communication, and Storage	3.43	3.57	3.76	3.95	4.01	3.96	3.78
Trade	3.26	3.34	3.54	3.82	4.06	4.20	3.70
Finance	3.49	3.59	3.79	4.08	4.33	4.45	3.95
Ownership of Dwellings and Real Estate	5.17	5.30	5.45	5.67	5.87	5.91	5.56
Private Services	6.21	6.60	7.00	7.39	7.74	8.05	7.16
Government Services	7.30	7.40	7.47	7.69	8.19	8.36	7.73

Source: Tables 1 and 2.

There are two ways of rebasing with the same results. One corresponds to the inflation method and the other to the deflation method of computing GDP in constant prices.

The inflation method works as follows. Select a column in Table 3 for a given year, for example, $t = 2004$. The column entries are ratios, i.e., prices in 2004 over the prices in 1985. Therefore, in using this column to multiply all the columns in Table 2, the 1985 prices cancel out and the latter columns are now valued in 2004 prices. Hence, summing up the results in each column yields GDP in constant 2004 prices for each year.

To illustrate the deflation method of rebasing, let the new base year be also 2004. In this case, divide each column of relative prices in Table 3 by those in 2004. Hence, the old 1985 base prices cancel out and the results in each column are now "current prices over 2004 prices," thus, yielding a column of "1" in 2004 because the base year price deflator equals 1. By dividing or deflating the GDP in current prices in Table 1 by these new set of deflators the current prices cancel out and each quantity is now multiplied by 2004 prices. Therefore, the sum of each column (year) yields GDP in constant 2004 prices each year. By similar procedure, GDP in constant prices can be computed for other base years shown in Table 4.

It can be checked that the price proportionality condition for rebasing not to change the GDP growth rates in constant prices is violated in Table 3. As a result, the rebased GDP in Table 4 have changing growth rates in the same year depending on the base year, as shown in

[11] Published GDP data do not show components at the commodity level but at some aggregated level, e.g., at the level of the industry. In this case, the product $p_{it}q_{it}$ may be interpreted as the product of industry "average price" and industry "total quantity." This interpretation is warranted by the framework presented in the Appendix that shows the conformability of available data to the analytical requirements in this paper.

Table 5. Hence, growth rate "cheating" is possible, for example, by choosing base year 2005 to obtain the highest growth rate of 5.48 percent in 2006.

Table 4. GDP in Constant Prices

	2002	2003	2004	2005	2006	2007
Philippines			(Billions)			
Constant 1985 Prices	1,033.0	1,085.1	1,154.3	1,211.5	1,276.9	1,368.6
Constant 1995 Prices	2,435.5	2,555.8	2,715.7	2,849.6	3,003.3	3,215.1
Constant 2005 Prices	4,634.8	4,868.8	5,179.3	5,444.0	5,742.6	6,150.4
Constant 2006 Prices	4,870.3	5,117.1	5,442.2	5,720.9	6,032.8	6,463.5
Constant 2007 Prices	5,009.2	5,263.6	5,597.5	5,884.1	6,203.7	6,648.2

Source: Tables 1, 2, and 3.

Table 5. Growth of GDP in Constant Prices

	2002	2003	2004	2005	2006	2007
Philippines			(Percent)			
Constant 1985 Prices	3.12	5.04	6.38	4.95	5.40	7.19
Constant 1995 Prices	2.80	4.94	6.25	4.93	5.39	7.05
Constant 2005 Prices	2.84	5.05	6.38	5.11	5.48	7.10
Constant 2006 Prices	2.91	5.07	6.35	5.12	5.45	7.14
Constant 2007 Prices	2.95	5.08	6.34	5.12	5.43	7.17

Source: Table 4.

As earlier noted, changing the base year of GDP in constant prices could lead to legitimate changes in GDP growth rates and shares of components when rebasing involves further adjustments to base year prices necessitated by a number of factors, for example, accounting for the disappearance of old commodities or appearance of new ones. But it follows that these legitimate changes are necessarily combined with the anomalous changes in Table 5. Therefore, the changes in growth rates from rebasing of our GDP in constant prices (Domingo, 1992; Virola, *et.al.*, 2001) are partly anomalous.

Table 6 shows one of the major results of chained prices that the Fisher quantity index (Q_{st}^F) does not change with the base year. However, there are different values of the chain type index (J_t) for different base years ($J_b = 1,\ b = 1985, 1995, 2005, 2006, 2007$). Given the Fisher quantity index, the chain type indexes are calculated forward and backward starting from the base year value of 1 by a recursive procedure,

$$\text{Starting from } J_b = 1, \qquad J_t = J_s Q_{st}^F \ \text{ if } \ t > b \quad \text{or} \quad J_s = \frac{J_t}{Q_{st}^F} \ \text{ if } \ s < b\,.$$

This implies that the chain type indexes are proportional to each other and their proportional value is the Fisher quantity index. For example, in Table 6, the ratio of the value of a chain type index in 2005 to its value in 2004 equals the value of the Fisher quantity index in 2005.

$$\frac{J_t}{J_s} = Q_{st}^F = \frac{2.1116}{2.0089} = \frac{1.5020}{1.4290} = \frac{1.0000}{0.9514} = \frac{0.9482}{0.9021} = \frac{0.8849}{0.8419} = 1.0511 \,.$$

This proportionality necessarily implies that the growth rate of chain type indexes and, hence, the growth rate of GDP in chained prices do not change with a change in the base year.

Table 6. Fisher and Chain Type GDP Quantity Indexes

	2002	2003	2004	2005	2006	2007
Philippines						
Fisher Quantity Index	1.0277	1.0502	1.0637	1.0511	1.0547	1.0715
Chain Type Quantity Index						
base year = 1985	1.7984	1.8887	2.0089	2.1116	2.2270	2.3863
base year = 1995	1.2792	1.3434	1.4290	1.5020	1.5841	1.6974
base year = 2005	0.8517	0.8945	0.9514	1.0000	1.0547	1.1301
base year = 2006	0.8075	0.8481	0.9021	0.9482	1.0000	1.0715
base year = 2007	0.7536	0.7915	0.8419	0.8849	0.9333	1.0000

Source: Tables 1, 2, and 3 and equations (14) and (16).

By multiplying the alternative values of the chain type quantity index in Table 6 for different base years by the corresponding scalar value of GDP in the base year ($\sum_i^N p_{ib} q_{ib}$), the GDP in chained prices are obtained and presented in Table 7.

Table 7. GDP in Chained Prices

	2002	2003	2004	2005	2006	2007
Philippines			(Billions)			
Chained 1985 Prices	1,028.5	1,080.1	1,148.9	1,207.6	1,273.6	1,364.7
Chained 1995 Prices	2,438.1	2,560.5	2,723.5	2,862.7	3,019.2	3,235.1
Chained 2005 Prices	4,636.7	4,869.5	5,179.4	5,444.0	5,741.7	6,152.4
Chained 2006 Prices	4,871.8	5,116.3	5,442.0	5,720.0	6,032.8	6,464.3
Chained 2007 Prices	5,010.4	5,261.9	5,596.9	5,882.8	6,204.5	6,648.2

Source: Tables 1, 2, and 3 and equations (14), (15), and (16).

Table 8 shows that the growth rate of GDP in chained prices remains the same whatever is the base year.

Table 8. Growth of GDP in Chained Prices

	2002	2003	2004	2005	2006	2007
Philippines			(Percent)			
Chained 1985 Prices	2.77	5.02	6.37	5.11	5.47	7.15
Chained 1995 Prices	2.77	5.02	6.37	5.11	5.47	7.15
Chained 2005 Prices	2.77	5.02	6.37	5.11	5.47	7.15
Chained 2006 Prices	2.77	5.02	6.37	5.11	5.47	7.15
Chained 2007 Prices	2.77	5.02	6.37	5.11	5.47	7.15

Source: Table 7.

The base-year dependence of the growth rate of GDP in constant prices in Table 5 makes growth decomposition misleading. However, for comparison with the case of chained prices in Table 10, Table 9 shows the decomposition of GDP growth in constant 1985 prices.

Table 9. Contributions to Growth of GDP in Constant 1985 Prices

	2002	2003	2004	2005	2006	2007	Average	Share
Philippines				(Percentage Points)				
Agriculture Sector	**0.76**	**0.79**	**1.03**	**0.39**	**0.71**	**0.92**	**0.77**	**14.3**
Agriculture and Fishery	0.79	0.77	0.98	0.39	0.70	0.93	0.76	
Forestry	-0.03	0.02	0.04	0.00	0.01	-0.01	0.00	
Industry Sector	**0.05**	**1.43**	**1.74**	**1.25**	**1.58**	**2.31**	**1.39**	**26.1**
Mining and Quarrying	0.52	0.25	0.04	0.15	-0.10	0.38	0.21	
Manufacturing	0.85	1.04	1.42	1.27	1.11	0.81	1.08	
Construction	-1.45	0.04	0.15	-0.25	0.36	0.91	-0.04	
Electricity, Gas, and Water	0.14	0.11	0.14	0.08	0.20	0.21	0.14	
Services Sector	**2.31**	**2.82**	**3.61**	**3.31**	**3.12**	**3.95**	**3.19**	**59.6**
Transport, Communication, and Storage	0.66	0.67	0.91	0.62	0.55	0.73	0.69	
Trade	0.93	0.94	1.13	0.94	1.02	1.40	1.06	
Finance	0.16	0.28	0.47	0.67	0.60	0.74	0.49	
Ownership of Dwellings and Real Estate	0.08	0.19	0.25	0.25	0.27	0.27	0.22	
Private Services	0.41	0.61	0.83	0.61	0.57	0.71	0.62	
Government Services	0.07	0.13	0.02	0.22	0.10	0.11	0.11	
Sum = GDP growth rate (Table 5)	**3.12**	**5.04**	**6.38**	**4.95**	**5.40**	**7.19**	**5.35**	**100.0**

Source: Table 2 and equation (10).

In comparing the 2002-2007 average shares of contributions to GDP growth, Tables 9 and 10 show that agriculture contributed 14.3 percent in constant 1985 prices but a smaller 10.8 percent in chained prices; industry, 26.1 percent (constant 1985) but a smaller 24.2 percent (chained); and services, 59.6 percent (constant 1985) but a larger 65.0 percent (chained). This shows that chained prices accentuate more than constant 1985 prices the declining importance of agriculture and industry and the rising importance of services.

Table 10. Contributions to Growth of GDP in Chained Prices

	2002	2003	2004	2005	2006	2007	Average	Share
Philippines				(Percentage Points)				
Agriculture Sector	**0.57**	**0.58**	**0.77**	**0.30**	**0.53**	**0.70**	**0.58**	**10.8**
Agriculture and Fishery	0.59	0.57	0.74	0.30	0.52	0.71	0.57	
Forestry	-0.02	0.01	0.03	0.00	0.01	-0.01	0.00	
Industry Sector	**-0.24**	**1.28**	**1.67**	**1.15**	**1.59**	**2.27**	**1.29**	**24.2**
Mining and Quarrying	0.30	0.15	0.03	0.10	-0.08	0.34	0.14	
Manufacturing	0.79	0.99	1.36	1.22	1.07	0.77	1.03	
Construction	-1.47	0.04	0.15	-0.26	0.37	0.92	-0.04	
Electricity, Gas, and Water	0.13	0.10	0.14	0.09	0.23	0.24	0.15	
Services Sector	**2.44**	**3.16**	**3.92**	**3.66**	**3.35**	**4.18**	**3.45**	**65.0**
Transport, Communication, and Storage	0.60	0.60	0.81	0.55	0.47	0.60	0.61	
Trade	0.80	0.79	0.95	0.79	0.88	1.20	0.90	
Finance	0.15	0.25	0.42	0.60	0.55	0.68	0.44	
Ownership of Dwellings and Real Estate	0.11	0.26	0.33	0.32	0.33	0.34	0.28	
Private Services	0.65	1.01	1.37	1.01	0.94	1.17	1.02	
Government Services	0.13	0.24	0.04	0.39	0.18	0.19	0.20	
Sum = GDP growth rate (Table 8)	**2.77**	**5.02**	**6.37**	**5.11**	**5.47**	**7.15**	**5.31**	**100.0**

Source: Tables 1, 2, and 3 and equation (26).

Table 11 shows, for example, that an industry's 2007 share in constant prices changes with the base year but its 2007 share in chained prices remains the same with any base year.[12]

Table 11. Shares in 2007 GDP in Constant and Chained Prices

	Shares in 2007 GDP in Constant Prices for Different Base Years						Shares in 2007 GDP in Chained Prices , Any Base Year
	1985	1995	2004	2005	2006	2007	
Philippines				(Percent)			
Agriculture and Fishery	18.26	18.54	14.03	13.70	13.78	14.02	13.90
Forestry	0.10	0.10	0.06	0.07	0.07	0.06	0.06
Mining and Quarrying	1.73	1.23	1.18	1.22	1.47	1.63	1.55
Manufacturing	23.18	21.27	22.10	22.23	22.09	22.02	22.05
Construction	4.52	4.61	4.67	4.61	4.57	4.58	4.58
Electricity, Gas, and Water	3.12	2.52	3.13	3.63	3.57	3.47	3.52
Transport, Communication, and Storage	8.82	7.05	7.85	7.75	7.48	7.20	7.34
Trade	17.08	15.43	14.30	14.51	14.70	14.76	14.73
Finance	5.94	5.84	5.33	5.39	5.45	5.44	5.45
Ownership of Dwellings and Real Estate	4.62	5.86	5.95	5.83	5.74	5.63	5.68
Private Services	8.50	11.05	14.08	13.99	13.93	14.09	14.01
Government Services	4.13	6.49	7.30	7.06	7.16	7.10	7.13
Sum	100.00	100.00	100.00	100.00	100.00	100.00	100.00

Source: Tables 1, 2, and 3, expression (13) and equations (27) and (28).

Table 12 compares the shares in constant 1985 prices to the shares in chained prices which do not change with the base year. A notable result is that the last three industries in the table (ownership of dwellings and real estate, private services, and government services) have shares in chained prices larger than their shares in constant 1985 prices each year during 2002-2007. The explanation may be seen in Table 3 where these same three industries have the highest prices each year relative to 1985 prices averaging 5.6, 7.2 and 7.7 times the 1985 prices. These factors tend to raise shares in chained prices relative to shares in constant prices because the latter in effect assume constant relative prices. Therefore, the result that the above three industries have shares in chained prices larger than their shares in constant 1985 prices is not at all surprising.

However, because shares must sum to 100 percent, the fact that some industries have shares in chained prices larger than their shares in constant 1985 prices implies the reverse

[12] In his *Discussion Comments* listed in the references, Intal, Jr. (2008) found the results in Table 11 on the rise of *private services* from 8.50 percent using 1985 prices to 14.01 percent using chained prices as "shocking" because, among other things, it implies that "… the continued use of 1985 as the base year is no longer tolerable. The errors are just too high." On the bright side, he found that: "The significant increase in the share of private services using chained prices is a most important piece of information. It validates what is the emerging dynamic of Philippine competiveness. That is, the country's growing industries are those that rely a lot on college educated service workers, simply because the country's labor pool has a larger share of college graduates than most countries in the region (and the world) within the same development stage or per capita income range."

for other industries. Indeed, there are industries that have shares in chained prices smaller than their shares in constant 1985 prices. Not surprisingly, the latter industries have prices each year averaging less than the averages of 5.6, 7.2 and 7.7 times 1985 prices for the above three industries during 2002-2007. For example, the averages for agriculture and fishery, trade, and finance are 3.3, 3.7, and 4.0. Thus, these three industries have shares in chained prices smaller than their shares in constant 1985 prices. For example, during 2002-2007, the share of agriculture and fishery in constant 1985 prices was in the range 18.3 to 20.0 percent but its share in chained prices was in the lower range 13.9 to 15.0 percent.

Table 12. Shares of GDP in Constant and Chained Prices

	2002	2003	2004	2005	2006	2007
Philippines			(Percent)			
Agriculture and Fishery						
Constant 1985 prices	19.99	19.76	19.50	18.95	18.64	18.26
Chained prices	15.04	14.73	14.70	14.39	14.02	13.90
Forestry						
Constant 1985 prices	0.07	0.08	0.11	0.11	0.12	0.10
Chained prices	0.05	0.05	0.07	0.07	0.08	0.06
Mining and Quarrying						
Constant 1985 prices	1.48	1.65	1.59	1.65	1.47	1.73
Chained prices	0.86	0.98	1.03	1.15	1.15	1.55
Manufacturing						
Constant 1985 prices	24.45	24.26	24.14	24.21	24.03	23.18
Chained prices	22.95	23.10	23.10	23.16	22.97	22.05
Construction						
Constant 1985 prices	4.52	4.34	4.22	3.78	3.94	4.52
Chained prices	4.59	4.50	4.37	3.89	4.00	4.58
Electricity, Gas, and Water						
Constant 1985 prices	3.31	3.25	3.18	3.11	3.14	3.12
Chained prices	3.17	3.13	3.16	3.37	3.61	3.52
Transport, Communication, and Storage						
Constant 1985 prices	7.82	8.09	8.46	8.65	8.73	8.82
Chained prices	7.07	7.24	7.56	7.65	7.53	7.34
Trade						
Constant 1985 prices	16.53	16.63	16.69	16.80	16.91	17.08
Chained prices	14.27	14.05	14.01	14.17	14.45	14.73
Finance						
Constant 1985 prices	4.74	4.77	4.93	5.33	5.63	5.94
Chained prices	4.34	4.33	4.44	4.81	5.13	5.45
Ownership of Dwellings and Real Estate						
Constant 1985 prices	4.74	4.70	4.65	4.66	4.68	4.62
Chained prices	6.38	6.29	6.10	5.95	5.86	5.68
Private Services						
Constant 1985 prices	7.55	7.78	8.09	8.29	8.40	8.50
Chained prices	12.18	12.75	13.41	13.67	13.79	14.01
Government Services						
Constant 1985 prices	4.81	4.70	4.44	4.44	4.31	4.13
Chained prices	9.11	8.84	8.06	7.73	7.43	7.13

Source: Tables 1, 2, and 3, expression (13) and equations (27) and (28).

The preceding explanations on the role of relative prices in differentiating between the evolutions of shares in constant prices and shares in chained prices reveal that the former shares are misleading indicators of relative importance of an industry in the economy precisely because they ignore the real effects overtime of changes in relative prices. To the extent that these real effects are incorporated by shares in chained prices, these shares are superior indicators of the growing or declining importance of an industry in the economy. The result could be a different picture of economic transformation as shown in Table 13.

Table 13. Sector Shares of GDP in Constant and Chained Prices

	2002	2003	2004	2005	2006	2007	Average
Philippines			(Percent)				
Agriculture Sector							
Constant 1985 Prices	20.05	19.84	19.62	19.06	18.76	18.36	19.3
Chained Prices	15.09	14.79	14.77	14.46	14.10	13.96	14.5
Industry Sector							
Constant 1985 Prices	33.75	33.50	33.13	32.76	32.58	32.55	33.0
Chained Prices	31.56	31.71	31.65	31.56	31.72	31.70	31.7
Services Sector							
Constant 1985 Prices	46.19	46.66	47.25	48.17	48.66	49.09	47.7
Chained Prices	53.35	53.51	53.57	53.98	54.18	54.34	53.8

Source: Table 12.

The above results show smaller and shrinking agriculture and industry sectors and enlarging services sector that is now over 50 percent of the Philippine economy than have been shown by valuation in constant 1985 prices. That is, chained prices accentuate more than constant 1985 prices the declining importance of agriculture and industry and the rising importance of services in Philippine economic transformation.

4. Framework for Separating Quantity Changes from Price Changes

The analysis so far examined mainly the *quantity* side of GDP because of the focus on the relative change (growth) of real GDP. However, there is the *price* side to consider in the overall framework of analyzing the relative change of GDP in current prices.

The relative change of GDP in current prices is measured by the "value index" (V_{st}), the ratio of GDP in current prices in the adjoining years s and t,

$$V_{st} = \frac{\sum_i^N p_{it}q_{it}}{\sum_i^N p_{is}q_{is}} . \tag{29}$$

By definition, the value index in (29) combines the effects of quantity changes and price changes and, thus, presents the problem of separating these combined effects. In this case, the role of the quantity index is to capture only the quantity changes while that of the price index is to capture only the price changes. It may now be shown that the fixed-base Laspeyres quantity and Paasche price indexes both fail to perform these roles while the chain type Fisher quantity and Fisher price indexes both succeed.

Recall that for the adjoining years s and t, i.e., $t = s + 1$, the fixed-base Laspeyres quantity and Paasche price indexes are,

$$Q_{bt}^{L} = \frac{\sum_i^N p_{ib} q_{it}}{\sum_i^N p_{ib} q_{ib}} \quad ; \quad Q_{bs}^{L} = \frac{\sum_i^N p_{ib} q_{is}}{\sum_i^N p_{ib} q_{ib}} \quad ; \quad P_{bt}^{P} = \frac{\sum_i^N p_{it} q_{it}}{\sum_i^N p_{ib} q_{it}} \quad ; \quad P_{bs}^{P} = \frac{\sum_i^N p_{is} q_{is}}{\sum_i^N p_{ib} q_{is}} .$$

On the other hand, the chain type Fisher quantity and price indexes are,

$$Q_{st}^{F} = (Q_{st}^{L} \times Q_{st}^{P})^{\frac{1}{2}} \quad ; \quad Q_{st}^{L} = \frac{\sum_i^N p_{is} q_{it}}{\sum_i^N p_{is} q_{is}} \quad ; \quad Q_{st}^{P} = \frac{\sum_i^N p_{it} q_{it}}{\sum_i^N p_{it} q_{is}} \ ;$$

$$P_{st}^{F} = (P_{st}^{L} \times P_{st}^{P})^{\frac{1}{2}} \quad ; \quad P_{st}^{L} = \frac{\sum_i^N q_{is} p_{it}}{\sum_i^N q_{is} p_{is}} \quad ; \quad P_{st}^{P} = \frac{\sum_i^N q_{it} p_{it}}{\sum_i^N q_{it} p_{is}} .$$

The fixed-base Laspeyres quantity and Paasche price indexes are dual to each other from the fact that the value index in (29) can be expressed as,

$$\frac{\sum_i^N p_{it} q_{it}}{\sum_i^N p_{is} q_{is}} = \frac{Q_{bt}^{L}}{Q_{bs}^{L}} \times \frac{P_{bt}^{P}}{P_{bs}^{P}} . \tag{30}$$

Similarly, the chain type Fisher quantity and price indexes are dual to each because the value index equals the product of these indexes,

$$\frac{\sum_i^N p_{it} q_{it}}{\sum_i^N p_{is} q_{is}} = Q_{st}^{F} \times P_{st}^{F} . \tag{31}$$

It may be noted that the equality in (31) is the well-known Fisher (1922) "factor reversal" property.[13]

Notice that the left-hand sides of (30) and (31) are exactly the same. To show once again the inherent anomalies in the indexes in right-hand side of (30) but their absence in the indexes in the right-hand side of (31), consider the following numerical example.

From the empirical results in section 3, the change in Philippine GDP in current prices from 2006 to 2007 is,

[13] The term "factor reversal" in the context of the equality in (31) comes from the fact that, by definition, the Fisher price index can be obtained from the Fisher quantity index, vice versa, by *reversing* the roles of prices and quantities. In addition, the Fisher index has the "time reversal" property which means that the quantity (price) index with time moving from s to t is the *reciprocal* of the quantity (price) index with time moving in reverse from t to s. According to Fisher (1922), the factor reversal and time reversal properties make an index "ideal." For this reason, the Fisher index is sometimes called the Fisher ideal index.

$$\frac{\sum_i^N p_{it}q_{it}}{\sum_i^N p_{is}q_{is}} = \frac{Q_{bt}^L}{Q_{bs}^L} \times \frac{P_{bt}^P}{P_{bs}^P} = 1.10201 = (1.07187) \times (1.02812) \quad , \quad b = 1985\,; \qquad (32)$$

$$\frac{\sum_i^N p_{it}q_{it}}{\sum_i^N p_{is}q_{is}} = \frac{Q_{ct}^L}{Q_{cs}^L} \times \frac{P_{ct}^P}{P_{cs}^P} = 1.10201 = (1.07051) \times (1.02943) \quad , \quad c = 1995\,. \qquad (33)$$

Between the above results, the only thing that changed was the base year. That is, the indexes in the top equation have a fixed 1985 base while those below have a fixed 1995 base.

It is important to note that the relative change in GDP in current prices (i.e., from 1 to 1.10201) is a *one-time* change from 2006 to 2007. Therefore, the change in the quantity index (from 1 to 1.07187) captures the change of q_{is} to q_{it} while that of the price index (from 1 to 1.02812) captures the change of p_{is} to p_{it}. Notice that there are *no* additional changes in quantities and prices. Therefore, the changes in the quantity index from 1.07187 to 1.07051 and in the price index from 1.02812 to 1.02943 are pure anomalies because they have nothing to do with additional quantity and price changes since there are none. This result demonstrates that the fixed-base Laspeyres quantity index fails to capture only quantity changes while the fixed-base Paasche price index fails to capture only price changes. For these reasons, GDP in constant prices is objectionable because its computation employs the above indexes.

Mathematically, the decompositions of the relative change of GDP in current prices in (32) and (33) are *exact* but *not unique* because it depends on the base year. Hence, the growth rate of GDP in constant prices and the GDP price inflation rate in the same year are not unique. In the above example, the 2007 growth rate is $[(1.07187) - 1] \times 100 = 7.19$ percent if the base year is 1985 but changes to 7.05 percent if the base year is 1995. Also, the GDP price inflation rate is 2.81 percent if the base year is 1985 but changes to 2.94 percent if the base year is 1995. There is no way out of this non-uniqueness problem except to abandon the framework of GDP in constant prices.

In contrast, given the same relative change in GDP in current prices from 2006 to 2007, the chain type Fisher quantity and price indexes also remain the same whatever is the base year. This is shown by,

$$\frac{\sum_i^N p_{it}q_{it}}{\sum_i^N p_{is}q_{is}} = Q_{st}^F \times P_{st}^F = 1.10201 = (1.07152) \times (1.02846) \quad , \quad \text{any base year}\,. \qquad (34)$$

Mathematically, the decomposition in (34) is *exact* and *unique* so that the 2007 growth rate of GDP in chained prices remains 7.15 percent and the GDP price inflation rate remains 2.85 percent whatever is the base year. By implication, the chain type Fisher quantity index captures only quantity changes while the Fisher price index captures only price changes. For these reasons, this paper recommends employing these indexes in GDP conversion from constant to chained prices.

5. Conclusion

Real GDP may be valued either in constant prices or in chained prices. Unfortunately, a change in the base year alone of GDP in constant prices leads inevitably to anomalous changes in the growth rate and shares of components because the condition for them to remain the same—which is the proportionality of prices between the two base years—is surely violated in practice. The above changes are anomalous because they may happen without a change in the volume of production. In contrast, the growth rate and shares of GDP in chained prices do not change with a change in the base year alone.

Therefore, while there are legitimate changes in growth rates and shares that arise from base year changes with necessary adjustments to base year prices, they must come with the anomalous changes in rebasing of GDP in constant prices. This paper showed, however, that these anomalous results will be avoided by conversion to chained prices. And if there are the above legitimate changes in growth rates and shares, these are the only ones that would show up in rebasing of GDP in chained prices.

Therefore, this paper proposes conversion of Philippine GDP to chained prices. The economic rationality, feasibility, and ease of conversion were illustrated using data on GDP in current prices and in constant 1985 prices. However, conversion still requires components in constant prices and these components together with those in current prices are sufficient data inputs to compute GDP in chained prices. But this paper objects to the present practice of measuring real GDP simply as the sum of components in constant prices because this GDP could yield anomalous results and, thus, is questionable as basis for valuation of the economy's production and analysis of its growth performance.

The illustrative conversion to chained prices showed that the results are not only free of the anomalies of constant prices but also portray a new picture of Philippine economic transformation grounded on a more realistic setting allowing for the effects of relative price changes over time. Emerging from the conversion are a smaller and shrinking agriculture and industry sectors and a larger services sector that is now over 50 percent of the Philippine economy than have been shown by valuation in constant 1985 prices. In both contributions to level and growth of GDP, chained prices accentuate more than constant 1985 prices the declining importance of agriculture and industry and the rising importance of services in Philippine economic transformation.

Finally, this paper showed that GDP in constant prices is objectionable for the failure of the underlying fixed-base Laspeyres quantity and Paasche price indexes to perform their purposes, which are for the quantity index to capture only quantity changes and for the price index to capture only price changes. Thus, this paper recommends GDP in chained prices precisely for the success of the underlying chain type Fisher quantity and price indexes in performing the above purposes.

Therefore, to establish the valuation of the Philippine economy's production and the analysis of its growth performance on theoretically solid and realistic footings, this paper concludes that GDP in constant prices give way to GDP in chained prices.

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Appendix

Interpreting Available Data for Conformability with Analytical Framework

At the commodity (i.e., final good or service) level, let,

$$z_{ijt} = \text{unit price} \quad ; \quad x_{ijt} = \text{total quantity} \; ; \tag{A-1}$$

$$i = 1, 2, \cdots, N \quad ; \quad j = 1, 2, \cdots, M \quad ; \quad t = 1, 2, \cdots, T. \tag{A-2}$$

The subscript i represents a group (e.g., a region, industry or product category) encompassing commodity j in year t. There are a total of N groups, M commodities, and T years. From (A-1) and (A-2), GDP in current prices in year t (Y_t^C) can be written as,

$$Y_t^C = \sum_i^N \sum_j^M z_{ijt}\, x_{ijt} \, . \tag{A-3}$$

Published GDP data are not normally available at the commodity level. Prior to publication, the data are subjected to *averaging of prices* and *aggregation of quantities*. In this light, (A-3) can be rewritten as,

$$Y_t^C = \sum_i^N \sum_j^M \left(\frac{x_{ijt}}{\sum_j^M x_{ijt}} z_{ijt} \right) \sum_j^M x_{ijt} \, . \tag{A-4}$$

In equation (A-4), the total or summation of quantities implicitly assumes that the quantity units are the same for all M commodities. This assumption is not true in practice because some x_{ijt} are in kilograms and others in pounds. However, there exists in principle a set of unit conversion factors (e.g., 2.2 pounds per kilogram) γ_j that transforms (A-4) into,

$$Y_t^C = \sum_i^N \sum_j^M \left(\frac{\gamma_j\, x_{ijt}}{\sum_j^M \gamma_j\, x_{ijt}} \right) \left(\frac{z_{ijt}}{\gamma_j} \right) \sum_j^M \gamma_j\, x_{ijt} \, . \tag{A-5}$$

Note that in (A-5), the units are now the same where,

$$\left(\frac{z_{ijt}}{\gamma_j} \right) = \text{unit price} \; ; \; \frac{\gamma_j\, x_{ijt}}{\sum_j^M \gamma_j\, x_{ijt}} = \text{weight} \quad ; \quad \sum_j^M \left(\frac{\gamma_j\, x_{ijt}}{\sum_j^M \gamma_j\, x_{ijt}} \right) = 1 \, . \tag{A-6}$$

Therefore, (A-5) and (A-6) yield,

$$p_{it} = \sum_j^M \left(\frac{\gamma_j\, x_{ijt}}{\sum_j^M \gamma_j\, x_{ijt}} \right) \left(\frac{z_{ijt}}{\gamma_j} \right) = \text{average price} \; ; \tag{A-7}$$

$$q_{it} = \sum_j^M \gamma_j\, x_{ijt} = \text{total quantity} \, . \tag{A-8}$$

Finally, by combining (A-5) to (A-8),

$$Y_t^C = \sum_i^N \sum_j^M \left(\frac{\gamma_j\, x_{ijt}}{\sum_j^M \gamma_j\, x_{ijt}} \right) \left(\frac{z_{ijt}}{\gamma_j} \right) \sum_j^M \gamma_j\, x_{ijt} = \sum_i^N p_{it}\, q_{it} \, . \tag{A-9}$$

The result that $\sum_i^N p_{it}\, q_{it}$ is the analytical expression for Philippine GDP in current prices in Table 1 where p_{it} is an industry's "average price" and q_{it} is an industry's "total quantity" from (A-7) and (A-8). Moreover, if a base year *b* is chosen and the average prices of each industry for this year are chosen as the set of constant prices p_{ib}, then $\sum_i^N p_{ib}\, q_{it}$ is the analytical expression for Philippine GDP in constant 1985 prices in Table 2 for *b* = 1985.

Rebasing or Updating the Base Year

The development of (A-5) to (A-9) is instructive for illustrating the importance of rebasing or updating the base year. First note from above that,

$$p_{ib} = \sum_j^M \left(\frac{\gamma_j\, x_{ijb}}{\sum_j^M \gamma_j\, x_{ijb}}\right)\left(\frac{z_{ijb}}{\gamma_j}\right) = \text{average price in the base year ;} \tag{A-10}$$

$$q_{it} = \sum_j^M \gamma_j\, x_{ijt} = \text{ total quantity in the current year .} \tag{A-11}$$

By construction, the commodity bundles encompassed by (A-10) and (A-11) are the same *at the start*. However, as the year *t* progresses far into the future, new commodities appear in the market that did not exist in the base year *b* and old commodities may also disappear. For example, cell phones did not exist in the market in the base year 1985.

Thus, there is now a mismatch between the prices in (A-10) and the quantities in (A-11) in the construction of Philippine GDP components in constant 1985 prices. Thus, rebasing is desirable to correct this mismatch. In practice, rebasing involves *adjustments* to the new base year prices beyond simply using a new set of prices as was done in Tables 4, 6, and 7. These adjustments would lead to legitimate changes in growth rates of GDP in constant prices. However, because a mere change in the base year leads to the anomalous changes in Table 5, the results from rebasing of GDP in constant prices are, in practice, partly anomalous. This gives rise to the confounding problem of separating the two types of changes above. In contrast, while the above legitimate changes would also change the growth rates of GDP in chained prices in Table 8, the problem of separation does not arise because only legitimate changes show up.