Economics Bulletin

# Volume 33, Issue 1

## Decomposing the changes of the Divisia price index: application to inflation in the Philippines

Tomoki Fujii
*Singapore Management University*

## Abstract

We decompose the logarithmic change in the Divisia price index into the pure price, substitution, and preference effects, although the latter two effects are hard to distinguish in practice. This decomposition allows us to identify the incidence and contributing factors of inflation. In the Philippines, we find that the preference effect is much smaller than the pure price effect in all provinces. We also find that rich deciles have experienced a higher inflation than poor deciles between 1988 and 2006. However, the gap in the standards of living has actually widened because poor deciles lagged behind in consumption growth.

This research was supported by the SMU Research Grant (C244/MSS8E005). The author thanks Vincent Morris D. Olaivar, Rosie B. Sta. Ana, two anonymous referees, and the participants of the SIBR-UniKL conference on Interdisciplinary Business & Economics Research. Tanushree Jhajharia provided research assistance.
**Citation:** Tomoki Fujii, (2013) "Decomposing the changes of the Divisia price index: application to inflation in the Philippines", *Economics Bulletin*, Vol. 33 No. 1 pp. 545-556.
**Contact:** Tomoki Fujii - tfujii@smu.edu.sg.
**Submitted:** November 26, 2012. **Published:** March 04, 2013.

## 1. Introduction

When we want to compare the standards of living over time, we need to take into account not only the changes in the nominal consumption but also the changes in the price levels. The comparison is straightforward if people consume the same bundle of goods over time, because we simply need to count the number of bundles consumed. In practice, however, the bundle of goods people consume changes over time. Yet, popular indices such as the Laspeyres index assume that the underlying bundle of goods do not change over time. This point is particularly serious when we want to make a comparison over a long period of time because the consumption bundle may change substantially. Hence, however carefully we choose the bundle, there is always a danger that the chosen bundle becomes irrelevant over time.

From this perspective, the Divisia price index named after Divisia (1925) has a number of desirable properties. It satisfies the invariance axiom (Richter, 1966; Samuelson and Swamy, 1974), which in our study corresponds to the requirement that the price index does not change when the consumption bundle changes over a given indifference curve. This means that the Divisia index allows for changes in the underlying bundle of goods used to evaluate the price level.

The Divisia index passes both the factor reversal test (the product of the proportionate changes in the price and quantity indices is equal to the proportionate change in the current value) and the time reversal test (when the prices and quantities are swapped between the initial and terminal periods, the resulting index is the reciprocal of the original index), which Fisher (1921) deemed prerequisites for an ideal index number. Further, as shown in Diewert (1976, 1978), the Törnqvist index named after Törnqvist (1936), which is a discrete approximation to the Divisia index, is a superlative index. That is, it is an exact index for a flexible functional form that can provide a second-order approximation to other twice-differentiable functions around a reference point.[1]

Despite these desirable properties of the Divisia index, it does not in itself tell, for example, whether and to what extent the effects of inflation have been mitigated or aggravated by substitution and preference change. Therefore, we propose a method to decompose the changes in the Divisia price index into the pure-price, substitution, and preference effects, although the latter two effects are difficult to separate in practice. Using fairly disaggregated data in the Philippines for the 1988-2006 period, we highlight the heterogeneity in the impact of inflation between the rich and poor and across provinces.

## 2. Methodology

We assume that a representative consumer has time-varying homothetic preferences with the $L$-vector of preference parameters $\alpha(t) \in \mathrm{R}^L$ at time $t \in \mathrm{R}_+$. While the assumption of homothetic preferences is admittedly strong, it incorporates commonly used preferences such as the log-linear and constant-elasticity-of-substitution preferences. We maintain this assumption because it is the only case in which there exists a price index that is

[1] See also Balk (2005) for a review of the Divisa index.

invariant under changes in the standards of living (Samuelson and Swamy, 1974). This assumption is commonly made in the literature.[2]

The representative consumer faces a $K$-vector of prices $p(t) \in \mathrm{R}^K_{++}$ of consumption goods. Because of the homotheticity, his demand and expenditure share functions for good $k \in \{1, \cdots, K\}$ can be respectively written as $q^k(p, \alpha) \in \mathrm{R}^K_+$ and $s^k(p, \alpha) \equiv q^k(p, \alpha)p^k y^{-1}$, where the superscript $k$ denotes the $k$th vector component and $y \equiv \sum_k p^k q^k$ is the total consumption. Using the chain rule and the dot notation for time derivatives, and normalizing the prices and quantities to unity at $t = 0$, the Divisia price index $P(t) \in \mathrm{R}_{++}$ and the Divisia quantity index $Q(t) \in \mathrm{R}_{++}$ are defined as follows:

$$\frac{\dot{y}}{y} = \sum_k s^k \frac{\dot{p}^k}{p^k} + \sum_k s^k \frac{\dot{q}^k}{q^k} \equiv \frac{\dot{P}}{P} + \frac{\dot{Q}}{Q}. \tag{1}$$

As is well known, $P(t)$ is a line integral and thus dependent on the path of $p$ and $\alpha$ in general. This point can be easily seen by noting that $\dot{P}/P$ depends on the expenditure shares $s(t) \equiv s(p(t), \alpha(t))$ at time $t$. In turn, this means that changes in the Divisia price index depend not only on price changes but also on substitutions and preference changes.

To decompose the changes in the Divisia price index, we first write $s(t) = s(r) + \int_r^t \dot{s}(\tau)\mathrm{d}\tau$, where $r$ is the reference time. Using this and the chain rule, we have $s^k(t) \equiv s^k(r) + \pi^k(t, r) + \psi^k(t, r)$, where $\pi^k$ and $\psi^k$ are defined as follows:

$$\pi^k(t, r) \equiv \int_r^t \sum_{j=1}^{K} \frac{\partial s^k(\tau)}{\partial p^j} \dot{p}^j(\tau)\mathrm{d}\tau \quad \text{and} \quad \psi^k(t, r) \equiv \int_r^t \sum_{l=1}^{L} \frac{\partial s^k(\tau)}{\partial \alpha^l} \dot{\alpha}^l(\tau)\mathrm{d}\tau. \tag{2}$$

We can interpret $\pi^k(t, r)$ and $\psi^k(t, r)$ as the deviations in the expenditure share of good $k$ from the reference level at time $r$ due to the price change and preference change, respectively. To understand the relevance of $\pi^k(t, r)$ and $\psi^k(t, r)$ to the price index, suppose that the expenditure share of good $k$ is decreasing due to preference change and that the price of good $k$ is increasing while other prices are constant. Then, the effect of preference change on the Divisia price index would be negative, because preference change allows the individual to shift away from a good that is getting expensive. Note also that $s$ is bounded between 0 and 1, whereas there is no such restrictions on $\pi^k$ and $\psi^k$ in general. However, when preferences [prices] do not change, $\pi^k$ [$\psi^k$] does not exceed one in absolute value.

Formally, we can decompose the logarithmic change $D$ of the Divisia price index between $t^1$ and $t^2$ using eq.(2) in the following manner:

$$D(t^1, t^2) \equiv \ln P(t^2) - \ln P(t^1) = \int_{t^1}^{t^2} \frac{\dot{P}}{P} \mathrm{d}t = \sum_{k=1}^{K} \Delta_p^k(t^1, t^2, r) + \Delta_\pi^k(t^1, t^2, r) + \Delta_\psi^k(t^1, t^2, r), \tag{3}$$

[2]One exception in which the Divisia price index is used for non-homothetic preferences is Feenstra and Reinsdorf (2000).

where $\Delta_p^k$, $\Delta_\pi^k$, and $\Delta_\psi^k$ are defined as follows:

$$\Delta_p^k(t^1,t^2,r)\equiv\int_{t^1}^{t^2}s^k(r)\frac{\dot{p}^k}{p^k}\mathrm{d}t,\quad \Delta_\pi^k(t^1,t^2,r)\equiv\int_{t^1}^{t^2}\pi^k(t,r)\frac{\dot{p}^k}{p^k}\mathrm{d}t,\quad \text{and}\quad \Delta_\psi^k(t^1,t^2,r)\equiv\int_{t^1}^{t^2}\psi^k(t,r)\frac{\dot{p}^k}{p^k}\mathrm{d}t.$$

Because $\Delta_p^k$ captures the change of $\ln P$ due to the price change for good $k$ with the expenditure shares fixed at time $r$, we call $\Delta_p^k$ the pure-price effect for good $k$. We refer to $\Delta_\pi^k(t^1,t^2,r)$ as the substitution effect, because it reflects the change of $\ln P$ due to the changes in expenditure shares, which in turn are driven by price changes. Finally, we call $\Delta_\psi^k(t^1,t^2,r)$ the preference effect for good $k$, because it reflects the effect of the changes in $\alpha$.

One obvious problem in this decomposition is the choice of the reference period. If we choose $r=t^1$ [$r=t^2$], we obtain Laspeyres- [Paasche-] perspective decomposition. We can also take an average of $\Delta_z^k(t^1,t^2,r)$ over $r(\in[t^1,t^2])$ for component $z\in\{p,\pi,\psi\}$ to eliminate the dependence on $r$. Letting the average be $\bar{\Delta}_z^k(t^1,t^2)\equiv(t^2-t^1)^{-1}\int_{t^1}^{t^2}\Delta_z^k(t^1,t^2,r)\mathrm{d}r$, we have the following results:

**Proposition 1.** *Let the average expenditure share for good $k$ over $t\in[t^1,t^2]$ be $\bar{s}^k\equiv(t^2-t^1)^{-1}\int_{t^1}^{t^2}s^k(t)\mathrm{d}t$ and the average rate of logarithmic price change be $\bar{\phi}^k\equiv(t^2-t^1)^{-1}(\ln p^k(t^2)-\ln p^k(t^1))$. Further, let the deviation from the average rate be $\delta_\phi^k(t)=\dot{p}^k/p^k-\bar{\phi}^k$. Then, $D(t^1,t^2)$ can be written as follows:*

$$D(t^1,t^2)=\sum_{k=1}^{K}\bar{\Delta}_p^k(t^1,t^2)+\bar{\Delta}_\pi^k(t^1,t^2)+\bar{\Delta}_\psi^k(t^1,t^2),\tag{4}$$

*where $\bar{\Delta}_p^k$, $\bar{\Delta}_\pi^k$, and $\bar{\Delta}_\psi^k$ can be written as follows:*

$$\bar{\Delta}_p^k(t^1,t^2)=(t^2-t^1)\bar{s}^k\bar{\phi}^k\quad \textit{and}\quad \bar{\Delta}_z^k(t^1,t^2)=(t^2-t^1)^{-1}\int_{t^1}^{t^2}\int_{t^1}^{t^2}z^k(t,r)\delta_\phi^k(t)\mathrm{d}t\mathrm{d}r\quad \textit{for}\quad z\in\{\pi,\psi\}.$$

*Proof.* Taking the average of eq. (3) over $r\in[t^1,t^2]$, we have eq. (4). To show that the expression for $\bar{\Delta}_p^k$ holds, first notice that we have $\bar{\Delta}_p^k(t^1,t^2)=(t^2-t^1)^{-1}\int_{t^1}^{t^2}s^k(r)\mathrm{d}r\cdot\int_{t^1}^{t^2}\dot{p}^k/p^k\mathrm{d}t$ by definition. The result for $\bar{\Delta}_p^k$ directly follows from this and the definitions of $\bar{s}^k$ and $\bar{\phi}^k$. Noting that we have $\int_{t^1}^{t^2}\int_{t^1}^{t^2}[\int_r^t\sum_j s_{p^j}^k(\tau)\dot{p}^j(\tau)\mathrm{d}\tau]\mathrm{d}t\mathrm{d}r=0$, it is straightforward to verify the results for $\bar{\Delta}_\pi^k(t^1,t^2)$. The proof for $\bar{\Delta}_\psi^k(t^1,t^2)$ is similar. □

There are four points worth making here. First, if all of the prices have a constant rate of change between $t^1$ and $t^2$, then $\delta_\phi^k(t)=0$ for all $k$ and $t\in[t^1,t^2]$, which implies $\bar{\Delta}_\pi^k=\bar{\Delta}_\psi^k=0$. Second, as a result of the first point, taking an average of $\bar{\Delta}_z^k$ over $r(\in[t^1,t^2])$ is useful only if we have frequent observations of prices. To highlight this point, consider the case when we have observations of the price of each good only for two periods. Then, we may have no option but to assume that the logarithmic prices change at a constant rate between these two periods. In such a case, decomposition with a specific reference period may be more useful.

Third, notice that $\bar{\Delta}_z^k$ has a covariance-like structure. For example, $\bar{\Delta}_\psi^k$ is larger when the deviation of the rate of price change from the mean and the deviation of the share from the reference level due to preference change tend to move together. Finally, because we generally do not know the functional form of $s$, it is difficult to distinguish between the preference and substitution effects in practice. Therefore, in our empirical application to the Philippines, we choose to use log-linear preferences so that all of the substitution effects are absorbed by the preference effects.

## 3. Application to Inflation in the Philippines

In this section, we apply our decomposition method to the Philippines for the 1988-2006 period. The Philippines is a particularly suitable country to apply the decomposition analysis, because the price changes are heterogeneous across provinces and the changes in preferences may also be heterogeneous.

We take the observations of expenditure shares from seven rounds of the Family Income Expenditure Survey (FIES) and the observations of prices from annual Consumer Price Index (CPI) with base year 2000. Both datasets are collected by the National Statistics Office of the Philippines. We have aggregated goods to $K(= L = 19)$ goods to match the definitions of consumption goods between FIES and CPI (see Table 1 for the list of goods) and merged these two datasets at the provincial level.[3]

Let the unit time length be a year and $t = 0$ correspond to the year 1988. We have observations $\hat{s}_t^k$ of expenditure shares at $t = 0, n, 2n, \cdots, mn$ and observation of prices $\hat{p}_t^k$ at $t = 0, 1, 2, \cdots, mn$, where we have $m = 6$ and $n = 3$, and use a hat to denote the observations in the data.

As is clear from eq. (1), the exact computation of the Divisia index would require continuous-time data. Therefore, in order to calculate the Divisia price index, we need to make some assumptions about the path along which the prices and expenditure shares change. For example, if we assume that prices don't change when the expenditure shares change, the substitution and preference effects are trivially equal to zero. A special case of this example is the case when all changes in prices precede those in expenditure shares. In this case, the Divisia price index is equal to the Laspeyres-perspective pure-price component: $\Delta_{p,LS}(t^1, t^2) = \sum_{k=1}^{K} s^k(t_1) \ln p^k(t_2)/p^k(t_1)$. This can be regarded as a continuous-time version of the standard Laspeyres price index, because we use the changes in the logarithmic price per period (i.e., $\ln p^k(t_2)/p^k(t_1)$) instead of the proportionate changes per period (i.e., $p^k(t_2)/p^k(t_1)$). Similarly, if we assume that all changes in expenditure shares precede those in prices, the Divisia price index is equal to the Paasche-perspective pure-price component: $\Delta_{p,PA}(t^1, t^2) = \sum_{k=1}^{K} s^k(t_2) \ln p^k(t_2)/p^k(t_1)$, which can be regarded as a continuous-time version of the standard Paasche index. Therefore, both the Laspeyres and Paasche price indices can be interpreted as a discrete approximation to the Divisia price index.

However, the assumptions about the path of the changes in prices and expenditure shares required for Laspeyres and Paasche price indices are not realistic. It would be more reasonable to assume that the prices and preferences change simultaneously and smoothly. Therefore, we assume that the logarithmic prices change at a constant rate

[3]Because we did not have share observations for Batanes province for 1988, we used a simple average between 1985 and 1991. For a few observations where provincial-level prices were not available, we used the regional-level prices.

between the observation points such that $\ln p^k(t) = (\lfloor t+1 \rfloor - t) \ln \hat{p}^k_{\lfloor t \rfloor} + (t - \lfloor t \rfloor) \ln \hat{p}^k_{\lfloor t+1 \rfloor}$ for $t (\in [0, mn])$, where $\lfloor \cdot \rfloor$ is the floor operator, which gives the largest integer not exceeding the argument. We also assume that the representative consumer has (time-varying) log-linear preferences so that his utility is $\ln U(q(t); \alpha(t)) = \sum_k \alpha^k(t) \ln q^k(t)$. Then, we can write the logarithmic price index in the following way: $P(t) = \sum_k \alpha^k(t) \ln p^k(t)$, where $\sum_k \alpha^k(t) = 1$ for all $t$. Assuming that the preference parameters also change piecewise-linearly, we can write the preference parameter in the following manner: $\alpha^k(t) = (\lfloor 1 + t/n \rfloor - t/n)\, \hat{s}^k_{n\lfloor t/n \rfloor} + (t/n - \lfloor t/n \rfloor)\, \hat{s}^k_{n\lfloor 1+t/n \rfloor}$. Under these assumptions, each component of the decomposition in Proposition 1 reduces to the following expressions (see Appendix for the details of derivation):

$$\bar{\Delta}^k_p(0, mn) = \sum_{\tau=0}^{m-1} \frac{\hat{s}^k_{n\tau} + \hat{s}^k_{n(\tau+1)}}{2m} \cdot \ln \frac{\hat{p}^k_{mn}}{\hat{p}^k_0} \equiv \tilde{s}^k \cdot \ln \frac{\hat{p}^k_{mn}}{\hat{p}^k_0} \tag{5}$$

$$\bar{\Delta}^k_\pi(0, mn) = 0 \tag{6}$$

$$\bar{\Delta}^k_\psi(0, mn) = \sum_{\tau=0}^{m-1} \sum_{v=0}^{n-1} \left( \frac{2v+1}{2n} \hat{s}^k_{n(\tau+1)} + \frac{2n-2v-1}{2n} \hat{s}^k_{n\tau} \right) \cdot \ln \frac{\hat{p}^k_{\tau n+v+1}}{\hat{p}^k_{\tau n+v}} - \bar{\Delta}^k_p(0, mn). \tag{7}$$

Five points are worth noting here. First, $\tilde{s}^k$ defined above is the average share between $t^1$ and $t^2$ under the assumption of piecewise linearity of $\alpha$. Second, we have $\bar{\Delta}^k_\pi(0, mn) = 0$ because the expenditure share for good $k$ is completely determined by the preference parameter $\alpha^k$ and independent of prices under the log-linear preferences. Therefore, we implicitly impose a zero substitution effect. This in turn means that $D(0, mn) = \bar{\Delta}_p(0, mn) + \bar{\Delta}_\psi(0, mn)$ holds under the log-linear preferences, where $\bar{\Delta}_z \equiv \sum_{k=1}^K \bar{\Delta}^k_z$ for $z \in \{p, \pi, \psi\}$ is the effect of component $z$ for all goods combined. Third, if $m = 1$, $\bar{\Delta}_p(0, mn)$ is the logarithmic change of the Törnqvist index for the price changes between $t = 0$ and $t = n$.

Fourth, while the assumption of log-linear preferences is admittedly strong, it is consistent with the observed data because the parameters are allowed to vary over time. Further, even if the preferences are misspecified, the estimate of $\bar{\Delta}^k_p(0, mn)$ is correct as long as $\tilde{s}^k = \bar{s}^k$ is satisfied. This is likely to hold in approximation, assuming that the share functions are not volatile. Hence, even if the preferences are misspecified, $\bar{\Delta}_\psi(0, mn)$ provides a reasonable approximation to the combined effect of substitution and preference change.

Fifth, while we have assumed the log-linear utility function, we can conduct a similar exercise under alternative utility functions. That is, once we specify a parametric utility function, we can estimate $\alpha$ for each observation point using cross-sectional variations. We can then intrapolate the changes in $\alpha$ between the observation points. Therefore, our specification of time-varying preferences is fairly general. Further, if we only specify the changes in the share function, we can also conduct the decomposition exercise without explicitly specifying the underlying utility function.

Table 1 shows the results of our decomposition by consumption item in the Philippines. To derive these results, we simply take the average expenditure shares in the Philippines from each round of the FIES data set and combine them with the national prices for each item and each year. The second column ($\tilde{s}$) gives the expenditure share averaged over

Table 1: Decomposition of the Divisia price index by goods in the Philippines.

| Item | $\tilde{s}^k$ | $\bar{\Delta}_p^k/\tilde{s}^k$ | $\bar{\Delta}_\psi^k/\tilde{s}^k$ | $D^k$ | $\Delta_{p,LS}^k$ | $\Delta_{p,PA}^k$ |
|---|---|---|---|---|---|---|
| Cereals | 0.135 | 1.202 | 0.022 | 0.165 | 0.147 | 0.177 |
| Dairy and eggs | 0.034 | 1.174 | 0.015 | 0.040 | 0.038 | 0.042 |
| Fish and sea food | 0.064 | 1.404 | 0.028 | 0.092 | 0.079 | 0.100 |
| Fruits and vegetables | 0.052 | 1.367 | -0.009 | 0.071 | 0.065 | 0.075 |
| Meat | 0.071 | 1.085 | -0.003 | 0.077 | 0.069 | 0.074 |
| Other food | 0.101 | 1.123 | -0.003 | 0.113 | 0.123 | 0.110 |
| Beverages | 0.023 | 1.214 | 0.002 | 0.028 | 0.027 | 0.029 |
| Tobacco | 0.014 | 0.999 | 0.048 | 0.015 | 0.010 | 0.020 |
| Clothes | 0.034 | 1.073 | 0.052 | 0.038 | 0.028 | 0.045 |
| Housing maintenance and repair | 0.010 | 1.285 | 0.058 | 0.013 | 0.008 | 0.015 |
| Rental of occupying dwelling unit | 0.146 | 1.660 | 0.038 | 0.249 | 0.220 | 0.260 |
| Utility | 0.063 | 1.591 | 0.017 | 0.102 | 0.128 | 0.090 |
| Education | 0.040 | 2.273 | -0.068 | 0.089 | 0.106 | 0.069 |
| Medical care | 0.023 | 1.602 | -0.039 | 0.036 | 0.049 | 0.028 |
| Personal care and household operation | 0.063 | 1.248 | -0.005 | 0.079 | 0.080 | 0.076 |
| Recreation | 0.005 | 1.326 | -0.044 | 0.006 | 0.007 | 0.006 |
| Transport and communication | 0.065 | 1.629 | 0.037 | 0.108 | 0.138 | 0.091 |
| Household equipment and furniture | 0.030 | 0.769 | -0.039 | 0.022 | 0.024 | 0.017 |
| Other goods and services | 0.027 | 0.657 | -0.043 | 0.016 | 0.020 | 0.016 |
| All goods | 1.000 | 1.348 | 0.010 | 1.358 | 1.364 | 1.338 |

the observation periods. The third column ($\bar{\Delta}_p^k/\tilde{s}^k$) and fourth column ($\bar{\Delta}_\psi^k/\tilde{s}^k$) give the pure-price and preference effects normalized by $\tilde{s}^k$, respectively, where we perform the normalization to clearly show the relative importance of each effect. The fifth column ($D^k(\equiv\ \bar{\Delta}_p^k + \bar{\Delta}_\psi^k)$) shows the contribution of each item to the overall increase in the logarithmic Divisia price index. Hence, the average increase in the Divisia price index is 7.8 $\left(= 100 \cdot (\mathrm{e}^{1.358/18} - 1)\right)$ percent *per annum* over the 18-year period between 1998 and 2006. The items that contributed most include cereals and rental of occupying dwelling units.

Table 1 shows that the pure-price effects dominate the preference effects for all items. The results do not change, even if we use Laspeyres- or Paasche-perspective decompositions as shown in the sixth column ($\Delta_{p,LS}^k(\equiv\ \hat{s}_0^k \ln \hat{p}_{mn}^k/\hat{p}_0^k)$) and seventh column ($\Delta_{p,PA}^k(\equiv \hat{s}_{mn}^k \ln \hat{p}_{mn}^k/\hat{p}_0^k)$). This finding should not be surprising because (i) the changes in preference parameters have a first-order effect only on the current rate of change (and not the current level) of the Divisia price index and (ii) the value shares were reasonably stable between 1988 and 2006. However, some items, such as education and recreation, exhibit noticeably negative preference effects, mitigating, if only marginally, the effects of inflation.

In Table 2, we report the decomposition results by provinces. We also compare the logarithmic changes in various price indices. The second column ($\Delta_{CPI}$) and third column ($D$) show the logarithmic changes of the CPI and Divisia price index between 1998 and 2006, respectively. The CPI and Divisia price index are reasonably close because of the

Table 2: Decomposition of the Divisia price index by province for 1988 to 2006.

| Province | $\Delta_{CPI}$ | $D$ | $\bar{\Delta}_p$ | $\bar{\Delta}_\psi$ | $\Delta_y$ | $\Delta_y - D$ | $\Delta_{p,LS}$ | $\Delta_{p,PA}$ |
|---|---|---|---|---|---|---|---|---|
| NCR | 1.444 | 1.479 | 1.462 | 0.017 | 1.567 | 0.088 | 1.464 | 1.484 |
| Abra | 1.411 | 1.412 | 1.381 | 0.031 | 1.695 | 0.283 | 1.411 | 1.350 |
| Agusan del Norte | 1.246 | 1.250 | 1.237 | 0.013 | 1.345 | 0.095 | 1.270 | 1.200 |
| Agusan del Sur | 1.241 | 1.230 | 1.221 | 0.009 | 1.289 | 0.059 | 1.252 | 1.178 |
| Aklan | 1.413 | 1.464 | 1.423 | 0.041 | 1.348 | -0.116 | 1.460 | 1.391 |
| Albay | 1.391 | 1.421 | 1.407 | 0.014 | 1.857 | 0.437 | 1.431 | 1.393 |
| Antique | 1.265 | 1.281 | 1.294 | -0.013 | 1.344 | 0.064 | 1.303 | 1.285 |
| Basilan | 1.350 | 1.382 | 1.380 | 0.003 | 0.818 | -0.565 | 1.353 | 1.345 |
| Bataan | 1.107 | 1.109 | 1.086 | 0.023 | 1.846 | 0.737 | 1.139 | 1.037 |
| Batanes | 1.245 | 1.299 | 1.298 | 0.001 | 1.914 | 0.615 | 1.406 | 1.249 |
| Batangas | 1.337 | 1.380 | 1.362 | 0.018 | 1.655 | 0.275 | 1.374 | 1.348 |
| Benguet | 1.309 | 1.334 | 1.326 | 0.008 | 1.762 | 0.428 | 1.366 | 1.271 |
| Bohol | 1.484 | 1.506 | 1.495 | 0.011 | 1.874 | 0.367 | 1.519 | 1.482 |
| Bukidnon | 1.354 | 1.371 | 1.356 | 0.015 | 1.275 | -0.096 | 1.366 | 1.338 |
| Bulacan | 1.247 | 1.252 | 1.260 | -0.008 | 1.401 | 0.149 | 1.314 | 1.230 |
| Cagayan | 1.310 | 1.331 | 1.322 | 0.008 | 1.726 | 0.396 | 1.340 | 1.302 |
| Carmarines Norte | 1.392 | 1.396 | 1.391 | 0.005 | 1.560 | 0.164 | 1.428 | 1.347 |
| Camarines Sur | 1.342 | 1.366 | 1.365 | 0.001 | 1.429 | 0.063 | 1.403 | 1.350 |
| Camiguin | 1.209 | 1.247 | 1.208 | 0.039 | 1.674 | 0.427 | 1.232 | 1.221 |
| Capiz | 1.341 | 1.348 | 1.344 | 0.004 | 1.762 | 0.414 | 1.356 | 1.338 |
| Catanduanes | 1.485 | 1.470 | 1.460 | 0.010 | 1.748 | 0.278 | 1.435 | 1.426 |
| Cavite | 1.274 | 1.335 | 1.333 | 0.002 | 1.766 | 0.430 | 1.372 | 1.269 |
| Cebu | 1.468 | 1.449 | 1.459 | -0.010 | 2.009 | 0.560 | 1.481 | 1.409 |
| Davao Norte | 1.195 | 1.211 | 1.186 | 0.025 | 1.318 | 0.107 | 1.211 | 1.178 |
| Davao Sur | 1.185 | 1.187 | 1.182 | 0.004 | 1.548 | 0.361 | 1.223 | 1.172 |
| Davao Oriental | 1.268 | 1.274 | 1.255 | 0.019 | 1.434 | 0.160 | 1.263 | 1.268 |
| Eastern Samar | 1.299 | 1.306 | 1.316 | -0.009 | 1.394 | 0.087 | 1.316 | 1.316 |
| Ifgao | 1.354 | 1.390 | 1.395 | -0.005 | 1.661 | 0.270 | 1.358 | 1.341 |
| Ilocos Norte | 1.345 | 1.347 | 1.348 | -0.001 | 1.641 | 0.294 | 1.375 | 1.320 |
| Ilocos Sur | 1.222 | 1.248 | 1.220 | 0.028 | 1.768 | 0.520 | 1.240 | 1.215 |
| Iloilo | 1.230 | 1.239 | 1.236 | 0.003 | 1.566 | 0.327 | 1.260 | 1.228 |
| Isabela | 1.259 | 1.265 | 1.266 | -0.002 | 1.496 | 0.231 | 1.297 | 1.233 |
| Kalinga | 1.266 | 1.295 | 1.268 | 0.027 | 1.129 | -0.166 | 1.293 | 1.254 |
| La Union | 1.390 | 1.413 | 1.402 | 0.011 | 1.450 | 0.037 | 1.439 | 1.382 |
| Laguna | 1.439 | 1.458 | 1.431 | 0.027 | 1.561 | 0.104 | 1.469 | 1.369 |
| Lanao del Norte | 1.354 | 1.340 | 1.330 | 0.010 | 1.403 | 0.063 | 1.382 | 1.319 |
| Lanao del Sur | 1.415 | 1.454 | 1.474 | -0.020 | 1.058 | -0.397 | 1.506 | 1.456 |
| Leyte | 1.271 | 1.266 | 1.245 | 0.021 | 1.653 | 0.387 | 1.266 | 1.227 |

Table 2 (cont'd): Decomposition of the price index by province for 1988 to 2006.

| Province | $\Delta_{CPI}$ | $D$ | $\bar{\Delta}_p$ | $\bar{\Delta}_\psi$ | $\Delta_y$ | $\Delta_y - D$ | $\Delta_{p,LS}$ | $\Delta_{p,PA}$ |
|---|---|---|---|---|---|---|---|---|
| Maguindanao | 1.419 | 1.473 | 1.452 | 0.021 | 0.948 | -0.525 | 1.492 | 1.413 |
| Marinduque | 1.281 | 1.323 | 1.310 | 0.012 | 1.539 | 0.217 | 1.350 | 1.315 |
| Masbate | 1.255 | 1.266 | 1.271 | -0.006 | 1.449 | 0.183 | 1.292 | 1.277 |
| Misamis Occidental | 1.335 | 1.332 | 1.317 | 0.015 | 1.365 | 0.033 | 1.331 | 1.283 |
| Misamis Oriental | 1.310 | 1.337 | 1.324 | 0.012 | 1.573 | 0.236 | 1.370 | 1.288 |
| Mt. Province | 1.374 | 1.377 | 1.395 | -0.018 | 1.536 | 0.159 | 1.448 | 1.384 |
| Negros Occidental | 1.225 | 1.268 | 1.242 | 0.026 | 1.604 | 0.336 | 1.244 | 1.248 |
| Negros Oriental | 1.433 | 1.506 | 1.475 | 0.031 | 1.392 | -0.114 | 1.477 | 1.458 |
| North Cotabato | 1.193 | 1.203 | 1.196 | 0.007 | 1.444 | 0.240 | 1.197 | 1.177 |
| Northern Samar | 1.324 | 1.321 | 1.327 | -0.007 | 1.821 | 0.501 | 1.336 | 1.348 |
| Nueva Ecija | 1.460 | 1.490 | 1.472 | 0.018 | 1.553 | 0.063 | 1.496 | 1.455 |
| Nueva Viscaya | 1.243 | 1.230 | 1.246 | -0.016 | 1.712 | 0.482 | 1.272 | 1.224 |
| Mindoro Occidental | 1.194 | 1.219 | 1.214 | 0.005 | 1.013 | -0.206 | 1.227 | 1.191 |
| Mindoro Oriental | 1.326 | 1.346 | 1.341 | 0.005 | 1.547 | 0.201 | 1.319 | 1.349 |
| Palawan | 1.100 | 1.112 | 1.098 | 0.013 | 1.418 | 0.306 | 1.118 | 1.073 |
| Pampanga | 1.177 | 1.240 | 1.209 | 0.031 | 1.634 | 0.393 | 1.220 | 1.198 |
| Pangasinan | 1.380 | 1.402 | 1.396 | 0.006 | 1.560 | 0.158 | 1.407 | 1.374 |
| Quezon | 1.230 | 1.230 | 1.231 | -0.001 | 1.481 | 0.250 | 1.252 | 1.204 |
| Quirino | 1.226 | 1.244 | 1.244 | 0.000 | 1.721 | 0.477 | 1.267 | 1.199 |
| Rizal | 1.348 | 1.346 | 1.328 | 0.017 | 1.694 | 0.348 | 1.353 | 1.321 |
| Romblon | 1.247 | 1.329 | 1.312 | 0.017 | 1.883 | 0.554 | 1.324 | 1.276 |
| Western Samar | 1.343 | 1.353 | 1.320 | 0.032 | 1.621 | 0.269 | 1.323 | 1.309 |
| Siquijor | 1.412 | 1.368 | 1.365 | 0.003 | 2.419 | 1.051 | 1.365 | 1.361 |
| Sorsogon | 1.436 | 1.455 | 1.450 | 0.005 | 1.665 | 0.210 | 1.477 | 1.423 |
| South Cotabato | 1.114 | 1.115 | 1.112 | 0.003 | 1.333 | 0.218 | 1.127 | 1.097 |
| Southern Leyte | 1.368 | 1.360 | 1.361 | -0.001 | 1.637 | 0.278 | 1.386 | 1.360 |
| Sultan Kudarat | 1.214 | 1.252 | 1.234 | 0.019 | 1.224 | -0.028 | 1.242 | 1.195 |
| Sulu | 1.753 | 1.769 | 1.773 | -0.004 | 1.110 | -0.659 | 1.759 | 1.763 |
| Surigao del Norte | 1.468 | 1.473 | 1.461 | 0.012 | 1.454 | -0.018 | 1.468 | 1.459 |
| Surigao del Sur | 1.188 | 1.202 | 1.199 | 0.003 | 1.270 | 0.068 | 1.203 | 1.178 |
| Tarlac | 1.341 | 1.375 | 1.356 | 0.019 | 1.648 | 0.273 | 1.395 | 1.331 |
| Tawi-Tawi | 1.475 | 1.529 | 1.530 | -0.001 | 1.115 | -0.414 | 1.549 | 1.515 |
| Zambales | 1.281 | 1.303 | 1.282 | 0.021 | 1.371 | 0.068 | 1.274 | 1.291 |
| Zamboanga del Norte | 1.303 | 1.347 | 1.310 | 0.037 | 1.543 | 0.195 | 1.333 | 1.309 |
| Zamboanga del Sur | 1.287 | 1.292 | 1.299 | -0.007 | 1.389 | 0.097 | 1.308 | 1.274 |
| Aurora | 1.250 | 1.258 | 1.265 | -0.007 | 1.532 | 0.274 | 1.314 | 1.226 |
| Philippines | 1.352 | 1.358 | 1.348 | 0.010 | 1.583 | 0.225 | 1.364 | 1.338 |

Table 3: Decomposition of the Divisia price index by consumption deciles.

| Decile | $D$ | $\bar{\Delta}_\psi/D$ | $\Delta_y$ | $\Delta_y - D$ | $\Delta_{p,LS}$ | $\Delta_{p,PA}$ |
|---|---|---|---|---|---|---|
| First (Richest) | 1.412 | 0.010 | 1.642 | 0.230 | 1.414 | 1.395 |
| Second | 1.356 | 0.008 | 1.624 | 0.268 | 1.374 | 1.317 |
| Third | 1.338 | 0.007 | 1.594 | 0.256 | 1.358 | 1.308 |
| Fourth | 1.327 | 0.006 | 1.573 | 0.246 | 1.341 | 1.297 |
| Fifth | 1.318 | 0.005 | 1.551 | 0.233 | 1.331 | 1.296 |
| Sixth | 1.313 | 0.005 | 1.520 | 0.207 | 1.324 | 1.292 |
| Seventh | 1.310 | 0.005 | 1.489 | 0.180 | 1.319 | 1.294 |
| Eighth | 1.305 | 0.004 | 1.463 | 0.158 | 1.313 | 1.290 |
| Ninth | 1.302 | 0.003 | 1.428 | 0.127 | 1.307 | 1.291 |
| Tenth (Poorest) | 1.299 | 0.002 | 1.431 | 0.131 | 1.303 | 1.294 |
| Philippines | 1.358 | 0.007 | 1.583 | 0.225 | 1.364 | 1.338 |

stability of the share functions. Therefore, even though the CPI does not allow for the possibility of substitution and thus may become irrelevant over time in general, it has been a relevant price index for a fairly long period of time in the Philippines. Given this result, it is not surprising that the Laspeyres and Paasche price indices are also close to $D$ as shown in the eighth column ($\Delta_{p,LS}$) and ninth column ($\Delta_{p,PA}$).

The fourth column ($\bar{\Delta}_p$) and fifth column ($\bar{\Delta}_\psi$) provide the pure-price and preference effects. Table 2 shows that the pure-price effects dominate the preference effects in all provinces. However, the magnitude of preference effects varies substantially across provinces. The sixth column shows the change $\Delta_y \equiv \ln(y(mn)/y(0))$ in the nominal logarithmic consumption *per capita,* whereas the seventh column ($\Delta_y - D$) shows the change in real logarithmic consumption *per capita.* The real consumption *per capita* has increased in most provinces but the growth rate has been heterogeneous, varying substantially across provinces from -3.6($= 100 \cdot (\mathrm{e}^{-0.659/18} - 1)$) percent in Sulu to 6.0($= 100 \cdot (\mathrm{e}^{1.051/18} - 1)$ percent in Siquijor.

We have also decomposed the Divisia price index by deciles of consumption *per capita* to determine whether inflation has affected the rich and poor differently. To this end, we calculated the share of each item for each decile for each round of the FIES data. We have then combined it with the national price data for each item to perform the decomposition analysis.

As the second column ($D$) of Table 3 shows, richer people generally have experienced higher inflation. The third column ($\bar{\Delta}_\psi/D$) shows that the inflation due to the preference effect is positive for all deciles and tends to be higher for richer people. This may be because rich people have stronger preferences for goods that are rapidly becoming expensive or because rich people do not need to substitute away from these goods. Either way, poor people have better mitigated the impacts of inflation than rich people have, but this difference is economically insignificant.

As shown in the fourth column ($\Delta_y$), the consumption growth for top deciles have outpaced that for bottom deciles. As a result, the gap between the rich and poor in terms of real consumption has widened over time as shown in the fifth column ($\Delta_y - D$). By comparing the sixth column ($\Delta_{p,LS}$) and the seven column ($\Delta_{p,PA}$) with $D$, we can see that this finding does not change qualitatively even if we use the Laspeyres- or Paasche-perspective decomposition.

## 4. Discussion

We have proposed a method to decompose the changes in the logarithmic Divisia price index into the pure-price, substitution, and preference effects, though we put the latter two together in our empirical application. These effects may be further decomposed by goods as shown in Table 1. The decomposition exercise allows us to identify which items contribute most to inflation and whether and to what degree inflation has been mitigated by substitution or preference change, a point that cannot be readily seen by standard price indices.

In the Philippines, the preference effect is small relative to the pure-price effect, showing that the CPI has been a relevant price indicator for the period 1988-2006. We also find that there is sizable heterogeneity in inflation both across provinces and consumption deciles. Hence, if we simply look at the national average, we will miss the underlying heterogeneity in the impact of inflation.

## References


Balk, B. (2005) "Divisia price and quantity indices: 80 years after" *Statistica Neerlandica* **59**, 119–158.

Diewert, W.E. (1976) "Exact and superlative index numbers" *Journal of Econometrics* **4**, 115–145.

Diewert W.E. (1978) "Superlative index numbers and consistency in aggregation" *Econometrica* **46**, 883–900.

Divisia, F. (1925) "L'indice monétaire et la theorie de la monnaie" *Revue d'Economie Politique* **39**, 980–1008.

Feenstra, R.C. and M.B. Reinsdorf (2000) "An exact price index for the almost ideal demand system" *Economics Letters* **66**, 159–162.

Fisher, I. (1921) "The best form of index number" *Quarterly Publications of the American Statistical Association* **17**, 533–537.

Richter, M. (1966) "Invariance axioms and economic indexes" *Econometrica* **34**, 739–755.

Samuelson, P.A. and S. Swamy (1974) "Invariant economic index numbers and canonical duality: survey and synthesis" *American Economic Review* **64**, 566-593.

Törnqvist (1936) "The Bank of Finland's consumption price index" *Bank of Finland Monthly Bulletin* **10**, 1–8.


## Appendix: Derivation of eqs. (5)-(7)

Consider the following maximization problem:

$$\max_q \ln U(q;\alpha) \quad \text{s.t.} \quad y = p \cdot q.$$

Solving this under the assumption of log-linear preferences, we have $q^k = \alpha^k y/p^k$ for all $k$. Hence, using the assumption of piecewise linearity of preference parameters, we have:

$s^k(t) = \alpha^k(t) = (\lfloor 1+t/n \rfloor - t/n)\, \hat{s}^k_{n\lfloor t/n \rfloor} + (t/n - \lfloor t/n \rfloor)\, \hat{s}^k_{n\lfloor 1+t/n \rfloor}$. Because $s^k(t)$ does not depend on $p(t)$, it is clear that eq. (6) holds. To find $\bar{\Delta}^k_p$, note that the following equation holds:

$$\begin{aligned} \bar{s}^k &= \frac{1}{mn-0}\int_0^{mn} s^k(t)\mathrm{d}t \\ &= \frac{1}{mn}\sum_{\tau=0}^{m-1}\int_{n\tau}^{n(\tau+1)} \alpha^k(t)\mathrm{d}t \\ &= \frac{1}{mn}\sum_{\tau=0}^{m-1}\int_{n\tau}^{n(\tau+1)} \left[(\tau+1-t/n)\,\hat{s}^k_\tau + (t/n-\tau)\,\hat{s}^k_{\tau+1}\right]\mathrm{d}t \\ &= \tilde{s}^k \end{aligned}$$

Using $\bar{\phi} = (\ln \hat{p}^k_{mn} - \ln \hat{p}^k_0)/mn$ and Proposition 1, we have eq. (5).

Finally, we have:

$$\begin{aligned} & D(0,mn) \\ = & \sum_{\tau=0}^{m-1}\sum_{v=0}^{n-1}\int_{\tau n+v}^{\tau n+v+1} s^k(t)\frac{\dot{p}^k}{p^k}\mathrm{d}t \\ = & \sum_{\tau=0}^{m-1}\sum_{v=0}^{n-1}\int_{\tau n+v}^{\tau n+v+1} \left((\lfloor 1+t/n \rfloor - t/n)\hat{s}^k_{n\lfloor t/n \rfloor} + (t/n - \lfloor t/n \rfloor)\hat{s}^k_{n\lfloor 1+t/n \rfloor)}\right)\cdot \ln\frac{\hat{p}^k_{\lfloor t+1 \rfloor}}{\hat{p}^k_{\lfloor t \rfloor}}\mathrm{d}t \\ = & \sum_{\tau=0}^{m-1}\sum_{v=0}^{n-1}\int_{\tau n+v}^{\tau n+v+1} \left((\tau+1-t/n)\hat{s}^k_{\tau n} + (t/n-\tau)\hat{s}^k_{n(\tau+1)}\right)\cdot \ln\frac{\hat{p}^k_{\tau n+v+1}}{\hat{p}^k_{\tau n+v}}\mathrm{d}t \\ = & \sum_{\tau=0}^{m-1}\sum_{v=0}^{n-1}\left(\frac{2v+1}{2n}\hat{s}^k_{n(\tau+1)} + \frac{2n-2v-1}{2n}\hat{s}^k_{n\tau}\right)\cdot \ln\frac{\hat{p}^k_{\tau n+v+1}}{\hat{p}^k_{\tau n+v}}. \end{aligned}$$

By this and eq. (4) in Proposition 1, we have eq. (7). □