ALMOST IDEAL DEMAND SYSTEM AND UNIFORM TAXATION IN PAKISTAN: ECONOMETRIC EVIDENCES FOR CONSUMER GOODS IN PAKISTAN, 1984-2008

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Abstract
Two main tasks have been pursued in this article. First, we estimate demand system for six composite goods by employing Almost Ideal Demand System for Pakistan. Second we analyze the welfare implications of tax reforms that replace the existing tax structure by uniform taxes on all goods. The parameter estimates of the model satisfied the theoretical restrictions. In particular all expenditure elasticities turned out to be positive and all the own price elasticities are negative with reasonable magnitudes. It has been found that the welfare gain of shifting to uniformity of tax rates from the existing tax structure is substantial. It is equivalent to 10% reduction in total expenditure while the total tax revenue stayed the same. In other words consumers would spend 10% less while the total welfare is kept constant at the existing level.

JEL classification: C33; D12; H21

Key Words: Uniform Tax, Household Demand, AIDS Demand System and Pakistan

1. Introduction
There is an extensive literature on the issue whether indirect taxes should be uniform or optimal. Several empirical studies have suggested that the optimal tax structures are non-uniform (Atkinson and Stigliz (1972), Sadka (1977)). On the other hand more recent studies have supported uniformity (see for example Hatta 1986, Fukushima (1989), Fukushima 1991, Hatta 2004, Asano and Fukushima 2006). In this paper demand system has been estimated by employing AIDS (Almost Ideal Demand System of Deaton and Muellbauer (1980)) for Pakistan to quantify the welfare gains (losses) from a tax reform that replaces the existing tax structure by uniform taxes for six composite goods. Over the past three decades a number of studies have estimated and analyzed household consumption pattern in Pakistan. However, most of the work has employed cross sectional data. And therefore either price elasticities have not been reported or have been indirectly derived by imposing a priori restrictions on the preferences. Furthermore the results of these studies are based on more rigid model specifications. Almost Ideal

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1 The theoretical issues concerning the debate about the viability of optimal taxation versus uniform taxes have not been dealt in this paper.
3 Burki (1997) did analyze household demands using time series data. However, the scope of the study has been limited, as the data employed covered only a small portion of households’ budget.
Demand System (AIDS) provides a framework which is consistent with known household-budget data, it is simple to estimate, largely avoiding the need for nonlinear estimation and it can also be used to test the restrictions of homogeneity and symmetry through linear restriction on the fixed parameter. In the context of Pakistan, Alderman (1988) was the first study reporting results based on AIDS by employing data of household income expenditure survey of 1979 and the urban survey of 1982. The paper analyzed regional variations in prices in addition to time series data. There are very few studies that analyze the welfare implications of tax reforms in the context of Pakistan. For example, Ahmad and Stern (1986) deal with effective tax reforms using a measure that they refer as marginal social cost of raising revenue through an increase in the tax on a specific good by employing 1975-76 data. Ahmad and Stern (1991) use LES to discuss tax reforms in Pakistan. However, their model is restrictive as demand functions from additive preferences do not permit inferior goods, and the substitution effects between commodities are also restrictive and do not permit complementarities between goods. Deaton (1997), in AIDS setting, estimated the shadow taxes and subsidies for Pakistan and concluded that an increase in export taxes increases consumer welfare while increasing the government revenue at the same time. Ali and Abedullah (1998) point out that the lower prices through lowering the tax rate or higher subsidies increase welfare in the agriculture sector. To the best of our knowledge the welfare impact of uniform taxes have not been analyzed in the context of Pakistan so far.

It is in this background, this study pursues two main objectives. First, the study estimates demand functions for composite consumer goods in Pakistan and presents estimates of price elasticities for a broader group of composite commodities. By incorporating price variation into the model, this paper tries to overcome the model misspecification problem of the previous studies and to get reliable estimates of the expenditure elasticities. Second, the study analyzes the nature of responses to alternative tax structures, in particular uniformity of taxes, for composite consumer goods and their welfare implications in Pakistan.

To accomplish the task, time series and cross sectional pooled budget data has been compiled for various commodity groups and household income groups from various issues of Household Income and Expenditure Survey (HIES) and Statistical Year Book. AIDS model of Deaton and Muellbauer (1980a) is used to obtain price and expenditure elasticities.

The paper is organized as follows. The econometric specification is discussed in section 2. Data and estimation strategy are provided in section 3. Empirical results are given in section 4, while section 5 concludes the paper.

2 Analytical Framework

In this section an econometric model, to estimate the demand system, has been presented first. Later the framework to analyze the effects of alternative tax regimes on household’s welfare has been presented.

2.1 Almost Ideal Demand system

In this paper we have employed AIDS, and the expenditure function is given by:

\[ \log c(u, p) = a(p) + ub(p), \]

where

\[ a(p) = \alpha_o + \sum_k \alpha_k \log p_k + \frac{1}{2} \sum_k \sum_{\ell} \gamma_{k\ell} \log p_k \log p_{\ell}, \]

2
and
\[ b(p) = \beta_o \prod p^\beta k^k \]

Here \( \alpha, \beta \) and \( \gamma^* \) are the parameters, \( u \) is utility and \( p \) is the vector of prices. When equations (2) and (3) are substituted into (1), the budget shares \( w_i \) can be derived in two steps. In the first step the compensated demand function is obtained in the form of expenditure share of good \( 'i' \) by taking the derivative of the expenditure function with respect to \( \log(p_i) \) and applying Shepherd’s lemma. In the second step resulting equation is substituted into the indirect utility function, the latter being obtained by inverting the above expenditure function. It gives the expenditure share equation of the form:
\[ w_i = \alpha_i + \sum_j \gamma_{ij} \log p_j + \beta_i \log(x/P) \]

where \( P \) is price index defined by
\[ \log P = \alpha_o + \sum_k \alpha_k \log p_k + \frac{1}{2} \sum_k \sum_{\ell} \gamma_{k\ell} \log p_k \log p_{\ell} \]

and the parameters \( \gamma \) are defined by
\[ \gamma_{ij} = \frac{1}{2} \left( \gamma_{ij}^* + \gamma_{ji}^* \right) = \gamma_{ji}^* \]

The model defined by (4) to (6) is the AIDS of Deaton and Muellbauer (1980a). The theoretical restrictions on (4) apply directly to the parameters. Adding up, homogeneity and symmetry conditions are given by equations 7, 8 and 9:
\[ \sum_k \alpha_k = 1, \sum_k \gamma_{ikj} = 0, \sum_k \beta_k = 0 \]
\[ \sum_k \gamma_{jki} = 0 \]
\[ \gamma_{ij} = \gamma_{ji} \]

The most interesting feature of (4), from the econometric point of view, is that it is very close to being linear. If ‘\( P \)’ can be estimated separately, the system will become linear in parameters. As to \( P \), the restrictions on \( \alpha \) and \( \gamma \) ensure that (5) defines \( P \) as a linearly homogeneous function of the individual prices.

**Uncompensated and Compensated Elasticities of Demands**

The uncompensated elasticities of demands from the AIDS are given by
\[ \eta_{ij} = \frac{d \ln Q_i}{d \ln P_i} = -\delta_{ij} + \frac{d \ln w_i}{d \ln p} = -\delta_{ij} + \left\{ \gamma_{ij} - \beta_i \frac{d \ln P}{d \ln p} \right\} / w_i \]

The term “\( \delta_{ij} \)” is the Kronecker delta, which is equal to one when \( i = j \), and equal to zero when \( i \neq j \). To get the correct expression for the elasticity of AIDS we substitute \( d \ln(P)/d \ln(P_j) = \alpha_j + \sum_k \gamma_{kj} \ln P_k \) in equation (10) to yield:
\[ \eta_{ij} = -\delta_{ij} + \gamma_{ij}/w_i - \beta_i \alpha_j / w_i - \frac{\beta_i}{w_i} \sum_k \gamma_{kj} \ln P_k \]
Next, the compensated elasticities are

$$\eta_{ij} = \eta_{ij} + w_i \left( 1 + \frac{\beta_k}{w_i} \right)$$

2.2 Changes of Tax Regime and its Welfare Implications

In this paper we would like to test the hypothesis that a uniform tax on all consumer goods would improve the welfare of the consumers if they replace the existing structure of taxes in Pakistan. (see Hatta 1986, Fukushima 1989, Fukushima 1991, Hatta 2004, Asano and Fukushima 2006). Alternatively, if the level of utility is kept under the existing level, the tax revenue under the uniform tax regime will be maximum. To evaluate this proposition numerically, we fix the level of utility at the existing level, replace the existing taxes by a uniform tax and observe the resulting change in the expenditure.

In order to calculate the tax rate under the uniform tax rate, say $t^{\text{new}}$, levied on each basket of good, provided the tax revenue remains unchanged the pre-tax expenditure on good $i$, $E_i^0$ and pre-tax total expenditure $c^0$ are obtained first:

$$E_i^0 = \frac{E_i}{1 + t_i}$$

$$c^0 = \sum E_i^0 = \sum \frac{E_i}{1 + t_i}$$

The total tax revenue from the existing tax structure is $\sum t_i E_i^0$, while the total tax collection from the new (uniform) taxes is given by $T^0 = \sum t^{\text{new}} E_i^0 = t^{\text{new}} \sum E_i^0$. If the tax collection under the new (uniform) tax regime is to be equal to that under the existing tax structure, we must have $t^{\text{new}} \sum E_i^0 = \sum t_i E_i^0$, therefore

$$t^{\text{new}} = \frac{\sum t_i E_i^0}{\sum E_i^0} = \frac{T^0}{c^0}$$

Where $T^0 = \sum t_i E_i^0$ the total is tax collection under the existing tax structure and $c^0 = \sum E_i^0$ is the existing pre-tax total expenditure. Now, on the basis of the above, we can obtain the new prices:

$$p_i^{\text{new}} = p_i^0 \left( 1 + t^{\text{new}} \right)$$

The indirect utility function can be obtained by inverting equation (1) to give $u$ as a function of $p$ and $x$

$$u = \log [c(p,u)] - \alpha_0 - \sum_k \alpha_k [\log (p_k)] - \frac{1}{2} \sum_k \sum_j \gamma_{kj} \left[ \log (p_k) \log (p_j) \right]$$

$$- \frac{\beta_0}{\prod_k [p_k]}$$

The value of $u$ will be calculated by using the post tax price index. Then the utility will be incorporated in both the expenditure functions, that is, post tax price index and new tax
price index. The new expenditure function can be obtained by incorporating \( t_{new} \) in equation (4):

\[
C = \log \left( \sum_{k} \alpha_k \left[ \log(p_{k}^{new}) \right] + \frac{1}{2} \sum_{k} \sum_{j} \gamma_{kj} \left[ \log(p_{k}^{new}) \log(p_{j}^{new}) \right] + u_{0} \prod_{k} \left[ p_{k}^{new} \right]^h \right)
\]

where the new price index \( P^{new} \) is obtained using (5) as

\[
P^{new} = \exp \left( \alpha_o + \sum \alpha_k \log p_{k}^{new} + \frac{1}{2} \sum_{k} \sum_{l} \gamma_{kl} \log p_{k}^{new} \log p_{l}^{new} \right)
\]

The consumer welfare or loss due to the change of tax regime, denoted by \( W \), is calculated by the formula:

\[
W = \frac{c^{new} - c}{c} \times 100
\]

If \( c^{new} \) is less than \( c \) then we may conclude that with the new tax rates consumers will enjoy gain in their welfare.

3. Data and Estimation Strategy

The pooled time series data for this study has been obtained from various issues of HIES and Statistical Yearbook for the years 1984-2008 which has classified the income and expenditure data for 11-12 income groups. The demand system has been estimated for six composite groups of commodities. These include: (1) Food, beverages and tobacco (denoted by food); (2) Textile, apparel and footwear (denoted by txtl); (3) Transport and communication (denoted by trns); (4) Rent and housing (denoted by hous); (5) Fuel and lighting (denoted by fuel); and (6) Miscellaneous (denoted by misc).

The other composite goods like furniture and household equipment, laundry, cleaning; personal effect, recreation and education have been included in the basket of ‘miscellaneous’. The rational for selecting these six categories is that these baskets of commodities have relatively larger share in the expenditure. Given this level of aggregation, Consumer Price Indices (CPI) for the corresponding commodity groups have also been taken from various issues of the Statistical Yearbook. All indices are converted to the base year 1980-81.

3.1 Estimation Strategy

in the context of above theoretical background, the econometric specification of share equations in 4 will be written as:

\[
w_{it} = \alpha_i + \sum_{j} \gamma_{ij} \log p_{j} + \beta_i \log(x/P) + \mu_{it}
\]

Where the additional subscript \( t \) represents the time period and \( \mu_{it} \) is the Gaussian error term.

A system of share equations based on equation (21) and subject to the restrictions in (7), (8) and (9) (adding-up, homogeneity, and symmetry) is estimated using the iterative least square method procedure. Due to adding up constraint, only five out of six equations are independent. Therefore, we delete the equation for the ‘miscellaneous’ group to ensure non-singularity of the error covariance matrix. The remaining parameters of the system are then recovered using the adding-up restrictions. The estimation technique ensures that
the estimated parameters remain invariant to the choice of equation dropped from estimation.

4 Empirical Results

Our estimates confirm that AIDS is a well-behaved demand system since the monotonicity and curvature conditions are satisfied. The monotonicity condition is fulfilled as all the budget shares are positive. The curvature condition is also satisfied, at the sample means (the point of approximation), as the Hessian matrix is negative semi-definite, as all the six Eigenvalues, presented in Table 1, are negative.

<table>
<thead>
<tr>
<th>Table 1: Test of Curvature Condition of LA/AIDS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Equations</td>
</tr>
<tr>
<td>Food</td>
</tr>
<tr>
<td>Txtl</td>
</tr>
<tr>
<td>trns</td>
</tr>
<tr>
<td>Hous</td>
</tr>
<tr>
<td>fuel</td>
</tr>
<tr>
<td>Misc</td>
</tr>
</tbody>
</table>

The estimated parameters in the AIDS model with homogeneity and symmetry restriction imposed are reported in the Table 2. The intercepts approximate the average budget shares and add to 1. The expenditure coefficients are positive for relative luxuries and negative for relative necessities. Since the coefficients must add up to zero, their value must be offsetting. Thus, it is meaningful to classify goods into luxuries and necessities in relative terms. It is further observed that the direct-price coefficients are positive and cross-price coefficients are symmetric.

<table>
<thead>
<tr>
<th>Table 2: Parameter Estimates of AIDS Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>food</td>
</tr>
<tr>
<td>------</td>
</tr>
<tr>
<td>const</td>
</tr>
<tr>
<td>expen</td>
</tr>
<tr>
<td>Food</td>
</tr>
<tr>
<td>txtl</td>
</tr>
<tr>
<td>trns</td>
</tr>
<tr>
<td>hous</td>
</tr>
<tr>
<td>fuel</td>
</tr>
<tr>
<td>misc</td>
</tr>
</tbody>
</table>

Note: const stands for constant and expen stands for expenditure
*: Significant at 1% **: Significant at 5% ***: Significant at 10%

The results show that the intercept terms for food & beverages, textile & footwear, and fuel & lighting are statistically significant and positive. It implies that the share of food & beverages, textile & footwear, and fuel & lighting would be positive if income and price effects are ignored. The estimated intercepts for transport & communication, rent & housing and miscellaneous, are also significant with negative sign.

The signs of the coefficients of total real expenditure indicate that food & beverages, textile & footwear and fuel & lighting can be classified as relative necessities, while
transport & communications, rent & housing and miscellaneous are relative luxuries. The parameter $\gamma_i$ measures the change in the budget share of good $i$ following a one-percent increase in its own price or the price of some other good, with real expenditure held constant.\textsuperscript{4}

There are two ways to approach the estimation of expenditure and price elasticities. Aldermann (1988) adopts the elasticity formulas of LA\AIDS for the computation of these elasticities based on the estimated (non-linear) AIDS. This is done basically to simplify the computations. Green and Alston (1990), however, point out that using LA/AIDS elasticities formulae in AIDS is only appropriate when either the preferences are homothetic or prices are proportional to one another. Importantly, the relationship between the parameters of the AIDS and the corresponding parameters of LA/AIDS is not known in general. Actually, AIDS and the LA\AIDS are non-nested models. When price changes are more-or-less proportional to one another, in such cases the estimates obtained from the LA/AIDS would approach the estimates from the AIDS except for the intercept term. In addition, it is not known whether the LA/AIDS has satisfactory theoretical properties (e.g., Green and Alston, 1990). The other approach is to use the full formula which is consistent with AIDS. We follow the later.

Table 3 shows that all the own-price elasticities estimated by AIDS have negative sign and have plausible magnitudes. Almost all the elasticity estimates are significant at 1% or 5% levels of significance. However, some magnitudes are on the higher side, which can be justified in the light of Alderman’s (1988) observation that the magnitude of elasticities are small for the cross sectional data but large for the time series data. Thus in the pooled time-series and cross-section data the elasticity estimates can be moderately on higher side.

<table>
<thead>
<tr>
<th></th>
<th>food</th>
<th>txtl</th>
<th>trns</th>
<th>hous</th>
<th>fuel</th>
<th>misc</th>
</tr>
</thead>
<tbody>
<tr>
<td>food</td>
<td>-0.305*</td>
<td>0.245**</td>
<td>-0.323</td>
<td>-0.175*</td>
<td>0.513*</td>
<td>-0.424**</td>
</tr>
<tr>
<td>txtl</td>
<td>0.231**</td>
<td>-0.405*</td>
<td>-0.711**</td>
<td>0.356*</td>
<td>-0.419**</td>
<td>-0.715**</td>
</tr>
<tr>
<td>trns</td>
<td>-0.937*</td>
<td>-0.719**</td>
<td>-0.595*</td>
<td>0.461*</td>
<td>0.615**</td>
<td>0.654*</td>
</tr>
<tr>
<td>hous</td>
<td>-0.597*</td>
<td>0.177*</td>
<td>0.951*</td>
<td>-0.570*</td>
<td>-0.356**</td>
<td>0.512**</td>
</tr>
<tr>
<td>fuel</td>
<td>1.084**</td>
<td>-0.315*</td>
<td>-0.691*</td>
<td>-0.374*</td>
<td>-0.171*</td>
<td>-0.901**</td>
</tr>
<tr>
<td>miscs</td>
<td>-1.521*</td>
<td>-0.641*</td>
<td>1.273*</td>
<td>0.600</td>
<td>-0.297**</td>
<td>-0.681*</td>
</tr>
</tbody>
</table>

*: Significant at 1% **: Significant at 5%

The expenditure elasticities, as presented in Table 4 for all the commodities are positive. The positive sign of expenditure elasticities combined with the negative sign of own-price elasticities show that the all goods are normal. The elasticities are less than one for food & beverages, textile & footwear and fuel & lighting and positive for transport & communication, rent & housing and miscellaneous, confirming that the former group of commodities corresponds to relative necessities, while the latter one to relative luxuries.

\textsuperscript{4} See Deaton and Muellbauer (1980b).
Table 4: Estimated Expenditure Elasticities for the AIDS

<table>
<thead>
<tr>
<th>Equation</th>
<th>Expenditure Elasticity</th>
</tr>
</thead>
<tbody>
<tr>
<td>food</td>
<td>0.6193*</td>
</tr>
<tr>
<td>txtl</td>
<td>0.7106*</td>
</tr>
<tr>
<td>trans</td>
<td>1.2368*</td>
</tr>
<tr>
<td>hous</td>
<td>1.4580*</td>
</tr>
<tr>
<td>fuel</td>
<td>0.7254*</td>
</tr>
<tr>
<td>miscs</td>
<td>1.4393*</td>
</tr>
</tbody>
</table>

*: Significant at 1%

Table 5 shows estimates of the compensated elasticities. The results show that signs of compensated elasticities are the same as of the uncompensated elasticities, but the magnitudes are different as expected. In particular, compensated elasticities are smaller, in absolute terms, than the uncompensated elasticities. The cross price elasticities show that some of pairs of goods are substitutes, a result generally not expected with goods defined at highly aggregate level, which are more likely to be complements.

Table 5: Compensated Elasticities for AIDS Model

<table>
<thead>
<tr>
<th></th>
<th>food</th>
<th>txtl</th>
<th>trans</th>
<th>hous</th>
<th>fuel</th>
<th>misc</th>
</tr>
</thead>
<tbody>
<tr>
<td>food</td>
<td>-0.113*</td>
<td>0.163**</td>
<td>-0.426*</td>
<td>0.193*</td>
<td>0.516**</td>
<td>-0.429*</td>
</tr>
<tr>
<td>txtl</td>
<td>1.073**</td>
<td>-0.434*</td>
<td>-0.559*</td>
<td>0.254*</td>
<td>-0.278*</td>
<td>-1.043**</td>
</tr>
<tr>
<td>trans</td>
<td>-3.747**</td>
<td>-0.518*</td>
<td>-1.023**</td>
<td>0.976**</td>
<td>0.136**</td>
<td>2.816**</td>
</tr>
<tr>
<td>hous</td>
<td>-0.828*</td>
<td>0.246**</td>
<td>1.801**</td>
<td>-1.301*</td>
<td>-0.181*</td>
<td>1.684*</td>
</tr>
<tr>
<td>fuel</td>
<td>3.021**</td>
<td>-0.378**</td>
<td>-1.273*</td>
<td>-0.354*</td>
<td>-1.699*</td>
<td>-1.373**</td>
</tr>
<tr>
<td>miscs</td>
<td>-1.778**</td>
<td>-0.181*</td>
<td>1.725*</td>
<td>0.362*</td>
<td>-0.115*</td>
<td>-2.302*</td>
</tr>
</tbody>
</table>

*: Significant at 1% **: Significant at 5%

4.1 Welfare Implications

The estimated parameters of the model can now be employed to compute the level of indirect utility from the function given in equation (17) and, hence, expenditure function from equations (18), with and without the tax reform, where the tax reform means a uniform tax rate estimated on the basis of (19) for all the commodities. The results are presented in Table 6, which show that there is almost 9.48% reduction in total expenditure to get the same level of welfare if the existing tax structure is replaced by uniform taxes that yield the existing level of total tax revenue. The required uniform tax rate according to these results is around 16%\(^5\). Thus the tax reform as proposed amounts to a substantial welfare gain as measured in terms of consumer surplus.

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\(^5\) Value added taxation system with uniform tax rates are generally preferred on administrative grounds. This system was declared as anew sales tax in Pakistan from the 1\(^{st}\) January 2010. However, it could not be implemented in its full spirit due to some political reasons.
Similar results have been reported by some other studies. For example, Fukushima and Hatta (1989) shows a 3% gain in welfare by imposing uniform tax rather than optimal tax in the case of Japan. The study also argued that the uniform tax structure is also closer to an optimal tax system. Hatta (2004) also concludes that the loss of welfare is less in the case of uniform tax rate structure. Asano and Fukushima (2006), using Japanese data, also show empirically that the optimal tax structure is close to uniformity. These results are also consistent with the findings of studies on optimal tax under revenue constraint. For example, Dahl et al. (1994) is reported small welfare loss 0.005% under the optimal tariff as compared to uniform tax regime in the case of Cameroon, and Mitra (1994) reported is 0.05% loss of welfare in the case of India.

5 Conclusion

This paper uses pooled time series and cross sectional data for the years 1984-2008, taken from HIES to estimate consumer demand system for Pakistan and draw quantitative implications of replacing the existing tax structure by a uniform tax package in which the total tax collection remains unchanged. The study employs AIDS to estimate the demand equations for six composite commodity groups: food, tobacco & beverages, textile & footwear, transport & communication, rent & housing, fuel and lighting and miscellaneous. The AIDS is estimated using the iterative Zellner efficient procedure with adding-up, homogeneity and symmetry conditions imposed.

The estimated demand system met all the theoretical restrictions and produced plausible parameter estimates. In particular all the expenditure elasticities are positive and all the own-price elasticities are negative with reasonable magnitudes. Even though signs and the magnitudes of the some parameters estimates do not meet the priori expectations, none contradicts the theory. All the six composite goods have negative own-price uncompensated elasticities measured around the mean.

The uniform tax package as discussed above has interesting welfare implications. Our results indicate that the welfare gain from replacing the existing tax structure by uniform tax system is quite substantial. This welfare gain is measured as the compensating variation in total expenditure while moving between the existing and the proposed tax systems. The welfare gain estimated is equivalent to almost 10% reduction in total expenditure of an average household.

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