WELFARE CONSEQUENCES OF A RECENT TAX REFORM IN MEXICO

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Resumen: El trabajo evalúa dos recientes reformas a los impuestos indirectos en México realizadas en 1995 y 1998, centrando la atención sobre su impacto en el bienestar social y el de los hogares. El análisis empírico se basa en la estimación del llamado sistema casi ideal de demanda, en su correcta versión no-lineal, y mediante el empleo del método generalizado de momentos.

Abstract: This paper evaluates the indirect tax reforms that took place in Mexico in 1995 and 1998, focusing on their impact on welfare at the household and social levels. The empirical analysis is based on the estimation of an Almost Ideal Demand system, using its correct nonlinear version and by means of the generalized method of moments.

1. Introduction

This paper assesses the impact of two indirect-tax reforms that took place in Mexico in 1995 and 1998. The empirical analysis is based on the estimation of a complete demand system using the 1994 income and expenditure survey *ENIGH*, an acronym for *Encuesta Nacional de Ingreso y Gasto de los Hogares* published by the National Statistics an Geography Institute

(INEGI, 1996). As such, this paper follows the empirical analyses presented in King (1983) the pioneer paper, as well as in Baccouche and Laisney (1990), Kaiser and Spahn (1989), Labeaga and López (1996), and Patrizi, Rizzi and Rossi (1991), for, respectively, the English, French, German, Spanish and Italian economies.

The demand model used in this paper is the Almost Ideal Demand (AID) system of Deaton and Muellbauer (1980), in its original nonlinear version (the only one that should be used for our purposes, as we will try to argue below). The fact that the model is a fully nonlinear demand system, and that expenditures can be zero for some goods, raises, in turn, some interesting econometric issues. These are also discussed in the paper. In particular, some arguments are given as to why the generalized method of moments (GMM) is the preferred method of estimation for nonlinear demand systems.

After estimating the model, the impact of the tax reforms at the household level is assessed using the equivalent variation function. Furthermore, an appraisal of the reforms in terms of social welfare is also provided using Atkinson's approach (1970). It should be stressed that an implicit assumption in these welfare assessments is that changes in the indirect taxes are fully passed on from the firms to the consumers; that is, we will implicitly assume that there is no monopoly power in the production sector. Although clearly unrealistic, that simplification can be somewhat justified in the case of small open economies. Also note that, due to the lack of data, the paper does not consider any changes in government transfers that may have taken place after the tax reform.

The content of the paper is as follows: The next section presents information on the cross-sectional data set to be used, as well as on the most recent changes in the Mexican indirect-tax system. Section 3 introduces the demand system, warns about some possible errors in its specification, reviews the problem that arises in the case of zero expenditures, suggests the use of GMM as the most appropriate estimation method, and presents the estimated system. Using the results thus obtained, section 4 assesses the welfare consequences of the tax reforms. Finally, section 5 concludes suggesting some directions for future research.

2. The data set

Our study is based on the income and expenditure survey of 12,815 Mexican households made by the government in 1994 (INEGI, 1996). Our actual

sample size is 12,696, since not all households reported expenditures on the goods to be considered here.[1] Note that the survey was taken a few months before the economic crisis that started at the end of that year. This is one of the reasons for not using a more recent survey, taken in 1996, since in 1966 most households were still recovering from a pronounced recession that lasted five quarters (an economic depression in technical terms). But there is still a more important reason for using the older survey: in what follows, we treat the indirect tax reforms that took place in 1995 and 1998 as a single reform, and so we need observations prior to both tax changes.

The structure of *ENIGH* is quite standard. It includes several socio-demographic variables, together with an assessment of net monthly income (including non-monetary income). On the expenditure side, the survey covers all non-durable goods, many durables, auto-consumption of non-durables (consumption of goods that were household-produced), and some financial transactions. Out of all those observations, we consider here the data set described in table 1.

As can be appreciated from that table, we aggregate a large number of consumption goods to obtain just four composite goods. Two main reasons can be given to justify that aggregation procedure. First, since we want to consider the possibility, hitherto unexplored in the literature as far as we know, of estimating the full nonlinear system by GMM, it is very important to keep the dimensions of the problem as small as possible. The second reason is that our aggregation procedure is consistent with the differential treatment accorded by Mexican tax laws to both the value added tax (VAT) and excise taxes at the federal level.[2]

More explicitly, the indirect tax reform that we analyze here began to take place in 1995, when the federal government decided to increase the general VAT rate from 10% to 15%. The reason behind that policy was simply the need to raise more revenue during the economic crisis that began at the end of 1994. Given the success of this measure in increasing revenue, in 1998 the government attempted to levy the general VAT rate on consumption goods that were, and still are, taxed at a zero rate (mostly

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[1] We also eliminated all the reported expenditures for which there was no quoted price. Finally, we also discarded a household, with folio number 42270100, that did report expenditures, albeit somewhat randomly, but no income.

[2] A general review of the Mexican tax system is given in Urzúa (2000a).

Table 1
Composite goods in the demand system

Key	Composite goods	Tax rates in 1994	Tax rates after reform (1995 & 1998)	Items included according to ENIGH-95 code
w_1	Cereals, vegetables fruits, non-processed meat, dairy products, eggs and fats[a]	0% VAT	0% VAT	A001-004, A007-008, A011-013, A015, A017, A019-020, A022-040, A049-055, A060-082, A085-111, A116-118, A121-142, A146-147, A149-150, A152, A156-158, A176, A184-185, A187, A191
w_2	Processed food, clothing, footwear and appliances	10% VAT	15% VAT	A005-006, A009-010, A014, A016, A018, A021, A041-048, A056-059, A083-084, A112-115, A119-A120, A143-145, A148, A151, A153-155, A159-175, A177-183, A186, A188-190, A192-193, A204-207, H001-H065, I001-I026
w_3	Beer, other alcoholic beverages and tobacco	10% VAT and excise tax of 22%, 44.5% and 79%, resp.[b]	15% VAT, and excise tax of 25%, 60% and 85%, resp.	A194-203, A208-210
w_4	Medicines	0% VAT	0% VAT	J004, J011, J018, J024, J029-J036

[a] Non-processed food. It also includes water, sugar, salt and coffee. Items A067-077 were classified as processed food after ther reform.
[b] Typical excise tax rates. The quoted excise tax rate for cigarrettes (79%) was the one effectively prevailing in November 1994.
[c] The zero VAT rate applies only to patent medicines.

goods that are considered to be primary necessities). However, after a bloody political fight among the representatives of the main party and the opposition parties, the authorities decided to increase instead several excise rates. As a summary of all those changes, table 1 also includes information about the tax rates before and after the reform.

Several more comments are in order to justify the choice of aggregate consumption goods made in that table. To start with, the lack of price information in the case of most durables and services made us discard them in our study. Thus, we will implicitly assume in what follows that the marginal rate of substitution among the goods considered in the study is independent of the consumption of durables and semi-durables.

Furthermore, because of the static nature of the model used here, we also excluded savings and all other financial transactions, as well as the goods that were not bought in a market. Although auto-consumption could be in principle an important component in the consumption pattern of rural income groups in particular (and this is only a hypothesis to be explored in the future), traditional demand models, such as the one that we are using here, cannot, for obvious reasons, accommodate this behavior.

As a final comment, before closing this section, note that all demand systems should be enriched in principle by the inclusion of socio-demographic variables. These are obviously important, especially in studies that are based on the consumption patterns of households rather than of individuals. In particular, the size of each household, the number of children and the level of education of each member may turn out to be relevant factors in explaining consumption patterns. In fact, Heien, Jarvis and Perali (1989) and Urzúa (1994) have already documented the importance of using key socio-demographic variables to explain consumption patterns in Mexico. In our case, however, the need to keep the number of parameters as small as possible, due to the estimation reasons given before, forced us to keep those variables out of our model.

3. The econometric model and some estimation issues

We turn now to the specification of the demand model to be used here, the nonlinear AID system. Given its popularity, and its reasonable properties, there is no need to defend its use in this paper (but see the final section). For each household h (= 1,...,H), assume that the budget share spent on the composite good i (= 1,...,n), denoted by w_i, is of the form

$$w_i = \alpha_i + \sum_{j=1}^{n} \gamma_{ij} \log p_j + \beta_i \log(y/P) + \varepsilon_i \tag{1}$$

where p_j is the price of good j, y is total expenditures on the composite goods, the logs are natural logarithms, and P is a price level index given by

$$\log P = \alpha_0 + \sum_{k=1}^{n} \alpha_k \log p_k + \frac{1}{2} \sum_{j=1}^{n} \sum_{k=1}^{n} \gamma_{kj} \log p_k \log p_j. \tag{2}$$

Note that the model given in (1)-(2) is a *bona fide* demand system provided that the following restrictions on the parameters are fulfilled:

$$\sum_{i=1}^{n} \alpha_i = 1, \ \sum_{i=1}^{n} \beta_i = 0, \ \sum_{i=1}^{n} \gamma_{ij} = 0, \tag{3}$$

$$\sum_{j=1}^{n} \gamma_{ij} = 0 \tag{4}$$

$$\gamma_{ij} = \gamma_{ji} \tag{5}$$

The restrictions in (3) are needed to satisfy adding-up, since the budget shares given in (1) have to add to one. Equation (4) is required to ensure homogeneity in each demand function. Finally, (5) is needed to assure symmetry in the corresponding Slutsky matrix. This last condition, it should be observed, involves restrictions across the system, and hence cannot be implemented, at least in a natural way, if the estimation method is a single-equation technique (which, in any case, would be inefficient).

Other remarks about the model are worth making at this point. To start with, the model described in equations (1)-(5) implies that prices vary across households. Although several studies similar to ours tend to use the simpler linear expenditure system with no variation in prices, such simplification does not seem to be justified when, as is usually the case, the data on goods is aggregated. This is because the implied price for each composite good does not have to be the same across households, unless the composition of expenditures is exactly the same.[3]

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[3] In this paper, the implied prices were constructed as the geometric mean of the prices involved, using as weights the relative expenditures.

It should also be noted that, in most of the applied literature that makes use of the AID model, the price index P defined in (2) is usually replaced by a simplified price level that does not contain any parameters. By doing that, one can circumvent the need for a nonlinear estimation of the full system. To that end, most applied researchers, following a suggestion already made by Deaton and Muellbauer (1980), use Stone's price index:

$$\log P = \sum_{j=1}^{n} w_j \log p_j$$

The simplicity of the resulting linear model comes, however, at a great cost. To start with, the restrictions stated in (3), (4) and (5), do *not* make the corresponding linear model theoretically consistent (see, e.g., Chen, 1998). Furthermore, as shown by Buse (1994), not only would the standard SUR estimators of the parameters in the linear case be inconsistent, but also consistent instrumental variable estimators can not ever be constructed. Finally, we add here that since all subsequent welfare exercises have to be based on the indirect utility functions underlying the original model, the use of such an approximation would certainly bias the final results.

Leaving for a moment the issue of the demand system to be used, there is still another problem that must be faced in studies such as ours; namely, the fact that some households could have zero expenditures for some goods. Several reasons could justify this behavior: non-interior solutions for the underlying utility maximization problem, infrequency of purchase, which is exacerbated by the fact that most surveys cover a very short period of time, or, finally, the no participation altogether of some households in the consumption of some goods. To give an idea of the magnitude of the problem in our case, table 2 presents the percentage of non-zero expenditures among the composite goods considered in this study. As can be observed, these percentages are not as high as we would like them to be. In particular, in the case of tobacco and alcoholic beverages the percentage of non-zero expenditures seems, a priori, *too* low (this finding suggests that the expenditures on some goods are underestimated by the survey).

Many different techniques have been suggested in the literature to deal with the zero-expenditure problem. The incorrect solutions range from the plainly wrong procedure of dropping the observations for which there are zero expenditures (which would induce a sample selection bias), to the artificial device of continuing to aggregate goods until the problem disappears.

Table 2

Percentage of households making non zero expenditures

Key	Composite goods	Percentage
w_1	Cereals, vegetables, fruits, non-processed meat, dairy products, eggs and fats	97.0
w_2	Processed food, clothing, footwear and appliances	96.2
w_3	Beer, other alcoholic beverages and tobacco	16.8
w_4	Medicines	55.2

The more sensible approaches vary according to the presumed source of such zeros. In particular, if they arise because of corner solutions rather than of infrequency of purchase or misreporting, it is natural to use standard tobit analysis. Jarque (1987) and Urzúa (1994) provide examples of the use of that technique in the case of the Mexican economy. There are, however, two problems with that approach: First, the few studies that examine at the data level the zero expenditure problem typically report that the most common explanation for that behavior is infrequency of purchase, rather than corner solutions (see, for instance, Labeaga and López, 1996). But the second problem is almost as important: the tobit method is quite cumbersome to apply in the case of nonlinear and full demand systems. Fortunately, if the reason for a zero expenditure is infrequency of purchase, Keen (1986) has suggested a simple way to evade the problem. Noting that consistency can be assured by choosing an appropriate instrument for total expenditures, Keen suggests using the true income reported by each household. We follow here that suggestion.[4]

The third and final issue that we have to face before estimating the nonlinear model revolves around the most efficient way to accomplish just that. Among the available estimation methods for our full demand system,

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[4] Although, as noted by an anonymous referee, the causes for zero expenditures on tobacco may be non consumption instead of infrequency of purchase. Note, however, that the corresponding composite good also includes alcoholic beverages, so that, unless we separate the two categories of goods, it would not be easy to determine the main reason for zero expenditures.

the only reasonable choices seem to be: nonlinear three stage least squares,[5] full information maximum likelihood estimation, and the generalized method of moments. Regarding the first, its assumption of homoskedasticity of the residuals in each equation is unduly restrictive. On the other hand, the method of maximum likelihood imposes the assumption of multivariate normality (or small departures from it) on the errors, another untenable hypothesis for cross-sectional data such as ours.[6] Thus, the GMM estimation method seems to be the most sensible choice (see also the forceful arguments in Davidson and MacKinnon, 1993). Surprisingly enough, aside from this work, there does not seem to be any other instance of applying GMM to estimate the full, nonlinear AID system.

Taking into consideration all the remarks given above, we now proceed to estimate the model described by equations (1) to (5). Given the large dimensionality of the unrestricted demand system, we decided to impose from the beginning restrictions (3)-(5). Thus, by the first condition in (3), we can drop one of the behavioral equations in the system. It should be noted, however, that in this demand system, as in all others, the final estimation results *do* depend on which equation is chosen to be dropped. We choose to drop the equation describing consumption of medicines ($i = 4$), since the tax increases that took place during the reform did not affect these items. Making use now of all the restrictions of the demand system, there are only thirteen parameters left to estimate. This is so because all the coefficients for $i = 4$ in equation (1) are implied by (3)-(4), and also the value of three other gammas is implied by (5).

On the other hand, there are fifteen moment conditions to be fulfilled by the corresponding GMM estimators:[7]

$$E\{\varepsilon_i\} = 0 \qquad\qquad i = 1, 2, 3,$$
$$E\{\varepsilon_i \log y^*\} = 0 \qquad\qquad i = 1, 2, 3,$$
$$E\{\varepsilon_i \log p_j\} = 0 \qquad\qquad i, j = 1, 2, 3,$$

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[5] Given the need for using an instrument for total expenditures, the SUR estimation method cannot be used here.

[6] In a preliminary examination of the data, not reported here, the ALM test for multivariate normality (Urzúa, 1997) was used for each of the budget shares. In all cases, the hypothesis of normality was overwhelmingly rejected.

[7] Note that, as was recommended before, we do not impose any constraints on the second moments of the residuals.

where y^* is reported income (following Keen, 1986), and

$$\varepsilon_i = w_i - \alpha_i - \sum_{j=1}^{n} \gamma_{ij} \log p_j - \beta_i \log(y/P) \quad i = 1, 2, 3, \qquad (6)$$

where the coefficients in (6) can be expressed, using (3) to (5), only in terms of the thirteen parameters to be estimated.

The problem given above was solved using the GMM subroutine written in GAUSS by Roncalli (1996), which in turn, uses White's variance-covariance matrix as its weighting matrix.[8] Although the numerical GMM procedure was quite slow in our case, it seems to have been robust (several trials with different initial conditions lead to the same outcome). The results were satisfactory: eleven coefficients were highly significant, and the statistics value for Hansen's test of over identifying restrictions was around 274 (with a P-value of less than 10^{-5}).

Although the coefficients are not informative by themselves, the corresponding elasticities can be derived after taking expectations on both sides of equation (1). In particular, after some simple algebra, the income elasticity of each good is found to be:

$$\eta_i = 1 + \frac{\beta_i}{E\{w_i\}}$$

where the population moment can be estimated by its sample moment. Likewise, the uncompensated price elasticities can be shown to be:

$$\eta_{ij} = -\delta_{ij} + \frac{\gamma_{ij}}{E\{w_i\}} - \frac{\beta_i}{E\{w_i\}} \left(\alpha_j + \sum_{k=1}^{n} \gamma_{kj} \ln p_k \right)$$

where δ_{ij}, Kronecker's delta, equals one when the subscripts coincide, and it is zero otherwise.

Using the last two equations, table 3 presents the estimated income and own-price elasticities. As can be appreciated from there, our results suggest that, out of the four composite goods, non-processed food and medicines can be considered as necessities, while processed food and clothing, as well as alcoholic beverages and tobacco, can be considered as luxuries. Another

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[8] As mentioned earlier, our sample consists of data for 12,696 households. Note that, merely for computational reasons, we did not use the expansion factors given in the survey to enlarge the sample to represent all the Mexican households. In a social welfare exercise given in the next section we do use such factors.

plausible result that is implied by table 3 is that the composite good made by alcoholic beverages and tobacco is more price-inelastic than the rest. Finally, note that the above expressions for the income and price elasticities are *exact*. By using the nonlinear AID system from the beginning, we can thus avoid the ad-hoc corrections to the elasticities necessary in the case of the linear AID model (a hopeless task, as shown by Buse, 1994).

4. Welfare impacts of the tax reform

Having estimated the demand system, we now proceed to assess the welfare impact of the Mexican indirect tax reform described in section 2. Although there are several empirical approaches available in the literature to accomplish that end (see Slesnick, 1998, for a good review), here we follow the orthodox methodology, first laid down by King (1983), which has become the norm for almost all studies on the subject.

Table 3
Estimated elasticities

Income Elasticities	e_1	e_2	e_3	e_4
	0.891	1.068	1.042	0.877
Own-Price Elasticities	e_{11}	e_{22}	e_{33}	e_{44}
	−0.717	−0.921	−0.367	−0.849

The key steps of what follows revolve around the so-called equivalent income function, which plays the role of a monetary measure of the households welfare. More precisely, for a given household h (= 1,...H), let $v(\mathrm{p}, y)$ denote the indirect utility function derived from a vector of prices p and an income y. Under a reference price vector p^R, and given the budget constraint determined by any (p, y), the equivalent income, denoted in what follows by y_E, is defined as the income required to attain the same utility level under the reference price vector. Thus, it is implicitly defined as:

$$v(\mathrm{p}^R, y_E) = v(\mathrm{p}, y)$$

or, using the expenditure function, it is explicitly given by:

$$y_E = e(\mathrm{p}^R, v(\mathrm{p}, y))$$

Since the nonlinear AID system is originally derived through the expenditure function, it is not difficult to show that in our case the corresponding equivalent income function is given by:[9]

$$\log y_E = \log P^R + \prod_{j=1}^{n} (p_j^R/p_j)^{\beta_j} \log(y/P) \tag{7}$$

where P^R and P are the price levels corresponding to the vectors of prices p^R and p faced by the household. It should be noted in passing that equation (7) implicitly assumes that, as it is done here but not in the vast majority of the papers on the subject, the AID system has been estimated using its nonlinear version.

Turning to the specific problem on hand, let p^b be the vector of final prices, faced by each household, given the VAT rates and excise taxes that prevailed before the tax reform (see again table 1). Also, let y^b be the household's income (which, it should be recalled, is proxied here by total expenditures). Furthermore, let p^a be the vector of final prices after the tax reform, and let y^a be the corresponding income. For each household, the welfare change arising from the tax reform can be then estimated, among other ways, by the so-called equivalent gain:

$$EG_h = y_E^a - y^b \tag{8}$$

which is the difference between the equivalent income after the tax reform, calculated using pre-reform prices as the reference prices, and the income before the reform (since, given the reference prices, it is also the pre-reform equivalent income).

Using the results in table 3, we now proceed to estimate, using (8), the welfare impact of the tax changes for each of the households. It should noted that, since the reform considered here is not revenue neutral, obviously all households lost after the increase in the indirect tax rates described in table 1. The interesting question, however, is which income groups lost most after the reform. Table 4 answers this question by showing the distribution by deciles of the equivalent losses arising from the increase in the indirect tax rates. As can be seen there, the losses are the highest for the

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[9] This follows from King (1983, p. 210), after correcting an obvious misprint in that paper.

upper-income groups. This is a plausible result, given that the tax reform left untouched most of the basic commodities.

Table 4
Distribution of losses, by deciles of original income
(1994 pesos)

Decile	Mean original (equivalent) income	Mean equivalent losses	Percentage of equivalent losses
1	39.56	0.79	2.00
2	96.29	2.49	2.59
3	151.92	4.25	2.80
4	213.79	6.20	2.90
5	285.79	8.52	2.98
6	372.08	11.36	3.05
7	486.90	15.18	3.12
8	658.97	20.98	3.18
9	940.29	30.88	3.28
10	2078.77	72.15	3.47

Note: "Income" corresponds here to total expenditures on the composite goods.

As a complement to those estimations, we can also try to address the welfare effects of the tax reform from a social point of view. Following Atkinson (1970), and most of the subsequent literature on the subject, this can be achieved by means of an indirect social welfare function that depends on the income of all the households in the survey: $W(y_1,...,y_H)$.[10] In particular, we posit a function of the form:

$$W(y_1,...,y_H) = \sum_{h=1}^{H} \frac{y_h^{1-\mu}}{1-\mu}$$

In this equation, an increase in the aversion to social inequality is captured by increasing the parameter μ (note that the function becomes a sum of natural logs when $\mu = 1$). Furthermore, the expansion factors of the survey *ENIGH* can be used to account for all Mexican households.

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[10] As stressed by Banks, Blundell and Lewbel (1996), among others, the use of this indirect welfare function can be only considered as a rough approximation. See Urzúa (2000b) for an example, in a different context, of the use of truly Bergsonian welfare functions.

Following Atkinson, let us now define the equally distributed level of equivalent income as the one that would produce, if shared equally, the same social welfare level as obtained by the actual distribution of equivalent income:

$$W(\tilde{y}_E,...,\tilde{y}_E)=W(y_{E1},...,y_{EH}).$$

Having calculated that number, we can then define the index of inequality as:

$$IN=1 - \tilde{y}_E / \bar{y}_E, \text{ where } \bar{y}_E = \sum_{h=1}^{H} y_{Eh}/H.$$

This index can be computed before and after the reform, taking care to use the same reference prices across households when calculating equivalent incomes. Since in our case there is price variability, we take as reference prices the means across households.

It should be noted that such an index, by itself, is not very informative, since it does not take into account the direct impact of the reform on incomes. In order to have an overall measure, we follow King (1983) in defining the proportionate social gain (or loss) from the tax reform as:

$$\lambda = \bar{y}_E^{a}(1-IN^a) / \bar{y}_E^{b}(1-IN^b)$$

In words, the proportionate social change takes into account the variation in mean equivalent income, after adjusting for the change in inequality. The results thus obtained are presented in table 5. Since an increase in the parameter μ represents an increase in the aversion toward social inequality, the results in that table suggest that the tax reform caused lower social losses the higher the inequality aversion is for the Mexican society as a whole.

Table 5
Proportionate social losses

Parameter of inequality aversion	Proportionate social losses
0	1.0336
0.5	1.0326
1	1.0314
2	1.0274

5. Possible extensions to the model

Aside from the potential extensions already commented on in this the paper, many other improvements can be made to this study. To start with, one has to contrast the results obtained here with the ones that would result from the inclusion of more variables, such as socio-demographic controls, or goods that are more disaggregated (e.g., as noted earlier, tobacco and alcoholic beverages). Another interesting avenue for further research is to use richer models, such as the system that allow for quadratic Engel curves proposed by Banks, Blundell and Lewbel (1997). Also, simpler models, such as the linear-expenditure system, can take into account the consumption of goods that don't exhibit cross-sectional variation in prices (such as gasoline), and have the added advantage of being very easy to estimate. Another alternative would be to estimate the demand system for different income groups, since one can surmise that the fits may vary as the mean income is changed.

In our judgment, however, the most important extension would consist on the inclusion, in this type of empirical framework, of the production sector. Although there have been attempts to do so in the literature (the pioneer work along that vein is Jorgenson and Slesnick, 1985), all of them are based on the simultaneous use of econometric systems and applied general equilibrium models, two techniques that, in our view, don't mix well.

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