Demand responses to changes in consumer prices in Mexico: lessons for policy and an application to recent tax reforms

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Abstract:

When prices change, consumers can respond by changing their spending patterns. In this paper, we estimate and utilise a consumer demand model of the Quadratic Almost Ideal (QUAIDS) form to analyse consumer demand in Mexico, and to explore some implications for indirect tax policy. The model covers virtually all categories of spending and is estimated using household expenditure and demographic data from the 2008 *Encuesta Nacional de Ingresos y Gastos de los Hogares* (ENIGH), and consumer price information from city-region price indices constructed by the *Banco de Mexico*. Estimated price elasticities and income elasticities are of plausible magnitude and sign. A simple test of separability between goods demand and leisure is rejected, and the implications for which goods should be taxed more than average and less than average are discussed, although the analysis is tentative and actual rates and potential welfare gains cannot be quantified. The demand model is also used to simulate the effects on welfare, spending patterns, and revenues of the initial proposals for reform and the approved changes to indirect taxes implemented in 2010. Accounting for behavioral change is seen to have a notable effect on estimates of revenues but little impact on the size or distribution of welfare effects for households.

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1. Introduction

Analysis of the distributional and welfare costs of indirect tax reforms or price changes often makes use of first-order approximations that do not account for the potential for consumers to substitute between goods as relative prices change (Banks et al (1996)). This generally leads to an over-estimate of the welfare effects of tax changes in applications of the standard methodology. A proper understanding of the welfare and behavioral impact of indirect taxes is particularly important in Mexico as, in the medium-term, the country requires a significant increase in its tax take to fund additional social and infrastructure spending and to offset declining oil revenues. An increase in the rate or coverage of VAT is likely to play a significant role in such an overall tax increase.

In this paper we implement a demand model for Mexico of the Quadratic Almost Ideal (QUAIDS) form (Banks et al (1997)) that allows us to take into account the substitution possibilities that exist when relative prices change following tax reforms. The model is estimated using household expenditure and demographic data from the 2008 *Encuesta Nacional de Ingresos y Gastos de los Hogares* (ENIGH), and consumer price level information from city-region price indices constructed by the *Banco de Mexico*. The use of official figures on prices instead of unit values derived from expenditures and quantities recorded in household surveys is a first for Mexico and significantly lessens the likelihood that observed price variation instead reflects variation in quality. To the best of our knowledge, this is also the first published integrable demand system covering all goods and services in Mexico with a detailed breakdown (into 10 categories) for non-food expenditure. Categories of expenditure are chosen so that they reflect not only functional groupings (e.g. food, transport, personal goods and services, leisure) but also reflect goods and services subject to different rates of VAT. This means the model is well suited to use in the analysis of certain aspects of indirect tax policy. Estimated price and income elasticities appear plausible in magnitude and sign. For instance, food on which no VAT is levied is found to be a necessity whilst food on which VAT is levied (including restaurants and fast food) is found to be a luxury. Other goods which are strong luxuries include private transport and vehicle fuels, leisure and hotel services, and other services.

Our demand model is integrated with a simple tax simulator for Mexico called MEXTAX (Abramovsky et al (2010, 2011)). Hence, we are also able to use it to estimate how consumers respond to changes in VAT and excise duties and the implications of this for consumer welfare and tax revenues. As an example, we examine both the proposed introduction of a 2% uniform expenditure tax and the approved 2010 increase in the rate of VAT in Mexico from 15% to 16% and increases in some excise duties (full details of these reforms can be found in the Appendix) as well as the application of the standard rate of VAT (15%) to all goods and services. We find that allowing for behavioral response makes some difference to estimates of the revenues obtained from tax reforms, but that it changes little estimates of the welfare cost of taxation relative to the first order approximation holding behavior fixed.

Atkinson and Stiglitz (1976) show that complementarity of demand for some goods with leisure and others with work allows the efficiency costs of taxation in general to be reduced by varying the rate of indirect taxes such as VAT across goods. Therefore, we use our demand model to test for the separability of leisure and the demand for goods and services in Mexico, and see the extent to which the existing set of VAT exemptions and zero-rates align with those that should

have lower rates of VAT for efficiency reasons. We strongly reject the assumption of separability between leisure and demand for goods and services and find evidence that the existing set of exemptions and zero-rates does not always align well with those goods that would optimally have lower than average rates of VAT.

The rest of this paper proceeds as follows. Section 2 provides a brief literature review, covering demand systems estimated in Mexico and Latin America more generally, and their use in the analysis of VAT systems in developed economies. Section 3 provides details on our demand model, the data used to estimate it, and the estimated price and income elasticities. Section 4 presents an analysis of the 2010 indirect tax reforms – both as initially proposed and subsequently approved – and a uniform VAT rate of 15% on all goods and services and analyses the extent to which incorporation of our demand model affects results. In section 5 we use the demand system to assess separability between consumption and leisure and examine the extent to which the existing VAT rate structure accords with the implications of our findings for the way in which VAT rates should differ across goods. We also, briefly, discuss the shortcomings with this method in the context of tax evasion and informality. Section 6 concludes.

2. Previous literature

The literatures on consumer demand and indirect tax reform are voluminous. Hence, rather than attempt to summarise these, we focus more narrowly on existing demand systems in Mexico and elsewhere in Latin America, and the development of micro-simulation tools in Mexico. We also briefly highlight links between this work and recent work in the United Kingdom.

Whilst the demand system estimated in this paper is the first for Mexico covering (nearly) all goods and services and providing a detailed breakdown of non-food expenditure, it follows a number of demand systems covering certain types of goods or services, or employing a greater degree of aggregation. For instance, Chávez Martín del Campo and Villarreal Páez (2008) develops a QUAIDS model covering: (1) meats, dairy and eggs; (2) grains, beans and root vegetables; (3) fruits, vegetables and pod vegetables; (4) other food products; and (5) all other non-food non-durable goods. This is used to carry out simulations of the impact of food price increases on consumer welfare and poverty rates using ENIGH as the source of expenditure, demographic and price data. Unfortunately, the income and price elasticities from this model are not published. Attanasio et al (2009) investigates the same issue, also using QUAIDS, but models only food demands (using 8 categories), assuming separability between the demands for food and other spending. They also simulate how simple transfers and price subsidies could ameliorate the effect of food price rises, finding transfers to be less distortionary and more progressive than subsidises.

Asano and Fiúza (2003) estimate a modified Almost Ideal Demand System for Brazil and aggregate expenditure into 7 categories: (1) food; (2) housing; (3) furniture and appliances; (4) clothing; (5) transport and communication; (6) health and personal care, and; (7) personal expenses, education and books. Prices for these categories are constructed from regional price indices produced by the Brazilian authorities. This combination of reasonably disaggregated non-food categories and use of official prices means the demand system of Asano and Fiúza is the most similar to ours for Latin America. However, unlike the model that is estimated and

utilised in this paper, the categories of goods do not align with the tax treatment of different goods and services, nor is it utilised for the analysis of indirect tax policy.

Analysis of indirect taxes in Mexico is a central part of a small but growing literature on tax micro-simulation models. For instance, under its former director, Héctor Villarreal, the *Centro de Estudios de las Finanzas Públicas* (CEFP) developed a number of micro-simulation models for various taxes and used them to analyse proposed and actual tax reforms (CEFP (2009a,b,c,d,e,f)). Similarly, a tax micro-simulator was developed under the auspices of the United Nations Development Programme by Carlos Absalón and Carlos Urzúa (Absalón and Urzúa (2009a,b and 2010)). Both models cover VAT and duties but unlike MEXTAX, the model used in this paper, they do not incorporate a demand system and so cannot account for the behavioral impact of tax reforms. Both models are applied to the 2010 reforms to indirect taxes which are found to be broadly progressive, whilst the initial proposals for reform are found to be distributionally neutral or slightly regressive. One contribution of our paper is to look how the results of analysis of these reforms changes when a demand model is used in conjunction with the tax micro-simulation methodology.

This paper also has links to the literature on the design of optimal indirect tax systems. In particular, section 5 applies the methods used in Crawford, Keen and Smith's (2010) analysis of structure of UK VAT rates which uses a conditional QUAIDS model to ascertain which goods and services should be subject to high or low VAT rates. They find that cross-price effects are an important determinant of this pattern meaning that some goods which are substitutes for work and which we might imagine should be taxed more heavily to encourage work, should actually be taxed less heavily, and vice versa. However they emphasise that the size of the gains from such optimal variation in rates may be small and may not outweigh the administrative and compliance burdens associated with multiple rates of VAT.

3. The consumer demand model, data, and elasticities of demand

3.1 The Quadratic Almost Ideal Demand System

The demand system used in this paper is the non-linear QUAIDS developed in Banks, Blundell and Lewbel (1997). It is a generalisation of the Almost Ideal Demand System (AIDS) model that allows for quadratic Engel curves. The rank 3 QUAIDS can therefore allow a good to be a luxury at one level of income and a necessity at another, a property Banks, Blundell and Lewbel find to be of empirical relevance. The model assumes that the utility obtained from any particular good is not affected by the amount one works and therefore demand for goods is also unaffected. Furthermore, it does not allow for positive or negative externalities from expenditure on certain goods (for instance fuel, alcohol and tobacco). The first assumption of separability of goods demand and leisure can be tested empirically (see section 5), but the assumption of no externalities cannot be easily altered and is a significant limitation on the usefulness of standard demand models for looking at the welfare effects of excise duties on goods with negative externalities.

QUAIDS is based on the following indirect utility function:

$$lnV = \left\{ \left[\frac{\ln x - \ln a(p))}{b(p)} \right]^{-1} + \lambda(p) \right\}^{-1} \quad \text{(A)}$$

Where x is expenditure, a(p), b(p) and λ(p) are defined as:

$$\ln a(p) = \alpha_0 + \sum_i \alpha_i \ln(p_i) + \frac{1}{2} \sum_i \sum_j \gamma_{ij} \ln(p_i) \ln(p_j) \quad \text{(B)}$$

$$b(p) = \prod_{i=1}^{n} p_i^{\beta_i} \quad \text{(C)}$$

$$\ln\lambda(p) = \sum_{i=1}^{n} \lambda_i \ln(p_i) \quad \text{(D)}$$

where (i=1,..., n denotes a good). Applying Roy's identity to equation (A) gives the following equation for w_i, the share of expenditure on good i in total expenditure is, for each household:

$$\mathrm{w_i} = \alpha_i + \sum_{j=1}^{n} \gamma_{ij} \ln(p_j) + \beta_i \ln\left(\frac{x}{a(p)}\right) + \frac{\lambda_i}{b(p)} \left(\ln\left(\frac{x}{a(p)}\right) \right)^2 \quad \text{(E)}$$

For the resulting demands to be consistent with utility maximisation, the demand system must satisfy four key properties: adding-up; homogeneity; symmetry; and negativity (negative semi-definiteness). The first three can be imposed using linear restrictions on the parameters of the model:

(adding up)

$$\sum_{i=1}^{n} \alpha_i = 1 ; \qquad \sum_{i=1}^{n} \beta_i = 0 ; \qquad \sum_{i=1}^{n} \gamma_{ij} = 0 \; \forall \, j \qquad \sum_{i=1}^{n} \lambda_i = 0$$

(homogeneity)

$$\sum_{j=1}^{n} \gamma_{ij} = 0 \; \forall \, i$$

(symmetry)

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

Negativity cannot be imposed in such a manner but the estimated Slutsky matrix can be tested to see if it satisfies this criterion.

This paper allows for household demographics to affect demands in a fully theoretically consistent manner. Demographics (denoted k = 1,…,K) enter as taste-shifters in the share equations, and to maintain integrability are therefore part of α_i terms in ln*a(p)*:

$$\ln a(p) = \alpha_0 + \sum_i \left\{ \alpha_i + \sum_{k=1}^{K} \alpha_{ik} z_k \right\} \ln (p_i) + \frac{1}{2} \sum_i \sum_j \gamma_{ij} \ln(p_i) \ln (p_j) \quad \text{(F)}$$

$$\mathrm{w_i} = \alpha_i + \sum_{k=1}^{K} \alpha_{ik} z_k + \sum_{j=1}^{n} \gamma_{ij} \ln(p_j) + \beta_i \ln\left(\frac{x}{a(p)}\right) + \frac{\lambda_i}{b(p)} \left(\ln\left(\frac{x}{a(p)}\right) \right)^2 \quad \text{(G)}$$

Which gives us the following new adding-up conditions that supersede $\sum_{i=1}^{n} \alpha_i = 1$:

$$\sum_{i=1}^{n} \alpha_i = 1 \; ; \qquad \sum_{i=1}^{n} \alpha_{ik} = 0 \; ;$$

Having estimated a fully specified demand system, one can estimate the impact of price changes on consumer welfare using the associated expenditure functions. An attractive measure of the welfare impact is the compensating variation (CV): the change in income a household would require in order to make them indifferent between the original price vector (with the original income) and the new price vector. This is calculated as:

$$CV = E(u^*, p^1) - E(u^*, p^0) \quad \text{(H)}$$

where u^* is the original value of the utility index, p^0 is the initial price vector, p^1 is the new price vector and $E(u^*, p^y)$ (y=0,1) is:

$$E(u^*, p^y) = e^{\ln a(p^y) + b(p^y) \left\{ \frac{1}{\ln u^*} \lambda(p^y) \right\}^{-1}} \quad \text{(I)}$$

and where $\ln u^*$ can be calculated using the indirect utility function. Price and total expenditure elasticities are derived and presented in Banks et al (1997).

3.2 Data and estimation

The demographic and expenditure data used in the estimation of our demand model comes from the 2008 ENIGH survey. This is a detailed survey of the demographic and socio-economic characteristics of Mexican households and covers, amongst other things, information regarding net income, expenditure, employment status, and various other demographic characteristics. The survey is conducted every 2 years (and is released for public use in July of the following year), with the 2008 sample consisting of 29,468 households of which 29,429 include responses to all the questions necessary for our model.

Respondents are asked to keep a diary of expenditure of household members on food and public transport during the survey week. They are also asked to estimate their spending on other items during either the past 1 month (for instance, for cleaning products and personal goods), past 3 months (for instance, for clothes and cutlery, crockery and glassware), or past 6 months (for

instance, for housing maintenance and renovations and electronic goods).[1] All expenditures are converted into a monthly equivalent for the purpose of our demand model and tax simulator.

In order to ensure that the model can be feasibly estimated it is necessary to aggregate the very detailed expenditure categories in ENIGH into a significantly smaller number of aggregate commodity groups. These are designed to ensure both that the groups make sense as functional product groups but also to allow for substitution between goods treated differently by the indirect tax system. The 12 categories chosen are[2]:

- Food on which no VAT is levied
- Food on which VAT is levied and meals out
- Alcoholic drinks and tobacco (VAT and duties levied)
- Clothing and footwear (VAT levied)
- Household goods, services and communications (VAT levied, duties sometimes levied)
- Household goods, services and communications (no VAT levied)
- Transport and vehicle fuels (VAT levied, duties sometimes levied but not modelled)
- Public Transport and other transport on which no VAT levied
- Health and Education goods (no VAT levied)
- Health and personal goods and services (VAT levied)
- Leisure and hotel services (VAT sometimes levied)
- Other services

By aggregating goods in such a way, our demand model is suitable for modelling the welfare impacts of changing the rate of VAT and imposing VAT on additional classes of goods. However, this level of aggregation means that we cannot model, for instance, substitution between different kinds of alcoholic beverage when the duties rates on different types of beverages change by different amounts. Whilst this limits the number of questions the existing demand model can be used to assess, we would argue that analysis of very detailed goods categories is best done using bespoke demand systems tailored to the question at hand.[3]

Our estimation strategy makes use of both cross-sectional and time-series variation in prices. The prices (and associated expenditure weights) used to calculate the prices of the aggregate commodities have been provided to us by the *Banco de Mexico* for 46 cities for every month for which we have expenditure information in the 2008 ENIGH. The *Banco de Mexico* also provided data on the city whose prices should be used for each municipality in Mexico with a population of greater than 15,000. The Bank determines these linkages using distance, population size, and other characteristics. Links between the cities and municipalities of less than 15,000 people are not made by the Bank, so in order to make our results representative for Mexico as a whole we assign such municipalities to their nearest city (measured using travel time according to Google maps). This simple method was chosen to ensure ease of replication by other researchers and for future (and past) waves of ENIGH. Results are fully robust to the exclusion of municipalities of less than 15,000 people, however.

[1] Respondents are also asked to record their consumption of home-produced goods and goods and services received as gifts, loans or in-kind remuneration from other households, businesses or government programs.
[2] A full description of the products in each category can be found in table A.2 in the appendix.
[3] For instance, if one wanted to estimate the impact of differential taxation of forms of alcohol and changes in alcohol taxation, one may want as categories the various forms of alcohol, tobacco, non-alcoholic drinks, food-out, food-in, other leisure, and "other goods and services".

To the best of our knowledge, this is the first time that prices constructed by the *Banco de Mexico* have been used in conjunction with expenditure and demographic data from ENIGH to estimate a demand system for Mexico. Previous studies have proxied prices with unit values calculated using expenditures and quantities at the household level as recorded by ENIGH. Using *Banco de Mexico* prices has two benefits relative to this. First, it enables us to include virtually all types of goods and services in the demand system relatively easily. Unit values can be constructed only for those goods for which quantity information is available in ENIGH, restricting the scope of the demand system unless one is willing to make fairly restrictive assumptions about the nature of demand for other goods. Second, variation in unit values can reflect variation in quality as well as price, confounding the estimation of the elasticities of demand with respect to price.[4] This problem is significantly reduced by using *Banco de Mexico* prices. Whilst it is possible that some of the variation in prices across city-regions according to the Bank reflects differences in quality of the items included in the Bank's inflation surveys in different cities, such differences will be much smaller than the differences in quality of goods purchased by different households.

The prices of the aggregated commodities are calculated as weighted arithmetic averages of the prices of the individual goods making up the commodity. Weighted arithmetic as opposed to weighted geometric averages (termed Stone prices) are used because geometric averages assume within-group own price elasticities of -1, which would mean that the welfare costs of changes in indirect taxes would be lower (than when not allowing for behavioral response) by assumption rather than because of the demand system estimates of the potential for substitution between different aggregate commodities.

Included in the share equations and price indices of the model are a number of demographic variables to control for preference variation (which cause spending patterns to differ) or needs that may be correlated with total expenditure, or prices. For instance, households with more children are likely to spend more in total and spend more on items such as food consumed at home, and health and education services. If this was not controlled for, income elasticities of demand for these goods would be upwardly biased. Table 1 provides details of the goods included in the model.

[4] Deaton (1988) and Crawford et al (2003) show how it is possible to overcome this problem in linearised demand models by making two main assumptions. First, that underlying prices are the same for all households within a certain geographical area (or 'cluster'), with any variation in unit values within clusters reflecting quality choice (or measurement error). Second, that the ratios of prices of products of different quality are the same for all clusters. Unfortunately, such techniques are not compatible with the non-linear integrable AIDS or QUAIDS models, meaning that such methods cannot be used when one wants to estimate the welfare as well as behavioral effects of price changes.

Table 1 Demographic variables used in the demand system

Variable name	Description
Demographic variables	
Child	Number of household members under 12 years old
Adults	Number of household members 12 years or over
Sex	= 1 if the head of the household is female, 0 otherwise
Empstat	= 1 if the head of the household is employed, 0 otherwise
Educlow	= 1 if the head of the household has primary education or less, 0 otherwise
Educmid	= 1 if the head of the household has secondary education, 0 otherwise
Central	Households in municipalities associated with the following cities: Cuernavaca, Puebla, Querétaro, Guadalajara, Aguascalientes, San Luis Potosí, Tlaxcala, Morelia, Jacona, Iguala, León, Tepatitlán, Tolouca, Tulancingo, Cortázar
North_interior	Households in municipalities associated with the following cities: Jiménez, Ciudad Juaréz, Chihuahua, Monclova, Monterrey, Torreón, Durango, Fresnillo, Cuidad Acuna
North_coastal	Households in municipalities associated with the following cities: La Paz, Mexicali, Matamoros, Hermosillo, Huatabampo, Tijuana, Culiacán
West	Households in municipalities associated with the following cities: Tepic, Acapulco, Colima
East	Households in municipalities associated with the following cities: Córdoba, Veracruz, San Andrés Tuxtla, Tampico
South	Households in municipalities associated with the following cities: Oaxaca, Tehuantepec, Tapachula, Villahermosa
South_east	Households in municipalities associated with the following cities: Campeche, Chetumal, Merida

Our model is estimated using a 2-step procedure, with standard errors calculated using a clustered bootstrap procedure. Because total expenditure may be endogenous we instrument for it using monetary income. This is done using a control function approach.[5]

Before estimation of equation (F), $a(p)$ and $b(p)$ are unknown. For this reason, $\ln a(p)$ is approximated using the Stone price index

$$\ln p^* \approx \sum_i w_i \ln p_i \qquad (J)$$

and $b(p)$ is approximated as 1. Conditional upon the price indices, QUAIDS is linear in parameters. Hence, a linear Seemingly Unrelated Regression (SURE) framework is used to estimate the model. Adding up is imposed by excluding the equation for the n*th* good from the estimated system of equations; parameters for this equation are calculated using the parameters from the other (n-1) equations and the adding up restrictions. Homogeneity and symmetry are imposed using linear restrictions on parameters.

The parameters estimated in the first stage are then used to calculate values for $a(p)$ and $b(p)$. The model is then re-estimated using the same specification as the first stage except that p^* is replaced with $a(p)$ and λ_i by $\frac{\lambda_i}{b(p)}$. The new parameter values are used to update $a(p)$ and $b(p)$, and the model is then re-estimated for a third time. This updating of price indices and re-estimation is iterated 12 times, by which point the parameter values have converged to 5 decimal places.

[5] That is we regress lnx and $(\ln x)^2$ on the prices and demographic variables included in our demand system and on the log of household monetary income and the square of the log of household monetary income and include cubic terms of the residuals from these regressions in our demand system equations.

Standard errors are calculated using bootstrapping with 500 iterations. We take into account that we use variation in prices across city-regions clusters and draw, with replacement, from within clusters.

3.3 Estimated Elasticities

Full results including demand equation parameters are available from the authors on request. Here we focus on the estimated Hicksian (compensated) price elasticities and the income (or more correctly, total expenditure) elasticities. Elasticities are evaluated at mean prices and total expenditure, and for a representative household with two adults and two children living in the Mexico City region where the head-of-household has a low level of education and is employed. Elasticities significant at the 10% level are highlighted in pale grey, and those significant at the 5% level are highlighted in dark grey.

Table 2 shows the full set of Hicksian price elasticities: own-price elasticities on the diagonal and cross-price elasticities off the diagonal. All own-price elasticities are negative as required by demand theory. Demand for basic foodstuffs on which no VAT is levied is very inelastic, whilst demand for public transport is most elastic. The patterns of substitution and complementarity seem reasonable. Food on which VAT is levied and meals out (2) is a substitute for alcohol and tobacco (3). Leisure and hotel services (11) are a substitute for (3) and private (7) and public (8) transport are also substitutes. Clothing (4) is complementary to (11), possibly reflecting additional demand for clothing when one is holidaying or engaged in leisure activities that require specialist clothing. Generally, cross-price elasticities are fairly small but they are usually highly statistically significant.

The income elasticities are also sensible with all goods found to be normal (i.e. the income elasticity of demand is positive). Food on which VAT is not levied (1) is a necessity whilst food on which VAT is levied and meals out (2) is a luxury. The other strong necessity is public transport, whilst private transport, leisure goods and services and other services are strong luxuries.

Table 2 Hicksian (compensated) price elasticities

Good	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
(1) Food on which no VAT is levied	-0.229	0.039	-0.040	0.051	0.087	-0.002	-0.013	0.069	0.015	0.041	-0.010	-0.009
(2) Food on which VAT is levied and meals out	0.077	-0.847	0.072	0.010	0.255	0.041	0.068	0.122	0.043	0.137	0.011	0.011
(3) Alcoholic Drinks and Tobacco (VAT and duties levied)	-1.762	1.390	-0.744	-0.370	-0.410	0.210	0.343	0.325	0.205	0.172	0.416	0.225
(4) Clothing and footwear (VAT levied)	0.181	0.043	-0.044	-1.049	0.530	0.070	0.125	0.026	0.018	0.063	0.052	-0.014
(5) Household goods, services and communications (VAT levied, duties sometimes levied)	0.199	0.191	-0.018	0.183	-0.886	0.006	0.027	0.083	0.029	0.108	0.059	0.020
(6) Household goods, services and communications (no VAT levied)	0.035	0.254	0.073	0.207	0.031	-1.050	0.065	0.312	-0.004	-0.043	0.168	-0.049
(7) Transport and vehicle fuels (VAT levied, duties sometimes levied but not modelled)	-0.180	0.246	0.058	0.166	0.184	0.041	-0.841	0.051	0.069	0.048	0.154	0.004
(8) Public Transport and other transport on which no VAT levied	0.364	0.286	0.041	0.037	0.223	0.108	0.041	-1.217	0.050	0.112	-0.036	-0.009
(9) Health and Education goods (no VAT levied)	0.204	0.189	0.050	0.030	0.166	-0.001	0.079	0.106	-0.954	0.012	0.085	0.034
(10) Health and personal goods and services (VAT levied)	0.177	0.276	0.018	0.058	0.269	-0.014	0.031	0.094	0.005	-0.934	0.019	0.001
(11) Leisure and hotel services (VAT sometimes levied)	-0.107	0.047	0.108	0.087	0.428	0.140	0.206	-0.075	0.102	0.046	-1.038	0.057
(12) Other services	-0.697	0.360	0.374	-0.214	0.821	-0.231	0.044	-0.133	0.238	0.005	0.366	-0.932

Notes: Standard errors are calculated using a 500-repetition bootstrap. Statistical significance here means significantly different from 0 (or complete inelasticity). Elasticities highlighted with light grey are statistically significant at the 10% level, whilst those highlighted with dark grey are statistically significant at the 5% level. Elasticities are estimated using mean prices and expenditures and for a household with 2 adults and 2 children, where the head is male, has low levels of education, is employed and lives in the DF.
Source: Authors' calculations using MEXTAX, Bank of Mexico price data and ENIGH 2008.

Table 3 Income (total expenditure) elasticities

Good	Income Elasticity
(1) Food on which no VAT is levied	0.52
(2) Food on which VAT is levied and meals out	1.34
(3) Alcoholic Drinks and Tobacco (VAT and duties levied)	1.16
(4) Clothing and footwear (VAT levied)	1.20
(5) Household goods, services and communications (VAT levied, duties sometimes levied)	1.20
(6) Household goods, services and communications (no VAT levied)	0.84
(7) Transport and vehicle fuels (VAT levied, duties sometimes levied but not modelled	2.06
(8) Public Transport and other transport on which no VAT levied	0.66
(9) Health and Education goods (no VAT levied)	1.12
(10) Health and personal goods and services (VAT levied)	0.98
(11) Leisure and hotel services (VAT sometimes levied)	2.09
(12) Other services	1.69

Notes: Standard errors are calculated using a 500-repetition bootstrap. Statistical significance here means significantly different from 1 (or unit elasticity). Elasticities highlighted with light grey are statistically significant at the 10% level, whilst those highlighted with dark grey are statistically significant at the 5% level. Elasticities are estimated using mean prices and expenditures and for a household with 2 adults and 2 children, where the head is male, has low levels of education, is employed and lives in the DF.
Source: Authors' calculations using MEXTAX, Bank of Mexico price data and ENIGH 2008.

4. Simulating tax reforms: the 2010 reforms and a uniform VAT

The demand model we estimate is integrated with MEXTAX, a tax micro-simulator covering VAT, excise duties, income tax on employment income and employees' social security contributions (Abramovsky et al (2010, 2011)). This means it is possible to use the model to simulate the effects of reforms to taxes on consumer spending patterns, and consumer welfare and tax revenues accounting for the changes in spending patterns. Estimates incorporating such behavioral response can then be compared to those based on no-behavioral-response static micro-simulation results.

When using the demand model in conjunction MEXTAX, changes in indirect taxes are modelled as changes in the prices of the twelve aggregate commodities included in the demand system. When an aggregate commodity contains goods which are seeing differential proportional increases in prices due to changes in tax (for instance, the alcohol and tobacco group where different changes may be made to the duty rates), the increase in the price of that commodity for a particular household is the arithmetic weighted average of price changes of the goods within that category for households in the same expenditure decile group as the household in question. We choose to use the average price increase for the relevant decile group instead of for the entire population because of systematic differences in the within-group composition of demand between poorer and richer households. For instance, if poorer households were consuming alcohol in the form of beer, and richer households in the form of wine, or the extent of tax evasion varies between rich and poor households (we assume tax increases do not affect the price of goods purchased informally), a population-level average price change might not reflect well the change in prices for the types of goods within that group that households in particular parts of the spending distribution face.

Another important issue is that when using the demand model in conjunction with MEXTAX, the distributional analysis of indirect tax changes are based on each household's predicted spending patterns as opposed to their actual spending patterns. This means that the results of the simulation exercise are no longer accurate at the household level, but given the demand system includes demographic controls and (by definition) allows spending patterns to vary with total expenditure and prices, the predicted spending patterns should be similar to (but not exactly the same as) actual spending patterns for broad groups of households (e.g. expenditure decile groups).

In 2009, in response to the short-run reduction in fiscal revenues,[6] the Mexican government approved a modest fiscal tightening starting in 2010 (from now on referred to as the 2010 tax reforms) through an increase in the rate of VAT of 1%[7], an increase in duties on alcohol, tobacco and communications services, an increase in the financial deposit tax from 2% to 3%, and a temporary increase in the top rate of income tax from 28% to 30%. The Mexican Congress rejected more radical proposals put forward by the Executive Power for larger increases in duty rates, increases in regulated prices, and the introduction of a comprehensive 2% VAT on all goods (including those currently not covered). Full details of the reforms can be found in the appendix and full analysis of them, including sensitivity checks, can be found in Abramovsky et

[6] There has been, as yet, less focus on the longer-term need to consolidate the budget in the face of the increasing cost of welfare and social security programmes and a projected decline in oil revenues.

[7] The main VAT rate increased from 15% to 16%, and the rate at which transactions subject to VAT are taxed in areas bordering the United States increased from 10% to 11%.

al (2011). Here, we analyse the impact of the VAT and duties elements of both the initial proposals and the approved and implemented reforms, as well as the impact of a counter-factual reform where all zero rates and exemptions are abolished and a uniform VAT at a rate of 15% is applied to all goods and services.

Table 4 Changes in average expenditure shares after changes in *indirect* taxes

Reform	***Share of good i in total expenditure***			
	Before reform	**After *proposed* reform**	**After *approved* reform**	**With uniform 15% VAT**
1) Food on which no VAT is levied	26.9%	27.1%	26.8%	29.0%
2) Food on which VAT is levied and meals out	12.9%	12.9%	12.9%	12.5%
3) Alcoholic Drinks and Tobacco (VAT and duties levied)	0.6%	0.6%	0.6%	0.5%
4) Clothing and footwear (VAT levied)	7.2%	7.2%	7.2%	7.0%
5) Household goods, services and communications (VAT levied, duties sometimes levied)	21.6%	21.5%	21.6%	21.2%
6) Household goods, services and communications (no VAT levied)	1.6%	1.6%	1.6%	1.6%
7) Transport and vehicle fuels (VAT levied, duties sometimes levied but not modelled)	7.3%	7.2%	7.3%	6.9%
8) Public Transport and other transport on which no VAT levied	6.3%	6.4%	6.4%	6.3%
9) Health and Education goods (no VAT levied)	3.2%	3.2%	3.2%	3.2%
10) Health and personal goods and services (VAT levied)	7.6%	7.6%	7.6%	7.4%
11) Leisure and hotel services (VAT sometimes levied)	4.1%	4.0%	4.0%	3.8%
12) Other services	0.6%	0.6%	0.6%	0.6%

Source: ENIGH 2008 and authors' calculations using Bank of Mexico price indices and MEXTAX
Notes: Reported shares are shares of aggregate household expenditure.

Table 4 shows spending patterns before the reforms, what they are estimated to be after the proposed reforms, what they are estimated to be after the approved reforms, and what they are estimated to be with a uniform VAT rate of 15%. Overall, neither the approved 2010 increase to VAT and duties, nor the initial proposals have a notable impact on spending patterns. The larger

change of introducing of a uniform 15% rate of VAT does have a more notable effect. In particular, the share of food on which VAT is not currently levied increases significantly (reflecting its low own-price elasticity of demand) whilst the share of other goods generally falls. However, the increase in the share of food of around 8% (2.2 percentage points) is less than the 11% increase in the price of food following the imposition of VAT, implying the quantity of food purchased would be lower if VAT were imposed at the standard rate.[8]

Table 5 shows various revenue estimates for the reforms.[9] The first column of the table shows the estimated revenues from the reforms using the static micro-simulation model allowing for no behavioral response and holding the quantity of purchases fixed; the second column assumes simple Cobb-Douglas preferences so that expenditure shares and total expenditure remain constant following a reform (with quantities of each good falling by the extent to which its price has risen); and the final column uses the QUAIDS model described above and incorporated in MEXTAX to allow spending patterns to change in response to the changes in prices.

Table 5 Effect of consumer demand response on revenues from changes in indirect taxes

Reform	Change in Annual Revenue ($ millions Mex)		
	Fixed Quantities (Static)	Cobb-Douglas Preferences	QUAIDS Preferences
Proposed			
VAT	38,020	34,487	33,851
Duties	4,083	3,818	3,795
Total indirect tax	42,104	38,305	37,646
Approved			
VAT	10,889	9,168	9,185
Duties	3,064	2,915	2,959
Total indirect tax	13,953	12,084	12,145
Uniform VAT			
VAT	140,459	129,600	128,826
Duties	0	-7	-748
Total indirect tax	140,459	129,593	128,077

Notes: Cash amounts are in millions of Mexican $ 2008 per annum.
Source: ENIGH 2008 and authors' calculations using MEXTAX

Given the barely changed spending patterns under the approved or proposed changes, it is perhaps not surprising that allowing for consumer spending patterns to change has a only a very modest (but non-negligible) impact on revenues from the indirect tax changes. For instance with fixed spending shares and fixed total spending (i.e. Cobb-Douglas preferences), revenues from the proposed reforms would be $38,305 million (Mex), but after allowing for changes in spending patterns this falls to $37,646 million (Mex). Allowing for spending patterns

[8] The estimated increase in the price of food is less than 15%, on average, because approximately 24% of food is purchased in the informal sector and prices in this sector are assumed to be unaffected by VAT changes.
[9] Note that the results reported here differ substantially from official estimates of revenues due to significant under-reporting of expenditure and incomes in the ENIGH survey. Abramovsky et al (2011) deals with this issue in some detail, showing how various methods of correcting for this under-reporting give different results.

to adjust also reduces the estimate of revenue from moving to a uniform VAT; this is because of shifts in spending towards goods that are more likely to be purchased from the informal sector (and on which no tax is collected). Estimated revenue after allowing for behaviour to adjust (in accordance with either Cobb-Douglas preferences or QUAIDS preferences) is lower than the estimate using the standard static micro-simulation methodology that holds fixed the quantity of goods and services purchased.

Table 6 shows the impact of the indirect tax changes across the distribution of equivalised[10] household expenditure (split into ten equal sized decile groups). Columns (1) and (4) show the cash and proportional change in tax payments as estimated by MEXTAX under the assumption of no behavioral response. Columns (2) and (5) again assume no behavioral response but the impact of the tax changes is calculated using the estimated (as opposed to actual) expenditure shares for the 12 commodity groups. Columns (3) and (6) show the estimated welfare cost of the tax reform after allowing for behavioral response measured by the compensated variation (see section 3.1).

Comparing columns (1) and (4) with (2) and (5) shows that the fact that we use estimated expenditure shares as opposed to actual shares makes a very modest difference to the magnitude of the losses due to the tax reforms across the distribution of expenditure and is not enough to change the patterns (i.e. the degree of progressivity or regressivity). Allowing for behavioral response (columns (3) and (6)) has a negligible effect in reducing the estimates of the welfare cost of the proposed and actual tax reforms. However, it has a noticeable but modest effect on the welfare costs of the introduction of a uniform VAT, reducing the welfare cost a little more in proportional terms for poorer households than for richer ones.

Focusing on the distributional impact of the reforms, the approved reforms to VAT and duties are shown to be moderately progressive (with losses higher as a fraction of total spending for richer households than for poorer households), whilst the initial proposals for a uniform 2% expenditure tax and higher rates of duties are shown to have a broadly distributionally neutral impact. This is similar to the results of earlier studies that do not incorporate a consumer demand system (CEFP (2009d), Absalón and Urzúa (2010)).

The introduction of a uniform VAT would entail a regressive pattern of losses, with poorer households suffering a larger decline in welfare than richer ones. However, as highlighted in the following section, redistribution is a poor reason for VAT rate differentiation, and the regressive impacts of shits to uniform expenditure taxation could be addressed through an increase in transfers and cuts in direct taxes targeted at poorer households. By removing distortions to relative prices, moves towards a uniform VAT rate could also lead to an improvement in economic efficiency. For instance, after redistributing the gains of the winners, a revenue-neutral uniform VAT rate of 7.86%, applied to all goods and services, could, in principle, allow all households to increase their welfare by an amount equivalent to 0.1% of current expenditure.

[10] The equivalence scale used in this paper assumes second and each subsequent adult needs 80% as much resources as the first adult for the household to obtain the same level of living standards as a single adult, and each child to need 50% as much. This compares to 50% and 30%, respectively, assumed in most studies in the European Union and 100% and 100%, respectively, in most previous Mexican studies. The distributional impact of the reforms modelled is invariant to the precise equivalence scales. See Abramovsky et al (2011) for further details.

Table 6 Welfare changes when allowing households to adjust their spending pattern as a consequence of changes in *indirect* taxes

Reform	***$ (mex) cash loss or gain due to changes in indirect taxes***			**Change as a % of expenditure**		
	Baseline – No behavioral response (1)	**No behavioral response – estimated shares (2)**	**With Behavioral Response (3)**	**Baseline – No behavioral response (4)**	**No behavioral response – estimated shares (5)**	**With Behavioral Response (6)**
Proposed						
Poorest Decile	-457	-458	-457	-1.24%	-1.24%	-1.24%
Decile Group 2	-723	-722	-722	-1.30%	-1.30%	-1.30%
Decile Group 3	-873	-874	-873	-1.31%	-1.31%	-1.31%
Decile Group 4	-1,014	-1,012	-1,011	-1.32%	-1.32%	-1.32%
Decile Group 5	-1,188	-1,188	-1,188	-1.35%	-1.35%	-1.35%
Decile Group 6	-1,355	-1,357	-1,356	-1.35%	-1.35%	-1.35%
Decile Group 7	-1,537	-1,537	-1,536	-1.34%	-1.34%	-1.34%
Decile Group 8	-1,810	-1,812	-1,810	-1.36%	-1.36%	-1.36%
Decile Group 9	-2,374	-2,369	-2,367	-1.38%	-1.37%	-1.37%
Richest Decile	-4,442	-4,431	-4,429	-1.32%	-1.32%	-1.32%
Approved						
Poorest Decile	-95	-98	-98	-0.26%	-0.27%	-0.27%
Decile Group 2	-169	-172	-172	-0.30%	-0.31%	-0.31%
Decile Group 3	-217	-229	-228	-0.33%	-0.34%	-0.34%
Decile Group 4	-275	-279	-278	-0.36%	-0.36%	-0.36%
Decile Group 5	-347	-351	-350	-0.39%	-0.40%	-0.40%
Decile Group 6	-419	-427	-426	-0.42%	-0.43%	-0.42%
Decile Group 7	-491	-489	-488	-0.43%	-0.43%	-0.43%
Decile Group 8	-616	-611	-609	-0.46%	-0.46%	-0.46%
Decile Group 9	-864	-845	-843	-0.50%	-0.49%	-0.49%
Richest Decile	-1,732	-1,744	-1,743	-0.51%	-0.52%	-0.52%
Uniform VAT						
Poorest Decile	-2,155	-2,117	-2,081	-5.83%	-5.73%	-5.63%
Decile Group 2	-3,232	-3,181	-3,128	-5.82%	-5.73%	-5.63%
Decile Group 3	-3,781	-3,626	-3,565	-5.68%	-5.44%	-5.35%
Decile Group 4	-4,114	-4,041	-3,974	-5.36%	-5.27%	-5.18%
Decile Group 5	-4,543	-4,495	-4,420	-5.15%	-5.09%	-5.01%
Decile Group 6	-4,888	-4,811	-4,730	-4.87%	-4.79%	-4.71%
Decile Group 7	-5,401	-5,437	-5,351	-4.72%	-4.75%	-4.68%
Decile Group 8	-5,802	-5,899	-5,807	-4.36%	-4.43%	-4.36%
Decile Group 9	-7,001	-7,238	-7,139	-4.06%	-4.19%	-4.14%
Richest Decile	-11,699	-11,410	-11,359	-3.47%	-3.39%	-3.37%

Notes: 100/80/50 equivalence scale, total expenditure includes monetary and non monetary consumption. Cash amounts are in Mexican $ 2008 per annum.
Source: ENIGH 2008 and authors' calculations using MEXTAX

5. Implications for the setting of VAT rates

As in Mexico, instead of applying a standard rate of VAT to all goods and services, most countries have either a range of different VAT rates or impose a zero rate on certain types of goods or services. One common argument for differentiated rates of commodity taxation is a desire for redistribution. For instance, most countries (including Mexico and the UK) have a zero or reduced rate of VAT for food, in part, because food is a larger share of household budgets for poor households than for rich ones. The zero-rating of food is therefore of greater benefit measured as a proportion of spending for poor households than for rich households, and is in this sense progressive. On its own, removing zero and reduced rates of VAT and applying the standard rate of VAT to all goods and services would be a regressive reform in most countries (see section 4 for Mexico and Institute for Fiscal Studies (2011) for the European Union). However, despite spending a lower fraction of their budget on food than the poor, the rich spend a greater amount in cash terms[11] and therefore the cash benefit of zero or reduced rating is greater for the rich. This means that the zero or reduced rating of food is not a particularly well-targeted method of redistribution. Other mechanisms (for instance welfare programs such as *Oportunidades* in Mexico, or direct taxes) may be able to be better targeted at poor households in middle income countries (like Mexico) or high income countries. Using the additional revenue that would be obtained from applying the standard rate of VAT to all goods and services to increase the support for poor households through the direct tax and welfare system would allow one to redistribute more effectively and cheaply than relying upon reduced rates of VAT. This would suggest that departures from uniform rates of commodity tax are difficult to justify on distributional grounds when non-linear direct-taxes and welfare policies are feasible.[12]

Hence, the case for uniform or non-uniform commodity taxes should be decided upon which system is most economically efficient. The standard view (since Atkinson and Stiglitz (1976)) is that uniformity of tax rates is optimal (in the presence of a non-linear income tax) unless preferences over different goods are affected by whether and how much one works. That is, uniformity is preferable (to avoid distortions to people's decisions about which goods to consume) unless some goods are complements for leisure and others substitutes. The reasoning behind this is that economic efficiency can be improved by taxing more highly goods that are complementary to leisure (and vice versa) to offset some of the disincentives to working resulting from taxation more generally. Therefore in order to judge whether the proposed introduction of a uniform expenditure tax is more or less efficient than an increase in the existing non-uniform VAT, we need to ascertain the degree to which commodity demands and working decisions are related (after controlling for income and other confounding factors). The argument for rate differentiation based on non-separability of leisure and consumption is very closely linked to the Ramsey Rule for differentiated indirect tax rates where the tax rate on a

[11] Although food is a necessity it is still a normal good.

[12] It should be noted that in optimal tax theory rather than redistributing from those with high incomes to those with low incomes, the objective is generally to redistribute from those of high earning ability to those of low earning ability. Mirrlees (1976) shows that even with a non-linear income tax this means one might want higher taxes on goods consumed disproportionately by high ability people, and vice versa. However, the gains in social welfare from such differentiation are likely to be small and may be outweighed by the administrative and compliance costs.

particular good depends on the effect of the price of that good on expenditure on all goods and services (through own and cross price elasticities of demand).[13]

As highlighted in section 3, the QUAIDS model used in this paper assumes that leisure and consumption are separable and the analysis and results in section 4 are based on this assumption. However, Browning and Meghir (1991) show that leisure-consumption separability can be tested relatively easily in demand systems like the QUAIDS by including hours of work or the employment status in the demand system share equations. We implement this method in this paper by including the employment status of the head of the household as one of the demographic variables in our demand system. Goods for which the coefficient on this is positive are complements for work, and goods for which the coefficient on this is negative are complements for leisure.[14]

Table 7 shows the coefficients on the employment indicator, and whether VAT is applied, for each of the 12 goods in our demand system. With the coefficient on employment being highly statistically significant for most expenditure categories, results show clearly that demand for goods is not separable from whether one works or not. This suggests that, in principle, there is scope for differentiated taxation of goods to offset the disincentive effects of income taxation on labor supply. But, the existing set of goods subject to VAT does not correspond clearly with substitutes for working (i.e. a negative coefficient in the table). For instance, clothing and food eaten outside the home are both complements to work, yet are subject to VAT, whilst "Non-VAT Household, etc", which as the name suggests is not subject to VAT is a substitute to work.

[13] The following example illustrates the close link between these concepts. Suppose that an increase in the price of some good has little effect on the demand for it, and none on the demand for other goods and services. An increase in the price of the good in question would lead to an increase in spending on this good and total expenditure on this good and therefore an increase in total expenditure. This increase in total spending could only be paid for by increasing income through working longer or harder. Therefore an increase in the price of the good leads to an increase in market work, and so the good in question must be a substitute to work effort (or, conversely, a complement to leisure).It should therefore be taxed more highly than other goods.

[14] It should be noted that this strategy requires that any mismeasurement of total expenditure and expenditure by sub-component is orthogonal to employment status. Browning and Meghir (1991) instrument for employment status using education: we do not do this in this paper as we feel it is likely education has an independent effect on goods demand (i.e. it fails to satisfy the excludability restriction and is therefore an invalid instrument).

Table 7 Effect of an employed household head on expenditure shares

Good	Coefficient on Employment	Current VAT Status
Non-VAT Food	0.0084**	No VAT
VAT Food and Food Out	0.0124**	VAT
Alcohol and Tobacco	0.0000	VAT
Clothing	0.0111**	VAT
VAT Household, etc.	-0.0311**	VAT
Non-VAT Household, etc.	-0.0041**	No VAT
VAT Transport	-0.0079**	VAT
Non-VAT Transport	0.0211**	No VAT
Non-VAT Health, Education	-0.0068**	No VAT
VAT Health, Education	0.0022*	VAT
Leisure Goods and Services	-0.0051**	Generally VAT
Other Services	0.0002	Generally VAT

Notes: ** means significant at the 1% level, whilst * means significant at the 5% level.
Source: ENIGH 2008, Bank of Mexico Price Indices and authors' calculations

However, the way tax rates would optimally differ across goods reflects not only the complementarity status of a particular good, but also cross-price effects on the demand for other goods, and the complementarity or substitutability of these other goods with work. Hence, a complement to work need not be taxed less heavily than a substitute to work if the complement is strongly complementary to other goods that are substitutes to work.

Crawford et al (2010) reports this it is possible to indicate which goods should have higher or lower than average VAT rates taking into account the cross-price effects and does so for the UK. Unfortunately the method they use is not reported, and at this stage, we are unable to replicate it. [15] The only other paper that we are aware of that directly addresses the issue of how commodity tax rates should vary to encourage labour supply is Pirttila and Suoniemi (2010). Rather than estimate a demand model, they estimate a model of hours of work using Finnish data, and include expenditure on various goods and services on the right hand side to see if, conditional on income, spending patterns are associated with hours of work. They find certain expenditures (such as housing) are negatively associated with hours of work, whilst spending at

[15] It is not possible to use the model coefficients directly in a linear fashion. For instance, using the notation from section 3, let α_{iK+1} be the coefficient on the labour supply measure (Z_{K+1}) in the share equation for good i, and let γ_{ij} be the coefficient on the log-price (lnp_j) of good j in the share equation of good i. A candidate equation initially considered was $\sum_{i=1}^{n} \gamma_{ij} . \alpha_{iK+1}$. The intuition was, if this is positive then an increase in the price of good j causes changes in spending patterns which, overall, shift consumption towards goods which are associated with work. This would indicate that the good should be taxed more highly than average. If it were negative the good should be taxed less highly than average (as an increase in the price of the good would shift consumption away from goods associated with work). However, this ignores the indirect effect of changes in the price of good j on demand for good i which enters via the prices also entering the b(p) and a(p) price indices.

work canteens is, unsurprisingly, positively associated with hours of work. They then argue that this suggests housing should be taxed more highly than it currently is (as in most countries it is currently tax-favoured in Finland). However, this reasoning is not sound for the same reason that one cannot infer the optimal tax treatment of a good from the coefficient on labour supply in its demand equation: cross-price effects also matter. One possible way to progress is to perform analysis of the kind Pirttila and Suoniemi pursue but include relative prices of goods in the hours equation instead: this should account for cross-price effects.

In any case, tax policy requires not only putting signs on which way VAT should vary between goods but also the calculation of actual rates and the gains that such optimal rates could achieve relative to uniform or existing systems. Unfortunately it is not possible to put a magnitude on the extent to which VAT rates should differ using a conditional demand system such as that estimated here. Such an undertaking would require integrating the modelling of consumer demand with labor supply and a social welfare function. Hence whilst we are able to conclude that the current set of zero rates is not optimal on efficiency grounds, and can state which goods and services should have lower or higher rates than the average, we are unable to say what those rates should be. Quantifying the actual rates and the welfare gains that could be obtained through such differentiation is an important and exciting piece of future research.

If estimated welfare gains from optimal differentiation are small, a consideration of administrative burden and compliance issues may mean that uniformity is the best policy. For instance, a key issue of rate differentiation is the creation of difficult 'boundary problems'. If one good is subject to the standard rate of VAT but a very similar good is not, producers may face difficulty in determining what rate of VAT should be charged on their product, increasing administration and compliance costs. There may also be costly disagreements between manufacturers and retailers and the tax authorities over the precise boundary between goods and the boundaries may lead to changes in ingredients or product characteristics that are designed to limit tax liability but are otherwise economically inefficient.

Another important issue in the context of a middle income country with a large informal sector like Mexico is the extent to which the ease of tax evasion varies between goods. For instance, if consumers can more easily evade taxes levied on food (by purchasing informally in a market) than taxes on electronics and telecommunications, it might be optimal to tax food less highly and electronics more highly. Differences in the ease of evasion may therefore reinforce the case for some form of VAT rate differentiation, but in directions that differ to those implied by our demand system. Existing demand systems such as that used in this paper do not allow for substitution between the formal and informal sectors following tax changes, largely because separate prices for each sector are not available. The development of demand systems that incorporate shifts between the formal and informal sectors is therefore another important area for research, requiring price indices for both formal and informal purchases of goods and services, and an understanding of the impact of VAT on informal sector prices (both due to competition between the formal and informal sector and the cascading of VAT paid on inputs by informal traders to final consumers buying from them).

6. Summary and discussion

In this paper we have estimated a demand system of the QUAIDS form for Mexico and used it in to analyse the optimal rate structure of indirect taxes in Mexico and to simulate actual and

counterfactual indirect tax reforms. This contributes both to the growing literature on micro-simulation of the tax system in Mexico (CEFP (2009a,b,c,d,e,f), Absalón and Urzúa (2010)) and policy-focussed demand analysis (Chávez Martín del Campo and Villarreal Paez (2008) and Attanasio et al (2009)). We have found evidence that the current VAT rate structure is not optimal for Mexico given the pattern of substitutability and complementarity between consumption and work. Taking into account behavioral response has been seen to have some effect on estimates of the revenue obtained from even fairly small changes in indirect tax such as those implemented in 2010, but only a very modest impact on estimates of the welfare cost of the reforms and the distributional pattern of welfare losses. An understanding of the interaction between indirect taxation and behavior therefore seems of more importance for understanding the 'big picture' issues such as optimal rate structures, and tax revenues than it is for the pattern of gains and losses across households.

There remain further problems and issues to address and a number of areas of research seem especially important for future research.

First, this paper has been able to show the direction in which VAT rates should vary for different kinds of goods and services but current models do not allow us to estimate the amount by which rates should vary, or the welfare gains from such variation relative to existing VAT systems or a uniform VAT system. The development of models that allow this would be a significant contribution to the design of optimal tax systems. Such a model would need to model labor supply and consumer spending patterns jointly, a substantial task given the difficulties involved in modelling them in a plausible manner separately. It would require good data on expenditure, income, and labour supply, and exogenous variation in both goods prices and work incentives to identify the parameters of the model. This does not exist at the moment for Mexico. Higher quality data is available in the US and Europe and a small number of papers have made of use of this to investigate the implications of non-separabilities between leisure and consumption for marginal tax reform and optimal tax rate structures (Madden (1995), and West and Williams (2007). However this small literature focuses either on a small subset of goods (e.g. gasoline in the case of West and Williams) or uses methods requiring major restrictions on the demand systems employed (e.g. Madden makes use of variants of the Linear Expenditure System).

Second, when modelling tax reforms we have made two assumptions. The first is that there is complete pass-through of changes in indirect taxes to consumer prices when the consumer good in question is subject to VAT. Second, we do not model the VAT embodied in the price of exempt goods (which are goods on which VAT is not levied, but for which the VAT paid on inputs cannot be reclaimed), in effect treating such goods as zero-rated. Abramovsky et al (2011) tests the sensitivity of the results of the analysis of the 2010 tax reforms to a number of stylised assumptions about indirect tax pass-through rates and the incidence of that part of the indirect tax burden not passed directly to consumers through prices. This shows that the distributional impact of the reforms varies quite substantially with the tax incidence assumptions made. Estimating the incidence of VAT is therefore an important but challenging future goal for research. Similarly, estimating the amount of VAT embodied in the price of exempt goods and services would be useful.

With interest in reform of the structure of the VAT system (such as changes in the rate of VAT and in the goods and services subject to VAT), and excise duties (or a reduction in fuel subsidies) in many countries, an understanding of the revenue, behavioral and distributional

implications of the indirect tax system is important. This paper contributes to a growing literature on this topic, but many issues remain to be resolved.

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Appendix

Table A.1 A description of the 2010 tax reforms

Item	**Status-quo**	**2010 tax reform *proposed* by the Executive power**	**2010 tax reform *approved* by the Congress and implemented**
1. Income tax: both personal and corporate (Impuesto sobre la Renta – ISR).	Top three marginal rates are 19.94%, 21.95% and 28%.	-Top three marginal rates increase to 21.36%, 23.52% and 30% in 2010, 2011, 2012, with a phased reduction to 28% in 2014. -Individuals earning up to 4 minimum wages are not affected. -The annual upper threshold of income band 3 (lower threshold of income band 4) decreases from 88,793.04 $ (mex) to 79,964.16.	-Top three marginal rates increase to 21.36%, 23.52% and 30% in 2010, 2011, 2012, with a phased reduction to 28% in 2014. -Individuals earning up to 6 minimum wages are not affected.
2. VAT (Impuesto al Valor Agregado - VAT)	General rate of 15%, and 10% in border areas	--	General rate of 16%, and 11% in border areas
3. Excise duties (Impuesto especial sobre la producción y servicios – DUTIES)			
3.a. Tobacco	160% rate	Additional flat-rate of 0.04 for each cigarette or 0.75 grams of snuff; to be increased to 0.10 by 2014.	Additional flat-rate of 0.04 for each cigarette or 0.75 grams of snuff; to be increased to 0.10 by 2014.
3.b. Beer	25% rate	28% rate	26.5% rate (temporary)
3.c. Lottery	20% rate	30% rate	30% rate
3.d. Drinks with alcohol content greater than 20% by volume	50% rate	Additional minimum charge per litre of 3 pesos	53% rate
3.e. Telecommunications	None	4% rate	3% rate, except for Internet connexions
4. New expenditure tax (*Contribucion para el Combate a la Pobreza*)	--	Introduction of a 2% expenditure tax on all goods and services (with the exception of the purchase of government licenses and donations to charity)	Rejected
5. Tax on cash deposits	2% rate of balance	3% rate of balance	3% rate of balance

Source: CEFP (2009f)

Table A.2 Definition of categories used in the demand system

Categories	Category	ENIGH codes	Bank of Mexico PRICES codes	Notes
Food on which no VAT is levied	1	A001-A197, A203-A214 A215-A216, A217-A218, A242	1-100, 103-110	Prices for A215 (sill bottled water - zero rate) and A216 (sparkling water -VAT is levied on this) are together so include in category 1 as A215 represents a bigger expenditure share in ENIGH 2008. A218 (bottled juices or cordials - zero rate) and A217 (prepared water and natural juices -VAT is levied on this) are together, include in 1 as A218 represents a bigger expenditure share in ENIGH 2008. No specific price for A242 (food dispensed by government agencies or NGOs).
Food on which VAT is levied and meals out	2	A198-A202, A219-A222, A243-A247, T901	101-102, 111-115, 378-381	
Alcoholic Drinks and Tobacco (VAT and DUTIES levied)	3	A223-A241	116-122	
Clothing and footwear (VAT levied)	4	clave>="H001" & clave<="H136", clave=="T908"	134-171	No prices for jewlery, wrist-watches and other women accessories (Banxico code 172, ENIGH code H125-H127, H129, H131): include them and use price of 171 (handbags)

Household goods, services and communications (VAT levied, DUTIES sometimes levied)	5	clave>="C001" & clave<="C024", G009-G010, G020-G022, I001-I026, K001-K044, T903, T907, T909, T911, electronics (L001-L022), F001-F009, G008.	184, 186, 189, 190-195, 205-246, 294, 355, 361	No information on the price level of electricity (Banxico code 188, ENIGH code G008); use the price of gas (Banxico code 189). No information on the price level of landline telephone services (Banxico code 190 and ENIGH code F003); or national inter-city phone calls and international calls (Banxico codes 191 & 192 and ENIGH code F002); use the price of internet conexion (Banxico code 355). No price information on mobile telephone services (ENIGH codes F004 and F005); public telephones (ENIGH codes F006); and mail and other communications services (ENIGH codes F007, F009).
Household goods, services and communications (no VAT levied)	6	G007, G011-G019	185, 187	Exclude housing renting cost and imputed rent from this category (Banxico codes 182 and 183 and ENIGH codes G001-G006)
Transport and vehicle fuels (VAT levied, DUTIES sometimes levied but not modelled)	7	F010-F017, M002-M004, M006, M012-M018, T906, T913,	310-318, 320-323, 325	No price level information for tolls (Banxico code and ENIGH code M005) or car insurance (Banxico code 319 and ENIGH code N008) ; exclude them. Exclude purchases of automobiles (including cars, bycicles, etc, Banxico codes 311 and 312, ENIGH codes M007-M011)
Public Transport and other transport on which no VAT levied	8	B001-B007, M001, E013, T902	305-309	
Health and Education goods (no VAT levied)	9	Health (J001, J004, J005, J007, J008, J013, J016, J017, J018, J036, J039, J062, J072, J009, J010, J014, J020-J035, J037, J038, J042, J044-J059, J063, J064, T910); Education (E014)	256-265, 268, 269, 271, 272, 276,277, 342, 343	No price level information for education fees (Banxico codes 335-342; ENIGH codes E001-E008, E017, E015, T905), exclude it from the system.

Health and personal goods and services (VAT levied)	10	Taxed education (E016, E018, E019); Taxed health (J002, J003, J006, J011, J012, J015, J019, J040, J041, J043, J060-J061, J065-J071); Personal goods and services (D001-D026, T904)	266-267, 270, 273-275, 278-293, 295, 344-346	Prices for J060 (cotton wool, dressings - VAT levied on this) and J061 (surgical alcohol -zero rated) are together so include in category 10 as J060 represents a bigger expenditure share in ENIGH 2008. Exclude education services E009-E012.
Leisure and hotel services (VAT sometimes levied)	11	Non-taxed leisure (E020-E022, E026, E029, L029); Taxed leisure (E023-E025, E027-E028, E030-E033, L023-L028, N003-N005, T912)	347, 349-354, 356-360,362-364,	No specific price for lottery (E029) or hotels.
Other services	12	N001-N002, T914	382-384	No prices information for other services ENIGH codes N006, N007, N009-N010; exclude them from the analysis.