Fiscal inclusive development: microsimulation models for Latin America

Edited by

Carlos M. Urzúa

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Foreword

The macroeconomic performance of Latin America and the Caribbean during the first decade of the new Millennium was remarkable. During 2000-2008, the average annual GDP growth in the region was 4.3%, a much larger figure than the growth rates obtained in the previous four decades. In 2009, as a result of the financial crisis, there was a decline of around 2%, but the region rebounded after that with an average growth rate close to 6% in 2010, and rates higher than 4% in 2011 and 2012.

One of the main impacts of those macroeconomic achievements occurred on social indicators. According to ECLAC, the incidence of poverty decreased in the region from 48.4% in 1990 to 31.4% in 2010, while extreme poverty decreased from 22.6 to 12.3 percent during the same period. Furthermore, income inequality also showed significant improvements across most countries in the region. Even more remarkable, by 2010 the region as a whole had met over 80% of the goals set in the United Nations Millennium Declaration.

Those achievements were not only the result of that economic growth, but also of the expansion of social spending, the increase in coverage of social policies and the establishment of human capital investment schemes. Nevertheless, deep social disparities still prevail in the region, and there is no way to solve that problem without strengthening the tax systems, in order to allow for higher levels of social spending. Indeed, the tax effort in the region is very low: in 2010 the average tax burden was only 16.7% of GDP. Furthermore, the tax structure is quite regressive for international standards: on average, the consumption tax collection almost doubles the income tax revenue.

Is there any space to have new tax reforms in the region? If so, what are the most adequate reforms in terms of their impacts on tax collection and social welfare? The answers to these questions depend on the

specific characteristics of each country. For instance, Guatemala has a per capita income level almost four times smaller than Mexico's, but the tax burden is quite similar in both countries (excluding oil revenue in the case of the latter); on the other hand, the tax system in Guatemala is much more regressive than in Mexico.

What segments of the population are the most affected in the case of a particular tax reform? Is there a way to mitigate the negative impact on the poor of, say, a consumption tax by increasing monetary transfers? As will be thoroughly explained and exemplified in this book, there is no possibility to answer those types of questions without a detailed analysis of the data and the construction of large microsimulation models.

It was a pleasure for the International Development Research Center and the United Nations Development Programme to have supported the work of the fifteen researchers that contribute to this volume. Although their models were built specifically for the case of Brazil, Chile, Guatemala, Mexico and Uruguay, it is our expectation that this book will soon promote the use of microsimulation models in the rest of Latin America and the Caribbean. We are convinced that since these models can help to assess the distributional impacts of tax and benefits reforms, they can be used in particular to design more inclusive fiscal systems. The latter are much needed for renewed social contracts between the citizens and their own governments, a critical ingredient to consolidate the democratic regimes in the region.

George Gray-Molina, United Nations Development Programme
Carolina Robino, International Development Research Center

Preface

This book constitutes the final outcome of the two-year project Fiscal Schemes for Inclusive Development (known in Spanish as *Fiscalidad para un Desarrollo Incluyente*), sponsored by the United Nations Development Programme (UNDP) and the International Development Research Center (IDRC) from mid-2009 to mid-2011. The objective of the project was to contribute towards more equitable, efficient, and transparent fiscal and social policy reforms in Latin America, through the generation and dissemination of open source microsimulation models for five countries in particular: Brazil, Chile, Guatemala, Mexico and Uruguay. The project aimed to promote the use of non-behavioral and behavioral microsimulation models to perform quantitative analysis of fiscal changes, as well as to contribute to national debates on the welfare consequences of policy reforms.

This is the second and last book of the project. The first, *Sistemas de impuestos y prestaciones en América Latina*, edited by L. F. López Calva and C. M. Urzúa and jointly published in Mexico by BUAP-IDRC-ITESM-UNDP in 2011, described the current tax-benefit system of each of those five Latin American countries in a very detailed fashion. This second book presents, on the other hand, several microsimulation models that can be used to simulate the welfare consequences of a number of policy reforms in each of those five countries. By using micro data from national surveys, the models not only characterize the population on the aggregate but also on a number of dimensions such as age, family composition and income level, which are important for distributive analysis. The models also quantify and identify those who win and those who lose with a reform. Furthermore, the open-source nature of the models presented here certainly helps not only to disseminate the results

of the project, but also to build-up technical capacities on the subject across Latin America. Indeed, any researcher interested on analyzing fiscal and social reforms in the region, may find that the open source models, written in Excel and Stata, can serve as a good platform for any future work along those lines.

Turning now to the acknowledgments, aside from the fifteen direct collaborators in this volume, several others helped along the way to bring the project to a fruitful end. During the first year, the project was undertaken under the leadership of Rebeca Grynspan, now UNDP Associate Administrator and UN Under-Secretary-General, and Edgard Rodriguez, Senior Program Specialist at IDRC. During the second year, the project has been under the direction of Heraldo Muñoz, Regional Director for Latin America and the Caribbean at UNDP, and Carolina Robino, Program Officer at IDRC. The editor is greatly indebted to them all. Special thanks to Luis F. López-Calva, former Chief Economist at the UNDP's Regional Bureau for Latin America and the Caribbean (RBLAC) and currently at the World Bank, who jointly with the editor designed, promoted and coordinated the initiative presented in this book.

Eduardo Ortiz-Juarez, at RBLAC, played a key role in the coordination and organization of the project; Amedeo Spadaro, at the Paris School of Economics, contributed with his deep knowledge on the subject; Guillermo Cruces, Samuel Freije, José Luis Machinea, Carolina Robino and Edgard Rodríguez made helpful comments on earlier drafts of the chapters; and George Gray Molina and Alfredo González Reyes, RBLAC's Chief Economist and Programme Specialist, respectively, supported the publication and dissemination of this book. The editor also would like to thank Pedro Manuel Moreno and Stefano Pettinato, at RBLAC, for their management advisory; Jacob Trejo, Dante Ruiz and Fernando Murillo, from Tecnológico de Monterrey, for their computer wizardry; and Elia Carrasco and Jacqueline Estevez, at RBLAC, Carolina Quintana, at IDRC, and Adolfo Cermeño and Ernesto Pacheco, at Universidad Rafael Landivar, for their support in the administration of the project. Last but not least, the editor is greatly indebted to the publishing staff from Tecnológico de Monterrey, for their terrific editorial support. Needless to add, none of them, nor UNDP or IDRC, should be held responsible for the opinions or misunderstandings contained in this book.

Introduction

Over fifty years ago, Guy Orcutt (1957) proposed to construct economic models by applying simulation methods on micro databases of representative agents in an economy. At that time his advice was largely ignored due to limited computer resources and lack of micro data. However, this has changed dramatically in recent decades allowing for microsimulation, as it is now known Orcutt's approach, to flourish and to be applied in many areas, such as demographics, health, transport, housing, taxes and social benefits. Regarding the state of the art of the subject, although Merz (1991 and 1994) provided excellent surveys of earlier works, we are not aware of any recent attempt to review it. With some reason, since the number of researchers and disciplines that espouse that approach is now extremely large.

In particular, tax-benefit microsimulation models have now become commonplace in Europe and the United States. Those models calculate the tax liabilities and benefit entitlements of individuals from household surveys that are statistically representative of the analyzed population. Making use of detailed information about socio-economic characteristics, these models compute the amount of taxes and benefits following closely the underlying legislation. Tax and benefit reforms can be then simulated by changing the parameters of the model, and their impact can be assessed by comparing *ex-ante* and *ex-post* disposable income for each household (see, e.g., Bourguignon and Spadaro, 2006). A very important advantage of Orcutt's methodology over, say, the computable general equilibrium approach or the typical econometric modeling strategy is that the microsimulation models can take into account the heterogeneity of the population and, therefore, can capture how the tax-benefit system treats households that face different circumstances.

It should be noted that those other modeling approaches may be seen as complements, rather than rivals, to Orcutt's approach. A fundamental aspect of the original tax-benefit microsimulation models, an aspect that is still quite common in applied work, is that they are "arithmetic" in their nature. That is, no behavioral responses from the part of the economic agents are allowed; if, for instance, the model is used to analyze the consequences of an increase in an excise tax on a particular good, the arithmetic model does not contemplate the possibility of households substituting part of the consumption of that good with the consumption of others. A more general approach, closer to the economic mainstream, complements microsimulation models with econometrically estimated demand responses. As will be seen later, some of the models in this book are examples of this behaviorist approach. But the refinements to the traditional microsimulation approach do not end there. Another approach, quite important in the case of socio-demographic models, embeds dynamic features into the models (see the survey by Klevmarken, 2008); while still another one merges microsimulation models with computable general equilibrium models (see Peichl, 2004).

All the references contained in the surveys mentioned insofar refer to work outside of Latin America. Given the attractive features of microsimulation models, one might wonder if its use is also common place in the region. Unfortunately, as reviewed by Absalón and Urzúa (2011), that is still not the case. For most countries in Latin America, fiscal and social reforms are typically subject to pronounced political swings, so it should not come as a surprise that tax-benefit systems are constantly changing. Furthermore, although social policies tend to be less comprehensive and generous in Latin American countries than in the European Union, to give the foremost contrasting example, the tax systems tend to be as varied, if not more, than those of more advanced countries. Finally, Latin American tax-benefit systems continue to be under reform also due to economic reasons, as there is still a continuous searching for more efficient and equitable fiscal policies. It is perhaps for those reasons that the number of microsimulation models is still modest.

This book attempts to ignite in Latin America an interest on the subject by providing several full-size microsimulation models in the case of five countries: Brazil, Chile, Guatemala, Mexico and Uruguay. In the case of all the models described below, their authors not only provide a detailed description of them, but also offer simulation examples based on recent reform proposals made in their own countries. Furthermore, for

the particular case of the arithmetic models, the authors provide internet links from which one can download the computer programs of their models. Those programs can be used not only to replicate results or simulate other possible tax-benefit reforms, but also as platforms for more complete microsimulation models to be developed in the future.

In Chapter 1, Nogueira, Bezerra and De Souza offer a comprehensive microsimulation model for the Brazilian economy. The model is capable of simulating six monetary social benefits, two non-monetary social benefits, nine social security contributions, the personal income tax, and two taxes on consumption. As such, their model is a more complete version of the pioneer models developed for Brazil by Siqueira, Nogueira and Levy (2003), as well as Immervoll, Levy, Nogueira, O'Donoghue and Siqueira (2006). An interesting feature of the model is that it may be used to simulate changes in household behavior on account of price variations. In order to simulate that behavior, it is assumed that household preferences can be represented by a linear expenditure system for each income group.

Larrañaga, Encina and Cabezas offer in Chapter 2 a microsimulation model for the Chilean economy. The model can be used to study the impacts on income distribution and poverty of a series of public policies that are to be evaluated *ex-ante*, such as changes in income taxes, health and pension contributions, monetary transfers and specific taxes. The model's operation is exemplified simulating the effect of a one-point cut in the value added tax rate and a progressive increase in income tax rates while maintaining a balanced budget. In Chapter 3, Cabezas and Acero complement that non-behavioral model with a module that allows for the possibility of behavioral changes in the case of labor participation. The authors then proceed to use the model to evaluate whether or not the "ethical family income" program that is currently being implemented in Chile has positive effects on income distribution and labor participation.

In Chapter 4, Castañón-Herrera and Romero present a tax-benefit microsimulation model for Guatemala. In that country there have been over the years numerous political discussions about the best way to increase government revenue, which is much needed for social programs and public investment. As reviewed by the authors, the proposed fiscal reforms have ranged from changes in the income tax schedule to changes in indirect tax rates. The microsimulation model presented in this chapter can be used to evaluate the distributive consequences of those possible changes in the Guatemalan tax system.

Absalón and Urzúa present in Chapter 5 a tax-benefit microsimulation model for the Mexican economy. Written in Excel, the model can be used to analyze the distributive impact of changes in the personal income tax schedule, the value added tax rates, the excise tax rates, and the social security contributions. The use of the model is exemplified by examining the distributive impact of the tax reform that took effect in 2010. It is interesting to note, in passing, that Abramovsky, Attanasio and Phillips (2011a) have recently developed, independently from the authors, a similar model. In Chapter 6, on the other hand, Castañón-Herrera and Urzúa present a behavioral model to examine the optimality, or the lack of it, of the current indirect tax system in Mexico. Regarding the use of behavioral models to appraise tax reforms, it is somewhat paradoxical that, until today, this approach has been preferred in Mexico over the use of arithmetic microsimulation models. Urzúa (1994 and 2001) provides some early models, while two of the most recent ones can be found in Abramovsky, Attanasio and Phillips (2011b) and in this book.

In Chapter 7, Amarante, Bucheli, Olivieri and Perazzo offer in turn a microsimulation model for the Uruguayan tax-benefit system, after carefully combining the information on income given in a household survey and the information contained in an expenditure survey. As an example of the use of their model, the authors explore the distributive impacts of alternative designs of direct and indirect taxes, focusing in particular in the case of a possible zero value added tax rate for a basket of goods consumed by the poorest population. In Chapter 8 the same authors, after estimating a full demand system, allow for the possibility of having behavioral changes in their model, and then proceed to investigate whether or not that extension modifies in a substantial way the results obtained in the earlier chapter.

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1 A Brazilian tax-benefit microsimulation model[1]

José Ricardo Bezerra Nogueira, Rozane Bezerra de Siqueira and Evaldo Santana de Souza

1. Introduction

As pointed out by Immervoll, Levy, Nogueira, O'Donoghue and Siqueira (2006), given "the great diversity observed among the population and the complexity of the Brazilian tax-benefit system, the redistributive analysis of the impact of social and fiscal policies requires that a high level of disaggregation be used in order to capture in fine detail their effects on the various types of individuals, families and households".

To carry out such an analysis while taking into account, on the one hand, that individuals in the population vary widely in terms of their socio-economic circumstances, and that, on the other hand, the different policy instruments are highly interdependent, detailed and disaggregated information about how taxes and benefits operate at the individual level is required. As is often the case when information is not usually available in survey data, it is necessary to simulate the operation of taxes and benefits on the population. The microsimulation approach is the one that permits that such a procedure be performed at the individual level.

Microsimulation models are built as computer programs that calculate tax liabilities and benefit entitlements for each unit of analysis (individuals, families or households) in a nationally representative micro-data sample of the population. The model's routines calculate each element of the tax-benefit system in the legal order so that interactions between different elements of the system are fully taken into account. Results for each individual, family or household are then weighted to provide results at the aggregate population level (Immervoll *et al*., 2006).

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This chapter reports the development of a tax-benefit microsimulation model for Brazil, as part of the FSID project sponsored by the UNDP and the IDRC. The chapter is organized as follows. Section 2 summarizes the main policy instruments of the Brazilian tax-benefit system. Section 3 presents the Brazilian tax-benefit microsimulation model, detailing which policy instruments (social benefits, not-strictly social benefits, and taxes) were selected to be part of the model's policy set and how they are simulated in the model. Finally, Section 4 displays examples of the output that the model generates, illustrating them with the simulation of the status quo.

2. The Brazilian tax-benefit system

Brazil's tax-benefit system comprises a wide array of social benefits and taxes. We briefly describe below its main elements, grouped into four categories, namely, social benefits, not-strictly social benefits, social security contributions, and taxes, both the personal income tax and taxes on goods and services. A more detailed account of the Brazilian system can be found in Nogueira, Siqueira and Souza (2011).

The Brazilian government sector comprises the federal government, 27 states, over 5,000 municipalities, the federal district and several agencies. Due to its federalist structure, the country is divided in states and municipalities, Brazil's tax-benefit system cuts across the three different levels of government: federal, state and municipal. However, the bulk of the social spending is realized by the federal government. As to the Brazilian tax system, about 70% of total tax revenue is raised by the federal government.

2.1. Main monetary social benefits

The most important monetary social benefits in Brazil are the following:

• Age-related pension: benefit paid to private workers at 65 years for men and 60 years for women, in urban areas, and at 60 years for men and 55 years for women, in rural areas, provided that they have contributed to social security for at least 15 years, for workers in the rural area, or worked for at least 15 years in the rural sector, for workers in the rural area. Civil servants have different eligibility rules, retiring at 60 years for men and 55 years for women, provided that they have contributed to social security for at least 35 years for men and 30 years for women,

except for primary- and high-school teachers, who can retire 5 years earlier than other civil servants.

• Length of contribution-related pension: paid to private workers who have contributed to social security for 35 years for men and 30 years for women, with no minimum retirement age. It is also possible to mix age and length of contribution to get a proportional pension. This requires 53 years of age and 30 years of contribution for men and 48 years of age and 25 years of contribution for women.

• Disability pension: benefit paid to workers rendered incapable to work due to sickness- or accident-related problems. There is no minimum length of contribution in the case of accident, but in the case of sickness the worker has to have contributed to social security for at least 12 months.

• Sickness benefit: paid to those who are prevented from working for more than 15 days due to sickness or accident, provided that they have contributed to social security for at least 12 months in the case of sickness (in the case of accident there is no minimum length of contribution requirement).

• Accident benefit: paid to those who had already enjoyed the sickness benefit and who had their ability to work permanently impaired by accident. There is no minimum length of contribution requirement.

• Imprisonment benefit: paid to the dependents of those who are in prison, during all of the imprisonment period. There is no minimum length of contribution requirement.

• Survivors pension: benefit paid to the surviving spouse and the children of deceased workers. There is no minimum length of contribution requirement.

• Maternity leave benefit: a payment made to pregnant women for a period of 4 months after child birth. There is no minimum length of contribution requirement.

• Family benefit: a means-tested benefit paid to workers with children aged less than 14 years or disabled. For each dependent child the person receives a pre-determined amount, which depends on the income bracket the person is included. Only formal workers are eligible to the benefit.

• Old age and disability benefit: a means-tested benefit that is paid to those aged 65 years or more, or to those who are unable to work because of a disability. To be eligible, the family per capita income must be less than a quarter of the minimum wage and the person cannot be receiving any other social benefit.

• Wage bonus: benefit paid to those formal workers who receive up to two minimum wages, are registered in one the social savings programs, PIS and PASEP, run by the government, and who worked for at least 30 days in the previous year.

• Unemployment benefit: paid to those formal workers who are unemployed. The person can receive from 3 to 5 installments, depending on the number of months worked in the period of 36 months before being unemployed. The value of the benefit is income-related.

• Family grant: benefit paid to poor families a benefit conditioned to children's school attendance and vaccination, to mother's prenatal exams, and the use other social services. The benefit is made up of three parts: a basic grant paid only to families in extreme poverty; a variable grant paid to all poor families with children up to 15 years of age, to a maximum of three children; and a further variable grant paid to all poor families with children between 16 and 17 years of age, to a maximum of two children.

• Annual bonus: benefit paid to all retired person receiving a state pension in the form of an extra monthly pension annually.

Table 1 lists the social benefits that are possible to simulate with the existing Brazilian data sets.

2.2. Main not-strictly social benefits

Below are two income components that are not strictly part of the benefit system but that are important in determining the direct taxes system in Brazil. Both are fully simulated in the Brazilian microsimulation model described later.

• Thirteenth wage*:* Benefit paid to all formal workers in the form of an extra monthly wage annually.

• Holidays bonus: Benefit paid to all formal workers, who are paid an extra 30% on top of their wages when on official holydays.

2.3. Social contributions

The social insurance system in Brazil is a pay-as-you-go scheme that covers civil servants (at the federal, state and municipal levels), as well as workers in the private sector. The main goals of the system are to secure maintenance income to those out of work due to old age, invalidity, retirement or due to the death of the head of the family, and to complement family income.

Table 1. *Simulation of social benefits*

	Treatment	Why not fully simulated?
Age-related pension	I	No data on contribution history
Length of pension	I	No data on contribution history
Disability pension	I	No data on contribution history
Sickness benefit	I	No data on contribution history
Accident benefit	I	No data on contribution history
Imprisonment benefit	I	No data on contribution history
Survivors pension	I	No data on contribution history
Maternity leave benefit	I	No data on contribution history
Family benefit	S	
Old age benefit	S	
Disability benefit	E	No data on contribution history
Wage bonus	S	
Unemployment benefit	S	
Family grant	S	
Annual bonus	S	

Notes: "E": excluded from the model as it is neither included in the micro-data nor simulated; "I": included in the micro-data but not simulated; "S" simulated, although some minor or very specific rules may not be simulated.

Brazilians compulsorily contribute to the social security system according to their occupational status and their income. There are two main regimes. The first is the social security general regime, which covers employed workers (including domestic and temporary workers), self-employed workers and employers. In this regime contributions are calculated as a percentage of wages following a rate schedule. The rates vary with income classes for workers, and for employers it is applied a constant rate on wages paid. The second is the public servant social security regime, which covers workers in the public service. There are different schemes for the federal government, the states and the municipalities, but there has been a convergence to the scheme followed by the federal government.

In addition to the above social contributions, the system is financed by payroll and earmarked social taxes. In the description that follows of the components of the social security regimes, we include the payroll-based social contributions, while the earmarked social taxes will be mentioned in the subsection on taxes.

• Employees' social contribution: paid by private workers, domestic workers, and temporary workers.

• Individuals' social contribution: made by self-employers, employers contributing as individuals, and members of religious institutions.

• Federal civil servants' social contribution: paid by civil servants in the federal government.

• Military federal servants' social contribution: paid by military servants in the federal government.

• State civil servants' social contribution: made by civil servants in state governments.

• Municipal civil servants' social contribution: paid by civil servants in municipal governments.

• Domestic employers' social contribution: made by employers of domestic workers.

• Employers' social contribution: paid by employers (except domestic employers).

• Workers' support fund: social contribution made by firms to a supporting fund to protect workers when they are unemployed or retired and finance social housing and urban infrastructure.

• Education wage: contribution paid by firms based on their payroll and used to finance basic education programs.

• S system (*Sistema S*): social contribution paid by firms affiliated with certain social institutions created to promote professional education and deliver social services to their workers. The contribution is on the payroll.

• Contribution for work-related accidents: A federal contribution levied on firms based on their payroll to finance work-related accident allowances.

Table 2 specifies which of the above social contributions are simulated in the Brazilian model.

2.4. Taxes

The power to tax is distributed among the federal, state, and municipal governments. A major characteristic of the Brazilian tax system is the fact that indirect taxes constitute the main source of tax revenue. Also, tax revenue is concentrated on a few of them. About a quarter of total revenue comes from a single tax, the ICMS (tax on the circulation of goods and transportation and communication services). A list of the main Brazilian taxes is presented next.

• Personal income tax: Tax falling on total personal income. The tax base is defined as the difference between gross personal income received

Table 2. *Simulation of social contributions*

	Treatment
Employees' social contribution	S
Individuals' social contribution	S
Federal civil servants' social contribution	S
Military federal servants' social contribution	S
State civil servants' social contribution	S
Municipal civil servants' social contribution	S
Domestic employers' social contribution	S
Employers' social contribution	S
Workers' support fund	S
Education wage	S
S system	S
Contribution for work-related accidents	S

Note: "S": simulated, although some minor or very specific rules may not be simulated.

in the calendar year and total tax reliefs. Gross income corresponds to earned incomes in general, including labor income, rental income, pensions and farming income.

• Corporate income tax: levied on taxable income, which corresponds to book profit before taxes, allowing for some additions (for example, losses on investments) and deductions (for instance, gains on investments). Taxpayers may choose to pay corporate income tax on net income on a calendar year or on a quarterly basis.

• Tax on industrialized products (IPI): a value-added type of tax levied on sales by manufacturers.

• Taxes on foreign trade: duties levied on imports and exports of products.

• Tax on ownership of rural state: levied on the ownership of real state outside the urban perimeters.

• Contribution to the social integration programs (PIS/PASEP): paid by firms based on gross revenue. Non-profitable organizations contribute based on their payroll. This tax is mainly used to finance unemployment benefits and wage bonuses.

• Contribution for social security financing (CONFINS): tax paid by firms based on their gross revenue and earmarked to finance the social insurance scheme.

• Social contribution on net profits (CSLL): tax levied on enterprises' gross revenue and destined to finance social insurance.

• Tax on financial transactions: levied on transactions involving credit, foreign currencies, insurance, stocks, etc.

• Tax on the circulation of goods, transportation and communication services (ICMS): a general sales tax levied by the states, imposed on the transfer of goods at all stages of production and distribution, including retail. As mentioned earlier, it is the main Brazilian tax.

• Tax on the ownership of motor vehicles (IPVA): levied at the state level, imposed on the ownership of cars and other motor vehicles.

• Tax on services (ISS): levied at the municipal level and imposed on the supply of services by firms and self-employees.

• Tax on the ownership of urban real state (IPTU): a municipal tax levied on the ownership of real state located within the urban perimeter.

• Tax on the transfer of urban real state (ITBI): a municipal tax levied on sales of urban real state.

• Tax on the inheritance and donation of assets (ITCDM): a state tax levied on assets inherited or donated.

Table 3 below lists the taxes that are possible to be simulated with the available information contained in the Brazilian data sets.

3. The model

This section details the model. First, we give an overview of the data set. Second, we present the legal rules that determine eligibility to the social benefits and payment of the taxes included in the model and how they are simulated, taking into consideration information availability and restrictions found in the official household survey used to build the model's data set. Third, since the simulation of indirect taxes requires that household expenditure information be imputed into the model's data set, we describe the imputation procedure used and how indirect taxes are simulated. Finally, we discuss how the model can be used to perform behavioral change analysis associated with price variations. In the Appendix to this chapter, we briefly sketch the basics of how to run the Brazilian model using its Stata commands. The model's computer code is freely and readily available, as described there.

3.1. The Brazilian data set

The data set used in the model was built using household micro data from Pesquisa Nacional por Amostra de Domicílios (PNAD) for the year

Table 3. *Simulation of taxes*

	Treatment	Why not fully simulated?
Personal income tax	S	
Corporate income tax	E	NIA
Tax on industrialized products	S	
Tax on foreign trade	E	NIA
Tax on ownership of rural state	E	NEI
Contribution to the social integration program	E	NIA
Contribution for social security financing	E	NIA
Contribution on banking transactions	E	NIA
Social contribution on net profits	E	NIA
Tax on financial transactions	E	NIA
Tax on the circulation of goods, transportation and communication services	S	
Tax on the ownership of motor vehicles	E	NEI
Tax on services	E	NEI
Tax on the ownership of urban real state	E	NEI
Tax on the transfer of urban real state	E	NIA
Tax on the inheritance and donation of assets	E	NIA

Notes: "E": excluded from the model as it is neither included in the micro-data nor simulated; "S": simulated, although some very specific rules may not be simulated; "NIA": no information available; and "NEI": not enough information available.

2009. PNAD is a rural-urban household survey, covering all Brazilian regions, carried out by IBGE, the Brazilian Institute of Geography and Statistics. But, as PNAD does not contain expenditure data and this information is needed in order to model and simulate indirect taxes and medical tax allowances, a separate survey, Pesquisa de Orçamentos Familiares (POF) for the period 2008-09, also produced by IBGE, was used. Similarly to PNAD, POF covers all Brazilian regions. Table 4 details the main characteristics of both the PNAD and POF surveys.

Despite the fact that the main unit of analysis of the model is the household, the Brazilian data set displays socio-economic-demographic information, separately, for all individuals in the sample. It is so because most social benefits and taxes have the individual as the legal unit. An aggregation is then performed for each household, over its individual members, to get the household total.

Incomes reported in PNAD are gross of taxes. They incorporate only incomes regularly received by individuals. Thus, the benefits such as the

Table 4. *Description of the Brazilian household surveys*

	PNAD	POF
Year of collection	2009	2008-09
Conducted	Yearly	At about a 5-year interval
Publication	One year after collection	One year after collection
Period of collection	Sept. 2008 to Sept. 2009	May 2008 to May 2009
Reference period	Month	Last 12 months, 3 months, month, and week
Sampling	Three-stage sampling stratified by municipal, 2000 official census and household levels	Two-stage sampling stratified by geographical and household levels
Unit of assessment	Household	Household
Coverage	National, permanent private households only	National
Other coverage	Representative at the state, urban, rural, regional and metropolitan areas levels	Representative at the state, urban, rural, regional and metropolitan areas levels
Sample size	153,837 households	55,970 households

Source: IBGE (2009 and 2010).

unemployment benefit, holiday bonus, and the thirteenth wage are not included. On the other hand, the family wage benefit is included in the reported incomes.

There are three sources of labor income: main job, secondary job, and other jobs. For simulations requiring information about formal labor status, only incomes from main and secondary jobs are considered since this information is absent for other jobs. For simulations requiring information about contribution to social security, all three sources of income are used.

Some adjustments are made in the construction of the Brazilian data set from the original PNAD data. First, since there are some cases where the household weight variable in PNAD is negative, the decision taken was to exclude these cases from the final data set. There are no equivalent problems with the individual and family weights. Second, given that some pension incomes are reported in PNAD with a value less than the official minimum wage, we impute the official minimum value

(equal to the official minimum wage) for these cases. Third, since some formal labor incomes are reported in PNAD with a value less than the official minimum wage, we impute the official minimum value for those cases. Fourth, since some individual incomes are reported as ignored in PNAD, we impute a zero value for such cases, which amount to less than one percent of total cases. Fifth, the incomes of children less than ten years old are not included in the total value of family/household income, which includes incomes from all types of sources (labor, pension, rent, private transfer, etc.). In the computation of family/household income, only the incomes of the head, the spouse, the children ten years old or more, and other relatives ten years old or more are included. This is the usual procedure adopted in the Brazilian surveys. And sixth, in PNAD there is a variable that assigns to every individual a "condition" within the household/family. For example, the individual may be the head of the household/family, a spouse, a child, a relative, etc. Individuals assigned with the condition "boarder" or "domestic employee" are retained in the final data only when they are reported as head of some household/family. All the others are withdrawn because they do not constitute a member of any household/family in the data set.

3.2. Simulation of the Brazilian tax-benefit system

The model simulates six monetary social benefits, two not-strictly monetary social benefits, nine social security contributions, the personal income tax, and two taxes on consumption. Calculations are performed for each individual, family or household, which are then weighted to provide results at the population level.

Monetary values of benefits and taxes are simulated in a monthly basis, as are the reported income values in PNAD. This means that those benefits that are not regularly received in a monthly basis, like the unemployment benefit and the wage bonus, have their annual value divided by 12 to get their corresponding monthly value.

We describe below each policy instrument's legal rule and how it is simulated in the model. The rules described refer to those in force in 2009, which constitutes the model's base year.

3.2.1. Social benefits

Only cash benefits are modeled. Benefits are simulated under the assumption that all entitled individuals/families actually receive them; that is, we ignore non-take-up and targeting problems. Thus, the model

simulates the potential impact of perfectly targeted and fully taken-up social benefits.

3.2.1.1. Family wage (*salário família*). A means-tested benefit paid to workers with children aged up to 14 years or disabled. For each dependent child the person receives a pre-determined amount, which depends on the income bracket in which the person is included. Only formal workers are eligible to the benefit. If both parents fulfill the legal conditions, they both can receive the benefit for the same children. The unit of assessment is the individual, and both fathers and mothers can claim the benefit for the same child. For lack of information in PNAD, we cannot verify the disability status of individuals. Therefore, the model only uses the age of children and individual income to select those eligible for the benefit. The benefit is calculated for the main and secondary jobs, and then summed up to get the total value of the benefit. For other jobs it is not possible to simulate the benefit for lack of information about job status (formal or not) in PNAD.

The model first calculates the number of dependent children for each household using the definition of dependent children as those classified as son or daughter and being up to 14 years old. Then, the model verifies the job status of spouses in order to select only those in formal employment. The recipients' monthly income must fall in one of the two income thresholds (up to R$500.41, and above R$500.41 and less than R$752.12) for which the benefit applies. The source of income included in the income assessment is labor income. For those in the first income threshold, the amount of the benefit is defined by the number of dependent children times the per children value of the benefit (R$25.66) for this threshold. For those in the second income threshold, the amount of the benefit is defined by the number of dependent children times the per children value of the benefit (R$18.08).

3.2.1.2. Unemployment benefits (*seguro desemprego*). Income-related benefit that is paid to those formal workers who are unemployed, had earned up to two minimum wages monthly in the previous year, and had worked for at least 30 days in that period. The person can receive from three to five installments, depending on the number of months worked in the period of 36 months before being unemployed. The unit of assessment is the individual.

As PNAD contains information only for the period of 12 months before the individual being unemployed, the condition of number of months previously worked is checked only for that time period, and not

for the legal period of 36 months. Due to this information restriction, the benefit is also simulated under the assumption that all beneficiaries receive five installments. This assumption produced a better adherence between simulation results and administrative data. Also, as the family wage benefit is not included in the assessment of their income, and as original incomes in PNAD include the benefit, it is necessary to deduct the simulated value of the benefit from their income base.

The model selects those who have received unemployment benefits and then calculates the amount received. The benefit differ among three income tiers (up to R$767.60, in between that and R$1,279.46, and higher). The source of income included in the income assessment is labor income. The amount of the benefit, which cannot be less than one minimum wage (R$465), is calculated as follows: For those in the first income tier, their income is multiplied by 0.8. For those in the second income tier, their income up to the first tier limit is multiplied by 0.8 and the extra income is multiplied by 0.5. For those in the third income tier, the amount of the benefit is fixed at (R$870.01).

3.2.1.3. Wage bonus (*bônus salarial*). Benefit paid to those formal workers who receive up to two minimum wages, are registered in one the social savings programs, PIS and PASEP, who worked for at least 30 days in the previous year. In practice it works as a fourteenth wage paid to low-income workers. Given that in PNAD there is no information about enrollment in the social savings program, this condition is not included in the simulation. The unit of assessment is the individual.

As with the unemployed benefit, the family benefit has to be deducted from the original income reported in PNAD in order to determine the individuals' income base used to calculate the value of the benefit. The benefit is calculated both for the principal job and for the second job, but not for any other job the individual may have due to lack of job status (formal or not) in PNAD data set. The benefit is paid to formal workers whose monthly labor income is up to two minimum wages (R$930). The amount of the benefit is equal to one minimum wage (R$465).

3.2.1.4. Annual bonus (*bônus anual*). Benefit paid to all retired person receiving a state pension in the form of an extra monthly pension. The unit of assessment is the individual. The model simulates the benefit for all those individuals that received that pension. The amount of the benefit is equal to the value of the state pension received by the individual.

3.2.1.5. Family grant (*Bolsa Família*). A conditional cash benefit paid to poor families, conditioned to children's school attendance and their

vaccination, to mother's prenatal exams, and to the use of other social services. However, the model simulates the social benefit without conditioning it to vaccination, prenatal exams, and use of social services, for lack of this information in PNAD. The unit of assessment is in this case the family.

The model first calculates the number of dependent children aged up to 15 years, and then the number of dependent children aged between 16 and 17 years. This is necessary since the benefit attributes different values for these two groups of dependents. Income assessment is made on the basis of per capita family income, defined as total family income (sum of all sources of income reported in PNAD) less the family wage divided by the number of members of the family.

The benefit is composed of two parts. The first, called basic benefit, is independent of presence of children in the family, being target to all families considered to be extremely poor (per capita family income equal or less than R$70) and its amount is equal to a fixed value (R$68). The second part, called variable benefit, is paid to all families considered to be poor (per capita family income equal or less than R$140) and with children up to 17 years of age. The amount of the variable benefit is defined per children and is differentiated according to their age. For children between zero and 15 years of age the value of the benefit is R$22 per child up to a maximum amount of R$66, corresponding to three children. For children between 16 and 17 years of age the value of the benefit is R$33 per child up to a maximum amount of R$66, corresponding to up to two children.

3.2.1.6. Old age and disability benefit (*LOAS*). A means-tested benefit paid to those aged 65 years or more or to those who are unable to work because of a disability. To be eligible, family per capita income must be less than one quarter of the minimum wage and the person cannot be receiving any other social benefit. However, the model takes only the individual income to assess eligibility to the benefit, since this resulted in a better fit with administrative data. The benefit is simulated only for old wage people since PNAD does not contain information on disability. The unit of assessment is the individual. As the benefit, if received, is already included in the "other incomes" variable in PNAD, mixed with several other sources of income, this type of income is deducted when calculating the individuals' income. The recipients' monthly income must be less than one quarter of the official minimum wage (R$116.25). The amount of the benefit is one minimum wage (R$465).

3.2.2. Not-strictly social benefits

Some work-related benefits that enter total income are not strictly part of the benefit system. However, they are simulated since they enter in the base for calculating social contributions and the personal income tax.

3.2.2.1. Thirteenth wage (*décimo terceiro salário*). Benefit paid to all formal workers in the form of an extra monthly wage annually. The unit of assessment is the individual. The amount of the benefit is equal to the value of the monthly wage received by the individual and is attributed only to those individuals who are reported as employed in formal, legally registered jobs.

3.2.2.2. Holidays bonus (*adicional de ferias*). Benefit paid to all formal workers, in the form of an extra 30% payment on top of their wages when on official holydays. The unit of assessment is the individual. The amount of the benefit is equal to 30% of the monthly wage received by the individual, who must be reported as enrolled in a legally registered employment.

3.2.3. Contributions

The Brazilian model simulates most contributions to the social security schemes at the federal, state, and municipal levels.

3.2.3.1. Employee's social contribution. It is paid by formal private sector workers and temporary workers based on their earnings, up to a ceiling. Contributory rates vary according to income: 8% for incomes up to R$965.67, 9.9% for the next bracket up to R$1,609.45, and 11% for incomes greater than R$1,609.45 and less or equal than R$3,218.90. This last amount constitutes the contributory ceiling for larger incomes.

3.2.3.2. Domestic employee's social contribution. It is contributed by formal domestic employees based on their earnings, up to a ceiling, in the same way and with the same rates as other formal employees. The difference is that, in this case, from the domestic employee's income base it is not possible to deduct the family wage, a benefit they are not legally entitled to.

3.2.3.3. Individual's social contribution. Contribution paid by self-employed workers, by applying a flat rate (20%) on their income. The model sets the value of the minimum wage (R$465) as the income base upon which the contributory rate applies, rather than the actual incomes, since this adjusts better the simulation results to administrative data.[2]

3.2.3.4. Federal civil servant's social contribution. It is paid by federal government workers based on their earnings, at a flat rate of 11%.

3.2.3.5. Federal military servant's social contribution. It is made by military servants working for the federal government based on their earnings, on which it is applied a flat rate of 7.5%.

3.2.3.6. State civil servant's social contribution. It is paid by civil servants working for the 27 state governments plus the federal district, with each state having its own social security scheme. However, recently, there has been a convergence towards the rate structure applied for federal civil servants. Of the 27 states, 22 currently follow the federal government's rate structure, with their civil servants contributing with a flat rate (11%) on their earnings. The other five states' contributions are simulated taking their own contributory rates structure.[3]

3.2.3.7. Municipal civil servant's social contribution. It is made by civil servants working for municipal governments. As only very few (large) municipalities have their own social security schemes, the great majority of municipalities have their servants enrolled in the federal social security scheme. The model simulates this contribution under the assumption that all municipal civil servants pay the same flat rate contribution (11%) on their earnings as the federal civil servants.

3.2.3.8. Domestic employer's social contribution. Contribution paid by those who hire domestic workers, by applying a flat rate contribution (12%) on the earnings paid to the workers.

3.2.3.9. Employer's social contribution. It is paid by the employers, except domestic employers, by applying a flat rate contribution (20%) on their payroll. The model simulates it by applying the rate on earnings of all formal private sector employees.

3.2.4. Personal income tax

The unit for the personal income tax is mainly the individual. However, spouses and dependents can file a joint income tax return, with their incomes taxed jointly. Also, some tax allowances and tax credits are jointly assessed. Moreover, individuals may choose to file either a simplified form or a complete form. In the first case, a standard deduction is applied. The objective is to simplify tax reporting for most taxpayers who have only a limited amount of deductions. In the complete form, individuals have to report all deductible payments. The income earned by dependent persons may be reported individually or together with one of their parents. The model assumes that spouses and dependent persons earning up to the income exemption limit are pulled together with the head of the family, their incomes being taxed jointly. The model

uses a maximization algorithm that selects the best option (simplified form or complete form) for the individual, that is, the alternative that generates the smaller amount of tax to be paid.

3.2.4.1. Taxable income. It is defined as total gross income minus the value of the exemptions. Gross income corresponds to earned incomes in general, including labor income, rental income, pensions, and farming income. Income from stock exchange transactions, called variable income, and from the sale of non-financial assets (for example, real state), called capital gains, are treated separately, being taxed at the moment the transaction is made. Return on financial assets and shares in corporate profits and dividends are also taxed separately at the time of their realization. For lack of information, however, these incomes are not included in the model.

3.2.4.1. Exemptions. There are several income components that are exempt from taxation but that have to be declared when filing the income tax return form. The exemptions incorporated into the model are: exempt part of the pension and annual bonus income of those aged 65 or more, equivalent to the general income exemption limit (R$1,434.59),[4] and the unemployment benefit. These components are subtracted from pre-tax income in order to have the taxable income.

Income from savings accounts is exempt from the income tax. However, in PNAD this type of income is reported together with income from several other sources such as government cash transfer programs, dividends, and investment incomes, some of which are taxable while others are not. As there is no way of separating out these income sources, the model is run under the assumption that these bundled incomes, labeled “other incomes”, are not taxable.

3.2.4.2. Tax base. The income tax base is defined as the difference between taxable income and total tax allowances. Aside from the social security contributions, the tax allowances built into the model are: allowances for dependents, medical expenses, and educational expenses. The dependent persons are made of spouses, children or relatives up to 21 years of age, children or relatives enrolled in university studies or technical colleges up to 24 years of age, and relatives who earn less than the exemption threshold (R$1,434.59). A standard deduction is applied for each dependent person (R$144.20). In the case of two-earner households, only one can claim the allowance.

Medical expenses, including those related to dependent persons, are fully deducted from gross income. However, there are some types of

medical expenses not eligible to the tax allowance, such as expenses with medicines, glasses and eye lenses. For modeling medical expenses it is necessary to impute medical expenditure into the PNAD-based data set. In order to do that we use the separate household expenditure survey POF since PNAD does not contain data on expenditure. The method employed is to calculate average values of medical expenses for each of 10 income groups, formed using the deciles of per capita regular monetary income,[5] in the POF data set, and then imputing these average values to the corresponding income groups in the PNAD-based data set.

In the case of the taxpayer's and his/her dependents' education expenses, these are subject to a pre-determined limit (R$225.75) per taxpayer. This tax allowance is simulated attributing that limit to those individuals who are attending a private school or a private university.

3.2.4.3. Tax schedule and deductions. Table 5 below presents the Brazilian personal income tax's rate structure. The individual may opt for filing his tax return using a simplified form consisting in applying a standard deduction (20% of taxable income, up to R$1,061.97) to his taxable income in order to determine his/her tax base. This option releases the individual of having to detail and, eventually, give proof of all deductible expenses incurred. The model sets a value for the standard deduction equal to whichever is greater, 20% of taxable income or R$1,061.97. Our model simulates both the complete tax return (detailing all deductible expenses and applying the income tax schedule) and the simplified tax return (using the standard deduction) for all individuals and chooses the one that minimizes their tax payments.

3.2.5. Indirect taxes

The indirect taxes in Brazil that are possible to be simulated are those levied on the consumption of goods and services, namely the tax on industrialized products, IPI, and the tax on the circulation of goods and transportation and communication services, ICMS. The first is a tax levied by the federal government on manufactured products. There are several different tax rates that apply to different groups of products (like, for example, motor vehicles, alcoholic beverages, tobacco, etc.). The ICMS, on the other hand, is a tax levied at the state level on transactions involving goods in general and on specific services related to transportation and communication. There are 28 different tax laws for the ICMS, corresponding to the 27 Brazilian states plus the Federal District. Tax rates can change within and across the states.

Table 5. *Personal income tax schedule, 2009*

Income (R$ per month)	Rate
Up to 1,434.59	Exempt
1,434.60 up to 2,150.00	7.5%
2,150.01 up to 2,866.70	15.0%
2,866.71 up to 3,582.00	22.5%
Greater than 3,582,00	27.5%

Source: *Receita federal*, Brazilian Ministry of Finance.

3.3. Simulation of indirect taxes for Brazil

The simulation of the tax on industrialized products and of the tax on goods and services involves some degree of complexity. As PNAD has no information about household expenditure, another data set, POF, has to be used. This implies that some form of expenditure imputation, from POF to the PNAD-based data set, has to be carried out.

The imputation procedure involves three main steps. First, aggregate groups of consumption expenditure are created in the POF data set. Second, total consumption is econometrically estimated and imputed into the model's data set. And third, average budget shares are calculated from POF and imputed into the model. Below we describe more precisely the imputation procedure adopted in developing the model.

3.3.1. Expenditure imputation

The nine expenditure groups that we create in POF are: food, alcoholic beverages and tobacco, clothing, housing, electricity and domestic fuel, health and education, transport and communication, recreation and culture, and other goods and services. Expenditure on these groups is imputed to the data set by econometrically estimating total expenditure for a range of household types in the POF data set, and using the estimated parameters to impute total expenditure in the PNAD-based data set. Average budget shares are then calculated in the POF data set for ten household income groups, using total regular monetary household income and socio-economic variables. These average budget shares are then imputed to the model's corresponding household income groups.

The use of the concept of regular monetary income as the basis to group households in income strata is due to the fact that there is a marked difference between the components of total household income in both data sets. POF reports regular and eventual monetary incomes plus non-monetary incomes. PNAD reports only regular monetary incomes and a

very small fraction of non-monetary incomes. In order to make the two data sets compatible, we create a new definition of household income which includes only regular monetary incomes. This procedure dispenses with the estimation of a complete demand system for Brazil. Such a procedure is adequate when one has problems with available data for estimating a complete demand system. In the case of Brazil, POF has price data only for food. Elsewhere we can find recent price data only for food, urban transport and fuel, and that only for metropolitan areas.

3.3.1.1. Imputation of total consumption.[6] The functional form to be estimated for total expenditure in the POF data set is:

$$(1) \qquad \ln C_{POF} = \alpha + \beta \ln Y_{POF} + \boldsymbol{\theta}\mathbf{X}_{POF} + \mu ,$$

where C is total household consumption, Y is total household income, $\mathbf{X}$ is a vector of socio-demographic characteristics, and α, β, and $\boldsymbol{\theta}$ are coefficients, with $\boldsymbol{\theta}$ being a vector.

The socio-demographic characteristics to be considered are as follows: household total income, sex of the head of household, age of the head, conjugal condition of the head of household (married or not), state of the federation, urban or rural area, household occupation condition (rented or not), education of the head of household, job occupation of the head of household, number of people in the household receiving income, number of children aged 0-6 years, number of children aged 7-14 years, number of children aged 15-17 years, number of adults aged 18-65 years, number of old people aged 66 or more years

The coefficients in equation (1) above are estimated by ordinary least squares and then used to impute total consumption into the PNAD-based data set according to the following equation:

$$(2) \qquad \ln C_{PNAD} = \hat{\alpha} + \hat{\beta} \ln Y_{PNAD} + \hat{\boldsymbol{\theta}}\mathbf{X}_{PNAD} + \hat{\mu} ,$$

where the disturbance term is simulated assuming that it is normally distributed with zero mean and variance equal to that of the residual of the POF regression given before. This is to ensure that in both POF and the PNAD-based data sets we have the same variance of consumption.

3.3.1.2. Imputation of budget shares. Budget shares for the nine consumption groups included in the Brazilian model are obtained in the POF data set by dividing expenditure on each consumption group by total household income. This procedure is followed in each decile of household regular monetary income. Average budget shares are next calculated for each income group by adding up the budget shares in the

group and dividing it by the total number of households in it. These average budget shares are then imputed into the corresponding household income groups of the model's PNAD-based data set.

3.3.2. Calculating indirect tax payments

The tax on industrialized products and the tax on goods and services, even though they are in principle value-added type of taxes, present in fact some degree of cumulative effects due to problems associated with the implementation of tax refunds, with the tax burden passed along to indirect firm purchases, and to final demand. This implies that legal tax rates may not be appropriate to calculate the tax burden faced by individuals and families. Instead, one has to estimate effective tax rates. Estimation of these rates for the IPI and ICMS is carried out outside the microsimulation model, following the method in Siqueira, Nogueira and Souza (2001), using POF and the Brazilian 2005 input-output matrix.

The vectors of the IPI effective rates and the ICMS effective rates, with one rate for each of the nine consumption groups, are introduced as fixed parameters into the microsimulation model. With these effective rates so introduced for each of the consumption groups, the model simulates the amounts of IPI and ICMS paid by households, in the status quo, by multiplying the household expenditure on each of the nine consumption groups by the respective tax rate. Household expenditure on each consumption group is calculated in turn by multiplying the average budget shares by total household expenditure.

3.4. Simulation of behavioral changes

The model may be used to simulate changes in household behavior on account of price variations. Household reaction to price variations takes the form of changes in the composition of total expenditure. In order to simulate the reaction, it is assumed that household preferences can be represented by the linear expenditure system (LES).[7] Households within the same income group are assumed to have the same preferences, but these vary according to the total expenditure of each group. Demand (expenditure), for each of the nine consumption groups, is given by:

$$(3) \qquad p_i x_i = p_i \gamma_i + \beta_i \left(E - \sum_{i=1}^{9} p_i \gamma_i \right),$$

where p_i is the price of the composite good i, x_i its consumption, γ_i is the subsistence consumption level (so that $x_i > \gamma_i$), E is total household

expenditure, and β_i is the expenditure weight. These last marginal budget shares have to add to one.

Broadly speaking, the following procedure, to be detailed later, is used to estimate the parameters in equation (3): Engel curves, giving the relationship, for each of the nine groups of consumption, between the budget shares (proportion of income allocated to the purchase of each of the nine consumption groups) and total household expenditure, are first estimated for each household group. Then, using the estimated parameters of the Engel curves, expenditure (income) elasticities are calculated. These elasticities are, in turn, used to determine the marginal budget shares. Finally, the estimated values of these parameters, together with assumptions about the committed expenditure on the several consumption groups, allow the model to simulate behavioral changes associated with price variations.

More precisely, the marginal budget shares are calculated using the fact that, for a linear expenditure demand system,

$$\beta_i = \varepsilon_i w_i \ , \tag{4}$$

where ε_i is the expenditure (income) elasticity of demand and w_i is the (average) budget share of consumption group *i*. Budget shares for each household income group are imputed directly from POF, as explained above. Expenditure elasticities are determined by first estimating, in the POF data set, for each of the ten household income groups, and for each of the nine consumption groups, the following budget share equation:[8]

$$w_i = \delta_{1i} + \delta_{2i} \ln E + \delta_{3i}(1/E) \ . \tag{5}$$

The last equation specifies the relationship between total household expenditure E and the proportion of the total household expenditure allocated to the consumption group $i = 1, \ldots, 9$. Expenditure elasticities, for each group and each household type (in terms of total income), can then be expressed as:

$$\varepsilon_i = 1 + \left[\left(\delta_{2i} E / \delta_{3i}\right) - 1\right] / \left[E\left(\delta_{1i} + \delta_{2i} \ln E\right) / \delta_{3i} + 1\right] . \tag{6}$$

Then the estimated elasticities, nine for each household income group, are imputed into the model's corresponding income groups. After that, the marginal budget shares are calculated in the model's data set using equation (4).

In the case of subsistence consumption, it is determined by first assuming that total committed expenditure, $\sum_i p_i \gamma_i$, is equal to R$70 per

capita and per month. This last amount is equal to the value of the absolute poverty line recently set by the Brazilian government. However, it should be understood neither as an endorsement of this particular level of the poverty line nor as an assessment of it. Rather, it should be seen merely as one possible alternative to be used, among several that can be thought of, for purpose of illustrating the model's output.

Given that amount of committed expenditure, the minimal level of consumption of composite good *i* is determined, in a per capita basis, by:

$$p_i\gamma_i = \beta_i\left(E_{pc} - 70\right) - E_{pci} \ , \tag{7}$$

where E_{pc} is the total household expenditure per capita, while E_{pci} is the expenditure on consumption group *i*. The committed quantity consumed is then determined by dividing the expenditure on the item by its price.

3.4.3. Behavioral analysis

If we want to consider the impact of price changes on household consumption behavior, it is first necessary to determine the consumer prices under the status quo. For each of the nine consumption groups, and after setting producer prices to one and using the definition of a tax-inclusive rate, the consumer price is given by:

$$p_i = \left[t_i /(1 - t_i)\right] + 1 \ . \tag{8}$$

The tax rate t_i is equal to the sum of the IPI effective tax rate and the ICMS effective tax rate. That is,

$$t_i = t_i^{IPI} + t_i^{ICMS} \ . \tag{9}$$

In order to illustrate a possible price change, we can use the example, called Reform 2 in the next section, of a tax reform that exempts food from the payment of ICMS. Operationally, this means that the ICMS rate for food is made equal to zero. We thus have that the new composite tax rate on food becomes $t_i = t_i^{IPI} + 0 = t_i^{IPI}$ and, consequently, the price of food becomes:

$$p_i = \left[t_i^{IPI} /(1 - t_i^{IPI})\right] + 1 \ . \tag{10}$$

With this post-reform price, the model calculates the new level of total household expenditure and the new amount spent on each of the consumption groups after the reform. It also calculates the new tax revenue raised by the government.

4. Model's output

Simulations carried out with the model generate information, for each household in the data set, about the impact of changes in the benefits and taxes on several definitions of income (initial, gross, disposable, and final). This information constitutes the model's basic output, upon which distributional, poverty, and inequality statistics are calculated.

The simulation output is displayed in the form of tables of results. Below we show examples of some of these tables based on simulation results for the status quo scenario, or base run, and for two policy reforms. However, one should take care in interpreting the simulation results. The model, for instance, does not take into account tax evasion and the non-take-up of social benefits.

What the model is primarily aimed at is to quantify the potential impact of the policy instruments by simulating the tax-benefit legal rules as close as possible given the available data. Sometimes, as with the unemployment benefit, the data base might underestimate the number of entitled individuals. In other instances, as with the personal income tax, since the model ignores tax evasion, it might overestimate the total value of the policy instrument.[9] One should also note that the results presented below are not intended as being the outcome of a thorough analysis of Brazil's current system of taxes and social benefits or of possible reforms to it. Rather, they should only be seen as illustrations of the model's output capabilities.

Results are shown taking the household as the unit of analysis. The results are generally aggregated for certain groups of household income. This aggregation is made using the concept of per capita equivalent gross regular monetary income (equivalent gross income, for short), which is defined as follows:

$$\textit{Equivalent gross income} = \textit{Gross income} / N^{\alpha},$$

where N is the number of persons in the household and $0 \leq \alpha \leq 1$. For the simulations presented here, α was set equal to one.[10]

4.1. Base-run simulation results

The starting point in the presentation of simulation output is to display, for the base-run, named here as the status quo, the average monthly household income according to the several income concepts mentioned above. The objective here is to give a picture of how household income

is affected by the receipt of social benefits and the payment of taxes. This is done by calculating initial income (defined as income before benefits and taxes), gross income (initial income plus social benefits plus not-strictly social benefits), disposable income (gross income minus direct taxes), and final income (disposable income minus indirect taxes) for different groups of household income. That picture is shown in Table 6 below.[11] The results presented there are but a tiny example of the several types of outcomes the model is capable to generate. A variant, for example, could be obtained by classifying household groups according to other socio-economic-demographic characteristics as those mentioned in the vector of household characteristics used in the imputation of expenditure described in subsection 3.3.1.1 above. Going back to Table 6, the results presented there may be interpreted as suggesting that gains associated with the receipt of social benefits, as captured in the gross income definition, are somewhat lessened by the payment of taxes; especially, in the case of the poorer households, by the payment of indirect taxes.

Table 7 shows, for the status quo, a good number of poverty statistics associated with the different household income concepts given above. The first statistics is the headcount index, which gives the incidence of poverty; that is, the number of people in the total population whose income is below a given poverty line. The headcount ratio gives, on the other hand, the proportion of poor people in the whole population. The third statistic is the poverty gap, which gives the depth of poverty or how

Table 6. *Initial, gross, and disposable household incomes under status quo*

	Mean monthly income (R$)			
Income groups	Initial income	Gross income	Disposable income	Final income
1	206.73	357.94	354.69	286.99
2	507.51	700.59	685.34	553.70
3	742.13	904.05	876.44	716.82
4	782.22	1,018.31	982.85	814.86
5	1,030.20	1,301.27	1,250.10	1,050.52
6	902.01	1,294.20	1,246.23	1,068.39
7	1,422.13	1,788.25	1,701.45	1,463.35
8	1,735.24	2,162.16	2,042.68	1,779.38
9	2,317.58	2,940.20	2,743.50	2,435.55
10	5,994.81	7,401.24	6,375.90	5,942.11

Table 7. *Poverty indicators under status quo*

Poverty indicators	Initial income	Gross income	Disposable income	Final income
Headcount (millions)	29.1	7.1	7.2	12.2
Headcount ratio	15.2	3.7	3.7	6.3
Poverty gap (R$billions)	1.5	0.21	0.2	0.4
Poverty gap ratio	0.72	0.36	0.36	0.44
FGT index	0.097	0.007	0.007	0.024

far off households are from the poverty line. It is obtained by adding up all the shortfalls of the poor, relative to the poverty line. The poverty gap ratio is calculated dividing the poverty gap by the maximum value of this statistics (that is, the number of poor times the poverty line). Finally, the FGT index is a combination of the headcount ratio, the poverty gap ratio and a measure of the income inequality among the poor.[12] It should be noted that the poverty line used is R$70, which has been established by the Brazilian government as its reference extreme poverty line.

Table 8 shows, also for the status quo, some inequality measures for the different income definitions. The Gini index is the most commonly used measure of inequality; the coefficient varies between zero, which reflects complete equality, and one, which indicates complete inequality (one person has all the income or consumption, all others have none). The concentration index, on the other hand, gives the cumulative share of total income going to individuals in the population, with people ranked from the poorest to the richest. The Kakwani index is the difference between the concentration index and the Gini coefficient. In the case of taxes, it shows the difference between the share of each household group in total tax revenue and the share of each group in total expenditure.

Table 8. *Inequality indicators under status quo*

Inequality indicators	Initial income	Gross income	Disposable income	Final income
Gini index	0.60	0.55	0.53	0.55
Concentration index				
IPI	0.23	0.19	0.19	0.11
ICMS	0.27	0.24	0.24	0.16
Kakwani index				
IPI	-0.37	-0.35	-0.34	-0.45
ICMS	-0.33	-0.30	-0.29	-0.39

As a general result, the tables show that the reduction in poverty and inequality obtained with benefit transfers to poor households is considerably diminished on account of the payment of indirect taxes by these same households. The negative sign of the Kakwani index implies, in particular, that the share of the poorer households in total tax revenue is greater than their share in total expenditure.

4.2. Simulation of policy reform

Two hypothetical policy reform scenarios are simulated as illustrations of the model's output capabilities. In the first, Reform 1, the value of the Family Grant (*Bolsa Família*)'s basic benefit is raised from R$68 to R$116.25. This new value corresponds to one quarter of the 2009 official minimum wage. In the second policy scenario to be considered here, Reform 2, food is exempted from the ICMS.

4.2.1. Reform 1 (no behavioral change)

Reform 1 consists in simulating a rise in the basic benefit element of the *Bolsa Família*. In 2009 this benefit was worth R$68 for all entitled families. Tables 9, 10, and 11 present results for the case where the value of the basic benefit is raised to R$116.25.

Overall, these tables suggest, as expected, that the rise in the Family grant benefit contributes to bring poverty and inequality down, but again the indirect tax system considerably lessens this gain in poverty and inequality reduction.

Table 9. *Initial, gross, and disposable household incomes under Reform 1*

	Mean monthly income (R$)			
Income groups	Initial income	Gross income	Disposable income	Final income
1	211.49	414.39	411.08	341.44
2	511.17	733.44	717.92	581.57
3	746.43	909.68	882.64	724.10
4	791.75	1,021.06	985.98	812.90
5	1,036.90	1,300.42	1,250.13	1,057.14
6	913.45	1,296.06	1,248.23	1,059.49
7	1,421.74	1,775.72	1,690.80	1,444.61
8	1,743.27	2,155.72	2,037.73	1,763.68
9	2,340.25	2,949.58	2,752.91	2,460.33
10	6,137.91	7,609.18	6,527.41	6,090.42

Table 10. *Poverty indicators under Reform 1*

Poverty indicators	Initial income	Gross income	Disposable income	Final income
Headcount (millions)	29.1	5.4	5.4	9.8
Headcount ratio	15.16	2.80	2.80	5.13
Poverty gap (R$billions)	1.5	0.1	0.1	0.3
Poverty gap ratio	0.724	0.276	0.281	0.406
FGT index	0.097	0.002	0.003	0.021

4.2.2. Reform 2 (behavioral change analysis)

Reform 2 is used to illustrate how behavioral change analysis can be introduced into the model, in the form of the impact of price changes on household consumption behavior. To that extent, assume that a tax reform is introduced that exempts food from the payment of ICMS. In the model, this means that the ICMS rate for food is made equal to zero. Applying the modeling procedures detailed in subsection 3.4 above, the model calculates the new consumer price of food and the new distribution of total expenditure on the nine different consumption groups among the households.

Table 12 shows the composition of household expenditure before (status quo) and after Reform 2, by household group. Comparing the tables' results, one can gauge how the households reacted to the tax reform by changing the amount of total expenditure allocated to the nine consumption groups. As a result of the reform, expenditure on food, a necessary good, is reduced across all income groups, with households using their extra disposable income to increase the consumption of other items such as transport and communications.

Table 11. *Inequality indicators under Reform 1*

Inequality indicators	Initial income	Gross income	Disposable income	Final income
Gini index	0.60	0.54	0.52	0.55
Concentration index				
IPI	0.23	0.17	0.16	0.07
ICMS	0.26	0.24	0.24	0.15
Kakwani index				
IPI	-0.37	-0.38	-0.36	-0.48
ICMS	-0.33	-0.30	-0.28	-0.40

Table 12. *Household expenditure under status quo and Reform 2*

Spending in consumption under status quo (R$ billions/month)									
Income group	I	II	III	IV	V	VI	VII	VIII	IX
1	0.78	0.03	0.18	0.19	0.26	0.18	0.36	0.82	0.16
2	1.50	0.06	0.33	0.38	0.45	0.34	0.59	0.14	0.29
3	1.70	0.07	0.42	0.45	0.56	0.44	0.88	0.18	0.41
4	1.90	0.10	0.50	0.53	0.69	0.56	1.14	0.20	0.52
5	2.20	0.11	0.57	0.59	0.83	0.67	1.50	0.27	0.70
6	2.70	0.14	0.63	0.77	1.10	1.09	1.69	0.29	0.82
7	2.50	0.17	0.68	0.67	1.04	1.00	2.07	0.34	0.88
8	3.10	0.19	0.84	0.78	1.38	1.35	2.94	0.44	1.22
9	3.40	0.19	0.96	0.83	1.83	1.88	3.92	0.58	1.61
10	3.90	0.17	1.37	0.83	3.21	2.84	6.11	0.94	2.49
Spending in consumption under Reform 2 (R$ billions/month)									
Income group	I	II	III	IV	V	VI	VII	VIII	IX
1	0.65	0.03	0.16	0.12	0.26	0.17	0.55	0.77	0.19
2	1.46	0.05	0.33	0.20	0.44	0.33	0.79	0.13	0.33
3	1.79	0.04	0.41	0.16	0.53	0.44	1.10	0.18	0.47
4	1.98	0.10	0.52	0.18	0.68	0.53	1.44	0.21	0.57
5	2.18	0.09	0.57	0.27	0.79	0.66	1.83	0.29	0.75
6	2.63	0.12	0.68	0.41	1.04	0.98	2.17	0.31	0.86
7	2.35	0.15	0.70	0.31	1.01	1.01	2.52	0.35	0.95
8	2.78	0.16	0.85	0.46	1.34	1.39	3.50	0.45	1.29
9	2.93	0.16	0.95	0.88	1.64	1.90	4.48	0.58	1.62
10	3.41	0.15	1.45	0.57	3.12	2.81	6.78	0.92	2.56

Notes: I. Food; II. Alcoholic beverages and tobacco; III. Clothing; IV. Electricity and domestic fuel; V. Housing; VI. Health and education; VII. Transport and communications; VIII. Recreation and culture; and IX. Other goods and services.

Appendix: How to run the model

This appendix briefly describes the basic steps for running the Brazilian tax-benefit microsimulation model. The model is freely available in the address *http://ideas.repec.org/c/ega/comcod/201102.html* through the Ideas-RePEc site.

The Brazilian microsimulation model was developed using the Stata software, version 10.0. To run the simulations one needs the model's Stata codes, that details the computer commands that are necessary to perform the simulations, and the data set on which the commands are applied. The zip file that can be downloaded in the address given above contains two types of files (aside from the Word and Excel files that serve as documentation): as separate text files (for example, one for the social benefits, one for the personal income tax, etc.), and as a Stata do-file containing the whole set of simulation commands. The text files could also be brought together but are presented separately to facilitate their reading and manipulation.

To begin using the model in a computer, the user should first create a folder where the model's Stata codes files and the data set file can be saved. Once this is done, go to the command files, both in the text files and in the do-file, and where it is indicated a data set file pathname, insert the same data set file pathname as created in the user's computer.

To run the model, the user can choose between:

(i) Open the Stata program and, in the command window, paste the simulation commands from the text files (the user can paste and run each file separately or paste and run all files altogether);

(ii) With the Stata do-file editor, open the model's do-file and execute it using the execute do-file button.

(iii) Open the Stata program and, in the command window, type the name of the model's do-file and give the enter command.

After doing the simulations, the model computes the aggregate results necessary to construct the output tables. The commands for doing this are already embedded in the command files.

Notes

[1] Chapter prepared for the project "An Integrated Framework for the Assessment of Equitable, Pro-Growth Fiscal Reform in Latin America and the Caribbean: Fiscal Schemes for Inclusive Development (FSID)", co-funded by UNDP and IDRC. Any errors or opinions are the authors' and do not necessarily represent the views of the United Nations Development Programme, or those of the International Development Research Centre.

[2] This suggests that, in practice, most self-employed workers actually choose to contribute based on the value of the official minimum wage.

[3] These differentiated rate structures are not presented here, but are detailed in the model's Stata codes.

[4] All personal income tax's parameter values presented are monthly.
[5] The reason for using this concept of household income is explained below, when discussing the simulation of indirect taxes.
[6] For more details on the technical procedures, see O'Donoghue, Baldini and Mantovani (2004).
[7] For an exposition and discussion of the linear expenditure system, see, for example, Lluch, Powell and Williams (1977), Creedy (1998), and Creedy and Sleeman (2006).
[8] For further discussion of this particular specification of budget share equations, see, for instance, Deaton and Muellbauer (1980), and Creedy and Sleeman (2006).
[9] On the other hand, one may use simulation results to have an idea, imperfect as it may be, of the extent of tax evasion
[10] Ideally, sensitivity analysis of the results to different adult equivalence scales should be performed. This is easily done by changing the value of α and running the simulations again.
[11] The results in the table could be further disaggregated by policy instrument.
[12] For further information on these indicators, see, for instance, Coudouel, Hentschel and Wodon (2002), and Hoffman (1998).

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2 A microsimulation model of distribution for Chile[1]

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1. Introduction

Microsimulation models have become increasingly important tools for the preliminary assessment of public policies. Although they are still relatively uncommon in Latin America, a good number of those models have been developed over the years for the industrialized countries, such as EUROMOD for the European Union, CBOLT for the US, and NATSEM for Australia (see, e. g., Absalón and Urzúa, 2011). According to Bourguignon and Spadaro (2006), the main strengths of these models are the use of the heterogeneousness of the databases in contrast to the models of representative agents, as well as the possibility of obtaining results on the economic level by aggregating individual results.

In this chapter we present a microsimulation model that has been developed for Chile with the explicit purpose of determining the distributive impacts of changes in tax policy and social spending. It is a free-access model, meaning that it can be used by all those interested in public policy issues. Along these lines, the model has a user-friendly interface that facilitates its use on the part of interested parties.

Our model is an instrument for analyzing public policy, inasmuch as it can assess in advance the effects that reforms and public policies will have on the population's welfare, the income distribution and poverty indicators. It is an arithmetic type of instrument; that is, it does not contemplate variations in the agents' behavior in response to policy changes. This, which could be considered a limitation, has the advantage of allowing a broad range of policies to be evaluated, from taxes to

Microsimulation Models for Latin America, Carlos M. Urzúa (ed.), Mexico City: ITESM.

subsidies or social security, or combinations of the same. Furthermore, as it is later shown in Chapter 3 of this book, it is also possible to use this basic model to create more advanced modalities that contain functions on the reactions of economic agents.

Specifically, the simulation possibilities in our arithmetic model include indirect taxes (the value added tax, as well as specific taxes on tobacco, alcoholic and non-alcoholic beverages, and fuels), the income tax for individuals, and the main monetary transfers that are used to fight poverty; namely, the single family subsidy, the family allowance, the basic solidarity pension, and the *Chile solidario* bonus. It can also simulate the distributive effects of changes in the contributions to the public health and pension system, and of changes in the poverty line.

This article has two central objectives: first, to present the model in terms of its characteristics and the modality of its construction; and second, to undertake an application by evaluating the impact on distribution and poverty of a tax reform that would cut the value added tax (VAT) by one per cent, from 19% to 18%, while keeping a balanced budget with a progressive increase in the personal income tax. The objective of the balanced budget is to focus the analysis on the impact of the tax reform without having to make any changes in the levels of social spending. The purpose of the exercise is to illustrate the model's operation and to demonstrate its potential contribution to the public policy debate by quantifying the expected effects that policies will have on the population's economic welfare. It is shown that the joint effect of the policies analyzed is a tax cut for the population in deciles one through nine, along with a tax increase for households in the top decile.

The chapter is organized in the following way: the model, its scope and characteristics follow this introduction. In particular the database construction process is described, along with the elements to be simulated and the premises used. The third section explains the tax policies to be simulated. The results are subsequently presented in the fourth section, after which the chapter ends with the conclusions.

2. Model

Our microsimulation model is an instrument for estimating the distributive effects prior to public policy changes, especially those related to taxes, pension contributions and monetary transfers.[2] Thus, it is

possible to determine which socioeconomic, demographic or geographic groups will be benefited or affected by changes to the aforementioned policy instruments.

In the Chilean model, the distributive impact of changes in direct taxes can be analyzed, specifically the income tax for private individuals, as well as changes in indirect taxes. With regard to the latter, the results refer to households, while when it comes to direct taxes the unit of analysis is the individual. The first result is derived from the traditional assumption that the household is the relevant economic unit in consumption and that household resources are part of a common budget. In contrast, direct taxes affect income at the point where it is generated, and it is therefore natural to refer to them in terms of the individuals who pay them. In Chile there is no different tax treatment in the event that more than one member of a household generates an income. Aside from those tax applications, the model can also be used to analyze the distributive impact of changes in pension contributions, in addition to the monetary transfers provided by the state, among which family benefits and welfare pensions stand out.

2.1. Characteristics of the model

The microsimulation model is arithmetic in nature and partially balanced. That is, it does not contemplate behavioral changes in individuals in the face of public policy changes, nor does it consider dynamic effects as a consequence of the changes analyzed. However, the base model can be expanded to consider the aforementioned aspects of behavior and dynamics. It was developed based on the Stata statistics software, which is widely used in the country and provides sufficient calculation power to be able to work with large samples. The model uses the total sample of the 2009 national survey known as Casen (acronym for Encuesta de Caracterización Socioeconómica Nacional).

The model is freely and readily available in the internet address *http://ideas.repec.org/c/ega/comcod/201103.html* through the Ideas-RePEc site. Its use is facilitated by an interface that consists in dialogue boxes that specify the policies to be considered. Figure 1 shows the dialogue box that allows one to generate the scenarios that are to be simulated. It contains all of the simulation possibilities and the reference values of the base scenario in view, in addition to allowing one to obtain help from a description of each variable and its simulation possibilities by clicking on the question mark in the lower left corner.

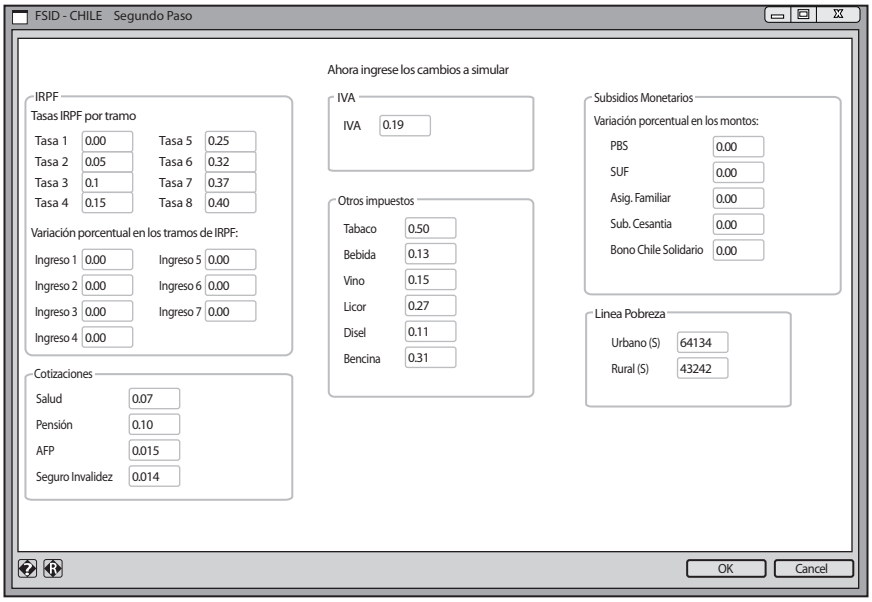

Figure 1. *Dialogue box of the microsimulation model*

2.2. Databases

As said before, the microsimulation model is built on the database of households contained in the 2009 Casen survey, the main socioeconomic characterization survey in the country. The survey is held every three years and is used for the effects of assessing, analyzing and evaluating social policy, poverty indicators and income distribution, among others. It provides information through seven modules: socio-demographic information, education, health, housing, income, occupation and others.

The Casen's coverage is national and is representative at a regional level, and also at the urban and rural levels. The sample is stratified by conglomerates and the reference period of the incomes declared is monthly; specifically, incomes from the month prior to the one when the survey was taken. In 2009, 71,460 households were interviewed, equivalent to 246,924 individuals and representative of the 4,685,490 households and 16,607,007 people nationwide, respectively.

The Casen survey contains the base information required to simulate the impact of changes in indirect taxes, pension contributions and monetary transfers. However, it does not contain the information on

consumer spending needed to analyze the effect of changes in indirect taxes. For that end the information provided by the Family Budget Survey (EPF) 2006-2007 is used. The purpose of this survey is to measure consumer spending in private households, and its traditional use has been the derivation of the weighting factors for the consumer price index. It is undertaken every ten years and covers a sample of 10,092 households that are nationally representative. The EPF asks about acquired consumption expenditures. That is, the goods and services acquired in the reference period are accounted for, regardless of whether the money is disbursed at a later time or in installments (all prices are referenced to April 2007). The microsimulation model requires transferring information on consumer spending from the EPF to the Casen survey to engage in an integrated and consistent analysis of public policies. This is done via an imputation process using the hot-deck method, which is described in the following section.

2.3. Imputation process

The hot-deck imputation process consists in transferring information on a level of subgroups or "cells" of households defined in variables that both databases have in common, after correcting for inflation so that the amounts are expressed in the same nominal terms. Specifically, households are considered grouped into percentiles of income per capita in each household. Other specifications were tried (combinations of variables) to obtain subgroups, but the best imputation is achieved when the subgroups consist in the aforementioned percentiles.

The procedure consists in assigning each subgroup in the Casen to the amounts spent on consumption by the same subgroup in the family budgets survey. This procedure is based on the assumption that within each group or cell the distribution of the variable is similar in both surveys. In this way, if the unavailable data is random, the process will result in unbiased estimators of the measure. Thus, the process begins by randomly assigning values from the EFP database to the Casen. A given piece of data in each percentile of the Casen is duplicated in the same percentile in the EPF. This number is randomly selected from within the group and assigned to its counterpart with the missing observation. This can be done several times to increase consistency and in general between two and ten repetitions are used. In our case, five repetitions were done since the process makes intensive use of computer resources.

The hot-deck procedure ensures that the variables being imputed have the same average level of sampling observations. However, there is a need to guarantee the equivalence of the variables on a population level, for which the imputation process needs to be undertaken with the variables multiplied by the expansion factors of the respective surveys. Furthermore, the imputation was undertaken on a household level, as that is the most disaggregated unit in the EPF survey.

Table 1 contains the descriptive statistics of spending in the survey of origin, the EPF, while the final result of the imputation is presented in Table 2 with descriptive statistics on the spending imputed in Casen. The imputation was undertaken on eight variables corresponding to expenditures associated with the seven indirect taxes to be simulated, plus the spending that is exempt of VAT, identified as "Exempt" in the tables below. Each category identifies the levels of spending.

A comparison of both tables shows that the two surveys are not the same in terms of expanded sample. The EPF represents close to 2.6 million households, while the Casen represents the existing 4.6 million. This difference is due to the fact that the EPF only covers regional capitals and their metropolitan areas. The hot-deck imputation shows positive results when one compares the spending averages in the EPF with what is imputed in the Casen. However, the variance of the imputations is less than what was observed in the EPF.

There should not be any effects from the reduced variance in spending, as the effect is produced in both directions. That is, for income in any given centile, a lower variance will have similar and inverse effects in both directions on the income distribution within the centile.

Table 1. *Descriptive statistics of variables in EPF (by household)*

Variable	Obs.	Obs. expand.	Avg.	Std. dev.
Exempt goods & services	10,088	2,649,429	78,207	179,265
Beverages	10,088	2,649,429	10,367	10,604
Wine	10,088	2,649,429	2,195	6,890
Liquor	10,088	2,649,429	4,715	11,001
Tobacco	10,088	2,649,429	6,151	12,076
VAT	10,088	2,649,429	452,913	562,654
Buses	10,088	2,649,429	15,841	23,503
Public transportation	10,088	2,649,429	7,443	15,747
Gasoline	10,088	2,649,429	6,957	26,912

Source: EPF 2006–2007.

Table 2. *Descriptive statistics of variables imputed in Casen (by household)*

Variable	Obs.	Obs. expand.	Media	Std. dev.
Exempt goods & services	71,460	4,685,490	80,998	62,622
Beverages	71,460	4,685,490	10,412	2,075
Wine	71,460	4,685,490	2,245	1,616
Liquor	71,460	4,685,490	4,853	2,627
Tobacco	71,460	4,685,490	6,169	1,628
VAT	71,460	4,685,490	472,038	387,039
Buses	71,460	4,685,490	15,985	4,587
Public transportation	71,460	4,685,490	7,692	2,771
Gasoline	71,460	4,685,490	7,331	9,805

Source: Casen 2009, EPF 2006–2007, and own estimations.

2.4. Calibration

Calibration consists in adjusting the spending levels and/or expansion factor reported in the surveys so that the total amounts collected, spending, and the number of taxpayers and beneficiaries can coincide with the administrative data that the respective agencies maintain: the internal tax service, social program administrators, etc. Discrepancies can originate in problems with the representativeness of the surveys, in mistakes made while collecting data (both on the part of the interviewer as well as the interviewees), or, in the case of tax payment, in evasion practices that make effective collection differ from the amounts forecast in the model. The calibration assumes that the totals reported in the administrative data are free of significant errors.

Calibration is done in two sequential steps: adjustment in the number of homes or individuals using expansion factors, and adjustments in the per-capita amounts. For indirect taxes only household level results are available in the poll, while administrative data does not provide information on "households-taxpayers", meaning that this calibration is only undertaken with the spending levels. In the case of subsidies and health coverage payments, the poll contains data on a personal level. The administrative data informs on the number of beneficiaries (or contributors) and the total amounts. Thus, the calibration consists in adjusting the expansion factors and the amounts of the benefits declared (or contributed) per person.

Regarding direct taxes, the administrative records give figures on the number of taxpayers based on total collection. The expansion factors are corrected based on this information. However, in order to correct for the

tax amounts paid, a structure of evasion rates by tax bracket is used based on a study by Barra and Jorratt (1999), adjusted to level according to effective collection in 2009.

Table 3 presents the results of the calibrations of indirect taxes, subsidies, health coverage contributions, and income taxes for 2009. The

Table 3. *Results of model calibration*

	Official amounts		Pre-calibration amounts	
	$Millions	N	$Millions	N
VAT	6,999,560	*	5,695,034	*
Tobacco	556,651	*	195,860	*
Special	194,627	*	190,540	*
Fuels	745,457	*	1,032,151	*
Family allocation	98,881	2,130,103	104,486	887,870
PBS	531,735	581,315	571,074	634,527
SUF	129,905	704,968	75,016	904,284
Unemp. subsidy	2,479	217,380	1,369	94,368
Chile solidario	19,380	222,044	4,811	273,732
Health contr.	1,023,350	4,798,769	1,444,887	4,716,564
Income taxes 2009	1,393,699	1,329,397	3,223,368	1,675,241
	Calibration		Post-calibration amounts	
	Exp. factor	Factor	$Millions	N
VAT	*	1.229064	6,999,559	*
Tobacco	*	2.842080	556,651	*
Special	*	1.021454	194,627	*
Fuels	*	0.722236	745,457	*
Family allocation	2.399116	0.394461	98,881	2,130,103
PBS	0.916139	1.016346	531,735	581,315
SUF	0.779587	2.221298	129,905	704,968
Unemp. subsidy	2.303535	0.786143	2,479	217,379
Chile solidario	0.811173	4.965693	19,380	222,044
Health contr.	1.017429	0.708187	1,023,250	4,798,768
Income taxes 2009	0.793496	Evasion rate	1,393,102	1,329,297

Source: EPF 2006-2007, Casen 2009, and own estimations.

administrative information, the results prior to calibration, the calibration procedure, and the final results are presented for each variable, in terms of the amount collected and the number of taxpayers or beneficiaries. The calibration allows one to undertake a precise adjustment of the official numbers and the database that was built, as can be observed upon comparing the table's first and last two columns.

2.5. Policies that can be evaluated

The model makes it possible to evaluate the distributive effect that the diverse public policies specified below have.

2.5.1. Direct taxes

The income tax charged to private individuals, also known as the global complementary tax, is an individual and progressive tax. For dependent workers it is withheld from their salaries every month and paid for by their respective employers. In the case of independent workers, they must pay 10% of their wages every month. Then, once a year, all taxpayers must calculate their total tax payment and if the amount to be paid is greater than what they have already paid they must pay for the difference. Should the opposite be the case, then the surplus is refunded to them.

Table 4 shows the structure of this tax and the base scenario on which simulations are carried out, which consists of changes in tax rates and/or the limits of each income bracket.

2.5.2. Indirect taxes

The indirect taxes that can be simulated in the framework of this model are the value added tax and the specific taxes on tobacco, alcohol (wine and liquor), non-alcoholic beverages, gasoline and diesel.

VAT is the main source of tax revenue in Chile. This tax is applied to all the goods and services, with the exception of exports, health services, public transportation, and interest from financial instruments and education. The tax is a flat 19% for all goods and services. The specific tax on tobacco is calculated as 50% of the sales price, after VAT. The tax on wine is 15%, while with other alcoholic beverages is 27%. The tax on non-alcoholic beverages is 13% (plain water is exempt).

The fuels tax is 1.5 UTM per cubic meter for diesel and 6 UTM for gasoline.[3] However, it is not applied directly in the construction of the model, but rather as the proportion of the tax that households spend on

Table 4. *Income brackets and tax rates (2009 pesos)*

Bracket	Lower limit	Upper limit	Deductible	Rate
1	0	497.651	0	0%
2	497.651	1.105.890	24.882	5%
3	1.105.890	1.843.150	80.177	10%
4	1.843.150	2.580.410	172.334	15%
5	2.580.410	3.317.670	430.375	25%
6	3.317.670	4.423.560	662.612	32%
7	4.423.560	5.529.450	883.790	37%
8	5.529.450	And more	1.049.673	40%

public transportation, buses, and while using their automobiles. Thus, the rate that constitutes the base scenario must be built. The proportional gasoline tax that households pay corresponds to the percentage of the final price that is due to the tax, which is calculated at close to 31%. In the case of diesel it is estimated that the specific tax is equivalent to 11% of the price of diesel, which in turn is 26% of bus fares. One can therefore deduce that about 3% of the fare corresponds to taxes. Lastly, to calculate how much of public transportation spending corresponds to the specific tax, the assumption is made that the proportion of fuels tax in the fare is 26% (the same as with the buses). Thus, the proportion of specific fuels tax paid when using public transportation services is 8%.

2.5.3. Transfers

Five monetary transfers are included in this microsimulation model: the basic solidarity pension (PBS), the family allowance, the single family subsidy (SUF), the unemployment subsidy, and the *Chile solidario* bonus.

The PBS is provided to men and women over the age of 65 who do not receive a contributory pension and who are part of the 60% of the population with the lowest socioeconomic levels. In addition to this, a PBS for disability is paid to those considered to have a physical and mental disability and who are between the ages of 18 and 65. The pension amounts to close to US$160 per month.

The family allowance is a benefit paid to salaried workers with low wages. The benefit is equal to US$13 per months and per family dependent for salaried workers who earn less than US$340 per month; it is US$10 for salaries between US$340 and US$580, and US$3 per

month per dependent for salaried workers who earn between US$538 and US$912 per month. Higher salaries do not receive the benefit.

The SUF is paid for every minor under the age of 18 in the poorest 40% of households. Those who do not receive the Family Allocation receive this benefit. The benefit is US$8 per month for every minor under the age of 18.

The unemployment subsidy is a cash benefit that dependent workers who have lost their jobs receive. The benefit is provided for a year and the amounts gradually drop.

Finally, the *Chile solidario* bonus is a benefit that is provided to the families who complete the Puente Programme. The benefit is paid monthly for three years and is close to US$12 per month.

2.5.4. Social security contributions

The elements to be simulated with regard to social security are: health coverage contributions, withholding for pension savings, withholding for the disability insurance coverage, and the commission charged by the AFPs (pension fund administrators). These are paid by all taxpayers and discounted every month from their gross income, after which the tax base for income tax payment is calculated. Thus, variations in the withholding rates affect workers' disposable income.

The withholding for coverage by the public health fund (Fonasa) is 7% of income. All salaried workers must make an obligatory health payment and can choose between the aforementioned public health system and private health insurance institutions (Isapre).

Every month workers must deposit 10% of their income in a savings fund for pensions in an individual capitalization system. In addition, together with this savings, 1.4% of earnings are withheld for a disability and premature death policy and 1.5% in commissions for the fund administrators.

2.5.5. Poverty lines

It is possible to undertake simulations with different poverty lines. Urban and rural poverty lines are calculated at $64,134 (US$136) and $43,242 (US$92), respectively. Thus it is possible to alter the basic food basket (CBA) and the factors that are used to calculate the lines by zone. The cost of the CBA in urban areas is $32,067 (US$68.2) and in rural areas it is $24,710 (US$52.6). The basket is multiplied by a factor of 2 in urban areas and 1.75 in rural ones.

2.6. Model assumptions

The model was built while making a series of assumptions for its operation. They are as follows:

- Consumers absorb the totality of the effect that tax changes have on prices.
- Being an arithmetic model, no behavioral changes in the agents are foreseen in response to changes in their budget limitations (due to income or price effects).
- Changes in contributions or in the income tax affect agents' net income. This is a short term assumption, as in the long term workers are expected to ask for salary adjustments to compensate for changes in contributions. This is particularly so in the public health system, where the payment might not be associated with a compensating benefit.

3. Simulation

The VAT is the most important tax in Chile, as it provides close to half of the taxes collected and has low evasion rates, between 8% and 15%, for the period spanning 2002-2008. It is therefore natural to resort to VAT increases when there is a need to increase tax collection. Thus, in 2003 the rate was increased by one percentage point (from 18% to 19%) to compensate the drop in customs income from the signing of free trade agreements with other countries. It was supposed to be a transitory increase, as the new businesses that would be started under the treaties would compensate the reduced customs. More recently, in the aftermath of the February 2010 earthquake, there were proposals to increase the VAT again to raise funds for reconstruction activities.

Notwithstanding its desirable qualities in terms of collection and evasion, the VAT is a regressive tax. The lowest-income households pay a larger proportion of their income in this tax, considering that their average propensity to consumption is higher than that of other groups.

The influential work by Engel, Galetovic and Raddatz (1999) contains one of the first microsimulation models for evaluating the effects of the tax burden on income distribution. The article's main conclusion is that the tax system is in the best of cases neutral from a distributive perspective, but somewhat regressive when considering that social spending (financed with taxes) results in fiscal action that ultimately

favors lower income households. They also show that the regressive pattern of the VAT tends to be compensated with income tax, which has a progressive structure.

The simulation exercise done below consists in returning to a VAT of 18%, its pre-2003 level, and to finance the reduced collection with an increase in income tax paid by the taxpayers in the highest income bracket. The exercise keeps the level of social spending constant, as fiscal revenues will not be altered.

The expected effects of the policy being simulated are a lower tax burden for lower income households, together with a greater effect on the part of taxes on the income of more accommodated households, thus reducing after-tax income inequality and lowering the poverty rate. The resulting amounts are less predictable and are provided by the microsimulation model.

4. Results

This section presents the distributive results of a one-point VAT reduction and a compensatory increase in income taxes. The effects of these policies on income distribution and poverty are described separately and then jointly.

4.1. VAT from 19% to 18%

The results show that a one-point VAT reduction causes tax collection to drop by some 6%, equivalent to $424.121 trillion (US$902 million). Total VAT collection in 2009 was $6.999 trillion (US$14,892 billion), but the amount collected for this concept after the tax cut would be close to $6.575 trillion (US$13.99 billion).

Table 5 shows the VAT burden on income, spending, and total taxes paid per household, by per capita income decile. The results in the first column illustrate the VAT's regressive nature. The higher income deciles pay a smaller fraction of their incomes in VAT: the 10th decile pays 14.3% of its income, while the first decile pays close to 19.8%. The second column shows the tax's impact in the simulated scenario. With a VAT of 18%, the impact (tax paid as a percentage of income) drops for all deciles, but to a greater degree in the first ones, as can be seen in the final column. The impact of the VAT drops 1.2 points in the first decile and the effect is diminished for the higher income deciles.

Table 5. *Impact of the VAT on income (% household income paid in taxes)*

Decile	Base scenario	Simulated scenario	Difference
1	19.75	18.56	-1.20
2	19.40	18.23	-1.18
3	19.11	17.95	-1.16
4	18.49	17.37	-1.12
5	18.63	17.50	-1.13
6	18.66	17.53	-1.13
7	17.82	16.74	-1.08
8	17.56	16.50	-1.06
9	17.99	16.90	-1.09
10	14.25	13.39	-0.86

4.2. Income tax increase

The increase in the income tax rates is applied to the highest income taxpayers and the amount collected compensates the cut in the value added tax. The model allows for different tax rate structures to be tested until one that maintains balanced fiscal accounts is found. The structure that is finally chosen maintains the first income tax bracket exempt; the second bracket sees an increase from 5% to 6%; the third from 10% to 12%; the fourth from 15% to 18%; the fifth from 25% to 29%, the sixth from 32 to 37%; the seventh from 37% to 43%; and the final from 40% to 48% (see again Table 4). Under that new tax structure, the income tax that can be collected increases by 31.7%, from $1.393 trillion in 2009 to $1.834 trillion in the simulated scenario. The difference is close to $441.543 billion.

The first column in Table 6 shows the tax impact as a percentage of household income (before taxes). The burden is positive after the fourth decile, fluctuating between 1% in that decile and 7.6% in the 10th decile in the base scenario. The effects of the variation in tax rates, in the third column, show an increase of between one hundredth of a percentage point to 2.4 points.

The following columns in that table show the average per capita income per decile. The fourth and fifth columns correspond to the averages in the base scenario and the simulated one, respectively. The final column shows the percentage variation of income between the two scenarios, which is significant after the seventh decile and has the greatest impact on the 10th decile, where per capita household income falls by 5.1%.

Table 6. *Impact and per capita income by decile (individuals)*

	Impact			Average per capita income		
Dec.	Base scenario	Simulated scenario	Difference (%)	Base scenario	Simulated scenario	Difference (%)
1	0.00	0.00	0.00	27,895	27,895	0.0
2	0.00	0.00	0.00	55,119	55,119	0.0
3	0.00	0.00	0.00	72,862	72,861	0.0
4	0.01	0.01	0.00	90,166	90,162	0.0
5	0.04	0.05	0.01	109,842	109,831	0.0
6	0.08	0.09	0.02	134,594	134,553	0.0
7	0.18	0.22	0.04	168,520	168,397	-0.1
8	0.39	0.48	0.08	220,156	219,785	-0.2
9	0.80	0.98	0.18	320,665	319,513	-0.4
10	7.64	10.00	2.37	920,369	873,669	-5.1

4.3. Joint effects

The model allows combinations of policies to be evaluated and provides results on a household level. The results of the proposed tax policy are presented below.

Total tax collection in the base scenario, considering all of the model's taxes, is close to $9.889 trillion and the amount collected in the simulated scenario is close to $9.899 trillion or a positive difference of $10.069 billion, equivalent to 0.1% of total tax collection. The importance of analyzing the two policies together is reflected in the variation in total collection. The variation in the VAT collection was less than $424.121 billion, while the variation in income tax collection was over 441.563 billion. The difference between the two concepts is over $17.422 billion, greater than the difference obtained. This is due to the fact that a change in the VAT also affects collection of other taxes like tobacco and gasoline.

Table 7 shows the effects in terms of impact on income before tax on a household level. The first column shows the base scenario, the second the simulated one and the third the difference in terms of percentage points. The impact of the total tax burden, both on the base scenario as well as the simulated one, is shown to be greater on the lower income deciles, ranging from 30% in the first one to 21.3% in the 10th. The variation in the impact caused by the simulated policies indicates that it drops until the ninth decile and that the impact is concentrated on the highest-income decile.

Table 7. *Effects in terms of impact on taxable income and its distribution*

	Impact on taxable income			Indirect taxes / Total taxes			Income distribution (percentages)		
De.	Base scen.	Sim. scen.	Dif. (pp)	Base scen.	Sim. scen.	Dif. (pp)	Before taxes	Base scen.	Sim. scen.
1	30.23	28.98	-1.25	100	100	0.00	0.93	0.76	0.78
2	27.50	26.29	-1.21	100	100	0.00	2.12	1.87	1.92
3	26.98	25.79	-1.19	99.99	99.99	0.00	2.92	2.64	2.70
4	24.78	23.64	-1.14	99.94	99.92	-0.02	3.84	3.54	3.62
5	24.71	23.57	-1.14	99.79	99.73	-0.06	4.84	4.54	4.64
6	24.04	22.90	-1.13	99.61	99.50	-0.11	6.07	5.81	5.93
7	22.63	21.58	-1.05	99.05	98.79	-0.26	7.75	7.57	7.71
8	21.83	20.85	-0.98	97.95	97.39	-0.56	10.23	10.23	10.42
9	21.80	20.91	-0.90	95.99	94.90	-1.10	14.89	15.11	15.32
10	21.29	23.03	1.74	63.66	55.59	-8.07	46.40	47.92	46.97

The next three columns in Table 7 illustrate the proportion of taxes that correspond to indirect taxes in the base scenario, the simulation and the difference between them. One can observe that the proportion of indirect taxes is close to 100% until the seventh decile. Only in the 10th is the proportion of direct taxes that are paid significant, which explains why the impact of the income tax increase is greater than the drop in the VAT for this decile. This could be explained by the falling marginal performances in consumption. That is, there is a maximum level of consumption that satisfies people's needs regardless of the income level. Therefore, if the difference between income and consumption is very great then the income tax will manage to attain greater representativeness in the total amount of taxes that are paid.

The last three columns of Table 7 present the results on income. The seventh column contains the income distribution before the payment of any taxes. The next column shows the current scenario and the final one considers the payment to be made under the simulated tax structure. Upon comparing income distribution between the fourth and fifth columns, one can see the distortion in income distribution that the tax burden generates, where the imposition of a tax system generates greater concentration in the higher-income deciles.

The simulation exercise shows that the tax system is not efficient as a redistributive policy, since even with the significant income tax increases and the reduction of a regressive tax like the VAT, the initial income

distribution structure remains without major changes. However, the new taxation structure does generate funds to finance social spending, which can be very effective in redistributive terms.

Upon comparing both tax systems, the base scenario and the simulated one, it can be seen that the latter manages to improve slightly the income distribution profile, although, as it might be expected, the improvement is very slight. One way to analyze this is with certain indicators of inequality, such as the percentage ratios D10/D1 and Q5/Q1, as well as indicators related to the Lorenz curve: the Gini and the Kakwani indexes. The former is more sensitive to income transfers that are close to the average, while Kakwani is more sensitive to transfers on the distribution extremes.

As shown in Table 8, the ratio of deciles D10/D1 in the distribution of before-tax income is 47 times, which increases to 55 in the base scenario tax structure. The income distribution produced by the simulation results in a ratio of D10/D1 is close to 53 times. The change is less pronounced in the ratio of quintiles Q5/Q1, going from 21.9 times in the base scenario to 21.6 times under the simulated scenario. The Gini index is between the ones corresponding to before-taxes and the base scenario, with a value of 0.58. The Gini income distribution index before taxes is 0.57 and the one corresponding to the base scenario is 0.59. Likewise, the Kakwani index shows similar variations.

The findings in Table 8 are complemented by Figure 2, which shows the distance between the Lorenz curve for the base scenario and the simulation in the case of after-tax income. It reveals that the positive effect on distribution is very small and concentrated in approximately the 50th centile. As can be seen from the figure, the only significant negative effects are found in the last percentiles.

Figure 3 shows, on the other hand, the difference between the tax payment concentration curves that arise in both scenarios. It reveals that the concentration of the tax payments drops in the higher percentiles. That is, with the new tax structure the upper deciles end up paying a larger proportion of the taxes.

Table 8. *Inequality indicators*

	D10/D1	Q5/Q1	Gini	Kakwani
Before-tax income	47.1	19.5	0.57	0.27
Base scenario	55.2	21.9	0.59	0.29
Simulated scenario	52.8	21.6	0.58	0.28

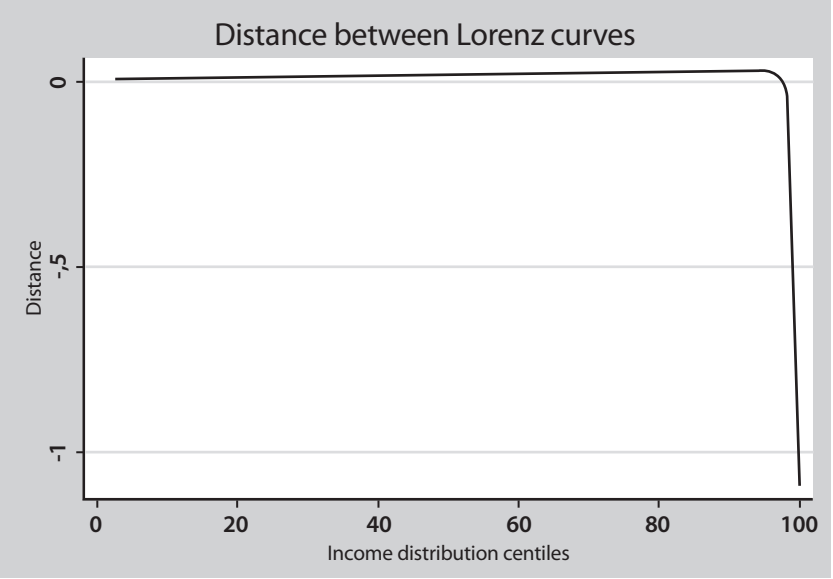

Figure 2. *Distance between Lorenz curves for base and simulated scenarios*

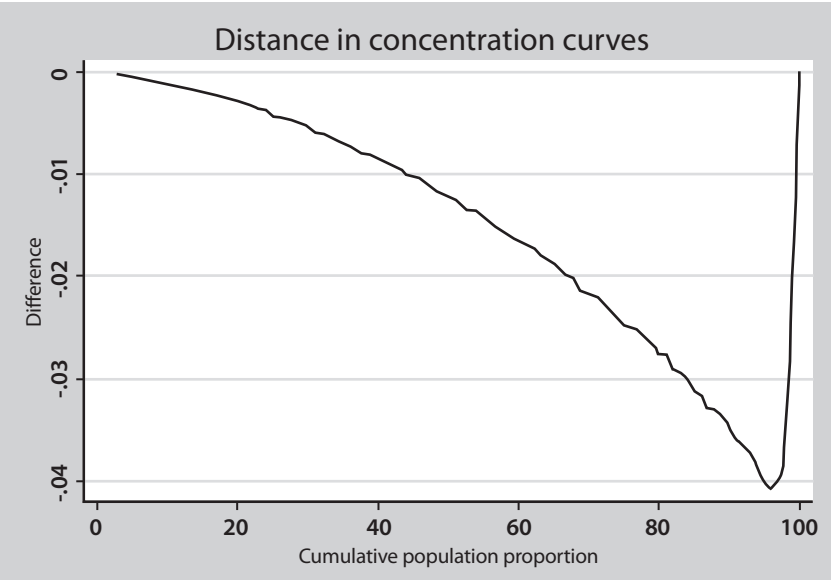

Figure 3. *Difference in tax payment concentration curves*

4.4. Effect on poverty

The one-point reduction in the VAT rate not only has an effect on the impact of taxes, but also on poverty according to the measurement method used in Chile. Since 100% of the goods and services included in the basic food basket are subject to the VAT, a reduction in this tax therefore means that the cost of the basket falls. The urban poverty line is $64,134 (US$136) and that of rural areas is $43,242 (US$92). Cutting the VAT rate from 19% to 18% causes the poverty line to drop by $641 (US$1.4) and $432 (US$0.9), respectively, and poverty levels to fall from 15.1% to 14.8%.

5. Final comment

The objective of this work has been to present a microsimulation model for the Chilean economy. The model, which is freely available and written in Stata, allows us to study the impacts on income distribution and poverty of a series of public policies that are to be evaluated *ex-ante*, such as changes in income taxes, health and pension contributions, monetary transfers and specific taxes. The ultimate purpose of the model is to serve as a support tool for the design and evaluation of public policies, as can be observed in the practice of developed countries. The model's operation was exemplified simulating the effect of a one-point cut in the VAT rate and a progressive increase in income tax rates while maintaining a balanced budget.

Notes

[1] Chapter prepared for the project "An Integrated Framework for the Assessment of Equitable, Pro-Growth Fiscal Reform in Latin America and the Caribbean: Fiscal Schemes for Inclusive Development (FSID)", co-funded by UNDP and IDRC. Any errors or opinions are the authors' and do not necessarily represent the views of the United Nations Development Programme or those of the International Development Research Centre.

[2] A detailed account of the tax-benefit system in Chile is provided in Larrañaga, Cabezas and Encina (2011).

[3] UTM stands for *unidad tributaria mensual* (monthly tax unit), which is an inflation-pegged accounting unit. It was equivalent to US$80.5 as of April 2011, at an exchange rate of $470 per dollar.

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3 Effects of the ethical family income on labor participation, income distribution and poverty[1]

Gustavo Cabezas and Carlos Acero

1. Introduction

In August 2007, the then President of Chile Michelle Bachelet convened a group of experts and representatives of civil society to sit on the Presidential Advisory Council on Labor and Equity, which was created with the purpose of coming up with proposals to fight inequality and to achieve greater equity in the labor market. In this way, after eight months of work, the Council proposed a series of measures to foster an "inclusive, modern progress in Chilean society that promotes competition and provides opportunities". Since this report, the concept of an "ethical family income" (*ingreso ético familiar*) has gained strength. According to the way that the current authorities define it, the objective is to eliminate extreme poverty by 2014 with a series of proposals that involve policies focused on the most vulnerable people.

The Sebastián Piñera administration implemented the first component of the program in March, 2011. It involves a subsidy to the poorest comprised by a base bonus and an additional bonus for the fulfillment of certain commitments. The base amount consists in a monthly sum for each family member. The increments are additional sums for fulfilling certain conditions on schooling and health for minors. In addition, there is a component to promote female employment, with a single bonus for women who start work while in the program and who have not worked for the last two years.

The second component of the ethical family income, as the authorities have said and as suggested in the report by the Advisory Council, should

Microsimulation Models for Latin America, Carlos M. Urzúa (ed.), Mexico City: ITESM.

be a policy that stimulates employment. It is hoped that an announcement will be made in the coming months. For this very reason our simulation exercise to be given below uses the proposal formulated in the Council, since the final scheme ought to be in line with the proposal, as it was the case when defining the bonus. The Council proposed a subsidy for the income of formal workers to stimulate the incorporation of new members of the household into the job market, to increase formal employment and with it the quality of work, in addition to increasing the income of the poorest people.

As it has been defined, the ethical family income program is comprised by the two components already mentioned. For this reason, the two policies are jointly considered here, since both affect the employment decisions of lower income families. An increase in the poorest families' income is expected as a consequence of implementing the program, in addition to reduced poverty and increases in labor participation. Thus, our work methodology consists in evaluating the proposals as a whole, with a model with or without behavior, for three groups of potential workers: heads of households, their partners and other adults in the household.

The next section details the characteristics of the ethical family income. After that, Section 3 presents the methodology and data to be used, while Section 4 presents the microsimulation model. The effects on labor supply of the ethical family income program are presented in Section 5, and the effects on income, inequality and poverty are reported in Section 6. The final section contains the conclusions.

2. The ethical family income

What follows is a detailed description of the two components of the ethical family income program. The first is a social bonus, which corresponds to the first part of the program and, as said before, it is already being implemented, while the second is a labor subsidy corresponding to the proposal made by the Advisory Council.

2.1. The social bonus

The social bonus is the first step toward creating the ethical family income program in the country. Its composition consists of a base component, called the base bonus, and another bonus that depends on the

fulfillment of a series of conditions that are related to schooling and health treatment for minors, in addition to women's participation in the job market.

The beneficiaries of the bonuses are the families that belong to an existing social program known as *Chile Solidario*, which provides certain transfers to the households that score under 4,213 points in the so-called *Ficha de protección social* (FPS).[2] The new base bonus is provided to the head of the household, or to the partner of the head of household in case that the head is a man. The base amount consists of a monetary transfer for each family member, and it varies depending on the family's score in the FPS. For families with a score of less than 2,515 points the benefit is $7,500 (about US$16).[3] For those with scores between 2,515 and 3,207 points the allocation becomes $6,000 (US$13), while households with scores in between 3,207 and 4,213 points receive a benefit of $4,500 (US$10) per member.

The additional bonuses for the fulfillment of commitments consist of a series of transfers as certain conditions are fulfilled. The increments are given for child health checkups, schooling, and women's insertion into the workforce. The first case consists of a variable bonus, according to the FPS score, for each minor in the family under the age of six whose health checkup file is up-to-date. The amount of the benefit is obtained by multiplying $5,000 (US$10.60) by the number of months in the program. That is, for those who have been in the program the entire time the number of months will be nine (from March to December). Families with FPS scores of less than 2,515 points receive 100% of the benefit, those with scores in between 2,515 and 3,207 receive 80%, and those with scores in between 3,207 and 4,213 points receive 60%.

The schooling bonus consists in one allocation for enrolment and another for attendance. Families receive an additional allocation for all minors between the ages of six and eighteen if they are enrolled in an educational establishment, and another additional variable amount if their attendance is equal to or greater than 85%. The amount of both increments is calculated identically to the way in which the increment for child health checkups is calculated, with the difference being the number of months in the program. The increase for enrolment is calculated based on the number of months in the program between the months of April and May, or a maximum of two months. In contrast, the increment for attendance is calculated according to the months in the program between June and December.

The bonus for women's insertion into the workforce consists of a subsidy to the salaries of women over the age of 18 who did not work in between January 2009 and March 2011, and who register health and pension contributions for at least 3 consecutive months in between April and August 2011. The amount of the benefit depends on the salaries that they receive. If the average of the monthly remunerations between April and October is lower than $172,000 (US$366), then the subsidy is 10% of that average multiplied by three. If the average is in between $172,000 and $215,000, then the increment is a single payment of $51,600 (US$110). And if the average is in between $215,000 and $387,000, then the increment is three times the difference between $17,000 and the ten percent of the difference between the average and $215,000.

2.2. Labor income subsidy

The labor income bonus recently proposed by the Advisory Council consists of a 30% subsidy, for a maximum of 7.5 UF per month.[4] It is distributed 20% in direct payment to the worker and the other 10% to the employer. Then, as income increases the subsidy ought to be gradually reduced until reaching zero for incomes equivalent to 15 UF.

This subsidy has been designed for formal workers. That is, salaried workers or self-employed workers who contribute to a pension fund, health insurance, and unemployment coverage. The subsidy is focused on the group of poor and vulnerable workers. For this reason, the households that benefit from it are those belonging to the first and second deciles as reflected in their FPS scores. This proposal is aimed at achieving various objectives: first, to increase the income of the poorest families via formal workers' salaries; second, to incentivize hiring; and third, to increase formal employment and its quality in the medium term.

3. Methodology and data

3.1. Discrete-choice models of labor supply

Ex-ante policy analysis of tax-benefit reforms has been one of the major concerns of public economics. The use of microsimulation models is a significant breakthrough in the field, allowing for observed heterogeneity that previous models based on representative individuals could not capture (Bourguignon and Spadaro, 2006).

Within this framework, consumers are regarded as utility-maximizing individuals who choose the optimal combination of consumption and leisure according to their preferences. The first generation of models of this type relied on maximizing continuous utility functions, facing serious problems due to the existence of non-convex budget constraints. This obstacle can be overcome by restricting the attention to discrete-choice models where individuals must choose among *J* alternatives:

$$V_{ij} = U(\mathbf{X}_{ij}, \mathbf{Z}_i) + \varepsilon_{ij} ,$$

where the expected utility of alternative *j* for household *i* depends on a vector $\mathbf{X}_{ij}$ of variables, specific to alternative *j* and household *i*, a set of socio-demographic characteristics $\mathbf{Z}_i$, plus an error term. If we assume that ε_{ij} follows a type I extreme value distribution, it can be proved that the probability that alternative *k* is chosen by household *i* is given by:

$$P_{ik} = \Pr(V_{ik} \geq V_{ij}, \forall j = 1,..., J) = \frac{\exp\{U(\mathbf{X}_{ik}, \mathbf{Z}_i)\}}{\sum_{j=1}^{J} \exp\{U(\mathbf{X}_{ij}, \mathbf{Z}_i)\}} .$$

The estimates of the underlying conditional/multinomial logit model are obtained by standard maximum likelihood techniques.

The framework above can be applied to describe the choice of the working hours of an individual that faces *J* alternatives, corresponding to a set of different work durations and labor supplies. In this chapter we posit the following general quadratic form:

$$V_{ij} = \beta_1 Y_{ij} + \beta_2 Y_{ij}^2 + \beta_3 L_{ij} + \beta_4 L_{ij}^2 + \beta_5 Y_{ij} L_{ij} + \boldsymbol{\gamma}' \mathbf{Z}_i Y_{ij} + \boldsymbol{\eta}' \mathbf{Z}_i L_{ij} + \varepsilon_{ij}$$

where Y_{ij} and L_{ij} stand, respectively, for the hourly disposable income and the number of leisure hours under alternative *j* for individual *i*, and $\mathbf{Z}_i$ is a vector of individual characteristics. These include age, schooling, number of children, zone (urban or rural), poverty condition, and dummy variables for part-time categories in order to capture the disutility of inflexible arrangements (see Wagenhals, 2009). The model is computed for all potential workers, irrespective of their actual working status. This means that hourly disposable income must be estimated using Mincerian equations for those individuals whose labor income is not observed. This can be done with a straightforward OLS model or correcting for selection bias using a two-step Heckman procedure.

Once an hourly income has been obtained for all individuals, the model simulates the potential income for each of the work options and

then compares the corresponding levels of utility. In order to make the model sensitive to unobservable components of labor supply, for each individual an error vector is extracted based on the type I extreme value distribution. Finally, the new post-reform incomes are calculated and the maximum-benefit option is identified. This process is repeated 50 times, so that for each individual a post-reform distribution of hours is obtained, conditional to the observed work hours. Thus, the option of post-reform hours chosen will be the distribution mode, with this option being the most likely, conditioned by individuals' observed characteristics and their pre-reform work hour preferences (Creedy and Kalb, 2005).

3.2. Data

The data to be used in the simulation comes from the 2009 national survey Casen (acronym for Encuesta de Caracterización Socioeconómica Nacional). Casen, is a household survey, statistically representative at national and regional levels, and for Chile's main cities. In the 2009 survey, 71,460 households were interviewed and information from 246,924 individuals was gathered. The Ministry of Planning conducts the Casen survey every three years and collects socioeconomic data on all household members, with questionnaire modules on income, socio-demographic characteristics, health, housing and labor, among others.

4. Microsimulation

The group included in the simulation of the ethical family income is made by the families that belong to the *Chile solidario* program, since the FPS scores are not available for all of them.[5] This focalization is the best approximation to the actual beneficiary group, as the families belonging to the program are those living in extreme poverty nationwide. For this reason, the amounts simulated for the social bonuses, which depend on FPS score ranges, are simulated as average amounts, after assuming that the proportion of families in each bracket is similar.

Not all family members are included in the labor supply simulation. The group of potential workers is defined as all people over 18 years of age and under retirement age (60 years for women and 65 for men) who are not attending any sort of educational establishment. Thus, it is in the group of potential workers that it is possible to find people who are in fact working and those who are not. Otherwise the analysis becomes

quite complex by having to model decisions on study-work (Bourguignon, Ferreira and Leite, 2003) or reinsertion into the labor market (Rogerson and Wallenius, 2010). The proportion of potential workers in the *Chile solidario* group of families is 47.4%, while in the rest of the population is 53.3%.

Once the potential workers are identified, they are classified as heads of households, partners of the heads of households, and others. Heads of households are understood to be primary income recipients; their partners are the secondary ones, and their decision to participate in the labor market is influenced by the decisions that the primary ones make. Regarding the others, it is assumed that the complementariness of their income is related to the total income of the main recipients. Descriptive statistics for each of these are presented in Table 1.

After establishing the universe where some sort of effect is expected, the model's discrete work hour ranges are defined. Five equal ranges were chosen for each of the groups: not working (0 hours), 1-15 hours per week, 16-31 hours per week, 32-45 hours per week, and, last, over 46

Table 1. *Descriptive statistics of potential workers and their classification*

	Sample	Mean	Std. dev.
Number of members in family	273732	3.5	1.5
Minors under 6 years	162852	1.7	0.9
Minors between 6 and 18 years	175857	1.7	0.9
Sector (urban = 1, rural = 0)	273732	0.8	0.4
Hourly income of heads	147,007	$1,662	$2,308
Hours worked by heads	222,779	29.1	23.6
Age of heads	222,779	40.6	10.5
Schooling of heads (years)	222,779	8.6	3.7
Sex of head (male = 1, female = 0)	222,779	0.5	0.5
Hourly income of partners	48,383	$1,572	$2,343
Hours worked by partners	132,605	15.4	21.8
Age of partners	132,605	38.9	10.1
Schooling of partners (years)	132,605	8.5	3.6
Sex of partner (male = 1, female = 0)	132,605	0.2	0.4
Hourly income of others	47,421	$1,290	$1,386
Hours worked by others	97,343	21.5	22.8
Age of others	97,343	27.7	10.1
Schooling of others (years)	97,343	9.6	3.9
Sex of others (male = 1, female = 0)	97,343	0.7	0.5

hours. The mode for each of these ranges is 0, 8, 30, 45, and 48 hours per week, respectively.

4.1. Salary estimation

In order to estimate the hourly salary of potential workers who are not participating in the labor market, Mincerian equations are estimated to predict the corresponding salary. The estimates are made for all potential workers, not just those belonging to the *Chile solidario* program, as that could bias the results.

The classification of potential workers by sex indicates that 14.5% of men have no income, while this proportion rises to 44.1% in the case of women. Thus, only in the case of women the estimated hourly salary should be corrected for selection bias. In order to estimate the income generation capacity we control for years of schooling, age, age squared and a dummy to identify people living in urban areas. As shown in Table 2, the results turn out to be significant and with the expected signs. Schooling, age, and belonging to urban areas have all positive effects, for

Table 2. *Estimates of potential workers' hourly salary*

	Males		Females	
	Coef.	t-statistic	Coef.	t-statistic
Ln hourly income				
Schooling	0.111	35.49	0.139	31.96
Urban = 1	0.117	8.64	0.289	10.73
Age	0.032	5.16	0.0311	6.13
Age squared	-0.00016	-1.96	-0.00020	-3.12
Constant	5.214	51.02	4.040	33.3
Selection equation				
Schooling			0.091	26.66
Age			0.00268	2.67
No. children < 14 yrs.			-0.100	-10.74
Head of household = 1			0.433	16.51
Urban = 1			0.196	9.63
Constant			-1.398	-22.62
Ath rho			1.032	13.52
Ln sigma			-0.0628	-2.51
Censored obs.			38,117	
Uncensored obs.			26,343	
N	51,103		64,460	

both men and women. Regarding the selection equation, the following variables are used: schooling, age, number of children under the age of 14 and dummies identifying female heads of households and whether people live in urban areas. As shown in Table 2, schooling, age, being head of household and living in urban areas have positive effects on labor participation, while the number of younger children has a negative impact on the likelihood that people will be working.

Once an hourly salary has been predicted for the potential workers who are not participating in the labor market, the coefficients and errors that represent their preferences according to the aforementioned classification were estimated. Table 3 presents the results obtained by estimating a conditional logit model for heads of households, partners, and other adults in the family. Note that that the explanatory variables that appear twice (age, schooling, children, their squares, and urban) interact in their first appearance with income and the other with leisure.

The model assumes dependence in decisions. That is, partners of the heads of households include the primary recipient's incomes in their utility function and those identified as others act similarly when making decisions regarding how much to work toward household income.

The marginal utility of income is positive for the three groups of potential workers. In all of them it is shown that the indirect utility function regarding income is convex. However, the marginal utility of leisure hours is negative. This could be due to the sample chosen for the simulation, as they are members of poor families who would prefer to work an extra hour to increase their incomes.

Upon observing the appreciation of leisure on the part of partners and other adults in the household regarding the income of the head of the household and the total income of the two main recipients, it is observed that the appreciation is positive. That is, the marginal benefit of the partners' leisure time is more positive the higher the income of the heads of households is. In the same way, other adults in the household have a greater positive appreciation of an additional hour of leisure time the higher the joint incomes of the head and the partner are.

5. Effects on labor supply

The effects on labor supply for all the potential workers simulated here (that is, those belonging to the *Chile solidario* program), are presented in

Table 3. *Estimates by group of potential workers*

	Heads		Partners		Others	
	Coef.	t-stat.	Coef.	t-stat.	Coef.	t-stat.
Income sq.	-8E-7	-43.3	-1E-6	-34.0	-1E-6	-17.7
Income	5E-2	115	3E-2	36.9	6E-2	50.0
Age	-5E-4	-35.2	-8E-4	-21.0	-4E-5	-1.0
Age sq.	6E-6	32.3	1E-5	23.4	-3E-6	-4.9
Schooling	-2E-3	-64.6	2E-4	6.2	-2E-3	-41.9
School. sq.	9E-5	66.3	-1E-5	-5.9	8E-5	36.4
Children	4E-4	7.2	5E-3	40.0	-2E-3	-13.2
Child. sq.	-1E-4	-8.5	-1E-3	-29.1	2E-4	3.1
Urban = 1	-5E-4	-8.6	-6E-3	-34.2	-5E-4	-3.3
1 to 15	-2E-2	-72.7	-1E-2	-24.3	-3E-2	-34.0
16 to 31	-3E-2	-103	-2E-2	-49.3	-4E-2	-39.3
32 to 45	-3E-2	-110	-2E-2	-55.7	-4E-2	-42.2
46 or more	-3E-2	-119	-3E-2	-63.9	-5E-2	-49.2
Inc. head			4E-6	32.3		
Leis. head			7E-5	35.5		
Leisure sq.	4E-3	162	6E-3	146	6E-3	137
Leisure	-9E-1	-124	-1.5	-129	-1.5	-116
Age	-8E-3	-74.7	-5E-3	-24.2	-6E-3	-31.5
Age sq.	9E-5	67.5	6E-5	26.1	7E-5	23.8
Schooling	-8E-3	-51.6	2E-3	11.9	-1E-2	-42.3
School. sq.	5E-4	47.9	-8E-5	-6.1	4E-4	27.0
Children	-7E-3	-16.9	2E-2	34.1	-2E-2	-18.2
Childr. sq.	4E-4	3.8	-4E-3	-27.4	2E-3	6.5
Urban = 1	-6E-3	-16.1	-3E-2	-47.4	-4E-3	-6.3
Indigent	6E-2	128	6E-2	60.4	5E-2	59.0
Poor	2E-2	77.5	2E-2	54.1	4E-2	79.1
Inc. recip.					1E-6	1.3
Sample size	1,113,895		631,905		486,715	
Log-likelih.	-294,843		-135,773		-112,961	

the first matrix given in Table 4. The results show that, for the population as a whole, after the ethical family income program is implemented the decisions regarding how many hours to work tend to drop. Before the ethical family income, 43% of potential workers do not participate in the labor market, while after it the percentage increases to 52%. Regarding the potential workers who remain on the labor market, it can be observed

Table 4. *Labor supply transition matrices*

Pre-reform ranges	Post-reform ranges					
All	0	1 - 15	16 - 31	32 - 45	46 & more	Total
0	43.27	0	0	0.08	0	43.36
1 – 15	0.96	4.18	0.01	0.22	0	5.38
16 – 31	2.78	0.01	4.17	0.72	0.05	7.74
32 – 45	3.10	0.01	0	24.47	0	27.58
46 & more	2.38	0.09	0.02	0.44	13.03	15.95
Total	52.49	4.30	4.20	25.92	13.08	100
Heads						
0	30.59	0	0	0.11	0	30.70
1 – 15	0.16	5.90	0.01	0.03	0	6.10
16 – 31	1.55	0	8.19	0	0	9.74
32 – 45	0.39	0.02	0	32.39	0	32.81
46 & more	0.31	0.06	0.02	0.07	20.19	20.66
Total	33.01	5.98	8.22	32.61	20.19	100
Partners						
0	61.08	0	0	0.1	0	61.17
1 – 15	1.75	2.80	0.02	0.45	0	5.02
16 – 31	5.18	0.05	0.31	0.47	0	6.01
32 – 45	8.71	0	0	8.61	0	17.32
46 & more	5.88	0.21	0	0.52	3.86	10.47
Total	82.59	3.06	0.33	10.16	3.86	100
Others						
0	48.04	0	0	0	0	48.04
1 – 15	1.73	2.14	0	0.33	0.02	4.23
16 – 31	2.32	0	0.26	2.69	0.24	5.51
32 – 45	1.67	0	0	27.93	0	29.59
46 & more	2.34	0	0.02	1.16	9.12	12.63
Total	56.10	2.14	0.28	32.10	9.38	100
Men						
0	25.25	0	0	0.18	0	25.43
1 – 15	0.82	3.06	0	0.25	0.01	4.14
16 – 31	0.91	0	4.26	1.16	0.03	6.37
32 – 45	1.42	0.02	0	38.41	0	39.84
46 & more	1.64	0.06	0.03	0.9	21.58	24.22
Total	30.03	3.14	4.29	40.91	21.63	100
Women						
0	58.36	0	0	0	0	58.36
1 – 15	1.08	5.12	0.02	0.19	0	6.41
16 – 31	4.34	0.03	4.1	0.34	0.07	8.88
32 – 45	4.51	0.01	0	12.8	0	17.32
46 & more	3	0.11	0	0.05	5.87	9.03
Total	71.29	5.27	4.12	13.38	5.94	100

that the percentage of people who increase their work hours is larger than the group that reduces them. This is proved by adding what is below and above the main diagonal, respectively: a 1.1% increase the supply of hours, and 0.08% even enter the market, but only 0.57% reduce the number of hours.

The next three matrices in Table 4 present the results of the simulation according to the considered typology of potential workers: head of household, partner and other adults. The results show the existence of heterogeneous effects according to the type of potential worker. Partners and other adults in the household are the groups that are the most affected. In these groups the predominant effect is to leave the labor market. Regarding the potential head of household, it is observed that only 3% decide to leave the labor market and 0.17% reduce the number of hours offered. Meanwhile, only 0.15% increase them. The effects on this group are minor.

The effect on the partners of heads of households is significant. Before the ethical family income, 61% of them did not participate in the labor market, but after it the percentage was close to 83%. The percentage of potential workers who continue working but with a reduced number of hours is 0.78%, while 1.04% increase them. There is also a larger percentage of other adults in the family who leave the labor market. The variation is close to 8%. However, this is the only group that increases the hours offered by close to 3% in the case of those who were already in the market.

The analysis by gender shows differences between men and women, as shown in the last two transition matrices in Table 4. For the group of men, close to 4.7% leave the labor market, a number that is almost three times lower than with women. The variations in hours among those who stay in the market are minor: 1% of men reduce the number of hours and 1.6% of them increase them. In the case of women, 0.2% reduce them and another 0.6% increase them.

6. Effects on income, inequality and poverty

The results in this section present the effects of the ethical family income on income distribution, inequality and poverty. Three scenarios are given for comparison: the base scenario, corresponding to the results of the 2009 Casen survey, the scenario with the effects of the proposal without

considering behavioral changes (only arithmetic), and, finally, the results considering variations in labor supply due to the introduction of the subsidy, whose effects were presented in the previous section.

In general the effects on each of these dimensions are positive, even after considering variations in labor supply and the rates at which people leave the market. It is important to note that to obtain these results the calculations are done on a household level. Table 5 illustrates the results on income distribution. The results on average incomes by autonomous income decile indicate that the autonomous income increases for all deciles. Monetary income increases in the same way; however, the variations in averages are higher in the latter. Indeed, as implied by the table, there are no significant variations in the distribution of autonomous income, while in the case of monetary income the percentage of total income for the first decile can be seen to increase by 0.1%.

Table 6 presents the effects that the ethical family income has on inequality. As shown there, the program contributes toward reducing inequality between the extremes of the income distribution, and the improvements are greater in the case of monetary income: the ratio of deciles for monetary income goes from 25.8 times to 25. This is a significant reduction and it reflects the weight that the transfer component of the ethical family income has. The same indicator in the case of autonomous income also drops, but to a lesser degree, while the Gini index is barely affected by the change in the distribution of income.

Finally, there is a significant effect on poverty. Table 6 shows how the implementation of the ethical family income program would manage

Table 5. *Effects on average autonomous and monetary income by decile*

	Autonomous income			Monetary income		
D	Base	Arithm.	Behav.	Base	Arithm.	Behav.
1	64574	65103	64928	114519	118371	118222
2	197684	200931	201095	230701	236925	237205
3	273527	274432	274357	300120	303340	303083
4	341200	341496	341881	360987	362955	363076
5	408560	410553	410675	425020	428734	428896
6	518246	518787	519233	532956	534620	534933
7	625845	628872	628819	637082	640788	640921
8	819056	818549	819841	827128	827073	828404
9	1149245	1149319	1150724	1155157	1155559	1157059
10	2958696	2958701	2959647	2960783	2961047	2962009

Table 6. *Inequality indexes and poverty statistics*

	Base	Arithmetic	Behavioral
Autonomous income			
Gini index	0.552	0.551	0.551
p10/p1	45.7	45.4	45.4
q5/q1	15.7	15.4	15.4
Monetary income			
Gini index	0.534	0.531	0.531
p10/p1	25.8	25	25
q5/q1	11.9	11.6	11.6
Poverty rate	15.1	14.4	14.5
Poverty gap	0.050	0.048	0.048

to reduce the poverty rate from 15.1% to 14.5%. It should also be noted that the difference between the arithmetic scenario and the one that considers a simulated behavior implies a 0.1% increase in the poverty rate, mainly due to variations in labor supply. The table also shows that the poverty gap is, on the other hand, reduced from 0.050 under the base scenario to 0.048 assuming that the ethical family income program is implemented (both, according to the arithmetic model and the one that allows for behavioral changes).

7. Conclusions

We have shown that an ethical family income program like the one presented in this chapter has positive effects on income distribution, inequality and poverty. However, the same cannot be said regarding labor participation. The effects on labor participation indicate that the social bonus has a negative impact on the work hours offered, and that the component proposed by the Council to incentivize labor participation is not enough to compensate the effects of people leaving the labor market. Along these lines, any proposal that accompanies the social bonus when implementing an ethical family income for the country must incorporate elements that incentivize labor participation and also that compensate for the transfer effects. Finally, it should also be mentioned before concluding that the results presented here might be biased downwardly due to the survey's problems with self-reporting and the focalization of simulated policies.

Notes

[1] Chapter prepared for the project "An Integrated Framework for the Assessment of Equitable, Pro-Growth Fiscal Reform in Latin America and the Caribbean: Fiscal Schemes for Inclusive Development (FSID)", co-funded by UNDP and IDRC. Any errors or opinions are the authors' and do not necessarily represent the views of the United Nations Development Programme or those of the International Development Research Centre.

[2] The *Ficha de protección social*, which can be translated as "social protection file", is the main instrument for focalization in the country. Its origins date back to the late 1970s, when it was called the CAS file and it measured households' socioeconomic condition. Later, in 2007, it was replaced by the current FPS, which seeks to identify families in vulnerable situation. This corresponds to the risk of poverty, which includes both poor households as well as those with a high likelihood of being so.

[3] In May 2011 the prevailing exchange rate was about $470 per dollar.

[4] The UF (*unidad de fomento*) is a monetary unit that is indexed to the inflation of the previous month. As of May 27, 2011, it was worth $21,801.41. At an exchange rate of $470 per dollar, this was approximately equal to US$46.40.

[5] See Larrañaga and Contreras (2010) for more in-depth information on the *Chile solidario* program.

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4 A microsimulation model for Guatemala: the case of direct and indirect taxes[1]

Alberto Castañón-Herrera and Wilson Romero

1. Introduction

The fiscal system in Guatemala can be characterized as one with a very low tax burden compared to most countries in Latin America (including Central America), as well as one that is quite regressive. Almost everybody in the country would agree with the statement that the government needs to count with more fiscal resources if it wants to improve the social welfare of the population. The proposed mechanisms to increase government revenue range from changes to the income tax rates to changes to the rates of some indirect taxes, such as the value added tax (VAT), and excise taxes for gas consumption, the use of cell phones, vehicular circulation, etc.

There are conflicting positions on that matter, however, as the business sector and some academic researchers consider that the current rates of the corporate income tax limit private investment and have negative effects in generating more employment, therefore affecting the tax collection. Their proposal is instead to lower government expenditures and/or to increase indirect taxes. On the other hand, most members of the civil society point out that such an increase in the indirect taxes would bring greater tax revenue but at a very high social cost, since the extra tax burden would be borne mostly by the poor. This claim is important, since Guatemala is a country where 51% of the population is poor, with a 15.2% being extremely poor. Furthermore, the country has also a very high income inequality: in the year 2007, and as measured by the Gini index, Guatemala had an inequality index of 55.1, which placed it on the eleventh place from a total of 135 countries.[2]

Microsimulation Models for Latin America, Carlos M. Urzúa (ed.), Mexico City: ITESM.

As a result of that debate, there is an urgent need to be able to assess, in an *ex-ante* fashion, the social welfare impact of possible tax reforms in Guatemala. It is the purpose of this work to provide a micro-simulation model that can be used for that end, in the case of possible changes to the personal income tax or the indirect taxes. Before presenting the model, the next section gives a brief overview of the current Guatemalan tax system, while Section 3 gives an account of some of the proposals for tax reform that ended up being rejected in the past. That section ends with a description of a new tax proposal recently made public. Section 4 then details our microsimulation model, which is used in the rest of the paper to evaluate some possible tax changes as an example of its use.

2. Brief remarks on the Guatemalan tax system

Although a detailed account of the tax-benefit system in Guatemala has been given already in Romero and Pineda (2011), it is worthwhile to briefly mention here the main aspects of the prevailing tax structure. The first point to make is that, as is illustrated in Table 1, the tax revenue of the Guatemalan central government has never been greater than 12.1% of GDP, in spite of several tax reforms that have been proposed over the years (to be reviewed later).

As can also be seen from that table, about three quarters of the revenue comes from indirect taxes. Among these, the foremost is the value added tax. Currently the general VAT rate is 12%. There are some exceptions, among which there is a zero rate in the case of the food bought in informal markets, and non-piped water, while education is exempted. On the other hand, there are specific taxes in the case of alcoholic beverages, gasoline and other fuels, tobacco products, and vehicle circulation for private use.

In the case of direct taxes, the major source of government revenue is the personal income tax (its features will be detailed in Section 4 below).

Table 1. *Tax revenue of the Guatemalan central government (% of GDP)*

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Indirect	8.2	8.7	8.6	8.7	8.3	8.5	8.7	8	7.2	7.4
Direct	2.6	3.1	3.0	2.8	2.9	3.3	3.3	3.3	3.2	3.1
Total	10.8	11.9	11.7	11.5	11.2	11.9	12.1	11.3	10.3	10.5

Source: Finance ministry. Note that, due to rounding errors, the sum of indirect and direct taxes can be different from the total.

There is also a corporate income tax, as well as a special tax known as the solidarity tax (*impuesto de solidaridad*, ISO). This contribution is made by all individuals or corporations that have commercial or agricultural activities in the national territory and obtain a margin of at least 4% over their gross income. Finally, it is also worth mentioning that the evasion in the case of income taxes (both personal and corporate) oscillate around fifty percent of the potential tax revenue.[3]

3. Failed past reforms, and a recent proposal

During the last decades, any attempt of fiscal reform has been received either by confrontation, by the private sector, or a negotiation between political and business elites, resulting in minor reforms that have consisted mainly in the imposition of temporary taxes, simplification of the tax system, or the erosion of direct taxation.

The year 1996 marked a transcendental point in the history of Guatemala, due to the peace agreements signed between the Government and the Unidad Revolucionaria Nacional Guatemalteca (an umbrella leftist organization). These agreements became a point of encounter and understanding, laying the groundwork to modernize the country. In particular, the agreement known as "Socio-economic aspects and agrarian situation" called for a new tax system that would be fair, equitable, progressive, universal, and compulsory; another requirement was that it would encourage savings and investment. That particular agreement stipulated that before 2000 the Guatemalan government would have to increase the tax burden by 50% compared to 1995, equivalent to a new tax burden of 13.2% of GDP.[4] It was also agreed that spending on health and education would be increased by 50% between 1996 and 2000. There were supposed to be also increases in spending on housing and the judicial sector, and reductions in military spending.

Before reaching the year 2000, the government recognized that such a goal could not be met and called for a rescheduling, determining the new due date as the year 2002. Along with that postponement, the government established a series of fiscal measures, out of which the following four stood out: the establishment of a new tax on corporate income (*impuesto a las empresas mercantiles*), the reformulation of property taxes at the municipal level, the adoption of better tax collection mechanisms, and the call for a fiscal covenant.

3.1. The Fiscal Pact and other attempts of reform[5]

The pact was an initiative of the commission in charge of following up the advance of the peace agreements. The main idea behind the covenant was that any tax reform would only be possible and sustainable with the consent of all the different social sectors. For that end, a preparatory commission was appointed to carry out consultations among different sectors and make a proposal. The result was made public in December 1998. The proposal was based on a series of principles aimed toward the medium and long term. It was discussed at a national forum, and eventually led to the signing of the Fiscal Pact in May 2000.

The discussion of concrete measures to reform the tax system was led by three main players: representatives of the civil society, the business sector, the Congress, and the Ministry of Finance. Because of disagreements between the business sector and civil society, on the one hand, and between the former and the government, which attempted to introduce new reforms, the agenda was left unfinished. What got approved instead by the Congress was not only partial, but it was also soon defied by the business sector.

The constitutional challenges raised by the private sector to oppose the tax measures before the Court resulted in a decline in resources in 2007. This situation led the government to create a technical committee that was to draft a new tax proposal. At last, a modification to the income tax was approved after creating two possible ways of taxation: 5% over gross income (in the case of the simplified regime) or 31% over profits. Exporters to Central American countries were exempted from paying direct and indirect taxes, and an anti-evasion law was approved, which allowed the tax administration entity to have a greater enforcement power. Also, it was established a temporary tax of 2.5% over net sales known as IETAAP (*impuesto extraordinario y temporal en apoyo de los acuerdos de paz*), as well as an excise tax on alcoholic beverages (with a variable rate depending on the type of liquor and its process). It may also be noted that when the temporary tax IETAAP came to an end, during the current UNE administration, it had to be replaced by the already mentioned solidarity tax (ISO) to arrest the fall in tax revenues.

3.2. Still another attempt of a reform

From 2008 up to date, the main effort to promote a new tax reform has been made by a group sponsored by the peace agreements commission.

Following its recommendations for the modernization of the Guatemalan tax system, the government presented a package of fiscal measures that included the following: to improve the quality of public expenditures, to have more transparency in the case of government activities, and to increase the tax revenue coming from income taxes. As a general goal, a proposal was made to raise the total tax burden up to 13.2% of GDP.

The reform contemplated in particular three changes in the case of income taxes: First, the tax rate was to be raised from 5% to 7% of gross income (excluding exempted income) for the simplified regime. Second, in the case of the general corporate income tax there was supposed to be a reduction in the rate from 31% to 25%, in exchange for the limiting of some deductions. And third, for the case of the personal income tax the proposal established a reduction of income brackets to just two, and in both of the new brackets a reduction in the tax rates. At the end, perhaps because of its own misgivings about the final impact of the reform on tax revenue, the government itself decided not to present the proposal for the consideration of the Congress.

3.3. The latest proposal

In April 2011, it was submitted to the Guatemalan Congress a new tax initiative (*iniciativa de ley* 4317). At the moment of this writing, it is unknown whether or not the proposal will be approved, but it is worth to mention some of its features. The main goal of the reform is to reduce tax evasion by strengthening the documentation requirements for: first, the corporate income tax, especially in the case of the declarations about wages effectively paid; second, the VAT exemptions; and third, the vehicles circulation tax. It also proposes to increase the penalization for tax evasion, and to stimulate tax payments through electronic means. On the other hand, as in the other reform mentioned earlier, the corporate income tax rate is to be reduced from 31% to 25%, in exchange for the limiting of some deductions.

4. A Guatemalan microsimulation model

As can be appreciated from the variety of tax proposals described in the last section, there is a need for developing simulation models that can be used by policy makers and legislators to evaluate possible tax reforms. This section contains a description of our microsimulation model, which

can be used to assess the impact of possible changes in the case of the personal income tax, the value added tax, and three specific taxes: the tax on beverages (the acronym in Spanish is ISDB), the tax on tobacco and its products (ISTP), and the tax on gasoline and other petroleum products (ISPPD). Our simulator, arithmetic in nature, was written using Excel (2007 or later), because it is a simple program and with easy access for the majority of the population. The model can be downloaded freely in the internet address *http://ideas.repec.org/c/ega/comcod/201104.html* through the worldwide economic database known as Ideas-RePEc. In some of the discussions below it is helpful to have already perused through the worksheets of that Excel file (note that one has to enable the macros in order to run the model).

4.1. The data base

The most appropriate source of information to simulate a tax system in Guatemala is the income and expenditure survey known as Encuesta Nacional de Condiciones de Vida (ENCOVI). There are two surveys available at the moment of this writing, for the years 2000 and 2006, and each one has detailed information about the economic characteristics of the households: their incomes, expenses and their living conditions during those years. In particular, the ENCOVI 2006 was collected between March and September 2006. It contains information about 68,641 individuals living in 13,686 households. Its sample design is reviewed in Romero and Pineda (2011), but for our purposes here it just suffices to say that it is representative at the national level.

4.2. Modeling the personal income tax

The ENCOVI, as in the case of most household surveys, contains information about the net income received by the workers in each household, but not about their gross income; that is, their income before taxes and social security payments. Thus, our first task is to recover from the answers given to the survey the original income earned by the members of the household that happen to work. For that end, we first make the following assumptions:

• The individuals to be considered working in the formal sector for our simulation model are the ones that make social security contributions to, or receive social benefits from, the Instituto Guatemalteco de

Seguridad Social (IGSS). We also include the workers that report in the survey that they have a private insurance plan.

• Due to the regionalization of the contributions to social security by the IGSS, we consider all the localities (*departamentos*) to belong to the first region, except for Petén, Santa Rosa and El Progreso, which are included in the second region. The social security contribution rates in the first region are 10.67% for the employers, and 6.67% for the employees. In the case of the second region, the contribution rates are 4.83% and 2.83% respectively.

• In those cases where the employees earn a net income of less than the minimum salary and they are registered at the IGSS, a minimum salary is attributed to them instead.

• The imputation of the net minimum wage is made according to each worker's activity. In the case of an agricultural activity, the daily minimum wage is 42.46 quetzales, while in the non-agricultural sectors is Q43.64. Note that those minimum wages correspond to 2006 (as it should be, since the ENCOVI that is being used in the microsimulation model was made in that year).

• Finally, it is also assumed that taxes apply to the worker's total income, which could be earned not only from a primary job, but also from secondary jobs (if any).

As it can be seen when opening the Excel file mentioned earlier, the microsimulation model is made of several worksheets. For the purposes of this subsection, which focuses on the direct taxes, the important ones are four: the first is the *Presentación*, which is the front-sheet and allows for the possibility of changing the personal income tax rates; on the other hand, *DISR*, *SISR* and *RISR* contain, respectively, the data set, the simulator itself and the results that would be obtained after running the microsimulation model.

The data set given in *DISR* contains selected information for the 13,686 households. It starts first with the column named *Folio* whose nine digits establish the administrative region, the locality and the area where the household is located, as well as its identification number. The next column, *Región de IGSS*, assigns the household to one of the two IGSS regions in order to determine the corresponding minimum wage, as mentioned earlier. The next columns provide information about whether or not the working members of the household are enrolled in IGSS or in a private insurance plan. Finally, the rest of the columns list the different income sources, based on the ENCOVI items detailed in Table 2.

Table 2. *Monetary income items*

Questions	Codes
Main job	
What was the gross monthly salary before deductions?	P10B08A
Did you work extra hours last month?	P10B09A
Did you get money from commissions or gratuities?	
How much did you receive?	P10B10A
Did you get money from a bonus in June (Bono 14)	
How much did you receive?	P10B11A
Did you get money from a December bonus?	
How much did you receive?	P10B12A
Did you get money from a differed 15th salary?	
How much did you receive?	P10B13A
Did you get money from a vacation bonus?	
How much did you receive?	P10B14A
Did you get money from productivity bonuses?	
How much did you receive?	P10B15A
Are you enrolled in IGSS as…?	
How much did you pay to IGSS?	P10B26A
Secondary jobs	
Aside from your main job, did you have another one last week?	P10C01
How much did you get from commissions, extra hours…?	P10C06A
Did you get any bonuses from your second job?	
How much did you receive?	P10C09A
Did you get money from a 15th salary, productivity bonus or incentive?	
How much did you receive?	P10C10A
Pensions	
Did you get money from retirement or pension?	
How much did you receive?	P11A04A
Did you get money from scholarships or transport bonuses?	
How much did you receive?	P11A07A

Source: INE, ENCOVI 2006.

The next worksheet in the Excel file is *SISR*, which contains all the operations that are needed to estimate the original (gross) income, using the net income reported in ENCOVI and the tax and social security laws prevailing in 2006. Theoretically, this task can be described as follows: if Y denotes the gross income and Y_{net} the net income, then

(1) $$Y = Y_{neto} + I + SS \ ,$$

where I and SS are the personal income tax payments and the social security contributions. Thus, if the exempted income is Y_{exento} , then

(2) $$I = C + t_y \cdot ([Y - Y_{exento}] - L) \ ,$$

where C, t_y, and L are, respectively, the flat amount of income tax payment in the individual's tax bracket (if any), the corresponding tax rate, and the lowest income in the tax bracket. The last variable on the right-hand side of (1) is SS, which, assuming that the income that is tax exempt is exactly the same as the one that is exempted from the social security contribution, is given by

(3) $$SS = t_s \cdot [Y - Y_{exento}] \ ,$$

where t_s is the social security contribution rate. Finally, if we substitute (2) and (3) in (1), then the original income, before taxes and social security contributions is given by:

(4) $$Y = \frac{Y_{neto} - (t_y + t_s) \cdot Y_{exento} - t_y \cdot L + C}{1 - t_y - t_s} \ .$$

Consequently, in order to calculate for each household the corresponding gross income, one has to find, to start with, its net income. This is done in *Tabla 1* and *Tabla 2* in the *SISR* worksheet. Note that those calculations, as well as the rest in the worksheet, correspond only to the first household in the survey. Once the model is run, a macro in Excel repeats the same calculations for the rest of the households. Returning to equation (4), the next key variable to estimate is the exempted income. This is done in *Tabla 3* and *Tabla 4* in the worksheet, where the monthly income items are grouped into total taxable and non-taxable income. Then, in *Tabla 5*, the estimated values are transformed to an annual basis.

The next table in the worksheet, *Tabla 6*, presents in its last columns a colored area that contains information about the personal income tax rates and social security contribution rates prevailing in Guatemala when the ENCOVI was collected, Note that it integrates the personal income tax rates and the two levels of the IGSS contribution in a single table. Thus, the corresponding values of C, t_y, L, and t_s for each member of the household can be retrieved all at the same time from there.

The other tables in the worksheet are used to estimate, for each member in the household, the amount of tax payments, the social security contributions, and, at the end, the original (gross) income by making use of equation (4).

Finally, the *RISR* worksheet presents the results for the particular tax and social security structures established by the user in the first worksheet mentioned earlier. In *RISR* one can find, for the chosen scenario, the estimated gross income, the estimated income tax payment, and the estimated social contribution for each of the 13,686 households reported in ENCOVI 2006.

4.3. The simulator for the value added tax

In the same Excel file one can find the second component of our microsimulation model, which estimates the impact of changes in the value added tax rates, as well as in some specific tax rates. This component shares the same *Presentación* worksheet with the personal income tax simulator. The other worksheets are: *DIVA*, *SIVA* and *RIVA*. These contain, respectively, the data set, the simulator and the results that would be obtained after running the model.

For most goods and services the current general VAT rate is 12%. As shown in Table 3 below, there are some exceptions, among which there is a zero rate in the case of food bought at informal markets, non-piped water, coal and wood, while education is VAT exempted. On the other hand, aside from the value added tax rate of 12% there are specific taxes in the case of beer (6%), other alcoholic beverages (30%), tobacco products (160%), and fuels for vehicles for private use (a quantity tax rather than an ad-valorem tax). In order to simulate the consequences of new VAT rates or new excise tax rates for the baskets listed in Table 3, the user simply has to fill out the new rates in the corresponding column of the second table in the *Presentación* worksheet.

On the other hand, the worksheet *DIVA* records the spending on each of the baskets by each of the 13,686 households. The microsimulations corresponding to the new indirect tax rates are performed in the worksheet *SIVA* in a manner similar to the direct tax case: the data that appears in the worksheet correspond only to the first household in the survey, and once the model is run, a macro in Excel repeats the same calculations for the rest of the households. Finally, the worksheet *RIVA* presents the spending on each of the baskets in Table 3 made by the 13,686 households if the new indirect tax reform were implemented.

Table 3. *Goods and services in the microsimulation model*

Goods and services	Codes
0% VAT rate or VAT exempted	
Food expenses at informal markets	P13a03a, P13a15
Non-piped water	P01d14b
Coal	P01e03_4
Wood	P01e03_7
Education expenses (exempted)	P06b12b
12% VAT rate	
Supermarket expenses	P13a12b, P13a13
Food and beverages out of home	P13b03a, P13b04
Household goods	P13b07a, P13b08 P01d19a, P01d19b P01d19d, P01d19d
Household services	P01d21b, P01e03_1 P01e03_2, P01e03_3 P01e03_5, P01e03_6
Uniforms, books and school materials	P06b13b, P06b20b P05c09c, P05c09a
Health services	P05c09b, P12a12a P05d14b, P05d16b P05d17b, P05d19b
Housing services	P01b03
12% VAT rate plus excise tax	
Beer	P13a03a, 913a15
Other alcoholic beverages	P13a03a, P13a15
Tobacco products	P13a03a, P13a15
Fuel for vehicles for private use	P13b03a, p13b04

Source: INE, ENCOVI 2006.

5. Is the current tax system progressive?

In this section we illustrate the use of our microsimulation model by examining the progressivity, or the lack of it, of the current Guatemalan tax system. We use both components of the model, so that we examine all the cases considered earlier: the personal income taxes, the social security contributions, the value added tax, and the special (excise) taxes listed in Table 3 above. Although we do not consider other taxes, such as the corporate income tax, our coverage seems to be adequate.

For that end, we first group the Guatemalan population into three different categories: households that are not in a poverty situation (67.4%), households that are poor but not extremely poor (28.0%), and households that suffer extreme poverty (4.6%). This classification is made by estimating, using the first component of our microsimulation model, the gross income earned by each of the 13,686 households in the ENCOVI survey, and then using the two poverty lines established by the Guatemalan government for the year 2006: Q3,206 (extreme poverty) and Q6,574 (poverty).

After that classification is obtained, we then estimate for each household its total income tax payments (made by all the workers in the family), as well as the corresponding social security contributions. Table 4 shows those results for the three groups of interest. As can be appreciated from that table, the direct tax system in Guatemala is quite regressive. This is so because, out of their own taxable income, the poorest individuals contribute in percentual terms to the government's tax collection (and social security contributions) almost the same, in relative terms, as the more affluent ones.

The regressivity of the Guatemalan direct taxes would not come as a surprise after examining the model's first worksheet, *Presentación*. One can find there the following personal income tax schedule: individuals have to pay a rate of 15% when their annual taxable income is less or equal than Q65,000 (about 8,825 US dollars using the exchange rate prevailing in the middle of 2011); 20% on the next increment up to Q180,000; 25% on the next increment up to Q295,000; and 31% on an annual taxable income above Q295,000. Thus, there are only four tax brackets, and, as opposed to other countries (see, for instance, the case of Mexico in the next chapter), an individual with a taxable income of even one quetzal has to pay taxes at a very high initial rate (15%). Table 4 also shows the same pattern in the case of the social security contributions, but this is to be expected given that there are only two flat contribution rates depending on the region where the worker resides.

Table 4. *Incidence of direct taxes and contributions*

Income group	Imputed income	Income tax paid	Social security contributions
Extreme poverty	1.32%	1.23%	1.32%
Poor but not extremely	9.71%	9.04%	9.59%
Not poor	88.97%	89.73%	89.09%

Using the second component of our microsimulation model, Table 5 presents a similar examination, but now in the case of the indirect tax system. For that end we consider that the 0% and 12% VAT rates apply to the different consumption baskets as given in Table 3, and also consider the following excise tax rates: 6% for beer, 30% for other alcoholic beverages, 160% for tobacco products, and the quantity tax of Q4.65 per liter in the case of fuels.

As can be appreciated from Table 5, and as one would expect a priori in any country in the world, the value added tax is highly regressive, with the poorest households contributing with 3.21% of total VAT revenue, even though their income only represents 1.32% of the total. In the case of the specific taxes, the regressivity in the case of the poorest households is ameliorated. This is so simply because few have a vehicle, and they can consume less alcoholic beverages and tobacco products than the rest of the population. But note that in the case of the next category, the poor but not extremely poor households, the regressivity persists if their contribution to tax revenue is compared, in relative terms, to the contribution made by the more affluent.

6. Concluding remarks

All policy makers in Guatemala hold the view that the current tax system requires an integral reform. We sympathize with that view, but we also think that such a reform has to be designed taking into account not only the potential extra-revenue that would come from it, but also its social welfare impacts. This chapter has presented a microsimulation model that can be used to illuminate those issues in the case of possible changes in the personal income taxes, social security contributions or consumption taxes. Needless to add, the model can be further enriched taking into account other important variables, such as social benefits, yet we believe that our model is the first step on the right direction.

Table 5. *Incidence of the valued added tax and special taxes*

Income group	Imputed income	VAT paid	Special taxes payment
Extreme poverty	1.32%	3.21%	1.09%
Poor but not extremely	9.71%	17.19%	11.47%
Not poor	88.97%	79.60%	87.45%

Notes

[1] Chapter prepared for the project "An Integrated Framework for the Assessment of Equitable, Pro-Growth Fiscal Reform in Latin America and the Caribbean: Fiscal Schemes for Inclusive Development (FSID)", co-funded by UNDP and IDRC. Any errors or opinions are the authors' and do not necessarily represent the views of the United Nations Development Programme or those of the International Development Research Centre.
[2] See *http://www.nationmaster.com/graph/eco_gin_ind-economy-gini-index* (last visit on May 16th, 2011).
[3] Cabrera (2009) reviews some of the studies on fiscal evasion.
[4] Guatemala changed the System of National Accounts in 2001. In 1996 the objective was actually to raise the tax burden to a 12% of GDP.
[5] Fuentes and Cabrera (2005) present a detailed and precise exposition about the Fiscal Pact.
[6] A new ENCOVI will be collected during the current year (2011).

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5 Distributive effects of the 2010 tax reform in Mexico: a microsimulation analysis[1]

Carlos Absalón and Carlos M. Urzúa

1. Introduction

There have been many attempts of comprehensive tax reforms in Mexico over the years. As early as 1960, the government commissioned no other than Nicholas Kaldor to draft an integral income tax law, but his proposal was vetoed by the private sector. Proposals have come and go since then, and the only important fiscal change that have taken place was in 1980, when a number of federal and state sales taxes were replaced by a single value added tax. That Mexico does need urgently a wide-ranging reform can be illustrated by the fact that, not counting its oil revenue (about 8% of GDP in 2011), the government's annual tax revenue has been less than 10% of GDP for a long time. This tax burden is so low that Mexico can be placed in that respect at the bottom of at least a dozen and a half Latin American countries.[2] With the hope of contributing to a much needed open (and reasoned) discussion on that subject, this chapter presents a microsimulation model for Mexico that can be used to analyze, in an *ex-ante* fashion, the social welfare impact of tax reforms that involve changes in the personal income tax schedule, in the value added tax rates, in the excise tax rates, and in the social security personal contributions.

As in the case of the other microsimulation models presented in this book, the model's computer program is freely available in the internet address *http://ideas.repec.org/c/ega/comcod/201105.html* through the Ideas-RePEC site. However, it should be noted that, as opposed to the majority of the other models, it is written using Excel (2007 or later) rather than Stata. This election would seem to be at first sight quite

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dubious in terms of computational efficiency, but we would like to give here three reasons for that choice. First, Excel, version 2007 or later, allows for 2^{14} columns and 2^{20} rows, so that any household survey that we know of can be easily accommodated in a worksheet. Second, the Excel macros are flexible enough to make programming a relatively easy task, and the handling of numerical operations can be faster than one would think (we invite the reader to take a look at the macros in the program). And third, by far the most important reason, by using an Excel format we can visually show to the readers that are unfamiliar with microsimulation the basic building blocks in the case of tax models.

The next section starts with a description of the main features of the current Mexican tax system, and ends with a description of a (minor) tax reform that took place in 2010, when the government tried to correct for a drastic fall in its revenues because of the economic collapse in 2009. The third section, on the other hand, describes in a detailed way our microsimulation model, which is made of three modules: for direct taxes, for indirect taxes, and for welfare indexes. Subsequently, the fourth section exemplifies the use of the model by examining the welfare and revenue impacts of the 2010 reform, and the final section concludes.

2. The Mexican tax system and a minor tax reform

As is evident from the long exposition in Absalón and Urzúa (2011), the Mexican tax-benefit system is a bit too complex to be explained in a few pages. Here we just focus on the case of federal taxes, leaving aside not only the social programs, but also the contributions imposed by the states and the municipalities.

2.1. Basic characteristics of the main taxes

The personal income tax, from now on denoted by ISR (*impuesto sobre la renta de las personas físicas*), can be filled out only individually, an important feature to be taken into account in the model to be given in Section 4 below, and its tax base is quite broad. Mexican residents are taxed on all their income, from whatever source, and the main exceptions and deductions are the following:

• In the case of earnings for overtime work, if the worker perceives at most the minimum wage salary, the exemption is 100%; otherwise is 50%. In the first case the exemption is valid provided the worker does not exceed three hours of daily overtime for at most three days per week.

In the second case, the exemption is valid provided the same condition and that the amount does not exceed five minimum wages per week.

• Social security benefits (mostly pensions) used to be exempt as long the amount did not exceed nine times the monthly minimum wage salary. In 2011, however, the Congress decided to fully exempt the social security benefits, a regressive measure that is quite uncommon across the world. In the case of retirement and other associated benefits from the part of the employer, these are exempt if the benefits do not exceed 90 times the minimum wage salary for each year of service.

• Profit sharing to employees and vacation allowances are exempt for at most 15 days of the daily minimum wage salary; annual bonuses are exempt if they don't exceed a monthly minimum wage salary; and interest paid on saving deposits is exempt as well.

• The tax allowances (which here are synonymous of deductions) contemplated in the ISR law are: voluntary contributions to the individual retirement funds, medical services, medical insurance, funeral expenses, donations, and school bus transportation. It should be noted that the law sets some limits on the amounts of some of those deductions (see Absalón and Urzúa, 2011). Also, the government decided in 2011, for political reasons, to make private education expenses tax deductible (up to some amount which depends on the education level).

• There are no tax credits in the current ISR law, if we understand by them deductions from tax due that are not refundable. On the other hand, we can define a tax subsidy as a deduction from tax due that could be at least partly refundable (from the part of the employer). If that is so, then for workers with low wage-earnings the corresponding income tax could turn out to be negative after subtracting from the tax due the subsidy for employment. In fact, as will be evident in the simulations below, this happens in the case of about one third of the workers in the formal sector.

We now turn to the other income tax, the one for firms. Although it is not modeled below, it is interesting to note that it is the typical corporate income tax that one may find elsewhere, except for a good number of exemptions in the case of special activities (e.g., farming and transportation), and a large number of deductions. Thus, revenues accruing from this tax are quite low for international standards. This was the reason for the introduction in 2008 of a new cash flow tax that is complementary to it, the IETU (*impuesto empresarial a tasa única*). There is a flat IETU rate, currently at 17.5%, and its tax base is calculated by netting the following inflows: cash collected from the sale

of inventory or other assets, cash collected from independent services, and cash collected from rental of property, from the following outflows: cash payments for purchases of assets, cash payments for services, and cash payments for the rental of property. For our purposes, it should be noted that individuals that receive payments from professional services or from rents are also required to pay the new tax. Although those self-employed individuals are supposed to pay also the personal income tax mentioned earlier, they are not included in our simulation model since there is not enough data that are public and trustworthy. Tax evasion has always been widespread among the members of that group, and it is only recently, with the introduction of the IETU, that such a behavior has started to change.

Regarding indirect taxes, the value added tax, from now on IVA (*impuesto al valor agregado*), has three different regimes (aside from a special rate at the border with the US): a general tax rate, which was 15% for more than a decade until, as will be explained soon, it was raised to 16% in 2010; a 0% rate in the case of food, medicines and exports; and some exemptions in the case of education services and agricultural activities. There are also excise taxes on some specific products, such as gasoline, diesel, beer, alcoholic beverages, and tobacco products.

Finally, the social security contribution rates vary according to the employee's social security system. The two main institutions in Mexico are the Instituto Mexicano del Seguro Social (IMSS) for private sector workers, and the Instituto de Seguridad y Servicios Sociales de los Trabajadores del Estado (ISSSTE) for public sector workers. There are some other systems at the federal level, such as the military security system, and the one for the workers in the oil company PEMEX, as well as some more at the state level (particularly in public universities). An interesting point is that, since 1997 in the case of IMSS and 2007 in the case of ISSSTE, pension regimes have been changed from a pay-as-you-go design to an individualized one. These changes are irrelevant for our model, however, since for all practical purposes there are no retirees under the new regime at this point in time.

2.2. The 2010 reform

In 2009 the gross domestic product of the Mexican economy dropped 6.2%, the largest fall in the Americas during that crisis. Given the accompanying drop in tax revenues, of 8.9% and 14.5% in the case of income taxes and VAT, respectively, the government decided in

September 2009 to submit to Congress a bill that proposed an increase in several indirect and direct taxes. We do not want to argue here whether or not that call for tax increases was reasonable during a recession period, instead we want to focus on the proposal and the eventual congressional resolution since they led to the most recent tax reform that have taken place in Mexico, even if it turned out to be a minor one.

The original proposal was actually somewhat bold. The government's most important point was to create a new fiscal "contribution to fight poverty". It called for a new sales tax of 2% that would be applied in a generalized fashion. As opposed to the case of the VAT that leaves them untouched, the new tax would affect in particular the final sales of food, medicines, and educational services. Part of the extra revenue thus obtained would be then used to bolster up programs against poverty such as Oportunidades (described in, e.g., Absalón and Urzúa 2011).

Among the other points in the proposal, there was to be a temporary increase of two percent in the maximum income tax rates for individuals and also corporations, an adjustment in the personal income tax rate rates in the five highest brackets, and an increase in the excise rates for beer, other alcoholic beverages, gambling and tobacco products. The tax rate on cash deposits, a contribution that is used to combat money laundering, was to be increased from two to three percent, and the exemption cash limit for that tax was to be lowered from 25,000 to 15,000 pesos.

The final tax reform turned out to be lighter. Most representatives in the Congress rejected the so-called contribution to fight poverty, and ended up agreeing only on an increase of one percent in the VAT general rate (without taxing food, medicines and education). Regarding the income tax rates, these were increased. In the case of the corporations the tax rate went up temporarily to 30%; but it will go down to 29% in 2013, and to 28% in 2014. In the case of the personal income tax, the rates for the three higher brackets were increased (instead of only for the highest, as in the bill), with the maximum rate being also 30%. The new tax schedule for the personal income tax is given in Table 1, while the old one can be found in the first worksheet of the Excel program.

The changes in the tax on cash deposits were also ratified, while the excise tax rates were raised (most in a temporary fashion). In particular, the tax rate on beer went up to 26.5% from 25%, on other alcoholic beverages to 53% from 50%, and on gambling to 30% from 20%. The typical cigarette pack ended up with an extra quantity tax of $0.80 in 2010 (in 2011 a new reform changed it to $7.00).

Table 1. *Personal income tax schedule, 2010*

Lower limit	Upper limit	Fixed quota	Rate on the excedent
$0.01	$5,952.84	$0.00	1.92
$5,952.85	$50,524.92	$114.24	6.40
$50,524.93	$88,793.04	$2,966.76	10.88
$88,793.05	$103,218.00	$7,130.88	16.00
$103,218.01	$123,580.20	$9,438.60	17.92
$123,580.21	$249,243.48	$13,087.44	21.36
$249,243.49	$392,841.96	$39,929.04	23.52
$392,841.97		$73,703.40	30.00

Source: *Ley del Impuesto sobre la Renta*, 2010.

3. A microsimulation model for Mexico

In this section we describe the three modules of our microsimulation model for the Mexican tax system: the first (ISR) can be used to simulate the consequences of changes in the structure of the personal income tax; the second (IVA) does the same for the case of the value added tax and other indirect taxes; and the third (Índices) calculates several well-known indexes that can be used to assess the impact of a given tax reform.

The data set derives from the Encuesta Nacional de Ingresos y Gastos de los Hogares (INEGI, 2009), from now on ENIGH. This income and expenditure survey is by far the most appropriate source of data for microsimulation in the case of Mexico. The survey is biannual, and, at the moment of the writing of this chapter, the most recent one was taken in the second semester of 2008. The ENIGH 2008 provides information on the occupational and socio-demographic characteristics of 29,846 households. As is detailed in Absalón and Urzúa (2011), the survey contains information about 78 possible sources of income, and on the expenditure side it covers more than 660 goods and services.

3.1. The ISR module

In order to build up the personal income tax simulator, the first task, simple but cumbersome, is what can be called an exercise in "reverse engineering". That is, from the survey we have to recover the pre-tax income, called from now on gross income, for each worker in the

household (as we said before, in Mexico it is not possible to file taxes jointly). For that end, there are some initial points that deserve to be mentioned in order to fully understand the model:

• Since we are using the ENIGH 2008, the Mexican tax and social security laws to be used for building the microsimulation models are the ones prevailing in 2008.

• For the simulation model at least, workers are considered to be in the formal sector if they receive any of the following social benefits from primary or secondary employment: IMSS, ISSSTE, state ISSSTE, PEMEX, the Army or the Navy.

• It is assumed that each worker complies with all his/her tax and social security obligations, that taxable income comes from principal or secondary jobs, and that the tax impact falls entirely on the worker.

• For those public sector workers who have medical services from ISSSTE, state ISSSTE, PEMEX, the army or the navy, we apply the contribution rates mandated by ISSSTE.

• We assume that all formal workers receive at least a minimum daily wage (otherwise it would be, at least in principle, unlawful). For the few cases when the reported income is less than that, then we impute a gross minimum daily wage by type of regime (IMSS or ISSSTE). In all cases, the minimum daily wage corresponds to the one prevailing in Mexico City in 2008: $52.59 pesos.

We urge the reader to open up at this point the Excel file that contains the first module of the simulator (please note that in order to run it you have to enable the use of macros). It has the following worksheets: *Presentación, Datos, Simulador and Resultados.* In the first of these the simulations are run. Also, there are two tables that contain the structure of the income tax rates for different income levels and the employment subsidy (a wage credit). In these tables one can change the upper limits of the income brackets, the income tax rates and the amount of subsidy granted. By selecting the button 2008 that appears in these tables, one can restore the original values that were in effect that year.

The *Datos* worksheet contains, on the other hand, the complete data set for the 29,468 households. Each row provides the relevant information for a particular household, which is distributed along at most 248 columns (most of them empty). This large number of columns is needed since all possible sources of income accruing from work have to be considered for each relevant member of the family. The income items according to the ENIGH are given in Table 2.

Table 2. *Sources of income according to the ENIGH 2008*

Source of income	Code
Wages and salaries	P001
Piecework	P002
Commissions and tips	P003
Overtime work	P004
Incentives, rewards and prizes	P005
Bonuses and additional wages	P006
Holiday bonuses and allowances in cash	P007
End-of-the-year profit-sharing	P008
End-of-the-year bonus	P009
Wages and salaries from main work in cooperatives and associations	P011
Other income from main work in cooperatives and associations	P013
Wages and salaries from secondary subordinated work	P015
Other income from secondary subordinated work	P017
Income from secondary subordinated work	P018
End-of-the-year profit-sharing and bonus from secondary work	P019
Retirement and pensions	P032

The *Simulador* worksheet contains thirteen tables (*tablas* in Spanish) that have to be used for running the model. The first of them, *Tabla 1*, is apparently incomplete, since it is made of a single row which contains only the relevant information for the very first household in the survey. Actually, when the model is run it iterates from one household to the next in the *Datos* worksheet, and a macro replaces the old information with the new one and modify all the subsequent tables accordingly. The first six columns in *Tabla 1* can be described as follows: *Factor* is the expansion factor for that household. *Estrato* indicates the size of the locality where the home is located: 1 for localities with 100,000 or more inhabitants; 2 for localities with 15,000-99,999; 3 for localities with 2,500-14,999; and 4 in the case of 2,500 inhabitants. The next column, *Tamaño*, gives the size of the household. *Folio* is a combination of housing and household identifiers: the first two digits refer to the entity, the third to the date, the next three are consecutive numbers, and the last digit identifies the nature of the home (0 if main, and greater than 0 otherwise). *Decena* refers to the ten days during which the survey was applied to the household; this information will be used later to calculate the exact monthly income. Finally, *Decil* indicates the income decil corresponding to that household.

The rest of the columns, and there could be many!, refer to each of the members of the household that receive any monetary income from work (not from interest payments, government transfers, etc.). If one finds under the headings *IMSS*, *ISSSTE*, *ISSSTE estatal* and *PEMEX/Defensa* a value of one, it means that the individual is enrolled in that social security system. The rest of the columns indicate the monetary income received by each individual for the reference period.

The same data on enrollment in social security institutions and quarterly earnings from work are presented in condensed form for the workers of each household in *Tabla 2* of the *Simulador* worksheet. From this table we can derive the monthly incomes presented in *Tabla 3*, depending on the period in which the survey was applied to each particular household. More precisely, quarterly income is divided by one of the following numbers: 2.99178 if *Decena* is equal to 1; 3.02465 if it is equal to 2, 3, 4, 8 or 9; and 3.00821 if *Decena* is equal to 5, 6 or 7.

The income sources are grouped in *Tabla 4* into monthly wage income (P001 + P002 + P003 + P006 + P011 + P015); income possibly exempted (P004 + P005 + P007 + P008 + P009 + P019 + P032); and other income (P013 + P017 + P018). The income that is actually exempted is less than the "income possibly exempted", because of several legal constraints (as of 2008). First, in the case of income from overtime work the tax rate is reduced 50% for the amount corresponding up to 5 minimum daily wages per week, but the tax rate is the normal one for the rest of the extra income. Second, in the case of the end-of-the-year bonus, it is exempted for up to 30 minimum daily wages, and in the case of other incentives they are exempted for up to 30 minimum daily wages as well. Third, holiday bonuses are exempted for up to 15 minimum daily wages, as well as profit-sharing. And fourth, in 2008 pensions were exempted for up to 9 minimum monthly wages. Taking into account the fourth constraints given above, *Tabla 5* in the worksheet classifies each income item in taxable income or exempted income.[3]

Using that table, *Tabla 6* shows the monthly net income reported by each member of the household in the formal sector, and the monthly net income that was indeed taxed (so that the difference between the two is income exempted). Next, *Tabla 7* presents annual figures for net income, taxable net income, exemptions and, if needed, an imputation of the income earned by the individual if he or she reported an income less than the corresponding to one minimum wage. More precisely, workers affiliated to IMSS and ISSSTE are imputed an annual minimum wage

income of $22,661.94 and $21,481.42 in cases when their wages were less than these amounts.

Before continuing with the other tables in the worksheet, it is worth to present some algebraic identities and transformations that may help to clarify the issues involved. Given the actual (net) income that is received by an individual, Y_{neto}, his/her original (gross) income is given by:

$$(1) \qquad Y = Y_{neto} + I + SS \ ,$$

where *I* and *SS* are the personal income tax payments and the social security contributions (made by the worker not the employer).

If the exempted income is now denoted by Y_{exento}, then

$$(2) \qquad I = C + t_y \cdot ([Y - Y_{exento}] - L) - SU \ ,$$

where *C*, t_y, *L* and *SU* are, respectively, the flat amount of income tax payment in the individual's tax bracket (if any), the corresponding tax rate, the lowest income in the bracket, and the so-called employment subsidy (if any). This last item might be thought to be a tax credit at first sight. But, as can be seen from (2), if income is small and/or the subsidy is large, then *IR* can become negative. As a matter of fact, in Mexico all tax payers that earn less than three monthly minimum wage salaries enjoy a negative tax, so that the worker's firm has to transfer to (not retain from) him/her some amount of money (the firm will then credit the subsidy when it makes its own tax payments to the government).

The last variable on the right-hand side of (1) is *SS*, the social security contributions. Assuming that the income that is tax exempt is exactly the same as the one that is exempted for the purposes of social security contributions,[4] then

$$(3) \qquad SS = CS + t_s \cdot [Y - Y_{exento}] \ ,$$

where *CS* and t_s are, respectively, a fixed payment (to be clarified later) and the contribution rate for social security.

To end the exercise, substitute (2) and (3) in (1), and get the following expression that can be used to recover the original income:

$$(4) \qquad Y = \frac{Y_{neto} - (t_y + t_s) \cdot Y_{exento} - t_y \cdot L + C + CS - SU}{1 - t_y - t_s} \ .$$

Alternatively, denoting by $Y_{gravado}$ the difference between net income and

exempt income, the following formula can be applied as well:

$$(5) \qquad Y = Y_{exento} + \frac{Y_{gravado} - t_y \cdot L + C + CS - SU}{1 - t_y - t_s} \ .$$

As is implied by the last equation, aside from the income exempted and the income actually taxed, we have to find for each working member in the household the effective tax and contribution rates, the fixed quotas paid, and the subsidy (if any). In that regard, the key tables in the *Simulador* worksheet are *Tablas 8*, *9* and *10* (the last two can be found scrolling to the right of the first). Because there is a given table to calculate the income tax, another for the employment subsidy, and two different rules for calculating the contributions to social security, it is very helpful to construct a single tax and contribution table depending on whether a particular individual is a member of IMSS or ISSSTE. One result is *Tabla 9*, with 19 different levels of income, for workers affiliated to IMSS, and the other is *Tabla 10*, with 18 income levels for workers affiliated to ISSSTE.

To be more precise, the information needed to calculate the social security contributions in the case of IMSS is as follows: for retirement and unemployment in advanced age (1.125%); for benefits in kind in the case of retirement, illness and maternity (0.4%); for medical insurance for retired workers (0.375%); for sickness insurance and maternity leave (0.25%); and for disability and life insurance (0.625%). On the other hand, in the case of ISSSTE the following contributions apply: for unemployment in advanced age and old age insurance (4.025%); for sickness insurance and maternity leave (2.75%); for sickness insurance for retired workers (0.625%); for disability and life insurance (0.625%); and for child care and social services (0.5%). The consolidated social security contribution rates, and the limits of the minimum and maximum incomes corresponding to each rate, are summarized in Table 3 below, where *Y* denotes, as before, gross income, and *Z* denotes the minimum wage. Note that, even though for a particular individual there is no fixed quota as such, in equation (3) above we introduce one, named there as *CS*, precisely to account for the varied possibilities in Table 3.

Using *Tabla 9* and *Tabla 10* thus constructed, together with equation (6) above, we then calculate each individual's taxable income, employment subsidy (if any), and social security contributions, as shown in *Tabla 11* and *Tabla 12* in the worksheet.[5] Finally, those incomes and payments obtained are multiplied by the so-called "Altimir factor", in our

Table 3. *Social security contributions*

	Payment	Condition
ISSSTE		
	None	$Y \leq Z$
	0.08525*Y	$Z < Y \leq 10Z$
	0.08525*10Z	$Y > 10Z$
IMSS		
	None	$Y \leq Z$
	0.02375*Y	$Z < Y \leq 3Z$
	0.02375*Y + 0.004*(Y-3Z)	$3Z < Y \leq 25Z$
	0.02375*25Z + 0.004*22Z	$Y > 25Z$

case equal to 1.33573, in *Tabla 13*. This number is the result of dividing the figure of labor earnings according to the System of National Accounts and the corresponding one implied by the ENIGH 2008. Thus, by using this factor we can bring closer to reality the aggregate monetary results derived from the simulator; yet, since the same factor is used in all of the adjustments, its application is irrelevant for all the other simulation exercises that focus on the distributive impacts of the reforms. Lastly, *Tablas 14-18* repeat the same procedure followed in *Tablas 9-13* but now for the new scenario proposed by the user.

The final worksheet in the ISR module of the microsimulation model is *Resultados*. This sheet simply records the results obtained, household after household, by the macros contained in the *Simulador* worksheet. It automatically presents the simulations for, both, the current scenario and the proposed scenario.

3.2. The IVA module

The second module of our microsimulation model calculates the impact of changes in the indirect tax rates, assuming that consumers do not modify their behavior once the changes in the corresponding final prices take place. It may be noted in passing that in Chapter 6 we present another model for the Mexican economy that does allow for the possibility of behavioral changes. However, the nature of that model is quite different from the one presented here, since it crucially depends on the estimation of a demand system that requires a good number of assumptions that are not needed in this chapter.

In the Excel file that contains this second module one can find the following worksheets: *Presentación, Datos, Simulador* and *Resultados*.

The simulations are run in the first of these worksheets. In there one can also find a table that present the different value added tax rates for different groups of goods and services in the economy, and another table that gives the corresponding excise tax rates (if any). That grouping of goods and services is made taking into account not only their different tax treatments, but also according to recent tax proposals that have been made by some legislators.

As can be appreciated from the *Presentación* worksheet, there are twelve baskets in total: 1) alcoholic beverages, except for beer, for which both VAT and excise taxes apply; 2) the food items, with a zero VAT rate, that are not included in the so-called "basic basket"; 3) the basic basket, also taxed at 0%, which corresponds to the items in the most basic diet among Mexicans and whose affordability is used to estimate if a family is extremely poor or not; 4) the other goods with a zero VAT rate; 5) beer, which is separated from the rest of the alcoholic beverages since it has a lower excise tax rate; 6) services that are VAT exempt, mostly educative services (note that for simulation purposes we can think them as having a zero VAT rate, even though that is incorrect from the point of view of the companies offering the product); 7) the goods and services to which the general VAT rate apply, and do not have (and probably will never have) excise tax rates; 8) gambling; 9) medicines, with a zero VAT rate; 10) soft drinks; 11) tobacco products; and, finally, 12) telecommunication services. The first columns of the two tables in the *Presentación* worksheet give the VAT and excise tax rates under the base scenario (2008 in the example given there, but that does not have to be the case), while the second columns can be used to modify any of the indirect tax rates.

The *Datos* worksheet contains information about each household's spending on those twelve baskets, as well as the household's id number and expansion factor. The next worksheet, *Simulador*, processes the arithmetic operations for each household, and sends the results to the last worksheet, *Resultados*. Note that the arithmetic that is behind the simulation is quite simple. If, for instance, one wants to calculate the monetary consequences of increasing the general tax rate from 15% to 16%, as it actually happened in 2010, then one has to select the goods and services to which that general rate apply and multiply the spending by the ratio 1.16/1.15. In the case of goods or services for which a specific tax applies as well, one just have to keep in mind that the value added tax has to be applied, by design, always at the final stage.

3.3. The Índices module

The third and final module of the microsimulation model simply calculates for each fiscal scenario, the following coefficients: the Gini inequality index, the Reynolds-Smolensky distributive index, and the Kakwani progressivity index.[6]

4. Distributive effects of the 2010 tax reform

As an example of the use of our microsimulation model, this section presents an appraisal of the 2010 tax reform that was described earlier, which involved changes in both the personal income tax schedule and the indirect tax rates.

4.1. Estimated effects of the changes in direct taxes

The first step in the analysis is to simulate the *status quo* in 2008, the year when the survey was taken, in the case of personal income taxes using the Excel module ISR. The results, in millions of pesos and distributed by income decile, are shown in Table 4. It is important to note that the table contains information about the monetary income of all households, regardless of whether or not the workers in each family are incorporated to the formal sector. Regarding that issue, it should also be

Table 4. *Estimated tax payments and social security contributions in 2008*
(Millions of 2008 pesos distributed by income deciles)

Decile	Estimated gross income	Personal income tax payments	Social security contributions
I	$37,574.19	-$568.42	$123.75
II	$87,414.01	-$1,018.69	$662.78
III	$122,616.91	-$1,035.32	$1,336.44
IV	$159,182.71	-$481.75	$2,333.92
V	$203,487.68	$811.82	$3,770.04
VI	$248,418.24	$3,285.97	$5,412.42
VII	$304,028.23	$8,720.41	$7,712.34
VIII	$383,254.07	$18,084.26	$11,498.91
IX	$493,996.35	$36,316.70	$16,161.99
X	$794,406.40	$96,315.91	$21,149.24
Total	$2,834,378.79	$160,430.90	$70,161.84

be noted that about 56% of the households in the survey do not have members affiliated to a social security institution.

As shown in Table 4, the first fourth deciles do not make, on the aggregate, income tax payments, but rather receive a transfer (a negative tax) due to the employment subsidy. The bulge of that subsidy goes to the second and third deciles because, on the one hand, most of the individuals in the first decile are not in the formal sector, while a number of workers in the fourth decile have an income that is high enough to pay taxes. Even though some measures of tax progressivity will be given at the end of the section, it is interesting to calculate already from Table 4 that about 23% and 60% of total income tax payments are made by the ninth and tenth deciles, while the corresponding percentages for social security contributions are 23% and 30%, reflecting the less progressive nature of the latter.

The new income tax schedule that took effect after the 2010 reform was presented earlier in Table 1. The changes with respect to 2008 are essentially in the rates for the three highest brackets, which go up from 19.94%, 21.95% and 28% to 21.36%, 23.52% and 30%, respectively. We estimate the new tax payments for each member of the household that works in the formal sector, and then aggregate the results by deciles in Table 5. Comparing the results in Table 4 and Table 5, it can be seen that tax payments for the eighth and ninth deciles increase by 3% and 4%, while taxes for the tenth decile increase by 7%.

Table 5. *Estimated tax payments and social security contributions in 2010*
(Millions of 2008 pesos distributed by income deciles)

Decile	Estimated gross income	Personal income tax payments	Social security contributions
I	$37,574.19	-$568.42	$123.75
II	$87,414.01	-$1,018.69	$662.78
III	$122,616.91	-$1,035.32	$1,336.44
IV	$159,182.71	-$481.75	$2,333.92
V	$203,487.68	$813.59	$3,770.04
VI	$248,418.24	$3,316.01	$5,412.42
VII	$304,028.23	$8,854.77	$7,712.34
VIII	$383,254.07	$18,478.82	$11,498.91
IX	$493,996.35	$37,420.28	$16,161.99
X	$794,406.40	$101,303.38	$21,149.24
Total	$2,834,378.79	$167,082.66	$70,161.84

Note that the implied real growth rate of the income tax revenue is of the order of 4.1%, comparing the 2008 and 2010 figures. Controlling for the corresponding changes in gross domestic product, did that expected rate of growth turn out to be close to reality? That question is difficult to answer since real GDP in 2010 happened to be 0.9% lower than in 2008, due to the 2009 crisis. Furthermore, at the moment of this writing the government had only liberated an aggregated figure for the case of both personal and corporate income tax revenues for 2010.[7] But if one were to use the growth rate of this aggregated figure, 3.5%, as a proxy, and were to estimate its income elasticity as 1.15%,[8] then (3.5+.9x1.15)% would not be far away from our forecasted growth rate.

4.2. Incidence of the indirect tax changes

As recounted in Section 2, the 2010 tax reform also involved changes in the indirect taxes: the VAT general tax rate was increased from 15% to 16%; the excise tax rate on beer went up from 25% to 26.5%; the rate on other alcoholic beverages was raised from 50% to 53%; on gambling the excise tax rate was increased from 20% to 30%; and on cigarettes, after approximating the extra quantity tax to an *ad-valorem* tax, the rate was increased from 160% to 169%.

Using the Excel module IVA of the microsimulation model, Table 6 presents the incidence of the indirect tax system before and after the reform. As opposed to the aggregate results for the personal income taxes

Table 6. *Estimated incidence of indirect taxes in 2008 and 2010*
(Average monthly tax payment per household, in 2008 pesos)

Decile	Indirect tax payments		Tax/spending (%)	
	2008	2010	2008	2010
I	$137.24	$146.40	5.27%	5.62%
II	$184.83	$197.16	5.55%	5.92%
III	$224.73	$239.73	5.74%	6.13%
IV	$251.57	$268.37	5.97%	6.37%
V	$299.82	$319.86	6.34%	6.77%
VI	$356.13	$379.84	6.74%	7.19%
VII	$445.01	$474.85	7.11%	7.58%
VIII	$541.33	$577.84	7.44%	7.94%
IX	$743.59	$793.71	8.01%	8.55%
X	$1,430.83	$1,528.06	8.92%	9.52%
Average	$461.51	$492.59	6.71%	7.16%

given earlier, this time we focus directly on the average tax payments that have to be made by the households monthly, in such a way that we can illustrate the impact at the household level of the indirect taxes. The readers interested instead on the aggregate results may consult the *Resultados* worksheet in the Excel file.

As shown in the table, after the 2010 reform the average monthly expenditure per household is increased by approximately $31, which represents an increase of about 6%. It might also be noted that the deciles that suffer the least impact, in terms of increases in tax payments relative to spending, are the first three. This is to be expected given that the consumption basket in the case of the poorest households is mostly made of goods that have a zero VAT rate. Likewise, since the consumption basket of the tenth decile contains, in relative and absolute terms, more goods subject to the 16% VAT rate, it is also to be expected that, as shown in Table 6, the largest increase in relative (and absolute) tax payments corresponds precisely to that decile.

4.3. The overall distributive effects of the 2010 tax reform

Taking together the results given in Table 5 and Table 6, the distributive impact of the entire 2010 tax reform can be now estimated. For that end, three indexes are calculated using the net incomes before and after the reform: the Gini index that evaluates changes in relative income inequality, the Reynolds-Smolensky index that quantifies the redistributive effects of the reform, and the Kakwani index that measures the progressivity of the tax schemes. In the first case, the pre-reform Gini is 0.6522 while the post-reform Gini is 0.6517, which suggests a marginal gain in terms of less income inequality.[9] On the other hand, the Reynolds-Smolensky index goes from 0.0133 to 0.0140, which implies a slightly better redistributive tax system after the reform, while the Kakwani index goes from 0.1412 to 0.1438, confirming the marginal progressivity effects of the tax reform.

4.4. Estimated impacts of the failed SHCP reform

As a final example of the use of the microsimulation model, consider the failed proposal made by the Secretaría de Hacienda y Crédito Público (SHCP) in 2009, as reviewed in Section 2 above. It involved in particular a new fiscal “contribution to fight poverty”, by means of a 2% sales tax that would apply to almost all goods and services. As opposed to the case

of the value added tax that under current law leaves untouched food and medicines (with a zero tax rate), and educational services (exempted), the new sales tax would apply to them as well. In return, the government proposal contemplated the use of part of the extra revenue to strengthen, in some unspecified way, the programs against extreme poverty.

Table 7 presents the results of increasing the two different VAT rates from 15% to 17% and 0% to 2%, as well as imposing a 2% tax on educational services.[10] It is evident from the table that the SHCP proposal is quite regressive. For example, households in the lowest income decile pay 36.2% more taxes than before, while tax payments in the case of the households in the highest decile grow 20.9%. If one were to present in the table the tax burden relative to income, rather than to spending, the SHCP proposal would be even more regressive.

5. Concluding remark

This chapter has presented a microsimulation model that can be used to estimate the social welfare impact of possible tax reforms. These may include changes in the personal income tax schedule, the VAT rates, the excise tax rates, and the social security contributions. The model is freely available and it is written using Excel, in such a way that it can be easily

Table 7. *Estimated incidence of VAT, under the 2008 and SHCP scenarios*
(Average monthly tax payment per household, in 2008 pesos)

Decile	VAT monthly payments		VAT/spending (%)	
	2008	SHCP	2008	SHCP
I	$133.24	$181.43	5.24%	7.13%
II	$179.40	$243.08	5.53%	7.41%
III	$216.84	$290.42	5.71%	7.59%
IV	$242.21	$323.82	5.94%	7.82%
V	$291.04	$382.17	6.31%	8.18%
VI	$342.86	$442.05	6.70%	8.56%
VII	$426.56	$541.28	7.06%	8.92%
VIII	$517.85	$650.78	7.39%	9.24%
IX	$721.70	$891.29	7.97%	9.81%
X	$1387.93	$1678.58	8.88%	10.69%
Average	$445.96	$562.49	6.67%	8.54%

modified by the users for their own needs. Two future improvements of the model come first to mind: to allow for the possibility of making monetary transfers to households, according to given social programs, and the updating of the database as new surveys are made public.

Notes

[1] Chapter prepared for the project "An Integrated Framework for the Assessment of Equitable, Pro-Growth Fiscal Reform in Latin America and the Caribbean: Fiscal Schemes for Inclusive Development (FSID)", co-funded by UNDP and IDRC. Any errors or opinions are the authors' and do not necessarily represent the views of the United Nations Development Programme or those of the International Development Research Centre. Without implicating them with any remaining errors, the authors appreciate the comments to an earlier draft from Samuel Freije, Luis F. López-Calva, Edgard Rodríguez and Amedeo Spadaro.

[2] See, for instance, the table presented in Cetrángolo (2011, p. 15).

[3] When calculating the exemption in the case of overtime earnings that exceed 1,577.70 pesos per month (5 minimum daily wages per week), we make the innocuous assumption that the net overtime wages reported by the individuals can be used instead of the gross overtime wages. Gross and net coincide, of course, when the overtime wages do not exceed that amount, but there could be some very small discrepancies when only part of that income is exempted.

[4] This assumption is harmless since the income that is exempt from social security contributions is slightly lower than the one exempted for tax purposes.

[5] How do we know which tax bracket correspond to an individual if we do not have yet his/her gross income when calculating (6)? We first use net income as a proxy and identify the corresponding bracket; we make then all calculations to get the presumptive gross income, and, finally reverse the calculations to see if the original number is obtained. If not, the adjacent bracket (upwardly) is used.

[6] See Lambert (2001) for a very good review of those indexes. In Chapter 7 of this book, Amarante, Bucheli, Olivieri and Perazzo also provide the definitions of those measures, among others.

[7] The same lack of enough information applies to indirect tax revenues, since the government subtracts from the excise tax revenue all the energy subsidies and only reports the final result (which sometimes is even negative!).

[8] See Cárdenas, Ventosa-Santaulària and Gómez-Zaldívar (2008).

[9] Note that these quite large Gini values do not have to coincide at all with the value of the typical income distribution Gini index that would be calculated using all sources of income, monetary and non-monetary, and not only using wage incomes.

[10] Since the model only considers final consumption, the effect of a 2% sales tax can be equated to an increase of 2% in the VAT rates. Regarding the change in

the exempted status of educational services, another qualification has to be made: The estimated increase in tax revenue would be overestimated by the model, since, after changing their status, the schools would be able to credit their own VAT payments.

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6 The non-optimality of the Mexican indirect tax system[1]

Alberto Castañón-Herrera and Carlos M. Urzúa

1. Introduction

There have been, for more than a decade, continuous and heated discussions in Mexico about the desirability of imposing a value added tax on food, medicines and education. Aside from the fact that the three main political forces have diverging views on that subject, perhaps another of the reasons for the failure of deciding, once and for all, whether or not to make an indirect tax reform is the lack of empirical assessments about its possible impacts on social welfare. Chapter 5 presents a microsimulation model that could be used for that end. In this chapter we present a complementary model that has a quite different nature: as opposed to the former, which is quite large and detailed but at the cost of neglecting possible behavioral responses, this smaller model is built on classical microeconomic foundations.

For that end, the model follows the marginal tax reform methodology that was first advanced by Ahmad and Stern (1984). Broadly speaking, their approach assesses the impact of tax reforms by means of a first-order approximation of a given social welfare function, in such a way that the only information needed are aggregate responses rather than individual demand responses. The attractiveness of such a simplification is attested by the large number of empirical papers that have applied that methodology over the years.[2]

However, as it has been forcefully argued by Banks, Blundell and Lewbel (1996), the measurement of social welfare through the use of first-order approximations may lead to biases. This is so because, in the case of substantial tax changes, "[the] substitution effects can be non-

Microsimulation Models for Latin America, Carlos M. Urzúa (ed.), Mexico City: ITESM.

trivial. The marginal (i.e. first order) approximations ignore these effects, and therefore can be seriously biased" (Banks et al., 1996, p. 1228). As is illustrated in this chapter, this shortcoming can be nevertheless ameliorated if one uses the second-order extension of the Ahmad-Stern marginal tax analysis due to Urzúa (2005), which makes use of sharper approximations of the welfare measures.

Toward that end, the next section reviews the key issues involved in the Ahmad-Stern methodology (AS from now on), as well as its second-order variant. After that, the third section reviews some aspects of the estimation of demand systems, a topic that, although well known to applied econometricians, might be unfamiliar to some of the readers. The fourth section, using the estimated demand system, identifies marginal and second-order improvements in the current indirect tax system. The conclusions are given in the fifth section, and, for the non-experts, an appendix provides a computer code in Stata that can be used to estimate demand systems of the type considered here.

2. The Ahmad-Stern approach and a generalization

According to Ahmad and Stern (1984), the optimality of an indirect tax structure may be evaluated by comparing the marginal cost, in terms of social welfare, of raising an extra unit of revenue by means of a tax increase on each good. Even though other possible criteria have been developed since then (see the references in Dahlby, 2008), the AS methodology continue to be quite reasonable. In particular, optimality requires that the marginal social welfare cost should be equal for all the relevant goods; otherwise a Pareto improvement could be implemented by lowering the excise tax on the good with the higher marginal cost and by raising the tax on the good with the lower marginal cost.

In order to be more precise about that criterion, we present here the model considered by those authors. On the production side, we simply assume that all prices are fixed and that there are constant returns to scale. Hence, indirect tax changes are only reflected as consumer price changes and there are no profits; although this simple model, it should be noted in passing, could be enriched to account for other firm responses. Given N goods, indexed by $i = 1, 2,..., N$, let $\mathbf{p}$ denote the corresponding (fixed) producer price vector. Thus, if $\mathbf{t}$ is the vector of specific taxes, then $\mathbf{q} = \mathbf{p}+\mathbf{t}$ is the final consumer price vector. There are, furthermore, H

households, indexed by h = 1, 2,..., H. For each household h, the consumption bundle that maximizes the utility function $u^h(\mathbf{x}^h)$ subject to the corresponding linear budget constraint is denoted as $\mathbf{x}^h(\mathbf{q},m^h)$, while the associated indirect utility function is expressed as $v^h(\mathbf{q},m^h)$. We also assume the existence of a social welfare function $W(u^1,\ldots,u^H)$, which can be rewritten in terms of prices and incomes as:

$$(1) \qquad V(\mathbf{q}, m^1,..., m^H) = W(v^1(\mathbf{q}, m^1),..., v^H(\mathbf{q}, m^H)) .$$

On the other hand, after defining the aggregate demand vector by

$$\mathbf{X}(\mathbf{q}, m^1,..., m^H) = \sum_h \mathbf{x}^h(\mathbf{q}, m^h) \ ,$$

the government tax revenue can be calculated as:

$$(2) \qquad R = \mathbf{t}'\mathbf{X} = \sum_i t_i X_i \ .$$

Now suppose that the excise tax on good i is to be increased at the margin. Given equations (1) and (2), the marginal social cost of that tax increase may be defined as the corresponding marginal decrease in social welfare relative to the corresponding marginal increase in government revenue. More formally, the marginal social cost of a marginal tax increase on good i is defined as:

$$\lambda_i = -\frac{\partial V / \partial t_i}{\partial R / \partial t_i},$$

where the negative sign on the right-hand side of (3) is needed to obtain a marginal social cost that is positive in general. This is so because $\partial V/\partial t_i$ will always be negative, and, furthermore, we would expect $\partial R/\partial t_i$ to be positive in general. Nevertheless, it should be stressed that a commodity-specific Laffer type effect cannot be ruled out a priori.

According to Roy's identity

$$(3) \qquad \frac{\partial v^h}{\partial t_i} = -\frac{\partial v^h}{\partial m^h} x_i^h ,$$

where the first term on the right-hand side of the equation is the private marginal utility of income for household h. Let us now consider its social counterpart, which is the social marginal utility of income for household h, defined as:

$$\beta^h = \frac{\partial V}{\partial v^h}\frac{\partial v^h}{\partial m^h}. \tag{4}$$

Each β^h might be thought as a welfare weight, since, using the last two equations, the numerator in (3) can be written as the negative of the sum across households of the consumption of good *i*, each level weighted by its corresponding beta:

$$\frac{\partial V}{\partial t_i} = -\sum_h \beta^h x_i^h \ . \tag{5}$$

In a similar fashion, taking the partial derivative with respect to t_i in (2), the impact on government revenue of a marginal increase in the excise tax is found to be

$$\frac{\partial R}{\partial t_i} = X_i + \sum_k t_k \frac{\partial X_k}{\partial t_i} = X_i + \sum_k \frac{t_k X_k}{q_i}\varepsilon_{ki}\ , \tag{6}$$

where ε_{ki} is the (uncompensated) cross-price elasticity of the aggregate demand for good *k* with respect to price *i*.

Finally, after defining $\tau_k = t_k / q_k$ (the proportion of the tax relative to the price),[3] we can then use equations (3), (5) and (6) to find the marginal social cost of taxation of good *i*:

$$\lambda_i = \frac{\sum_h \beta^h q_i x_i^h}{q_i X_i + \sum_k \tau_k \varepsilon_{ki} q_k X_k}. \tag{7}$$

An extensive discussion of the meaning of this expression is given in Ahmad and Stern (1984, p. 265). For our purposes, it suffices to note that in order to apply the AS methodology, which requires computing and comparing each marginal social cost across the *N* goods, we would just need the following data: the final consumer prices, the welfare weights for all households, the consumption levels, and the aggregate own- and cross-price elasticities.

Thus, it would not seem to be necessary to estimate a full demand system. However, this last appreciation would be correct *only if* the welfare weights defined in (4) were independent of prices. Ahmad and Stern were, of course, fully aware of that fact and so they assumed in their model, as is commonly done in most of the applied papers on the

subject, that the indirect social welfare function could be locally approximated by a function independent of prices. More specifically, they made use of the following function popularized by Atkinson (1970):

$$(8) \qquad V^A(m^1,...,m^H) = k\sum_h \frac{[m^h]^{1-e}}{1-e},$$

where *e* is a nonnegative parameter that reflects the degree of aversion to social inequality, *k* is a constant of normalization, and where the arguments of the function may be taken to be, say, total expenditure per household. Note that each of the terms in the sum of equation (8) becomes a natural log function when *e* tends to 1.

Using (4) and (8), each social marginal utility of income β^h may be calculated by taking the derivative of the social indirect utility function with respect to m^h. Furthermore, Ahmad and Stern suggested, the constant *k* may be chosen in such a way that the welfare weight for the poorest household is equal to one (and hence marginal social costs are always relative to the poorest household). That is to say, assuming that households are ordered according to their ascending incomes total expenditures, the welfare weight for household *h* would be given by $\beta^h = (m^1/m^h)^e$. Thus, for instance, when *e* = 0, the social marginal utility of income is equal to one for all households and there is no aversion to social inequality; while if, say, *e* = 1, then a household with an income twice as large as the poorest would have a social marginal utility half as large. That is, as the parameter of inequality aversion is increased, the relative weight of the poorest household is increased as well. In the limit to infinite it is obtained the Rawlsian criterion of measuring social welfare only in terms of the well-being of the poorest household.

It is important to note, however, that the assumption of independence of prices that lies behind (8) is quite restrictive. Indeed, as shown by Banks, Blundell and Lewbel (1996, Theorem 1), the welfare weights defined in (4) are independent of prices if and only if the indirect social welfare function is of the form

$$V(\mathbf{q}, m^1,...,m^H) = \sum_h [\kappa^h \ln m^h - a^h(\mathbf{q})],$$

for some functions a^h of prices and constants κ^h. In order to see how restrictive this last condition is, we can extend (8) to include the general class of indirect social welfare functions due to Bergson (1938):

$$W(v^1(\mathbf{q}, m^1),...,v^H(\mathbf{q}, m^H)) = k\sum_h \frac{v^h(\mathbf{q}, m^h)^{1-e}}{1-e}.$$

According to the theorem just cited, the only members in the class that would have welfare weights independent of prices would be the ones for which each indirect utility function is multiplicatively separable in prices and income, and for which the parameter of inequality aversion is equal to one. Thus, in the particular case of (8) the local approximation argument is formally correct only when *e* is near to one.

Given that all tax reforms are far from being marginal, it would be interesting to extend the AS methodology using at least second-order approximations as recommended by Banks, Blundell and Lewbel (1996). In our context, such an extension requires that, both, the numerator and the denominator in equation (3) be replaced by sharper approximations.

More formally, we would like to compute for each good the approximate impact on welfare that would have a tax increase that is small, but not marginal. That is, in principle, we would like to estimate for each good the following expression

$$\Lambda_i = -\frac{\Delta V / \Delta t_i}{\Delta R / \Delta t_i}, \tag{9}$$

where the numerator is of the form

$$\frac{W(v^1(q_i + \Delta t_i, \mathbf{q}_{-\mathbf{i}}),...,v^H(q_i + \Delta t_i, \mathbf{q}_{-\mathbf{i}})) - W(v^1(\mathbf{q}),...,v^H(\mathbf{q}))}{\Delta t_i} \tag{10}$$

(the income arguments are dropped to make the expression shorter), and where the denominator is given by

$$\frac{\Delta R}{\Delta t_i} = \frac{R(q_i + \Delta t_i, \mathbf{q}_{-\mathbf{i}}, m^1,..., m^H) - R(\mathbf{q}, m^1,..., m^H)}{\Delta t_i}. \tag{11}$$

In the last two equations by $\mathbf{q}_{-\mathbf{i}}$ is meant, as usual, the vector that includes all the elements of **q** except for its *i-th* component.

We now proceed to obtain the second-order approximations for (10) and (11). In the first case, the Taylor expansion of (10) is given by

$$\frac{\Delta V}{\Delta t_i} \approx \frac{\partial V}{\partial t_i} + \frac{\Delta t_i}{2}\frac{\partial^2 V}{\partial t_i^2},$$

so that

$$(12) \qquad \frac{\Delta V}{\Delta t_i} \approx -\sum_h \beta^h \left[1 + \frac{\Delta t_i}{2q_i} \left(\varepsilon_{\beta i}^h + \varepsilon_{ii}^h \right) \right] x_i^h ,$$

where, for each household *h*, the first elasticity inside the parentheses refers to the price elasticity of the welfare weight defined in (4), while the second one refers to the own-price elasticity of individual demand. Likewise, the second-order Taylor expansion of (11) gives

$$(13) \qquad \frac{\Delta R}{\Delta t_i} \approx X_i + \frac{\Delta t_i \varepsilon_{ii} X_i}{q_i} + \sum_k \frac{\tau_k q_k}{q_i} \left[\varepsilon_{ki} + \frac{\Delta t_i}{2q_i} \left(\varepsilon_{ki}^2 - \varepsilon_{ki} + q_i \frac{\partial \varepsilon_{ki}}{\partial t_i} \right) \right] X_k .$$

Finally, after simplifying (12) and (13), we end up with the variant to the Ahmad-Stern approach suggested in Urzúa (2005). That is, in order to analyze the approximate impact on social welfare that would have a tax increase that is small but not necessarily marginal, instead of the first-order approximation given in equation (7) above, use, for each good, the following second-order approximation for the marginal social cost of taxation of good *i*:

$$(14) \qquad \Lambda_i = \frac{\sum_h \beta^h \left[1 + \frac{\Delta t_i}{2q_i} \left(\varepsilon_{\beta i}^h + \varepsilon_{ii}^h \right) \right] q_i x_i^h}{\left[1 + \frac{\Delta t_i}{q_i} \varepsilon_{ii} \right] q_i X_i + \sum_k \tau_k \left[1 + \frac{\Delta t_i}{2q_i} (\varepsilon_{ki} - 1) \right] \varepsilon_{ki} q_k X_k} .$$

If there is not enough information to estimate in a reliable way the welfare weights as function of prices (see the discussion on demand estimation in the next section), then equation (14) can be approximated using the Atkinson social indirect utility function, given in (8), as:

$$(15) \qquad \Lambda_i \approx \frac{\sum_h \left(m^1 / m^h \right)^e \left[1 + \frac{\Delta t_i}{2q_i} \varepsilon_{ii}^h \right] q_i x_i^h}{\left[1 + \frac{\Delta t_i}{q_i} \varepsilon_{ii} \right] q_i X_i + \sum_k \tau_k \left[1 + \frac{\Delta t_i}{2q_i} (\varepsilon_{ki} - 1) \right] \varepsilon_{ki} q_k X_k} .$$

It is important to note that, as opposed to the Ahmad-Stern approach, both equations (14) and (15) recognize that tax changes involve more than variations at the margin, and also that a tax reform typically includes

a differential treatment across goods. Also note that in the numerator of both equations appear the own-price elasticities for each household. Although it is unlikely to have the required information for their estimation, given the lack of this type of panel data in most countries, one could use instead, if available, the average demand responses in each income decile. Furthermore; if one does not count with that disaggregate information either, then one could use as a proxy the own-price elasticity of aggregate demand.

3. Brief remarks on the estimation of demand systems

In order to estimate for each good the marginal social cost of taxation, be that (7) or (15), we need to estimate the own- and cross-price elasticities using a demand system. More realistically, we are interested in estimating those elasticities for baskets of goods which are grouped according to the different value added tax treatments and the variety of excise taxes that exist in an economy. For that end, both data collection and the estimation of a full demand system are required. Even though those tasks would seem relatively simple to accomplish, the following discussion shows that it is not necessarily so.

• The first issue to face is whether or not there are available data that are totally suitable for demand estimation. Unfortunately, the answer is negative in the case of many developing countries. This is so because most expenditure surveys do not follow specific households over time; that is, the surveys are not longitudinal, but only cross-sectional. This implies, in particular, that the changes in the unit values of the goods implied by the survey may reflect variations in quality rather than only in prices. For instance, one household could have bought a kilo of steak while other a kilo of a much cheaper meat, and yet in the survey both purchases would be reported as a kilo for the same item (meat), but at different prices. Is it possible to take into account that variation in quality? Deaton (1987 and 1997) and Crawford, Laisney and Preston (2003) propose two different approaches for that end. However, it is not clear that their estimation procedures render robust results (see, for instance, Lahatte, Laisney, Miquel and Preston, 1998). Thus, in this chapter we will follow the traditional approach and will regard the unit values reported by the households (indirectly, since they typically report expenditures and quantities) as the correct prices.

• The second problem to solve is the dimension of the demand system. To start with, although the number of composite goods should depend in principle only on how varied the country's indirect tax regimes are, in practice one should try to keep that number as small as possible. Five composite goods or less is perfect, more than seven is adventurous.

• The next problem arises in the construction of the composite goods' prices. Given a basket of goods, the simplest way to do that is to use Stone's price index. For that end, first identify for each household the spending on each of the M items in the basket, as well as the prices (unit values). Then, for each good i one can compute the weighting factor a_i as the amount of money spent on it over the total spending on the basket. Finally, using these weights and the unit prices of the items Stone's price index of the composite good is given by:

$$p = p_1^{a_1} \times ... \times p_M^{a_M} .$$

The implicit "quantity" could be derived (if needed, which is usually not the case) as the amount spent on the basket over its price index. Since the use of Stone's price index is not exempt of criticisms (see Moschini, 1995), sometimes the price of the composite good is calculated mimicking one of the several procedures used to compute price indexes (Fisher's, Paasche's, etc.) when prices change over time. But since in contexts as ours the changes are across households instead of over time, the reference prices used in those procedures are *ad-hoc* as well.

• Another issue to face is the case of goods and services for which households do not report quantities, but only spending. This happens especially in the case of services (e.g., phone payments), and some energy goods (e.g., electricity payments). There are some procedures that have been devised over the years to try to estimate price elasticities without data on prices. The classical reference is Frisch (1959), and a more recent one is Lewbel (1989).[4] Since these procedures depend on some separability conditions on the utility function that may not be warranted, it is better, if possible, to avoid the estimation of those cases.

• A problem that typically arises when estimating demand systems is that for some goods the majority of households could report a zero consumption demand (e.g., for cases such as cigarettes, liquor, gasoline, etc.). What to do in that case? It all depends. In the case of single goods, the reasons for zero consumption could be, first, that the good is not bought because of a corner solution (the relative price is too high), or second, that the household simply buys the good in an infrequent fashion

or does not buy it at all. In the first case, the censored outcome, there are several ways to do the estimation, but one that is solid and not too difficult is due to Shonkwiler and Yen (1999). On the other hand, if the reason for zero consumption is infrequency of consumption, then Keen (1986) shows that the problem can be solved by instrumenting total spending with some measure of total income.

• Another point that is often forgotten by practitioners is the difficulty of including, in a theoretically sound way, socio-demographic variables in the demand system. At first sight, one would just need to add on the right-hand side of each structural equation the exogenous variables that that may help to better explain the expenditure shares (like number of children in the household, regional dummies, etc.), and almost all researchers just do that. However, a *bona fide* demand system has to satisfy some conditions on the parameters, and those could be distorted once exogenous variables are included in the system (see Ray, 1983, and Blundell and Stoker, 2005).

3.1. The QUAIDS model

The last decision to make deserves a subsection by itself: What is the best demand system specification to use? There is no clear-cut answer to that question, but if one wants a relatively simple, comprehensive and popular one, we believe that the best choice is the Quadratic Almost Ideal Demand System (QUAIDS) due to Banks, Blundell y Lewbel (1997). This model can be seen as the extension of the Almost Ideal Demand System (AIDS), proposed earlier by Deaton and Muellbauer (1980), with the added feature that it allows for quadratic Engel curves. In what follows we describe the QUAIDS specification, while in the Appendix we provide the code that can be used to estimate it using Stata (for the case of five goods).

As a first step, we define the representative household's expenditure shares on basket *i* as:

$$w_i = q_i x_i / m, \tag{16}$$

where, following the same notation as in Section 2 above, q_i is the after-tax price, x_i is the quantity demanded, and m is total expenditure. Clearly, the following adding-up condition holds:

$$w_1 + w_2 + ... + w_N = 1. \tag{17}$$

According to the QUAIDS, the spending shares can be estimated as:

$$(18) \qquad w_i = \alpha_i + \sum_{j=1}^{N} \gamma_{ij} \ln q_j + \beta_i \ln\left[\frac{m}{a(\mathbf{q})}\right] + \frac{\lambda_i}{b(\mathbf{q})}\left\{\ln\left[\frac{m}{a(\mathbf{q})}\right]\right\}^2 + \varepsilon_i \ ,$$

where ε_i is the error term that is assumed to be normally distributed with zero mean. The price index $a(\mathbf{q})$ has the (translog) form

$$(19) \qquad \ln a(\mathbf{q}) = \alpha_0 + \sum_{i=1}^{N} \alpha_i \ln q_i + \frac{1}{2}\sum_{i=1}^{N}\sum_{j=1}^{N} \gamma_{ij} \ln q_i \ln q_j \ ,$$

while $b(\mathbf{q})$ is a price aggregator function that is homogenous of degree zero in prices

$$(20) \qquad b(\mathbf{q}) = \prod_{i=1}^{N} q_i^{\beta_i} \ .$$

By the adding-up condition, the homogeneity of degree zero in prices and spending for each demand function, and the Slutsky symmetry conditions, the parameters in the N equations (18) have to satisfy the following constraints:

$$(21) \qquad \sum_{i=1}^{N} \alpha_i = 1, \ \sum_{i=1}^{N} \beta_i = 0 \ , \ \sum_{i=1}^{N} \lambda_i = 0 \ , \ \sum_{i=1}^{N} \gamma_{ji} = \sum_{i=1}^{N} \gamma_{ij} = 0 \ , \text{ and } \ \gamma_{ij} = \gamma_{ji}$$

for any j. After differentiating (18) with respect to both ln m and ln q_j, it follows that

$$\mu_i \equiv \frac{\partial w_i}{\partial \ln m} = \beta_i + \frac{2\lambda_i}{b(\mathbf{q})}\left\{\ln\left[\frac{m}{a(\mathbf{q})}\right]\right\} \text{ and}$$

$$\mu_{ij} \equiv \frac{\partial w_i}{\partial \ln q_j} = \gamma_{ij} - \mu_i\left(\alpha_j + \sum_{k=1}^{N} \gamma_{jk} \ln q_k\right) - \frac{\lambda_i \beta_j}{b(\mathbf{q})}\left\{\ln\left[\frac{m}{a(\mathbf{q})}\right]\right\}^2 \ .$$

Consequently, the income elasticities in the QUAIDS are given by

$$(21) \qquad e_i = \frac{\mu_i}{w_i} + 1 \ ,$$

which can be higher or lower than one at different levels of spending, so that the same good can be a luxury or a necessity depending on the level of expenditure. On the other hand, the Marshallian (uncompensated) own and cross-price elasticities are of the form:

$$(22) \qquad e_{ij} = \frac{\mu_{ij}}{w_i} - \delta_{ij} \ ,$$

where Kronecker's delta equals 1 if $i = j$, and 0 otherwise.

Finally, as illustrated in the Appendix, the system made by the nonlinear equations given in (18) and constrained by the conditions in (21), can be transformed into an N-1 equations system that can be estimated by, for instance, feasible generalized least squares.

4. Marginal tax analyses

We now proceed to estimate the QUAIDS. For that end, we use the income and expenditure survey known in Mexico as ENIGH (Encuesta Nacional de Ingresos y Gastos de los Hogares). This official survey is by far the most appropriate source of data for demand estimation in Mexico. Although it is not longitudinal, and hence it is subject to the criticism mentioned earlier, the survey is biannual and representative at the national, urban and rural levels. At the moment of this writing the latest survey available is the ENIGH 2008, which was applied to 29,846 households in the second half of the year 2008. The survey contains information about 78 possible sources of income, and on the expenditure side it covers more than 660 goods and services.

As shown in the first column of Table 1, we decided to group the goods and services reported in that survey into five different categories: 1) food, for which the VAT rate is currently equal to zero; 2) the goods for which

Table 1. *Own- and cross-price elasticities of composite goods*

	1	2	3	4	5
1. Food	-1.132	0.358	-0.092	-0.097	-0.196
2. Subject to VAT	-0.092	-0.905	-0.058	-0.018	-0.060
3. Medicines	0.042	0.676	-1.591	-0.007	0.007
4. Alc. bev. & tobacco	0.101	0.184	0.001	-0.915	-0.072
5. Education	0.185	0.249	0.033	0.035	-0.931

the VAT general rate applies (15% when the survey was taken); 3) medicines, which are subject to a zero VAT rate; 4) a composite good made of all alcoholic beverages, including beer, and tobacco products, all of which are not only subject to VAT, but also to specific taxes; and 5) educational services, which are exempted from the value added tax. Regarding the fourth composite good, it should be noted that in 2008 the excise tax rate for most of the alcoholic beverages was 50%, for beer 25%, and for cigarettes 160%. On the other hand, the demand system was complemented with the following socio-demographic variables: the size of the household, the number of children and the gender of the head of the household.

Table 1 also presents the uncompensated price elasticities that are found after estimating the full demand system made of those five composite goods. As shown there, the demands for food and for medicines are the only ones that are price elastic. It should also be pointed out that the income (expenditure) elasticities for food, the items subject to VAT, medicines, alcoholic beverages and tobacco, and education, turn out to be 0.667, 1.056, 0.825, 0.693 and 0.596, respectively. Thus, except for the items subject to VAT all the other goods turn out to be necessities.

Using the own- and cross price elasticities in Table 1, the data on the market demand of those composite goods, as well as equations (7) and (15) above, we can then calculate the marginal (λ_i) and approximate (Λ_i) social costs of taxation for each of the five composite goods. In order to compute the Λ_i's, it is also necessary to provide discrete (not marginal) tax changes as well. For that end, we set $\Delta t_i = 0.0666$ in the case of all goods, an increase in the quantity tax that roughly corresponds to an increase in the ad-valorem general tax rate from 15% to 16%, as it was the case after a 2010 tax reform. The results thus obtained are shown in Table 2 for three different levels of inequality aversion: the first is $e = 0$, which means that there is no inequality aversion whatsoever; the second is $e = 1$, the classical case of a mild aversion; and the third is $e = 2$, which implies a definite aversion to inequality, since the welfare of the poorest has a substantial relative weight in the social welfare function.

Now suppose that the Mexican government decides to increase tax revenue at the lowest social welfare cost. According to Table 2, when there is no inequality aversion, the Ahmad and Stern's marginal approach suggests to increase taxes in the case of alcoholic beverages and tobacco (since the value of λ_4 is the lowest among the small lambdas in the column

Table 2. *Marginal and approximate social welfare costs*

		Degree of inequality aversion		
		e=0	*e*=1	*e*=2
1. Food	λ_1	1.1887	0.0267	0.0013
	Λ_1	1.1911	0.0266	0.0018
2. Subject to VAT	λ_2	1.4523	0.0185	0.0006
	Λ_2	1.4523	0.0186	0.0029
3. Medicines	λ_3	0.5912	0.0092	0.0004
	Λ_3	0.5914	0.0093	0.0097
4. Alc. bev. & tobacco	λ_4	*0.2917*	*0.0050*	*0.0002*
	Λ_4	*0.2918*	*0.0051*	*0.0019*
5. Education	λ_5	0.5804	0.0078	0.0003
	Λ_5	0.5805	0.0079	0.0127

for $e = 0$); the next two composite goods with the lowest social costs are medicines and education since they have similar values. In the case of the second-order approach (represented by the big lambdas), the social costs are almost the same as in the first-order approach, and so is the ranking.

When e is increased to one, which corresponds to a mild inequality aversion, the absolute and relative choices continue to be the same in the case of both the first- and second-order approaches. Nevertheless, when the inequality aversion becomes stronger ($e = 2$), and even though alcoholic beverages and tobacco continue to be the preferred goods to tax, the ranking for the rest of the goods depend on the lambda used: in the case of first-order approach the goods that could be taxed next continue to be medicines and education, but in the second-order approach the goods are now food and the items subject to VAT.

5. Concluding remark

The approach suggested here constitutes a preliminary analysis that can shed some light on the optimal tax changes across goods. After such directions are identified, the analysis of the reform could be complemented with a systemic one, more akin to the literature on optimal taxation. A classical paper on that regard is King (1983), which shows how to make use of the equivalent income concept to make global welfare comparisons among different tax regimes. See Urzúa (1994 and 2001) and Campos (2002) for some examples in the case of Mexico.

Appendix: Stata program

Given that the writing of the computational code for a demand system as large as QUAIDS can quickly become prone to error, in this Appendix we present the Stata program for the five goods case given in the text. The program does not include socio-demographic variables, but these can be easily incorporated.

```
program nlsurquaids
syntax varlist(min=10 max=10) if, at(name)
tokenize `varlist'
args w1 w2 w3 w4 lnq1 lnq2 lnq3 lnq4 lnq5 lnm
tempname a1 a2 a3 a4 a5
  scalar `a1' = `at'[1,1]
  scalar `a2' = `at'[1,2]
  scalar `a3' = `at'[1,3]
  scalar `a4' = `at'[1,4]
  scalar `a5' = 1-`a1'-`a2'-`a3'-`a4'-`a5'-`a6'
tempname b1 b2 b3 b4 b5
  scalar `b1' = `at'[1,5]
  scalar `b2' = `at'[1,6]
  scalar `b3' = `at'[1,7]
  scalar `b4' = `at'[1,8]
  scalar `b5' = -`b1'-`b2'-`b3'-`b4'-`b5'-`b6'
tempname g11 g12 g13 g14 g15
tempname g21 g22 g23 g24 g25
tempname g31 g32 g33 g34 g35
tempname g41 g42 g43 g44 g45
tempname g51 g52 g53 g54 g55
  scalar `g11' = `at'[1,9]
  scalar `g12' = `at'[1,10]
  scalar `g13' = `at'[1,11]
  scalar `g14' = `at'[1,12]
  scalar `g15' = -`g11'-`g12'-`g13'-`g14'
  scalar `g21' = `g12'
  scalar `g22' = `at'[1,13]
  scalar `g23' = `at'[1,14]
  scalar `g24' = `at'[1,15]
  scalar `g25' = -`g21'-`g22'-`g23'-`g24'
  scalar `g31' = `g13'
  scalar `g32' = `g23'
  scalar `g33' = `at'[1,16]
  scalar `g34' = `at'[1,17]
  scalar `g35' = -`g31'-`g32'-`g33'-`g34'
  scalar `g41' = `g14'
  scalar `g42' = `g24'
  scalar `g43' = `g34'
  scalar `g44' = `at'[1,18]
  scalar `g45' = -`g41'-`g42'-`g43'-`g44'
```

```
  scalar `g51' = `g15'
  scalar `g52' = `g25'
  scalar `g53' = `g35'
  scalar `g54' = `g45'
  scalar `g55' = -`g51'-`g52'-`g53'-`g54'
tempname l1 l2 l3 l4 l5
  scalar `l1' = `at'[1,19]
  scalar `l2' = `at'[1,20]
  scalar `l3' = `at'[1,21]
  scalar `l4' = `at'[1,22]
  scalar `l5' = -`l1'-`l2'-`l3'-`l4'
quietly {
tempvar lnap
gen double `lnap' = 5+`a1'*`lnq1'+`a2'*`lnq2'+`a3'*`lnq3'+`a4'*`lnq4'+`a5'*`lnq5'
forvalues i = 1/5 {
  forvalues j = 1/5 {
    replace `lnap' = `lnap'+0.5*`g`i'`j'"*`lnq`i'"*`lnq`j'"
  }
}
tempvar bp
gen double `bp' = 0
forvalues i = 1/5 {
  replace `bp' = `bp'+`lnq`i'"*`b`i'"
}
replace `bp' = exp(`bp')
replace `w1' = `a1'+`g11'*`lnq1'+`g12'*`lnq2'+`g13'*`lnq3'+`g14'*`lnq4'+`g15'*`lnq5'+
               `b1'*(`lnm'-`lnap')+`l1'/`bp'*(`lnm'-`lnap')^2
replace `w2' = `a2'+`g21'*`lnq1'+`g22'*`lnq2'+`g23'*`lnq3'+`g24'*`lnq4'+`g25'*`lnq5'+
               `b2'*(`lnm'-`lnap')+`l2'/`bp'*(`lnm'-`lnap')^2
replace `w3' = `a3'+`g31'*`lnq1'+`g32'*`lnq2'+`g33'*`lnq3'+`g34'*`lnq4'+`g35'*`lnq5'+
               `b3'*(`lnm'-`lnap')+`l3'/`bp'*(`lnm'-`lnap')^2
replace `w4' = `a4'+`g41'*`lnq1'+`g42'*`lnq2'+`g43'*`lnq3'+`g44'*`lnq4'+`g45'*`lnq5'+
               `b4'*(`lnm'-`lnap')+`l4'/`bp'*(`lnm'-`lnap')^2
}
end
```

Finally, the Stata command that should be used to estimate the QUAIDS system is the following:

```
nlsur quaids @ w1 w2 w3 w4 lnq1 lnq2 lnq3 lnq4 lnq5 lnm, parameters (a1 a2 a3 a4 b1
        b2 b3 b4 g11 g12 g13 g14 g22 g23 g24 g33 g34 g44 l1 l2 l3 l4) neq(4) ifgnls
```

Notes

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IDRC. Any errors or opinions are the authors' and do not necessarily represent the views of the United Nations Development Programme, or those of the International Development Research Centre.

[2] For the Mexican case, see in particular Nicita (2004), Urzúa (2005), Palacios (2006), and Valero Gil (2006).

[3] Note that in our model t_k is a quantity tax, not an *ad-valorem* tax. Thus, given a 15% VAT rate, the corresponding τ_k (the proportion of the tax relative to the consumer price) is $0.15/1.15 \approx 13\%$.

[4] See Urzúa (2009) for an example in the case of Mexico.

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7 Distributive impacts of alternative tax structures: the case of Uruguay[1]

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1. Introduction

The redistributive action of the state is undertaken through taxes and spending. A usual concern among economists is the association between these actions of the state and their redistributive effects. The effects of this Robin Hood role of the state, aiming to reduce welfare disparities, will depend both on the progressivity of the tax system and on the degree to which social benefits go to the less well off. But extensive empirical research concludes that most of the redistribution is accounted for by spending rather than by taxation (see Esping-Andersen and Miles, 2009).

Despite the fact that redistribution through taxes is limited, the tax system has a role to play in terms of achieving higher equality, and knowledge about how tax reforms may potentially affect income distribution is central for policy makers. On theoretical grounds, properties derived from the theory of optimal taxation indicate that direct income taxation should be preferred to indirect taxes as instruments to achieve redistribution.

The analysis of the performance of Latin American fiscal systems from the perspective of redistribution presented in Goñi, López and Servén (2008) highlights that, contrary to industrial countries, in most Latin American countries the fiscal system does not significantly reduce inequality. The main explanation for this is driven by two facts. On the one side, transfers, which are the main mechanism of redistribution in European countries, have a limited effect in redistribution in the region. On the other side, redistribution is severely constrained by the region's

Microsimulation Models for Latin America, Carlos M. Urzúa (ed.), Mexico City: ITESM.

low levels of tax collection.[2] The authors argue that the region's low income tax receipt is associated with narrow tax bases (due to evasion, informality and low levels of income) rather than tax rates. They conclude that even significant increases in the progressivity of Latin America's tax systems are likely to have modest effects on the distribution of income, as the priority to reduce inequality is the overall volume of tax revenue.[3]

In Uruguay, the recent changes in the tax system, under the reform implemented in 2007, enhanced progressivity through the tax system, mainly due to the creation of a dual income tax and, to a lesser extent, through the reduction in the VAT rate (see Instituto de Economía, 2006; Amarante, Arim and Salas, 2007; and Llambí, Laens, Perera and Ferrando, 2009). New modifications are being discussed at present. In this public discussion, achieving higher equality has been highlighted as one of the main objectives in any reform. This article aims at providing new evidence on the redistributive impacts of alternative modifications in the actual tax system.

2. The Uruguayan tax system[4]

2.1. The actual system

The Uruguayan tax system relies mainly on indirect taxes. As shown in Table 1, the value added tax (VAT) accounts for 55% of total tax collection, whereas IMESI, an excise tax, represents almost 10% of total tax revenue. On the other hand, the recently implemented dual personal income tax (IRPF) represents 11% of the tax revenue whereas the corporate income tax (IRAE) accounts for 14% of it.

Table 1. *Tax revenue in Uruguay in 2008*

	Millions of dollars	Relative contribution
Indirect taxes	*3626*	*64.28%*
VAT	3113	55.18%
IMESI	513	9.10%
Direct taxes	*2015*	*35.72%*
IRPF	647	11.47%
IRAE	785	13.91%
Other direct taxes	583	10.34%

Source: Dirección General Impositiva, *Boletín* 2008.

Most of the sales are taxed by the basic VAT rate of 22%. A rate of 10% applies to certain basic goods and services such as basic food (bread, meat, chicken, etc.), medicines and transportation. In turn, the IMESI applies to a few goods; the rates vary from 4% (as it is the case of sugar) to 81.5% (spirits). Finally, a series of goods and services are zero-rated (for example milk, water, books). The main principle behind the assignation of different VAT rates is whether the good is considered a necessity or a luxury.

Regarding direct taxes, the system consists of a dual personal income tax (IRPF) that combines a progressive tax schedule for labor income with a low flat tax rate on capital income. This dual system was installed in 2007, when an important tax reform was undertaken, seeking to create a more efficient and equitable tax system. Its dual structure responds to the plight of small open economies that are unable to trace non-domestic sourced income in the face of increased capital mobility across countries. Thus, a low flat tax on capital income was chosen to reduce the risk of tax evasion from residents with foreign investments (World Bank, 2008).

As shown in Table 2, the tax on labor income consists of six marginal income tax rates ranging from zero in the first bracket to 25 percent in the 6-th bracket. In that table annual incomes are expressed in terms of BPC units, an acronym for *base de prestaciones y contribuciones*. Table 2 also presents the 2008 US dollar equivalent incomes.

The tax rates on capital income vary depending on the source. It is 3% in the case of interest earnings on fixed deposits (in domestic currency or in *unidades indexadas*) that mature in more than a year, as well as on debentures and public debt titles. The tax rate increases to 5% for other deposits, and to 7% in the case of profits and utilities from IRAE contributors. Finally, rental and lease income above a certain threshold (around 3,000 dollars per year) is taxed at 12%.

Table 2. *Tax schedule for the labor income component of the IRPF*

Annual income in BPC	Annual income in US$	Rate
Less than 84	Less than 8,878	0%
From 84 to 120	From 8,878 to 12,683	10%
From 120 to 180	From 12,683 to 19,025	15%
From 180 to 600	From 19,025 to 63,415	20%
From 600 to 1,200	From 63,415 to 12,6831	22%
More than 1,200	More than 126,831	25%

The tax system also includes a tax on pensions (IASS), whose marginal rates are presented in Table 3.[5] Thus, in this paper we consider that the IRPF has three components: the labor income tax, the capital income tax and the pension tax. In the case of tax deductions, they include: a proportion of the social security contributions; health expenditures corresponding to children younger than 18, up to 6.5 BPC by year and child; health expenditures of pensioners, up to 120 BPC by year; and a proportion of a tax that finances public tertiary education. Deductions can also be made from capital income for the following concepts: bad debts, real estate taxes, and commissions for renting. The latter are not considered in our simulations. Additionally, some capital rents such as donations to public entities are exempt.

2.2. Alternative schemes

We evaluate in this paper the distributional effects of different modifications of the Uruguayan tax system. First of all, we consider the impact of modifications in indirect taxation. We analyze two different scenarios. The first one consists on a reduction of the basic VAT rate from 22% to 20%. It turns out that this reform is very costly in fiscal terms, as it implies a reduction of the VAT collection of 16.1% and a decline of total tax revenues of 8.9%, as shown in Table 4.

Alternatively, in the second scenario we simulate the effects of setting a zero VAT rate in the case of a consumption basket composed by goods that are intensively consumed by the poor. In order to choose this ideal basket, we first use a set of 52 prototypical consumptions baskets to be described in the next section. For each of those baskets we calculate its participation in the spending of the whole population, denoted by z_i, (where i is the basket), and in the spending of the first decile of the per capita household income distribution. Denoting by w_i this last quantity, we next calculate the difference $d_i = z_i - w_i$ and we select the baskets that have the largest differences, until finding one with a fiscal cost similar to

Table 3. *Tax schedule for pensions (IASS)*

Annual income in BPC	Annual income in US$	Rate
Less than 96 BPC	Less than 10,146	0%
From 96 to 180	From 10,146 to 19,025	10%
From 180 to 600	From 19,025 to 63,414	20%
More than 600	More than 63,414	25%

Table 4. *Fiscal cost of alternative tax modifications*

Tax system modification	Change in tax revenue
1. Reduction of two points of VAT rate	-8.9%
2. Zero VAT rate for specific goods	-8.5%
3. Widening of the IRPF (labor) untaxed bracket	-1.7%
4. Combination of scenarios 1 and 3	-10.6%
5. Combination of scenarios 2 and 3	-10.2%

the one in scenario 1 (compare them in Table 4). This so-called basket of the poor is composed by food items that are taxed with a zero VAT rate.

Regarding direct taxes, we consider an increase in the upper limit of the untaxed bracket for the labor component of the dual income tax, from 80 to 100 BPC. Note that we do not consider the potential effects of changes in the tax burden on capital income, as our simulations are based on information from household surveys, and the latter tend to significantly underestimate that source of income (see Amarante, Arim and Salas, 2007). The corresponding changes in tax revenue for each scenario are also presented in Table 4.

3. Methods and data

3.1. Data

Theoretically, we would need a data base that reports the pre-tax income of individuals and their spending. With this information we would be able to calculate the per capita direct and indirect taxes paid by the households, and so to perform the inequality and progressivity analysis. In order to calculate the amount of direct taxes paid by each individual we use the income information reported by the Household Survey (HS) collected by the Institute of Statistics (INE) in Uruguay in 2008. The HS gives information about characteristics of the household and its members (sex, age, relationship, etc.), labor attachment of individuals and their income by source. It also records the after-tax income received the month before the interview. Some sources of income are reported at the person level but other ones are reported at the household level.

Specifically, the HS reports the labor income and transfers of every member of the household. Using the schedules of social contribution rates and IRPF, we estimate for each individual the pre-tax labor income and pensions, and the amount of tax paid.[6] Notice that in the analysis of

inequality and progressivity, we assign to each individual the per capita labor income and tax payments of the household.

In order to estimate the per capita indirect taxes paid by the households, we combine the information of the HS with the information of the Expenditure Survey (ES), collected throughout November 2005 and October 2006 by the INE.[7] The ES reports the expenditure of the household and records many of the characteristics informed by the HS. To combine both data sets, we follow three steps. First, we classify household spending on the basis of three criterions: the standard classification used by the INE that basically identifies the type of good or service by purpose; the tax structure of 2006; and the tax structure of 2008. Using that procedure we obtain 52 consumption baskets.

The second step consists on predicting the 52 consumption baskets of the HS. For each household we proceed to impute a consumption basket based on a multiple regression on variables reported by the ES and the HS. More specifically, to perform the match we use the command "uvis" of the software Stata (version 11). We assume that the household's spending on each basket depends on: the household's income; the size of the household; the average years of schooling of the adults of the household; a deprivation index; the total hours worked in the labor market by all the members of the household; the participation of age-groups by sex in the household (we consider ten age groups); and a set of regional dummies. The first five variables are introduced as a polynomial of degree three in order to have a more parsimonious functional form. Finally, we assign to each individual the per capita spending of his household. Thus, the indirect tax paid by each individual is the per capita indirect tax paid by his household.

3.2. Consistency

Our simulation exercise is based on data reported by households, which usually present some shortcomings that are worth considering. On the side of expenditure, one major shortcoming is that we are considering that all consumption is undertaken in legal or formal markets, and so it is subject to indirect taxes.[8] We are not making any adjustments due to informal consumption. Nevertheless, we can evaluate the goodness of our exercise by comparing tax revenue from indirect taxes coming from the ES with administrative data. This comparison shows that the indirect tax revenue estimated using the ES, as well as the estimation based on the combination of this survey with the HS one is relatively similar to the

Table 5. *Estimated tax revenues and administrative data, 2008*

	IVA	IRPF
ES (2005-06) & HS (2008)	60,431 million	14,273 million
DGI	67,958 million	12,940 million
Ratio	0.89	1.10

Note: IRPF = labor taxes +IASS (the latter implemented in mid-2008).
Sources: Based on HS, ES and DGI.

information given by the Uruguayan Tax Office (DGI), assuming a tax evasion of 20.6%. See Table 5.

On the side of the HS, the problem stemming from evasion is also present. The HS allows identifying those workers who contribute to the social security system. In this article we assume that these formal workers are the ones that pay taxes.[9] Our simulation exercise makes the reasonable assumption that a tax reform does not change the contributory status. It must be stressed that existing studies for Uruguay indicate that the HS captures very well income from wages, salaries and pensions (Mendive and Fuentes 1996, Arim and Vigorito 2006). As discussed before, it presents serious problems for capturing capital income, both rental and interest income from bank deposits (Amarante, Arim and Salas, 2007), and that is why simulations on the capital component of IRPF are not performed. The comparison of our estimations of tax revenue with the information from administrative records shows that we tend to overestimate direct taxes (Table 5). Nevertheless, global results are adequate and validate the data used for the micro-simulations.

3.3. Microsimulations

Our model is written in Stata and it is freely available in the address *http://ideas.repec.org/c/ega/comcod/201106.html* through the Ideas-RePEc site. It basically allows for the calculation of the total amount of direct and indirect taxes paid before and after the change in the tax system. In our model, the effect of an increase in the indirect tax rate on good *i* for individual *j* is to reduce the "real" disposable income of *j* by an amount equal to the change in the final price caused by the tax times the consumption of good *i* by that individual. On the same token, the effect of a reform of the income tax is the generated change in the real disposable income. This arithmetic model allows considering how each individual and household are affected by the policy change, identifying winners and losers and assessing the overall impact on population

welfare. With this purpose, inequality and progressivity indexes are calculated before and after the reform. This technique has the advantage of allowing the possibility to consider the heterogeneity of economic agents observed in the data, as well as evaluating the financial costs or benefits of any reform (Bourguignon and Spadaro, 2006).

As our analysis is based on a static model, it does not incorporate changes in individual behavior in response to changes in the tax system. So we are estimating first order changes in tax incidence. This is one obvious shortcoming of this exercise, as we are assuming that the population does not change its labor market attachment or its consumption pattern as a result of the modification of the tax system.[10]

Some other simplifying assumptions undertaken in this exercise deserve to be clarified: First, markets are assumed to be competitive, and so the burden of indirect taxes falls entirely on consumers. Second, direct taxes are paid by the taxed factors, except in the case of workers who do not contribute to the social security system, who are supposed not to pay the labor income tax. And third, the household survey does not indicate the currency of bank deposits in the case of interest. In our simulation exercise, all interests from tax deposits are taxed at 12%, assuming that they are in foreign currency (approximately 86% of deposits in the Uruguayan financial system are foreign currency deposits)

In order to carry out our simulations, we first define the following income variables:

(0) *Ypre*: Original income before taxes,

including labor income (wages, salaries, self-employment income), pensions and capital income; contributions to social security and income taxes are also included.

(1a) $Ypost\ true\ VAT = Ypre - ITt$
(1b) $Ypost\ true\ IRPF = Ypre - IRPFt$
(1c) $Ypost\ true\ total = Ypre - VATt - IRPFt$,

where *t* indicates the "true" variable and *IT* refers to the indirect taxes ($IT = VAT + IMESI$).

For simulations of changes in indirect taxes, we define:

(2) $Ypost\ sim1 = Ypre - ITs$,

where *s* indicates that the variable is being simulated. The analysis of the redistributive impact of the actual VAT is done by comparing (1a) and

(0). The effect of the proposed tax reform (indirect taxes) is reflected by comparing (1a) with (2).

For simulations of changes in direct taxes, we define:

(3) *Ypost sim2 = Ypre – IRPFs*.

The analysis of the redistributive impact of the actual income tax is done by comparing (3) and (0). The effect of the potential tax reform (direct taxes) is reflected by comparing (3) with (1b).

For simulations of changes in both direct and indirect taxes, we define:

(4) *Ypost sim3 = Ypre – IRPFs – ITs*.

The analysis of the redistributive impact of the actual VAT and income tax is done by comparing (4) and (0). The effect of the tax reform (direct and indirect) is reflected by comparing (4) with (1c).

3.4. Progressivity and distributional impact

The literature about the effect of taxes on income inequality distinguishes between measuring the progressivity of a certain tax, and assessing its distributional impact. A tax is said to be progressive when its payments are an increasing proportion of the ability to pay, whereas it is regressive when payments are a decreasing proportion of the ability to pay. Evaluating the progressivity of a tax implies comparing its concentration curve with the pre-tax income distribution. On the other hand, the indexes of redistribution assess the distributional impact basically comparing income distribution pre and post taxes. If households were identical in their composition and taxes were determined only on the basis of income, the concepts of progressivity and re-distributional impact of a certain tax would coincide, and a progressive tax would imply an improvement in the distribution of income pre- and post-tax. But households are heterogeneous and so progressivity and distributional impact can differ. This is due to reordering of households that takes place after a tax is introduced.

In this article, we consider two progressivity indexes, the Kakwani index (1977) and the Suits (1977) index. The Kakwani index is calculated by comparing the Lorenz curve of pre-tax income and the tax concentration curve.[11] The index is defined as two times the area comprised between the concentration curve of the tax C_T, and the Lorenz curve of the initial income distribution L_X. It is then equivalent to the

difference between the Gini coefficient and the concentration index (or pseudo-Gini index):

$$K = 2\int_0^1 \left[C_T(p) - L_X(p)\right]dp \;\Rightarrow\; K = G_X - C_T\,.$$

If the tax rate is proportional to income for all households, then the Kakwani index is zero. If the tax is progressive (tax payments increase with income), then the Kakwani index is positive, whereas if tax payments are decreasing with income, the Kakwani index is negative, indicating that the tax is regressive. The value of the Kakwani index depends on the level of inequality prevailing in the pre-tax distribution. It takes the value $G_X - 1$ if the tax is totally regressive, and $G_X + 1$ if it is totally progressive.[12]

Another well-known progressivity index is the Suits (1977) index, which is an adaptation of the Gini index. Suits proposed a figure similar to the Lorenz curve, but plotting the cumulative percentage of tax burden on the vertical axis, against the cumulative percentage of income on the horizontal axis. In this way, he is comparing a relative concentration curve with a 45 degree line. The index can then be formulated as:

$$S = 2\int_0^1 \left[i - C_F(i)\right]di\,.$$

If the tax is proportional, the concentration curve coincides with the 45 degree line and the Suits index is zero. If the tax is progressive, the Suits index will be positive, whereas if it is regressive, the concentration curve will be above the 45 degree line and the Suits index will be negative. If only the poorest person paid taxes, the Suits index would be -1, whereas if only the richest person paid all the tax, the Suits index would be 1.

The Kakwani and Suits index are similar in design, but there are some differences between them. Whereas the Kakwani index integrates with respect to population, the Suits index integrates with respect to income. Formby, Seaks and Smith (1981) showed that both indexes differ by a weighting factor equal to the slope of the Lorenz curve, and this may result in conflicting evolutions of both indexes in time or in cross sectional comparisons.

The most well-known index to analyze the net redistributive impact of a tax is the redistribution index proposed by Reynolds and Smolenky (1977), which compares the Gini indices of pre-tax and post-tax income:

$$RS = G_X - G_{X-T}\,.$$

This RS reformulated index[13] can be decomposed into two terms:

$$RS = \frac{t}{1+t} K - R .$$

The first term is the Kakwani index weighted by $t/(1+t)$ where t is the average tax; the second term is the re-ranking effect. The formula indicates that the redistributive effect depends positively on progressivity but negatively on re-ranking, and that it is monotonically increasing in the average tax rate.[14]

4. Results

Before considering the distributive impacts of the different tax reforms, we analyze the overall effect of the actual tax system on income distribution. With this purpose, we compare pre-tax income with post-tax income, separating the effect of indirect taxes and direct taxes, and, in the case of the latter, considering the role of the capital, labor and pensions components separately.

The ratio of *IT* to income is decreasing by percentile, as shown in Figure 1. Along the first decile, this ratio decreases sharply from 0.56 at the 1st percentile to 0.21 at the 8th percentile. From this percentile on, the

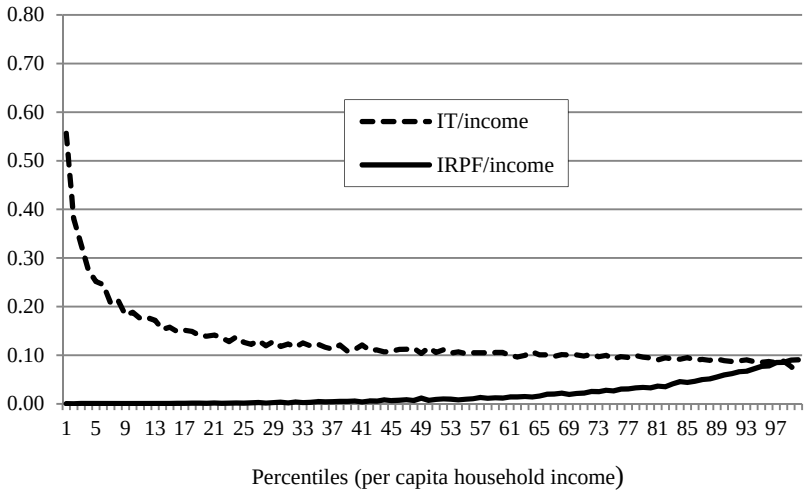

Figure 1. *Tax/income ratio by percentile of per capita household income*

ratio declines gradually taking the value 0.11 at the median of the distribution and 0.09 at percentile 95. The fact that the *IT* burden on household income decreases with income indicates that indirect taxes are regressive both in absolute and relative terms. In Figure 1 we also illustrate the *IRPF* burden. It is null up to the 35th percentile and for higher incomes, it increases gradually and reaches the value 0.09 at the 97th percentile.

In Table 6 we present four measures of inequality of the per capita income of the households before and after taxes. All of them indicate that indirect taxes are regressive and direct taxes (and each component separately) are progressive. However, as is also shown in Table 6, when taken as a whole, the total effect of the present Uruguayan tax system on inequality is mixed, depending on the indexes considered.

Both, the Gini index and the Generalized Entropy (GE) index with parameter 1, also known as Theil's index, indicate that the tax system is progressive as a whole, contributing to more equality. On the contrary, the GE index with parameter 0 (mean log deviation), as well as the ratio 90/10 indicate a regressive effect. This is explained by the fact that the GE(0) gives more weight to distances in the lower tail. The same is true for the ratio 90/10, which directly considers distances among tails. On the other hand, as the Gini and the GE(1) give similar weights across the distribution, these indexes are more sensitive to changes around the mode. The regressive impact of the indirect taxes in the lower tail is then amplified by the former measures and drives the unequalizing result.

In what follows, we present the main results from our simulation exercises. To assess the overall impact on welfare, we use different distribution indicators. We present the results of changes in indirect taxes in subsection (4.1), a change in direct taxes in (4.2), and the combination of changes in direct and indirect taxes in (4.3).

Table 6. *Distributive impact of the Uruguayan tax system*

Pre-tax and post-tax income	Gini	GE(0)	GE(1)	90/10
Pre-tax	0.518	0.500	0.521	12.514
Post-tax (only VAT)	0.530	0.547	0.551	14.142
Post-tax (only labor)	0.508	0.480	0.499	11.940
Post-tax (only capital)	0.516	0.496	0.515	12.444
Post tax (only pensions)	0.517	0.498	0.519	12.440
Post-tax (IRPF)	0.504	0.473	0.490	11.780
Post-tax (VAT and IRPF)	0.515	0.517	0.517	13.222

4.1. Changes in indirect taxes (VAT)

As stated before, when we consider the prevailing indirect tax system in Uruguay, the pre-tax Gini is lower than the post-tax Gini, implying that the progressivity indexes, Reynolds-Smolensky and Kakwani, are in turn negative. More precisely, their values are -0.012 and -0.108, respectively, as it is shown in Table 7. Regarding the changes in indirect taxes contemplated under Scenario 1, a reduction of the VAT basic rate from 22% to 20% brings a decline of the average *IT*/income ratio from 9.4% to 8.9%. Under this alternative scenario, the ratio *IT*/income by percentile is always lower than in the baseline. Indeed, as Figure 2 shows, the difference between the tax burden in the baseline and the alternative scenario 1 is negative along all the income distribution.

Also, as reported in Table 7, the post-tax Gini and the progressivity indexes are similar in the alternative scenario 1 than in the baseline. In brief, the reduction of two percentage points of the VAT does not change the overall picture regarding the progressivity of the tax.[15]

Alternatively, under Scenario 2 the change of the VAT rate to zero for a basket of food items that are consumed by the poorest households maintains the average tax rate of Scenario 1, lower than in the baseline, but has a slightly progressive impact. In effect, progressivity indexes continue to be negative but their absolute values are lower than those of the baseline and of the Scenario 1. The post-tax Gini declines, according to that table, from 0.531 to 0.529, indicating a redistributive effect. The change in the RS index is statistically significant, although its magnitude is very small. In Figure 2 we can appreciate the reduction of the IT/income ratio along the distribution with respect to the baseline. This reduction is higher than in Scenario 1 for the poorest up to percentile 80, and then becomes smaller.

Table 7. *Redistributive impact of changes in VAT*

Measures	Baseline	Scenario 1	Scenario 2
Pre-tax Gini	0.518	0.518	0.518
Post-tax Gini	0.530	0.530	0.528
Average tax rate	0.095	0.089	0.089
RS net redistributive effect	-0.012	-0.011	-0.010
Kakwani	-0.108	-0.108	-0.093
Re-ranking	0.001	0.001	0.001
Suits	-0.124	-0.125	-0.109
Change in total tax revenue		-8.9%	-8.5%

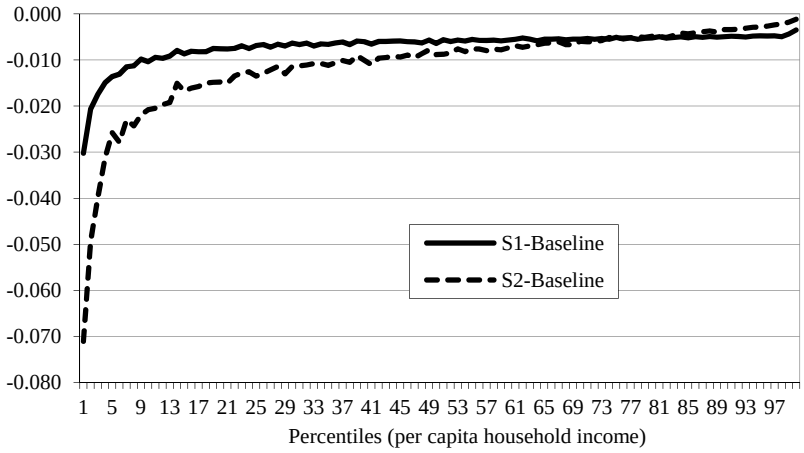

Figure 2. *Difference between the tax burden in the scenarios and the baseline*

In sum, as expected, in both scenarios indirect taxes continue to have a regressive impact. Although changes are of a very small magnitude, the second alternative, consisting on a zero VAT rate for a basket of goods consumed by the poorest population, implies a more progressive change, with a higher re-distributional effect driven by its higher progressivity. Nevertheless, decisions about the best modification in indirect taxes must also take into account efficiency considerations. In effect, this second alternative is more difficult to implement in practical terms and may have undesired effects in terms of the efficiency of the tax system.

4.2. Changes in direct taxes (IRPF)

Under Scenario 3, we study an increase in the upper limit of the untaxed bracket of the labor component of the IRPF, from 84 to 100BPC. The tax rates for the different income brackets remain the same. As shown in Table 8 and Figure 3, Scenario 3 brings a reduction in payments of the labor income component of the IRPF along all the income deciles, a reduction that is decreasing in percentage terms by income decile.

Furthermore, as shown in Table 9, the average tax rate decreases from 4.6 to 4.3%. The simulated change on labor tax suggests an improvement in terms of progressivity according to both the Kakwani and the Suits indexes, although the Reynolds-Smolensky index does not show any significant change. The two divergent trends, the decrease in the average

Table 8. *Payments of IRPF (labor component, per capita) by income decile*

	IRPF 2008	Simulated	Relative change	Absolute change
1	50.5	0.0		
2	32.6	18.4	-43.6	-14.2
3	76.9	58.8	-23.5	-18.1
4	114.0	84.0	-26.2	-29.9
5	167.2	135.5	-19.0	-31.7
6	232.3	194.6	-16.2	-37.7
7	377.6	313.1	-17.1	-64.4
8	620.9	525.5	-15.4	-95.4
9	1162.7	1004.3	-13.6	-158.5
10	3108.7	2894.5	-6.9	-214.2

tax rate (which decreases RS) and the increase in progressivity (which increases RS) cancel each other, and there are no reordering effects.

In brief, the simulated labor tax rate continues to be progressive, but the proposed change under Scenario 3 does not reduce the income inequality respect to the baseline. Further increases in progressivity at the expense of lower average tax rate end up not having a net effect on distributional terms.

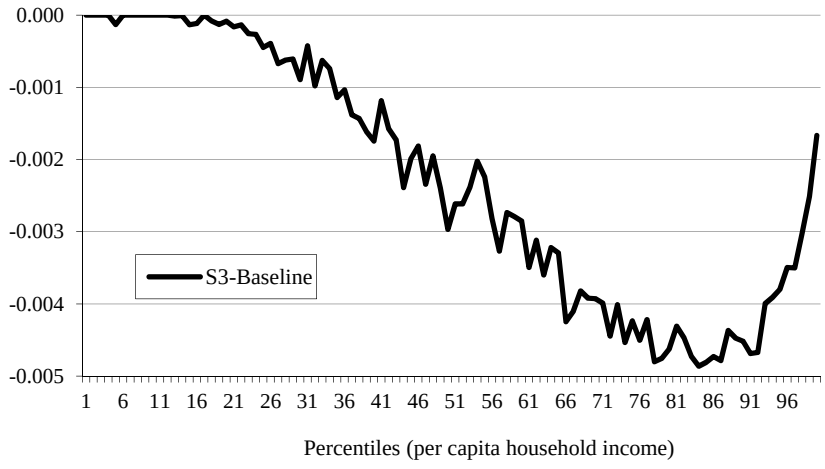

Figure 3. *Difference between the tax burden in the scenario and the baseline*

Table 9. *Redistributive impact of changes in IRPF on labor*

Measures	Baseline	Scenario 3
Pre-tax Gini	0.518	0.518
Post-tax Gini	0.504	0.504
Average tax rate	0.046	0.043
RS net redistributive effect	0.014	0.014
Kakwani	0.297	0.311
Re-ranking	0.000	0.000
Suits	0.393	0.419
Change in total tax revenue		-1.7%

The main message of this particular exercise is that it is very difficult to achieve important decreases in inequality through changes in direct taxes on labor income, as the actual design of this component of the IRPF is already progressive. Although more progressiveness could be achieved, it would imply no changes in overall inequality.

4.3. Changes in indirect and direct taxes (VAT and IRPF)

As a final step, we analyzed joint effects of changes in direct and indirect taxes, as specified in Table 4. In Scenario 4, there is a reduction of two points in the VAT rate, and an increase in the upper limit of the IRPF untaxed bracket. In scenario 5, the change in direct taxes is the same, but there is an elimination of the VAT for certain goods.

As shown in Table 10, both scenarios show a progressive impact respect to the baseline. Even when the average tax rate declines, the increase in progressivity leads to an increase in the net re-distributional effects. Obviously, given the modification in direct taxes, the progressive

Table 10. *Redistributive impact of changes in direct and indirect taxes*

Measures	Baseline	Scenario 4	Scenario 5
Pre-tax Gini	0.518	0.518	0.518
Post-tax Gini	0.515	0.515	0.513
Average tax rate	0.141	0.132	0.132
RS net redistributive effect	0.003	0.003	0.005
Kakwani	0.025	0.029	0.039
Re-ranking	0.001	0.001	0.001
Suits	0.046	0.052	0.063
Change in total tax revenue		-10.6%	-10.3%

impact is higher when we simulate a reduction of the VAT rate for the goods consumed by the poor rather than the elimination (zero rate) for only some of those goods (the RS index is statistically higher in Scenario 5 when compared to the baseline, although Scenario 4 and the baseline are equivalent on statistical grounds).

5. Final remarks

The design of the tax structure is a central issue in any economy due to its implications on efficiency and equity grounds. In this article, we focused on the distributive impacts of alternative designs of direct and indirect taxes. Two scenarios of changes in indirect taxes were analyzed, both implying a similar and significant cost in fiscal terms. We concentrated on equity effects, leaving aside efficiency considerations. As expected, these two scenarios continue to have a regressive impact. Although changes are of very small magnitude, the second alternative, consisting on the elimination of the VAT for a basket of goods consumed by the poorest population, implies a net redistributive effect with respect to the baseline. On the direct taxes side, our results indicate that it is very difficult to achieve important decreases in inequality. As the actual design of this component of the IRPF is already progressive, an increase of progressivity through the proposed labor component tax does not have any significant redistributive effect.

Overall, more progressivity is achieved through the combination of reductions in the VAT rates for specific goods and changes in the labor component of IRPF. Nevertheless, as found for other countries in the region by Goñi, López and Servén (2008), redistribution through the tax system in Uruguay, at least with the tax changes that have been considered here, seems to be limited.

Notes

[1] Chapter prepared for the project "An Integrated Framework for the Assessment of Equitable, Pro-Growth Fiscal Reform in Latin America and the Caribbean: Fiscal Schemes for Inclusive Development (FSID)", co-funded by UNDP and IDRC. Any errors or opinions are the authors' and do not necessarily represent the views of the United Nations Development Programme or those of the International Development Research Centre. We are grateful for useful

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[2] As an example, those authors argue that whereas the direct taxation system lowers the Gini coefficient of household income by an average of about five percentage points for fifteen European countries, the average decline in the Gini coefficient for Latin American countries due to direct taxes is just about a single percentage point.

[3] In the case of Chile, the analysis presented by Engel, Galetovic and Raddatz (1997) shows that before- and after-tax Gini coefficients go from 0.4889 to 0.4929, suggesting that the redistributive role of taxes is limited.

[4] What follows is a brief account of the Uruguayan tax system. An in depth description of both taxes and social benefits in Uruguay is given in Amarante, Bucheli, Olivieri and Perazzo (2011).

[5] In the original tax reform, pensions were taxed by the labor component of the IRPF. Pension preceptors, arguing that this was not constitutional, took legal actions. As a result of the judicial resolutions favorable to pensioners, the IRPF on pensions was derogated, and a new tax, the IASS, was installed in July 2008.

[6] In the case of the workers, we take into account the specific social security and health contributions that correspond to the individual occupational group. Furthermore, in the case of both workers and pensioners we consider their personal tax conditions.

[7] The HS 2006 has a sample size of 85,316 households, while the ES sample was made of 7,043 households. Both surveys are representative at the national level.

[8] Other minor concern refers to the under reporting of consumption of certain goods, such as alcohol, cigarettes, etc.

[9] In 2008, 67% of workers made contributions to the social security system.

[10] Bourguignon and Spadaro (2006) argue that ignoring behavioral responses may not be so restrictive. The estimation of first round effects may be a good approximation of the final welfare effect if changes are small enough and individuals operate in perfect markets.

[11] The concentration curve of a tax plots the cumulative percentage of tax burden on the vertical axis against the cumulative percentage of population on the horizontal axis.

[12] If only the poorest household paid taxes, then the pseudo-Gini index would be 1, and the Kakwani index would be $G_X - 1$, its minimum possible value. If only the richest household paid taxes, the pseudo-Gini index would be -1, and the Kakwani index would be $G_X + 1$.

[13] This index is also known as RS reformulated, to differentiate it from the RS that prevails when there is no reordering among households. In this case, $RS = G_X - C_{X\text{-}T}$. See Lambert (2001) for a discussion on this.

[14] Note that if taxes do not imply re-ranking, the *K* and *RS* indexes are only differentiated by a function of the average tax rate, and are equivalent in qualitative terms.
[15] Confidence intervals for all indexes are available upon request.

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8 Redistributive effects of indirect taxes: comparing arithmetic and behavioral simulations in Uruguay[1]

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1. Introduction

The literature that analyzes the redistributive effect of taxes and/or public benefits using microsimulation models is quite extended. Indeed, those models constitute useful tools to assess the distributional impact of policy changes (see, e.g., Bourguignon and Spadaro, 2006). In this paper, we use a microsimulation model to analyze, in the case of Uruguay, the redistributive impact of setting the value added tax (VAT) rate to zero in the case of specific goods that make up for a large share of consumption among the low income population.

Most of the ex-ante analyses of changes in taxes and transfers are undertaken using typical microsimulation models (including ours in Chapter 8 of this book). However, a well-known limitation of these models is that they only use arithmetic (accounting) rules for determining the outcome of some economic policy, and not behavioral relations. This implies that the results thus obtained assume, in particular, that the individuals do not change their consumption patterns as a result of a modification of tax rates. This may be a strong assumption especially in the case of indirect taxes, as the variation in rates results in variation in consumer prices, and this might probably lead to variations in the individuals' demand.

In this paper we compare results from an arithmetic model and a behavioral model when both are used to evaluate a change in the VAT rates. The arithmetic model is the same as in Chapter 8, while the

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behavioral microsimulation model is based on the estimation of a demand system using the Quadratic Almost Ideal Demand System (QUAIDS) proposed by Banks, Blundell and Lewbel (1997). Our analysis is made using data from the combination of income and expenditure surveys of Uruguayan households. We also make two key assumptions: that the effects of changes in indirect taxes are beard entirely by the consumers, and that there is no tax evasion. We present the methodological details of the microsimulation models in Section 2, and contrast the main results of both models in Section 3. The conclusions are given in Section 4.

2. Methodological aspects

In order to undertake a welfare analysis that takes into account demand responses, we first estimate income and price elasticities for a limited number of baskets of goods. As mentioned earlier, these estimations are done using the QUAIDS, a consumer demand system with Engel curves that include on the right-hand side log income and higher order income terms. Based on an empirical analysis of Engel curve relationships for different goods for the United Kingdom, Banks, Blundell and Lewbel (1997) show that although the traditional definition of expenditure share over the logarithm of deflated income or total expenditure provides a reasonable approximation for some goods (for example in the case of the food share curve), non-linear behavior is evident for other goods (for example in the case of clothing). On this basis, those authors argue that higher order income terms have to be included in the estimation, allowing goods to be luxuries at some income levels and necessities at others. Their proposed quadratic logarithmic model nests the Almost Ideal (AI) model of Deaton and Muelbauer (1980) and the Translog model of Jorgenson, Lau and Stocker (1982).

As a first step, we define the household's expenditure shares on basket *i* as:

$$(1) \qquad w_i = \frac{p_i q_i}{m} \ ,$$

where p_i is the price and q_i the quantity of good *i*, and *m* is total expenditure. If the number of goods is *N*, then $w_1 + \ldots + w_N = 1$, and each expenditure share can be estimated, according to the QUAIDS, as:

$$(2) \qquad w_i = \alpha_i + \sum_{j=1}^{N} \gamma_{ij} \ln p_j + \beta_i \ln\left[\frac{m}{a(\mathbf{p})}\right] + \frac{\lambda_i}{b(\mathbf{p})}\left\{\ln\left[\frac{m}{a(\mathbf{p})}\right]\right\}^2 + \varepsilon_i \ ,$$

where **p** is the vector of prices and ε_i the error term.[2]

The price index $a(\mathbf{p})$ has a translog form, being homogenous of degree one in prices:

$$(3) \qquad \ln a(\mathbf{p}) = \alpha_0 + \sum_{i=1}^{N} \alpha_i \ln p_i + \frac{1}{2}\sum_{i=1}^{N}\sum_{j=1}^{N} \gamma_{ij} \ln p_i \ln p_j \ ,$$

and $b(\mathbf{p})$ is a price aggregator function that is homogenous of degree zero in prices:

$$(4) \qquad b(\mathbf{p}) = \prod_{i=1}^{N} p_i^{\beta_i} \ .$$

Considering equation (1), the parameters have to fulfil the following conditions:

$$(5) \qquad \sum_{i=1}^{N} \alpha_i = 1 \ ; \ \sum_{i=1}^{N} \beta_i = 0 \ ; \ \sum_{i=1}^{N} \lambda_i = 0 \ \text{ and } \sum_{i=1}^{N} \gamma_{ij} = 0 \ \text{ for all } j \ .$$

By differentiating equation (2) with respect to ln m and ln p_j, one can obtain:

$$\mu_i = \frac{\partial w_i}{\partial \ln m} = \beta_i + \frac{2\lambda_i}{b(\mathbf{p})}\left\{\ln\left[\frac{m}{a(\mathbf{p})}\right]\right\}$$

$$\mu_{ij} = \frac{\partial w_i}{\partial \ln p_j} = \gamma_{ij} - \mu_i\left(\alpha_j + \sum_k \gamma_{jk} \ln p_k\right) - \frac{\lambda_i \beta_j}{b(\mathbf{p})}\left\{\ln\left[\frac{m}{a(\mathbf{p})}\right]\right\}^2 .$$

Consequently, the income elasticities are given by:

$$(6) \qquad e_i = \frac{\mu_i}{w_i} + 1 \ ,$$

which can be higher or lower than one at different levels of expenditure, allowing for a good to be a luxury or necessity depending on the

household's total expenditure. On the other hand, the uncompensated price elasticities are given by:

$$(7) \qquad e_{ij}^{u} = \frac{\mu_{ij}}{w_i} - \delta_{ij} \ ,$$

where Kronecker's delta equals 1 if $i = j$, and 0 otherwise. Finally, the compensated or Hicksian price elasticities are calculated through the Slutsky equation:

$$e_{ij}^{c} = e_{ij}^{u} + w_j e_i \ .$$

Our estimations are based on the income information reported by the household survey (HS) collected by the Institute of Statistics (INE) in Uruguay in 2008. Specifically, the HS contains information about labor income, transfers and other income for every member of the household. Given that the HS does not include information about household spending, we combine this survey with the Expenditure Survey (ES), collected throughout November 2005 and October 2006 by the INE (see Chapter 8 in this volume for more details).

We estimate an eight demand equation model, and the estimation is done using an extension of the *nlsur* Stata command.[3,4] We classify the expenditure in nine baskets. One of them corresponds to services; we do not consider it in the demand system to avoid the usual problem of lack of report of data on unit values. The other eight ones represent 62% of expenditure and 58% of the VAT. The description of these eight composite goods, their expenditure and VAT are reported in Table 1. We also report the expenditure by decile in Table 2. Finally, it should also be noted that, in what follows, the price of each of the eight composite goods is calculated as:

$$P = p_1^{a_1} \times ..... \times p_n^{a_n} \ ,$$

where a_i represents the spending on good i in relation to total spending on the composite good.

Before carrying out our simulations, we also have to define the following income variables:

(8) *Ypre*: Original income before taxes,

including all labor income (wages, salaries, self-employment income), as

Table 1. *Distribution of expenditure and VAT among baskets*

Basket	VAT rate	Spending (%)	VAT (%)
1. Low income basket	10%	7.2	6.7
2. Food and beverages	Exempt, 10%	3.5	1.9
3. Food and beverages	22%	8.6	15.5
4. Apparel and shoes	22%	4.2	7.5
5. Furniture and building	Exempt, 10%	20.9	0.2
6. Furniture and building	22%	10.7	17.7
7. Entertainment	Exempt, 10%	2.8	1.1
8. Entertainment	22%	4.2	7.2
9. Services	Exempt, 10%, 22%	37.9	42.2
Total		100	100

Source: calculations based on household expenditure survey
Note: Most of the sales are taxed by the basic VAT rate of 22%. A rate of 10% applies to certain basic goods and services such as basic food (bread, meat, chicken, etcetera), medicines and transportation. Finally, a series of goods and services are zero-rated (for example milk, water, books). The main principle behind the assignation of different rates schedule is whether the good is considered essential or luxury.

well as pensions and capital income; contributions to social security and income taxes are also included. The second variable is

(9) $Ypost\ true\ VAT = Ypre - ITt$

where *t* indicates the "true" variable and *IT* refers to the indirect taxes.

Table 2. *Expenditure on the eight composite goods (%)*

	Deciles										
	I	II	III	IV	V	VI	VII	VIII	IX	X	Total
B1	19.6	18.1	17.3	16.0	14.9	13.6	12.3	10.7	8.7	5.7	11.5
B2	9.5	8.6	7.8	7.4	6.9	6.3	5.8	5.2	4.7	3.2	5.6
B3	13.8	14.8	14.2	14.4	14.7	14.8	14.7	14.8	14.6	11.8	13.9
B4	6.7	6.7	6.5	6.7	6.6	6.6	6.9	6.7	7.0	7.0	6.8
B5	26.3	27.2	28.2	29.6	30.4	31.7	32.2	34.2	35.7	40.2	33.7
B6	16.8	16.9	17.4	17.2	17.1	17.1	17.3	16.7	16.6	17.4	17.1
B7	2.6	2.6	2.8	2.6	3.2	3.5	4.0	4.1	5.3	7.0	4.5
B8	4.5	5.3	5.6	6.1	6.4	6.5	7.0	7.4	7.4	7.7	6.8
	100	100	100	100	100	100	100	100	100	100	100

Source: calculations based on the household expenditure survey.

For simulations of changes in indirect taxes, we define:

(10) $Ypost\ sim1 = Ypre - ITs,$

where *s* indicates that the variable is being simulated. The analysis of the redistributive impact of the actual VAT is done by comparing (8) and (9).

The effect of the proposed tax reform (indirect taxes) is reflected by comparing (9) with (10). In the arithmetic model, ITs comes from changing the VAT rate and assuming that consumption remains unchanged, whereas in the behavioral model, the change in consumption due to the change in prices is included in the simulation. To perform the redistribution analysis, we calculate the Gini index of both distributions and its difference, that is, the Reynolds-Smolensky index. We also calculate two progressivity indexes: the Kakwani and Suits indexes.

3. Results

After estimating the demand system and using equation (7) above, Table 3 presents the own- and cross-prices elasticities in the case of the eight composite goods. As expected, the own-price elasticity is negative for all baskets considered, as shown in the diagonal of the table. On the other hand, the first composite good, which corresponds to the consumption basket of the poorest population, is a substitute of those baskets that are made of other food and beverages (baskets 2 and 3), while it is complementary to the rest of the goods.

Using the estimated behavioral model, as well as a typical arithmetic model, Table 4 presents the redistribute impact of a reform that reduces to zero the VAT rate of specific goods. These are the ones that constitute

Table 3. *Own- and cross-price elasticities of the eight baskets*

	B1	B2	B3	B4	B5	B6	B7	B8
B1	-0.968	0.203	0.107	-0.017	-0.008	-0.001	-0.048	-0.221
B2	0.545	-1.224	0.187	-0.006	0.002	0.017	-0.040	-0.241
B3	0.183	0.106	-1.023	0.003	0.003	-0.022	0.009	-0.081
B4	0.076	0.037	0.058	-0.633	-0.015	-0.016	0.013	0.000
B5	0.242	0.112	0.158	-0.093	-0.468	0.002	0.016	-0.114
B6	0.098	0.049	0.017	-0.017	0.003	-0.648	-0.006	-0.019
B7	0.004	0.010	0.092	0.030	0.018	0.006	-0.591	0.013
B8	-0.046	-0.031	-0.031	-0.025	-0.019	-0.027	-0.021	-0.994

Table 4. *Redistributive impacts of changes in VAT*

	Baseline	Arithmetic model	Behavioral model
Pre-tax Gini	0.518	0.518	0.518
Post-tax Gini	0.527	0.525	0.525
Average tax rate	0.049	0.044	0.041
Reynolds-Smolensky net effect	-0.009	-0.007	-0.007
Kakwani progressivity index	-0.168	-0.150	-0.149
Reranking	0.000	0.000	0.000
Suits progressivity index	-0.190	-0.171	-0.170
Change in total tax revenue	-.-	-0.064	-0.096

the consumption basket of the population with the lowest income. The table also presents the impact under the current VAT rate structure.

As can be observed from there, in the case of both models the Kakwani and Suits indexes indicate that the value added tax is regressive, whereas the Reynolds-Smolensky index shows that it has a negative redistributive effect as well.[5] Naturally, the elimination of the VAT rate for those goods implies a decrease in the average tax rate, and hence a decrease in tax revenue. Under the arithmetic model this reduction is the highest (the average tax rate is 4.1 under the reform, whereas it is 4.9 under the baseline scenario). According to the arithmetic model, the regressivity of the VAT decreases when we eliminate the tax for the consumption basket of the low-income population. We also observe that the negative redistributive effect is weaker: the post-tax Gini is 0.527 in the baseline and 0.525 after the reform.

Finally, it is important to note that in the case of the arithmetic model the spending on the basket of the low-income population declines 9% (given the no VAT payments), but when we introduce the possibility of behavioral reactions, it only decreases by 1.1%. On the other hand, regarding the progressivity and redistributive impact of indirect taxes, the results obtained under both the arithmetic and the behavioral models are quite similar.

4. Conclusions

In this paper, we considered an arithmetic model and a behavioral model to simulate the redistributive effect of the elimination of the VAT in the

case of the basket that is intensively consumed by the by the poorest population. We find that the negative redistributive effect of the reform declines under the simulated regime. The proposed change in the VAT rate implies an equalizing change in the distribution, but the magnitude is very small. Though in the behavioral model the patterns of consumption change, the global effects are almost the same than those obtained under the arithmetic model.

Notes

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[2] Note that the QUAIDS model reflected in (2) can turn into the AI model when the parameters λ are zero across all equations.
[3] We are thankful to Carlos Urzúa for providing us the STATA code for this extension.
[4] These equations do not include demographic variables, usually introduced to control for heterogeneity across households.
[5] Results from the arithmetic model differ from those presented in Chapter 8 because expenditure in services is excluded from the analysis. Another methodological difference is that in this exercise we consider only eight consumption baskets, as a relatively small number of baskets is needed in order to estimate the QUAIDS.

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This book presents several microsimulation models that can be used to assess the welfare consequences of a number of policy reforms in five countries: Brazil, Chile, Guatemala, Mexico and Uruguay. By using micro data from national surveys, the models not only characterize the population on the aggregate but also on a number of dimensions such as age, family composition and income level, which are important for distributive analysis. The models also quantify and identify those who win and those who lose with a reform. Furthermore, the open-source nature of the models presented here will help to build-up technical capacities on the subject across Latin America.

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