ELSEVIER

Journal of Development Economics
Vol. 59 (1999) 155–192

JOURNAL OF
Development
ECONOMICS

Taxes and income distribution in Chile: some unpleasant redistributive arithmetic

Eduardo M.R.A. Engel [a,b], Alexander Galetovic [a,*], Claudio E. Raddatz [a]

[a] *Centro de Economía Aplicada (CEA), Dep. Ing. Industrial, Universidad de Chile. República 701, Santiago, Chile*

[b] *National Bureau of Economic Research, Cambridge, MA, USA*

Abstract

This paper quantifies the direct impact of taxes on income distribution at the household level in Chile and estimates the distributional effect of several changes in the tax structure. We find that income distributions before and after taxes are very similar (Gini coefficients of 0.488 and 0.496, respectively). Moreover, radical modifications of the tax structure, such as raising the value added tax from 18 to 25% or substituting a 20% flat tax for the present progressive income tax affect the after-tax distribution only slightly. We present some arithmetic showing that the scope for direct income redistribution through progressivity of the tax system is rather limited. By contrast, for parameter values observed in Chile, and possibly in most developing countries, the targeting of expenditures and the level of the average tax rate are far more important determinants of income distribution after government transfers. Thus, a high-yield proportional tax can have a far bigger equalizing impact than a low-yield progressive tax. Moreover, a simple model shows that the optimal tax system is biased against progressive taxes and towards proportional taxes, with a bias that grows with the degree of inequality of pre-tax incomes. Our results suggest that to reduce income inequality, the focus of discussion should be on the amount to be redistributed, the

* Corresponding author. E-mail: agaleto@dii.uchile.cl

PII: S0304-3878(99)00009-7

targeting of public spending, and the relative efficiency of alternative taxes, and *not* on the progressivity of the tax system.

JEL classification: H22; H24; H29

Keywords: Income distribution; Progressivity; Taxes

1. Introduction

Income distribution remains one of the most debated economic issues in developing countries, and Chile is no exception. [1] Although poverty has declined fast and steadily during the last decade, inequality has not changed much. Quite often it is concluded that the stagnation of income distribution is due to inappropriate policies that should be replaced by direct redistributive measures. Given that one of the ways the state can affect income distribution is through the tax system, there is permanent discussion on the distributional effects of taxes. This discussion heats up whenever the government proposes some tax amendment. For example, whenever it has announced its intention to raise the rate of the Value Added Tax (VAT), a heated debate has ensued over its incidence and distributional impact. On the other hand, many people react with concern when the possibility of reducing the progressivity of income taxes is raised, because they think that it will significantly increase income inequality.

The purpose of this paper is to quantify the distributional impact of the Chilean tax system and to assess the sensitivity of the distribution of income to changes in the structure of taxes and rates. We do so by constructing a model that incorporates the main taxes and allowances in place in Chile in 1996. We estimate the true income of individuals [2] with data from the 1996 National Socioeconomic Characterization Survey (CASEN) taken by the Planning Ministry, and 'match' this information with taxpayer records kept by the Chilean Internal Revenue Service (SII). In this way we are able to estimate the extent of underreporting of income, as well as deductions for allowances which we impute for each income percentile. At the same time, using data from the Family Budget Survey (EPF) from the National Institute of Statistics (INE), carried out in 1996–1997, we estimate the composition of household consumption and the amount of indirect taxes that each household pays.

[1] For recent studies on income distribution in Chile see Contreras (1996), Cowan and De Gregorio (1996) and Beyer (1997).

[2] The definition of income we use is given in Section 3.1.

Like most studies for developed countries, we conclude that the tax system has little effect on income distribution (before- and after-tax Gini coefficients of 0.488 and 0.496). In addition, our methodology enables us to study the distributive effect of changes in the current tax system. Somewhat surprisingly, we show that major departures from current tax rates do not significantly affect income distribution either. For example raising the VAT rate from 18% to 25%, or replacing the present income tax (top marginal rate of 45% for monthly incomes above US$6500) by a flat tax with an initial exempt bracket and a uniform marginal rate of 20% thereafter, hardly alters income distribution. The data suggest that this is not due to tax loopholes or massive evasion: while around 23% of the theoretical income tax base is not reported, [3] most household incomes, including some from the wealthiest decile, are relatively low. [4] For that reason, although most of income tax revenues come from individuals from households in the wealthiest decile, the average income tax rate is low, slightly below 3%. Even if all tax-free allowances and underreporting of income were eliminated, the average rate would increase to only 6%. The second conclusion is that the tax system in place in 1996 was slightly regressive. This is because a regressive tax (VAT) is very important, and is only partially compensated by the progressive income tax, which, as we already mentioned, collects little income from the wealthiest decile. This slight regressivity of the Chilean tax system contrasts with most studies of the distribution of tax burdens in developing countries, which find overall tax systems to be broadly progressive. [5]

Motivated by these results we present a simple formalization showing that the scope for direct income redistribution through a progressive tax system is small. [6] Moreover, we also show that progressivity is increasingly ineffective the more *unequal* the pre-tax distribution. By contrast, for parameter values observed in Chile, the targeting of expenditures and the level of the average tax rate are far more important determinants of the after-tax-and-expenditures income distribution. For example, after accounting for redistribution, the high-yield but slightly regressive VAT reduces inequality far more than the low-yield, strongly progressive income tax.

If all taxes cost the same to administer, have the same revenue potential and create the same excess burden, progressive taxes should always be preferred over

[3] Which leads to an evasion rate for the income tax of 54%.

[4] By convention, the last decile is the one with highest incomes. For expositional purposes we will refer to the first decile as the poorest and the last decile as the wealthiest. Although the poorest decile is indeed poor, most of the households in the wealthiest decile are not what in ordinary language would be called 'rich'. The income distribution within the wealthiest decile is summarized in Table 7, presented in Section 3.2.

[5] See, for example, Jayasundera (1986) for Sri Lanka, Lovejoy (1963) for Jamaica, Malik and Saquib (1989) for Pakistan, McLure (1971) for Colombia and Sahota (1969) for Brazil.

[6] Harberger (1998) presents some examples making the same point.

proportional taxes. Nevertheless, in practice the VAT scores better than progressive income taxes on all three counts. We present a simple model showing that when this is so the optimal tax system is biased against progressive taxes and towards proportional taxes. Somewhat surprisingly, this bias is stronger the more *unequal* the pre-tax distribution.

This paper contributes to the empirical literature on the distribution of the annual tax burden pioneered by Ockner and Pechman (1974).[7] Most of these studies allocate the actual amount paid in taxes to the different brackets of the income distribution on the basis of estimates of consumption patterns and income for each household and a series of incidence assumptions.[8] We depart from these studies in that we do not allocate the actual tax burden across deciles but independently calculate the amount that each household pays in each tax. In the case of the income tax, we do so by applying the statutory income tax schedule to the actual income of each individual in the CASEN incomes survey, after deducting income that is not reported and the main allowances that benefit her. In turn, to estimate the amount that each household pays in indirect taxes, we use actual spending patterns and make standard incidence assumptions. This methodology has several advantages. First, we obtain an estimate of the number of non-filers and the magnitude of underreporting and evasion of the income tax by comparing data from the CASEN incomes survey with actual tax returns filed with the SII. Second, and more important, we are able to simulate the distributive impact of changes in tax rates, allowances and evasion. An additional innovation of our study is that we incorporate the multisectoral effects of indirect taxes. Using the 1986 National Accounts Input–Output Matrix (IOM) we estimate the effect of taxes charged on inputs on the tax burden faced by households that consume the final goods incorporating those inputs.

Our work updates that of Aninat et al. (1980), who used a similar methodology to study the distribution of the tax burden under the tax system in force in Chile in 1969, and the study by Schkolnik (1993), who estimated the distribution of the tax burden and government spending at the quintile level in 1990. Access to a series of data sources at the micro level which have not been previously exploited, in particular individual taxpayer records kept by the SII, enable us to work at the level of each income percentile, thereby obtaining more precise estimates. Moreover, we present the first estimation of the magnitude of underreporting of incomes in Chile and its distributive impact using detailed and comprehensive microdata.

---

[7] See also Pechman (1985).

[8] A second type of study estimates the income each individual perceives over her lifetime and the total amount of taxes she will pay. The most important study in this line of research is that of Fullerton and Rogers (1993) for the United States, which uses a panel of individuals and determines the incidence of each tax with the help of a computable general equilibrium model.

Before proceeding, we mention the main limitations of our model. In the first place, the calculations assume that changes in the tax system do not affect the composition of spending or production decisions. Therefore, our model does not allow us to assess the welfare effect of the distortions that taxes create, nor how the costs of such distortions are distributed. Incorporating these effects would require a computable general equilibrium model, which goes beyond the scope of this paper. [9] On the other hand, the approach we adopt has the virtue of allowing us to work with microeconomic information which is considerably more detailed than what can be incorporated in computable general equilibrium models. [10]

In the second place our income definition is annual. As is well known, annual income is not always a good reflection of permanent income, and this may lead to an exaggeration of both inequality and the regressivity of consumption taxes (see the discussion in Section 3.1).

Third, income figures reported by the CASEN survey are likely to be less reliable for the higher centiles, for which reason this paper may underestimate the distributive impact of the tax system on these centiles.

Fourth, in some cases, the CASEN survey does not allow us to distinguish incomes that should form part of the taxable base from those that are exempt and must not be reported. Thus, part of what we identify as underreporting of income does not correspond to evasion but to income that taxpayers legally do not have to report.

Fifth, we assume that the evasion of indirect taxes (e.g., VAT) only benefits producers. The reason is that the available data does not enable us to estimate the distributional effects of the evasion of indirect taxes, because the CASEN survey does not allow us to identify the owners of firms evading taxes. Finally, and for the same reason, we assume that profits retained by firms are not income for the households that own those firms during the year in which the income accrues. [11] This has two implications: (a) income is probably more concentrated than is suggested either by the CASEN survey or the results we present, and (b) undistributed profits from 'investment companies', which are widely set up by high-income tax payers to avoid the highest marginal rates of the income tax, are not included as household income in our calculations. [12] This, together with the fact that income taxes in Chile are integrated, means that the business income tax, which is charged on company profits, has no effect on the income distribution.

[9] Studies which use a computable general equilibrium model for the United States are Ballard et al. (1985) (one year horizon) and Fullerton and Rogers (1993) (intertemporal horizon).

[10] To solve a computable general equilibrium model one needs to iterate repeatedly until an equilibrium set of prices is found; this can only be done by limiting the size of the sample or by aggregating microdata.

[11] Only dividends paid out to shareholders are incorporated into households' incomes.

[12] In Section 4 we briefly discuss how our results would be affected by including income from investment companies in our definition of income.

The remainder of this paper is organized as follows. In Section 2 we briefly describe the main features of the Chilean tax system. Section 3 presents the methodology and the data sources we use. This section may be skipped by the trusting reader who can move on to Section 4, where we estimate the progressivity of the tax system in place in 1996, and show that the distribution of income is remarkably insensitive to radical modifications of the tax structure. In Section 5 we present the arithmetic exercises showing that the scope for direct income redistribution through a progressive tax system is small. Section 6 presents the model. Section 7 summarizes the conclusions.

2. The Chilean tax system: a primer

In this section we briefly describe the main features of the Chilean tax system.

2.1. Direct taxes

The main direct tax in Chile is the income tax or *Impuesto a la Renta*. In 1996 it comprised three taxes: (a) A 15% flat business tax (*Primera Categoría*); (b) a progressive wage tax (*Segunda Categoría*) and a progressive general income tax (*Global Complementario*, henceforth GC). [13] On an annual basis, marginal rates and income brackets of the wage and general income tax are the same. However, while the wage tax is paid on a monthly basis, the GC tax is levied on annual income. Both the wage and GC taxes are personal, that is they are levied on individuals and not households.

The main feature of the income tax is that it is integrated. Each year individuals consolidate all their incomes, regardless of their source, into a comprehensive tax base, and then compute their *total* tax obligation by applying the progressive scale of the GC tax. All business and wage taxes paid on incomes included in the comprehensive tax base are then deducted as credits from the GC tax dues. Two features of the income tax imply that it is not *fully* integrated, however. First, profits retained by firms do not enter the GC comprehensive base; correspondingly, credits on the business tax cannot be claimed until profits are paid out. Second, the progressive wage tax is levied on a monthly basis. Those individuals whose only source of income are wages do not file a GC tax return. If their wage income fluctuates significantly from month to month they may end up paying higher taxes than an individual with exactly the same annual income but who receives income from sources different than wages.

[13] See Table 3 for income tax brackets.

There are four major allowances in the income tax. First, Article 57 bis., letters (a) and (b) of the income tax law, which allows GC taxpayers to deduct from their tax base in perpetuity 20% of the amount purchased in newly issued shares of publicly owned corporations, as well as financial savings in specially designated instruments. [14] Second, an exemption on savings of less than about US$1000 per year, which benefits taxpayers who pay only the wage tax. Third, an exemption on income arising from properties favored by the Law Decree 2 of 1968 (DFL2). Lastly,unincorporated businesses in several activities (among them agriculture and transport) and small businesses are favored by simplified accounting rules, which in practice means that most of their income is tax exempt.

In addition, the Chilean tax law allows individuals to set up a company, transform part of their personal incomes into business income, compute various expenses as costs, and pay the flat 15% business tax on profits. As long as earnings are not distributed they avoid the highest brackets of the GC tax. This enables individuals both to smooth their tax burden and to postpone paying the GC tax. Moreover, several schemes allow them to partially avoid the top brackets of the GC tax altogether. For example, relatives in lower brackets may own part of the company, the company may buy assets that are used in personal consumption, or the business can be sold after accumulating profits and be favored by exemptions granted to non-habitual capital gains.

Table 1 shows the yield of each direct tax both as a percentage of total tax revenues and as a percentage of GDP. It can be seen that in 1996 direct taxes accounted for 29.5% of total tax revenues (5.4% of GDP). There are two direct taxes that we ignore in this study because we lack the data needed to allocate them to households: A yearly property tax and an inheritance tax which jointly represent 4.2% of total tax revenues. Moreover, for obvious reasons we do not consider the additional tax paid by foreign corporations when profits are paid out at their headquarters, and the business tax paid by state-owned companies.

2.2. Indirect taxes

The main indirect taxes in Chile are a comprehensive VAT which in 1996 was levied on most transactions at the uniform rate of 18%, a general uniform import tariff of 11%, [15] and a series of excise taxes levied on particular goods like alcohol, tobacco, gasoline and luxury goods (e.g., jewelry, most cars, lotteries and furs). Some goods and services are exempted from VAT, notably professional, educational and health services, transportation, and cultural and sports events. As

[14] This break has often been criticized for favoring the ‘rich’.

[15] Because of several free trade agreements, imports from some countries pay lower tariffs. Also, selected imports pay antidumping counterveiling duties.

Table 1
Chilean tax system (1996)

	% of total revenue	% of GDP
Direct taxes		
Business tax	12.8	2.3
Personal taxes[a]	7.9	1.5
Inheritances	0.2	0.0
Real estate	4.0	0.8
Foreign corporations	3.4	0.6
State-owned corporations	1.2	0.2
	29.5	5.4
Indirect taxes		
VAT	42.2	7.7
Alcohol and tobacco	4.7	0.9
Gasoline	7.4	1.4
Luxury	1.6	0.3
Import tariffs	10.8	2.0
Bank operations	3.7	0.7
	70.5	13.0
Total	100%	18.4

[a] Net of business tax credit.
Source: SII.

can be seen from Table 1, indirect taxes account for more than 70% of tax revenues (13% of GDP). In the exercises below we ignore the indirect tax that is levied on bank cheques and credit operations, because we lack the data needed to impute this tax to households (it amounts to 3.7% of total tax revenues).

3. Concepts, data sources and methodology

3.1. Definition of income

This paper focuses on income distribution at the household level. By ‘income of a household’ we mean the sum of the incomes of the members of the household. These incomes are those received from work, retirement and subsistence pensions, allowances for the disabled, interest paid by firms and financial institutions, profits distributed by firms, consumption of own production, private transfers (e.g., alimony payments and allowances) and imputed income from housing. This definition does not consider any accrued income or government transfers. It therefore excludes: (a) Profits that firms did not distribute during 1996. (b) Government transfers in money or kind. (c) Proceeds from the sale of financial or physical assets. Company profits are excluded because our source of data on income, the CASEN survey, does not identify to whom profits retained by firms belong.[16] For the same reason, we are not able to impute the income received through companies formed to avoid the higher brackets of the GC tax. Government transfers (e.g., family allowances, welfare payments) are not included because our aim is to estimate the distributive impact of the tax system prior to any government redistribution.

We measure income on an annual basis. As is well known, there are several reasons why current income may not be an appropriate measure of the lifetime income of an individual: the individual may be unemployed during the year the survey was taken; some individuals are subject to considerable yearly income fluctuations; incomes vary over the life cycle, and towards the end of their lives people tend to consume part of their savings. Thus, for example, a person whose current income is low may have a high permanent income and be intertemporally wealthy. Unfortunately, there is no data in Chile to carry out a study of intertemporal incidence. As regards our aim in this paper, it should be noted that studies which have estimated income distribution over the life cycle in developed countries usually find that inequality is considerably less than that suggested by annual studies.[17] Second, when the definition of intertemporal income is used, saving is not necessarily exempt from consumption taxes. This point is important, for in the next section we find that in Chile VAT is regressive, largely because income saved during a given year does not pay this tax, and the wealthiest deciles save a larger fraction of their incomes. It follows that the regressivity of the VAT would be less if one considered an intertemporal framework.

3.2. Data requirements

As we already mentioned, in Chile, the income tax is levied at the individual, not at the household level. Therefore, to estimate the distributive impact of the tax system at the household level we need the following information.

- Amount and origin of income actually received by each of the individuals in the household.
- Compliance of each individual, that is the fraction of income that each individual declared.
- Tax-free allowances that benefit each individual.
- Distribution of each household's spending on each type of good, as well as its level of spending, so as to estimate the amount that the household pays in each indirect tax.
- The incidence of each tax.

[16] Ockner and Pechman (1974) distribute profits retained by firms in proportion to each individuals dividend income. The 1996 CASEN survey includes dividend incomes, yet these correspond to only 3.4% of actual dividends paid out by firms. For this reason, we decided to exclude retained profits from incomes.

[17] See chapter 1 of Fullerton and Rogers (1993) for a review of studies of intertemporal incidence.

Ideally, we would like to obtain all the data from the same source: taking a sample of households for which one knows each of its income sources, its consumption patterns, the tax-free allowances it was granted and what it paid in each tax. However, in Chile, no sample of households with these characteristics is available, so instead we use several sources and make assumptions to splice them together. [18] Below we briefly describe our data sources, the assumptions on incidence we make and the methodology we use to calculate taxes. A detailed description is relegated to a rather lengthy Methodological Appendix, available upon request from the authors.

3.3. The data

3.3.1. Incomes

The incomes of each individual and household were estimated with data from the 1996 CASEN survey. This is a biannual survey taken by the Planning Ministry. In 1996, it comprised 134,262 individuals from 33,967 households. The survey separates the income of each individual into its different sources and allows us to identify the household to which the individual belongs. Our calculations assume that each individual reports her true income. Survey data were adjusted by ECLAC [19] so that once the appropriate weights are applied total per capita sample income coincides with the national accounts figures for each income category. [20] Table 2 shows the top, bottom and average monthly per-capita income of households in each income decile, before taxes (all the figures we present are in US dollars of November of 1996).

3.3.2. Direct taxes

The SII database contains data on 385,075 taxpayers of GC and 371,779 taxpayers who pay only the wage tax. These correspond to 1997 income tax returns (fiscal year 1996). Column 2 in Table 3 shows the number of taxpayers by income bracket according to SII data.

3.3.3. Allowances

The amount of tax-free allowances corresponding to Article 57 bis., letters (a) and (b), deducted by each individual was estimated using data from the SII

[18] In their classic study, Ockner and Pechman (1974) also splice different data sources. However, the information available allowed them to make more precise splices than those permitted by the data available in Chile.

[19] The United Nation's Economic Commission for Latin America and the Caribbean.

[20] The proportional difference between the CASEN and national account data is imputed uniformly for each income category. The one exception is capital income, which is fully imputed to the top quintile of households.

Table 2
Household monthly per-capita income before taxes (in Nov. 1996 dollars)

Decile	1 Minimum US$	2 Maximum US$	3 Average US$
1	0	52	33
2	52	78	65
3	78	105	91
4	105	135	119
5	135	169	151
6	169	217	193
7	217	287	249
8	287	405	341
9	405	665	512
10	665	28,940	1457

database described in the previous paragraph. In 1996, 50,700 taxpayers took advantage of letter (a) of Article 57 bis., deducting slightly more than US$208 million from their taxable base. A further 5791 taxpayers took advantage of letter (b) allowing them to deduct slightly less than US$9 million from their tax burden. Moreover, most residential housing income is favored by the DFL2 allowance. In fact, according to estimations of the SII, only 20% of residential real estate incomes did not benefit from the DFL2 allowance in 1996. Finally, allowances that favor small businesses and unincorporated businesses in particular sectors are not accounted for, because we lack the data to impute them. For this reason, in the calculations that follow we are unable to distinguish between income that was legally not declared and outright tax evasion. [21]

3.3.4. Composition and level of consumption

The consumption patterns of each household was estimated on the basis of the EPF carried out by the INE in Greater Santiago between August 1996 and July 1997. To estimate the tariffs paid by each household when consuming imported goods, one needs to know what fraction of their expenditure falls on imports and traded goods, not only of final goods, but also inputs used in producing domestically produced final goods. The IOM calculated by the Central Bank of Chile for 1986 was used to determine the foreign content of domestically-produced goods, both traded and non-traded. Consumption shares were calculated using the EPF data.

[21] We will see in Section 3.5 that, at the aggregate level, 95% corresponds to evasion and only the remaining 5% to legally undeclared income.

Table 3
Taxpayers by income bracket

Bracket (monthly US$)	1 Tax rate (%)	2 IRS	3 CASEN
659–1647	5	508,475	825,463
1647–2746	10	132,613	200,608
2746–3845	15	53,162	65,029
3845–4943	25	27,315	30,321
4943–6591	35	19,002	26,367
Larger than US$6591	45	16,273	32,970

3.3.5. Impact of indirect taxes charged on inputs

Import tariffs and the specific tax on gasoline affect the prices of inputs used in the production of final goods consumed by households. [22] The IOM was used to estimate the impact of indirect taxes on the prices of final goods. For each type of good included in the IOM, coefficients were estimated enabling us to determine what fraction of a household's spending on a given type of good corresponds to the indirect payment of a tariff or gasoline tax.

3.4. Incidence assumptions

We assume that direct taxes (business, wage and GC) are paid wholly by the taxed factors, whereas indirect taxes (VAT, tariffs, and excise taxes) are paid entirely by consumers. We also assume that the savings rate is exogenous, and that the fraction of a household's income spent on each good is independent of the tax structure; [23] these are standard assumptions in the literature (see for example Ockner and Pechman, 1974, Chap. 3). [24] Finally, in the case of Chile it is reasonable to assume that the business tax is not passed on to consumers, because almost all types of businesses are subject to it.

There are two scenarios (at least) under which these assumptions are appropriate and consistent. First, a small open economy where all goods are tradable, and purchasing power parity (PPP) holds. Under such conditions, direct taxes cannot be passed on to consumers because they would switch towards imported goods.

[22] The excise tax on gasoline is levied only when gasoline is used as an input of transport services.
[23] The latter holds when the utility function of the household is Cobb–Douglas.
[24] Shah and Whalley (1991) strongly criticize these assumptions for developing-country studies. They point out that import quotas, price controls and black markets, the fact that income taxes tend to be paid only in cities and corruption associated with tax evasion radically change incidence patterns. However none of these apply to Chile: quotas and price controls are virtually nonexistent; income taxes are also monitored in the rural sector, which, in any case, is small; and corruption in tax administration is, by international standards, low.

On the other hand, if both national and foreign goods are subject to indirect taxes, these will be passed on to consumers. The second scenario is that of a closed constant-returns-to-scale economy with Leontief production functions, together with perfectly inelastic factor supplies. In this case any direct tax falls on factors (because their supply is perfectly inelastic) and all indirect taxes are transferred to consumers, because supply prices are determined solely by technology. Note that the national accounts, which we use to estimate the impact of indirect taxes, are constructed on the basis of these assumptions.

Finally, we assume that only profits distributed by firms affect the distribution of income, and that the business tax is paid wholly by those who receive those profits. As we have already mentioned, company profits that are not distributed do not enter our calculation of the income distribution.

3.5. Determination of the tax burdens

The distribution of household incomes can be constructed on the basis of income data obtained from the adjusted CASEN survey. [25] The distributional impact of the tax system, and its progressivity, are found by substracting an estimate of what each household pays in direct and indirect taxes from its incomes. We now describe the methodology for estimating the amount of direct taxes paid by each household. [26]

3.5.1. Amount paid in direct taxes

As we mentioned before, income taxes in Chile are personal. Therefore, to estimate the direct tax burden borne by each household, we first estimate the direct taxes paid by each individual and then add up these amounts across individuals within each household. It should be stressed that, contrary to standard studies, we do not allocate to the different deciles the actual amount of taxes paid. Instead we (i) estimate the actual and reported income of each individual; (ii) estimate the amount in allowances that each individual deducted from reported income; and (iii) apply the statutory income tax schedule to estimated reported income net of allowances. Thus, we obtain an estimate of the tax paid by each individual, which can be compared with the actual figure. This is the main methodological departure from studies in the Pechman–Ockner tradition. Underreported income and tax-free allowances benefiting each individual are estimated according to the following procedure.

(1) The CASEN database does not indicate which home rental income is favored by the DFL2 allowance. To determine which home rental incomes from

[25] Some income from the CASEN survey is collected on an after-tax basis. For details on how we obtained pre-tax estimates of these incomes see the Methodological Appendix.

[26] In the following discussion we leave out certain details that may be found in the Methodological Appendix.

those reported in CASEN benefited from this allowance, we proceeded as follows. We classified both the home rental reported in the SII and the CASEN data bases into 8 groups, in ascending order of income. The number of properties was smaller in the SII database, because income favored by the allowance must not be reported. For each of the 8 groups, the CASEN's rental incomes that did not benefit from the DFL2 allowance were determined by choosing a random sample (of incomes within the CASEN group) of size equal to that of the corresponding SII group.

(2) CASEN incomes from interests on deposits was only 4.5% of that calculated by National Accounts; the number of individuals reporting interest incomes was also much smaller than the true number. For this reason we calculated the average interest income in every decile among those who reported such incomes, and imputed this income to a random sample of individuals within that decile. In doing so we selected the sample size so that aggregate figures after correction match those of National Accounts. [27]

A similar procedure to that described in the previous point was used to adjust CASEN incomes from dividend payments. [28]

(3) To determine the amount of income tax that individuals chose to pay we proceeded as follows: Individuals in the CASEN database whose incomes are high enough to be subject to income tax were separated out. [29] The procedure was then repeated with taxpayers in the SII database. In both cases individuals were grouped into centiles. [30] Table 3 shows the number of taxpayers declaring income to the SII by income bracket, and the number that should have declared according to the CASEN survey.

(4) The number of non-filers is defined as the difference between the number of individuals in the CASEN survey with incomes high enough to be subject to the income tax, and those individuals who actually filed a tax return with the SII. A total of 423,904 individuals were classified as non-filers. To estimate the income of non-filers, a sample of individuals of size equal to this number was drawn among CASEN individuals and assumed to be the non-filers. The sample was obtained as follows. We assumed that those with annual incomes higher than

[27] The usual correction consists in multiplying all interest incomes by a correction factor (in our case: 22.2 = 100/4.5). This leads to implausible interest incomes for most individuals reporting such incomes. Our procedure is designed under the assumption that a large number of individuals that received interest incomes forgot to report them in the CASEN survey. See the Methodological Appendix for additional details.

[28] Aggregate underreporting was even larger than with interest incomes, which forced us to use additional information. See the Methodological Appendix for details.

[29] In addition, individuals subject to the income tax are divided into GC taxpayers and wage taxpayers, so as to impute the allowances provided by Article 57 bis only to the former.

[30] It is worth remembering that it is not possible to identify individuals covered by the CASEN survey in the SII data base, as the tax ID numbers of those surveyed are not recorded.

US$28,500 (15% of all taxpayers) always report at least some of their income to the SII. For the rest, the probability of not reporting decreases linearly with income. The distribution was parameterized so that (a) the probability of not filing is zero for incomes equal to US$28,500; and (b) the expected number of non-filers is equal to the actual number of non-filers. Table 4 ranks CASEN individuals according to their taxable (monthly) income bracket. The first two columns show the estimated number of non-filers by income bracket; column 3 shows the amounts underreported.

(5) To estimate the amount underreported by filers, we ranked by income percentile those CASEN individuals who were not randomly excluded, and compared the sum of the incomes in each percentile with the sum of incomes declared to the SII by the equivalent percentile. [31,32] The difference is the amount underreported by that percentile. Within each percentile of the CASEN survey, underreporting is distributed proportionately to the income of each individual. The third and fourth columns of Table 4 show the number of filers and the amount underreported by income bracket. For example, underreporting by individuals with incomes large enough to fall in the top bracket is 41% of income.

(6) Tax allowances under Article 57 bis., letters (a) and (b) for each individual in the CASEN survey were imputed following a similar approach to the one used to impute underreporting. For each percentile of the CASEN survey the individuals benefiting from Article 57 bis allowances were chosen via a random sample of size equal to the actual number of beneficiaries in the corresponding SII percentile. The size of the allowance for an individual that was selected was set proportional to her income, with the constant of proportionality chosen so that the percentile's allowance is equal to that of the corresponding SII percentile.

(7) Last, the taxable income declared by each individual in the CASEN survey was obtained by subtracting underreporting from their true income. The amount of tax paid by each taxpayer was then obtained by applying the corresponding GC structure of rates and Article 57 bis. allowances.

Once we know the incomes before and after paying the income tax for each individual, it is possible to construct the income distribution at the household level. Since each individual in the CASEN survey belongs to a household, the income of every household, both before and after paying direct taxes, can be found by adding together the incomes of its members. The impact of changes in the tax structure is found by repeating this exercise with new tax parameters.

[31] As mentioned before, this underreporting does not necessarily amount to evasion, because some taxpayers declare less income than their true total income. The CASEN survey does not enable us to identify incomes that do not pay tax for this reason, yet at the aggregate level they account for only 5% of the income tax evaded.

[32] The wealthiest decile accounts for 57% of percent of the total amount underreported.

Table 4
CASEN individuals by income bracket

Monthly income bracket	1 # Non filers	2 # Filers	3 Amount underreported (MMUS$)	4 Amount reported (MMUS$)	5 3/(3+4)
US$659–1648	392,126	433,337	5081	4876	0.51
US$1648–2746	29,351	171,257	1501	3624	0.29
US$2746–3845	0	65,029	600	1980	0.23
US$3845–4943	0	30,321	461	1105	0.29
US$4943–6591	0	26,367	539	1257	0.30
Larger than US$6591	0	32,970	1824	2670	0.41

3.5.2. *Amount paid in indirect taxes*

The amount of indirect taxes paid by each household is estimated as follows.

(1) A tax on transactions can affect the price of final goods both directly (if the final good itself is taxed) and indirectly (if the inputs into the final good are taxed). For this reason, to estimate the effect of indirect taxes on the prices of final goods we used the coefficients from the IOM. Using this information together with the tax rates applied to different goods, the fraction of the final price corresponding to each of the indirect taxes was calculated for each type of good in the IOM classification. [33]

(2) The composition of household expenditure on 467 goods and services was obtained from the EPF at the decile level. These goods were grouped in 74 categories that matched the IOM classification and the tax structure existing in 1996. [34] Households covered by the family expenditure survey were ordered by income decile, and for each decile the expenditure of the average household was calculated. This spending pattern was then assumed to be representative of the expenditure of all households in that decile.

(3) Indirect taxes paid by households were computed as follows. Goods were classified into the 74 categories mentioned in the previous point; we assumed that all goods within the same category paid the same rates. The fraction of income paid by each household in indirect taxes was obtained by adding together, over all categories of goods considered in the IOM, the product of (a) the fraction of the final price of each category attributable to each of the indirect taxes (point 1), [35]

[33] The details of this procedure and those described in the following points can be found in the Methodological Appendix.

[34] It was not possible to use directly the IOM classification because some goods grouped in the same category by the IOM were affected by different taxes.

[35] This fraction was estimated considering the IOM classification of each category. In this way, two categories that belong to the same IOM group have the same fractions.

and (b) the expenditure of the representative household on each category, expressed as a fraction of its income (point 2).

Using the results obtained in the previous points, for each household in the CASEN survey the percentage of total expenditure used in paying each indirect tax was estimated. CASEN survey households were grouped in deciles (in the same order as EPF households), and the amount paid in each indirect tax was obtained by adding over the different goods. The impact of changes in the structure of indirect taxes was obtained by repeating this procedure with new parameters. Note that, as with the income tax, we are not allocating the actual taxes paid, but estimating the amount that should have been paid by each household given our incidence assumptions.

4. Results

In this section, we present the results of a series of exercises we carried out with the model described in Section 3. In Section 4.1 we examine the distributive consequences of the 1996 tax structure. We conclude that the tax structure had little effect on the distribution of income and was slightly regressive. Section 4.2 suggests that this result is not due to avoidance or evasion: we show that even if all incomes had paid the tax due on them, the distribution would not have changed much. Finally, in Section 4.3 we show the distributional impact of four big changes to the tax structure: the abolition of import tariffs, a rise in VAT from the actual rate of 18% to 25%, a doubling of the rate of the gasoline tax and the substitution of a flat tax for the present progressive income tax. In each case we conclude that the distributional impact is surprisingly small.

4.1. The distribution of the tax burden in 1996

Column 1 in Table 5 shows the distribution of income by deciles in 1996 before any tax is paid. The Gini coefficient is 0.488, and the ratio between the incomes of the wealthiest and the poorest quintile (henceforth ‘ratio’) is equal to 13.4. It is clear that income is very unequally distributed: the wealthiest quintile receives 56.2% of total income against 4.2% of the poorest quintile.

Column 2 in Table 5 shows the after-tax income distribution. This is slightly *more* unequal than the pre-tax distribution. The Gini coefficient rises from 0.488 to 0.496, and the ratio goes up from 13.4 to 14.1. Column 3, which shows the fraction of income that each decile pays in taxes, suggests why the 1996 tax system marginally worsened the distribution. On average the five poorest deciles paid 15.3% of their incomes in taxes, compared with 13.0% paid by the five wealthiest deciles. The second decile is the group that pays the largest fraction of its income in taxes (16%) whereas the tenth decile pays the lowest rate (11.8%).

To see why the Chilean tax system is slightly regressive, it is useful to look at the last three columns of Table 5 which show the progressivity of the income tax,

Table 5
Before- and after-tax income distribution

Decile	1 IS pre-tax	2 IS after	3 Progressivity tax system	4 Progressivity income tax	5 Progressivity VAT	6 Progressivity other taxes
1	1.45	1.40	14.4	0.00	11.0	3.42
2	2.74	2.63	16.0	0.00	11.8	4.20
3	3.77	3.61	15.8	0.00	11.4	4.33
4	4.73	4.59	15.2	0.00	10.9	4.25
5	5.57	5.47	15.0	0.01	10.7	4.21
6	6.76	6.64	14.3	0.04	10.2	4.07
7	8.22	8.20	13.8	0.11	9.7	4.00
8	10.60	10.61	13.1	0.23	9.0	3.85
9	15.42	15.75	12.2	0.62	8.0	3.54
10	40.75	41.09	11.8	2.54	6.3	2.96
Gini	0.4883	0.4961				
Ratio	13.41	14.12				

the VAT, excise taxes (gasoline, jewelry, tobacco, etc.) and import tariffs. On the one hand, the regressivity of the VAT is evident: the highest-income deciles pay a smaller fraction of their incomes in VAT. The only exception is the poorest decile which spends a smaller fraction on VAT than deciles 2 and 3, because a significant part of this group's consumption is not subject to VAT as it constitutes consumption of own production. [36,37]

The income tax, on the other hand, is clearly progressive, yet the revenue it raises is small. [38] Only the wealthiest decile pays more than 1% of its income in income tax, and even in this case its average rate is only 2.54%, compared with 6.3% paid in VAT and 2.96% paid in other taxes. [39]

[36] It should be noted that if the only tax were VAT charged at a rate of t percent, a family that consumes all its income in goods subject to this tax would pay a fraction equal to $t/(1+t)$ percent in tax. Thus, with VAT at 18%, the family would pay 15.25% of its income in tax. Nevertheless, since we assume that evasion only benefits producers, the 7% rate which appears in Table 6 suggests that only 46% of the income of the wealthiest decile pays VAT. This is because the wealthiest decile has a higher savings rate, and several items of consumption, personal services in particular, are not subject to VAT. In fact, the fraction of expenditure not subject to VAT is slightly above 20% for all deciles.

[37] As has been mentioned in the previous section, considering annual incomes probably exaggerates the regressivity of the VAT.

[38] Fontaine and Vergara (1997) emphasize this point.

[39] It is important to remember that our definition of income does not include undistributed profits of investment companies set up to avoid the highest marginal rates of GC tax. If these were included, income would be even more concentrated, since one reason for setting up such a company is to avoid marginal tax rates above 15% (the business tax rate) and incomes at this level are only found in the wealthiest decile. Nevertheless, since profits retained in a company pay an average rate of 15%, the progressivity of the income tax would probably increase.

4.2. Scenario with neither underreporting nor allowances

The meager revenue performance of the income tax is surprising, although it does coincide with the impression widely held in Chile that 'everybody avoids the income tax'. An interesting exercise is to calculate whether the income distribution would become more equal if both tax-free allowances and underreporting were completely eliminated. In so far as the assumptions of our model are valid, this exercise sets an upper bound on what the 1996 tax system could have achieved in terms of income distribution.

Table 6 shows income distribution and progressivity of the income tax when (a) only tax-free allowances are eliminated, and (b) both tax-free allowances and underreporting of income are eliminated. Column 1 shows again the income distribution resulting from the 1996 tax structure, and column 4 shows the progressivity of the corresponding income tax.

The second column of Table 6 shows that the effect of allowances (mainly Article 57 bis, and DFL2) on the distribution of income is irrelevant: the income share of the wealthiest decile goes down slightly from 41.09% to 40.99%; the progressivity of income tax (column 4) rises marginally. A somewhat greater impact would be achieved by eliminating underreporting, which is significant as we saw in the previous section. The third column of Table 6 shows that, in this case, the share of the wealthiest decile falls to 39.35% of total income. The Gini coefficient improves from 0.496 to 0.484, whereas the ratio falls from 14.1 to

Table 6
Scenario with neither underreporting nor allowances

Decile	1 IS1	2 IS2	3 IS3	4 PIT1	5 PIT2	6 PIT3
1	1.40	1.40	1.44	0.00	0.00	0.00
2	2.63	2.64	2.71	0.00	0.00	0.00
3	3.61	3.62	3.73	0.00	0.00	0.00
4	4.59	4.60	4.74	0.00	0.00	0.01
5	5.47	5.48	5.64	0.01	0.02	0.03
6	6.64	6.66	6.87	0.04	0.05	0.11
7	8.20	8.22	8.45	0.11	0.12	0.25
8	10.61	10.62	10.90	0.23	0.25	0.54
9	15.75	15.78	16.17	0.62	0.65	1.29
10	41.09	40.99	39.35	2.54	2.68	5.99
Gini	0.4961	0.4954	0.4837			
Ratio	14.12	14.07	13.37			

IS: Income Share.
PIT: Progressiveness of the income tax.
Scenario 1: Tax system in 1996.
Scenario 2: Tax system in 1996 without allowances.
Scenario 3: Tax system in 1996, with neither underreporting nor allowances.

Table 7
Monthly income distribution: richest decile

Percentile	1 Minimum (US$)	2 Maximum (US$)	3 Average (US$)
91	665	720	692
92	720	776	748
93	776	841	807
94	841	929	886
95	929	1055	983
96	1056	1205	1124
97	1206	1465	1328
98	1465	1829	1630
99	1830	2510	2145
100	2518	28,939	4209

13.3. However, while this is the biggest change in income distribution we shall see in this section, it is still far from impressive, especially when one considers that it assumes that income tax evasion is completely eliminated. It is interesting to mention that the second-richest decile is the one that increases its after tax share in income the most, rising from 15.75% to 16.17%. Any improvement among the poorest deciles is minimal: for example, the poorest decile raises its income share from 1.40% to 1.44%. The share of the wealthiest decile share is the only one that falls, but not by much, from 41.09% to 39.35%.

The last column of Table 6 shows that if both underreporting and tax-free allowances are eliminated, the average tax rate of the wealthiest decile rises from 2.54% to 5.99%. This average rate is low if we consider that in 1996 the top marginal rate was 45% for individuals with monthly incomes over US$6591. Table 7, which shows the distribution of income within the wealthiest decile, reveals why the revenue potential of the income tax is so small. One needs to get to the 97th *percentile* to find households whose monthly per-capita income is above US$1250. In other words, a significant fraction of households in the 'wealthiest' decile are not so wealthy after all, so the revenue potential of a progressive income tax is low. [40]

[40] It is important to remember, however, that the distribution figures are calculated without including profits retained by firms. Therefore, the figures we have at our disposal do not allow us to identify income retained by investment companies formed to postpone/avoid/evade the GC tax. Furthermore, it is important to note that the CASEN survey is not intended to characterize the wealthiest percentile, so the probability that the country's really wealthy households are surveyed is low. On the other hand, there is additional evidence showing most people in the wealthiest decile are not rich: Only 78,400 homes in Chile were valued by the government at more than US$70,000 in 1996. Hence, making the conservative assumption that government valuations underestimate market value by a factor of two, we have that less than 3% of Chilean families live in homes worth more than US$140,000.

4.3. Radical modifications of the 1996 tax structure

The results reported above suggest that the 1996 tax structure did not greatly affect the distribution of income. To see whether this conclusion holds for a variety of possible modifications to the tax structure, in this section we explore the distributional impact of four radical changes: (a) increasing the VAT rate from 18% to 25%; (b) abolishing import tariffs; (c) doubling the excise tax rate on gasoline; and (d) substituting a flat tax for the current income tax. It should be noted that our exercises are not designed to be revenue neutral.

Table 8 suggests that the distributive impact of the three first changes is not large (columns 2, 3 and 4). Particularly surprising is the negligible impact caused by the increase in VAT. The Gini coefficient goes up marginally from 0.4883 to 0.5003, and the ratio from 14.12 to 14.44. The wealthiest deciles share of income grows from 41.09% to 41.47%, whereas the shares of the other deciles fall slightly. The distributive impacts of eliminating tariffs or doubling gasoline taxes are even smaller (columns 3 and 4), although the distribution does improve slightly.

The Flat Tax has been under discussion for some time in the United States, its main academic advocates being Hall and Rabushka (1996). The main virtue of this tax is that it supposedly favors saving, apart from allowing considerable simplification in tax administration. However, it is criticized for being regressive. Here we examine the effects of a flat tax that leaves the first US$2196 of monthly income

Table 8
Three radical modifications

Decile	1 IS1	2 IS4	3 IS5	4 IS6
1	1.40	1.37	1.43	1.40
2	2.63	2.59	2.71	2.64
3	3.61	3.54	3.69	3.62
4	4.59	4.52	4.68	4.60
5	5.47	5.42	5.53	5.48
6	6.64	6.59	6.78	6.66
7	8.20	8.15	8.22	8.19
8	10.61	10.56	10.63	10.60
9	15.75	15.78	15.69	15.73
10	41.09	41.47	40.66	41.09
Gini	0.4883	0.5003	0.4906	0.4958
Ratio	14.12	14.44	13.64	14.08

IS: Income share 1996.
Scenario 1: Tax system in 1996.
Scenario 4: Tax system in 1996 with 25% VAT.
Scenario 5: Tax system in 1996 without import tariffs.
Scenario 6: Tax system in 1996 doubling the excise rate on gas.

Table 9
Flat-tax

Decile	1 IS1	2 IS7	3 IS8	4 PIT1	5 PIT7	6 PIT8
1	1.40	1.38	1.41	0.00	0.00	0.00
2	2.63	2.61	2.65	0.00	0.00	0.00
3	3.61	3.58	3.64	0.00	0.00	0.00
4	4.59	4.55	4.63	0.00	0.00	0.00
5	5.47	5.42	5.52	0.01	0.00	0.00
6	6.64	6.59	6.70	0.04	0.00	0.00
7	8.20	8.14	8.28	0.11	0.00	0.00
8	10.61	10.51	10.70	0.23	0.00	0.00
9	15.75	15.74	16.01	0.62	0.03	0.14
10	41.09	41.49	40.47	2.54	1.28	3.48
Gini	0.4883	0.4995	0.4925			
Ratio	14.12	14.35	13.92			

IS1, PIT1: Income share and progressiveness of income tax. Tax system in 1996.
IS7, PIT7: Income share and progressiveness of income tax. Flat-Tax.
IS8, PIT8: Previous case with neither underreporting nor allowances.

exempt. [41] The flat tax is interesting because it represents a radical change to the tax in force in 1996 and apparently ought to significantly worsen the income distribution. [42]

Table 9 shows the distributional impact of a reform of this type. The first and fourth columns once again show the income distribution in 1996. Columns 2 and 3 show the distributive impact of the flat tax, in the first case assuming no change in allowances and underreporting, and in the second case assuming that both are completely eliminated. As a flat tax ought to reduce underreporting because it facilitates enforcement by tax authorities and makes avoidance less worthwhile, it is to be expected that the actual effect of a reform of this type would fall between the two scenarios considered.

Table 9 suggests that the regressive impact of a flat tax of the type considered is surprisingly small. When the current tax-free allowances are maintained, together with the same level of underreporting, the fraction of income received by the wealthiest decile rises from 41.09% to 41.49%; the Gini coefficient rises slightly from 0.4883 to 0.4995, and the ratio from 14.12 to 14.35. If tax-free allowances and underreporting are eliminated, the income distribution would be

[41] A flat tax proposal typically includes an exempt bracket, so as to give it a certain degree of progressivity.

[42] Even though the tax-free bracket mentioned above makes the flat tax progressive, it is less progressive than the current income tax. The tax-exempt bracket was chosen so that no taxpayer ends up paying a higher average rate than with the current tax structure.

slightly better than that obtaining under the 1996 tax structure. The wealthiest decile's share decreases only marginally, from 41.09% to 40.47%.

5. Some unpleasant redistributive arithmetic

The results in the previous section suggest that changes in the progressivity of the tax system do not affect the distribution of income significantly, even when quite radical modifications of the tax structure are considered. In this section we perform some simple arithmetic exercises that suggest why this is so. [43] We show that the amount a tax levies has a larger redistributive impact than its progressivity. Furthermore, the difference between both determinants of redistribution is larger when the distribution of incomes before taxation is more unequal.

For the discussion that follows we need some notation. Let λ_i denote the share of income of the ith decile before taxes and redistribution, t_i denote the average tax rate paid by the i-th decile, and $t \equiv \sum_{j=1}^{10} \lambda_j t_j$ denote the share of total income paid in taxes. Then the share in income of the ith decile after taxes but before redistribution (this is the measure reported in the tables presented in the previous section) is [44]

$$\lambda'_i \equiv \frac{1-t_i}{1-t}\lambda_i. \tag{1}$$

Let $(1-\alpha)\beta_i$ denote the share of government transfers that reaches the ith decile, with $\sum_i \beta_i = 1$ and α denoting the fraction of income lost in redistribution. Then the share of income of the ith decile after taxes and redistribution is

$$\lambda''_i = \frac{1}{1-\alpha t}\left[(1-t_i)\lambda_i + (1-\alpha)t\beta_i\right]. \tag{2}$$

From Eqs. (1) and (2), it follows that the change in the share of income of the ith decile is

$$\lambda''_i - \lambda_i = \frac{1-\alpha}{1-\alpha t}t\beta_i - \frac{t_i-\alpha t}{1-\alpha t}\lambda_i, \tag{3}$$

which is equivalent to:

$$\lambda''_i - \lambda_i = \frac{1}{1-\alpha t}\left[(t-t_i)\lambda_i + (1-\alpha)(\beta_i-\lambda_i)t\right]. \tag{4}$$

Expression (3) decomposes the redistribution of income that results from the combined effect of taxation and government expenses, into two components. The

[43] Harberger (1998) presents examples making the same point.

[44] The expressions that follow assume that no individual changes deciles after paying taxes or after social expenditures take place. The tables in the preceding section do incorporate such changes.

decile's change in the share of income is the net result of what it receives in expenditures financed through taxation ($\beta_i t$ when $\alpha = 0$) and what it contributes towards financing these expenditures ($\lambda_i t_i$ when $\alpha = 0$).

Two extreme cases can be analyzed based upon Eqs. (3) and (4), where for simplicity we assume $\alpha = 0$. First consider a poor decile ($\lambda_i \simeq 0$). In this case

$$\lambda_i'' - \lambda_i \simeq \beta_i t, \tag{5}$$

so that, unless targeting is extremely bad, this decile improves its share of income, benefiting both from an increase in the overall tax burden and from better targeting. The poorest taxpayers care little about the progressivity of the tax system, since their tax burden is small compared to what they receive in any case.

Next consider the richest decile. It follows from Eq. (4) that this decile's share in income will decrease more the better targeted government expenditures are (larger $\lambda_{10} - \beta_{10}$), the larger the overall tax burden (larger t), the more progressive the tax rate (larger $t_{10} - t$) and the larger its original share of income (larger λ_{10}).

Next we consider some arithmetic exercises where we calculate the impact on income distribution of taxes and redistribution. The redistribution coefficients (the β's) in all the exercises that follow are chosen to mimic the actual distribution of transfers in Chile. [45] Table 10 shows the impact of a progressive income tax that generates the same average rates than the income tax in place in 1996, except that it takes 10% of the richest decile's income. This exercise assumes a progressivity of the income tax that is rather unrealistic and extreme: the average rate paid by the richest decile is more than three times the actual rate (2.54%) and almost twice the rate that would attain with no underreporting and tax brakes (5.99%). Column 1 reproduces the before-tax distribution in Chile in 1996. Column 2 shows the tax burden as a percentage of income. Column 3 shows the distribution of income after taxes are levied but before transfers. Column 4 shows the income distribution after taxes and transfers. For the poorest deciles the impact of taxes on their share

[45] Government expenditures are divided into three categories: pensions (27.7%), transfers (both in money and kind: (37.4%) and general expenses (34.9%). Our income measure includes pensions, thus we set $\alpha = 0.277$ thereby ignoring administrative costs and deadweight losses associated with taxation. To determine how well public transfers are targeted, we follow Schkolnik (1993) who finds that the poorest quintile receives 37.5% of all transfers, and the next four quintiles receive, respectively, 28.0%, 19.5%, 11.8% and 3.2%. We assume that each decile receives half of the expenditure of the quintile it belongs to. As to the distribution of general expenses, we assume that they are distributed uniformly across deciles. We report in footnotes how our findings change if we assume that these expenses benefit nobody (thus setting $\alpha = 0.626$). Finally we have that approximately 75% of government expenditures are financed with taxes; we assume that the same fraction of the three kinds of expenditures mentioned above are financed with taxes.

Table 10
Highly progressive income tax

Decile	1 λ_i%	2 t_i%	3 λ'_i%	4 λ''_i%
1	1.45	0.00	1.51	1.91
2	2.74	0.00	2.86	3.22
3	3.77	0.00	3.94	4.19
4	4.73	0.00	4.94	5.16
5	5.57	0.01	5.81	5.94
6	6.76	0.04	7.05	7.14
7	8.22	0.11	8.57	8.54
8	10.60	0.23	11.04	10.94
9	15.42	0.62	16.00	15.68
10	40.75	10.00	38.29	37.28
Gini	0.4883		0.4707	0.4506
Ratio	13.41		12.41	10.32

of income is quite small (see column 4). The reason, quite simply, is that with $t_{10} = 10\%$, $\sum_{j=1}^{10} \lambda_j t_j \equiv t = 4.21\%$, so that

$$\lambda'_i = \frac{\lambda_i}{1 - 0.0421} \cong \lambda_i \times 1.051.$$

In other words, while this progressive income tax decreases the share of the richest decile by almost 2.5 percentage points (from 40.75% to 38.29%), it increases the share of the poorest five deciles by little more than 4.13% of their pre-tax income share. [46] Thus, for example, the share of the poorest decile increases only by 0.06 points, from 1.45% to 1.51%. Levying this tax decreases the ratio from 13.41 to 12.41 and the Gini coefficient from 0.4883 to 0.4707. By contrast, redistribution has a far bigger impact, especially for the three poorest deciles.

The share of the poorest decile increases by 0.4 additional percentage points, almost 7 times the impact of the progressive tax. Also, with redistribution the ratio falls to 10.32 and the Gini coefficient to 0.4507. Thus, more than half of the improvement in income distribution, as measured either by the ratio or the Gini coefficient, [47] is attributable to redistribution, and not to the progressivity of the tax system.

Table 11 shows the effect of a 10% proportional tax. By definition, the after-tax income distribution does not change. The effect of redistribution, on the other hand, is stronger, because the average tax rate is higher. The ratio falls to 8.75 and

[46] Bird and De Wulf (1973) (p. 675) stress this point when they conclude that ''the principal potential role of the tax system in redistributive policy is not to make the poor richer, but the rich poorer''.

[47] In the case of the ratio it is more than two thirds.

Table 11
Proportional income tax

Decile	1 λ_i%	2 t_i%	3 λ_i'%	4 λ_i''%
1	1.45	10.00	1.45	2.42
2	2.74	10.00	2.74	3.62
3	3.77	10.00	3.77	4.39
4	4.73	10.00	4.73	5.28
5	5.57	10.00	5.57	5.89
6	6.76	10.00	6.76	6.99
7	8.22	10.00	8.22	8.18
8	10.60	10.00	10.60	10.38
9	15.42	10.00	15.42	14.69
10	40.75	10.00	40.75	38.14
Gini	0.4883		0.4883	0.4386
Ratio	13.41		13.41	8.75

the Gini coefficient to 0.4386. Thus, a realistic proportional tax improves the distribution of income more than an unrealistically progressive tax.

Analyzing how the share of income of every decile changes after taxation and redistribution can become rather cumbersome, since in the case of intermediate deciles both the decile's tax burden and what it receives in transfers may be significant. This motivates deriving a simple expression for the change in an aggregate measure of inequality.

Proposition 5.1 (Change in the Gini coefficient) *Assume that the absolute tax burden is increasing in before-tax income ($\lambda_i t_i < \lambda_j t_j$, for $i < j$),*[48] *and that the β_i's are decreasing in i. Denote by G_β and $G_{\lambda t}$ the Gini coefficients of the shares of expenditures (the β_i's) and the absolute tax burdens (the $\lambda_i t_i$'s). Denote the Gini coefficients of the income distribution before any taxes and redistribution, and after taxes and redistribution, by G and G'' respectively, and let $\Delta G \equiv G'' - G$. Then*

$$\Delta G = -\frac{t}{1-\alpha t}\left[(1-\alpha)G_\beta + G_{\lambda t} - \alpha G\right]. \tag{6}$$

In particular, for $\alpha = 0$,

$$\Delta G = -t\left[(G_\beta + G_{\lambda t}\right]. \tag{7}$$

[48] This assumption holds even if the tax system is somewhat regressive, given the degrees of inequality prevalent in most countries. In particular, it holds by a wide margin with the Chilean data presented in Table 5.

Table 12
Income distribution after government expenditures: Chile, 1996

Decile	1 λ_i%	2 t_i	3 λ_i'%	4 λ_i''%
1	1.45	14.4	1.43	2.70
2	2.74	16.0	2.64	3.80
3	3.77	15.8	3.65	4.47
4	4.73	15.2	4.61	5.34
5	5.57	15.0	5.44	5.87
6	6.76	14.3	6.66	6.97
7	8.22	13.8	8.14	8.10
8	10.60	13.1	10.58	10.30
9	15.42	12.2	15.56	14.59
10	40.75	11.8	41.30	37.83
Gini	0.4883		0.4959	0.4300
Ratio	13.41		13.97	8.06

Proof See Appendix A. ■

It follows directly from Eq. (6) that, for a given overall tax burden (value of t), a more progressive tax system (larger value of $G_{\lambda t}$) achieves a larger improvement in the Gini coefficient.

With a proportional tax system we have $G_{\lambda t} = G$. Thus, since most tax systems are not significantly regressive, the scope for improving the distribution of income via increased progressivity is limited to improving $G_{\lambda t}$ from G to 1. In this sense we have that if the initial distribution of income is more unequal, the scope for improving the distribution of income via increased progressivity is smaller. Furthermore, from Eq. (7) we see that increasing the progressivity of the tax burden, while the overall tax burden (t) remains fixed, offers less scope for improving the distribution of income than increasing the overall tax burden while the distribution of the tax burden remains unchanged. If the initial Gini is in the neighbourhood of 0.5, as is the case for many developing countries, the first strategy can improve the Gini by at most twice as much as the current redistribution of income does, while the second strategy faces no such stringent upper bound.

Table 12 shows the distribution of income with the tax structure in place in Chile in 1996, both before taxation and redistribution, and after taxation and redistribution. Even though tax collection is slightly regressive, after government expenses the distribution of income improves considerably: the ratio and Gini fall to 8.06 and 0.4300, respectively. [49] Table 13 decomposes the improvement of the

[49] If we assume that general government expenses do not benefit anybody, the ratio and Gini fall to 9.26 and 0.4512, respectively.

Table 13
Decomposition of decrease in Gini coefficient

Tax	Average rate (%)	% of change in Gini
VAT	8.27	55.9
Income	1.17	17.7
Additional	3.53	26.4
TOTAL	12.97	100.0

Gini into the contribution of the VAT, the income tax and indirect taxes. [50] Table 13 shows that more than half (56%) of the improvement in income distribution, as measured by the Gini coefficient, is due to the regressive value added tax. The highly progressive income tax accounts for less than one fifth (18%) of the improvement. This difference is explained by the fact that the VAT levies more than five times the amount levied by the income tax.

Since how well expenditure is targeted is unrelated to the progressivity of the tax system, when progressive and proportional taxes are equally costly to levy and cause the same deadweight loss, it is always better to levy a progressive tax. However, in practice indirect taxes are much easier to levy and administer than direct progressive income taxes. Moreover, the main indirect tax levied in Chile, the VAT, is less distortionary than income taxes. In Section 6, we present a simple model that enables us to study the determinants of the optimal tax structure when taxes are costly to levy.

6. Inequality and the optimal tax structure

In this section, we present a simple model of the optimal determination of the tax structure that incorporates the effectiveness in collecting alternative taxes, their progressivity, the distributional preferences of society and the extent to which government expenditures are targeted. We find that proportional taxes are more desirable the more *unequal* the pre-tax income distribution.

6.1. The model

Society consists of two individuals with, respectively, gross incomes of λ_r and λ_p, with $\lambda_r > \lambda_p$ and $\lambda_r + \lambda_p = 1$. The issue is how and how much to redistribute from the rich to the poor individual. We denote the after-tax-and-redistribution

[50] To obtain this decomposition we compute the change in Gini, after taxation and redistribution, for each tax separately, and then approportionate the total change based on these partial changes.

income of individual i by d_i and define $d \equiv d_r + d_p$ and $\Delta d \equiv d_r - d_p$. Similarly, $\Delta\lambda \equiv \lambda_r - \lambda_p$. [51]

The government can levy two taxes. The first is a proportional income tax, at rate t_1, that entails collection costs equal to a fraction α_1 of the tax collected. The second is a progressive income tax that is levied only on the rich individual, at rate t_2. This tax entails collection costs equal to a fraction α_2 of the tax collected. [52] The degree to which government expenditures are targeted to the poor individual is captured by the parameter $\beta \in [0,1]$, the fraction of any government expenditure that accrues to this individual. Last, we assume that the trade-off between inequality and the deadweight loss of tax collection is captured by a social welfare function that is increasing in the aggregate after-tax income and decreasing in after-tax income inequality. For simplicity we assume this function takes the following form:

$$S(t_1,t_2) \equiv d - \frac{c}{2}(\Delta d)^2, \tag{8}$$

where $c > 0$ captures the degree to which society cares about distributional issues. In Appendix B (Proposition B1) we show that maximizing this function is (almost) equivalent to maximizing the expected utility of an individual with constant absolute risk aversion coefficient c who ex ante is poor with probability $1/2$.

The following four constants will simplify our presentation:

$$K_1 \equiv (2\beta - 1)(1 - \alpha_1),$$

$$K_2 \equiv 1 + (2\beta - 1)(1 - \alpha_2),$$

$$L_1 \equiv \frac{(2\beta - 1) + \Delta\lambda}{(2\beta - 1) + (c\Delta\lambda)^{-1}},$$

$$L_2 \equiv \frac{2\beta c\Delta\lambda}{1 + c\Delta\lambda(2\beta - 1)}.$$

The first two are measures of the overall effectiveness of tax collection and expenditure targeting in redistributing income to the poor individual. Larger values of either constant are associated with a more efficient system; the largest possible

[51] Note that with two individuals $2\Delta\lambda$ is the Gini coefficient of the before-taxes-and-transfers income distribution.

[52] The α's can also be interpreted as representing the deadweight loss associated with both taxes. For simplicity we assume that they depend neither on the tax rate nor on the amount collected.

values are 1 for K_1 and 2 for K_2. Economic interpretations of L_1 and L_2 are presented shortly. It is also useful to define $M \equiv L_2/L_1$ and to note that

$$M = \frac{\beta}{\beta - \lambda_p}.$$

6.2. The optimal tax system

We study the problem of choosing a tax system (t_1, t_2) to maximize Eq. (8). We are interested in the dependence of the solution on the parameters of the problem: α_1, α_2, β, $\Delta\lambda$ and c. Since collection costs are linear, either none or only one of the taxes will be levied at the optimum, but not both. The following proposition characterizes the optimal tax system.

Proposition 6.1 (The optimal tax system) *Assume that $\beta > 1/2$.*[53] *Given the values of β, c and $\Delta\lambda$, Fig. 1 divides all possible combinations of α_1 and α_2 into three regions. In region 0, characterized by $\alpha_1 \geq L_1$ and $\alpha_2 \geq L_2$, it is optimal to levy no tax at all. In region 1, characterized by $\alpha_1 \leq L_1$ and $\alpha_2 \geq M\alpha_1$, it is optimal to levy only the proportional tax. The corresponding tax rate is*

$$t_1^* = \frac{\Delta\lambda}{\Delta\lambda + K_1} - \frac{\alpha_1}{c(\Delta\lambda + K_1)^2}.$$

Finally, in region 2, characterized by $\alpha_2 \leq L_2$ and $\alpha_2 \leq M\,\alpha_1$, it is optimal to levy only the progressive tax.[54] *The corresponding optimal rate is*

$$t_2^* = \frac{\Delta\lambda}{\lambda_r K_2} - \frac{\alpha_2}{c\lambda_r K_2^2}.$$

Proof See Appendix B. ■

The first statement in the proposition implies that it may be optimal to levy no tax at all when collection costs are high (large values of α_1 and α_2), society does not care much about inequality (low c), or initial inequality is low (small $\Delta\lambda$).[55] Better targeting of expenditures (an increase in β) implies that a given level of

[53] This assumption ensures that L_1 and L_2 in Fig. 1 are positive (see below). It may be relaxed at the expense of having to consider three additional figures.

[54] That these three regions define a partition of the unit square follows from the fact that $M = L_2/L_1$.

[55] A straightforward calculation shows that the partial derivatives of the L_i with respect to c and $\Delta\lambda$ are positive.

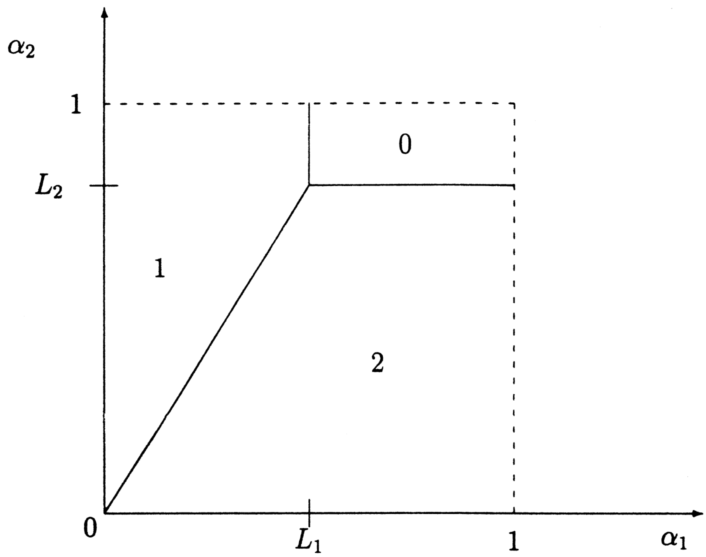


Fig. 1.

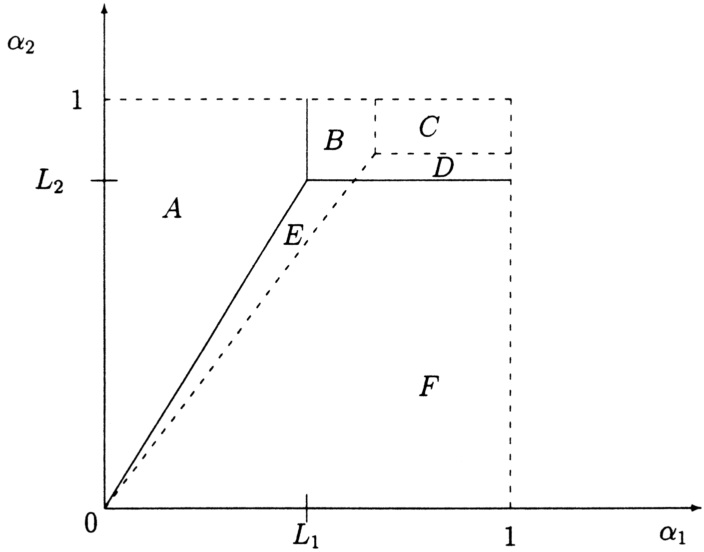
redistribution can be attained with lower taxes. If society does not value redistribution very much (low value of c) this makes levying taxes less attractive. [56] Yet if society values reducing inequality a lot, it becomes worthwhile to increase taxes after an increase in β.

When redistribution is socially worthwhile, the government chooses the tax that causes the smallest resource loss. If both taxes are equally costly to levy (that is, $\alpha_1 = \alpha_2$) it is always better to levy the progressive tax. [57] The reason is that when taxes are proportional some of the income taken away from the poor individual is wasted $(\lambda_p t_1 \alpha_1)$, and another part is redistributed to the rich individual $([1-\beta](1-\alpha_1)\lambda_p t_1)$; both losses are avoided with a progressive tax. Nevertheless, when α_2 is large enough so that it satisfies $\alpha_2 L_1 > \alpha_2 L_2$, it becomes optimal to levy the proportional tax. What is lost when the progressive tax is levied $(\alpha_2 t_2 \lambda_r)$ exceeds what is lost levying the proportional tax.

It follows from Proposition 6.1 that it is more likely that levying the proportional tax is optimal the more targeted is expenditure (larger β) and the more *unequal* the initial distribution (larger $\Delta\lambda$). An increase in $\Delta\lambda$ leads to an increase in L_1 and L_2, and a decrease in M (see Fig. 2, where the solid and dashed lines depict the situation before and after the increase in $\Delta\lambda$). It follows that there exists

[56] We have $\partial L_1/\partial\beta > 0$ if and only if $c < (\Delta\lambda)^{-2}$ and $\partial L_2/\partial\beta > 0$ if and only if $c < (\Delta\lambda)^{-1}$.

[57] This follows directly from Fig. 1, since the slope of the line joining (0,0) and (L_1, L_2), M, is larger than one.



	Before	After
A	1	1
B	0	1
C	0	0
D	0	2
E	2	1
F	2	2

Fig. 2.

a region in (α_1, α_2)-space where the progressive tax is replaced by the proportional (E), but no region where the proportional tax is substituted by the progressive tax. When β increases we have that the impact on L_1, L_2 and M depends on whether $c < (\Delta\lambda)^{-1}$, $(\Delta\lambda)^{-1} < c < (\Delta\lambda)^{-2}$ or $c > (\Delta\lambda)^{-2}$. An analysis of the three cases shows that for all of them there exists a region where it is optimal to substitute the proportional tax for a progressive tax, and no region where it is optimal to substitute the progressive tax for the proportional tax.

It is quite obvious that the disadvantages of a proportional tax are moderated by adequate targeting, because most of what the poor individual pays in taxes is returned to her. What is somewhat surprising is that a proportional tax is more desirable when the initial distribution is more unequal. The intuition is that a proportional tax takes very little from the poor individual when λ_p is small, so that both $t_1 \alpha_1 \lambda_p$ and $[1-\beta](1-\alpha_1)\lambda_p t_1$ are small. In the extreme case where $\lambda_p = 0$

the loss is zero. On the other hand, when $\alpha_2 > \alpha_1$ levying the progressive tax is more wasteful. When the initial distribution is very unequal, the incremental waste of resources from levying progressive taxes is more important than what is lost when the poor individual pays the proportional tax.

7. Conclusions

To conclude, let us summarize our main findings.

(1) The Chilean tax system has little direct effect on income distribution. Pre- and after-tax distributions are quite similar. It is slightly regressive, this being the result of the combination of a progressive income tax that exacts little income from the richest decile, and a set of indirect taxes that are mildly regressive but yield much more revenue.

(2) Income tax evasion and avoidance are quite large: around 23% of the potential tax base is not reported due to loopholes and evasion. Nevertheless, loopholes and evasion are not responsible for the low yield of the income tax. Completely eliminating them increases the average income tax rate paid by the richest decile from 2.54% to 6%, which is less than the 6.3% paid in VAT.

(3) Radical modifications to the tax structure in place in 1996 (e.g., significantly increasing the rate of VAT or substituting a flat tax for the current progressive income tax) have little effect on income distribution.

(4) Some simple arithmetic shows that the scope for directly improving the income distribution via progressive taxes is quite small in general, the more so the more *unequal* the pre-tax income distribution. Thus, even unrealistically progressive taxes have little direct impact on the income distribution at the inequality levels currently prevalent in Chile and most developing countries.

(5) The targeting of expenditures and the average tax rate have a far bigger quantitative impact on income distribution. In the case of Chile, the Gini coefficient falls from 0.496 (after taxes but before redistribution) to 0.430 (after redistribution) while the ration falls from 13.97 to 8.06. Once the targeting of expenditures is taken into account, high-yield indirect taxes are responsible for 82.3% of the reduction in income inequality achieved through the redistribution of the taxes considered in this paper. By contrast, the low-yield progressive income tax accounts only for the remaining 17.7% of the reduction.

(6) A simple model shows that when progressive taxes are more costly to levy and cause a larger excess burden, broad-based proportional taxes become more desirable. Somewhat surprisingly, the optimal tax system is more biased towards proportional taxes the more *unequal* the pre-tax distribution. Thus, the current tax structure in Chile, which relies heavily on broad-based indirect taxes like VAT, that are cheap to administer and are generally thought to produce less distortions, is probably closer to the optimum than what is usually thought.

(7) The main policy implication of this paper is that the tax structure should be chosen on the basis of tax collection and efficiency criteria, and not according to its redistributive merits. Distributional considerations should enter only when deciding the size of the overall tax burden. Once the amount to be redistributed is decided (which depends on the distributional preferences of society, the efficiency of redistributive programs and the extent to which expenditures are targeted to low-income households), revenue should be raised with the most efficient taxes and income inequality should be ameliorated through expenditures.

Acknowledgements

The authors thank Patricio Barra, José De Gregorio, Sebastián Edwards, Tomás Flores, James Hines, Michael Jorrat, Osvaldo Larrañaga, Rodolfo Manuelli, Patricio Meller, Joseph Ramos, Claudio Sapelli, Salvador Valdés and seminar participants at the NBER's Interamerican Seminar on Economics (Santiago, 1997), Latin American Meeting of the Econometric Society (Lima, 1998), Central Bank of Chile, Universidad de Chile and Universidad Católica de Chile for comments and suggestions. They also thank the Chilean Ministry of Planning and Juan Carlos Feres from ECLAC for help with the CASEN survey; the National Institute of Statistics, especially Pedro Menéndez and Günther Hinze, for helping us with the EPF, and the Subdirección de Investigación at SII for help with the data. This paper was written while the authors were consultants for the Chilean Internal Revenue Service (Servicio de Impuestos Internos, SII). However, all opinions expressed are our own and not necessarily those of the SII.

Appendix A. Proofs of Section 5

Proof of Proposition 5.1

Consider a sequence $x_1, x_2, \ldots, x_n$ such that $\sum x_i = 1$. If the x_i's are arranged in increasing order, the corresponding Gini coefficient is

$$G = \frac{2}{n}\sum i x_i - 1 - \frac{1}{n}, \tag{9}$$

while if they are arranged in decreasing order it is

$$G = 1 + \frac{1}{n} - \frac{2}{n}\sum i x_i. \tag{10}$$

We then have

$$\Delta G = \frac{2}{n}\sum_i i(\lambda''_i - \lambda_i) = \frac{2}{n}\sum_i i\left\{\frac{(1-\alpha)t}{1-\alpha t}\beta_i - \frac{1}{1-\alpha t}\lambda_i t_i + \frac{\alpha t}{1-\alpha t}\lambda_i\right\}$$
$$= \frac{(1-\alpha)t}{1-\alpha t}\left\{\frac{2}{n}\Sigma i\beta_i\right\} - \frac{t}{1-\alpha t}\left\{\frac{2}{n}\Sigma i\frac{\lambda_i t_i}{t}\right\} + \frac{\alpha t}{1-\alpha t}\left\{\frac{2}{n}\Sigma i\lambda_i\right\}$$
$$= \frac{(1-\alpha)t}{1-\alpha t}\left[1+\frac{1}{n}-G_\beta\right] - \frac{t}{1-\alpha t}\left[1+\frac{1}{n}+G_{\lambda t}\right] + \frac{\alpha t}{1-\alpha t}$$
$$\times\left[1+\frac{1}{n}+G\right] = -\frac{t}{1-\alpha t}\left[(1-\alpha)G_\beta + G_{\lambda t} - \alpha G\right].$$

In the fourth step we used Eqs. (9) and (10) and the assumptions that the β_i's are decreasing and the $\lambda_i t_i$'s increasing. ■

Appendix B. Proofs of Section 6

Proposition B.1

Consider an individual whose income is equally likely to be d_r or d_p, with $d_r > d_p$. Assume that the individual's utility has a constant coefficient of absolute risk aversion, c. Let $d_{tot} = d_r + d_p$ and $\Delta d = d_r$-d_p. Then maximizing her expected utility is equivalent to maximizing d_{tot}-$c/2(\Delta d)^2 + O((\Delta d)^3)$.

Proof A Taylor expansion of $U(d)$ around $d = \bar{d} \equiv (d_r + d_p)/2$, evaluated at $d = d_r$ and $d = d_p$, leads to

$$E[U(d)] = U(\bar{d}) + \frac{1}{4}U''(\bar{d})(\Delta d)^2 + O\big((\Delta d)^3\big). \tag{11}$$

Since:

$$U(d) = -\frac{1}{c}e^{-cd},$$

we have that Eq. (11) implies that maximizing $E[U(d)]$ is almost equivalent to maximizing

$$e^{-c\bar{d}}\left[-\frac{1}{c} - \frac{c}{4}(\Delta d)^2\right]. \tag{12}$$

Maximizing $E[U(d)]$ is equivalent to minimizing $\log(-E[U(d)])$, which due to Eq. (12) is (almost) equivalent to maximizing

$$c\bar{d} - \log\left(\frac{1}{c} + \frac{1}{4}c(\Delta d)^2\right). \quad (13)$$

But

$$\log\left(\frac{1}{c} + \frac{1}{4}c(\Delta d)^2\right) = \log\left(\frac{1}{c}\left[1 + \frac{1}{4}c^2(\Delta d)^2\right]\right)$$
$$\simeq -\log(c) + \frac{1}{4}c^2(\Delta d)^2,$$

where we used the approximation $\log(1+x) \simeq x$ (the error this introduces is of order $(\Delta d)^4$). The last expression and Eq. (13) imply that maximizing $E[U(d)]$ is equivalent, up to a term of order $(\Delta d)^3$, to maximizing $d_{\text{tot}} - 1/2c(\Delta d)^2$. ■

Proof of Proposition 6.1

We have that

$$d_p = (1-t_1)\lambda_p + \beta[(1-\alpha_1)t_1 + (1-\alpha_2)t_2\lambda_r],$$
$$d_r = (1-t_1-t_2)\lambda_r + (1-\beta)[(1-\alpha_1)t_1 + (1-\alpha_2)t_2\lambda_r],$$
$$d = 1 - \alpha_1 t_1 - \alpha_2 t_2 \lambda_r,$$
$$\Delta d = (1-t_1)\Delta\lambda - K_2 t_2 \lambda_r - K_1 t_1.$$

Thus, the objective function (8) can be rewritten as

$$S(t_1,t_2) = 1 - \alpha_1 t_1 - \alpha_2 t_2 \lambda_r - \frac{c}{2}[(1-t_1)\Delta\lambda - K_1 t_1 - K_2 t_2 \lambda_r]^2.$$

The partial derivatives of this function with respect to t_1 and t_2 are

$$\frac{\partial S}{\partial t_1} = -\alpha_1 + c[(1-t_1)\Delta\lambda - K_1 t_1 - K_2 t_2 \lambda_r](\Delta\lambda + K_1);$$
$$\frac{\partial S}{\partial t_2} = -\alpha_2 \lambda_r + c[(1-t_1)\Delta\lambda - K_1 t_1 - K_2 t_2 \lambda_r]K_2 \lambda_r.$$

The Hessian of $S(t_1, t_2)$ can be calculated from the following second partial derivatives:

$$\frac{\partial^2 S}{\partial t_1^2} = -c(\Delta\lambda + K_1)^2,$$
$$\frac{\partial^2 S}{\partial t_1 \partial t_2} = -cK_2\lambda_r(\Delta\lambda + K_1),$$
$$\frac{\partial^2 S}{\partial t_2^2} = -cK_2^2\lambda_r^2.$$

Since $\partial^2 S/\partial t_1^2$ is negative and the Hessian is equal to zero, it follows that $S(t_1, t_2)$ is concave. Hence: (1) Region 0 is characterized by

$$\frac{\partial S}{\partial t_1}(0,0) < 0,$$

$$\frac{\partial S}{\partial t_2}(0,0) < 0.$$

(2) Region 1 is characterized by

$$\frac{\partial S}{\partial t_1}(t_1^*,0) = 0,$$

$$\frac{\partial S}{\partial t_2}(t_1^*,0) < 0,$$

with $t_1^* > 0$.

(3) Region 2 is characterized by

$$\frac{\partial S}{\partial t_2}(0,t_2^*) = 0,$$

$$\frac{\partial S}{\partial t_1}(0,t_2^*) < 0,$$

with $t_2^* > 0$.

Some patient, but straightforward algebra derives the expressions for t_1^* and t_2^* from the characterizations mentioned above, and shows that the three sets of conditions are equivalent to the regions depicted in Fig. 1. ■

References

Aninat, E., Arellano, J.P., Foxley, A., 1980. Las Desigualdades Económicas y la Acción del Estado, Fondo de Cultura Económica, Mexico.

Ballard, Ch., Fullerton, D., Shoven, L., Whalley, J., 1985. A General Equilibrium Model for Tax Policy Evaluation, Chicago: University of Chicago Press for the National Bureau of Economic Research.

Beyer, H., 1997. Sobre distribución del ingreso: Antecedentes para la discusión, Estudios Públicos, 65.

Bird, R.M., De Wulf, L.H., 1973. Taxation and income distribution in Latin America: a critical review of empirical studies. International Monetary Fund Staff Papers 2, 639–682.

Contreras, D., 1996. Pobreza y desigualdad en Chile: 1980–1992. Discurso, metodología y evidencia Empírica, Estudios Públicos 64, 57–94.

Cowan, K., De Gregorio, J., 1996. Distribución y pobreza en Chile: ¿estamos mal?, ¿ha habido progreso?, ¿hemos retrocedido?. Estudios Públicos 64, 27–56.

Fontaine, B., Vergara, R., 1997. Una reforma tributaria para el crecimiento. Estudios Públicos 67, 23–75.
Fullerton, D., Rogers, D., 1993. Who Bears the Lifetime Tax Burden? Washington: The Brookings Institution.
Hall, R., Rabushka, A., 1996. Putting the flat tax into action. In: Hall, R. et al. (Eds.), Fairness and Efficiency in the Flat Tax. The AEI Press, Washington, DC.
Harberger, A., 1998. Monetary and fiscal policy for equitable economic growth. In: Chu, K., Tanzi, V. (Eds.), Income Distribution and High-Quality Growth. MIT Press, Cambridge.
Jayasundera, P., 1986. Economic Growth, Income Distribution, and Welfare Expenditure: the Case of Sri Lanka. PhD Dissertation, Boston Univ.
Lovejoy, R., 1963. The burden of Jamaica taxation, 1958. Social and Economic Studies 12, 442–448.
Malik, M., Saquib, N., 1989. Tax incidence by income classes in Pakistan. The Pakistan Development Review 28, 13–26.
McLure, C., 1971. The incidence of taxation in Colombia. In: Gillis, M. (Ed.), Fiscal Reform for Colombia: Final Report and Staff Papers of the Colombian Commission for Tax Reform. Harvard Univ. Press, Cambridge, pp. 239–266.
Ockner, B., Pechman, J., 1974. Who Bears the Tax Burden. The Brookings Institution, Washington.
Pechman, J., 1985. Who Paid the Taxes. The Brookings Institution, Washington.
Sahota, G., 1969. Three Essays on the Brazilian Economy. Minisitry of Finance, Rio de Janeiro.
Schkolnik, M., 1993. Estudio de Incidencia Presupuestaria: El Caso de Chile. CEPAL, Santiago.
Shah, A., Whalley, J., 1991. Tax incidence analysis of developing countries: an alternative view. The World Bank Economic Review 5, 535–552.