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LA ECONOMÍA DE LA EVASIÓN IMPOSITIVA
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RESUMEN

Este trabajo comienza discutiendo el problema de la medición de la evasión impositiva. Basado en los datos disponibles, concluyo que este problema está lejos de ser despreciable, tanto para países en desarrollo como para los más desarrollados. También presento detalladamente las razones que justifican la preocupación por la evasión impositiva y, consecuentemente, la necesidad de estudiar más rigurosamente este fenómeno. Luego reviso algunos de los principales resultados obtenidos en la literatura teórica, empírica y experimental sobre la evasión al impuesto a los ingresos personales y las contribuciones teóricas respecto a la evasión de las empresas. Finalmente, presento algunas implicaciones de política, y las ilustro utilizando casos reales.

Palabras clave: sistema impositivo, crecimiento, estabilidad, desigualdad, informalidad, moralidad impositiva

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ABSTRACT

This paper begins by reviewing the problem of tax evasion measurement. Based on available data, I conclude that this problem is far from being negligible, both for developed and developing countries. I also present in more detail the reasons that justify worrying about tax evasion, and thus the need to study more rigorously this phenomenon. I also revise some of the main results that appear in the theoretical, empirical, and experimental literature of personnel income tax evasion and the theoretical contributions on firms' tax evasion. Finally, I present policy implications and illustrate them with real case studies.

Keywords: tax structure, growth, stability, inequality, informality, tax morale

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The Economics of Tax Evasion*

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1 Introduction

In order to pay less taxes, individuals can adopt two types of actions: avoidance and evasion. Tax avoidance refers to legal actions (e.g. exploiting loopholes in the tax law) that individuals or firms undertake, to reduce their tax burden. Tax evasion refers to illegal and intentional actions taken by individuals or firms, to also reduce their tax burden or, directly, to avoid paying their due tax.

Tax evasion is a crucial problem that threats the equity, efficiency and sustainability of most government's fiscal policies (Cowell (1985), Skinner and Slemrod (1985)). Although many issues explain individual decisions to evade taxes, economic factors seem to be among the most important. Therefore, understanding the economics of tax evasion is worthwhile, not only for theoretical purposes, but more importantly, to design successful anti-evasion policies. The goal of this paper is precisely to analyze some of the main results that appear in the economic literature of personnel income and firms' tax evasion, in particular those that motivate reforms that aim to attenuate this misbehavior, and to increase tax revenues.

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The paper is structured as follows. The first section reviews the problem of tax evasion measurement. Based on the available data, I will show that this problem is far from being negligible, both for developed and developing countries. Then, I present in more detail the reasons that justify worrying about tax evasion, and thus the need to study rigorously this phenomenon. Next, in sections 4 and 5, I revise some of the main results that appear in the theoretical, empirical and experimental literature of personnel income tax evasion. Section 6 considers theoretical contributions on firms' tax evasion. Finally, Section 7 presents some policy implications that I can derive from the previous sections, illustrated with real case studies.

2 Measurement and importance of tax evasion

2.1 Measurement

The first issue that one has to consider when dealing with tax evasion is its quantification: how can we measure it, which by its nature it is a concealed misbehavior? In fact, there is an absence of reliable data on reporting/evading individual behaviors. The methods of measuring tax evasion can be divided in two: direct and indirect.

The former try to estimate non-compliance behavior directly from individuals. The most reliable data comes from the National Research Program (NRP), the new version of the Tax Compliance Measurement Program (TCMP). Every 3 years, the Internal Revenue Service (IRS), the US tax administration, conducts detailed line-by-line audits on a fraction of returns from a stratified random sample of 46,000 individuals.[1] The sample includes an oversampling of high income returns. These audits enable the IRS to estimate auditees' 'true' income, which is then compared to their actual reported income. Then, individual differences are extrapolated, to obtain an aggregate measure of tax evasion. Unfortunately, the NRP has its drawbacks: not all undeclared income is detected, non-filers are not identified and honest errors cannot be disentangled from fraudulent errors. Moreover, due to its high cost of implementation, this study is not replicated in other countries.

[1] Stratification is based on the level and primary source of income.

Two other direct methods are answers to surveys and the use of information conveyed by individuals (or firms) during tax amnesties.

Indirect methods compute tax evasion via some proxis, like the difference between income reported to the tax administration and income that emerges from the national accounts; the difference between real activity (as obtained from the use of inputs like electricity) and the actual level of activity that appears in the official statistics.

2.2 The US case

Before showing the available data for Latin American countries, it is worthwhile to analyze the U.S. case, and this for the following reasons. First, as was mentioned in the previous paragraphs, it is in this country where the most reliable direct data on tax evasion is generated. This data is not only used as a diagnosis of the problem and a guide for the political discussion about tax design, but, most importantly, as an input during the first stage of IRS's enforcement activity (see Section 4.1.3). Second, because by showing the importance of this social misbehavior in one of the most developed countries in the world, one can have an idea of the magnitude of this problem in less developed countries, with less institutional advances.

Using data from the last NRP, the IRS updated in 2006 its estimation of the **overall gross tax gap** for the Fiscal Year 2001. The overall gross tax gap is the difference between the tax that taxpayers should pay (potential tax collection) and what they actually pay on a timely basis (effective tax collection). For Fiscal Year 2001, the overall gross tax gap amounted to U$S 345 billion. IRS enforcement activities, coupled with other late payments, recover about U$S 55 billion, leaving a **net tax gap** of U$S 290 billion for Fiscal Year 2001. This amounts to almost 15% of total potential tax revenue, which is far from being a negligible figure.

Figure 1 shows the different components of the tax gap: nonfiling (failure to file a tax return), underreporting (understating income, overstating

deductions) and underpayment (failure to fully pay reported taxes owed).

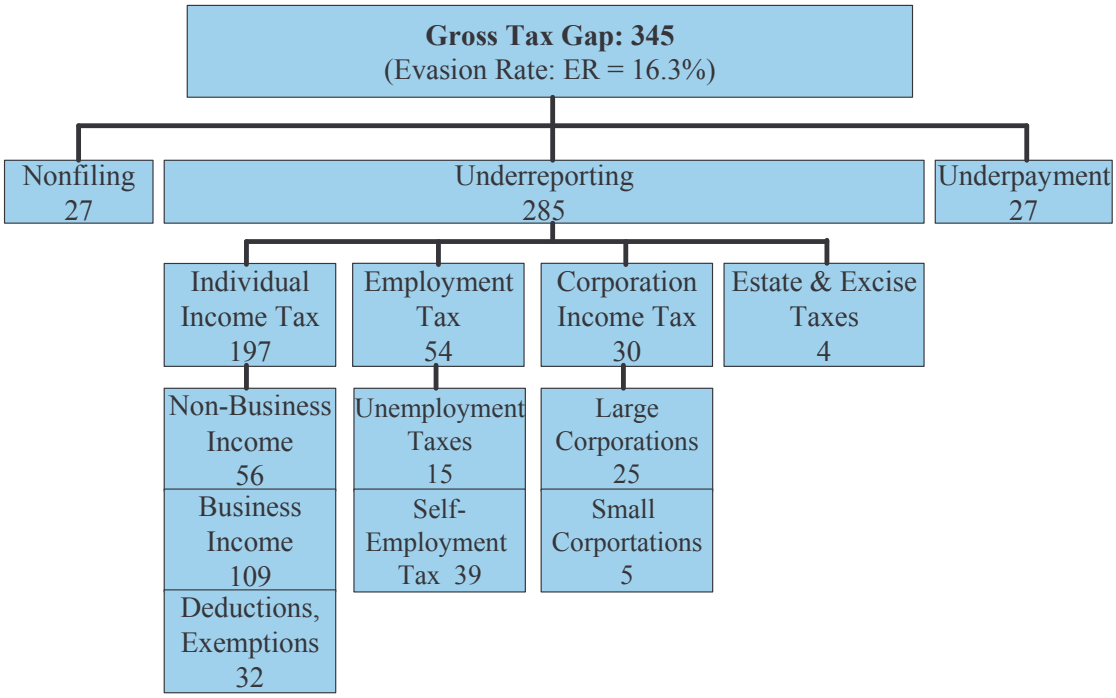

Figure 1: Tax Year 2001 Federal Tax Gap (in billions of dollars)

Clearly, more than 80% of the tax gap comes from underreporting. In particular, underreporting for the individual income tax is the most important issue that the IRS has to deal with: U$S 197 billion (57% of the tax gap). Next table shows, in more detail, how the different components of individual income are misreported.

Type of Income	Tax Gap (U$S billion)	NMP
Underreported Income	**166**	**11%**
Non-business income	*56*	*4%*
Wages, salaries, tips	10	1%
Interest income	2	4%
Dividend income	1	4%
State income tax refunds	1	12%
Alimony income	*	7%
Pensions and annuities	4	4%
Unemployment compensation	*	11%
Social Security benefits	1	6%
Capital gains	11	12%
Other income	26	64%
Business income	*109*	*43%*
Nonfarm proprietor income	68	57%
Farm income	6	72%
Rents and Royalties	13	51%
Partnerships, etc.	22	18%

Table 1: Main components of the Individual Income Tax Underreporting Gap estimates, for the FY 2007.

From this table, several comments can be made. The first concerns the power of withholding. Because employers withhold taxes from wages and remits them, and reports those payments at the end of the year, individual income reporting is almost perfect: 1% of net misreporting percentage (NMP).[2] The second comment concerns again the power of third-party reporting. Reporting for interest payments, dividend income and pensions, and annuities are made by the financial entity that make these payments to the individuals. Therefore, individuals report almost truthfully these incomes: misreporting amounts just to 4% for all these items. The third comment

[2]NMP measures underreported income, as a fraction of total potential income tax revenue. This measure is also called the **evasion rate**.

has to do with the extent to which non-compliance varies across types of business. "Non-Business Income" explains U$S 56 billion, whereas "Business Income" is the line where, on absolute and relative terms, income is more evaded. In particular, evasion in "Farm Income" is not important in absolute terms (only U$S 6 billion), but it is very high in relative terms: 72% of the total amount that should have been declared is misreported. As many Latin American countries have agricultural sectors that generate a higher fraction of the GDP than the American agricultural sector, this figure suggests that these governments should consider carefully evasion in this sector. As a final comment, non-compliance increases substantially when there is no withholding or third-party reporting.

To conclude, these figures help to understand the tax evasion phenomenon in the USA. Despite having different economic and social structures, Latin American countries could use them as inputs in their design of anti-evasion policies [see Sections 4.1.3. and 7.1].

2.3 Results in other countries

In general, in less developed countries, and for many reasons, income taxation is more difficult to enforce than in the USA. Table 2, obtained by Gómez Sabaíni, Jiménez and Podestá (2010), shows estimations of personnel income tax evasion, for some Latin American countries.

Country and year	Tax gap (in % of GDP)	Evasion rate
Argentina (2005)	5.6	49.7%
Chile (2003)	3.8	46%
El Salvador (2005)	3.1	36.3%
Ecuador (2005)	5.5	58.1%
Guatemala (2006)	5.5	69.9%
Perú (2006)	5.8	32.6%
México (2004)	2.9	38%

Table 2: Estimations of personnel income tax evasion in Latin America

In the first column, we can observe the tax gap, in percent of GDP. In the second column, we can see the different evasion rates. These figures are computed using indirect methods: to estimate the potential tax collection,

the studies made in these different countries use declared income that appear in General Household Surveys. As this information is not perfect (due to underreporting and lack of representativeness of higher income levels), it is adjusted using information that comes from the National Accounts.

These figures are significantly higher than in the U.S.A. For some countries, like Ecuador and Guatemala, the amount evaded is larger that the resources collected by the tax administration.

2.4 Data for other taxes

In many countries, indirect taxation raises a large fraction of aggregate tax proceeds. Evasion of indirect taxes, such as VAT, is then the crucial problem that these governments have to deal with. Nam, Parsche and Schaden (2001) present estimates for VAT evasion (as a percent of total potential VAT revenue) inside the European Union, between 1991 and 1993: their figures vary from 2.4% in the Netherlands to 20.2% in Greece, 22.6% in Spain and 34.5% in Italy. In Latin American countries, where tax revenues from indirect taxation are also very important, these estimates are, on average, higher: 29.6% for Argentina (AFIP (2008)), 35.3% for Mexico (Hernández Trillo and Zamudio (2004)), and 54.8% for Guatemala (SAT (2007)). All these figures were computed using indirect methods.

To conclude this section, it is worthwhile to discuss the following issue. Many authors take these figures of the tax gap as estimates of the amount of additional tax revenue that would be collected if evasion could be totally eliminated. As an example, Argentina could collect 5.6% of GDP more on income taxes. In fact, this idea is misleading, for the following two reasons. First, in order to collect the total tax gap, a tax administration needs to expend a huge amount of resources. And, as the amount recovered per $ of expenditure in the tax administration is not constant[3], the net final result is not easy to compute a priori. Second, as will be clear in next sections, when evasion decreases, tax rates should also change, modifying the value of the potential tax collection.

[3]Moreover, there is no real concensus about the value of this figure in the profession.

3 Why should we care about tax evasion?

Having shown that, for most countries, tax evasion is quantitatively important, a new question arises: why should we care about it? There are many reasons for that, as follows.

- **Loss of tax revenues**

  As we have shown in the previous section, tax evasion implies an important loss of public resources. Therefore, any government that faces this problem is unable to fully attain it's economic, social and political objectives.

  Accepting this, governments can try to solve this problem by simply increasing the tax rate and recover funds on those who pay taxes. As basic Public Finance teaches, this option is not optimal because the deadweight loss of taxation increases with the tax rate. Hence, increasing the tax rate on individuals that effectively pay generates more distortions in the tax system.

- **Efficiency**

  First of all, in order to deal with tax evasion (in particular, to implement its enforcement policy), governments have to divert public funds, from more productive uses. Second, evasion generates inefficiencies due to misallocations of resources, when individuals alter their decisions in order to evade taxes: e.g. use of extra accounting services to maintain a hidden balance sheet.

- **Vertical equity**

  Wealthier individuals earn income in forms that are not directly reported to the tax authorities. Therefore, they have much more possibilities to evade than poor people, whose income taxes are, for a large fraction of them, directly withheld from their wages. Table 1 confirms this assertion. There, we observed that "Wages, salaries, tips" are misreported at a 1%, whereas "Business Income" is misreported at a 43%, on average. So, if cheating is likely to be higher among wealthy people, the incidence of the tax system is altered, at the detriment of poor taxpayers. The tax system looses vertical equity with evasion, with respect to a no-evasion situation.

- Horizontal equity

  The tax burden between two identical individuals, an honest and a fraudster, is different. This clearly violates horizontal equity.

- **Weak accountability**

  There is a growing literature in political science conjecturing that evasion undermines accountability: individuals who pay taxes and understand the link between revenue generation and spending seem to exert more control on the government that individual who do not pay taxes.

Clearly, fiscal systems do not work well when tax evasion is pervasive. Therefore, states should set policies to curb it. But, in order to attain their objectives efficiently, anti-evasion policies should be designed taking into account the most important features that impact on individual's evasion decisions. The goal of the next section is to study these factors, i.e. the economic determinants of individual evasion decisions.

4 Personnel income tax evasion

4.1 Theoretical models of evasion and enforcement decisions

This section will survey the theoretical results about behaviors/actions that have an impact on the individual and aggregate level of evasion: taxpayers' declarations and enforcement strategies decided by tax administrations. The starting point of this section is the analysis of Allingham and Sandmo (1972), the seminal article [hereinafter A-S]. This is the first analythical model of the individual tax evasion behavior. Then, we will consider some of the extensions of this article, in particular those that highlight non-economic factors like morality and social norms. Finally, we will analyze the interactive approach to tax evasion.

4.1.1 Allingham and Sandmo (1972)

The first insight of this article is that tax evasion is a problem of asymmetric information. Taxable income is only known to taxpayers, but not by the tax collector. Therefore, in order to assess the due tax, the tax administration

asks taxpayers to report their income. And, as the theory of asymmetric information has shown, most individuals will strategically use their private information to their benefit. Thus, the tax administration has to control this information transmission with audits.

The second insight of the model is the picture of the taxpayer when he fills in his income tax return. The authors adopt a positive approach, based on Becker's (1968) analysis of criminal behavior. In their view, the declaration of income to be taxed is a decision under uncertainty: on the one hand, the individual can be audited by the tax administration and, if he is caught undereporting his income, he is taxed and penalized; on the other hand, he might not be audited, and thus escapes from being duly taxed. Therefore, the analysis of the optimal level of income to declare has to be done using a 'portfolio approach'. Allingham and Sandmo (1972) obtain the equilibrium characterization of the individual declaration of income and undertake comparative statics, with respect to income, taxes, audit probabilities and penalties.

Because it is the canonical model of tax evasion, it deserves to go through it. The taxpayer is characterized by a cardinal utility function U, with monetary income as its unique argument. The marginal utility of income is positive but decreasing: the taxpayer is risk-averse. Actual income W is exogenously given. As mentioned above, it is only known by the taxpayer and not by the tax administration.[4] Therefore, taxpayers have to report their income to the tax administration.

Taxes are levied at a given and constant rate t on the amount of declared income X, which is the taxpayer's decision variable. After having paid tX, the taxpayer is audited with an exogenously given probability p. It is important to mention that, throughout the main part of their paper, A-S assume that the probability of investigation p does not depend upon the amount of declared income X. They also assume, as most of the following literature, that audit is perfect: if the taxpayer is audited, the tax collector knows his true income W. If caught, an evader pays a tax on undeclared income $(W - X)$, but at a penalty rate $\pi > t$.

Two assumptions of this model (and of almost all the literature on the economics of tax evasion) deserve some comments. The first assumption is

[4] As Sandmo (2005) pointed out, this assumption that all income is equally unknown to tax authorities is clearly unrealistic. Tax authorities know partially some information about taxpayers' income. The model thus applies to the fraction of income that is totally unknown to the tax administration.

the following: for taxpayers, complying with the tax law is costless, in terms of resources spent. This is clearly unrealistic. A large body of evidence suggest that individuals and firms have to divert a huge amount of resources (e.g. time for tax planning and paperwork) from their most efficient use, in order to comply with tax laws. Slemrod (1992) asserts that compliance costs of the US personnel income tax amount to 5-10% of total tax revenues, whereas IRS's overall budget is only 0.6% of total tax revenues. Despite this fact, almost all contributions neglect compliance costs. The second assumption that needs caution is the fact that taxpayers know the audit strategy of the tax administration. As I will show bellow, this assumption is far from being realistic.

The taxpayer decides his report in order to maximize his expected utility. The first-order condition that characterizes his optimal report is

$$(\pi - t)pU'(Z) = t(1-p)U'(Y), \tag{1}$$

where primes denote first-order derivatives, $Y = W - tX$ is the available income if the taxpayer is not audited, and $Z = W - tX - \pi(W - X)$ the income net of taxation and punishment if caught evading. The intuition of this expression is straightforward: the left-hand side of (1) represents the marginal desutility if caught evading, and the right-hand side, the marginal utility of escaping detection.

Having characterized the optimal individual declaration of income X^*, the authors undertake comparative statics with respect to the income level, the tax rate, audit probabilities and penalties. It turns out that some results are non-ambiguous: higher detection probabilities and higher penalties increase reported income, thus reducing evasion. But the remaining results, namely the effect of a higher wealth or tax rate, are ambiguous. Regarding the former, A-S show that, when actual income W varies, the declaration increases, stays constant or decreases according as relative risk aversion is an increasing, constant or a decreasing function of income. Regarding the latter result, A-S explain its economic meaning as the result of an income and a substitution effect. The latter is negative because an increase in the tax rate makes it more profitable to evade taxes on the margin. The former is positive because an increased tax rate makes the taxpayer less wealthy, reducing both Y and Z for any level of the report X, and this, under decreasing absolute risk aversion, tends to reduce evasion.

Yitzhaki (1974) shows that the structure of penalties is crucial to determine the non-ambiguity of this last result. If instead of being proportional

to evaded income, the penalty is proportional to evaded taxes (as is the case in many countries, e.g. USA), the substitution effect disappears, and only remains the income effect. Thus, the amount reported increases with the tax rate. Although this result eliminates the ambiguity of the A-S finding, it is clearly at odds with many empirical findings (see Section 5.1).

Box 1: Highlights of the A-S model

- ❑ Tax evasion as a problem of asymmetric information between the tax administration and the taxpayer.
- ❑ Description of the individual's decision to evade as a choice of a lottery: income obtained by evading and not being audited by the tax administration vs. income resulting after being caught evading.
- ❑ Characterization of the optimal income report.
- ❑ Comparative static results
  - When income increases, income report increases, stays constant or decreases if relative risk aversion is an increasing, constant or decreasing function of income.
  - When the audit probability and the penalty for evaders increase, evasion decreases.
  - If penalties are proportional to evaded taxes, evasion decreases with the tax rate.

4.1.2 Extensions to A-S

Although this paper has the merit to analyze, for the first time and in a rigorous way, the individual decision to evade, it immediately became evident that something was missing in it. As stated by Erard and Feinstein (1994), the A-S model substantially overpredicts both the frequency and the level of evasion.[5] Using parameters characterizing US tax-enforcement policy, they show that

- an individual that earns U$S 100,000,
- whose coefficient of relative risk aversion is 0.5,
- the penalty rate (on evaded tax) is 50%,

[5] See Section 5.2 on this issue of the overestimation of the evasion rate.

- the audit probability is[6]

$$p(X) = 0.5 - \frac{X}{200,000}$$

should declare only U$S 38,350, understating true income by 62%. In order to fit the US data, the coefficient of risk aversion should be set at 30! As stated by Mikesell and Birskyte (2007), the puzzle is not why people evade, but instead, given the current parameters of the tax-enforcement policy in many countries, why people pay taxes!

In order to try to solve this puzzle, a large number of contributions extended the original model in a number of directions, either by relaxing some of its extreme assumptions or by incorporating other features, like morality and social norms. We now review the literature that deals with the latter.

Morality The first paper to introduce formally morality in the A-S model was Benjamini and Maital (1985). These authors simply add a fixed 'stigma' cost of evading, in the utility function. This generates that, even under the parameter assumptions that ensure evasion in A-S, the authors obtain that individuals with high stigma cost do not evade, whereas those with low stigma cost evade as in A-S. Gordon (1988) generalizes the previous model, by assuming a variable stigma cost. Although the result that people with high stigma cost do not evade still obtains, Gordon finds a positive relation between stigma costs and compliance, for those who evade.

Social interactions and evasion Regarding social interactions, many authors have followed the idea that tax compliance is affected by social norms. Myles and Naylor (1996), Kim (2003) and Traxler (2010) consider models where individual welfare depends, on the one hand, on the A-S expected utility of income and, on the other hand, upon a cost (benefit) of evading (complying). This cost is, in turn, determined by two factors. First, an exogenously given, individual-specific degree of norm internalization. Second, by the endogenously determined share of evaders in society. Having solved for the individual equilibrium level of evasion (taking as given the number

[6] This function has been chosen to match the actual probability of detection that, on average, an individual earning U$S 100,000 faces.

of evaders), the authors then find the social equilibrium. This is the self-fulfilling equilibrium number of evaders in the society. In all these models, multiple equilibria emerge. The first equilibrium is characterized by the fact that, as the number of evaders is low, the individual cost of evading is high and thus it is individually optimal to not evade. On the other hand, in the second equilibrium, there are so many evaders that the norm internalization is weak. Thus, it is individually optimal to evade, which explains why evasion is widespread.

Although these models cannot generate explanations about the difference between Latin American countries (characterized by high levels of tax evasion) and, e.g. USA, some of their results are important for their policy implications. In particular, Traxler (2010) shows that if a stricter deterrence policy is accompanied by a shock in agents' beliefs such that they expect a level of norm violations which is above the true level, these initially false beliefs can become self-fulfilling. In the context of multiple equilibria, stricter deterrence could then trigger more evasion.

Box 2: Morality and social norms

- ❑ Extend the basic A-S framerwork to incorporate moral considerations and social norms.
- ❑ Explain some observed levels of high compliance.
- ❑ Individuals consider other's evasion behavior when they decide whether to comply.
- ❑ Multiple equilibria emerge.

4.1.3 The interactive approach

Another drawback of A-S is that the audit probability is exogenously given. Some articles find the optimal probability of detection, when the government maximizes a social welfare function. But these studies have restricted the probability of audit to be independent of taxpayers' reported income. Clearly, and as also shown to be empirically proved, tax administrations trigger audits in reaction of tax reports (see Andreoni, Erard and Feinstein (1998)).

In order to address this issue, the next generation of papers propose (what is now called) the 'interactive approach' to tax evasion. Basically,

these papers find the optimal/efficient probability of detection and/or penalty for evasion as a function of the taxpayer's reported income, which in turns depends upon this probability. Therefore, the methodology of analysis moves from basic individual optimization to game theoretical models.

These models can be divided in two groups. On the one hand, authors like Reinganum and Wilde (1985) assume that the tax administration can pre-commit to an audit probability $p(X)$. In order to find the enforcement policy that maximizes net tax revenues[7], these authors adopt a Principal-Agent approach. Reinganum and Wilde (1985) find that the net tax revenue maximizing strategy typically involves a "cut-off" rule, like

$$\begin{cases} p^* = \frac{1}{1+\pi} & \text{if } X \leq \underline{X} \\ p^* = 0 & \text{if } X > \underline{X} \end{cases}$$

when the tax and the penalty schedules are linear functions of reported income and evaded taxes, respectively, and taxpayers are risk neutral. The threshold $\underline{X}$ depends positively on the tax rate and on the penalty rate, and negatively on the audit cost. With this policy, taxpayers with income below $\underline{X}$ report honestly, whereas those with income above $\underline{X}$ report just $\underline{X}$, and thus underreport income by an amount $W - \underline{X}$. Therefore, this model generates the prediction that richer individuals do evade.

The most important features of this optimal audit rule are the following. First, it is non-increasing in income: individuals with lower incomes are audited, whereas individuals with higher incomes are not. This seems to be counter-intuitive: does the tax administration audit poor individuals, instead of rich, which have more opportunities to evade (as we observed in Table 1)? In fact, this vision is misleading. The optimal audit policy obtained by Reinganum and Wilde (1985) audits *low income reports*. The intuition is the following. In order to induce high income individuals to report at least $\underline{X}$, the tax authority has to threat them with an audit if they report less than the abovementioned threshold. As the next paragraph shows, this theoretical results has indeed been applied in practice.

In the USA, tax returns are selected for audits in several ways. The primary way by which the IRS selects returns for audit is by using the Discriminate Function (DIF) system. The DIF system weights the various characteristics of tax returns and scores them according to mathematical formulas, in

[7] In these models, each audit costs c. Therefore, the tax authority takes into account that enforcement is costly when it designs its audit policy.

an effort to find the returns that would most likely have a difference between taxes owed and reported.[8] For example, if an individual reports that he earns U$S50,000 in a year and makes a charitable contribution of U$S5,000, this last piece of information would more than likely carry a higher weight than it would for an individual who had $500,000 in income and made that same charitable contribution. Hence, ceteris pribus, the first return would receive a higher score. Generally, the higher the score, the higher the probability of the IRS recovering non-paid taxes; the highest scoring returns are then forwarded for further review. Thus, in a given income bracket, low-income reports trigger audits, as found by the theory.

Second, the optimal audit policy generates the following comparative statics results. An increase in the tax rate increases the stake for evasion, thus increasing the amount of auditing because individuals with higher incomes will be audited. On the other hand, an increase in the audit cost decreases the threshold $\underline{X}$, reducing the number of individuals that are audited, and thus increasing evasion of the richest.[9] Finally, an increase in the penalty rate increases the number of audits but decreases their frequency.

A drawback of the previous approach is that, at the optimum, the tax authority commits to audit all reports $X \leq \underline{X}$ with probability p^*. Facing a report lower than the threshold $\underline{X}$, the tax authority should proceed to audit it (according to the predetermined audit probability p^*), despite the fact that it knows that no taxpayer with income $W \leq \underline{X}$ will misreport (because, as we mentioned above, p^* is set to induce taxpayers with income $W > \underline{X}$ to not make a very low-income report, and those with income $W \leq \underline{X}$ to not misreport). But it is costly to not renege upon this announced policy.[10] Assuming that the tax authority is not able to commit itself to not renege upon any

[8] It is important to stress the fact that the main input for the design of the mathematical formula that supports the DIF system is the result of the NRP. Specifically, as the NRP enables the IRS to identify evaders, and thus to characterize them in a very precise way, the DIF system puts higher weights on individual characteristics that reflects (on average) the similarity with those of an evader.

[9] Recall that individual compliance costs are neglected from all these models. Despite this fact, we can assume that they can be included as another tax administration's cost. Thus the comparative statics result (with respect to the compliance cost) is the same.

[10] When the tax administration observes a low report, it knows that, because of the properties of the optimal mechanism, this report is truthful. Thus, it has no incentives to audit. But, if it reneges upon the predetermined and announced audit strategy p^* and does not audit after all, as taxpayers can anticipate this, the incentive properties of the mechanism disappear.

announced enforcement policy, Graetz, Reinganum and Wilde (1986) were the first to solve a dynamic game, where taxpayers report their income first, and then the tax authority decides which reports to audit, and their corresponding audit frequency. In their model, individuals can be rich or poor, according to their income level $W_p < W_r$. Hence, in this model, there can be only two reports: $X \in \{W_p, W_r\}$. Given the (exogenous) values of taxes and penalties for evaders, two equilibria emerge in the reporting-audit game played between taxpayers and the tax authority. Their type depend upon the value of the audit cost c. If $c > \widetilde{c}$ (an endogenous threshold that depends upon the parameter configuration of the model), the government never audits and rich taxpayers always misreport.[11] This is intuitive: if the audit cost is sufficiently high, a "full-evasion" regime obtains. On the other hand, if $c < \widetilde{c}$ (i.e. the audit cost is sufficiently low), a "partial-evasion" regime emerges. In this case, there is a mixed-strategy equilibrium of the report-audit game. Anticipating that the government will audit (but not with certainty), rich taxpayers misreport with probability

$$\widehat{\alpha} = \frac{\mu c}{(1-\mu)(t+\pi-c)} > 0,$$

where μ is the fraction of poor individuals in the population, and t the tax owed by rich taxpayers. Then, given the updated probabilities it attaches to the taxpayer being rich or poor, the tax authority audits any report of a low income level with probability

$$\widehat{\beta} = \frac{U(W_r) - U(W_r - t)}{U(W_r) - U(W_r - t - \pi)} > 0$$

In equilibrium, both probabilities are consistent.

As for models in the Principal-Agent literature, the non-commitment model obtains the result that the tax administration should audit low income reports and that rich taxpayers misreport randomly. But some results are different, in particular those pertaining to the impact of an increase in the fine. When the fine increases, the Principal-Agent model predicts auditing more people less frequently. This model also predicts a lower aggregate audit probability.

Recently, some authors have presented interactive models that incorporate dimensions previously not taken into account, in particular the effect

[11] In this model, as taxation is progressive (i.e. $t_p = 0 < t_r = t$), poor taxpayers never find profitable to misreport their low income.

that simplifying the tax law has upon individual declarations (Kopczuk, 2006).

Box 3: Higlights of the interactive approach

- ❑ Endogenizes the frequency of auditing.
- ❑ Audit probability decreases with income report.
- ❑ Comparative static results
  - An increase in penalty for evaders increases the number of audits, but decreases the frequency of controlling each individual.
  - An increase in the tax rate increases the number of audits to be done.

4.2 Optimal tax-enforcement policies

Based on the results of the abovementioned Principal-Agent models, the next step in the tax evasion literature has been to find the optimal/efficient tax scheme and probability of detection and/or penalty for evasion, as functions of taxpayers' reported income. This is called the 'optimal tax-enforcement' literature, and the main articles are Sandmo (1981), Border and Sobel (1987), Mookherjee and Png (1989, 1990), Cremer, Marchand and Pestieau (1990), Cremer and Gahvari (1995), Chander and Wilde (1998) and Pestieau, Possen and Slutsky (2004). In the following paragraphs, I illustrate the main findings of this literature as obtained by Besfamille and Parlatore Siritto (2009).

There is a continuum of individuals of measure 1. Each individual can be of two different types $i \in \{p, r\}$. A 'poor' individual ($i = p$) has no income whereas a 'rich' individual ($i = r$) earns a strictly positive taxable income W. Types are random variables, identically and independently distributed according to the (commonly known) probability distribution $(\mu, 1-\mu)$, where μ is fraction of rich individuals in the population. Each individual privately knows his type.

Poor individuals only benefit from a public good, provided by the government, in quantity g. Their ex-post welfare is given by

$$w_p = g.$$

Rich individuals also derive utility from consumption of a private good q, the

price of which is normalized to 1. So their ex-post welfare is

$$w_r = U(q) + g.$$

The government follows a welfarist criterion Ω that can be represented by a weighted sum of the individuals' welfares, as follows

$$\begin{aligned} \Omega &= \mu w_r + (1-\mu) w_p - \mu(1-\alpha)(w_r - w_p) \\ &= \alpha\mu U(q) + g \end{aligned}$$

where the parameter $0 \leq \alpha \leq 1$ measures preferences for redistribution. To be more specific, the government is averse to inequality, with a degree of aversion proportional to $(1-\alpha)$. In order to maximize its criterion, the government designs a fiscal policy, to be implemented by the tax administration.

The timing of the model is as follows.

1. In the first stage, the government designs the tax law, which specifies the tax $t \geq 0$ owed by rich individuals (from now on, taxpayers) and the enforcement policy to be conducted afterwards by the tax administration. The enforcement policy consists specifically of an audit probability $p \in [0,1]$ and a fine for evaders $\pi \geq 0$. The unique restriction to this tax law is taxpayers' limited liability.

2. In the second stage, the tax law is implemented. As the tax administration does not observe types i, individuals are requested to report them, e.g. by filling in an income tax form. We denote such reports by $\widetilde{i}$. Then, following the enforcement policy previously designed by the government, the tax administration audits each report $\widetilde{i}$ with probability $p_{\widetilde{i}}$.

   Each audit costs $c \geq 0$.[12] When a taxpayer is not audited, he pays the tax that corresponds to his report $\widetilde{i}$. But if he is audited, the tax administration discovers his true type i. And, if a misreport is detected, the evader has to pay the tax that he legally owes plus the additional fine f. With all revenues collected (taxes and fines, net of investment and audit costs), the government finances the provision of the public good g, which has a unit cost equal to γ.

[12] This level c is an exogenous function of the stock of capital the tax administration is endowed with and/or other exogenous parameters that are related to the difficulty in auditing (e.g. percentage of farmers in the population).

The optimal tax law can be easily characterized adopting a mechanism design approach. According to Mookherjee and Png (1989), the tax administration does not need to audit a taxpayer that has reported to be rich. So π denotes the probability of auditing an announcement $\widetilde{i} = p$. The optimal tax law (t, π, p) is as follows. First, penalties should be set at their maximum legal level.[13] Hence, the government sets the audit strategy

$$\pi = 1 - \frac{U(W-t)}{U(W)}$$

such that a potential evader is indifferent between truthfully reporting his type and misreporting. The expression that characterizes the optimal tax $\widehat{t}$ is

$$\alpha U'(W-\widehat{t}) = \frac{1}{\gamma}\left[1 - \frac{(1-\mu)c}{(1-\mu)c + \alpha\mu U(W)}\right]$$

The taxpayers' social marginal utility of consumption equals the social marginal utility of the expenditure in the public good. But, due to the necessity of auditing reports in order to collect taxes, this expenditure is less than the tax collection. Therefore, in order to reduce the stake for evasion, and thus the necessity of auditing, the optimal tax $\widehat{t}$ is *downwardly* distorted with respect to the optimal full information tax t^*. The threat of evasion creates a limit to the redistributive aim of the state, making the tax scheme less progressive.

Besfamille and Parlatore Siritto (2009) undertake comparative statics exercises that generate important policy implications. In particular, they show that

- The regressivity bias increases and enforcement decreases when the audit cost c increases.[14]
- The tax and enforcement policy increase with the aversion for inequality $(1-\alpha)$.
- The tax and the enforcement policy increase with the fraction of rich in the population μ. This last result seems counter-intuitive: if p is the

[13] For ethical considerations, the tax evasion literature excludes infinite penalties. This assumption helps to avoid the Beckerian paradoxical result: "it is optimal to hang evaders with probability zero".

[14] Recall that this cost is related to the difficulty of auditing the population.

frequency of auditing low income reports, why such an increase? The reason is related to the result that taxes should increase, and thus the stake for evasion increases.

- Similarly, as the optimal tax increases when rich taxpayers' income W increases, the optimal audit probability should also increase.
- Finally, when the price of the public good γ increases, both the taxes and the enforcement policy should decrease.

Box 4: Models of optimal tax-enforcement policies

- ❑ Use the highlights of the Principal-Agent models of optimal auditing to characterize the optimal tax structure.
- ❑ The main result concerns the regressivity of the tax structure.
- ❑ Main comparative static results: how the tax structure and enforcement policy is modified when the audit cost and the parameters characterizing the income distribution change.

4.3 Optimal 'tax systems'

Finally, the last step of this literature has been the inclusion, in models that characterize optimal tax-enforcement policies, of administrative issues. This yields to what Slemrod (1990) has called the determination of 'optimal tax systems'. In particular, I review the main results obtained in Besfamille and Olmos (2011). This paper shows how government investments aimed to modernize the tax administration impacts on the optimal tax-enforcement structure.

The model builds up on Besfamille and Parlatore Siritto (2009), but generalizes it in three directions. First, poor individuals also earn an income, and thus can be taxed. Specifically, individual income W_i that takes values in the set $\{W_p, W_r\}$, with $0 < W_p < W_r$. A taxpayer with income W_r is henceforth called 'rich'; otherwise, he is called 'poor'. Each taxpayer's income W_i is his private information. Let μ be the fraction of rich individuals in the population.

Taxpayer i's ex-post welfare is given by

$$w_i = U(q_i) + g$$

where q_i is his private-good consumption, and g is the government's provision of a public good.

The government designs the fiscal policy to maximize the utilitarian criterion $\mu w_r + (1 - \mu)w_p$.

The second difference is the inclusion of an initial stage, when the government invests capital κ to improve the tax administration's capacity to detect evaders.[15] The price of capital is normalized to one.

The last difference with respect to the previous model appears in the last (enforcement) stage. Specifically, when the tax administration audits, it discovers an evader with probability δ : audits are imperfect. The authors assume that the detection probability δ is a logistic function, as follows

$$\delta(\kappa) = \delta_\iota + \nu \frac{1 - e^{-\kappa}}{1 - ne^{-\kappa}}.$$

On the one hand, the initial level δ_ι is exogenously determined by technology and human capital available to the tax administration at the beginning of the first stage, and by other parameters related to the difficulty of observing true incomes. On the other hand, the exogenous parameter ν affects the function $\delta(\ )$ as follows: when ν is higher, so is the capacity of any level of investment to improve the detection probability δ. Then, ν is the 'investment productivity'. As mentioned by Bird and Zolt (2008), its value depends, among other things, on the training, skills and resistance to change of the people who are expected to operate the (new) technology.

The authors solve numerically the model. Table 3 bellow gathers the parameter values used in the numerical simulations. All money values are in thousand dollars. These values are representative of the US tax system and

[15] In Besfamille and Parlatore Siritto (2009), the government also invests resources, but to reduce the audit cost c.

the IRS's operations in 2006.

PARAMETER	DEFINITION	BASELINE VALUE
σ	Coefficient of relative risk aversion	0.71
μ	Percentage of rich taxpayers	67
W_r	Rich taxpayers' income	\$52.304
W_p	Poor taxpayers' income	\$6.747
c	Cost of a single audit	\$14.833
δ_ι	Initial detection probability	0.4
ν	Investment productivity	0.225

Table 3: Baseline parameters in Besfamille and Olmos (2011)

With these baseline parameters, Besfamille and Olmos (2011) obtain the equilibrium values of the model. First, they consider a government that cannot invest, and thus that the tax administration's detection probability is exogenously given by δ_ι. In this case, the optimal fiscal policy is characterized by $t_p = \$6.03, t_r = \$44.35$ and $g = \$26.81$. Moreover, deterministic full auditing (i.e. auditing all low income reports) is indeed optimal. As the average tax payments verify $\tau_r = 85$ percent $< \tau_p = 89$ percent, the progressivity index

$$IP = \frac{\tau_r - \tau_p}{y_r - y_p} = -0.087 :$$

the tax structure is regressive. Individuals end up facing quite high average tax payments, but they are compensated with an important provision of the public good. Finally, the authors study the efficiency of the public sector EPS, which is a measure of the percentage of the potential tax collection used to provide public goods. When the government cannot invest to modernize its tax administration, EPS attains 85.3 percent.

Next, they consider a government that has the option to invest. At the first-stage, it chooses optimally $\widehat{\kappa} = \$0.059$, and thus the detection probability δ increases 55 percent, from 0.4 to 0.62. As expected, the other components of the optimal fiscal policy change: $\widehat{t_p} = \$5.83$ (a 2.9 percent reduction) and $\widehat{t_r} = \$47.4$ (a 6.9 percent increase). This last result contradicts the assertion, often made in administrative and political circles, that if investments that help to improve tax compliance were made, the highest marginal tax rates could be cut. The reason why this prescription is not optimal is the following. When the government could not invest, the highest tax t_r was

set at a 'relatively' low level, to attenuate rich taxpayers' stake for evasion. But when investments can be made, the improvement in detection attenuates the revelation of income's problem, and this enables the government to tax rich taxpayers more. These changes in taxes imply that average tax payments $\widehat{\tau}_r = 94$ percent $> \widehat{\tau}_p = 86$ percent, and thus $IP = 0.176$. As conjectured by Bird and Zolt (2008), the tax structure becomes progressive when investments in tax administration's technology are made. Despite this fact, which calls for a high examination coverage, the government leaves up full auditing and sets $\widehat{p} = 0.89$. Finally, $\widehat{g}$ increases 14.06 percent, to attain \$30.58. Optimal investment, combined with the modified fiscal policy, makes the efficiency of the public sector to increase 2.4 percent, whereas expected welfare increases more, by 10.27 percent.

Box 5: Models of optimal tax systems

- Incorporate issues of tax administration: investments to improve the detection technology of the tax administration or to reduce audit costs.
- When such investments are done, the tax administration should audit less frequently.
- When such investments are done, we should observe improvements in the regressivity/progressivity of the tax structure.
- When such investments are done, we should observe Improvements in the efficiency of the public sector.

5 Empirical evidence of behavioral aspects of tax evasion

The models presented in the previous section generate some important testable implications. In this section, I will review the empirical findings that concern taxpayer compliance and the behavior of tax administrations.

The empirical literature on tax compliance can be divided in three groups, according to the data used for the estimations: econometric studies using TCMP/NRP data about individual tax compliance, controlled field experiments, and laboratory experiments.

5.1 Econometric studies using TCMP/NRP data

5.1.1 Impact of tax rates on evasion

Clotfelter (1983) is the first study that uses the 1969 TCPM data, to estimate the impact of different marginal tax rates upon individual tax compliance. The sample includes 47,000 individual returns for 1969. As a measure of tax evasion, he uses the log of the difference between the amount of AGI (taxable income) obtained by the IRS in the 1969 TCMP, and the amount reported by the individual. For every audit class (i.e. range of income reports), he finds a positive and significant impact of marginal tax rates upon evasion. Specifically, the elasticity of tax evasion with respect to the marginal tax rate varies from 0.515 for non-farm business returns, to 0.844 for non-business returns. For a taxpayer with a combined federal and state marginal tax rate of 40% (the average for the sample), these elasticities imply that a 10% decline in the marginal tax rate would reduce evasion by 5 to 8%. These results have been validated by other studies.

But, as is often the case when one considers income and tax rates as dependent variables, there can be an identification problem about their independent impacts because these variables are very correlated. To circumvent this issue, Feinstein (1991) estimates a model that uses pooled data from the 1982 and 1985 TCMPs. As for some income brackets marginal tax rates changed between those years, for individuals that earn the same income the separate effects of income and tax rates can be identified. His results contradict those of Clotfelter (1983): the effect of marginal tax rates on evasion is negative and highly significant. But these results are consistent with Yitzhaki's (1974) theoretical results.

As already mentioned in Section 2.1, the direct measure of tax evasion used in the abovementioned studies has its drawbacks, because TCMP/NRP programs cannot discover true evasion. In order to deal with this issue, Slemrod (1985) presents an interesting exercise, based on the following simple theoretical result: as the tax function is not continuos but it is instead stepped, evaders should choose to report an income at the top of the next lower income range. Using IRS's individual data for 1977, he finds significant evidence that there are more individuals reporting in the top of their income bracket, more than with respect to a random distribution of declarations. He also confirms Clotfelter's (1983) results regarding the impact of marginal tax rates on individual tax evasion.

5.1.2 Impact of audit probabilities and fines on evasion

Regarding penalties and audit probabilities, the empirical studies are more difficult, due to the endogeneity bias (as shown by the theoretical models of the interactive approach). Using IV techniques, Witte and Woodbury (1985) find evidence of a significant and positive relationship between the risk of audit (percent of taxpayers in each audit class filing a return that was audited) and their measure of individual tax compliance, for 1969. The elasticity of compliance with respect to the audit probability ranges from 0.02 for small proprietors to 0.002 for middle income wage and salary workers (thus verifying econometrically the picture of Table 1, in the sense that individuals with higher probabilities of being audited underreport less their income). They also find that audit frequencies have a lagged effect on compliance: the audit rates for 1967 and 1968 have more impact than the audit rate of the year when tax evasion was measured. Their results about the relation between civil or penal sanctions and compliance contradict the theory. Unfortunately, the authors do not study the reasons for such an intriguing result.

Another issue related to audit probabilities is studied by Scholz and Pinney (1995). In a sample of Long Island taxpayers, they obtain 747 answers about each individual subjective estimation of the IRS audit strategy. Then, they compare these answers to the result of an econometric estimation of the IRS audit probability. They find that the vast majority of taxpayers substantially overestimate the IRS audit probability.

The last issue concerning the impact of audits on tax evasion has to do with amnesties. If the possibility of an amnesty is interpreted ex ante as a softening of enforcement, the theory suggests that evasion should increase. Indeed, Das-Gupta and Mookherjee (2000) find that India's repeated use of tax amnesties may have weakened tax compliance in that country.

5.1.3 The optimality of endogenous audit rules

Alm, Bahl and Murray (1993) confirm econometrically the optimality of endogenous audit rules.[16] They use two microlevel data sets for Jamaican taxpayers. The first data set has estimates of individual income tax evasion, based upon audited income tax returns. The second data set has detailed individual information of a randomly selected pool of individuals, from wich

[16] The goal of their paper is also to estimate the determinants of individual tax compliance.

the audited returns were selected.

They use a three-stage estimation procedure, which applies the Heckman self-selectivity process and which allows for strategic behavior by taxpayers and by the Jamaica Income Tax Department (ITD). In the initial two stages, they apply bivariate probit analysis to the pooled data sets to estimate the factors that determine the ITD's selection of returns to be audited, and also the factors that determine the likelihood of noncompliance. Factors that determine the first-stage audit selection include items that the taxpayer reports on the return, as well as information capturing the resource capacity of the ITD. The first component of the bivariate probit analysis controls for and identifies the audit selection criterion. The authors find strong evidence that audit rates are endogenous: the tax administration uses systematically information from the returns to determine strategically whom to audit. The ITD does not audit randomly.

5.1.4 Importance of tax administration issues

Regarding the effectiveness of the tax administration, Feinstein (1991) and Erard and Feinstein (2010) confirm that audits are far from being perfect. Using data from the IRS, they estimate that detection rates vary between 30 and 50%.

5.2 Controlled field experiments

Recently, controlled field experiments have been undertaken to overcome some of the drawbacks of studies that use empirical data on tax evasion, e.g. identification and endogeneity problems. Slemrod, Blumenthal and Christian (2001) were the first to do this kind of quasi-natural experiment. They use a controlled field experiment in Minnesota to analyze taxpayers' response to an increased probability of audit. In 1995, a group of 1,724 randomly selected Minnesota taxpayers was informed by letter that the returns they were about to file would be 'closely examined'. Compared to a control group that did not receive this letter, low and middle-income taxpayers in the treatment group on average increased tax payments compared to the previous year, which the authors interpret as indicating the presence of noncompliance. The effect was much stronger for those with more opportunity to evade. Surprisingly, the reported tax liability of the high income treatment group fell sharply relative to the control group.

Using the same controlled framework, Blumenthal, Christian and Slemrod (2001) explore the effectiveness of alternative enforcement strategies. Two letters containing different normative appeals were sent to two large groups of taxpayers; a control group received no letter. The authors find little evidence of an impact of normative appeals on average compliance.

Kleven, Knudsen, Kreiner, Pedersen and Saez (2011) adopt the basic A-S framework to analyze a tax enforcement field experiment in Denmark. In the base year, a stratified and representative sample of over 40,000 individual income tax filers was selected for the experiment. Half of the tax filers were randomly selected to be thoroughly audited, while the rest were deliberately not audited. The following year, threat-of-audit letters were randomly assigned and sent to tax filers in both groups. The main empirical findings are the following.

First, using baseline audit data, the authors find that evasion rate is close to zero for income subject to third-party reporting, but substantial for self-reported income. This result is very important because it re-establishes the validity of the incentive theory in tax evasion issues. The authors did not need to consider morality or social norm considerations to match the data; the simple A-S model, modified to incorporate different audit probabilities, was sufficient for that.

Second, using quasi-experimental variation in marginal tax rates created by large kinks in the income tax schedule, they conclude that marginal tax rates have a positive impact on tax evasion for self-reported income, but that this effect is small in comparison to legal avoidance and behavioral responses.

Third, using the randomization of enforcement, they find that threat-of-audit letters have significant effects on self-reported income, but no effect on third-party reported income, as expected according to the theory.

5.3 Laboratory experiments

The laboratory experimental approach seems very adequate to apply to the tax evasion phenomenon, for the following reasons. First, as stated by Torgler (2002), even if data about individual tax compliance could be obtained, tax evaders' behavior depends upon many circumstances that cannot be controlled econometrically. Second, the experimental approach enables to do comparative static analysis, because they are undertaken in a controlled framework. It is not exaggerate to state that almost all issues regarding tax evasion have been tested in laboratory experiments. I will only review someof

them.

Friedland, Maital and Rutenberg (1978) were the first to undertake a laboratory experiment about tax evasion. As it is the seminal article, it is important to describe the experiment in detail. Participants were 15 Israeli undergraduate psychology students (eight women and seven men), with average age of 25. Each subject was given a folder containing tax tables and a form for reporting income and calculating tax and net income. First, questionnaires eliciting the background data previously described were tilled out. Then the subjects were instructed as follows: "They will receive a salary each 'month'. On the form received, they should report their income and pay an income tax according to the reported income. Each month a random audit will be made (according to a preannounced frequency, either one out of fifteen or five out of fifteen), and fines will be imposed, as a preannounced multiple of the sum of tax evaded. Participants were told that their objective was to maximize their net income (gross income less tax less fines). At the end of each round of ten months, their net income will be calculated and posted. At the end of four rounds, a small money prize will be distributed in proportion to each person's total net income."

The following table shows the main results:

Fine magnitude	Tax rate: 25%	Tax rate: 50%
15 times sum evaded	$p = 47\%$	$p = 78\%$
3 times sum evaded	$p = 57\%$	$p = 81\%$

Table 4: Results of the Friedland, Maital and Rutenberg (1978) experiment

where p is the number of months (out of 10) for which reported income was less than earned income, i.e. a measure of the tax evasion rate. As audit probabilities were the inverse of the fines, the authors found that large fines are more effective to curb non-compliance than frequent audits.

In a similar environement, Alm, Cronshaw and McKee (1993) simulate exogenous and endogenous audit rules. An exogenous audit rule means that the audit probability was random but fixed. The authors use different endogenous audit rules, but all depending upon the subjects' actions: (i) an audited individual found misreporting its income in period t will be always audited the next d periods, (ii) if an audited individual is found misreporting its income in period t, their previous k periods' reports will be audited, (iii)

the cutoff rule: a subject that reports less than a given income level will be audited with certainty. The authors find that the endogenous audit rules are able to generate substantially more compliance than random audit rules, even when, in the latter, the audit probability is set at 30 or 50%. In another experiment, Alm, McClelland and Schulze (1992) confirm the results of Scholz and Pinney (1995), namely that individuals overweight IRS audit probability.

An important contribution of the laboratory experimental approach is the confirmation that social factors affect tax compliance. In particular, Alm, Jackson and McKee (1993) show that compliance is affected by the use of the tax revenue, and also by the decision process by which these uses are chosen. In particular, several treatments are examined. In some treatments, subjects must choose among two alternative types of public goods, with the type of public good that will be provided decided by majority vote; in other treatments, the public good is imposed on the group.

Compliance is significantly higher when individuals vote on the use of their taxes than when the identical result is imposed upon them. But compliance is significantly lowered by the imposition of an unpopular expenditure program. Indeed, compliance is lower with an imposed and unpopular public good than in the complete absence of any public good.

6 Evasion by firms

6.1 Positive models

Although most studies on tax evasion deal with personnel income taxes. Nevertheless, since Marelli (1984), many articles started to analyze indirect tax evasion by firms, under different market structures. Marelli (1984), Wang and Conant (1988) and Yaniv (1995) consider a risk-averse monopolist deciding simultaneously how much to produce and to evade. In particular, Yaniv (1995) presents the first rigorous analysis of the necessary conditions under which production is independent from evasion. Virmani (1989) and Cremer and Gahvari (1993) present models of risk-neutral firms that evade sales/profit taxes under perfect competition. Virmani (1989) was the first to introduce (concave) concealment costs, as a way to reconcile the conventional industrial organization framework with risk-neutral firms with Alligham and Sandmo (1972)'s paradigm of evasion under uncertainty. Following this methodology,

Goerke and Runkel (2006, 2007), Bayer and Cowell (2009) and Besfamille, De Donder and Lozachmeur (2009) analyze production and evasion decisions in imperfectly competitive environments. As these articles share a framework that has become the canonical model to analyze the interaction between tax evasion and market structure, I present it in detail.

A good is produced by n identical, risk neutral firms labelled $i = 1, ..., n$. The number of firms is exogenous, so that all situations are covered, from monopoly ($n = 1$) to perfect competition ($n \to \infty$). Each firm i simultaneously decides how much to produce (q_i). Firms have constant returns to scale technologies, with the same marginal cost $c > 0$. Given output decisions $(q_1, ..., q_n)$, the price adjusts to the level that clears the market. Denote by $p(Q)$ the inverse market demand, where $Q = \sum_i q_i$ is aggregate output.

Each firm i has to pay a sales tax at a constant proportional rate $0 < \tau < 1$. As for the literature on income tax evasion, sales pq_i are private information, and taxes due are computed based on the amount of sales reported by the firm to the tax administration. Denote by $e_i \in [0, 1]$ the fraction of sales that firm i does not report. If $e_i = 0$, the firm fully complies with the tax law. But if $e_i > 0$, we say that there is tax evasion. As in Virmani (1989), in order to be successful, concealment of the fraction e_i entails a cost of

$$g(e_i) = k\frac{e_i^2}{2}$$

per \$ of sale, where the parameter $k \geq 1$ reflects the (in)efficiency of the evasion technology.

The government audits each firm i with the same probability $a \in (0, 1)$. When a firm is not audited, it pays sales taxes based on the amount reported – i.e., it pays $\tau(1 - e_i)pq_i$. Audits are costless and perfect, so that the government identifies the true sales amount of audited firms with certainty. If under-reporting of sales is detected, the evading firm has to pay the tax that it legally owes, τpq_i plus an additional fine, which is a fraction $\lambda > 0$ of the amount of taxes evaded.

The timing of the model is the following:

1. Firms compete *à la* Cournot in the market.

2. Firms decide the fraction of sales to report.

3. The government audits firms, collects taxes and fines due.

As is usual, the game is solved backwardly.[17] In stage 2, each firm i chooses the level of evasion e_i^* that maximizes its expected profit

$$\mathbb{E}\Pi_i = [p(Q)(1 - \tau(1 - e_i(1 - \xi)) - g(e_i)) - c]q_i,$$

where $\xi = a(1 + \lambda)$ denotes "enforcement", i.e. the expected payment rate on undeclared sales tax, expressed as a proportion of the tax rate τ. The following first-order condition

$$\tau(1 - \xi) = g'(e_i)$$

characterizes the optimal fraction e_i^*, in case of an interior solution. At the optimum, each firm declares a fraction of sales such that the marginal expected net benefit from evading this fraction equals the marginal cost of concealing it. Observe that e_i^* is independent of the market structure (the number of firms n), of the firms' cost c and of the variables determined in the market (price and quantities). Moreover, as all firms are audited with equal probability, they all evade the same fraction of sales taxes. Using the functional form adopted for the concealment costs function, the explicit solution for the optimal evaded share is $e^* = \tau(1-\xi)/k$. In order to evade, a firm must face an expected rate of payment on undeclared sales that is lower than the tax itself. If this is not the case (i.e. if $\xi \geq 1$), there is no evasion in equilibrium. This fraction e^* increases with the tax rate τ and decreases with enforcement ξ and with the inefficiency of the evasion technology k.

Moving back to the first stage of the game, substituting the optimal evasion share e^* into firm i's expected profit function obtains

$$\mathbb{E}\Pi_i = [p\,(Q)\,(1 - \tau^e - g(e^*)) - c]\,q_i,$$

where $\tau^e = \tau(1 - e^*(1 - \xi))$ denotes the expected effective tax rate paid by firms. The legal tax rate τ is modified by incorporating the evasion decision and the expected fine paid on the amount evaded.

Each firm chooses q_i in order to maximize its expected profit, taking as given the decisions of all other firms $j \neq i$. In equilibrium, one obtains the usual inverse-elasticity rule

$$\frac{p^* - \tilde{c}}{p^*} = \frac{1}{n\eta},$$

[17] As stage 3 is purely mechanical, I will not describe it.

where p^* is the equilibrium market price, η is the (absolute value of the) price elasticity of demand and

$$\tilde{c} = \frac{c}{1 - \tau^e - g(e^*)}$$

represents the effective marginal cost paid by firms. It is easy to see that $\tilde{c} > c$ when $\tau > 0$ and that $\tilde{c}$ increases with τ and with ξ: taxation is equivalent to an increase in the marginal cost faced by the firm, but evasion allows to dampen in part this impact.

The main results that can be obtained from this model are the following.

- Relation between enforcement, evasion and equilibrium prices.

  Since the equilibrium price p^* is a continuous function of the enforcement parameter ξ (via $\tilde{c}$), straightforward use of the implicit function theorem allows to conclude that when $\xi < 1$, the equilibrium price p^* increases with the enforcement level ξ. As mentioned above, evasion helps firms attenuate the impact of taxation on their marginal cost. Hence, with evasion, the consumer price is lower than the level that would have prevailed with full compliance. Therefore, the higher the level of enforcement, the lower the evasion and thus the higher is the equilibrium price level. As a consequence, the higher the level of enforcement, the lower the market aggregate output, but for a given market structure.

- Relation between enforcement, evasion and market structure.

  When firms have to decide whether to enter in the market, they need to anticipate the market conditions. As evasion alters the market equilibrium, and thus the expectations of firms' profitability (with respect to a no evasion situation), its existence alters the market structure. By endogenizing the number of firms in the market, Goerke and Runkel (2006) show that the conclusions of the previous point are reversed. As evasion fosters each firm profitability, new firms enter in the market. Although each (incumbent) firm reduces its production, the additional output of entrants outweights this decline, and thus aggregate output increases. As a consequence, tax evasion tends to render the market structure less efficient because there will be more firms in equilibrium, with respect to a no-evasion situation.

- As a corollary, it is clear that, starting from an free-entry equilibrium situation, if enforcement is increased, some firms present in the market have to leave it. This rationalizes the idea that, if evasion were to be totally eliminated, many firms would disappear from the market. Although this conclusion is true, it results from an analysis with a given tax structure (that does not need to be the optimal). To the best of our knowledge, there is still no contribution that has analyzed these issues from a general normative point of view.

- Besfamille, De Donder and Lozachmeur (2009) show that more enforcement may decrease government revenues. This is due to countervailing effects in the market: for a given market structure (i.e. number of firms), an increase in enforcement increases the price and decreases the aggregate product. Therefore, tax revenues can increase and decrease, depending upon the parameter configurations of the retained model.

6.2 Optimal tax-enforcement policies

The main paper that analyzes, from a normative point of view, the optimal indirect tax structure when firm tax evasion prevails is Cremer and Gahvari (1993). These authors show that, in an economy formed by separated competitive markets, social optimality may call for differences in indirect tax enforcement policies between these different markets. Moreover, many of their results contradict Ramsey's postulates. In particular, in the presence of indirect tax evasion, optimal commodity taxation should not discourage (compensated) demands equally (in percentage terms) across markets, with respect to a no-taxation situation.

Box 6: Models of firms' tax evasion

- Analysis of indirect tax evasion by firms, in different market structures.
- Equilibrium evasion increases with the tax rate, and decreases with the enforcement intensity and the efficiency of the concealment technology.
- Comparative static results
  - For a given market structure, the equilibrium price (total output) increases (decreases) with the enforcement intensity.
  - With respect to a no-evasion situation, the existence of evasion increases the number of firms in the market.
  - Increasing enforcement does not necessarily imply increasing tax revenues.
- In the presence of tax evasion, the optimal schedule of indirect taxes does not verify the Ramsey rules.

7 Policy implications: how to fight against tax evasion?

The previous sections have surveyed some of the most important results in the economic theory of tax evasion. Although there is still room for research on this topic, there are clear policy implications of these theories, empirical estimations and experiments. As Alm (2011) states, the theory suggests three paradigms to guide reforms in this important area of the government activity: enforcement - service - trust. Based on my own research, I will add another three: improvement in evasion measurement, better tax design and modernization of tax administrations. To illustrate the policy prescriptions, I will describe, whenever possible, real cases in Latin America.

7.1 Improvement in evasion measurement

In Section 2, I highlighted the importance of measuring, as rigorously as possible, the level of evasion. For two reasons, the USA were described as the

paradigmatic case. First, it is the unique country where the tax administration measures tax evasion using a direct method, in a systematic way. This enables the IRS to have the most accurate picture of this phenomenon, picture that guides the projects of tax reforms that are currently under scrutiny of the U.S. Congress (i.e. the Fair Tax Act). But, perhaps more importantly, the data obtained from the NRP is used as the main input in the design of sophisticated mathematical formulas that help to screen which tax returns to audit.

In Latin American countries, studies have been conducted, either by public entities (e.g. tax administrations) or private organizations (e.g. universities) in order to measure tax evasion [see Gómez Sabaíni, Jiménez and Podestá (2010) for a list of these studies]. Despite their importance, these studies have always been done using indirect methods. Moreover, there is no intention to continue them in a systematic way.

The exception is Mexico. According to Alvarez Estrada (2009), in the period 2004-2009, there have been more studies about evasion in this country than during the previous twenty years. This is due as a consequence of a congressional mandate to the Servicio de Administración Tributaria (SAT), to contract with national academic institutions to measure tax evasion. The official goal for this mandate was "*to increase the array of empirical instruments available, both to fiscal authorities, legislators and judges in Mexico, to improve the tax design and find better forms to reduce the stakes for tax avoidance and evasion*". Since 2004, Colegio de México (COLMEX), Colegio de la Frontera Norte (COLEF), Centro de Investigación y Desarrollo Económico (CIDE), Universidad de Nuevo León and ITAM were engaged by SAT to analyze evasion for different income sources. Again, all these studies use indirect methods. It could be very important that international financial institutions, like the IADB or CAF, could help financially Latin American countries to start undertaking systematic studies that, using direct methods (like the NRP), aim at quantifying tax evasion.

7.2 Enforcement

The economic literature on tax evasion is unanimous with respect to enforcement. Section 4 and 5 have shown the importance of a well-designed audit strategy. In order to increase fiscal revenues, the main policy implications are the following:

- To increase the number of audits, either by hiring additional auditors or by contracting out audits to private firms.

  - Although to the best of my knowledge there exists no rigorous study about the extent of audit activities in Latin American tax administrations, some changes have been observed during the last fifteen years, suggesting that, before them, audit strategies were not at their optimal level. For example, in 1998, the Argentine tax administration AFIP had 34% of its personnel in the enforcement area (FIEL, 1998). By 2007, this figure raised to 40.1% (OECD, 2010).

- More systematic selection of returns for audit and greater use of "scoring" tax returns.

  - Again, the DIF system of the IRS is the paradigmatic case of the use of scoring of returns. I am not aware of any Latin American country that uses this kind of system, which as was mentioned above, needs lots of data in order to be implemented.

- Improve the quality of audits – and of auditors.

  As mentioned in Section 5.1, many authors showed that the audit detection probability was quite low (for the IRS, between 30 and 50%). Despite the fact that no study about this issue exists for Latin American tax administrations, one can conjecture that a similar result applies. Therefore, actions aimed at improving the quality of audits seem worthwhile, as shown by the following example.

  - In February 2007, the *Dirección de Rentas de la Provincia de Buenos Aires* (the tax authority of the Buenos Aires province) subscribed to Google Earth to download high-quality satellite images that could serve as evidence of evasion to the property tax. This technology enabled the tax agents to discover, in less than one semester, 68,844 undeclared properties, 1,458 undeclared swimming-pools and more than 13 million square meters with undeclared silos.

- Increase taxpayer registration and identification via better use of third-party information.

In theory, using third party information is equivalent to a sharp decrease in the audit cost or to an increase in the probability of detecting an evader. Therefore, as theory suggests, evasion should decrease. Indeed, this has been informally shown in Table 1 in Section 2.2 (where individuals subject to withholding evade much less than others), and econometrically verified by Kleven et al. (2011).

Most Latin American countries have proceeded to establish a system of information crossing or provision of information to the tax administration by third parties. For example, in Argentina, there exists a system called "base e-fisco" where the tax administration has all information reported by taxpayers in their tax returns, and by third parties, like banks and credit card companies.

- Increase penalties for tax cheating.

  In Section 4.2, I showed that, according to the theory, optimal penalties should be set at their maximal legal level. In practice, this is seldom the case. Regarding tax evasion as a civil case, penalties are generally relatively low. In the USA, GAO (2007) shows that inflation has significantly decreased the real value of some civil penalties. Therefore, this office advices the Congress to enable the IRS to adjust penalties according to the level of inflation.

  During the nineties, many Latin American countries have passed laws that create the penal figure of tax evasion, and determine whether the particular case is a civil or a penal case, and its corresponding sanctions. For example, in Argentina, the Law 24.769 was sanctioned in 1996, and in Peru, the Legislative Decree N^o 813 was passed during the same year. Law 24.769 establishes the limit (100,000 pesos) between a case of civil and penal evasion. In the latter case, it describes very clearly the types of misbehavior that are unlawful, and stipulates penalties in form of jail conviction for each of these cases. As I will mention bellow, real convictions have been extremely rare in Argentina.

- Publicize tax evasion convictions in the media.

  According to the theories that incorporate morality considerations and social norms into tax evasion models, this kind of actions can help to curb tax evasion via two channels. The first one follows a "deterrence" argument: it is related to the bias that such publicity can imply in

the individual perceptions of the probability of being audited. The second one follows a "stigma" argument: such publicizations increase the social cost of being caught as an evader.

  - It has been argued by Blank and Levin (2010) that, in the USA, the U.S. Department of Justice Tax Division uses such channels to influence taxpayers' behavior, by issuing a disproportionately large number of tax enforcement press releases during the weeks immediately prior to Tax Day compared to the rest of the year.

7.3 Tax design

As shown in Section 4, tax design is crucial to deal with non-compliance, because it affects its stake. Thus, as enforcement is costly, the theory suggests that distorting tax rates downwardly, and thus decreasing the tax system's progressivity, may be optimal. Although I am not aware of any real example of a country that designs its tax policy considering explicitly curbing tax evasion as one of its goals, one can suspect that, in Latin America, the extent of tax evasion is one of the causes of the prevalence of tax structures that are not very progressive, or even regressive. It could be interesting to test empirically this implication.

Section 6 presents results about indirect taxation and tax evasion. Two results should be stressed as guides for tax policy design. First, Cremer and Gahvari (1993) proved that if tax evasion is an issue, indirect taxation has to be planned taking into account that some of the predictions of the traditional Ramsey taxation are reversed. Second, it is important to coordinate competition policy with tax and enforcement policies. If this does not happen, unwanted effects of a well designed-but-partial competition policy can emerge, e.g. less tax revenues.

7.4 Services to taxpayers

This paradigm for policy design has the goal to decrease individual's compliance costs. As we mentioned in Section 4.1.3. (footnote 9), an increase in compliance costs increases evasion. Therefore, it is worhtwhile to consider actions that aim to decrease these costs. In particular, one can consider

- Simplification of the tax legislation

– Number of taxes

The following table shows a relation between the number of taxes that a medium-sized firm has to pay, and the VAT evasion rate, for a selected group of Latin American countries.

Country	Number of Taxes on Firms	VAT Evasion rate
Chile	8	11%
Brazil	23	n.a
Argentina	35	21.2%
Mexico	49	20%
Uruguay	54	26.3%
Nicaragua	64	38.1%

Table 5: Relation between the number of taxes on firms and VAT evasion rate.

- – Although the figures show a simple relation, and the evasion rate is only computed for a single tax, it seems clear that, when a firm e.g. from Nicaragua has to pay so many taxes, their compliance costs are very high, thus facing a high stake for evasion. Those countries can reduce the number of taxes, and thus reduce the compliance costs, in order to diminish the evasion rate on indirect taxation.

  – Complexity of the tax law

  As briefly mentioned in Section 4.1.3., complexity of the tax law is an issue when analyzing the determinants of evasion. But the impact of a complicated tax system on the level of compliance is unresolved. Even so, in 1993, New Zealand embarked upon an ambitious project to respond to calls for reducing complexity to stimulate further compliance by taxpayers through rewriting its income tax legislation. The project was essentially a reorganization of existing material followed by a progressive rewriting of the statutory language, with minor policy changes implemented throughout the process. The rewrite project, originally intended to take 5 years, took 15 years and considerable expense to be achieved.

- Provide taxpayer services to assist taxpayers in filing returns and paying taxes.

This measure also helps reducing compliance costs. Since the end of the eighties, many tax administrations around the world have started to change their exclusive focus on enforcement in their fight against evasion, to consider also this service dimension. The following examples illustrate this movement.

- The new mission of that Chilean tax administration SII (Servicio de Impuestos Internos) is: "Administrar con equidad y justicia el sistema de tributos internos de destino fiscal, *facilitando el cumplimiento voluntario mediante la provisión de servicios de calidad, adecuados a cada tipo de contribuyente*; velando por el correcto cumplimiento tributario con estricto apego a la legalidad vigente y focalizando el esfuerzo fiscalizador en los contribuyentes con comportamiento tributario riesgoso." Italics are mine.
- The Taxpayer Advocate Service (TAS) is an independent organization within the IRS. It helps taxpayers who are experiencing economic harm, such as not being able to provide necessities like housing, transportation, or food; taxpayers who are seeking help in resolving problems with the IRS; and those who believe an IRS system or procedure is not working as it should. The TAS service is free, and specifies:

  "If you qualify for our help, we'll do everything we can to get your problem resolved. You will be assigned to one advocate who will be with you at every turn."

7.5 Tax administration

Section 4.3 addressed theoretically the issue of tax administration, considering in particular investments in technology to modernize the tax administration.

- In 1998, the US Congress created a special 'Information Technology Investment' account, to fund IRS's modernization activities. With these funds, in 1999, the IRS launched 'Business Systems Modernization' (BSM), an ambitious multianual project to modernize its information technology infrastructure. One of its pillars is the change of the old data system, the Master File system.

Among others, the Master File system has an important drawback. The entire process of entering account data into the Master File and make the updated information available for researching taxpayer accounts can take from four to six weeks. Because of these delays, IRS employees frequently have inconsistent and out-of-date information about a given taxpayer. Under these circumstances, conducting timely audits and going after tax evaders is extremely difficult. The Master File system will be replaced by the Customer Account Data Engine (CADE), which will allow IRS employees to post changes and update taxpayers accounts and returns from their desks. According to the IT 'Modernization Vision & Strategy' guidelines (IRS 2007), CADE will improve the quality of examinations, by reducing errors.

But there are many other examples of successful changes in tax administration, both in developed and in Latin American countries. Concerning the former, we have already indirectly shown in Table 1 the success of the use, by the IRS, of third party information. According to McCarten (2004), an example of a successful reform in a Latin American country is the Large Taxpayer Unit (LTU) in Argentina.

- – This organizational form[18] began in Argentina in the late 1970s. The focus was made more efficient and systematic in the early 1990s, through the development of a computer-based accounting system called *Sistema 2000*, initially for the control of compliance with filing and payment for the 2,000 largest taxpayers. This system has been progressively extended to cover 230,000 large and medium size taxpayers, although a single LTU in Buenos Aires monitors only 3,700 taxpayers who account for approximately 50 percent of all revenue generated. The Argentine large taxpayer software was applicable to all taxpayers so that, in this case, the LTU exerted a positive externality across the entire organization of the national tax administration.

[18] Today, the use of LTU has spread to over fifty counties by 2004 largely, though not exclusively, among the developing economies.

7.6 Contractual relationship between individuals and their government

The articles that incorporated non-economics issues to explain individual compliance behaviors and the new experimental literature on tax evasion clearly show that a climate of trust between taxpayers and the government improves tax collection. This climate of trust has many dimensions, but in this last section I want to stress just one, namely tax law enforceability. When the population recognizes that the government is unable to enforce the tax law, society is stuck in the bad equilibrium described by Traxler (2010). Consider the cases of Argentina and Chile. According to Bergman (2003), "*Chile has been more successful in achieving better tax compliance rates because tax enforcement has been perceived as more credible.*" A particular dimension of this credibility has to do with effective punishment. Again Bergman (2003) asserts "*The severity of sanctions only deters taxpayers when there is a significant subjective perception about the certainty of being detected. In Argentina the penal deterrence strategy categorically failed. More than 10,000 cases of tax evasion were filed in criminal courts between 1990 and 1994 with no direct effects on the level of tax compliance. Until 1997 1,596 cases were adjudicated by the criminal courts and in only 82 cases did the DGI secure a favorable resolution. Chile averages 100 cases a year of penal prosecutions for tax evasion, with a 90 per cent conviction rate.*".

Changes in this dimension are hard to implement, because they need strong political commitment. Besfamille, De Donder and Lozachmeur (2011) show how a society, in order to avoid some of the consequences of taxation (i.e. high prices of private goods), votes for low enforcement of indirect sales taxes, like the VAT. Hence, although the theory suggests many ways to deal efficiently with tax evasion, they are not easy to implement because, at the end, it is a matter of political will. And it is well known that it is very difficult to explain, and more to implement, a change from one political equilibrium to another. Nevertheless, at least one example exists where a government was able to establish a new climate more prone to tax compliance, thanks to a political commitment to a modern tax administration. According to Bergman (2003), this example is Chile: "*Tax compliance differed greatly in Chile and Argentina because state capacities were more developed in Chile and fostered a greater compliance among its taxpayers.*". Later, he wrote "*The success of Chile vis-à-vis Argentina is explained by the political capac-*

ity of both the Pinochet regime and the first Concertación government to neutralize rent seeking and predatory pressures, leading to the strengthening of the SII. Under different circumstances, both governments supported professionalisation of the tax administration authorities, de-politicised the agency and legislated taxes that relied on friendly enforcement. This was possible because the resistance and veto power of political opponents were neutralized by coalitions that understood that horizontal equity and solid fiscal performance was paramount for the success of the government. While Pinochet imposed and the Concertación accepted the logic of fiscal balance, no government in Argentina could muster a consensus about the need for fiscal restraint.". The conclusion is thus that, although such political changes a very difficult to implement, there have been Latin American successful examples.

8 Appendix

8.1 Derivation of the A-S model

The optimal taxpayer's behavior solves

$$\underset{X}{Max} \quad E[U] = (1-p) \underbrace{U(W-tX)}_{Utility\ if\ not\ audited} + p \underbrace{U(W-tX-\pi(W-X))}_{Utility\ if\ audited}$$

Let's define

$$Y = W - tX$$
$$Z = W - tX - \pi(W-X),$$

where Y is ex-post income in the no-audit case, and Z, ex-post income when the tax administration audits.

The first-order condition is

$$-t(1-p)U'(Y) - (t-\pi)pU'(Z) = 0.$$

The second-order condition

$$t^2(1-p)U''(Y) + (t-\pi)^2 pU''(Z) < 0$$

is automatically satisfied, due to the concavity of the utility function U.

It is not obvious to obtain an interior solution to this problem. To ensure that, one needs

$$\left.\frac{\partial E[U]}{\partial X}\right|_{X=0} = -t(1-p)U'(W) - (t-\pi)pU'(W(1-t)) > 0$$

$$\left.\frac{\partial E[U]}{\partial X}\right|_{X=W} = -t(1-p)U'(W(1-t)) - (t-\pi)pU'(W(1-t)) < 0$$

These conditions can be re-written as

$$p\pi > t\left[p + (1-p)\frac{U'(W)}{U'(W(1-t))}\right]$$

$$p\pi < t.$$

The second condition states that the taxpayer will declare less than his actual income provided the expected payment rate on undeclared income (if caught) is less than what it should have paid with a truthful report. As the bracket in the first condition is positive and less than 1, the two conditions are congruent and give a set of positive parameters (and parameter specifications of the utility function U) such that an interior solution

$$0 < X < W$$

does exist.

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