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Hidden Economies and the Socially Optimal Fiscal-Tax to Liquidity-Tax Ratio

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Abstract:

Differential tax analysis is used to show how the socially optimal fiscal-tax to liquidity-tax ratio changes with the relative size of the tax-evading hidden economy. The smaller the relative size of the hidden economy, the larger the optimal fiscal-tax to liquidity-tax ratio. The empirical cross-section and panel evidence supports this theoretical result.

JEL: E31, E52, H21, O17

Keywords: inflation tax, hidden/shadow/underground economy, seigniorage

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1 Introduction.

This paper presents a formal theoretical analysis and empirical evidence for the inverse relationship between the degree of fiscal-tax evasion and the socially optimal ratio of fiscal-tax to liquidity-tax rates. The unambiguity of this result relies on the relationship being defined on the ratio of tax-rates and is therefore independent of scale factors such as total economy size or the size of the government sector.

Raising tax revenue when a large proportion of economic activity is hidden from the fiscal-tax authorities is a pressing problem in many countries. In this paper standard differential tax analysis is used to show how the socially optimal ratio of fiscal-tax rate to the liquidity-tax rate changes with the relative size of the fiscal-tax evading hidden economy. The smaller the relative size of the hidden economy, the larger the optimal fiscal-tax to liquidity-tax ratio. Though this inverse relationship appears obvious, its unambiguity is owed to the relationship being defined with respect to the *ratio* of the aforementioned tax-rates and the rate of tax-evasion. Empirical evidence from cross-section data and an unbalanced panel of data on 36 countries is presented that supports this theoretical result. Though the material herein draws on many sources, the proposed theoretical model is fundamentally an extension of Phelps (1973) to include a private sector where agents avoid or evade the fiscal tax.

For the sake of completeness, two liquidity-taxes are considered. The first is simply the inflation rate, this is because the inflation rate is the liquidity-tax-rate that is most commonly taken into consideration in the literature. The second liquidity-tax under consideration is the nominal-interest-rate and this is the liquidity-tax that emerges from the formal theoretical model proposed in Section 3. The reason for this is evident; the nominal-interest-rate is the difference in the rate of return that is foregone when economic agents choose to hold their money in liquid cash rather than interest bearing accounts. This difference is the sum of the negative return resulting from inflation and the positive return resulting from the real rate of interest. In both cases these liquidity-taxes can be interpreted as the implicit tax rate on liquid cash holdings. In this paper, the fiscal-tax-rate is taken to be the ratio of total government revenue, excluding seigniorage revenue, to total taxable output. It therefore includes all direct and indirect taxes but excludes any taxes on liquid assets.

The paper proceeds as follows. Section 2 discusses background material and surveys the literature. In Section 3 the theoretical model is developed and the inverse relationship between the relative size of the hidden economy and the ratio of the fiscal-tax to the liquidity-tax is derived. In Section 4, data for 36 countries are presented and regression results are reported that confirm the inverse relationship derived in Section 3. The final section concludes.

2 Background and Literature Survey.

Addressing the link between the optimal tax-mix and the degree of tax evasion calls upon two strands in the economic literature. The first refers to the formal links between seigniorage and the liquidity tax-rate. The second strand refers to the evasion, or avoidance, of the fiscal tax and the existence of a hidden economy.

2.1 Seigniorage and the Liquidity-Tax.

The choice of the optimal liquidity-tax is closely related to the choice of the optimal level of seigniorage. Phelps (1973, p.75) states that, subject to conditions outlined in Section 3, the “revenue from the inflation tax is simply its contribution to the government’s *seigniorage* ... a tax on *liquidity*”.¹ Seigniorage can be a useful source of government revenue and even economies that possess effective fiscal tax gathering institutions use it to some extent. Estimates by Fisher (1982) for several developed economies reveal that during 1960-78 seigniorage accounted for about 6% of government revenue. The problem with high seigniorage is that it may lead to high price inflation. From a sample of nine developed economies in Fisher (1982, table A1) one can calculate that on average (unweighted mean) during 1960-73, seigniorage accounted for 5.3% of government revenue and inflation was 4.2%, during 1973-78 seigniorage rose to 6.8% and mean inflation rose to 10.3%.

In the presence of fiscal-tax evasion by agents in the hidden economy, raising money through an implicit tax on liquidity is an effective solution. Economic agents in the hidden economy cannot avoid the liquidity-tax because they require cash to carry out transactions making this an effective tax against fiscal-tax evasion. The downside is that the liquidity-tax can distort the market for liquidity and can therefore distort the optimal allocation of resources. This distortion is analogous to that caused by the fiscal-tax. Given that both the fiscal-tax and the liquidity-tax distort, the challenge for the policy maker is to set these two taxes at rates which minimize these distortions while still financing the government expenditure requirement. This optimal mix of fiscal and inflation taxes is obviously affected by the relative size of the hidden economy.

To reiterate, the question addressed in this paper is: does the socially optimal (distortion minimizing) fiscal-tax to liquidity-tax mix change with the relative size of the hidden economy? If the answer is in the affirmative, then policy should not focus exclusively on the attainment of low inflation but should also take into consideration

¹Due to different manufacturing costs, the seigniorage value of coins is low and of paper money is considerably higher; the seigniorage value of the monetary base created through *money on call* nearly equals the full value of the monetary base increase.

the impact of the hidden economy. This is particularly true in countries where the proportion of the hidden economy is relatively large such as in Bolivia (0.396, see Figure 1). In this paper the fiscal to inflation tax-mix is formalized as the ratio of the fiscal-tax rate to the liquidity-tax rate. The question is addressed in the context of the optimal tax model proposed by Phelps (1973). Phelps's model is extended by splitting the private sector into the hidden and visible economies. The issue of tax evasion and the optimal tax has also been considered by Nicolini (1998) who adapts the model by Chari et al. (1996) to quantify the welfare effect of the inflation tax by calibrating models of the Peruvian and US economies. In contrast, the analysis in this paper is an adaptation of Phelps' model where *all* agents are assumed to face the cash-in-advance constraint. This constraint means that the optimal tax-mix policy reduces to a single steady-state equation.

2.2 Fiscal-Tax Evasion and the Hidden Economy.

Defining and measuring the hidden economy raises many additional issues which are only touched upon here but which are discussed in depth in Friedman et al. (2000) and in Schneider and Enste (2000). The hidden economy is sometimes called the black, informal, parallel, second, shadow or underground economy; each implies a different pejorative connotation because it implies (fiscal) tax evasion. In some contexts there may be no pejorative connotation, there may simply be economic agents who can avoid, rather than evade, taxation for legal or institutional reasons. Furthermore, the analysis could have been extended by requiring that agents in the hidden economy require a higher cash ratio than those in the visible economy or by assuming that government expenditure benefits proportionally more the tax-paying visible economy than the tax-evading hidden economy. The effect of the first extension would be to strengthen the policy implications in this paper, the effect of the second extension would be to weaken them. Finally, the measurement of the hidden economy has given rise to a huge literature in its own right. The issue of measurement is not addressed in this paper and other authors' estimates are taken as given. Typically, the size of these hidden economies is estimated by comparing the size of the economy as measured by tax returns to estimates of the economy based on other measures. These other measures include the 'household electricity demand', 'currency demand' and 'multiple indicators multiple causes' methods. Good critical surveys of all these methods can be found in Tanzi (1999) and Feige and Urban (2003). Another good critique of these methods, with particular reference to former Soviet countries, can be found in Alexeev and Pyle (2003).

3 The Theoretical Model.

As in Phelps (1973), assume an economy where the government raises revenue by a liquidity-tax and by a fiscal-tax. In contrast to Phelps (1973), extend the private sector to include a hidden economy which is not subject to the fiscal tax. The private sector is made up of the visible and hidden economies in the proportions $1 - \bar{h}$ and \bar{h} respectively. The government sector seeks to maximize social welfare by co-ordinating the actions of its three administrative branches; the Expenditure Branch, the Treasury and the Central Bank. As in Phelps (1973), the path of the total tax burden is predetermined by the government's exogenous expenditure policy which can include some deadweight loss. Differential tax analysis is used to determine the government's optimal allocation between liquidity and fiscal taxation in order to maximize private sector utility by minimizing both tax distortions. The notation and formulation presented below follows as closely as possible that of Phelps (1973). Equations (1-8) correspond exactly to equations [10-17] in Phelps (1973). Equations (9-17) are the extensions to [19-27], equations (18-19) are the extensions to [33-34] and equation (20) is the extended equivalent of [41]. The more technical steps in the derivation of the theoretical model are presented in the Algebraic Appendix.

To obtain equivalence between the liquidity-tax and seigniorage revenue, and therefore simplify the analysis, the following assumptions are made (i) agents forecast inflation perfectly, (ii) the natural rate of output is not affected by the level of inflation, (iii) the economy is closed so that inflation is irrelevant as a stabilization policy, (iv) there are no costs to adjusting wage and prices, and (v) no interest is paid on money balances.

3.1 The Liquidity Tax.

Three equations are specified to satisfy conditions (i) to (v). Firstly, the 'forcing' function (1) ensures that the total (liquidity and fiscal) tax burden θ is invariant to changes in the tax-mix,

$$\theta(t) = T + \frac{\pi M}{p} - \frac{(i_D - \pi)D^*}{p} \quad (1)$$

where the "wondrous dynamic parameter" θ (see Phelps, 1973, p.73) is a function only of time t , total revenue from fiscal taxation is T , π is the inflation rate, M is money, p is the price level, i_D is nominal interest on the debt and $D^*(=D-M)$ is the part of the public debt held by the private sector. The derivation of equation (1) is discussed in Appendix A. Secondly, the level of private real wealth Δ is invariant to changes in the tax-mix. This ensures that the real level of wealth is a function only

of time and is not affected by the level of inflation,

$$\Delta(t) = \frac{D}{p} = \frac{M + D^*}{p} \quad (2)$$

where $D(=M+D^*)$ is the accumulated government debt. Thirdly, to avoid a wealth effect at time $t=0$ from a change in inflation policy π , the price level is held constant at this time,

$$p(0) = p_0 > 0. \quad (3)$$

Of course, the rate of inflation may change at time $t=0$ following a change in policy but the price level should not. Substituting (2), (3) and $M=D-D^*$ (equation A.3 in Appendix A) into (1) and re-arranging gives the seigniorage tax $i_D \frac{M}{p_0}$, at time zero:

$$i_D \frac{M}{p_0} = \theta(0) - T + (i_D - \pi)\Delta(0) \quad (4)$$

where increased inflation generates increased seigniorage and reduces the tax burden. To further simplify the analysis, the arbitrage condition that the real rate of return on the debt D equals the real rate of return on capital r_K is imposed,

$$(i_D - \pi) = r_K = \varsigma \quad (5)$$

where these real rates of return are assumed to be constant ς . Substituting (5) into (4) defines,

$$(\varsigma + \pi) \frac{M}{p_0} = \theta(0) - T + \varsigma \Delta(0) \quad (6)$$

which specifies how much the private sector pays to hold a particular level of liquidity. Partially differentiating the following money demand equation,

$$\frac{M}{p_0} = L(Y, r_K + \pi, K + D/p_0). \quad (7)$$

and substituting it into the partial derivative of equation (4) with respect to inflation gives,

$$\frac{-\partial T}{\partial \pi} = \frac{\partial(iM/p_0)}{\partial \pi} = \frac{M}{p_0} + i \frac{\partial L}{\partial(r_K + \pi)} + i \frac{\partial L}{\partial Y} \frac{\partial Y}{\partial \pi}. \quad (8)$$

This describes how fiscal tax revenue (T) changes with inflation (π) where $i(= \varsigma + \pi)$ is the nominal interest rate and ς is the (constant) real rate of return on capital. Equation (8) is crucial in solving the private sector and government optimizations presented in the next subsection. The implications of equation (8), in the context of Friedman (1971), are discussed in Appendix B.

3.2 Preferences and Constraints.

In this subsection, the preferences of the private sector and the constraints facing both the private and government sectors are specified. The government's preferences are simply to minimize fiscal and liquidity tax distortions subject to maintaining its pre-determined expenditure policy. The private sector's preferences are specified by these utility functions,

$$U^v = U(C^v, S^v, L^v, H^v) \quad (9a)$$

$$U^h = U(C^h, S^h, L^h, H^h) \quad (9b)$$

where U^v is utility in the visible economy, U^h is utility in the hidden economy and agents in both economies have the same preference structure over consumption ($\frac{\partial U^{v,h}}{\partial C} > 0$), saving ($\frac{\partial U^{v,h}}{\partial S} > 0$), liquidity ($\frac{\partial U^{v,h}}{\partial L} > 0$) and hours worked ($\frac{\partial U^{v,h}}{\partial H} < 0$). Different utility functions are specified for the two groups because agents in the hidden economy do not pay the fiscal-tax-rate and the two groups may therefore be at different points on their utility functions in equilibrium.

Gross economic output Y is derived subject to the following simplifications: a short-run framework such that the capital stock is taken as given, a proportional wage tax, perfect substitutability between capital and work hours with constant marginal returns,

$$Y = \bar{w}H + (\bar{r} + \bar{\delta})K = C + G + \dot{K} + \bar{\delta}K \quad (10)$$

where \bar{w} , \bar{r} and $\bar{\delta}$ are all fixed in time, where w is the pre-tax wage, r is the real rate of interest and δ is the rate of capital depreciation.

The government budget constraint is calculated with inflation and fiscal taxes changing such that the prescribed path of government debt $\dot{\Delta} = \frac{\dot{D} - \pi D}{p}$ defined by equations (1) and (6) remains unchanged. Let pre-tax earnings be $Z = \bar{w}H$ and let τ be the implicit fiscal tax rate on all economic activity. Substituting equation (2, $D/p = \Delta(t)$), the pre-determined time paths of government expenditure $G = \gamma(t)$ and benefit expenditure $B = \beta(t)$ (see equations A.1 in Appendix A) into the dynamic equation,

$$G + B + (\bar{r} + \pi)\left(\frac{D}{p} - L\right) - \tau Z - \pi \frac{D}{p} = \dot{\Delta}, \quad (11)$$

gives the government budget constraint:

$$(1 - \bar{h})\tau Z + iL = \gamma + \beta + \bar{r}\Delta - \dot{\Delta}. \quad (12)$$

The left hand side of equation (12) represents all government revenues and the right hand side all expenditures. As already stated, at any point in time the magnitude of equation (12) remains constant and only the tax mix of the left hand side changes as

policy changes. The private sector's budget constraint, with all expenditures on the left hand side and all revenues on the right hand side is given by,

$$C + S = (1 - \tau)(1 - \bar{h})Z + \bar{h}Z + (r + \delta)K + \bar{B} + i(\Delta - L) - \pi\Delta - \delta K. \quad (13)$$

Assuming all aspects of the visible and hidden economies are functions of the population proportions, with the exception of the income tax burden, equation (13) can be re-arranged and split between the visible and hidden economies,

$$(1 - \bar{h})[C + S + iL] = (1 - \bar{h})[\bar{r}W + B + (1 - \tau)Z] \quad (14a)$$

$$\bar{h} [C + S + iL] = \bar{h} [\bar{r}W + B + Z] \quad (14b)$$

wealth and savings are given by,

$$W = K + \Delta, \quad S = \dot{W} \quad (15)$$

where W is “real net spendable [i.e. disposable] wealth (real marketable net worth)” Phelps (1973, p73).

3.3 The Private and Government Optimization.

In this subsection, the optimizing behavior of private sector and the government are used to finalize the solution to the model. First specify the private sector's optimization behavior and then the government's optimization taking into account the private sector's behavior. In order to derive the behavior of the private sector the following Lagrangeans are specified using the utility functions (9a,b) and the budget constraints (14a,b) for the visible and hidden economies,

$$\Lambda^v = U^v(.) - \lambda^v(1 - \bar{h})([C + S + iL] - [B + \bar{r}W + (1 - \tau)Z]), \quad (16a)$$

$$\Lambda^h = U^h(.) - \lambda^h \bar{h} ([C + S + iL] - [B + \bar{r}W + Z]). \quad (16b)$$

Solving these Lagrangean functions and substituting in equations (14a, 14b), details for which are in Appendix C, generates the following marginal conditions,

$$\frac{\partial V^v(\tau, i)}{\partial \tau} = -\frac{\partial U^{v*}}{\partial C} Z \quad (17a)$$

$$\frac{\partial V^v(\tau, i)}{\partial i} = -\frac{\partial U^{v*}}{\partial C} L \quad (17b)$$

$$\frac{\partial V^h(\tau, i)}{\partial \tau} = -\frac{\partial U^{h*}}{\partial C} 0 = 0 \quad (17c)$$

$$\frac{\partial V^h(\tau, i)}{\partial i} = -\frac{\partial U^{h*}}{\partial C} L \quad (17d)$$

where $V^v(\tau, i)$ and $V^h(\tau, i)$ are the value functions for *maximized* indirect utility in the visible and hidden economies. Indirect utility is maximized insofar as the benevolent government agencies have set the fiscal tax rate (τ) and the liquidity-tax rate (i) to minimize these taxes' distortionary effects (see equations 29a,b in Appendix C). Equations (17a,b,d) are analogous to those in Phelps (1973, eq.33), equation (17c) has no analogous equivalent and it suggests that at the margin the level of utility in the hidden economy does not change with the burden of fiscal taxation (τ).

The government sets tax policy to maximize utility represented by $V^v(\tau, i)$ and $V^h(\tau, i)$, subject to the constraint in equation (12). To establish this optimal tax policy the following Lagrangean is specified where the utility functions of the visible and hidden economies are weighted according to their population shares,

$$\Psi(\tau, i) = (1 - \bar{h})V^v(\tau, i) + \bar{h}V^h(\tau, i) + \mu[\tau(1 - \bar{h})Z + iL - \bar{R}]. \quad (18)$$

Solving this Lagrangean and substituting in conditions (17a,b,c,d) defines the government policy rule (19), where the optimal fiscal tax and liquidity tax rates (τ, i) are functions of the compensated marginal labor and marginal liquidity demands ($\frac{\partial Z}{\partial \tau}, \frac{\partial L}{\partial i}$) and of the relative size of the hidden economy (\bar{h}) (details of the derivation are in Appendix D),

$$\frac{\tau}{Z} \left[(1 - \bar{h}) \left(\frac{\partial Z}{\partial \tau} \right)_{\bar{V}^v} + \bar{h} \left(\frac{\partial Z}{\partial \tau} \right)_{\bar{V}^h} \right] = \frac{(1 - \bar{h})i}{L} \left[(1 - \bar{h}) \left(\frac{\partial L}{\partial i} \right)_{\bar{V}^v} + \bar{h} \left(\frac{\partial L}{\partial i} \right)_{\bar{V}^h} \right]. \quad (19)$$

In the limiting case where there is no hidden economy ($\bar{h} = 0$) equation (19) collapses to equation (41) in Phelps (1973). In the limiting case where there is no visible economy ($\bar{h} = 1$) the optimal fiscal tax rate τ equals zero. Rearranging equation (19) gives,

$$\frac{\tau}{i} = (1 - \bar{h}) \frac{Z}{L} \frac{(1 - \bar{h}) \left(\frac{\partial L}{\partial i} \right)_{\bar{V}^v} + \bar{h} \left(\frac{\partial L}{\partial i} \right)_{\bar{V}^h}}{(1 - \bar{h}) \left(\frac{\partial Z}{\partial \tau} \right)_{\bar{V}^v} + \bar{h} \left(\frac{\partial Z}{\partial \tau} \right)_{\bar{V}^h}} \quad (20)$$

Equation (20) suggests that the larger the relative size of the hidden economy (\bar{h}), the lower the optimal (distortion minimizing) ratio of the fiscal tax rate (τ) to the liquidity-tax rate (i). This is because as \bar{h} becomes bigger, the right hand side of (20) becomes smaller, thus requiring a smaller optimal tax ratio (τ/i) to maintain the relation, assuming that both liquidity and earnings are normal goods ($(\frac{\partial L}{\partial i})_{\bar{V}} < 0$, $(\frac{\partial Z}{\partial \tau})_{\bar{V}} < 0$).

An intuitive interpretation of (20) is straightforward. The larger the relative size of the hidden economy, the greater the need for liquidity taxes relative to fiscal taxes in order to maintain the exogenously determined level of government expenditure and minimize tax distortions.

3.4 First, Second, Third-Best Worlds and the Exogeneity of the Hidden Economy.

The model presented here is clearly one of a *third best* world where the hidden economy share is taken as exogenously given or tax avoidance/evasion is simply too costly or complicated for the tax authorities to tackle. These costs include the inability to gather information on the activities of all its citizens (i.e. the tax-evaders) and some activities (such as religion or charities) being beyond the reach of the tax authorities and therefore genuinely exogenous. Under even modest assumptions the hidden economy share can be endogenized at least to some extent. This leads us to a *second best* world where the government sector can co-ordinate its three administrative branches: Expenditure, Treasury and Central Bank to improve on the social welfare outcome. Obviously, in a second best world the government sector sets the tax rate, inflation rate, expenditure on catching tax-evaders and punishment for tax evasion as part of social welfare function optimization. In a *first best* world the issue of fiscal tax evasion becomes redundant because the government is assumed to be all-knowing and can simply tax everyone to maximize social welfare. In this first best world tax evasion disappears and the model collapses to the one first presented by Phelps (1973).

Throughout we have also assumed that the Government is acting as a *benevolent dictator*. Potentially one could extend to model to include self-seeking behavior on the part of those administering the Expenditure Branch, Treasury and Central Bank. In this case the *social planner* has to choose institutional structures that ensure the second best outcome for the social welfare function. The global trend for increased Central Bank independence from the Government can be seen in this context.

In summary, one could endogenize the hidden economy share (\hat{h}), government expenditure (G) and/or benefit expenditure (B) in order to incorporate these into the Public Sector optimization. Though not focused on the impact of the hidden economy, Végh (1989) presents a model that does explicitly include collection costs on the fiscal tax. Such a model allows for the determination of the optimal inflation tax rate for different levels of government expenditure. Buitier (2007) presents a theoretical model that explicitly includes separately the operational constraints facing the Central Bank and the Treasury. In Buitier's extension the resource transfers between the private sector and the two public bodies are modeled allowing for further policy recommendations under different scenarios such as an economy caught in a liquidity trap.

4 The Empirical Evidence.

In this section, data for 36 countries are illustrated and analyzed. Scatter plots of the data confirm the inverse relationship between the fiscal-to-liquidity tax ratio (τ/i) and the hidden economy share (\bar{h}) suggested by equation (20). Regression results are presented that also confirm this inverse relationship.

4.1 The Data.

The data come from a variety of sources and consist of an unbalanced panel spanning 1989 to 1999. Summary statistics in terms of the mean values per country are given in Table 1, including the years covered for each country. Scatter plots of the data are illustrated in Figures 1 to 4 and data sources are in subsection 4.2. The range for the mean hidden economy share is relatively large, from around 0.07 to 0.40. OECD economies tend to have the lower hidden economy shares than developing economies. Among the developing economies, Chile has a relatively low hidden economy share. Among the OECD economies, Greece seems to have a relatively high hidden economy share. Transition economies represent an intermediate case.

Figure 1 illustrates a scatter plot of the mean fiscal-tax to liquidity-tax ratios (τ/i) against the mean hidden economy shares (\bar{h}) from Table 1. This scatter plot appears to support the theoretical result that, assuming a socially optimizing policy-maker, countries with a higher hidden economy share should have a lower fiscal-tax to liquidity-tax ratio. Figure 2 illustrates the same scatter plot but for the panel data rather than the mean values (excluding Panama). Here too the negative relation between τ/i and \bar{h} appears non-linear and well-defined. In order to verify the statistical significance of this inverse relationship, the results from cross-section and panel regressions are reported in subsection 4.3.

Figure 3 illustrates a scatter of the mean fiscal-tax to inflation ratios ($\tau/(\pi+.02)$) plotted against the mean hidden economy shares (\bar{h}) reported in Table 1. Here too the inverse relationship suggested by equation (20) is confirmed. The reason for presenting data on the inflation rate is that this is the focus of interest in a vast majority of the literature. It is therefore important to establish the robustness of this inverse relationship to the alternative fiscal-tax to inflation ratio. The principal reason for including the value .02 in the ratio $\tau/(\pi+.02)$ is to accommodate cases where the inflation rate is negative and therefore avoid indeterminate values when taking the natural logarithm of this ratio for the regression analysis of subsection 4.3. Figure 4 illustrates the same scatter plot (again excluding Panama) for the panel data. Here too the inverse relationship seems to be confirmed and to confirm the statistical significance of this relationship, results from panel regressions are presented

Country	Label	Period	Mean Values for: [†]					
			\bar{h}	$\frac{\tau}{i}$	$\frac{\tau}{\pi+.02}$	τ	i	π
Developing Economies								
Argentina	Arg	1993-1998	0.310	1.828	3.413	0.129	0.072	0.033
Bolivia	Bol	1990-1993	0.396	0.416	0.643	0.096	0.233	0.148
Chile	Chi	1989-1993	0.189	0.786	0.928	0.180	0.254	0.186
Colombia	Col	1989-1993	0.242	0.320	0.412	0.118	0.375	0.270
Ecuador	Ecu	1990-1993	0.238	0.383	0.310	0.159	0.428	0.494
Guatemala	Gua	1989-1993	0.348	0.655	0.536	0.093	0.157	0.218
Mexico	Mex	1989-1993	0.248	0.548	0.715	0.137	0.289	0.190
Panama	Pan	1989-1993	0.354	2.493	6.146	0.174	0.072	0.009
Peru	Per	1989-1993	0.348	0.175	0.091	0.122	7.203	23.726
Uruguay	Uru	1989-1993	0.260	0.120	0.308	0.243	2.109	0.839
OECD Economies								
Australia	Aus	1990-1999	0.129	3.336	5.554	0.214	0.072	0.025
Austria	Aut	1989-1998	0.074	8.086	7.572	0.329	0.050	0.026
Belgium	Bel	1989-1998	0.174	9.423	10.051	0.420	0.058	0.023
Canada	Can	1989-1999	0.127	3.179	4.889	0.190	0.070	0.025
Denmark	Den	1989-1999	0.138	6.613	7.848	0.332	0.060	0.024
Finland	Fin	1989-1998	0.144	4.833	6.992	0.279	0.063	0.027
France	Fra	1989-1997	0.116	6.027	8.879	0.374	0.074	0.024
Germany	Ger	1989-1998	0.117	6.407	6.196	0.263	0.049	0.025
Greece	Gre	1989-1998	0.210	1.135	1.668	0.204	0.184	0.122
Ireland	Ire	1989-1997	0.124	3.891	7.189	0.317	0.086	0.026
Italy	Ita	1989-1998	0.201	4.471	6.323	0.387	0.096	0.046
Japan	Jap	1989-1993	0.085	4.398	3.818	0.159	0.040	0.023
Netherlands	Net	1989-1997	0.115	8.000	9.827	0.421	0.062	0.024
New Zealand	NZ	1989-1999	0.096	3.707	8.265	0.323	0.095	0.025
Norway	Nor	1989-1999	0.150	4.085	7.226	0.321	0.083	0.026
Portugal	Por	1989-1998	0.165	3.201	4.088	0.295	0.118	0.070
Spain	Spa	1989-1997	0.164	2.889	4.163	0.276	0.106	0.050
Sweden	Swe	1989-1998	0.154	6.513	8.302	0.336	0.068	0.039
Switzerland	Swi	1989-1998	0.069	9.289	5.701	0.208	0.038	0.026
United Kingdom	UK	1989-1999	0.106	4.592	6.219	0.331	0.083	0.041
United States	US	1989-1999	0.077	3.912	3.656	0.180	0.049	0.032
Transition Economies								
Belarus	Blr	1992-1995	0.280	0.417	0.027	0.323	1.381	13.680
Bulgaria	Bul	1991-1995	0.237	0.554	0.271	0.282	0.515	1.380
Croatia	Cro	1992-1995	0.243	2.238	1.752	0.367	4.676	35.839
Hungary	Hum	1989-1995	0.207	2.046	1.639	0.416	0.213	0.247
Poland	Pol	1989-1995	0.204	0.959	0.630	0.351	0.401	1.789
Slovenia	Slo	1992-1995	0.200	2.164	1.416	0.386	0.192	0.395

[†] \bar{h} is the hidden economy share, τ is the fiscal-tax rate, i is the liquidity-tax rate (which is the nominal interest rate) and π is the rate of inflation.

Table 1: Summary statistics, mean values.

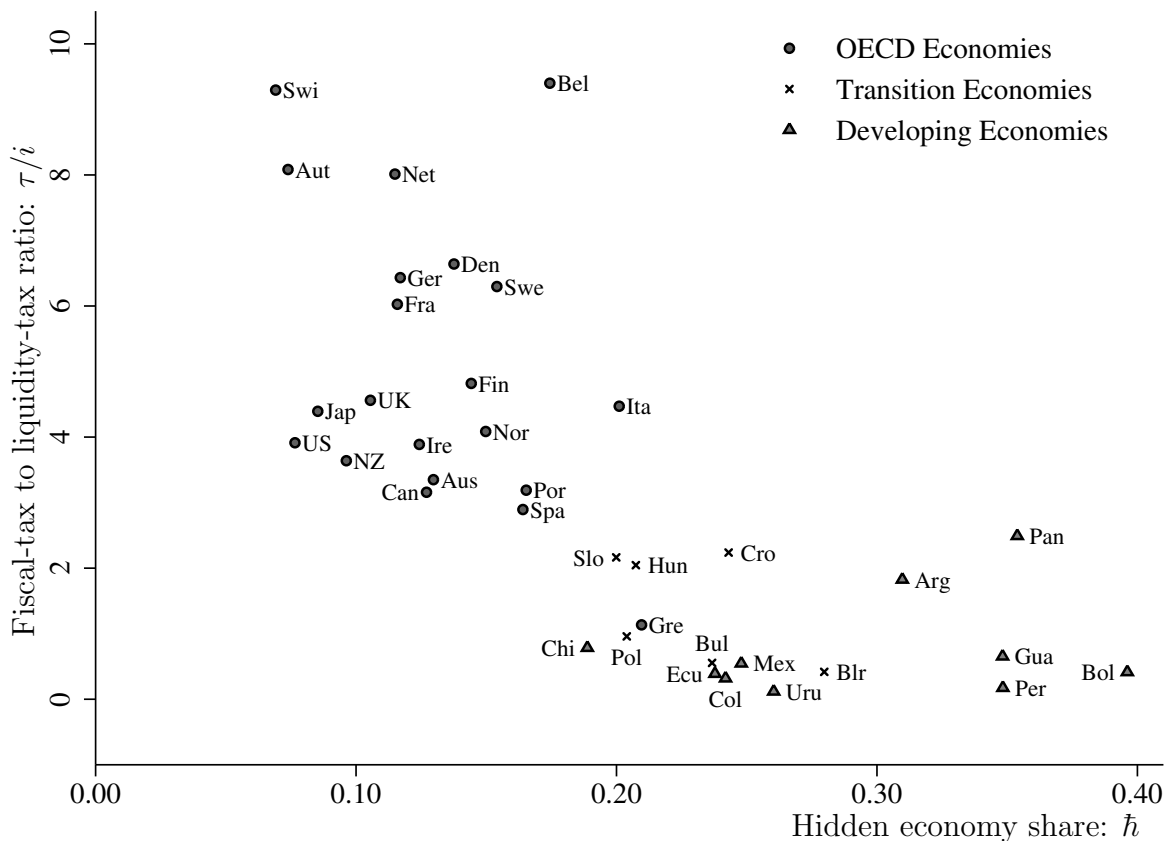


Figure 1: Fiscal-tax to liquidity-tax ratio and hidden economy share, mean values.

in subsection 4.3.

Inspection of Figures 1 to 4 raises questions regarding outlier countries. One evident outlier in Figure 1 is Panama. Panama's economy does not fit the model described by the theory in Section 3 because the Panamanian Balboa is fixed at a one-to-one parity with the US Dollar. US dollar notes (and locally minted coins) are used as currency, hence, Panama does not have its own independent monetary policy and is therefore excluded from the regression analysis in subsection 4.3. From Table 1 one sees that though Panama's mean fiscal-tax rate is 0.174, the fiscal-tax rate is only 0.072 and the inflation rate is only 0.009, this makes Panama an outlier in terms of its tax-ratios (τ/i , τ/π). The fact that Panama is an outlier in terms of its hidden economy share is *not* the reason for its exclusion. Panama's large hidden economy share (0.354) is a consequence of illegal trafficking along the Panama Canal both between the Americas and across the Atlantic and Pacific Oceans, see CIA (2004). Other evident outliers in the Figures are Belgium and Argentina. From Table 1 it seems that Belgium has a particularly high fiscal-tax rate at 0.420 and Argentina has a particularly low mean inflation rate of 0.033. There seems to be no particular justification for excluding Argentina and Belgium and they are therefore kept in the regression analysis. Finally, the United States is a potential outlier. The reason for

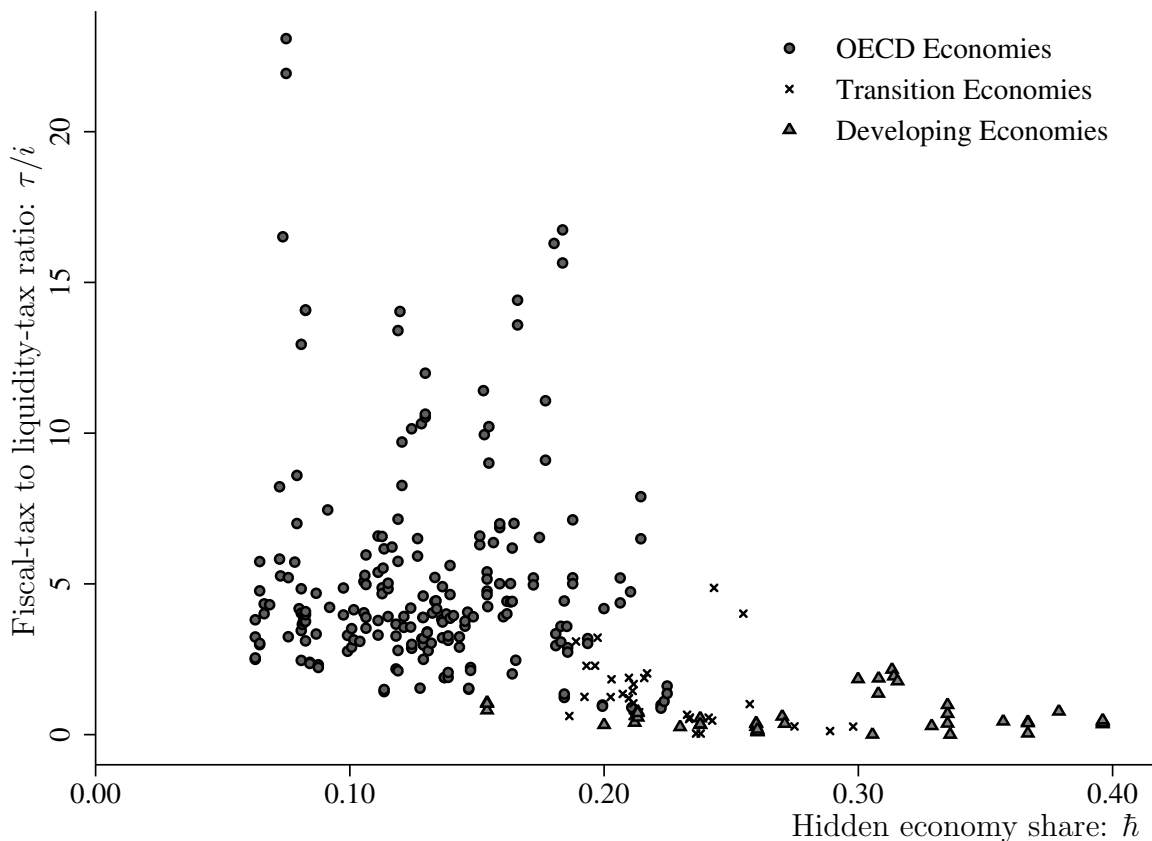


Figure 2: Fiscal-tax to liquidity tax-ratio and hidden economy share, panel data.

this is that the United States is able to raise large amounts of seigniorage without this affecting its own monetary policy because the world economy uses US Dollars for international transactions. Despite this, the United States is included in the regression analysis.

4.2 The Data Sources.

The estimates of the hidden economy shares (\hat{h}) out of total economic activity are derived from the various sources described below and illustrated in the Appendix Table 7. Table 7 shows that for some countries the hidden economy share has been falling, while for others it has been rising over the available sample period. This diversity in trends should help in the estimation as it represents variation in the variable of interest. Obtaining such estimates is, by definition, the most challenging and contentious part of the data collection process. In those cases where more than one estimate is available in any given year, mean values for each year are used. The data sources for the hidden economy shares are: Ahumada et al. (2001, Table 2)², Lackó (2000, Table 6), Loayza (1997, Table 1), Schneider (2000, Table 2), Schneider (2002,

²Quarterly values are converted to annual means.

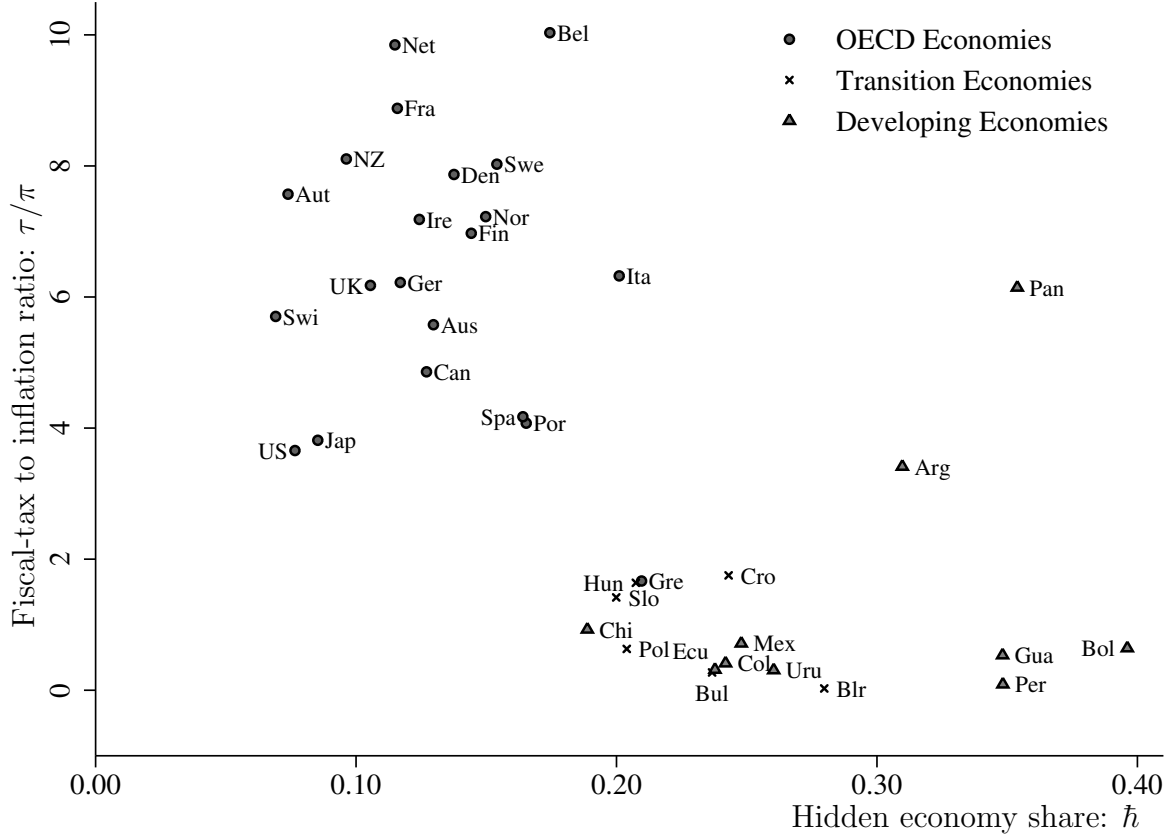


Figure 3: Fiscal-tax to inflation ratio and hidden economy share, mean values.

Tables 2 and 3) and Schneider and Bajada (2003, Table 2). In these data sources the hidden economy share is originally defined as $h = Y_h/Y_r$ where Y_h is hidden economic activity and Y_r is recorded economic activity. For the analysis in this paper these values are converted using the formula $\tilde{h} = h/(h + 1) = Y_h/Y_t$, where Y_t is total economic activity.

Most of the above sources report measures of the hidden economy (Y_h) as the discrepancy between recorded economic activity (Y_r) and estimated total economic activity (Y_t) using one of these methods: electricity consumption, multiple-indicators multiple causes (MIMIC) or dynamic mimic (DYMIMIC). The one exception is Schneider (2002, Table 3) who uses the currency demand method for the OECD economies. Ahumada et al. (2007) present a critique of all monetary methods based on the notion that the velocity of circulation in the hidden and visible economies may not be the same because economic agents in the hidden economy do not have the same access to banking institutions.³ We should therefore bear in mind that the proposed mea-

³The correction proposed by Ahumada et al. (2007) can, if the relevant information is available, be relatively straightforward. The corrected hidden economy share is given by the formula $h = (h_b)^\beta$ where h_b is the biased measure and β is the parameter in a currency demand equation such as $C_r = Y_r^\beta A(1 + \Theta) \exp(-\gamma i)$ where C_r are recorded cash balances, Y_r is recorded economic activity, Θ is a vector of variables that induce hidden economic activity, and i is the opportunity cost of

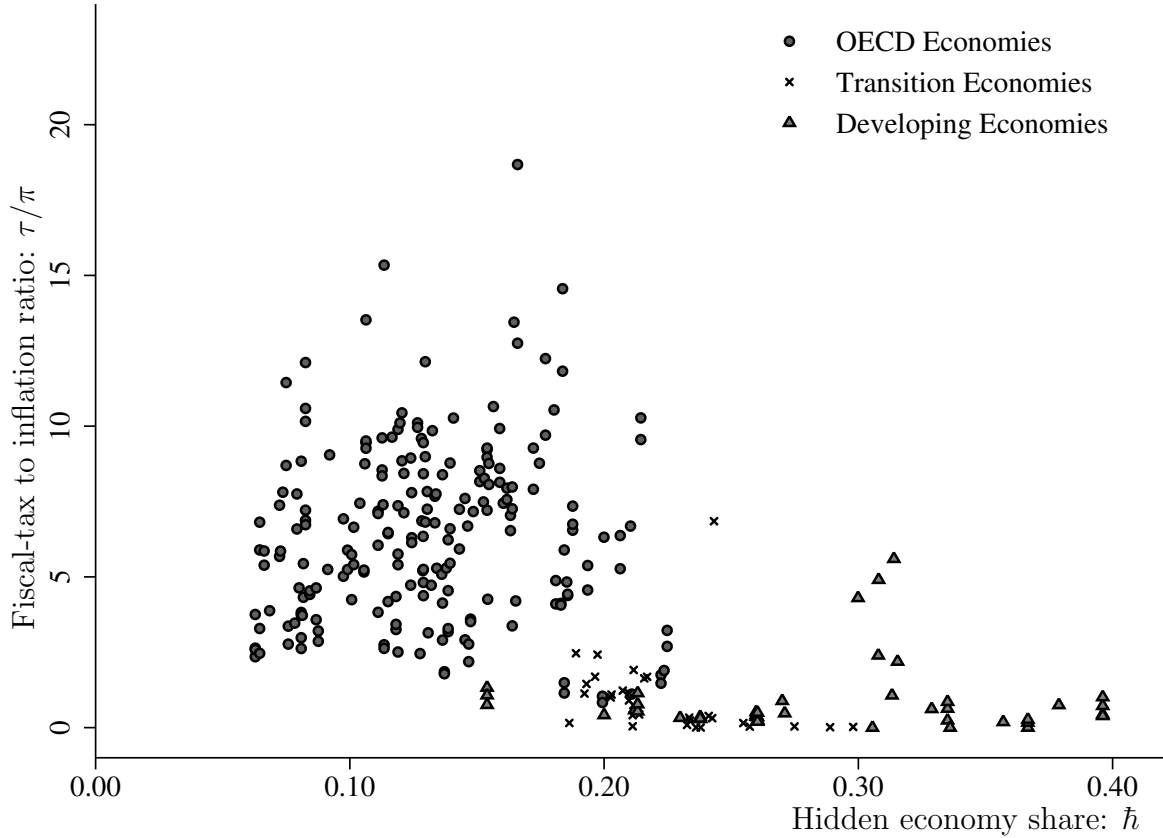


Figure 4: Fiscal-tax to inflation ratio and hidden economy share, panel data.

asures of the hidden economy share for the OECD economies probably require further refinements.

Data on the fiscal-tax rate (τ) are obtained principally from the World-Bank (2002, code GB.TAX.TOTL.GD.ZS). These are total tax revenues as a proportion of GDP, excluding seigniorage. This tax rate therefore represents a composite tax rate on all economic activity that includes both income and expenditure taxes. In the case of Guatemala, data on the fiscal-tax rate are not available from the World Bank, so data from the IMF (2004) are used instead. For Guatemala the fiscal-tax rate is calculated as the ratio of total government revenue excluding grants from abroad (IMF-IFS line 81...ZF) to GDP (IMF-IFS line 99B..ZF).

Data for the inflation rate (π) are obtained from the IMF (2004, IMF-IFS line: 64.XXZF), these are measures of annual inflation based on, according to availability, either the Retail Price Index or Consumer Price Index.

Data on the liquidity-tax (nominal interest) rate (i) are mainly from the IMF (2004). Because of varying institutional structures, each country's base interest rate may be set by different institutional frameworks. In the majority of cases the

holding cash (inflation or the interest rate). Having obtained h , one can then calculate the hidden economy share out of total economic activity using $\bar{h} = h/(h + 1)$.

liquidity-tax rate is defined as the discount rate (IMF-IFS line: 60...ZF). In the case of Argentina, Australia, France, Guatemala, Mexico, the Netherlands and the United Kingdom the money market rate (IMF-IFS line: 60B..ZF) is used. In the cases of Guatemala and Panama the deposit rate (IMF-IFS line: 60L..ZF) is used. Finally, in the cases of Bolivia and Chile there are so many missing observations in the IMF (2004) that the series for the deposit rate in the World-Bank (2002, code FR.INR.DPST) are used instead.

In addition to the hidden economy share, three further regression variables are included to capture other factors affecting fiscal taxes and liquidity taxes, i.e. fiscal and monetary policy. All the variables are defined using data from the World Bank's World Development Indicators. The first of these is **Growth**, defined as the real growth rate for the economy in that year. The variable **Growth** is generated as the growth rate of real GDP defined constant 1995 US dollars, this ensures cross-country comparability. We expect *Growth* to be positively related to the tax-ratio because high growth is associated with rapid increases in fiscal tax remittances due to fiscal-drag. The second of these is the variable **Openness** used to identify how open the economy is to the Global economy. The variable **Openness** is defined as the ratio of exports to GDP, again, both numerator and denominator are defined in constant 1995 US dollars. We have no strong priors as to the influence of **Openness** on the tax-ratio. The third extra regression variable is **WagePressure** defined as the annual real income in 1000s of 1995 US Dollars per capita. This is generated using the measures of population and GDP in constant 1995 US Dollars. We also have no strong prior as to the influence of **WagePressure** on the tax ratio because on the one hand wage pressure feeds into higher inflation and therefore higher nominal interest rates but on the other hand wage pressure can be tackled by higher taxation. Finally, a time **Trend** is included. The trend is intended to capture any global trends in the tax-ratio policies taken by various economies. We suspect that during the 1990's there has been a trend toward fiscal and monetary prudence implying, *ceteris paribus*, lower inflation rates and higher fiscal tax rates. This implies we expect the parameters on the **Trend** to be positive.

4.3 Regression Analysis.

The regression results presented below support the theoretical results of Section 3 and the discussion on Figures 1 to 4. Because of the apparent non-linear form suggested by Figures 1 to 4 the natural logarithms of the variables are used and the estimated parameters can therefore be interpreted as elasticities. Static-panel regressions and dynamic-panel regressions are reported to check the robustness of the results to different functional forms.

	Regressand: $\ln(\tau/i)$			
	(2.1)	(2.2)	(2.3)	(2.4)
Regressors:	OLS on panel	Between Effects OLS	Fixed Effects OLS	Random Effects GLS
$\ln \bar{h}$	-0.756 (-5.06)	-0.633 (-1.62)	0.184 (0.49)	-0.754 (-2.74)
Growth	6.657 (5.41)	9.615 (2.77)	8.152 (7.86)	7.084 (6.71)
Openness	1.094 (3.97)	1.105 (1.70)	-3.074 (-3.82)	-0.287 (-0.54)
WagePressure	0.0451 (7.92)	0.0450 (3.21)	-0.0663 (-2.25)	0.0437 (3.81)
Trend	0.124 (7.73)	0.345 (3.82)	0.136 (7.51)	0.109 (7.12)
Constant	-2.521 (-9.81)	-3.534 (-5.64)	2.600 (2.79)	-2.060 (-4.39)
R^2	0.692	0.830	0.474	0.660
Overall Signif.	$F_{272}^5=122.19$	$F_{30}^5=29.95$	$F_{237}^5=42.78$	$\chi_5^2=265.88$
Observations	278	278	278	278
# of countries	36	36	36	36

Absolute t-statistics in (parentheses).

Panama is excluded from all regressions.

Table 2: Static panel regressions, tax to interest rate ratio.

Presented in Table 2 are the results for the static panel regressions with the natural logarithm of the liquidity-tax to fiscal-tax ratio $\ln(\tau/i)$ as the regressand. In three cases the estimated parameters on the natural logarithm of the hidden economy share $\ln \bar{h}$ are, as expected, negative and in two cases they are significantly so. Column 2.1 reports the regression results for the raw panel data, here the parameter on $\ln \bar{h}$ is negative, significant and greater than minus one suggesting an inelastic response. Column 2.2 gives the results for the between effects regression, in other words, this captures the variation between countries. It seems that in this case the negative parameter on the hidden economy share is still negative but the statistical significance drops. Column 2.3 gives the results for the fixed (within) effects regression. Here the parameter on $\ln \bar{h}$ is not statistically different from zero. The implication is that much of the variation that determines the parameter on $\ln \bar{h}$ is due to the between variation across countries (between effects) rather than the within variation (fixed effects) within countries. Finally, column 2.4 reports the random effects GLS regression results. This is a weighted regression of the between and fixed effects regressions.

Regressors:	Regressand: $\ln(\tau/i)$			
	(3.1) Common ρ^a Common σ^c	(3.2) Specific ρ^b Common σ^c	(3.3) Common ρ^a Specific σ^d	(3.4) Specific ρ^b Specific σ^d
$\ln \bar{h}$	-0.594 (-2.44)	-0.792 (-4.00)	-0.594 (-2.72)	-0.792 (-5.55)
Growth	5.975 (6.07)	6.689 (7.71)	5.975 (3.08)	6.689 (3.97)
Openness	0.359 (0.81)	0.129 (0.32)	0.359 (0.57)	0.129 (0.20)
WagePressure	0.0512 (5.28)	0.0467 (6.07)	0.0512 (5.87)	0.0467 (6.47)
Trend	0.108 (5.27)	0.118 (6.12)	0.108 (6.03)	0.118 (6.76)
Constant	-2.009 (-4.93)	-2.256 (-8.37)	-2.009 (-4.10)	-2.256 (-8.48)
(mean) ρ	0.750	0.666	0.750	0.666
R^2	0.422	0.632	0.422	0.632
Overall signif.	$\chi^2_5=242.87$	$\chi^2_5=505.39$	$\chi^2_5=178.41$	$\chi^2_5=474.44$
Observations	278	278	278	278
# of countries	36	36	36	36

Absolute t-statistics in (parentheses) with panel-corrected standard errors.

Panama is excluded from all regressions.

Prais-Winsten estimated first-order auto-regressive errors $u_t = \rho u_{t-1} + e_t$.

^a Auto-regressive parameter ρ common to all countries.

^b Auto-regressive parameter ρ_i specific to each country.

^c Disturbance standard-error σ common to all countries.

^d Disturbance standard-error σ_i specific to each country.

Table 3: Autoregressive residual regressions, tax to interest rate ratio.

The results in column 2.4 are very similar to those in column 2.1.

Presented in Table 3 are the results for dynamic panel regressions, again with the natural logarithm of the liquidity-tax to fiscal-tax ratio $\ln(\tau/i)$ as the regressand. In all four regressions the parameters on the natural logarithm of the hidden economy share $\ln \bar{h}$ are negative and statistically so. The dynamics are parameterized as first-order autoregressive in the residual structure AR(1) and are estimated using the Prais-Winsten method to avoid losing the first observation for each country. Though there is no pretense that the true dynamic structure can be estimated on such short runs of panel data, these dynamic regressions do accommodate first order autoregression in the residuals leading to more robust inference. To verify the robustness of these results

	Regressand: $\ln(\tau/(\pi + .02))$			
	(4.1)	(4.2)	(4.3)	(4.4)
Regressors:	OLS on panel	Between Effects OLS	Fixed Effects OLS	Random Effects GLS
$\ln \bar{h}$	-0.865 (-4.33)	-0.558 (-1.05)	0.259 (0.65)	-0.895 (-2.64)
Growth	14.80 (9.00)	26.24 (5.55)	10.20 (9.27)	9.776 (8.20)
Openness	0.535 (1.45)	0.447 (0.51)	-4.070 (-4.76)	-1.950 (-2.90)
WagePressure	0.0515 (6.78)	0.0553 (2.90)	-0.136 (-4.35)	0.0433 (2.91)
Trend	0.110 (5.10)	0.412 (3.35)	0.149 (7.75)	0.103 (5.75)
Constant	-2.632 (-7.67)	-3.994 (-4.68)	4.409 (4.46)	-1.780 (-2.99)
R^2	0.638	0.816	0.475	0.557
Overall Signif.	$F_{272}^5=96.01$	$F_{30}^5=26.63$	$F_{237}^5=42.89$	$\chi_5^2=211.24$
Observations	278	278	278	278
# of countries	36	36	36	36

Absolute value of t-statistics in (parentheses).

Panama is excluded from all regressions.

Table 4: Static panel regressions, tax to inflation ratio.

to various functional forms, four alternative error parameterizations are specified. The regressions reported in columns 3.1 and 3.3 specify one autoregressive parameter ρ on the residual term to be common for all countries. The regressions reported in columns 3.2 and 3.4 allow the autoregressive parameter ρ on the residual term to be specific to each country. The regressions reported in columns 3.1 and 3.2 specify that the standard error for the disturbance term is common for all countries. The regressions reported in columns 3.3 and 3.4 specify that the standard error for the disturbance term is specific to each country. In the regressions, no cross-country error covariances are allowed for, this is because in this unbalanced panel 1993 is the only year common to all countries. The cross-country covariances would therefore be calculated only on the cross-section of residuals for 1993.

Presented in Tables 4 and 5 are the same regression specifications as in Tables 2 and 3 but with the natural logarithm of the liquidity-tax to inflation-rate ratio $\ln(\tau/(\pi + .02))$ as the regressand. These are presented for the sake of completeness given the interest in the relation between fiscal policy and the resulting rate of infla-

Regressors:	Regressand: $\ln(\tau/(\pi + .02))$			
	(5.1) Common ρ^a Common σ^c	(5.2) Specific ρ^b Common σ^c	(5.3) Common ρ^a Specific σ^d	(5.4) Specific ρ^b Specific σ^d
$\ln \bar{h}$	-0.822 (-2.94)	-1.008 (-3.70)	-0.822 (-3.01)	-1.008 (-4.10)
Growth	8.655 (6.99)	7.819 (6.90)	8.655 (3.64)	7.819 (3.09)
Openness	-0.253 (-0.50)	-0.258 (-0.55)	-0.253 (-0.37)	-0.258 (-0.35)
WagePressure	0.0549 (4.97)	0.0506 (4.95)	0.0549 (5.50)	0.0506 (5.76)
Trend	0.115 (4.74)	0.117 (5.61)	0.115 (5.35)	0.117 (6.39)
Constant	-2.312 (-4.93)	-2.545 (-6.72)	-2.312 (-3.88)	-2.545 (-6.10)
(mean) ρ	0.709	0.794	0.709	0.794
R^2	0.429	0.600	0.429	0.600
Overall signif.	$\chi^2_5=251.01$	$\chi^2_5=388.33$	$\chi^2_5=151.19$	$\chi^2_5=356.58$
Observations	282	282	282	282
# of countries	36	36	36	36

Absolute t-statistics in (parentheses) with panel-corrected standard errors.

Panama is excluded from all regressions.

Prais-Winsten estimated first-order auto-regressive errors $u_t = \rho u_{t-1} + e_t$.

^a Auto-regressive parameter ρ common to all countries.

^b Auto-regressive parameter ρ_i specific to each country.

^c Disturbance standard-error σ common to all countries.

^d Disturbance standard-error σ_i specific to each country.

Table 5: Autoregressive residual regressions, tax to inflation ratio.

tion. The results in Tables 4 and 5 are much the same as those in Tables 2 and 3. The results for the static regressions in Table 4 are, as in Table 2, mixed with the highest statistical significance on the hidden economy share being found in columns 4.1 and 4.4. The results for the dynamic regressions in Table 5 are, as in Table 3, far better defined with statistically significant parameters being found on the hidden economy share for all four columns. It therefore seems that the dynamic autoregressive residual regressions present in all cases far better specified regression equations.

Finally, further dynamic regression equations are presented in Table 6 with the lagged dependent variable included to explain the dynamics instead of the autoregressive residuals. Although in all cases the parameters on the hidden economy share

Regressors:	Regressand: $\ln(\tau/i)$		Regressand: $\ln(\tau/(\pi + .02))$	
	(6.1)	(6.2)	(6.3)	(6.4)
	Common σ . ^a	Specific σ . ^b	Common σ . ^a	Specific σ . ^b
$\ln \bar{h}$	-0.136 (-1.30)	-0.136 (-1.17)	-0.0902 (-0.81)	-0.0902 (-0.79)
Growth	3.550 (4.00)	3.550 (2.40)	4.319 (4.33)	4.319 (2.55)
Openness	0.174 (0.90)	0.174 (0.63)	-0.0341 (-0.17)	-0.0341 (-0.14)
WagePressure	0.0161 (3.92)	0.0161 (3.37)	0.00911 (2.08)	0.00911 (1.99)
Trend	0.0593 (5.26)	0.0593 (5.04)	0.0446 (3.79)	0.0446 (3.91)
$\ln(\tau/i)_{t-1}$	0.667 (17.9)	0.667 (7.13)		
$\ln(\tau/(\pi + .02))_{t-1}$			0.752 (25.3)	0.752 (9.83)
Constant	-0.641 (-3.21)	-0.641 (-2.26)	-0.300 (-1.47)	-0.300 (-1.13)
R^2	0.861	0.861	0.886	0.886
Overall signif.	$\chi_6^2=1656.31$	$\chi_6^2=1322.95$	$\chi_6^2=2093.17$	$\chi_6^2=1014.59$
Observations	275	275	275	275
# of countries	36	36	36	36

Absolute t-statistics in (parentheses) with panel-corrected standard errors.
Panama is excluded from all regressions.

^a Disturbance standard-error σ common to all countries.

^b Disturbance standard-error σ_i specific to each country.

Table 6: Lagged dependent variable regressions.

are negative, the statistical significance of these is much lower than in the regressions with the lagged residuals. Though the parameters on the lagged dependent variables are very significant, they are nowhere near close to unity suggesting non-stationarity is not an issue.

4.4 Regression Interpretation.

To summarize the results of the empirical analysis; in all regressions where the hidden economy share $\ln \bar{h}$ is statistically significant, the parameter estimate is negative. The static regressions where the parameters on the hidden economy share are significantly different from zero, and negative, are found in the regression that include the full

between and within variation of the data (columns 2.1, 2.4, 4.1 and 4.4). This suggests that the full variation across and within countries is needed to identify any statistical relationship suggested by the theory. The dynamic regressions with the autoregressive residuals shown in Tables 3 and 5 all show a significantly negative parameter on the hidden economy share, again lending support to the theory in Section 3. The parameters on the hidden economy share, in Table 6, are still negative but statistically less significant suggesting the lagged dependent variable regressions may be a less satisfactory dynamic specification. In all the regressions the parameter on the time **Trend** is positive and statistically significant. This is interpreted as, all other things being equal, a trend toward fiscal and monetary prudence during the 1990's.

The various χ^2 and F -tests of overall significance show a very large significance for every regression. The ρ parameters on the autoregressive residuals $u_{i,t} = \rho_i u_{i,t-1} + \varepsilon_{i,t}$ have mean values in the range 0.666 to 0.794 suggesting a large degree of persistence in the residual terms, this is typical of large macroeconomic systems.

5 Conclusion.

The theoretical analysis in Section 3 suggests that the socially optimal ratio of the fiscal-tax rate to the liquidity-tax rate decreases with the relative size of the fiscal-tax evading hidden economy. This tax ratio is optimal in the sense that it is designed to maximize welfare by minimizing the distortions caused by these tax rates. A larger hidden economy share implies a proportionally smaller fiscal-tax base and therefore the fiscal-tax rate is less effective relative to the liquidity-tax rate. The empirical evidence presented in Section 4 suggests that a negative relation between the tax-ratio and the hidden economy share is observed in practice. Estimates based on a sample of 36 countries and a parsimonious model suggests that the elasticity of the tax ratio with respect to the hidden economy share may be negative and less than unit elastic. The data also suggest that this issue on formulating the optimal tax-mix is particularly relevant for developing and transition economies given their relatively large hidden economy shares.

The analysis presented in this paper also indicates many interesting extensions. Firstly, one could be more specific about the private sector's preferences by specifying utility functions, calibrating the model and running simulations along the lines of Nicolini (1998). Secondly, the issue of currency substitution as proposed by McKinnon (1985) should be incorporated into the model. There is strong evidence that some degree of currency substitution into US dollars occurred in Soviet-Block and Latin-American countries during the time-period under analysis. Although it seems that currency substitution is likely to attenuate the effectiveness of the liquidity tax,

quantifying this effect presents the more challenging task as data on this activity are not readily available. Finally, the model presented in this paper, like many others, is one that only focuses on the steady state equilibrium. Another possible extension is therefore to consider the dynamic implications of changing the tax-mix. This theoretical extension will be particularly appropriate once enough annual estimates of the hidden economy share are available to carry out a satisfactory dynamic econometric analysis.

Evidently, the ratio of fiscal to liquidity taxes is determined by a wider set of parameters than just the relative size of the hidden economy and one can consider many other ways in which to extend the analysis. However, Schneider (2005) suggests that in many countries the relative share of the hidden economy is persisting or even increasing, therefore, the existence of these hidden economies will continue to influence the tax-mix over fiscal and monetary policies.

Algebraic Appendix

Throughout the Appendix, the notation and the equation numbering (though not the equation lettering) follows that of Phelps (1973). This is intended to facilitate cross-referencing.

Appendix A: Solving the Government's Optimization.

In this section the policy decisions facing the government sector and the optimization decisions facing the private sector are considered. The expenditure branch determines government expenditure (G) and benefits (B) as functions of time and exogenously of other factors,

$$G = \gamma(t) \geq 0, \quad B = \beta(t) \geq 0. \quad (\text{A.1})$$

The treasury, in financing these expenditures, faces the budget constraint of matching all costs and all revenues, including payments on the existing debt,

$$T + \frac{\dot{D}}{p} = G + B + i_D \frac{D^*}{p} \quad (\text{A.2})$$

where T is fiscal taxation on the visible economy, D is the accumulated debt which includes both the public debt (D^*) and money (M), D^* is the part of the accumulated debt held by the private sector, p is the price level and i_D is the nominal interest rate on the debt. The central bank sets the money supply (M) independently of the treasury,

$$M = D - D^*. \quad (\text{A.3})$$

The money supply affects the price level, therefore, the central bank determines alternative price level programs in the form,

$$p(t) = \phi(t; \pi) \quad (\text{A.4})$$

where π is the target inflation rate.

The behavior of the private sector is determined by the following consumption demand (C) and work hour supply (H) functions. Total consumption is determined by consumption in the hidden and visible economies ($C^h + C^v$). Total work hours are determined by hours in the hidden and visible economies ($H^h + H^v$). The parameter \hbar determines the proportion of the population N that is in each sector, so

$$C = C^v(\tilde{Y}^v, W; \dots; (1 - \hbar)N; t) + C^h(\tilde{Y}^h, W; \dots; \hbar N; t) \quad (\text{A.5})$$

$$H = H^v(\tilde{Y}^v, W; \dots; (1 - \hbar)N; t) + H^h(\tilde{Y}^h, W; \dots; \hbar N; t) \quad (\text{A.6})$$

where real net disposable income \tilde{Y} in each sector is determined by the population proportions and by the difference between revenues and costs,

$$\tilde{Y}^v = (1 - \hbar) \left[\bar{Y} + B + i_D \frac{D^*}{p} - \pi \left(\frac{M+D^*}{p} \right) \right] - T \quad (\text{A.7a})$$

$$\tilde{Y}^h = \hbar \left[\bar{Y} + B + i_D \frac{D^*}{p} - \pi \left(\frac{M+D^*}{p} \right) \right] \quad (\text{A.7b})$$

where real disposable wealth is given by,

$$W = K + \frac{D}{p} = K + \frac{M+D^*}{p} \quad (\text{A.8})$$

and potential pre-tax income is,

$$\tilde{Y} = r_K K + wH \quad (\text{A.9})$$

where K is the real value of the capital stock, r_K is the return on the capital stock and w is the wage rate. Note that homotheticity is assumed throughout, that is, the visible and hidden economies are scale values of one another. This implies that $Y^i, B^i, M^i, D^i, H^i, N^i$ and W^i for $i = v, h$ are purely functions of the population proportions in the hidden and visible economies with the exception of the tax burden T which only affects the visible economy.

Appendix B: Addressing Friedman's Propositions.

As in Phelps (1973) two propositions by Friedman (1971) are briefly addressed. The first is that seigniorage revenue may actually fall following an increase in inflation. Phelps shows how his own model is consistent with this result subject to particular values for the interest elasticity of liquidity preference. The second proposition is of 'no conflict between full liquidity and inflation tax revenue maximization' but Phelps (1973, p.76) argues this is inconsistent with his own model: "If, with Friedman, we identify full liquidity ... as occurring if and only if $i \leq 0$, and if we assume, again with Friedman, that

$$L(Y, 0, K + D_0/p_0) < \infty \quad (\text{B.18})$$

then the revenue from the inflation tax, $i_D M/p_0$ must be non-positive at full liquidity. ... Hence there is a conflict between acquiring revenue and achieving full liquidity."

Appendix C: Solving the Private Sector's Optimization.

Using equations (16a) and (16b), the first order conditions for the visible and hidden economies are,

$$\begin{aligned}
 \frac{\partial U^v}{\partial C} &= \frac{\partial U^v}{\partial S} = \lambda^v(1 - \hbar) \\
 \frac{\partial U^v}{\partial L} &= \lambda^v(1 - \hbar)i = \frac{\partial U^v}{\partial C}i \\
 \frac{\partial U^v}{\partial H} &= -\lambda^v(1 - \hbar)(1 - \tau)\bar{w} = -\frac{\partial U^v}{\partial C}(1 - \tau)\bar{w} \\
 \frac{\partial U^v}{\partial Z} &= -\lambda^v(1 - \hbar)(1 - \tau) = -\frac{\partial U^v}{\partial C}(1 - \tau)
 \end{aligned} \tag{C.28a}$$

$$\begin{aligned}
 \frac{\partial U^h}{\partial C} &= \frac{\partial U^h}{\partial S} = \lambda^h\hbar \\
 \frac{\partial U^h}{\partial L} &= \lambda^h\hbar i = \frac{\partial U^h}{\partial C}i \\
 \frac{\partial U^h}{\partial H} &= -\lambda^h\hbar\bar{w} = -\frac{\partial U^h}{\partial C}\bar{w} \\
 \frac{\partial U^h}{\partial Z} &= -\lambda^h\hbar = -\frac{\partial U^h}{\partial C}.
 \end{aligned} \tag{C.28b}$$

Using these first order conditions one can specify maximized utility U^* subject to the fiscal-tax rate τ and the liquidity-tax rate i . Write the value functions for this optimization in the visible and hidden economies as,

$$V^v(\tau, i) = U^{v*}[C(\tau, i), S(\tau, i), L(\tau, i), Z(\tau, i)] \tag{C.29a}$$

$$V^h(\tau, i) = U^{h*}[C(\tau, i), S(\tau, i), L(\tau, i), Z(\tau, i)]. \tag{C.29b}$$

The effect of the tax rates on the optimized level of utility is given by the derivatives on equations (C.29a) and (C.29b),

$$\begin{aligned}
 \frac{\partial V^v(\tau, i)}{\partial \tau} &= \frac{\partial U^{v*}}{\partial C} \frac{\partial C}{\partial \tau} + \frac{\partial U^{v*}}{\partial S} \frac{\partial S}{\partial \tau} + \frac{\partial U^{v*}}{\partial L} \frac{\partial L}{\partial \tau} + \frac{\partial U^{v*}}{\partial Z} \frac{\partial Z}{\partial \tau} \\
 \frac{\partial V^v(\tau, i)}{\partial i} &= \frac{\partial U^{v*}}{\partial C} \frac{\partial C}{\partial i} + \frac{\partial U^{v*}}{\partial S} \frac{\partial S}{\partial i} + \frac{\partial U^{v*}}{\partial L} \frac{\partial L}{\partial i} + \frac{\partial U^{v*}}{\partial Z} \frac{\partial Z}{\partial i}
 \end{aligned} \tag{C.30a}$$

$$\begin{aligned}
 \frac{\partial V^h(\tau, i)}{\partial \tau} &= \frac{\partial U^{h*}}{\partial C} \frac{\partial C}{\partial \tau} + \frac{\partial U^{h*}}{\partial S} \frac{\partial S}{\partial \tau} + \frac{\partial U^{h*}}{\partial L} \frac{\partial L}{\partial \tau} + \frac{\partial U^{h*}}{\partial Z} \frac{\partial Z}{\partial \tau} \\
 \frac{\partial V^h(\tau, i)}{\partial i} &= \frac{\partial U^{h*}}{\partial C} \frac{\partial C}{\partial i} + \frac{\partial U^{h*}}{\partial S} \frac{\partial S}{\partial i} + \frac{\partial U^{h*}}{\partial L} \frac{\partial L}{\partial i} + \frac{\partial U^{h*}}{\partial Z} \frac{\partial Z}{\partial i}.
 \end{aligned} \tag{C.30b}$$

Substituting the first order conditions in (C.28a) and (C.28b) into (C.30a) and (C.30b) gives,

$$\begin{aligned}
 \frac{\partial V^v(\tau, i)}{\partial \tau} &= \frac{\partial U^{v*}}{\partial C} \left[\frac{\partial C}{\partial \tau} + \frac{\partial S}{\partial \tau} + i \frac{\partial L}{\partial \tau} - (1 - \tau) \frac{\partial Z}{\partial \tau} \right] \\
 \frac{\partial V^v(\tau, i)}{\partial i} &= \frac{\partial U^{v*}}{\partial C} \left[\frac{\partial C}{\partial i} + \frac{\partial S}{\partial i} + i \frac{\partial L}{\partial i} - (1 - \tau) \frac{\partial Z}{\partial i} \right]
 \end{aligned} \tag{C.31a}$$

$$\begin{aligned}
 V^h(\tau, i) &= U_C^{h*} \left[\frac{\partial C}{\partial \tau} + \frac{\partial S}{\partial \tau} + i \frac{\partial L}{\partial \tau} - \frac{\partial Z}{\partial \tau} \right] \\
 V_i^h(\tau, i) &= U_C^{h*} \left[\frac{\partial C}{\partial i} + \frac{\partial S}{\partial i} + i \frac{\partial L}{\partial i} - \frac{\partial Z}{\partial i} \right].
 \end{aligned} \tag{C.31b}$$

Differentiation of the budget constraint represented by equations (14a) and (14b) gives,

$$\begin{aligned} (1 - \bar{h})Z + (1 - \bar{h}) \left[\frac{\partial C}{\partial \tau} + \frac{\partial S}{\partial \tau} + i \frac{\partial L}{\partial \tau} - (1 - \tau) \frac{\partial Z}{\partial \tau} \right] &= 0 \\ (1 - \bar{h})L + (1 - \bar{h}) \left[\frac{\partial C}{\partial i} + \frac{\partial S}{\partial i} + i \frac{\partial L}{\partial i} - (1 - \tau) \frac{\partial Z}{\partial i} \right] &= 0 \end{aligned} \quad (\text{C.32a})$$

$$\begin{aligned} \bar{h} \left[\frac{\partial C}{\partial \tau} + \frac{\partial S}{\partial \tau} + i \frac{\partial L}{\partial \tau} - \frac{\partial Z}{\partial \tau} \right] &= 0 \\ \bar{h}L + \bar{h} \left[\frac{\partial C}{\partial i} + \frac{\partial S}{\partial i} + i \frac{\partial L}{\partial i} - \frac{\partial Z}{\partial i} \right] &= 0. \end{aligned} \quad (\text{C.32b})$$

Substituting (C.32a) and (C.32b) into (C.31a) and (C.31b) generates (17a,b,c,d).

Appendix D: Solving the Government's Optimization.

Setting $\bar{R} = \tau(1 - \bar{h})Z + iL$, the first order derivatives for Lagrangean (18) are $\frac{\partial \Psi}{\partial \tau} = (1 - \bar{h}) \frac{\partial V^v}{\partial \tau} + \frac{\partial \bar{h}V^h}{\partial \tau} + \mu \frac{\partial R}{\partial \tau}$ and $\frac{\partial \Psi}{\partial i} = (1 - \bar{h}) \frac{\partial V^v}{\partial i} + \frac{\partial \bar{h}V^h}{\partial i} + \mu \frac{\partial R}{\partial i}$. The corresponding first order conditions are,

$$\begin{aligned} (1 - \bar{h}) \frac{\partial V^v}{\partial \tau} + \bar{h} \frac{\partial V^h}{\partial \tau} &= -\mu \frac{\partial R}{\partial \tau} \\ (1 - \bar{h}) \frac{\partial V^v}{\partial i} + \bar{h} \frac{\partial V^h}{\partial i} &= -\mu \frac{\partial R}{\partial i}. \end{aligned} \quad (\text{D.35})$$

The government sets the tax-mix policy to maximize utility (minimize tax distortions) in both the visible and hidden economies, so the derivatives of utility with respect to inflation tax must be equal $\frac{\partial V^v}{\partial i} = \frac{\partial V^h}{\partial i}$. This implies through equations (17a,b,c,d) that $\frac{\partial U^{v*}}{\partial C} = \frac{\partial U^{h*}}{\partial C} = \frac{\partial U^*}{\partial C}$. This last condition, together with the conditions represented by (17a,b,c,d), can be substituted into (D.35) to give,

$$\begin{aligned} (1 - \bar{h}) \frac{\partial U^*}{\partial C} Z + \bar{h} \frac{\partial U^*}{\partial C} 0 &= \mu \frac{\partial R}{\partial \tau} &\Rightarrow & \frac{U_C^*}{\mu} = \frac{\partial R / \partial \tau}{(1 - \bar{h})Z} \\ (1 - \bar{h}) \frac{\partial U^*}{\partial C} L + \bar{h} \frac{\partial U^*}{\partial C} L &= \mu \frac{\partial R}{\partial i} &\Rightarrow & \frac{U_C^*}{\mu} = \frac{\partial R / \partial i}{L}. \end{aligned}$$

Equating the two expressions above gives the government policy target,

$$\frac{\partial R / \partial \tau}{(1 - \bar{h})Z} = \frac{\partial R / \partial i}{L} = \frac{\partial U^* / \partial C}{\mu}. \quad (\text{D.36})$$

This defines the tax-mix that maximizes social welfare subject to a constant total tax revenue, $\bar{R} = \tau(1 - \bar{h})Z + iL$. The increases in overall income (I) required to compensate for any change in the fiscal-tax rate τ or the liquidity-tax rate i are,

$$\left(\frac{\partial I}{\partial \tau} \right)_{\bar{V}^{v,h}} = -Z, \quad \left(\frac{\partial I}{\partial i} \right)_{\bar{V}^{v,h}} = -L. \quad (\text{D.37})$$

The subscripts in equations (D.37) indicate that utility is being kept constant in the respective sectors by compensating agents for changes in the tax-mix. Taking partial derivatives of the government revenue function and substituting in (D.37) specifies,

$$\begin{aligned}
\frac{\partial R}{\partial \tau} &= (1 - \hbar) \left[\tau \left[\left(\frac{\partial Z}{\partial \tau} \right)_{\bar{V}^v} - Z \frac{\partial Z}{\partial I} \right] + i \left[\left(\frac{\partial L}{\partial \tau} \right)_{\bar{V}^v} - Z \frac{\partial L}{\partial I} \right] + Z \right] \\
&\quad + \hbar \left[\tau \left[\left(\frac{\partial Z}{\partial \tau} \right)_{\bar{V}^h} - Z \frac{\partial Z}{\partial I} \right] + i \left[\left(\frac{\partial L}{\partial \tau} \right)_{\bar{V}^h} - Z \frac{\partial L}{\partial I} \right] + Z \right] \\
\frac{\partial R}{\partial i} &= (1 - \hbar) \left[\tau \left[\left(\frac{\partial Z}{\partial i} \right)_{\bar{V}^v} - L \frac{\partial Z}{\partial I} \right] + i \left[\left(\frac{\partial L}{\partial i} \right)_{\bar{V}^v} - L \frac{\partial L}{\partial I} \right] + L \right] \\
&\quad + \hbar \left[\tau \left[\left(\frac{\partial Z}{\partial i} \right)_{\bar{V}^h} - L \frac{\partial Z}{\partial I} \right] + i \left[\left(\frac{\partial L}{\partial i} \right)_{\bar{V}^h} - L \frac{\partial L}{\partial I} \right] + L \right].
\end{aligned} \tag{D.38}$$

By re-arranging, these equations can be expressed more compactly as,

$$\begin{aligned}
\frac{\partial R}{\partial \tau} &= (1 - \hbar) \left[\tau \left(\frac{\partial Z}{\partial \tau} \right)_{\bar{V}^v} + i \left(\frac{\partial L}{\partial \tau} \right)_{\bar{V}^v} \right] + \hbar \left[\tau \left(\frac{\partial Z}{\partial \tau} \right)_{\bar{V}^h} + i \left(\frac{\partial L}{\partial \tau} \right)_{\bar{V}^h} \right] + Z \left(1 - \tau \frac{\partial Z}{\partial I} - i \frac{\partial L}{\partial I} \right) \\
\frac{\partial R}{\partial i} &= (1 - \hbar) \left[\tau \left(\frac{\partial Z}{\partial i} \right)_{\bar{V}^v} + i \left(\frac{\partial L}{\partial i} \right)_{\bar{V}^v} \right] + \hbar \left[\tau \left(\frac{\partial Z}{\partial i} \right)_{\bar{V}^h} + i \left(\frac{\partial L}{\partial i} \right)_{\bar{V}^h} \right] + L \left(1 - \tau \frac{\partial Z}{\partial I} - i \frac{\partial L}{\partial I} \right)
\end{aligned} \tag{D.39}$$

where the substitutions $\left(\frac{\partial L}{\partial \tau} \right)_{\bar{V}^v} = \left(\frac{\partial Z}{\partial i} \right)_{\bar{V}^v}$ and $\left(\frac{\partial L}{\partial \tau} \right)_{\bar{V}^h} = \left(\frac{\partial Z}{\partial i} \right)_{\bar{V}^h}$ have been made, these hold due to Slutsky symmetry. Substituting the behavioral equations (D.39) into the policy target equations (D.36) yields the following rather unwieldy equation which represents a special case of equation (3) in Ramsey (1927),

$$\begin{aligned}
\frac{\partial U^*}{\partial C} - \left(1 - \tau \frac{\partial Z}{\partial I} - i \frac{\partial L}{\partial I} \right) &= \frac{(1 - \hbar) \left[\tau \left(\frac{\partial Z}{\partial \tau} \right)_{\bar{V}^v} + i \left(\frac{\partial L}{\partial \tau} \right)_{\bar{V}^v} \right] + \hbar \left[\tau \left(\frac{\partial Z}{\partial \tau} \right)_{\bar{V}^h} + i \left(\frac{\partial L}{\partial \tau} \right)_{\bar{V}^h} \right]}{(1 - \hbar) Z} \\
&= \frac{(1 - \hbar) \left[\tau \left(\frac{\partial Z}{\partial i} \right)_{\bar{V}^v} + i \left(\frac{\partial L}{\partial i} \right)_{\bar{V}^v} \right] + \hbar \left[\tau \left(\frac{\partial Z}{\partial i} \right)_{\bar{V}^h} + i \left(\frac{\partial L}{\partial i} \right)_{\bar{V}^h} \right]}{L}.
\end{aligned} \tag{D.40}$$

Assuming there are no cross substitution effects in the demand for one commodity (Z, L) with respect to the price of the other commodity (i, τ) , then $\left(\frac{\partial L}{\partial \tau} \right)_V = \left(\frac{\partial L}{\partial i} \right)_V = 0$ and equation (D.40) simplifies to equation (19) in the main text.

Data Appendix

Country	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Developing Economies											
Argentina					.313	.315	.308	.314	.308	.300	
Bolivia		.396	.396	.396	.396						
Chile	.270	.212	.154	.154	.154						
Colombia	.200	.230	.260	.260	.260						
Ecuador		.238	.238	.238	.238						
Guatemala	.379	.357	.335	.335	.335						
Mexico	.329	.271	.213	.213	.213						
Panama	.286	.334	.383	.383	.383						
Peru	.306	.336	.367	.367	.367						
Uruguay	.260	.260	.260	.260	.260						
OECD Economies											
Australia		.128	.118	.128	.129	.136	.131	.132	.132	.134	.129
Austria	.065	.065	.066	.066	.073	.079	.079	.081	.083	.083	
Belgium	.162	.162	.172	.172	.175	.177	.177	.180	.184	.184	
Canada	.113	.113	.119	.119	.124	.129	.129	.134	.139	.139	.138
Denmark	.097	.097	.130	.130	.141	.151	.151	.153	.155	.155	.153
Finland	.118	.118	.139	.139	.146	.154	.154	.156	.159	.159	
France	.083	.083	.121	.121	.124	.127	.127	.128	.130		
Germany	.106	.106	.111	.111	.115	.119	.119	.124	.130	.130	
Greece	.184	.184	.199	.199	.211	.222	.222	.224	.225	.225	
Ireland	.099	.099	.124	.124	.129	.133	.133	.136	.139		
Italy	.186	.186	.194	.194	.200	.206	.206	.210	.214	.214	
Japan	.081	.081	.087	.087	.091						
Netherlands	.106	.106	.113	.113	.117	.120	.120	.120	.119		
New Zealand	.084	.084	.083	.083	.092	.102	.102	.104	.106	.106	.113
Norway	.129	.129	.143	.143	.149	.154	.154	.159	.164	.164	.160
Portugal	.137	.137	.147	.147	.164	.181	.181	.184	.188	.188	
Spain	.139	.139	.147	.147	.165	.183	.183	.185	.188		
Sweden	.136	.136	.145	.145	.154	.163	.163	.165	.166	.166	
Switzerland	.063	.063	.065	.065	.068	.072	.072	.074	.075	.075	
United Kingdom	.088	.088	.101	.101	.106	.111	.111	.113	.115	.115	.113
United States	.063	.063	.076	.076	.078	.081	.081	.081	.082	.082	.080
Transition Economies											
Belarus				.257	.275	.289	.298				
Bulgaria			.233	.234	.233	.243	.241				
Croatia				.236	.238	.255	.243				
Hungary	.197	.193	.210	.216	.217	.212	.207				
Poland	.186	.211	.214	.212	.210	.203	.192				
Slovenia				.211	.203	.196	.189				

Table 7: Hidden economy shares (\hat{h}).

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