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

Marco G. Ercolani*

University of Birmingham, UK B15 2TT

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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*

**I thank Alessandro Amelotti for his comments. Any shortcomings are mine.*

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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 literature strand 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. This survey is therefore proceeds along two sub-sections.

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

[1] Because of 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.

exclusively on the attainment of low inflation but should also take into consideration 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 $1 - \hbar$ and $\hbar$ 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,

$$\theta(t) = T + \frac{\pi M}{p} - \frac{(i_D - \pi)}{p} \tag{1}$$

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 and i_D is nominal interest on the debt. The derivation of equation (1) is discussed in Appendix A. Secondly, the level of 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,

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

where $D(=M+D^*)$ is the accumulated government debt and D^* is the public debt held by the private sector. 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,

$$p(0) = p_0 > 0. \tag{3}$$

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:

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

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 K is imposed,

$$(i_D - \pi) = r_K = \varsigma \tag{5}$$

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

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

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

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

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

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

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,

$$U^v = U(C^v, S^v, L^v, H^v) \tag{9a}$$
$$U^h = U(C^h, S^h, L^h, H^h) \tag{9b}$$

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,

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

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 τ be the implicit fiscal tax rate on all economic activity, substituting the level of private wealth,

$$\frac{D}{p} = \Delta, \tag{11}$$

and 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,

$$G + B + (\bar{r} + \pi)(\frac{D}{p} - L) - \tau Z - \pi\frac{D}{p} = \dot{\Delta}, \tag{12}$$

gives the government budget constraint:

$$(1 - \hbar)\tau Z + iL = \gamma + \beta + \bar{r}\Delta - \dot{\Delta}. \tag{13}$$

The left hand side of equation (13) represents all government revenues and the right hand side all expenditures. As already stated, at any point in time the magnitude of equation (13) 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,

$$C + S = (1-\tau)(1-\hbar)Z + \hbar Z + (r+\delta)K + \bar{B} + i(\Delta - L) - \pi\Delta - \delta K. \tag{14}$$

Assuming all aspects of the visible and hidden economies are functions of the population proportions, with the exception of the income tax burden, equation (14) can be re-arranged and split between the visible and hidden economies,

$$\begin{aligned} (1-\hbar)[C+S+iL] &= (1-\hbar)[\bar{r}W + B + (1-\tau)Z] && \text{(15a)} \\ \hbar \quad [C+S+iL] &= \quad \hbar \quad [\bar{r}W + B + Z] && \text{(15b)} \end{aligned}$$

where wealth and savings are given by,

$$W = K + \Delta, \quad S = \dot{W}. \tag{16}$$

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 (15a,b) for the visible and hidden economies,

$$\begin{aligned} \Lambda^v &= U^v(.) - \lambda^v(1-\hbar)([C+S+iL] - [B + \bar{r}W + (1-\tau)Z]), && \text{(17a)} \\ \Lambda^h &= U^h(.) - \lambda^h \quad \hbar \quad ([C+S+iL] - [B + \bar{r}W + Z]). && \text{(17b)} \end{aligned}$$

Solving these Lagrangean functions and substituting in equations (15a, 15b), details for which are in Appendix C, generates the following marginal conditions,

$$\begin{aligned} \tfrac{\partial V^v(\tau,i)}{\partial \tau} &= -\tfrac{\partial U^{v*}}{\partial C} Z && \text{(18a)} \\ \tfrac{\partial V^v(\tau,i)}{\partial i} &= -\tfrac{\partial U^{v*}}{\partial C} L && \text{(18b)} \\ \tfrac{\partial V^h(\tau,i)}{\partial \tau} &= -\tfrac{\partial U^{h*}}{\partial C} 0 = 0 && \text{(18c)} \\ \tfrac{\partial V^h(\tau,i)}{\partial i} &= -\tfrac{\partial U^{h*}}{\partial C} L && \text{(18d)} \end{aligned}$$

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 (18a,b,d) are analogous to those in Phelps (1973, eq.33), equation (18c) 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 (13). 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,

$$\Psi(\tau, i) \;=\; (1-\hbar)V^v(\tau, i) + \hbar V^h(\tau, i) \;+\; \mu[\tau(1-\hbar)Z + iL - \bar{R}]. \tag{19}$$

Solving this Lagrangean and substituting in conditions (18a,b,c,d) defines the government policy rule (20), 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 ($\hbar$) (details of the derivation are in Appendix D),

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

In the limiting case where there is no hidden economy ($\hbar = 0$) equation (20) collapses to equation (41) in Phelps (1973). In the limiting case where there is no visible economy ($\hbar = 1$) the optimal fiscal tax rate τ equals zero. Rearranging equation (20) gives,

$$\frac{\tau}{i} = (1-\hbar)\frac{Z}{L}\,\frac{(1-\hbar)\left(\frac{\partial L}{\partial i}\right)_{\bar{V}^v} + \hbar\left(\frac{\partial L}{\partial i}\right)_{\bar{V}^h}}{(1-\hbar)\left(\frac{\partial Z}{\partial \tau}\right)_{\bar{V}^v} + \hbar\left(\frac{\partial Z}{\partial \tau}\right)_{\bar{V}^h}} \tag{21}$$

Equation (21) suggests that the larger the relative size of the hidden economy ($\hbar$), the lower the optimal (distortion minimizing) ratio of the fiscal tax rate (τ) to the liquidity-tax rate (i). This is because as $\hbar$ becomes bigger, the right hand side of (21) becomes smaller, thus requiring a smaller optimal tax ratio (τ/i) to maintain the relation, assuming that both liquidity and earnings are normal goods $(\left(\frac{\partial L}{\partial i}\right)_{\bar{V}}<0$, $\left(\frac{\partial L}{\partial \tau}\right)_{\bar{V}}<0)$.

An intuitive interpretation of (21) 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.

4 The Empirical Evidence.

In this section data for 36 countries are illustrated and analyzed. Scatter plots of these data confirm the inverse relationship between the fiscal-to-liquidity tax ratio (τ/i) and the hidden economy share ($\hbar$) suggested by equation (21). 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 these data are illustrated in Figures 1 to 4 and data sources are in subsection 4.2.

Figure 1 illustrates a scatter plot of the mean fiscal-tax to liquidity-tax ratios (τ/i) against the mean hidden economy shares ($\hbar$) 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 $\hbar$ 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 ($\tau/(p{+}.02)$) plotted against the mean hidden economy shares ($\hbar$) reported in Table 1. Here too the inverse relationship suggested by equation (21) 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 $\tau/(p{+}.02)$ 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 cross-section and panel regressions are presented in subsection 4.3.

Inspection of Figures 1 to 4 raises a number of questions. The first question is that all we may be observing is a clustering of country groups into OECD, Transition and Developing economies. The implication being that the negative relationship implied by equation (21) may not actually hold within these groups. To check that

			Mean Values for:[†]					
Country	Label	Period	$\hbar$	$\frac{\tau}{i}$	$\frac{\tau}{p+.02}$	τ	i	p
Developing Economies								
Argentina	Arg	1993-1998	0.237	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	1989-1998	0.149	4.142	7.271	0.324	0.083	0.027
Poland	Pol	1989-1995	0.204	0.959	0.630	0.351	0.401	1.789
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	Hun	1989-1995	0.207	1.983	1.584	0.402	0.213	0.247
Slovenia	Slo	1992-1995	0.200	2.164	1.416	0.386	0.192	0.395

[†] $\hbar$ is the hidden economy share, τ is the fiscal-tax rate, i is the liquidity-tax rate (which is the nominal interest rate) and p is the rate of inflation.

Table 1: Summary statistics, mean values.

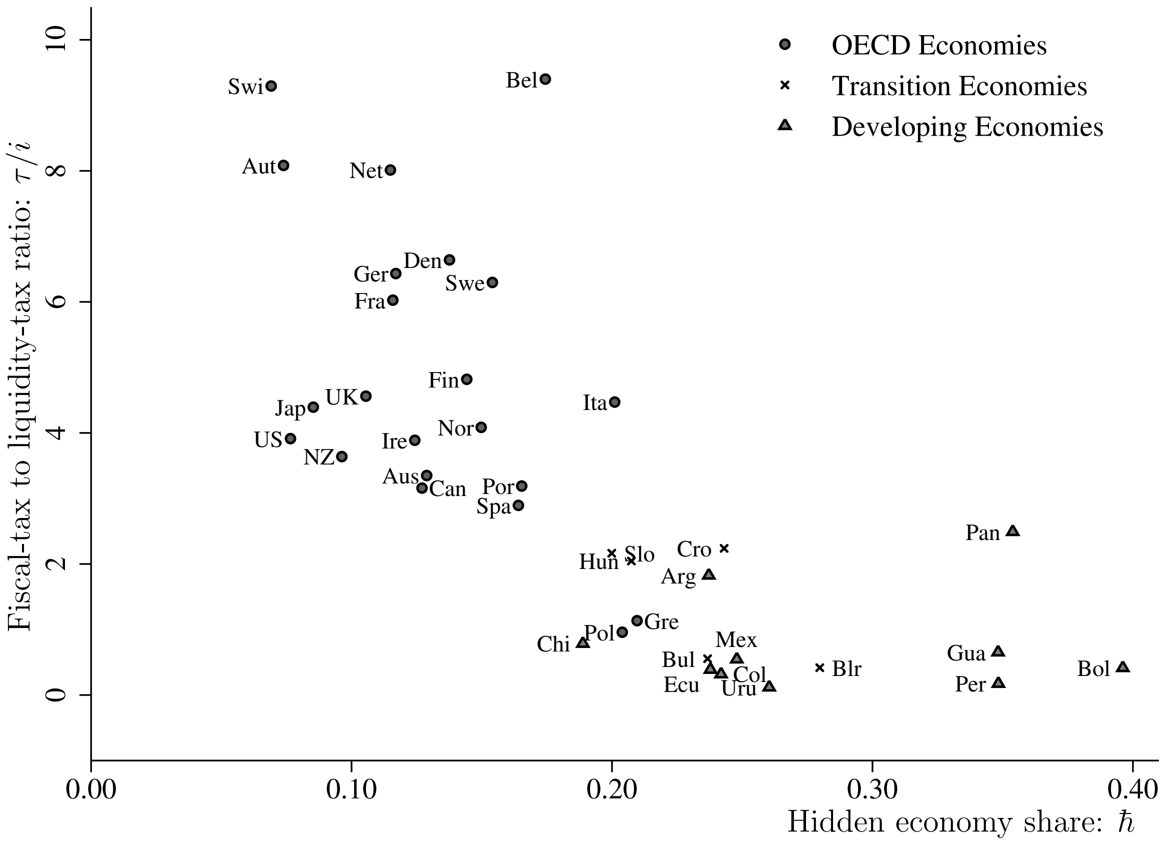

Figure 1: Fiscal-tax to liquidity-tax ratio and hidden economy share, mean values.

the negative relationship does indeed hold within country groups, region dummies are included in the regressions reported in subsection 4.3. If clustering is the only explanation for the apparent negative relationship, then the region dummies will be significant and the slope parameter on the hidden economy share will be insignificant. The second question regards any potential outliers. 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 rate is only 0.009, this makes Panama an outlier in terms of its tax-ratios (τ/i, τ/p). 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). Another outlier evident in Figure 1 is Belgium. From Table 1 it seems that Belgium has a particularly high fiscal-tax rate at 0.420, however, there seems to be no particular justification for its

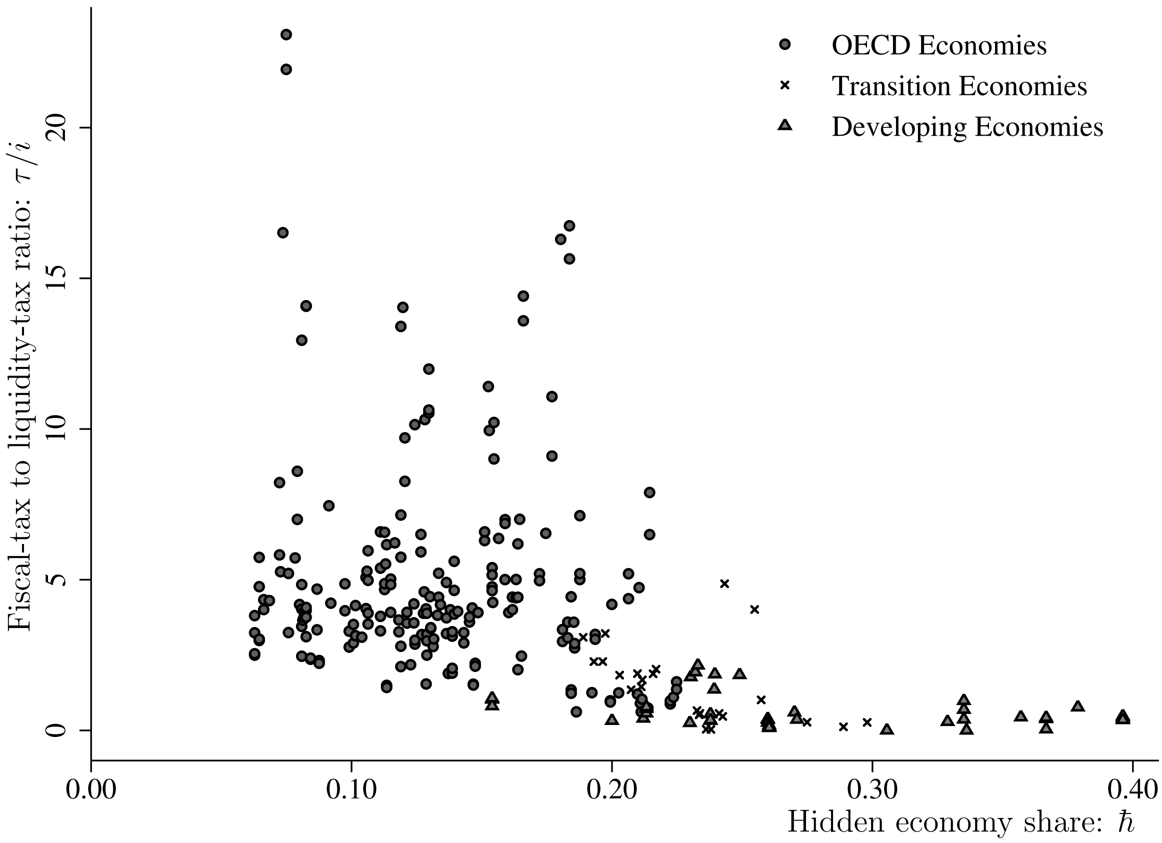

Figure 2: Fiscal-tax to liquidity tax-ratio and hidden economy share, panel data.

exclusion. Finally, the United States is a potential outlier. The reason for 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 ($\hbar$) out of total economic activity are derived from the various sources listed below. 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. Table 6 in the Data Appendix reports the resulting values for the hidden economy shares. The data sources for the annual 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, Tables 2 and 3) and Schneider and Bajada (2003, Table 2).

Data on the fiscal-tax rate (τ) are obtained principally from the World-Bank

[2]Quarterly values are converted to annual means.

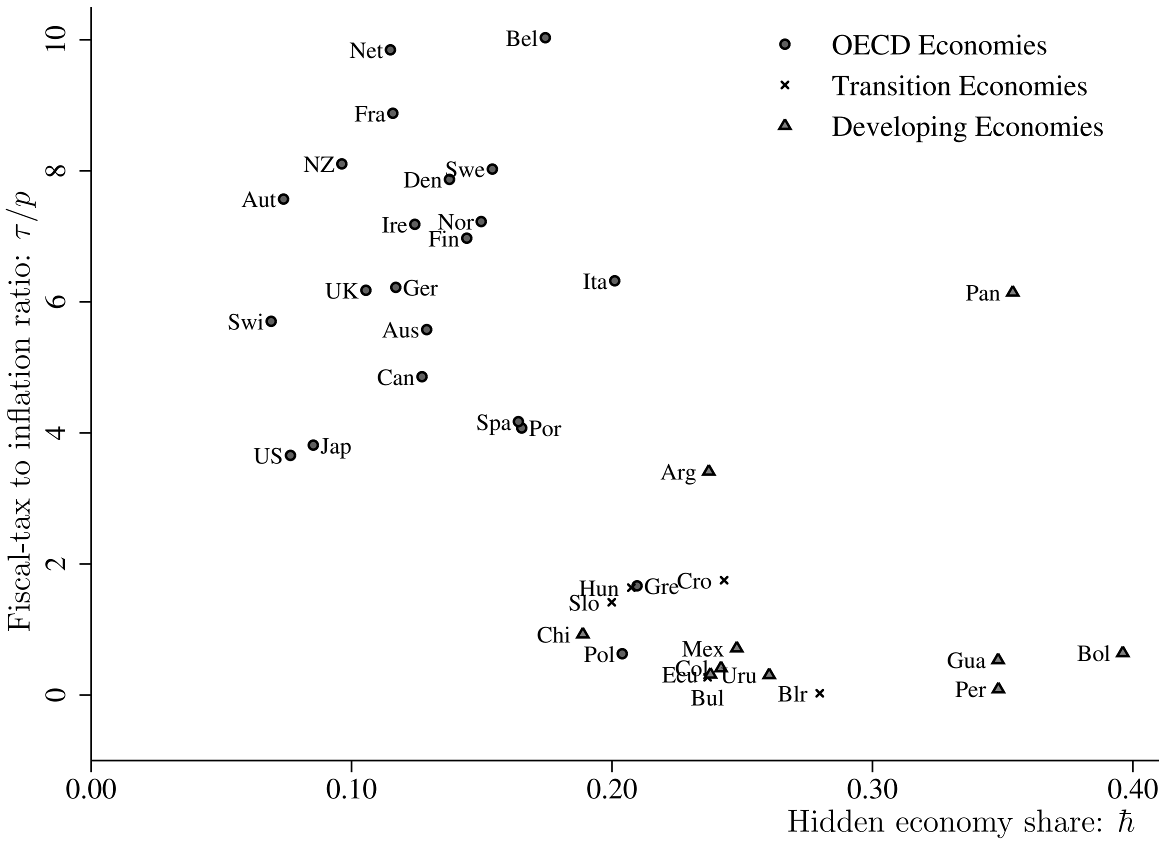

Figure 3: Fiscal-tax to inflation ratio and hidden economy share, mean values.

(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 (p) 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 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

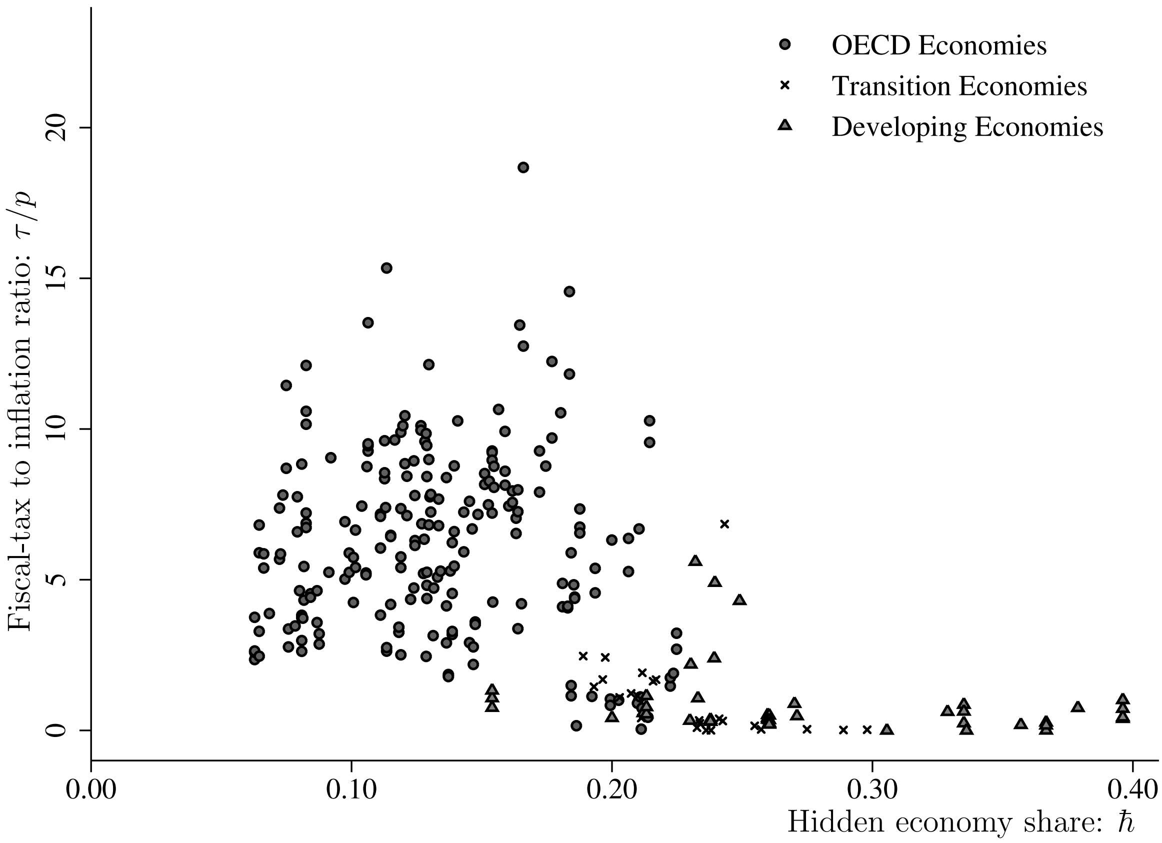

Figure 4: Fiscal-tax to inflation ratio and hidden economy share, panel data.

the IMF (2004) that the series for the deposit rate in the World-Bank (2002, code FR.INR.DPST) are used instead.

Auxiliary regressions are presented in the Regression Appendix that also include the level of corruption and the level of economic development as explanatory variables. Although these factors cancel-out in the theoretical model, it is important to test their statistical significance from a positivist point of view. The variable on economic development is 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 from the World Bank World Development Indicators. The measure of corruption is taken from the International Country Risk Guide produced by Political Risk Services. This measure has been normalized so that it is in the range 0 to 1, where 1 is the highest value of corruption. In the words of Knack and Keefer (1995), who introduced the variable to the economics literature, the measure captures the extent to which "high government officials are likely to demand special payments" and whether "illegal payments are generally expected throughout lower levels of government". This measure of corruption is not available for some two years on Germany (1989-1990) and not at all for Belarus, Croatia and Slovenia, thus reducing the sample to 32 countries (excluding Panama).

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. Cross-section, panel and dynamic-panel regressions are reported to check the robustness of the results to different functional forms. Where possible, a `Time Trend` is included in the regression as are a binary `Transition Dummy` and a binary `Developing Dummy`. The latter two are included to control for any clustering effects. Additional regressions that include corruption and development are reported in the Regression Appendix.

Presented in Table 2 are the results for the static cross-section and static panel regressions with the natural logarithm of the liquidity-tax to fiscal-tax ratio $\ln(\tau/i)$ as the regressand. In all cases the estimated parameters on the natural logarithm of the hidden economy share $\ln\hbar$ are negative and in most cases they are significantly so. Column 2.1 reports the regression results on the mean values in Table 1, here the parameter on $\ln\hbar$ is less than minus one and statistically significant suggesting an elastic response in the tax-ratio to different levels of the hidden economy share. Obviously, the `Time Trend` is excluded from this regression as there is no temporal variation in the means. Column 2.2 reports the regression results for the raw panel

Regressand: $\ln(\tau/i)$ Regressors:	(2.1) OLS on means	(2.2) OLS on panel	(2.3) Between Effects OLS	(2.4) Fixed Effects OLS	(2.5) Random Effects GLS
$\ln\hbar$	-1.128	-0.896	-1.088	-0.224	-0.703
	(2.78)	(6.24)	(2.80)	(0.54)	(2.49)
`Transition Dummy`	-0.967	-0.957	-0.924		-1.175
	(2.33)	(5.37)	(2.32)		(3.19)
`Developing Dummy`	-1.531	-1.435	-1.143		-1.608
	(3.75)	(8.60)	(2.63)		(4.68)
`Time Trend`		0.148	0.236	0.124	0.138
		(9.13)	(2.01)	(8.09)	(10.47)
`Constant`	-0.949	-1.262	-2.137	-0.172	-0.812
	(1.11)	(3.85)	(2.12)	(0.20)	(1.27)
R-squared	0.7489	0.6673	0.6443	0.3442	0.6644
Overall Signif.	F^3_{32}=31.81	F^4_{276}=138.37	F^4_{31}=27.13	F^2_{243}=57.64	χ^2_4=218.58
Observations	36	281	281	281	281
# of countries	36	36	36	36	36

Absolute value of t-statistics in (parentheses).

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

Regressand: `ln`(τ/i) Regressors:	Panel corrected standard error regressions. First-order auto-regressive errors AR(1) estimated by Prais-Winsten. (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]
$\ln \hbar$	-0.688	-0.852	-0.688	-0.852
	(2.80)	(3.65)	(3.46)	(3.74)
`Transition Dummy`	-1.097	-1.381	-1.097	-1.381
	(3.59)	(4.85)	(1.81)	(1.46)
`Developing Dummy`	-1.603	-1.411	-1.603	-1.411
	(5.53)	(5.63)	(6.45)	(7.29)
`Time Trend`	0.132	0.141	0.132	0.141
	(6.43)	(7.02)	(7.63)	(7.79)
`Constant`	-0.713	-1.084	-0.713	-1.084
	(1.28)	(1.99)	(1.59)	(2.04)
`(mean)`ρ	0.760	0.794	0.760	0.794
		(0.59)		(0.59)
R-squared	0.3494	0.5323	0.3494	0.5323
Overall signif.	χ^2_4=189.11	χ^2_4=276.71	χ^2_4=139.02	χ^2_4=151.79
Observations	281	281	281	281
# of countries	36	36	36	36

Absolute value of t-statistics in (parentheses).
[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: Dynamic panel regressions, tax to interest rate ratio.

data, here too the parameter on $\ln \hbar$ is negative and significant but greater than minus one. Column 2.3 gives the results for the between effects regression. The results are very similar, but not identical, to those in column 2.1 because this is a regression on mean values from an unbalanced panel and the `Time Trend` can therefore be included. Column 2.4 gives the results for the within effects regression, here the parameter on $\ln \hbar$ is still negative but appears statistically insignificant. The implication is that much of the variation that determines the parameter on $\ln \hbar$ is due to the between variation (between effects) rather than the within variation (fixed effects). The `Transition Dummy` and the `Developing Dummy` are obviously redundant because perfectly collinear with the intercept term when considering the within country variation of the fixed effects regression. Finally, column 2.5 reports the random effects GLS regression results. Given this is a weighted regression of the between and fixed effects regressions, we expect the parameter on $\ln \hbar$ to lie between

Regressand: $\ln(\tau/(p+.02))$ Regressors:	(4.1) OLS on means	(4.2) OLS on panel	(4.3) Between Effects OLS	(4.4) Fixed Effects OLS	(4.5) Random Effects GLS
$\ln\hbar$	-1.352	-0.962	-1.299	-0.375	-0.783
	(2.22)	(4.95)	(2.20)	(0.76)	(2.08)
Transition Dummy	-2.228	-2.201	-2.169		-2.521
	(3.57)	(9.12)	(3.59)		(4.65)
Developing Dummy	-1.494	-1.524	-0.969		-1.690
	(2.44)	(6.75)	(1.47)		(3.42)
Time Trend		0.151	0.319	0.120	0.132
		(6.88)	(1.79)	(6.61)	(8.14)
Constant	-1.183	-1.165	-2.788	-0.321	-0.716
	(0.92)	(2.62)	(1.82)	(0.32)	(0.83)
R-squared	0.6747	0.6124	0.5640	0.3387	0.6092
Overall Signif.	F^3_{32}=22.13	F^4_{276}=109.00	F^4_{31}=18.54	F^2_{243}=36.00	χ^2_4=142.53
Observations	36	281	281	281	281
# of countries	36	36	36	36	36

Absolute value of t-statistics in (parentheses).

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

the estimates in columns 2.3 and 2.4 and indeed it does.

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 $\ln\hbar$ are negative and statistically so. The dynamics are parameterized as first-order autoregressive in the error structure AR(1) and are estimated using the Prais-Winsten method to avoid loosing 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 autoregressive correlation in the error structure leading to more robust inference. To verify the robustness of these results to various functional forms, four alternative error parameterizations are specified. The regressions reported in columns 3.1 and 3.3 specify one auto-regressive parameter ρ on the error term to be common for all countries. The regressions reported in columns 3.2 and 3.4 allow the auto-regressive parameter ρ on the error 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 (error) term is common for all countries. The regressions reported in columns 3.3 and 3.4 specify that the standard error for the disturbance (error) 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

	Panel corrected standard error regressions, First-order auto-regressive errors AR(1) estimated by Prais-Winsten.			
Regressand:	(5.1)	(5.2)	(5.3)	(5.4)
`ln`$(\tau/(p+.02))$	Common ρ.[a]	Specific ρ.[b]	Common ρ.[a]	Specific ρ.[b]
Regressors:	Common σ.[c]	Common σ.[c]	Specific σ.[d]	Specific σ.[d]
`ln`$\hbar$	-0.893	-0.977	-0.893	-0.977
	(3.08)	(3.22)	(3.45)	(3.34)
`Transition Dummy`	-2.280	-2.458	-2.280	-2.458
	(6.40)	(8.14)	(3.35)	(4.42)
`Developing Dummy`	-1.494	-1.415	-1.494	-1.415
	(4.41)	(4.72)	(4.79)	(6.06)
`Time Trend`	0.149	0.142	0.149	0.142
	(5.97)	(6.08)	(6.88)	(7.07)
`Constant`	-1.018	-1.150	-1.018	-1.150
	(1.55)	(1.70)	(1.65)	(1.73)
`(mean)`ρ	0.760	0.794	0.760	0.794
		(0.59)		(0.59)
R-squared	0.3649	0.5278	0.3649	0.5278
Overall signif.	χ^2_4=201.32	χ^2_4=369.59	χ^2_4=125.46	χ^2_4=333.59
Observations	281	281	281	281
# of countries	36	36	36	36

Absolute value of t-statistics in (parentheses).
[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: Dynamic panel regressions, tax to inflation ratio.

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 $\ln(\tau/(p+.02))$ 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 inflation. The results in Tables 4 and 5 are much the same as those in Tables 2 and 3. The estimated parameter on the natural logarithm of the hidden economy share $\ln\hbar$ is in every case negative and in most cases statistically so.

The auxiliary regressions presented in Tables 7, 8, 9 and 10 of the Regression Appendix confirm the negative relationship suggested by the theory, though the statistical significance of does drop in most cases.

To summarize the results of the empirical analysis; in all cases the estimated parameters on the hidden economy share $\ln \hbar$ are negative and in most cases statistically different from zero. These negative parameters confirm the negative relationship suggested by equation (21) and Figures 1 to 4. The inclusion of the region dummies `Transition Dummy` and `Developing Dummy` does not negate the statistical significance of the negative slope parameter on $\ln \hbar$. This indicates that the observed negative relationship is not due purely to regional clustering effects. Closer inspection of the between-effects regressions 2.3 and 4.3 suggest the parameter on $\ln \hbar$ is negative and statistically different from zero. The fixed-effects regressions 2.4 and 4.4 suggest the parameter on $\ln \hbar$ is negative but not statistically different from zero. The implication is that much of the variation that leads to the negative estimated parameter on $\ln \hbar$ comes from the variation between countries rather than the variation within countries. This difference in the between and within variation is evident in Figures 1 to 4. Though the inverse relationship implied by equation (21) is evident in the data variation between different countries, it is less evident when considering the data within each country. The lack of variation in the within analysis is probably due to the small number of years available for each country.

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 the negative relation between the tax-ratio and the hidden economy share is observed in practice. In particular, estimates based on a diverse sample of 36 countries suggests that the elasticity of the tax ratio with respect to the hidden economy share is close to minus one. 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, one could consider endogenizing the hidden economy share ($\hbar$), 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 for the fiscal tax. Such a model allows for the determination of the optimal inflation tax rate for different levels of government expenditure. Buiter (2007) presents a theoretical model that explicitly includes separately the operational constraints facing the Central Bank and the Treasury. In Buiter'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 a economy caught in a liquidity trap. 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.

Of course, 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, as Schneider and Enste (2000) suggest, the global trend is for an increase in the relative size of hidden economies and, therefore, the impact of these hidden economies on the determination of government policy is set to become increasingly important.

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,

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

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

$$T + \tfrac{\dot{D}}{p} = G + B + i_D \tfrac{D^*}{p} \tag{A.2}$$

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,

$$M = D - D^*. \tag{A.3}$$

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

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

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

$$\begin{aligned} C &= C^v(\tilde{Y}^v, W; ...; (1-\hbar)N; t) \ + \ C^h(\tilde{Y}^h, W; ...; \hbar N; t) & \text{(A.5)} \\ H &= H^v(\tilde{Y}^v, W; ...; (1-\hbar)N; t) \ + \ H^h(\tilde{Y}^h, W; ...; \hbar N; t) & \text{(A.6)} \end{aligned}$$

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

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

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

where real disposable wealth is given by,

$$W = K + \tfrac{D}{p} = K + \tfrac{M+D^*}{p} \tag{A.8}$$

and potential pre-tax income is,

$$\tilde{Y} = r_K K + wH \tag{A.9}$$

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

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

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 (17a) and (17b), the first order conditions for the visible and hidden economies are,

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

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

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),

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

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

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

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

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

Differentiation of the budget constraint represented by equations (15a) and (15b) gives,

$$\begin{aligned}(1-\hbar)Z+(1-\hbar)\left[\tfrac{\partial C}{\partial\tau}+\tfrac{\partial S}{\partial\tau}+i\tfrac{\partial L}{\partial\tau}-(1-\tau)\tfrac{\partial Z}{\partial\tau}\right]=0\\ (1-\hbar)L+(1-\hbar)\left[\tfrac{\partial C}{\partial i}+\tfrac{\partial S}{\partial i}+i\tfrac{\partial L}{\partial i}-(1-\tau)\tfrac{\partial Z}{\partial i}\right]=0\end{aligned}\tag{C.32a}$$

$$\begin{aligned}\hbar\left[\tfrac{\partial C}{\partial\tau}+\tfrac{\partial S}{\partial\tau}+i\tfrac{\partial L}{\partial\tau}-\tfrac{\partial Z}{\partial\tau}\right]=0\\ \hbar L+\hbar\left[\tfrac{\partial C}{\partial i}+\tfrac{\partial S}{\partial i}+i\tfrac{\partial L}{\partial i}-\tfrac{\partial Z}{\partial i}\right]=0.\end{aligned}\tag{C.32b}$$

Substituting (C.32a) and (C.32b) into (C.31a) and (C.31b) generates (18a,b,c,d).

Appendix D: Solving the Government's Optimization.

Setting $\bar{R}=\tau(1-\hbar)Z+iL$, the first order derivatives for Lagrangean (19) are $\frac{\partial\Psi}{\partial\tau}=(1-\hbar)\frac{\partial V^v}{\partial\tau}+\frac{\partial\hbar V^h}{\partial\tau}+\mu\frac{\partial R}{\partial\tau}$ and $\frac{\partial\Psi}{\partial i}=(1-\hbar)\frac{\partial V^v}{\partial i}+\frac{\partial\hbar V^h}{\partial i}+\mu\frac{\partial R}{\partial i}$. The corresponding first order conditions are,

$$\begin{aligned}(1-\hbar)\tfrac{\partial V^v}{\partial\tau}+\hbar\tfrac{\partial V^h}{\partial\tau}=-\mu\tfrac{\partial R}{\partial\tau}\\ (1-\hbar)\tfrac{\partial V^v}{\partial i}+\hbar\tfrac{\partial V^h}{\partial i}=-\mu\tfrac{\partial R}{\partial i}.\end{aligned}\tag{D.35}$$

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 (18a,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 (18a,b,c,d), can be substituted into (D.35) to give,

$$\begin{aligned}(1-\hbar)\tfrac{\partial U^*}{\partial C}Z+\hbar\tfrac{\partial U^*}{\partial C}0=\mu\tfrac{\partial R}{\partial\tau}\qquad&\Rightarrow\qquad\tfrac{U^*_C}{\mu}=\tfrac{\partial R/\partial\tau}{(1-\hbar)Z}\\ (1-\hbar)\tfrac{\partial U^*}{\partial C}L+\hbar\tfrac{\partial U^*}{\partial C}L=\mu\tfrac{\partial R}{\partial i}\qquad&\Rightarrow\qquad\tfrac{U^*_C}{\mu}=\tfrac{\partial R/\partial i}{L}.\end{aligned}$$

Equating the two expressions above gives the government policy target,

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

This defines the tax-mix that maximizes social welfare subject to a constant total tax revenue, $\bar{R}=\tau(1-\hbar)Z+iL$. 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,

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

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 thanks 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),

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

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 (20) in the main text.

Data Appendix

Country	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Argentina					.233	.230	.239	.232	.240	.249	
Australia		.129	.123	.127	.128	.133	.131	.132	.129	.130	.128
Austria	.065	.065	.066	.066	.073	.079	.079	.081	.083	.083	
Belarus				.257	.275	.289	.298				
Belgium	.162	.162	.172	.172	.175	.177	.177	.180	.184	.184	
Bolivia		.396	.396	.396	.396						
Bulgaria			.233	.234	.233	.243	.241				
Canada	.113	.113	.119	.119	.124	.129	.129	.134	.139	.139	.138
Chile	.270	.212	.154	.154	.154						
Colombia	.200	.230	.260	.260	.260						
Croatia				.236	.238	.255	.243				
Denmark	.097	.097	.130	.130	.141	.151	.151	.153	.155	.155	.153
Ecuador		.238	.238	.238	.238						
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	
Guatemala	.379	.357	.335	.335	.335						
Hungary	.197	.193	.210	.216	.217	.212	.207				
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						
Mexico	.329	.271	.213	.213	.213						
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	
Panama	.286	.334	.383	.383	.383						
Peru	.306	.336	.367	.367	.367						
Poland	.186	.211	.214	.212	.210	.203	.192				
Portugal	.137	.137	.147	.147	.164	.181	.181	.184	.188	.188	
Slovenia				.211	.203	.196	.189				
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
Uruguay	.260	.260	.260	.260	.260						

Table 6: Hidden economy shares ($\hbar$).

Regression Appendix

This appendix contains auxiliary regressions to those in the main text that also include corruption and development among the explanatory variables. Because of data non-coverage three further countries (Belarus, Croatia and Slovenia) are excluded from the regressions.

Regressand: $\ln(\tau/i)$ Regressors:	(7.1) OLS on means	(7.2) OLS on panel	(7.3) Between Effects OLS	(7.4) Fixed Effects OLS	(7.5) Random Effects GLS
$\ln\hbar$	-0.498	-0.358	-0.499	-0.122	-0.389
	(1.03)	(2.51)	(1.12)	(0.38)	(1.49)
Transition Dummy	-0.379	-0.246	-0.180		-0.668
	(0.68)	(1.21)	(0.35)		(1.31)
Developing Dummy	-1.604	-1.362	-1.271		-1.555
	(2.83)	(7.51)	(2.33)		(4.10)
Corruption	0.965	0.515	1.320	0.267	0.055
	(0.73)	(1.53)	(1.08)	(0.71)	(0.15)
Development	0.039	0.036	0.038	-0.057	0.016
	(2.15)	(6.58)	(2.32)	(2.21)	(1.31)
Time Trend		0.116	0.264	0.137	0.118
		(8.13)	(2.43)	(8.81)	(9.10)
Constant	-0.691	-0.907	-2.169	1.077	-0.462
	(0.74)	(3.07)	(2.06)	(1.38)	(0.83)
R-squared	0.7898	0.7460	0.6707	0.4415	0.7303
Overall Signif.	F^{5}_{27}=20.291	F^{6}_{260}=127.28	F^{6}_{26}=21.12	F^{4}_{230}=45.46	χ^{2}_{6}=282.83
Observations	33	267	267	267	267
# of countries	33	33	33	33	33

Absolute value of t-statistics in (parentheses).

Table 7: Static panel regressions including corruption and development, tax to interest rate ratio.

	Panel corrected standard error regressions. First-order auto-regressive errors AR(1) estimated by Prais-Winsten.			
	(8.1)	(8.2)	(8.3)	(8.4)
Regressand: $\mathtt{ln}(\tau/i)$	Common ρ.[a]	Specific ρ.[b]	Common ρ.[a]	Specific ρ.[b]
Regressors:	Common σ.[c]	Common σ.[c]	Specific σ.[d]	Specific σ.[d]
$\ln \hbar$	-0.253	-0.354	-0.253	-0.354
	(1.27)	(1.83)	(1.29)	(1.50)
`Transition Dummy`	-0.293	0.286	-0.293	0.286
	(0.97)	(0.89)	(1.00)	(0.94)
`Developing Dummy`	-1.239	-1.271	-1.239	-1.271
	(5.20)	(7.07)	(4.89)	(7.86)
`Corruption`	0.015	0.348	0.015	0.348
	(0.05)	(1.25)	(0.06)	(1.66)
`Development`	0.036	0.038	0.036	0.038
	(4.48)	(5.22)	(5.70)	(6.44)
`Time Trend`	0.104	0.108	0.104	0.108
	(6.54)	(7.30)	(6.99)	(7.40)
`Constant`	-0.538	-0.830	-0.538	-0.830
	(1.34)	(2.09)	(1.34)	(1.79)
`(mean)` ρ	0.714	0.779	0.714	0.779
		(0.60)		(0.60)
R-squared	0.5514	0.7124	0.5514	0.7124
Overall signif.	χ^2_6=382.35	χ^2_6=582.10	χ^2_6=253.75	χ^2_6=478.00
Observations	267	267	267	267
# of countries	33	33	33	33

Absolute value of t-statistics in (parentheses).

[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 8: Dynamic panel regressions including corruption and development, tax to interest rate ratio.

	(9.1)	(9.2)	(9.3)	(9.4)	(9.5)
Regressand:	OLS	OLS	Between	Fixed	Random
$\mathtt{ln}(\tau/(p+.02))$	on	on	Effects	Effects	Effects
Regressors:	means	panel	OLS	OLS	GLS
$\mathtt{ln}\hbar$	-0.584	-0.415	-0.602	-0.202	-0.538
	(0.84)	(2.18)	(0.96)	(0.56)	(1.69)
Transition Dummy	-1.104	-1.082	-0.840		-1.914
	(1.38)	(4.00)	(1.14)		(2.64)
Developing Dummy	-1.550	-1.403	-1.113		-1.939
	(1.92)	(5.80)	(1.44)		(3.71)
Corruption	0.451	-0.185	1.019	-0.297	-0.665
	(0.24)	(0.41)	(0.59)	(0.71)	(1.60)
Development	0.034	0.025	0.033	-0.125	-0.016
	(1.34)	(3.37)	(1.41)	(4.29)	(0.97)
Time Trend		0.125	0.372	0.157	0.128
		(6.56)	(2.41)	(9.01)	(8.26)
Constant	-0.468	-0.451	-2.575	2.450	0.279
	(0.35)	(1.14)	(1.72)	(2.80)	(0.39)
R-squared	0.682	0.652	0.745	0.370	0.599
Overall Signif.	F^5_{27}=11.59	F^6_{260}=81.20	F^6_{26}=12.65	F^4_{230}=33.79	χ^2_6=173.09
Observations	33	267	267	267	267
# of countries	33	33	33	33	33

Absolute value of t-statistics in (parentheses).

Table 9: Static panel regressions including corruption and development, tax to inflation ratio.

	Panel corrected standard error regressions, First-order auto-regressive errors AR(1) estimated by Prais-Winsten.			
Regressand:	(10.1)	(10.2)	(10.3)	(10.4)
$\mathtt{ln}(\tau/(p+.02))$	Common ρ.[a]	Specific ρ.[b]	Common ρ.[a]	Specific ρ.[b]
Regressors:	Common σ.[c]	Common σ.[c]	Specific σ.[d]	Specific σ.[d]
$\mathtt{ln}\hbar$	-0.362	-0.514	-0.362	-0.514
	(1.38)	(2.09)	(1.49)	(2.06)
Transition Dummy	-1.117	-0.447	-1.117	-0.447
	(2.82)	(1.20)	(2.34)	(0.84)
Developing Dummy	-1.177	-0.587	-1.177	-0.587
	(3.74)	(1.94)	(3.04)	(1.31)
Corruption	-0.576	-0.477	-0.576	-0.477
	(1.39)	(1.27)	(1.69)	(1.47)
Development	0.026	0.051	0.026	0.051
	(2.48)	(4.68)	(2.37)	(3.19)
Time Trend	0.119	0.109	0.119	0.109
	(5.66)	(5.62)	(6.01)	(5.87)
Constant	-0.310	-1.185	-0.310	-1.185
	(0.59)	(2.33)	(0.54)	(1.74)
(mean)ρ	0.711	1.000	0.711	1.000
		(0.50)		(.50)
R-squared	0.4290	0.6415	0.4290	0.6415
Overall signif.	χ^2_6=248.63	χ^2_6=503.92	χ^2_6=176.55	χ^2_6=441.44
Observations	267	267	267	267
# of countries	33	33	33	33

Absolute value of t-statistics in (parentheses).
[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 10: Dynamic panel regressions including corruption and development, tax to inflation ratio.

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