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Frode Brevik and Manfred Gärtner

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Department of Economics University of St. Gallen

Editor: Prof. Jörg Baumberger
University of St. Gallen
Department of Economics
Bodanstr. 1
CH-9000 St. Gallen
Phone +41 71 224 22 41
Fax +41 71 224 28 85
Email joerg.baumberger@unisg.ch

Publisher: Department of Economics
University of St. Gallen
Bodanstrasse 8
CH-9000 St. Gallen
Phone +41 71 224 23 25
Fax +41 71 224 22 98

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Author's address:

Prof. Manfred Gärtner
Forschungsgemeinschaft für Nationalökonomie
Bodanstrasse 1
CH-9000 St. Gallen
Tel. +41 71 224 2307
Fax +41 71 224 2874
Email manfred.gaertner@unisg.ch
Website http://www.fgn.unisg.ch/gaertner/index.html

Abstract

We analyze an overlapping-generations world comprising two groups of small countries whose preferences for public spending differ. Key steady-state effects from introducing bank secrecy and a withholding tax in countries with low government spending are: a reduction of global capital and income, a shift of wealth towards bank-secrecy countries, and falling consumption, welfare and government spending despite rising tax rates in the rest of the world. Qualitative results are robust to changes in tax-payer honesty, the Leviathan effect (permitting governments to drive public spending higher than citizens prefer), and the fraction of withholding taxes repatriated to countries of residence.

Keywords

Bank secrecy, distribution, government, overlapping generations, public spending, tax coordination, tax evasion, welfare, withholding tax.

JEL Classification

E2, E62, F42, H2

1 Introduction

Spurred by the continuing integration of international markets for capital, services and goods, supra-national organizations and bodies such as the International Monetary Fund (IMF), the Organization for Economic Cooperation and Development (OECD) or the Commission of the European Union (EU) have turned their attention to what they see as a widespread and growing use of unfair tax practices. In the words of the OECD:

> The goal is to secure the integrity of tax systems by addressing the issues raised by practices with respect to mobile activities that unfairly erode the tax bases of other countries and distort the location of capital and services. Such practices can also cause undesired shifts of part of the tax burden to less mobile tax bases, such as labor, property, and consumption, ... [OECD (2000), p.5].

Bank secrecy, by providing opportunities for tax fraud and evasion, is one such practice, and it is being debated particularly hotly. There has been an ongoing debate within the European Union focussing on Austria, Belgium, and Luxembourg as well as the role of offshore tax jurisdictions such as Jersey or the Dutch Antilles. It has been a key issue during recent bilateral negotiations between Switzerland and the EU. And it was characterized by various non-governmental organizations as being particularly harmful to the economic prospects of developing nations.

Much of this debate surrounding bank secrecy, however, proceeds on a moral or ideological level, with one side claiming bank secrecy to provide other countries' residents with well-deserved escapes from their Leviathan governments, and the other side accusing the first side of propagating assistance to help tax evaders cover their trail. This paper will not engage in this moralizing debate. Instead, it adopts a detached macroeconomic perspective and works out the effects of certain abstract interpretations of bank secrecy laws on major macroeconomic variables, including gross domestic product, gross national product, consumption, the capital stock, interest rates, wages, taxes and the provision of public goods, as well as social welfare in general. The purpose is to provide a rational, scientific basis for political debate and future research that may disagree with and refine our framework and assumptions.

2 Related work

As mentioned, the macroeconomic repercussions of bank secrecy have attracted the attention of various non-governmental organizations[1], of national governments, and of international organizations. There is also an ethical discussion within the scientific community as well as between the scientific community and exponents from the banking industry.[2] And there is complementing econometric work attempting to identify the characteristics of countries which adhere to unfair tax practices in the definition of the OECD (see Masciandaro and Portolano, 2002). However, surprisingly little work of direct relevance is found in the scientific debate.[3] Contributions most closely related to the issues to be addressed in this paper come from the area of tax competition.

From the perspective of the questions asked in the current paper, though, the literature on tax competition has two drawbacks: First and foremost, its focus is on the derivation of competitive results, of the outcome of static or dynamic tax games, between jurisdictions or governments. The insights gained from such analysis should be of considerable relevance for the evolution of pertinent institutional designs to come, but the identified optima often bear only vague resemblance with the international patterns of taxes as they have existed for decades. Second, the thrust of this literature is not macroeconomic, and, hence, either a partial view is being employed, with no macroeconomic model at all, or the macroeconomic focus is a very narrow one. Representative recent contributions with the features stressed here are Eggert and Kolmar (2004), Huizinga and Nielsen (2002), Kollintzas et al. (2000), Marchand et al. (2003), and Traxler (2002). Huizinga and Nielsen (2002) analyze static and dynamic tax games between countries in which households deposit given funds at either domestic or foreign banks. Thus, the employed view is partial, not macroeconomic. Addressing the EU Commission's proposal, it is found that optimal regimes in the presence of

[1]The home page of the Swiss Coalition of Development Organizations, found at http://www.swisscoalition.ch/english/pagesnav/T.htm, gives a good flavor of this discussion as well as many references.

[2]See Thielemann and Ulrich (2003), particularly chapter IV, for a Swiss contribution to this discussion. Their home page features links to other documents from the recent exchange on the ethics and moral of bank secrecy in the popular media.

[3]E.g., searching the Social Science Citation Index for keywords combining bank secrecy with terms such as macroeconomics, welfare, or distribution yields no results.

bank secrecy can be a withholding tax at home and abroad, information exchange in both directions, or even a mixed regime in which on country levies a withholding tax on interest earned while the other provides information. Eggert and Kolmar (2004) employ a version of the Wilson (1991) model of tax competition. One key result of their analysis is that the integration of capital markets drives all taxes on capital, including withholding taxes, to zero, so that governments effectively become indifferent between a regime of information exchange and a withholding tax.

Marchand et al. (2003) use a small open economy model with mobile factors capital and labor and immobile land. Different tax rates on wage and interest income and a lump sum tax on land are used to redistribute income. They reproduce the well-known race to the bottom, as opening the economy drives tax rates to zero when cooperation is lacking. A cooperative solution reproduces the autarky results. However, and this is new, if only one tax can be coordinated, the obtained solution may be inferior to non-cooperation. Kollintzas et al. (2000) resort to a two-country Cass-Koopmans growth model. They conclude that Nash equilibria are degenerate and interpret this as a new and stronger reason for tax coordination. Under coordination tax rates are equal across countries, reflecting the involved countries' bargaining power and preferences. Traxler (2002) employs a macroeconomic model in which policy instruments are lump-sum subsidies for workers and a tax rate on interest income. It is shown that Nash equilibria imply the under-taxation of capital and, regarding the distribution of income, giving preferential treatment to the mobile factors of production at the expense of the immobile ones.

So while the key issue addressed in the literature on international tax competition is whether such competition is harmful or beneficial, the current paper looks at issues of taxation in open economies from a different angle. It takes the existence of bank secrecy laws, combined with a withholding tax on interest earnings, in major financial centers as given, and asks to what extent this has contributed to currently observed cross-country patterns in incomes, taxes, public sectors size, and other macroeconomic variables. Since such institutional structures have been in existence since decades, we settle for an analysis of the steady-state effects.

This paper is organized as follows: section 3 introduces the model and discusses analytical results. Section 3.1 starts with an open economy setting without bank secrecy, and discusses key properties. Section 3.2 introduces bank secrecy and prepares the model for numerical work by calibration, which

is done in section 4. Section 5 turns to a numerical evaluation of the model, drawing on a basic set of calibrated parameters. Section 6 looks at the sensitivity of the obtained results, focussing on the role of parameters that are difficult to quantify, such as the honesty of tax payers or what we call the Leviathan effect. It also looks at the potential effects of international agreements on tax cooperation that are currently being discussed. Finally, section 7 evaluates the results, points out shortcomings of the analysis, and concludes.

3 The Model

The model is a multi-country extension of Diamond's overlapping-generations model.[4] The global economy comprises a large number of two types of countries, subscripted eu and ch.[5] The eu countries have a stronger preference for government spending which results, as we will show later, in higher income tax rates. Each individual country is so small that it ignores any responses its own saving and tax decisions may draw from other countries. The world population L is given by the sum of the populations of the two types of countries, $L = L_{eu} + L_{ch}$; and each type's world population share is denoted by lower case letters l_{eu} and l_{ch}. As we will later associate the ch countries with tax havens, their share will in general be much lower: $l_{ch} \ll l_{eu}$.

In all countries, output per unit of labor is determined by the same Cobb-Douglas production function

$$y = k^{\alpha}.$$

Further, we assume competitive labor markets and a perfect world capital market, which implies that the same amount of capital per head will be

[4]Choosing an overlapping-generations model over a representative agent model has two advantages. More of a cosmetic nature, it avoids the result that in equilibrium one of the countries does not save at all, because the net interest rate, after taxes, falls short of the time discount rate. On a more substantial level, OLG models produce a richer set of results on issues surrounding the distribution of income and wealth, and they provide a more promising basis for future extensions of this paper's work that may include social security aspects, which may interact with the tax issues considered here.

[5]Subscripts ch and eu have been chosen, instead of some abstract label such as a and b, with the sole purpose of making this paper easier to read. Associations regarding bank secrecy and high levels of public spending are intended and should assist the readers. Beyond that, this is basically a theoretical exercise with no claim towards capturing specific quantitative issues between any two real-world economies.

available to workers in both countries. The pretax interest and wage rates are given by the net marginal product of capital and labor, respectively,

$$\begin{aligned} r &= \alpha k^{\alpha-1} - \delta \\ w &= (1-\alpha)\, k^{1-\alpha}, \end{aligned} \tag{1}$$

where δ denotes the depreciation rate. Individuals live for two periods, so period length is measured in decades. During the first period of their lives, the agents supply a fixed amount of labor, which we normalize to one.[6] During the second period of their lives, the agents are rentiers, living of whatever wealth they accumulated during the first period of their lives. For simplicity, we assume that the two periods are of equal length and that there is no population growth. Agents lifetime utility U, is determined by the logarithmic utility function

$$U = \log c_y + \beta \log\ c'_o + \psi_i(1+\beta) \log g. \tag{2}$$

Thus, individuals derive utility from consumption when young (c_y) and consumption during retirement (c'_o), as well as from the level of government spending per capita (g).[7] Implicitly, leisure time generates utility as well. However, since work time is constant, no insights are lost by dropping leisure from the utility function. A prime denotes the value of a variable one period ahead. In our case, we use this to distinguish between the prospective next period consumption of the present working generation c'_o and the consumption of the currently retired generation c_o. The weight given to government spending ψ_i is indexed in order to permit differences in preferences for government expenditures between the two types of countries. Individuals are

[6]The assumption of a constant labor supply is equivalent to augmenting equation 2, the utility function, with a term of the form $B \log(1-l)$, where B is a parameter and l denotes the fraction of time supplied on the labor market. With a utility function of this functional form, the agents will also supply a fixed proportion of their time endowment on the labor market. Since we will be looking at steady states only, and operate in a deterministic scenario, the gains from using a more elaborate labor supply function would be minimal.

[7]Including government spending in the utility function as a specific form of consumption is but one option for motivating taxation in models with micro foundations. Alternative ways would be to make government spending a factor of production, as proposed by Barro (1990) in the context of economic growth, or to assume that individuals prefer even to uneven distributions of income, with taxes being used for the purpose of redistribution. An example of this approach (which dates back to Mirrlees (1971) and is at the core of the optimal taxation literature) that we have already mentioned is Marchand et al. (2003).

born without wealth, and they leave no bequests. The domestic government finances spending by taxing both wage and interest income at the same rate t_i. From the perspective of the individual households, the level of government expenditures as well as the wage, interest, and tax rates are exogenous.

3.1 The case without bank secrecy

3.1.1 The savings decision

Effectively, the only decision that the agents have to make is how to split the wages they earn during the first period of their lives between consumption and saving. Upon retirement, during the second period of their lives, individuals consume all their youth savings and any interest income that accrues. They make this decision in a manner as to maximize their lifetime utility given their lifetime budget constraint. That is, their consumption and saving decision solves the following maximization problem

$$\begin{aligned} \max_{c_{y,i}} & \log c_{y,i} + \beta \log \; c'_{o,i} + \psi_i(1+\beta)\log g \\ & \text{s.t.} \\ & c_{y,i} + \frac{c'_{o,i}}{1+(1-t_i)r} = (1-t_i)w, \\ & c_{y,i}, c_{o,i} \geq 0 \end{aligned} \tag{P1}$$

Rearranging the budget constraint to obtain an expression for c'_o, substituting this for c'_o in the utility function and taking the derivative with respect to $c_{y,i}$ yields

$$c_{y,i} = \frac{1}{1+\beta}(1-t_i)w. \tag{3}$$

Thus, independent of the level of the interest rate, a constant fraction $1/(1+\beta)$ of disposable wage income is consumed in the first period while the remaining share, $s \equiv \beta/(1+\beta)$, is being saved for the second period.

The savings of the young generation this period correspond to the assets owned by the old generation next period a', or

$$a'_i = \frac{1}{1+\beta}(1-t_i)w. \tag{4}$$

The old generation consumes its total wealth and all its net capital income:

$$c_{o,i} = (1+(1-t_i)r)\, a_i. \tag{5}$$

3.1.2 The steady-state capital stock

Given that a period lasts decades, we may reasonably assume that capital depreciates completely within one period. With free movement of international capital, we can use the fact that workers in both countries receive the same gross wage rate w and save the same fraction s of disposable income. The global capital stock is given by total assets held in the two countries, or

$$\begin{aligned} K' &= a'_{eu} L_{eu} + a'_{ch} L_{ch} \\ &= s\left(1 - t_{eu}\right) w L_{eu} + s\left(1 - t_{ch}\right) w L_{ch} \end{aligned}$$

Dividing both sides by the total population L and substituting for the wage rate, we arrive at the per worker capital stock:

$$k' = s\left(1 - t_{eu} l_{eu} - t_{ch} l_{ch}\right)\left(1 - \alpha\right) k^{\alpha}. \tag{6}$$

After making use of the equilibrium condition, $k' = k$, we can rearrange equation (6) to solve for the steady state value of the capital stock:

$$k = \left[s(1 - t_{eu} l_{eu} - t_{ch} l_{ch})(1 - \alpha)\right]^{1/(1-\alpha)} \tag{7}$$

Thus global capital per worker is a function of the time discount factor, which determines the savings rate, and of national tax rates. It also reflects the share of each country type. Equation (7) also gives capital per worker in each individual country, because free capital flows equate gross interest rates. Hence, while wealth per retired person may differ between the two country types ($a_{eu} \neq a_{ch}$), the capital *employed in production* is identical ($k_{eu} = k_{ch}$).

Convergence to the steady state is illustrated in figure 1. The young generations in both countries save the same constant fraction of their net labor income. By the assumption of perfect international capital markets, the net wage rate for a given tax regime is completely determined by the global per worker capital stock. The highest curve displays per worker assets acquired by the young generation in the *ch* countries, as a function of the capital stock per worker. The lowest curve shows those of the *eu* countries. Next period's capital stock is given by the bold line, and is a weighted average of the assets acquired by the young generation in the two types of countries. Due to the assumption that only a small proportion of the global population lives in the *ch* countries, the bold line is very close to the one showing assets of the *eu* population.

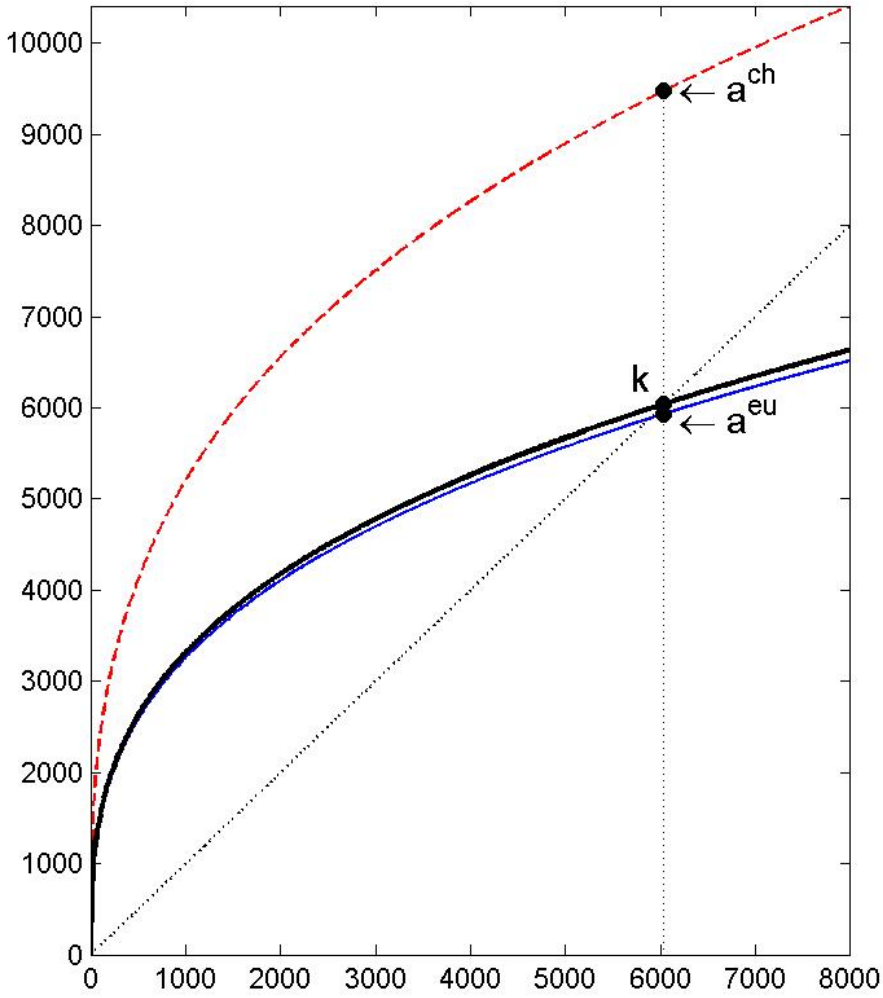

Figure 1: Convergence of the capital stock to its steady state value.

3.1.3 The government optimization

The tax rate, which households consider given, are being set so as to maximize government utility. Suppose for now that perfect political competition forces the government to effectively maximize their constituency's utility as given in equation (2). In this case, each government sets the tax rate so as to maximize the steady state value of the utility function of the representative individual of its constituency.

Since we are interested in the long-run implications of the model, in

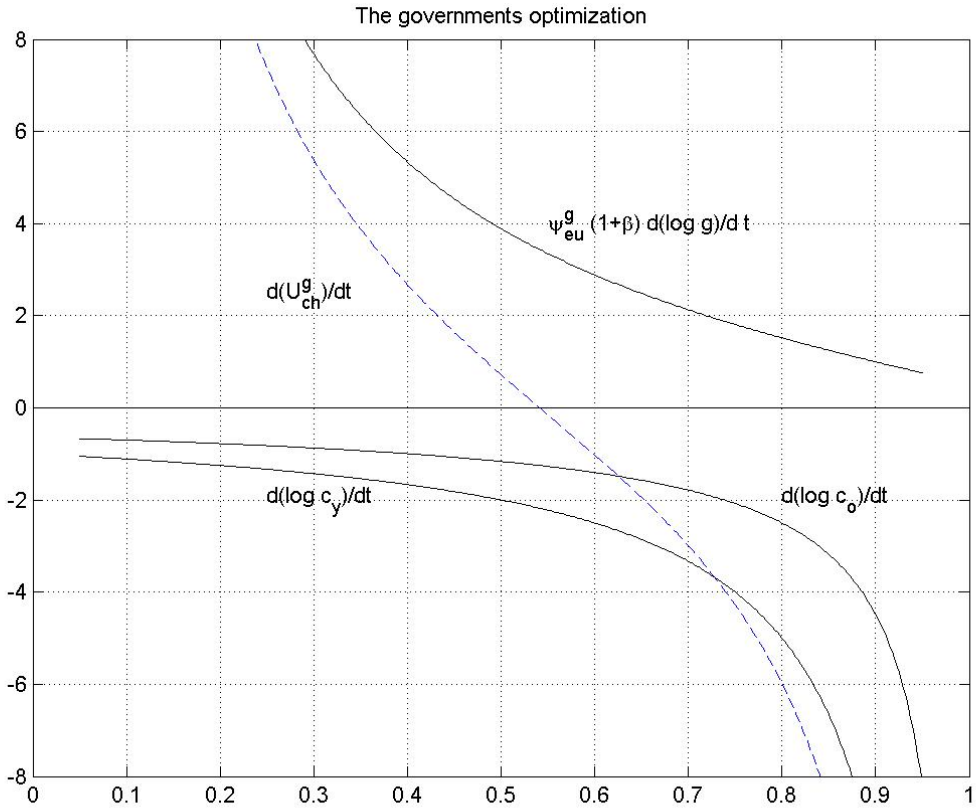

Figure 2: The government optimization.

steady-state scenarios, it is reasonable to consider the government budget balanced. Accordingly, per-capita government spending is always given by-per capita tax revenues:

$$g_i = \frac{t_i(w + ra_i)}{2}, \tag{8}$$

The optimal tax rate solves the maximization problem

$$\begin{aligned} \max_t \ & \log c_y + \beta \log \ c'_o + \psi_i(1+\beta)\log g \\ & \text{s.t.} \\ & \text{equations (3), (5), and (8).} \end{aligned} \tag{P2}$$

The optimality condition for the tax rate is that the derivative of the

government utility function with respect to the tax rate is zero:

$$\frac{dU_i}{dt_i} = \frac{d\log c_{y,i}}{dt_i} + \frac{\beta d\log c_{o,i}}{dt_i} + \frac{\psi_i(1+\beta)d\log g_i}{dt_i} = 0. \tag{9}$$

Analytical expressions for the individual terms of (9) are given in the appendix. The appendix also contains a more thorough discussion of the optimization of the two types of governments. Figure 2 plots the individual terms of (9), drawing on the parametrization described in section 4. The optimum tax is where the dotted line, which is the sum of the three terms, crosses the abscissa.

Proposition 1 states the intuitive result that the optimal tax rate is increasing in the preference for government consumption. In the absence of secret bank accounts, it follows that the inhabitants of the *eu*-type countries face higher tax-rates and consume less, but benefit from higher government expenditures.

Proposition 1. *For all countries, the optimal tax rate is increasing in the preference parameter for government consumption.*

A preliminary intuition for this proposition can be derived from figure 2: A higher preference parameter for government expenditures, shifts the curve associated with government consumption up while not affecting the position of the others. It also follows from the implicit function theorem applied to the government optimality condition, which we can denote by F. By the implicit function theorem,

$$\frac{dt}{d\psi} = -\frac{\partial F/\partial t}{\partial F/\partial \psi}.$$

The partial derivative of F with respect to the tax rate equals the second derivative of the government utility function with respect to the tax rate at the point where utility is maximized. It follows from the second order condition for a maximum that this derivative is negative. In the optimality condition, ψ only enters the term $\frac{\psi_i(1+\beta)d\log g_i}{dt_i}$, so the derivative of F with respect to ψ is positive. It follows that

$$\frac{dt}{d\psi} > 0.$$

3.2 Enter bank secrecy

Let the *ch*-type countries introduce bank secrecy legislation combined with a withholding tax t_f on interest income. We assume that the withholding tax is exogenous, and somewhere between the two countries' tax rates, $t_{ch} < t_f < t_{eu}$. Only then it makes domestic residents declare all their income while attracting capital from abroad. Rather than explicitly modeling the choice of how much of their wealth *eu* residents will transfer to secret *ch* bank accounts (as a function of tax differentials, the detection probability — probably a function of the fraction transferred, potential punishments, etc.), we assume that a fixed fraction f will be transferred. Postulating an exogenous dishonesty coefficient is but a moderate loss in generality, since optimal dishonesty in the steady-state would be constant anyway, and depend mostly on parameters exogenous to our model.

Secret bank accounts and the withholding tax affect government revenue and spending in both (types of) countries. Generally, public spending is given by the tax rate times the income that is being taxed in each country:

$$\begin{aligned} g_{eu} &= t_{eu}\left[w + (1-f)\, r k_{eu}\right] \\ g_{ch} &= t_{ch}\left[w + r k_{ch}\right] + t_f f \frac{l_{eu}}{l_{ch}}\left(1 - t_{eu}\right) r k_{eu}. \end{aligned} \tag{10}$$

The equations reflect that secret, low-tax off-shore bank accounts erode the tax-base in countries with high tax rates, while the presence of a withholding tax contributes to the public finances of the tax havens. The consumption of the old is still given by their saving plus their net interest income. But the tax rate that the retired generation in the *eu* countries now faces is a weighted average of the domestic tax rate and the withholding tax in the tax haven, the weight being the fraction of wealth held abroad.

$$c_{eu,o} = \left[\left(1 - t_{eu}\left(1-f\right) - t_f f\right) r + 1\right] k_{eu} \tag{11}$$

Apart from these modifications, the optimization of the government is identical to the one without bank secrecy. Accordingly, it has been relegated to the appendix. Proposition 2 relates the tax rate in both types of countries to the amount that the inhabitants of the *eu* countries chose to keep in off-shore bank accounts.

Proposition 2.

(a) *The tax rate in the eu countries is increasing in the fraction of wealth the inhabitants keep in offshore bank accounts.*

(b) *The tax rate in the ch countries is decreasing in the fraction of wealth that foreigners keep in offshore bank accounts.*

The proposition follows directly from equation (22) in the appendix. To understand the importance of proposition 2, consider the case where there exists secret bank accounts, but the population of the *eu* countries do not use these to evade taxes (ie, $f = 0$). It is straightforward to show that the equilibrium values in this case will be the same as in the case of no secret bank accounts. If offshore bank accounts are actually used, it hence follows by proposition 2 that their existence leads to a even lower tax rate in the *ch* countries and increased tax rates in the *eu* countries. Alas, as is shown in the appendix, the impact of f on the aggregate capital stock, and hence on most other variables of interest, is indeterminate on such a general level. To bypass this restraint, we will now calibrate the model with sensible parameter values and and compare numerically the steady states generated under different assumptions on bank secrecy. In addition to enabling us to gauge its *qualitative* influence on a range of macroeconomic aggregates, this approach will also provide us with a first indication of its *quantitative* impact on these variables.

4 Calibration

For the purpose of calculating a benchmark, we assume that the capitals share of output α is equal to 0.3, which is approximately equal to its historical value in many industrial countries. The fraction f of wealth kept in offshore accounts varies greatly from country to country. We use a value of 10 percent, which is at the lower end of the numbers reported by the Boston Consulting Group (BCG, 2003). The fraction l_{ch} of the world population living in tax havens is set to 1/30.

The remaining parameters, ψ_{eu}, ψ_{ch}, and β, are difficult to pin down using microeconomic studies or long term economic ratios. In a different context, Jermann (1998) suggests to choose parameters that maximizes the models ability to match a set of empirical moments. Let θ_1 denote the vector of the three missing model parameters: $\theta_1 = (\psi_{eu}, \psi_{ch}, \beta)'$. Analogous to the GMM methodology in econometrics, we choose θ_1 so as to minimize

$\Im = [\theta_2 - f(\theta_1)]'\Omega[\theta_2 - f(\theta_1)]$, where θ_2 is the vector of the moments we seek to match, and Ω is a weighting matrix. For our model, this function is well behaved, and it is straightforward to implement the maximization using a grid search.

The moments to match are: (1) The share of government expenditures in each type of country, and (2) the average pre-tax return to capital. For the purpose of getting reliable statistics, we use the Eurozone as a stand-in for the *eu* countries and Switzerland as a stand-in for *ch* countries. The total government disbursements as a percentage of GDP was 49.5 in the Eurozone and 36 in Switzerland.[8] The average annual pre-tax return to capital in the US national accounts data is 4 percent (MacGrattan and Prescott, 2003). Our model reproduces these moments (brings $\Im$ to zero) for $(\beta, \psi_{ch}, \psi_{eu})' = (0.236, 0.425, 1.826)'$.

5 Numerical Results

5.1 The case without bank secrecy

Table 1 provides steady-state results computed from the calibrated model. All columns labeled (a) refer to the situation without bank secrecy. Columns labeled (b) show steady-state values in a scenario with bank secrecy and a withholding tax in the *ch* countries. Columns labeled (c) report the percentage changes of steady-state values triggered by the implementation of bank secrecy.

By showing global data, the upper section of table 1 provides the backdrop for subsequent discussions of the experiences of individual countries. Here column (a) gives global income for the benchmark scenario of no bank secrecy, as well as capital per worker and gross factor incomes. Perfect competition and capital mobility ensure that each individual country's per-worker capital stock, gross wage rate and gross interest rate equal the respective global values. This does not, of course, extend to other variables, nor to net factor incomes reported in the individual-countries sections of table 1.

A comparison of columns (a) for the *ch* and *eu* countries reveals the distinctive macroeconomic profiles chiseled out by the difference in the utility functions that drive both individual decisions and government policies. As

[8]Sources: ECB, Statistics Pocket Book and OECD, Economic Outlook.

	Global economy		
	(a)	(b)	(c)
k	2699	2663	-1.31
w	29958	29839	-0.39
r	3.98	4.00	0.60
GDP, GNP	13224	13172	-0.39

	ch countries			*eu* countries		
	(a)	(b)	(c)	(a)	(b)	(c)
t	24.78	11.20	-54.82	53.66	54.51	1.59
a	4,303	5,060	17.60	2,651	2,592	-2.23
c	17,347	21,790	25.61	9,249	9,148	-1.09
c_y	18,231	21,439	17.60	11,232	10,981	-2.23
c_o	16,463	22,140	34.49	7,266	7,314	0.66
g	5,715	7,673	34.26	10,710	10,550	-1.49
w_{net}	22,534	26,499	17.60	13,882	13,573	-2.23
r_{net} (annualized)	3.41	3.76	10.19	2.55	2.63	2.93
GDP	385	384	-0.39	12,839	12,788	-0.39
GNP	454	487	7.35	12,770	12,685	-0.67
Labor income	270	269	-0.39	8,987	8,952	-0.39
Capital income	184	219	18.69	3,783	3,733	-1.32
U			21.96			-1.57

Table 1: Simulation results. The columns (a) and (b) display the cases without and with secret bank accounts, respectively. The percentual change from (a) to (b) is reported in (c).

already suggested by proposition 1 above, the *ch* countries prefer to implement a much lower tax rate of 24.78 percent, compared to 53.66 percent for the *eu* countries. Since this permits *ch* residents to save a much larger fraction of gross income, their accumulated assets per retired person a exceed those of *eu* residents by a ratio of 4,303 to 2,651. From the fact that the capital stock per worker k is the same in both countries at 2,699 (taken from the global data), it follows that *ch* residents own part of the capital stock

employed in the *eu* countries.

As already mentioned, identical per-capita capital stocks in both type of countries imply identical gross factor incomes, wages and interest rates, as given in the global economy's column (a). Both net wage and interest rates are higher in the *ch* countries due to lower tax rates.

Regarding those variables that enter utility functions, each country gets what suits its preferences. The *ch* countries excel in consumption, while the *eu* countries enjoy a much higher level of public spending. Life cycle consumption patterns are qualitatively the same in the two countries, though not equally pronounced. Primarily as a reflex of households' time preferences, individuals choose to consume more when young.

Turning to the macroeconomic aggregates reported in the lower section of table 1, labor income in all countries stands at 70 percent of GDP, the labor income share of our calibrated Cobb-Douglas production function. Capital incomes on a geographical basis make up for the remaining 30 percent of GDP. This does not hold on a residential basis, of course. Reflecting what we said about tax differences and their effect on saving, GNP exceeds GDP in the *ch* countries. This is mirrored by a shortfall of the same magnitude in the *eu* countries. These differences are due to interest payments from or to abroad, respectively. Due to owning part of the foreign capital stock, capital income in *ch* amounts to 48 percent of GDP, while, technically the closed-economy reference value would be 30 percent. In the *eu* countries the capital income share is 29.6 percent only.

5.2 Enter bank secrecy

Now we look at what happens when *ch*-type countries introduces bank secrecy along with a withholding tax of 35 percent. Columns (b) report steady state values that obtain in this new scenario, whereas columns (c) report the percentage differences between the equilibrium values of the respective variables without and with bank secrecy.

From the perspective of global aggregates nothing positive seems to come out of bank secrecy. The global capital stock falls by 1.3 percent, pulling down income and wages as well. Interest rates do rise, but not enough to compensate for the reduction of the capital base. So global capital income goes down as well. Of course, these global implications conceal that the two types of countries are being affected in different ways.

One key result is that the tax rate in *ch* countries falls by more than half

of its original value, whereas it rises in *eu* countries. This result is important, as it contradicts the frequently advanced argument that the competition from tax havens forces governments in high-tax countries to lower taxes as well. In the context of our model and the calibrations employed here, this does not work.

In the countries implementing bank secrecy, all other variables also improve: Wealth per retired person rises from 4,303 to 5,060. Life-time consumption goes up by 26 percent, while the life-time pattern changes towards higher consumption during retirement. This reflects the fact that the old generation profits from both a higher wealth level and lower taxes on capital income. Net wage and interest rates rise because of the reduced tax rate. Finally, and this is also important, the level of government spending is boosted by about a third of its previous value. In the face of a drop in the income tax rate of some 55 percent, this cannot be paid for by domestic residents' taxes, since GNP increases by 7 percent only. The gap is filled by taxes withheld from foreign residents who deposit part of their wealth with *ch* banks. With consumption increasing for both generations, and public spending being much higher also, the introduction of bank secrecy must raise *ch* residents' utility, as shown in the bottom line of table 1.

The changes experienced in the *eu* countries mostly mirror what we observed in the *ch* countries. In addition to the rising tax rate which we already noted, wealth deteriorates, as do life-time consumption, public spending, the net wage rate, GDP, GNP, and the incomes from labor and capital. The only positive change is increased consumption during retirement, which comes mostly as a result of part of the capital income new being taxed at the *ch* countries' withholding tax rate of 35 percent instead of the *eu* countries' no-bank-secrecy income tax rate of 53.66 percent. Since this is more than eaten up by a drop of consumption for the working generation, making total life-time consumption fall, and since public spending has fallen as well, *eu*-type countries experience a utility loss corresponding to a general drop in all aggregates of 1.57 percent.[9]

[9]As proposed by Lucas (1987), we bypass the problem of interpreting changes to the ordinal values of the utility function by computing the percentual shift in the utility generating variables which would generate the same utility level change.

6 Sensitivity tests

The results reported in table 1 reflect calibration decisions and assumptions about the efficiency of the political process that may be questioned. They are also sensitive to how international tax cooperation is being modeled. While the proposed cooperation scenario appears to describe the recent and more distant past, which determine current steady states, reasonably well, pertinent changes are in the offing. It is advisable, therefore, to look at how sensitive results are with respect to such changes and to changes of crucial parameters.

6.1 Tax payer honesty

The first parameter we want to look at is the fraction f of their saving which *eu* residents choose to hide in foreign bank accounts, which we may call the dishonesty ratio.[10] The results given in table 1 are based on a rather conservative calibration of f to a value of 0.1. Figure 3 shows how tax rates, wealth and factor prices are affected if we allow f to vary across the full range from 0 to 1. Note that in the limiting case of $f = 0$ bank secrecy is ineffective. The respective outcomes, therefore, are the same as if bank secrecy did not exist. They are depicted as horizontal lines and serve as benchmark values. When picking a specific value for f, the vertical distance to the non-horizontal response lines, shows by how much each variable changes after the implementation of bank secrecy if a particular parameter value for f applies. Vertical arrows positioned at convenient, but arbitrarily chosen values for f serve to illustrate this.

Over the range $0 < f < 1$ the qualitative consequences of implementing bank secrecy do not depend on the magnitude of f. In the cases of *eu* taxes, *eu* wealth, *eu* and *ch* interest rates, *eu* wages, as well as global capital and factor prices, this relationship is even monotonous in the sense that the effect grows stronger as f increases. In the cases of *ch* taxes, *ch* wealth and *ch* wages, this does not apply however, and there is also a kink in the response line for *eu* interest rates. The reason for this is that the model does not permit *ch* tax rates to become negative. As the upper left panel shows,

[10] The fraction f does not necessarily measure the total fraction of saving invested abroad, but only the share not reported to the *eu* tax man. When interest revenues are being correctly declared, *eu* residents are indifferent between investing at home or abroad, and this decision also does not have any macroeconomic consequences.

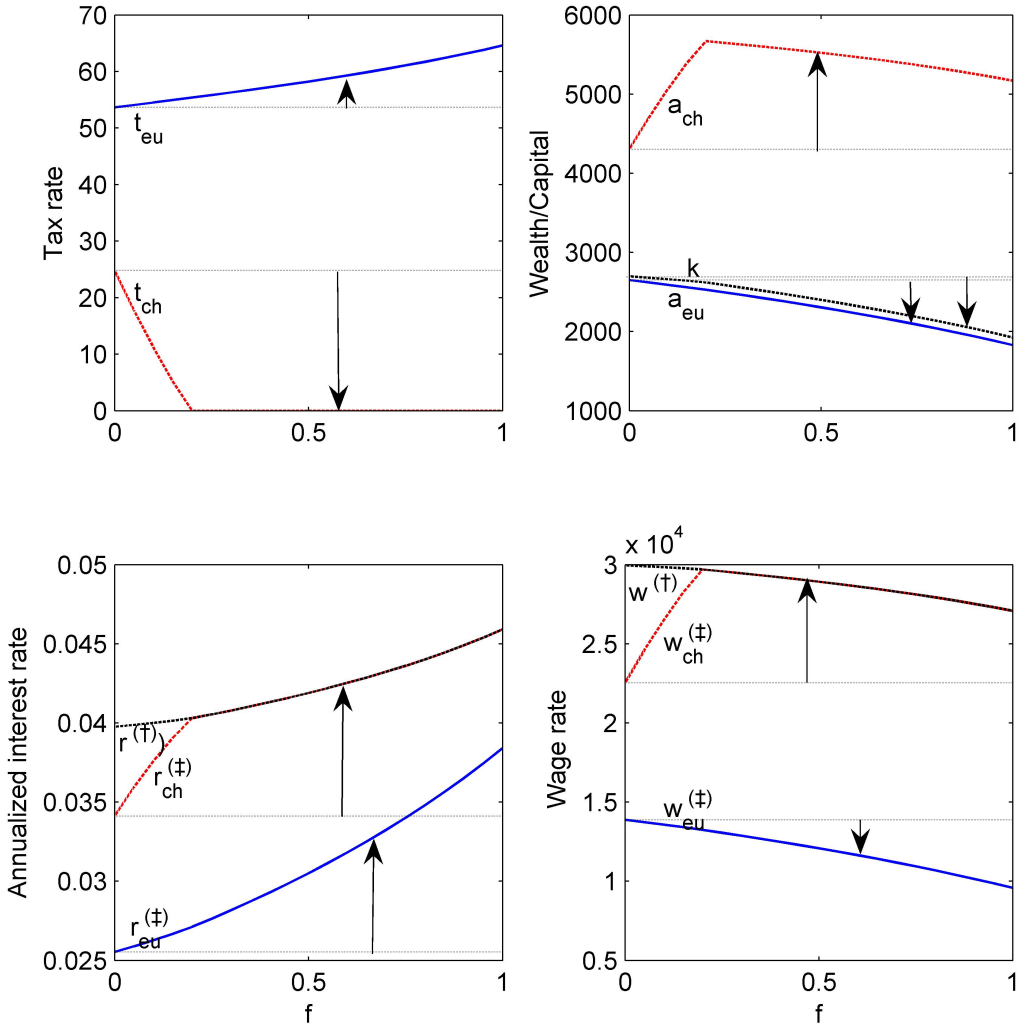

Figure 3: Steady State values for key macroeconomic variables as a function of the fraction of the wealth that the *eu* citizens keep in *ch* bank accounts. (†: gross variable; ‡: net variable .)

the downward effect on t_{ch} becomes large quickly as f rises. The tax rate already hits bottom at a dishonesty ratio of 20 percent, and cannot fall any further if f continues to rise. This kink in the response line of the tax rate is responsible for kinks in the response lines of other variables.

Restricting *ch* tax rates to non-negative values is also responsible for the kinks in some of the utility-generating variables reported in figure 4. For example, the public-spending response line for the *ch* countries becomes steeper at $f = 0.2$. The reason is that up to this value the increase in withholding taxes from abroad, caused by an increase in f, is partially offset by a reduction of the *ch* tax rate, which adds up to a modest increase in government revenues and spending. Beyond this threshold, however, after the *ch* tax rate hits zero, this compensating reduction in t_{ch} is not possible any longer. Hence government revenues and spending rise by the full increase in withholding tax revenues from abroad.

6.2 The Leviathan effect

Our model so far assumed that the political process was efficient in the sense that society succeeded in electing a government that represents its preferences for public spending in an unbiased fashion. We therefore made no distinction between the preferences of a country's residents, which would eventually gauge the utility levels generated by specific macroeconomic outcomes, and the preferences of the government, which determine the tax rate.

An argument advanced quite often is that government policies and society's preferences may not always match. Due to imperfections and distorting incentives in the political process, governments may, in fact, be driven by an appetite for public spending that exceeds the desires of its constituencies.[11] Tax-haven countries often call upon such distortions in defence of their policies. By providing escapes from overtaxation, the argument goes, secret *ch* bank accounts with attractively low withholding tax rates may not only be to good for *ch*, but to the benefit of *eu* residents as well. Until now our analysis

[11] Such arguments are already at the core of Wagner's law of the secular increase in the government sector. Later and more recently it has received attention in the direct versus representative democracy discussion of the democratic process (see, in particular, the empirical study by Pommerehne and Schneider, 1982), the theory of bureaucracy (see Peacock and Wiseman, 1961; Niskanen, 1971), the theory of fiscal illusion (see Mueller, 1979), the theory of interest groups (see Mueller and Murrell, 1986), and in the literature on time inconsistency and policy biases (see Gärtner, 2000).

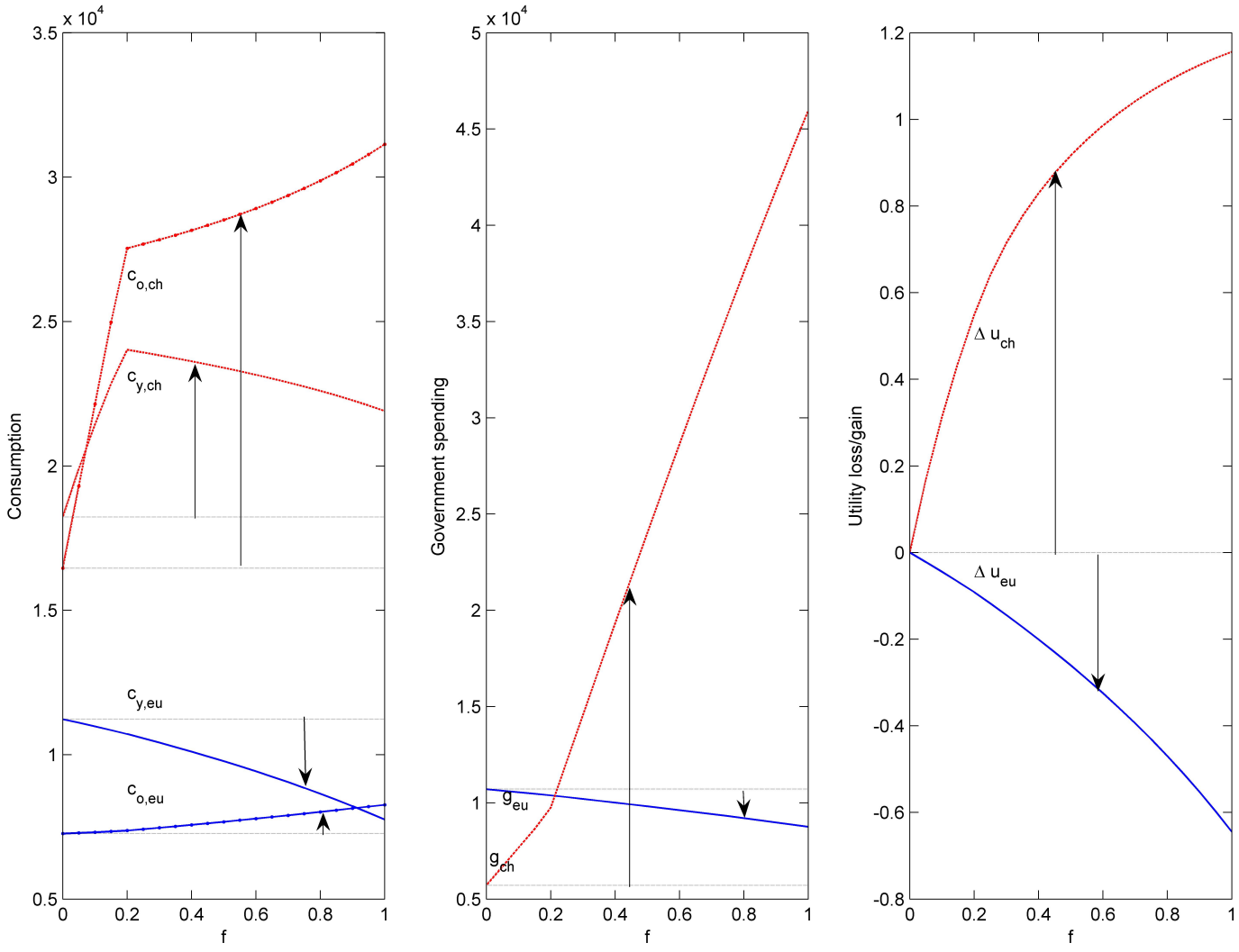

Figure 4: Steady State values for the utility components as a function of the fraction of the wealth that the *eu* citizens keep in *ch* bank accounts.

has not done justice to this argument by simply assuming this possibility of imperfections in political markets away.

In order to deal with this argument, we now permit *eu*-type governments' preferences for public spending, as gauged by the weight factor ψ_{eu}, to differ from *eu* residents' preferences, expressed by $\psi_{eu,r}$. The government's weight factor retains the value employed so far. As a consequence, tax policies and macroeconomic outcomes remain the same. However, these outcomes generate different levels of utility than previously reported when residents possess preferences that differ from the ones that drive tax policies. By defining a Leviathan effect $LE \equiv 100(\psi_{eu} - \psi_{eu,r})/\psi_{eu}$, we measure government power abuse over a spectrum ranging from a value of zero, a situation in which current tax rates fully reflect what citizens want, to a value of 100. At this upper limit, taxes are entirely due to an abuse of power by the government, and, since $\psi_{eu,r} = 0$, citizens actually would have preferred no public spending at all. Figure 5 looks at whether the possible existence of a Leviathan effect provides a new perspective on tax rates and government revenue and spending levels.

The left panel shows tax rates. While the lower part covers a wider spectrum that reveals the non-linear nature of the relationship between society's optimal tax rate and our definition of the Leviathan effect, the upper part shows a magnified smaller range that makes differences between lines easier to recognized and describe. The crucial lines are the two bold ones, which both refer to the scenario without bank secrecy. The horizontal one shows the tax rate set by the government, which is independent of the Leviathan effect, and which coincides with the tax rate society wants when there is no Leviathan effect. However, as the negatively sloped solid line indicates, society, by definition, wants a lower tax rate as the Leviathan effect increases, thus opening a gap between what the governments does and what its constituencies want.

Now, the first answer to whether the implementation of bank secrecy by *ch* countries may benefit *eu* residents in the presence of a Leviathan effect appears to be a clear no. Since *eu* governments respond to bank secrecy by raising the tax rate, the gap between actual tax rates and society's optimal tax rate always widens, no matter what size the Leviathan effect has. This still holds after we take into account that the tax rate effectively paid is a weighted average of the *eu* tax rate and withholding tax in the *ch* countries, though the effect is softened somewhat.

Things become more complicated when we turn to the panel on the right.

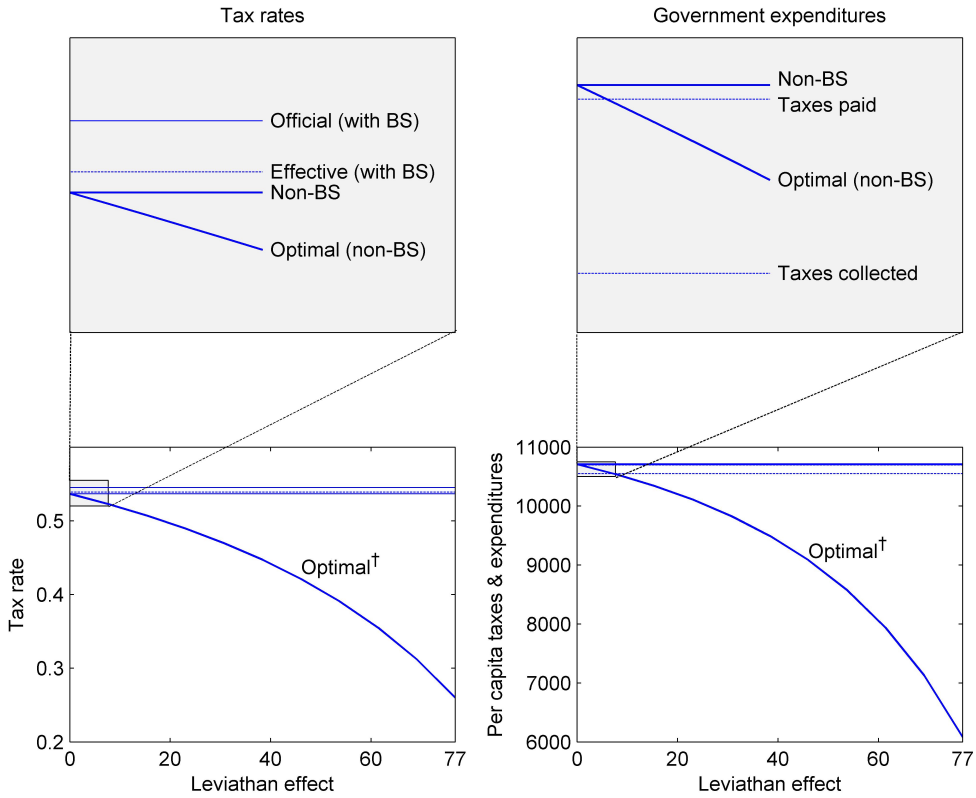

Figure 5: Comparison of actual and individually desired tax rates and government expenditure levels for different levels of ψ. (†: From the perspective of the agents.)

Instead of tax rates it shows *eu* government revenues and spending levels per capita, also from a bird's eye perspective in the lower part, and under a magnifying glass in the upper part. Again, the two bold lines indicate what society wants and what the government provides, this time in terms of public spending and taxes per capita. The thin dashed line, the lowest of the horizontal lines, marks the amount of public spending and taxes collected by the *eu* government. It appears to indicate that *ch* bank secrecy indeed succeeds in taming the Leviathan *eu* governments, lowering public spending and, beyond a certain threshold, bringing it closer toward what society wants. Before getting too excited about this, however, we need to note two things: First, the reduction occurs most visibly on the expenditure side, where public spending generates utility. Taxes paid, marked by the thin dotted line, fall by much less, since there is a tax drain from the *eu* countries to the *ch*

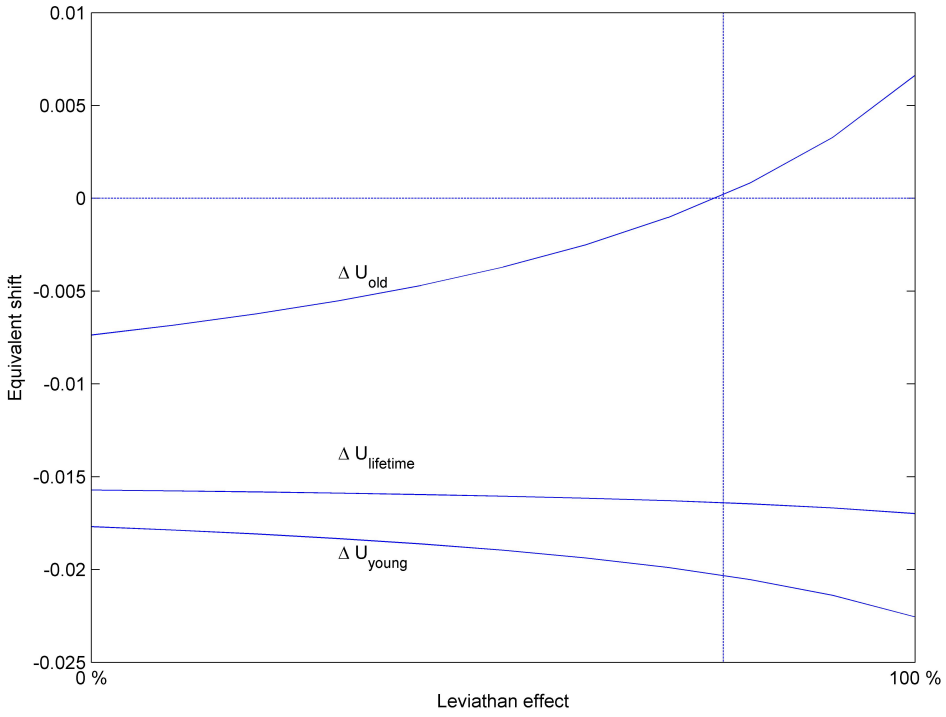

Figure 6: Impact of bank secrecy on the utility of *eu* citizens. (Percentage shifts in all macroeconomic aggregates which would have the same impact on utility as a switch to a regime with bank secrecy.)

countries. Not all taxes paid by *eu* residents are being received by their own governments and converted to public spending. And, in fact, since the left panel reported an increase in the tax rate, taxes paid can only fall if the tax base shrinks. Therefore, *eu* residents pay lower taxes only because they now have lower taxable incomes. So the bottom result is that bank secrecy reduces the level of government spending in the *eu* countries, but it raises the tax burden as measured by the tax rate on reported income.

Figure 6 widens this partial look at the government sector to a discussion of how bank secrecy affects overall generational and lifetime utility under different magnitudes of the Leviathan effect in the *eu* countries.

As the upper line shows, the negative effect of bank secrecy on the older generation's utility level, expressed by ΔU_{old} and already diagnosed in table

1, does indeed grow smaller as the Leviathan effect increases. It may even become positive when the Leviathan effect is very large. With the calibration employed here, this threshold, beyond which $\Delta U_{old} > 0$, is roughly where *eu* residents possess the same preferences as *ch* residents.

The young generation's period utility is always affected negatively by bank secrecy, and this effect becomes stronger as the Leviathan effect increases. The same applies to lifetime utility which, due to old-age utility being discounted, is dominated by the effect of bank secrecy on working-age utility. The bottom line from this is that calling on the possibility of Leviathan governments abroad in defence of bank secrecy is an own goal. Rather than turning foreign repercussions beneficial, a strong Leviathan effect aggravates the detrimental welfare effects of bank secrecy on other countries.

6.3 International tax cooperation

The increasing international sensitivity to what is called unfair tax practices and their potentially negative repercussions on other countries' welfare has led to cooperative efforts on matters of taxing mobile factors of production. One such effort, relevant for the issues addressed in this paper, is the agreement between Switzerland and the European Union on the taxation of interest payments negotiated in 2004. This agreement stipulates that, as a price for maintaining bank secrecy, the Swiss government will return some fraction of its withholding-tax revenues from foreign investors to their respective home countries. Our model accommodates a stylized interpretation of such cooperative practices.

Table 2 looks at the macroeconomic repercussions of bank secrecy under three different withholding-tax repatriation ratios. If this ratio is 0 percent, i.e. if *ch* retains all withholding taxes from foreigners, the results from table 2 are being replicated. Additional columns report bank-secrecy effects when *ch* does repay 50 or 100 percent of foreigner-paid withholding taxes.

The global results may appear surprising: Cross-border repatriation of withholding taxes turns out to be only a third-best solution. Both the world capital stock and world income fall as the repatriation ratio increases. But then, what is the rationale for the observed tendencies towards more tax cooperation? The intuition for this is given by the numbers for the two individual countries.

Starting with the last line, we see that *ch* and *eu* utility levels are be-

	Global economy		
Repatriation ratio	0 %	50 %	100 %
k	-1.31	-1.43	-1.59
w	-0.39	-0.43	-0.48
r	0.60	0.66	0.74
GDP, GNP	-0.39	-0.43	-0.48

	ch-type countries			*eu*-type countries		
Repatriation ratio	0 %	50 %	100 %	0 %	50 %	100 %
t	-54.82	-28.52	-0.11	1.59	1.31	1.01
a	17.60	8.92	-0.44	-2.23	-1.94	-1.65
c	25.61	13.05	0.07	-1.09	-0.70	-0.29
c_y	17.60	8.92	-0.44	-2.23	-1.94	-1.65
c_o	34.49	17.62	0.64	0.66	1.23	1.81
g	34.26	17.13	-0.08	-1.49	-1.01	-0.53
w_{net}	17.60	8.92	-0.44	-2.23	-1.94	-1.65
r_{net} (annualized)	10.19	5.82	0.82	2.93	3.19	3.47
GDP	-9.61	-7.83	-6.74	-9.61	-7.83	-6.74
GNP	15.45	14.92	0.19	-10.50	-8.64	-6.99
Labor income	-9.61	-7.83	-6.74	-9.61	-7.83	-6.74
Capital income	52.13	48.21	10.33	-12.62	-10.56	-7.57
U	21.96	11.74	-0.19	-1.57	-1.13	-0.70

Table 2: Bank secrecy with cooperating tax authorities. Each column reports percentual changes with respect to the situation without secret bank accounts. The situation with no cooperation (repatriation ratio of 0 %) mirrors case (c) in table 1.

ing affected in opposite ways. While the negative effect of bank secrecy on *eu* utility is cut in half when withholding taxes are being fully repatriated, the positive effect on *ch* utility, which is 21.96 percent in the absence of tax repatriation, vanishes and, in fact, becomes negative in the full-repatriation case.[12] The mechanism behind this is that, when withholding taxes on in-

[12]One may question, then, the rationality of a *ch*-type country agreeing to tax cooperation, as it is being observed in reality. In defence of this we may note that tax cooperation

terest income obtained abroad are being repatriated, partially or in full, the *eu* tax rate need not rise as much to finance optimal public spending. This has a positive effect on saving and thus, via the accumulation of wealth a, on *eu* GNP. This way, positive effects are made possible on consumption during both phases of the life cycle and on public spending g.[13]

The opposite argument applies to the *ch*-type countries. Deprived of withholding tax revenue from foreign investors, the tax rate cannot fall that much any more. In the extreme case of full tax repatriation, a number of variables, including working-age consumption and public spending, are now even being affected negatively by bank secrecy. A positive effect on retirement-age consumption remains, due to the reduction of the capital stock and the resulting higher interest rates. But this cannot compensate for utility lost due to lower public spending and reduced consumption when young.

In the light of the results presented in table 2, the incentives for agreeing on international tax cooperation as defined here are: While such cooperation makes the global cake smaller in size, it increases the piece going to the *eu* countries, not only in relative terms, but also in absolute size. The *ch* piece definitely shrinks, but as long as there is no full repatriation, it can remain larger than if the *ch* countries had been arm-twisted into abolishing bank secrecy altogether.

While varying any one of the sensitive coefficients of our model alone does not appear to affect the direction of the effect of bank secrecy on other countries' economy and welfare, may be effects add or interact. In order to briefly look at this possibility, the 3-dimensional graphs in 7 show how the simultaneous variation of the Leviathan effect and the repatriation rate affects *eu* utility.

Partial effects are as already described in figure 6 and table 2. Repatriation of withholding taxes reduces the negative effect of bank secrecy on *eu* residents' utility, but, except for the period utility of the old, the effect always remains negative. The Leviathan effect make the negative effect of

is often part of a larger package in which both sides give and take. In addition, the recent agreement between Switzerland and the European Union on the taxation of interest payments limits the withholding tax repatriation ratio to 75 percent which, even in our stylized scenario, leaves the tax heaven with a positive effect from bank secrecy.

[13]When we speak of a positive effect, say, on g, we mean that the negative effect is smaller. In numbers, when the repatriation ratio is 0 percent, bank secrecy introduced by the *ch* countries reduces public spending per capita in the *eu* countries by 1.49 percent. When the repatriation ratio is 100 percent, g falls by 0.53 percent only.

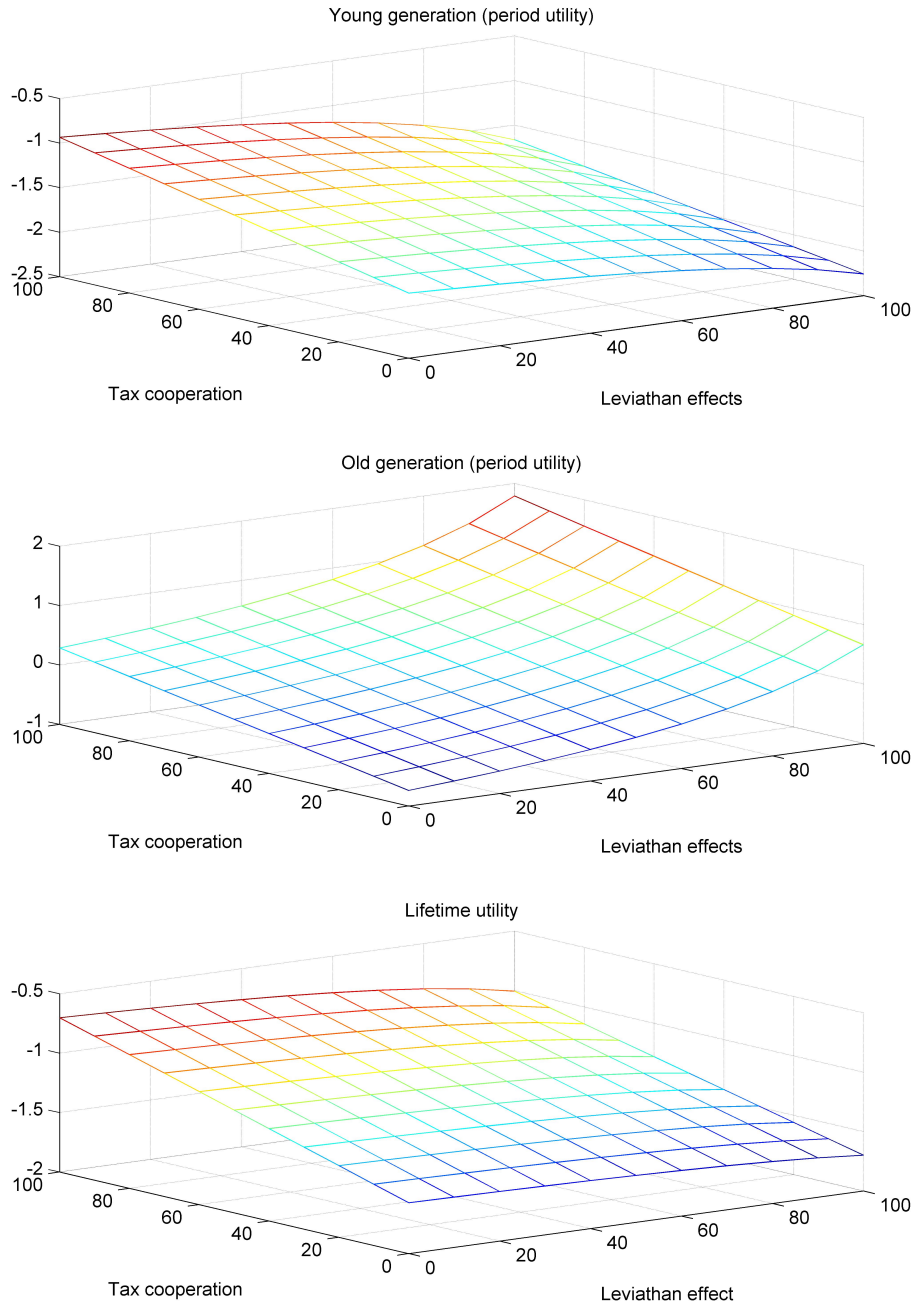

Figure 7: Impact on *eu* utility levels by simultaneous variation of the Leviathan effect and the repatriation ratio.

bank secrecy even worse during working-age and over the entire lifetime. It has a moderating effect on utility experienced during retirement, and actually can turn this effect positive. Putting the effect from withholding-tax repatriation and the Leviathan effect on top of each other, we see three things: First, while the detrimental effect of *ch* bank secrecy on *eu* working-age utility is smallest when withholding taxes are fully repatriated and there is no Leviathan effect, its sign always remains negative. The same holds for lifetime utility. Regarding *eu* utility experienced during retirement, a wide range of repatriation ratios and Leviathan effect levels exist which render *ch* bank secrecy beneficial. However, such effects never make up for utility lost while young and working.

7 Summary and Conclusions

We have analyzed a multi-country OLG model in which the world comprises a majority of small countries with a strong preference for government spending, labeled *eu*, and a minority of small countries with a weak preference for government spending, labeled *ch*. Perfect competition and capital mobility equalize GDP per capita and gross factor incomes across countries. But since differences in the preference for government spending lead to different income tax rates, this translates into differences in net factor incomes and wealth. In the default scenario without bank secrecy, lower tax rates provide *ch*-type countries with higher per-capita GNP (due to owning part of the *eu* capital stock), higher net wage and interest rates, and a lower level of government consumption.

When *ch*-type countries launch bank secrecy combined with a withholding tax, this depresses the global capital stock and, hence, global income. Interest rates rise and wage rates fall. These countries nevertheless benefit in terms of increases of all relevant macroeconomic variables. Tax rates fall, but tax injections from foreign investors permit a hike in public spending. *eu*-type countries suffer. The reduced capital stock leads to lower wages, and since a tax drain towards countries *ch* forces *eu* taxes up, net wages fall even more, and so does lifetime consumption. The only positive effect is on consumption during retirement, made possible by higher net interest rates. But this effect is too small to compensate for losses in other areas, such es reduced public spending that have to be digested despite higher tax rates.

Sensitivity analyses show that quantitative effects depend on the honesty

of tax payers, but qualitative results do not. Somewhat more surprisingly, the Leviathan argument does not cut within our framework. Even if foreign residents initially were the victims of governments that abuse imperfections in the political market to implement excessively high tax rates and public spending levels, the option of enjoying interest incomes from *ch* bank accounts at much lower tax rates does not generate a net benefit to the *eu* residents. There are two reasons for this: One the one hand, withholding taxes paid to a *ch* government do not generate any public spending in *eu* countries in return, and are thus wasted from the *eu* residents' perspective. On the other hand, the governments in the *eu* countries react to the tax shortfall by raising the tax rate on domestic income.

We finally looked at the long-run effects of agreements to repatriate withholding tax revenues to the source countries. One key result is that, while imperfect repatriation is an improvement for *eu*-type countries at the expense of *ch*-type countries, it leaves *ch*-type countries better off than if it had been pressured into discarding bank secrecy altogether.

Our analysis provides some first answers as to how patters in income and wealth and the public sector are being affected by bank secrecy and withholding taxes. But it also suffers from shortcuts that need to be attended in subsequent work. Besides straightforward generalizations that model tax regimes in a more realistic fashion, it would be desirable to endogenize behavioral features that our model has simply tied to exogenous parameters:

One such feature is tax payer honesty. While we looked at how changes in the dishonesty ratio affected outcomes, it was always exogenously determined. A more satisfactory alternative would be to make honesty the result of some cost-benefit calculation under uncertainty. This might dampen *eu* governments' appetite for public spending, since raising taxes has a direct effect on tax payer honesty and thus, the tax drain.

Also, a more refined look at the Leviathan effect is required, a look that models political competition explicitly: In this paper *eu*-type governments adjust tax rates to *ch* bank secrecy and withholding taxes, but it is always the same (type of) government that gets elected, the same government preferences that drive tax policy. So, at its roots, the Leviathan effect is exogenous. Could it not be that, in the face of bank secrecy and low withholding taxes abroad, *eu* voters elect a government with different preferences, that is, that tax competition from *ch* reduces the Leviathan effect, making it an endogenous phenomenon? This might require some imperfect competition approach to party politics instead of a median voter or exogenous monopoly

power approach.

Finally, one more aspect where our model lacks realism is the assumption of perfect competition in the international capital market. This generates the trivial but nevertheless puzzling implication that the *ch* banking industry does not generate any profits from the foreign assets it manages due to bank secrecy and, hence, is indifferent towards it. The only reason for defending bank secrecy is its positive effect on public revenues and spending. In a more realistic model *ch*-type countries would generate income from the foreign assets its financial sector manages.

Appendix

Government optimization

From the text, we know that the aggregates in the *eu* utility function are given by:

$$\begin{aligned} c_{y,eu} &= \frac{1}{1+\beta}(1-t_{eu})w \\ c_{o,eu} &= \left(1+\left[1-(1-f)t_{eu}-ft_f\right]r\right)\frac{\beta}{1+\beta}(1-t_{eu})w \\ g_{eu} &= \frac{1}{2}\left(t_{eu}w + t_{eu}(1-f)r\frac{\beta}{1+\beta}(1-t_{eu})w\right). \end{aligned}$$

The semi-elasticities are given by:

$$\begin{aligned} \frac{d\log c_{y,eu}}{dt_{eu}} &= -\frac{1}{1-t_{eu}} \\ \frac{d\log c_{o,eu}}{dt_{eu}} &= -\frac{1}{1-t_{eu}}\left(1+\frac{(1-t_{eu})(1-f)r}{1+\left[1-(1-f)t_{eu}-ft_f\right]r}\right) \\ \frac{d\log g_{eu}}{dt_{eu}} &= \frac{1}{t_{eu}}\left(1-\frac{t_{eu}s(1-f)r}{1+s(1-t_{eu})(1-f)r}\right). \end{aligned} \tag{12}$$

A one percent increase in taxes hence reduces the first term of the utility function by $1/(1-t_{eu})$ percent, which is equal to the semi elasticity of their disposable income to the tax rate. For the old generation, the semi-elasticity of consumption to the tax rate is larger, since there are two channels through which it is influenced. First, a one percent tax-increase reduces their log wealth by $1/(1-t_{eu})$ percent. Second, the return they receive on this wealth is also lower by the tax increase. This is captured by the term within the large parenthesis. The non-linearity that adverse effects taxes have on savings is also inherited by government expenditures through the tax basis.

The optimality condition for the government is that an appropriately weighted sum of the semi-elasticities is equal to zero.

$$\frac{dU_{eu}}{dt_{eu}} = \frac{d\log c_{y,eu}}{dt_{eu}} + \frac{\beta d\log c_{o,eu}}{dt_{eu}} + \frac{\psi_{eu}(1+\beta)d\log g_{eu}}{dt_{eu}} = 0.$$

For the *ch* type of government, the equations are slightly different. Here the

long run values of utility generating aggregates are given by

$$\begin{aligned} c_{y,ch} &= \frac{1}{1+\beta}(1-t_{ch})w \\ c_{o,ch} &= (1+[1-t_{ch}]\,r)\,\frac{\beta}{1+\beta}(1-t_{ch})w \\ g_{ch} &= t_{ch}w + t_{ch}(1-t_{ch})rsw + t_f(1-t_{eu})\frac{l_{eu}}{l_{ch}}rsw. \end{aligned}$$

It follows that the semi elasticities for these variables are:

$$\begin{aligned} \frac{d\log c_{y,ch}}{dt_{ch}} &= -\frac{1}{1-t_{ch}} \\ \frac{d\log c_{o,ch}}{dt_{ch}} &= -\frac{1}{1-t_{ch}}\left(1+\frac{(1-t_{ch})r}{1+(1-t_{ch})\,r}\right) \\ \frac{d\log g_{ch}}{dt_{ch}} &= \frac{1}{t_{ch}}\left[1-\frac{T_{eu}}{g_{ch}}\right]\left(1-\frac{t_{ch}sr}{1+s(1-t_{ch})r}\right). \end{aligned} \tag{13}$$

Also for the ch countries, the optimality condition for government consumption is a weighted sum of the semi-elasticities:

$$\frac{dU_{ch}}{dt_{ch}} = \frac{d\log c_{y,ch}}{dt_{ch}} + \frac{\beta d\log c_{o,ch}}{dt_{ch}} + \frac{\psi_{ch}(1+\beta)d\log g_{ch}}{dt_{ch}} = 0.$$

The two optimality conditions links each tax rate to the other variables as implicit functions, which paves the way for using the implicit function theorem. To complete the reduced system, we use the long run equilibrium condition for the capital stock as a third implicit function. Denoting the optimality condition for the eu and ch types of government by F^1 and F^2, and using F^3 to denote the equilibrium condition for the capital stock results in the following system of implicit equations:

$$\begin{aligned} F^1 &= -\frac{1+\beta}{1-t_{eu}} - \frac{\beta(1-f)r}{1+[1-(1-f)t_{eu}-ft_f]\,r} \\ &\quad + \frac{\psi_{eu}(1+\beta)}{t_{eu}}\left(1-\frac{t_{eu}s(1-f)r}{1+(1-t_{eu})s(1-f)r}\right) && = 0 \\ F^2 &= -\frac{1+\beta}{1-t_{ch}} - \frac{\beta r}{1+(1-t_{ch})\,r} \\ &\quad + \frac{\psi_{ch}(1+\beta)}{t_{ch}}\left[1-\frac{T_{eu}}{g_{ch}}\right]\left(\frac{1}{t_{ch}}-\frac{sr}{1+s(1-t_{ch})r}\right) && = 0 \\ F^3 &= k - s\,(1-t_{eu}l_{eu}-t_{ch}l_{ch})\,(1-\alpha)\,k^{\alpha} && = 0 \end{aligned} \tag{14}$$

To use the implicit function theorem, we need to find the Jacobian of the system of equations. That is, we are looking for:

$$J = \frac{\partial \left(F^1, F^2, F^3\right)}{\partial \left(t_{eu}, t_{ch}, k\right)} = \begin{bmatrix} \frac{\partial F^1}{\partial t_{eu}} & \frac{\partial F^1}{\partial t_{ch}} & \frac{\partial F^1}{\partial k} \\ \frac{\partial F^2}{\partial t_{eu}} & \frac{\partial F^2}{\partial t_{ch}} & \frac{\partial F^2}{\partial k} \\ \frac{\partial F^3}{\partial t_{eu}} & \frac{\partial F^3}{\partial t_{ch}} & \frac{\partial F^3}{\partial k} \end{bmatrix}$$

We denote the generic element (i, j) of J by $j_{i,j}$. Since F^1 and F^2 describes situations where the respective governments have optimized the domestic tax-rate, it follows that the second order derivative with respect to the tax-rate will be negative. By the assumption that the country is small, changes in the domestic tax rate has no impact on the world aggregates and the derivative will equal the outer derivative of the F^1, so that

$$\begin{aligned} \frac{\partial F^1}{\partial t_{eu}} &< 0 \\ \frac{\partial F^2}{\partial t_{ch}} &< 0. \end{aligned} \tag{15}$$

Also, the tax rate of foreign countries have only indirect effects on the utility level, so that

$$\begin{aligned} \frac{\partial F^1}{\partial t_{ch}} &= 0 \\ \frac{\partial F^2}{\partial t_{eu}} &= 0. \end{aligned} \tag{16}$$

The derivatives of F^1 and F^2 with respect to the capital stock are the ones which are the most difficult to find. The capital stock enters both implicit functions through the wage and interest rate. Since both consumption aggregates, as well as the level of government expenditures are proportional to the wage rate, a change of the wage rate has no effect on any of the semi-elasticities. Accordingly, we only have to look on the interest rate channel. A glance at the semi-elasticities of (12) and (13) tells us that both of these are higher, the higher the interest rate is. This is quite intuitive, since for the old, only the interest income is taxed, while there is no taxation of their wealth. As a result, the higher the interest rate, the more elastic the consumption of the old reacts to it. Likewise, the adverse effect of tax rates on the tax-base is stronger the higher a proportion of the tax income comes from interest rates. Both effects goes in the same direction: a higher interest rate makes

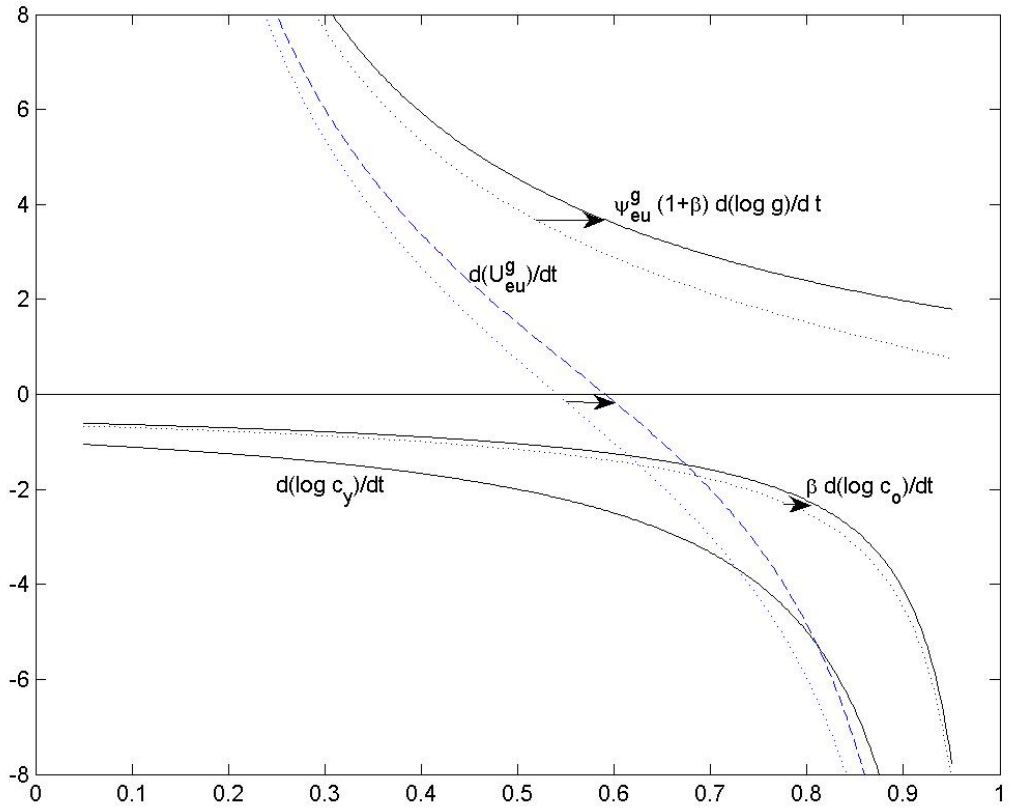

Figure 8: The impact of an exogenous increase in the capital stock.

the negative impact of tax hikes on log consumption of the old react stronger while diminishing its positive impact on log government expenditures.

Figure 7 links the above discussion graphically to the underlying optimization of the government. The lower interest rate that results from an increase in the aggregate capital stock makes log consumption for the old less responsive to changes in the interest, shifting the $\mathrm{d}(\log c_o)/\mathrm{d}t$ upwards, away from the abscissa. The result that taxes induce a smaller percentual decline in the tax-base is reflected by an upward (away from the abscissa) shift of the graph of $\psi_{eu}(1+\beta)\mathrm{d}(\log g)/\mathrm{d}t$. In aggregate, the upward shift of the two graphs also shifts the total sum upwards. As we can see from the figure, the new optimal tax rate after an exogenous increase in the capital stock is higher.

Applying the chain rule and using the fact that the equilibrium rental rate of capital is a negative function of the level of the capital stock, it follows

directly that

$$\frac{\partial F^1}{\partial k} = \frac{\partial F^1}{\partial r}\frac{\partial r}{\partial k} > 0. \tag{17}$$

The derivatives of the equation for the evolution of the capital stock with respect to both domestic tax rates are

$$\frac{\partial F^3}{\partial t_i} = -sl_i(1-\alpha)k^{\alpha} < 0, \tag{18}$$

since the average tax rate is monotonously increasing in the individual tax rates in each country. The last term that remains to be found is the derivative of steady state capital stock equation with respect to capital:

$$\frac{\partial F^3}{\partial k} = 1 - \alpha s\,(1-t)\,(1-\alpha)\,k^{\alpha-1} = 1 - \alpha > 0. \tag{19}$$

The last transformation follows directly from the fact that we can rearrange equation (6) as:

$$\alpha s\,(1-t)\,(1-\alpha)\,k^{\alpha-1} = 1.$$

From inequalities (15)–(19), we now know the sign of every element of the Jacobian matrix:

$$J = \begin{bmatrix} - & 0 & + \\ 0 & - & + \\ + & + & + \end{bmatrix}$$

It is now easy to show that the determinant of the Jacobian is positive. By a Laplace-expansion along the first row:

$$\left|J\right| = \sum_{j=1}^{3} j_{1,j}(-1)^{(1+j)}M_{1,j} = j_{1,1}M_{1,1} + j_{1,3}M_{1,3} > 0, \tag{20}$$

since

$$j_{1,1} < 0; \qquad M_{1,1} = \begin{vmatrix} - & + \\ + & + \end{vmatrix} < 0 \qquad \Rightarrow \qquad j_{1,1}M_{1,1} > 0$$

$$j_{1,3} > 0; \qquad M_{1,3} = \begin{vmatrix} 0 & - \\ + & + \end{vmatrix} > 0 \qquad \Rightarrow \qquad j_{1,3}M_{1,3} > 0$$

We'll now use the implicit function theorem to find how the tax rates are influenced by the fraction that *eu* nationals transfer abroad. To that end,

we first need to find the derivatives of the implicit functions with respect to this fraction:

$$\begin{aligned} F_f^1 &= \frac{\beta r\left[1+(1-t_f)r\right]}{\left(1+\left[1-(1-f)t_{eu}-ft_f\right]r\right)^2}+\frac{\psi_{eu}(1+\beta)t_{eu}sr}{(1+(1-t_{eu})s(1-f)r)^2}>0 \\ F_f^2 &= -\frac{\psi_{eu}(1+\beta)}{t_{ch}g_{ch}}\left(\frac{1}{t_{ch}}-\frac{sr}{1+s(1-t_{ch})r}\right)\frac{\partial T_{eu}}{\partial f}<0 \\ F_f^3 &= k-s\left(1-t_{eu}l_{eu}-t_{ch}l_{ch}\right)(1-\alpha)\,k^{\alpha}=0. \end{aligned} \tag{21}$$

Substituting the vector of derivatives with respect to f for the appropriate column of J, we can use Cramer's rule to find the effect of a change in the transferred fraction on the two tax rates as well as on the equilibrium capital stock. Denoting the matrix where the column i is replaced by the derivatives with respect to a generic variable x by $J_{i,x}$, the three derivatives are given by

$$|J_{1,f}|=\begin{vmatrix}- & 0 & +\\ + & - & +\\ 0 & + & +\end{vmatrix}>0 \qquad |J_{2,f}|=\begin{vmatrix}- & - & +\\ 0 & + & +\\ + & 0 & +\end{vmatrix}<0 \qquad |J_{3,f}|=\begin{vmatrix}- & 0 & -\\ 0 & - & +\\ + & + & 0\end{vmatrix}=?$$

By Cramer's rule, it follows that

$$\frac{\partial t_{eu}}{\partial f}=\frac{|J_{1,f}|}{|J|}>0 \quad \frac{\partial t_{ch}}{\partial f}=\frac{|J_{2,f}|}{|J|}<0. \tag{22}$$

That is, the more of their assets the *eu* citizens transfer to their off shore bank accounts, the higher their remaining income is taxed and the lower tax rate the *ch* citizens face. Since the sign of $|J_{3,f}|$ is indeterminate, we cannot say anything about the impact on the aggregate capital stock based on this analysis.

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