Public Debt Levels and Corruption in High-Income Economies

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Abstract
This paper proposes a possible explanation of different and positive government debt levels observed in developed economies. It builds a simple model that relates the level of government debt to the degree of corruptness of the public officials in the country, using neoclassical economy framework with discretionary and non-benevolent government. Public corruption results in higher public debt levels in the steady state. The model reproduces about 76% of debt-to-GDP levels in a sample of advanced OECD countries as a function of the measure of public corruption in these countries. In the empirical part of the paper the assumptions and predictions of the model are tested in a panel of OECD member states.

Keywords: optimal public debt; corruption; time-consistent fiscal policy; Markov-perfect equilibrium.

JEL Classification Numbers: E61, E62, H21, H63.

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1 Introduction

This paper proposes to explain public debt levels observed in advanced economies by existence of corruption among the governmental officials of these economies. This conjecture is incorporated in a simple model featuring a partially benevolent government which operates in a time-consistent manner and expropriates a part of budget revenues while conducting otherwise optimal fiscal policy. The model explains on average 76% of the debt to GDP levels in a sample of 19 high-income countries, given the measure of public corruption in these countries. Empirical analysis based on the panel data for 23 most advanced members of OECD supports the claim that public corruption is a positive and significant determinant of high public debt to GDP shares in high-income economies.

According to the literature, some amount of positive debt level can be preferable to a balanced budget for essentially two reasons. The first is the so-called fluctuations-smoothing role of public debt, as defined and empirically supported by Barro (1979). The second is the wealth-redistributive role of public debt, as explained, for example, in Cukierman and Meltzer (1989). The wealth-redistributive role of debt may be at odds with the dynamics of falling population levels and growing debt-to-GDP levels observed in developed economies. The tax-smoothing optimal fiscal policy under the benevolent government leads to the long-run optimal debt level being zero (Debortoli and Nunes, 2008), or, in stochastic setup, fluctuating around zero, or even tending to large negative values (Aiyagari, Marcet, Sargent and Seppala, 2002). The question why the most advanced countries in the world hold positive, different, and sometimes quite large public debt levels still remains insufficiently investigated (see Alesina and Perotti (1994) for a critical survey of the related literature).

There is a long going debate about the alternative measures to preclude growing public indebtedness. Some economists have pointed out, that these debates may become by themselves the source of inefficient debt accumulation. Alesina and Tabellini (1990) and Persson and Svensson (1989) developed a positive debt theory, stating that high public debts exist only because of impossibility of consensus among the ruling politicians. There

\[1\] Unless some friction is added, such as a debt transaction cost as in Kumhof and Yakadina (2006), or the government is induced to operate more that one asset in the time-consistent way, as in Martin (2007) or in Ortigueira and Pereira (2009).
is a little evidence that the political elite noticeably reacted on the theory of Alesina, Tabellini, Persson and Svensson. Instead, since then many econometricians test the significance of political disagreement as an inevitable component of fiscal policy imperfections. However, the empirical studies do not share the same conclusions in favor or against the existence of influence of political factors on the fiscal policy outcomes.

The underlying idea of the political disagreement theory of large and different public debts assumes different preferences of partisan politicians to the allocation of public goods, and is difficult to test in practice. For instance, Roubini and Sachs (1989) find empirical support of political management problems and a frequent political turnover as predictors of public debt overaccumulation. Their results have been doubted by de Haan and Sturm (1997) who reestimate the extended Roubini and Sachs' dataset with the corrected political dispersion measures and do not find any relation of that measure to public debt or deficits in the OECD. The strategic use of public funds as theorized by Alesina and Tabellini (1990) was tested by Lambertini (2003). She concluded that there is a little evidence that public debt is used strategically. Also, Woo (2003) analyses a large panel of the developed and developing countries and claims that the institutions and social polarization together with the typical characteristics of the government (size, fragmentation) constitute the robust determinants of public deficits.

To get some raw evidence about the political disagreement effect on fiscal policy, I looked at the composition of government expenditures for high-income countries generally considered as politically unstable (e.g., Italy, Belgium). The time-series of public expenditures, when decomposed by function, do not show significant fluctuations in composition over time (see appendix A), implying either that the political incumbents and their opponents do not significantly differ in the preferences for public policy, or that these differences exist but do not result in the observable actions. That is, the political factor influence might be hidden in something, that is not reflected directly in the traditional public budget items.

This paper tries to capture the "hidden item", which affects public debt accumulation in developed economies, by means of accounting for public corruption levels in these economies. Public corruption is usually defined as "misuse of public office for private gain" (Alt and Lassen, 2010). It has been commonly considered as an innate characteristic
of developing world; however, the traditional corruption perception indices assign a no corruption grade to no country in the world (see, for example, Transparency International Reports, various years). While not so severe in developed as in developing countries, public corruption can still have a crucial negative influence on the countries’ economic performance, in particular, on government debt levels.

This work broadly defines by corruption all inefficiencies prevailing in the public governance of the country, that result in the usage of public funds for the goals different from those, aimed to improve the representative citizen’s welfare. It is not intended to claim that governmental officials directly expropriate public funds. However, they can do it indirectly, through legislative support of their political parties, the choice of sellers in the tenders for government purchases, the power to set own salaries and benefits and regulate self-protection and the protection of the families of representatives of the public authorities. The distorting effect of taxation may make it unaffordable for the government to keep deficit levels low by ways of increased income taxes. Thus, the inefficiently large government expenditures may result in higher than optimal public debt levels.

In the empirical part of the paper, the effect of public corruption on public debt shares is tested in a panel of 23 OECD member states for years 1995-2007. The Transparency International Index of public corruption and, for robustness check, the World Bank index of public corruption, constitute the measure of corruption used in the estimation. Additionally, the estimation includes the variables reflecting the political instability measure (the number of cabinet changes in a year), and political disagreement measure (an index of political polarization). The results reported from the dynamic panel model support the hypothesis that public corruption constitutes an economically and statistically significant determinant of public debt accumulation. The political instability variable is not significant, but has an expected sign in the majority of specifications; the political disagreement variable turns out to be insignificant and with the opposite of the expected sign in all specifications.

From the theoretical side, this work takes a stand that all authorities care about the same quantity and quality of public good, regardless of to which party they belong. Instead, this paper suggests, that all government officials are corrupted to some extent, and thus overaccumulate public debt holdings in favor of private rent extraction. Another
crucial viewpoint of this work is that full commitment is not quite realistic description of the government’s behavior, therefore, the government is allowed to reoptimize on its fiscal plan whenever it is optimal to do so.

The model features a neoclassical economy with the government able to run unbalanced budget, as considered by Ortigueira and Pereira (2009). The existence of public corruption among the authorities is incorporated by assumption that the government is only partially benevolent. Similar to the political disagreement literature, the model considers a discretionary government that cannot commit to the issues of government debt. The government is assumed to repay the debt outstanding from the previous period, and to commit within a period to the tax rate announced in the current period. Differently from the previous political disagreement literature, the economy is also endowed by physical capital (this insures positive debt level in the steady state even in the absence of public corruption), and the objectives of the competing parties about the composition and/or quantity of public good do not differ. The strategic complementarity makes all competing parties equally corrupted, and in equilibrium the country is characterized by some stationary level of public corruption and public debt. It is assumed that the degree of corruption is exogenous. Furthermore, similar to Kumhof and Yakadina (2006), the effect of the government’s planning horizon is considered in the extensions.

The model considered in this paper delivers stationary public debt levels (for empirical support see Bohn, 1998). That is, the effect of temporary shocks such as for example, financial crises, reelects, temporary shocks to TFP, public expenditures, and public corruption, do not have the effect on public debt-to-GDP shares in the long run.

The rest of the paper is organized as follows. Section 2 proposes some empirical evidence about the influence of corruption on level of public debt in the panel of advanced OECD economies. Section 3 builds a theoretical model consistent with the empirical facts listed in section 2. Section 4 attempts to use the model developed in section 3 to replicate debt-to-GDP ratios in a sample of OECD countries. Section 5 extends the model to existence of aggregate uncertainty. Section 6 concludes.
2 Empirical Evidence

This section analyzes the validity of the following statement: public debt of developed
country is the higher, the higher the level of public corruption, and the higher the level
of political instability in this country.

Here several notes are in order. First, this statement may not hold for developing or
emerging economies, where political instability and corruption may be transitional, the
fiscal policy is not stable, and government debt is heavily affected by the international
supervising organizations and borrowing constraints\(^2\). Therefore, the analysis here and
in the rest of the paper is concentrated only on developed countries, characterized by
economic conditions close to or on the steady state growth path.

Second, the aim of this section is to give some basic evidence of the importance of
public corruption for public debt accumulation. I examine the effect of corruption on
public debt shares in the economy, in the scope of traditional models of government debt
or deficit determination, by the traditional estimation techniques that take some possible
endogeneity issues into account. The analysis is restricted to the determination and
robustness check of positiveness and significance of public corruption influence on real
public debt levels, and is not intended to evaluate precise coefficients, as long as these
coefficients are statistically significant\(^3\).

Third, public corruption is considered as an exogenous variable throughout the pa-
per. Differently from the clearly mutual causation of public corruption-economic growth
relationship\(^4\), public corruption-public debt mechanism works more probably in one direc-
tion, except of possible indirect influence on both variables through the economic growth.
Estimation of the considered regressions controlling for endogeneity of public corruption
does not change the results reported in this section. The exogeneity assumption simpli-
fies significantly the theoretical framework, and, for consistency, is kept in the empirical
analysis.

Finally, I follow Barro (1979), Roubini and Sachs (1989) and others, assuming the

\(^2\) The factors influencing the quantity and composition of the government debts in the developing
countries (including corruption) was studied for example by Guscina (2008), and Alesina, Campante and

\(^3\) The public corruption indices represent the ordinal measures; therefore, I do not intent to evaluate
the magnitude of the effect of change in public corruption on the public debt.

\(^4\) As studied by Mauro (1995).
tax-smoothing optimizing approach to fiscal deficit. This assumption is maintained in the theoretical section, where I try to build a model accounting for the dependence of public debt on public corruption measures.

Brief examination of possible relationship between public debt and the Transparency International index of corruption (scaling from 10 - no public corruption to 0 - complete public corruption) for a sample of European countries is presented in the Figure 1 below. One can observe that the countries characterized by higher corruption level have on average higher public debt to GDP ratios.

![Figure 1. Central government debt levels and Corruption Perception Index (higher values mean less corruption), for a sample of EU countries. Source: OECD and Transparency International.](image)

For the formal empirical estimation I use the logic outlined already, for example, in Roubini and Sachs (1989) and Bohn (1998). Consider traditional budget constraint of the government:

\[ B_{t+1} = G_t - T_t + (1 + R_{t+1})B_t, \]  

where \( B_t \) is government debt in period \( t \), \( G_{t-1} \) represent total public expenditures in the previous period, \( T_{t-1} \) - total government revenues in the previous period, and \( 1 + R_t \) - a gross interest rate on government debt in period \( t \).
This budget constraint may be rewritten with all the variables expressed as the shares of GDP (this eliminates the need for accounting for inflation, and corrects for clear non-stationarity of the original variables):

\[
\frac{B_{t+1}}{Y_{t+1}} = \frac{G_t}{Y_t} + \left(1 + \frac{R_{t+1}}{Y_{t+1}} - \frac{Y_{t+1}}{Y_t}\right) \frac{B_t}{Y_t}.
\]  
(2)

If the fiscal policymaking obeys the tax-smoothing theory, then the fluctuations in government debt may be provoked by: changes in economic growth rate, changes in the interest rate on previously accumulated debt, or changes in temporary government expenditures, as reflected in the unemployment indicators. The fiscal policy pattern may deviate from the optimal one expressed by the equation (2) because of political factors influence, and, according to this study, the presence of public corruption.

I estimate the following model (in line with Roubini and Sachs (1989), de Haan and Sturm (1997), augmented by the presence of corruption variable):

\[
DBY_{i,t} = a_0 + a_1 DBY_{i,t-1} + a_2 DU_{i,t} + a_3 DDY_{i,t} + a_4 DRB_{i,t} + a_5 PI_{i,t} + a_6 PP_{i,t} + a_7 COR_{i,t},
\]  
(3)

where \(DBY\) denotes public deficit as a share of GDP, calculated as a change in government debt to GDP ratio, \(DU\) is the change in unemployment rate, \(DDY\) is the change in the growth rate of GDP, and \(DRB\) is the change in the debt service cost, calculated as a change in (nominal interest rate rate of inflation) multiplied by debt in the previous period. The additional variables include \(PI\) - the measure of political instability, \(PP\) - the measure of political polarization, and \(COR\) - the measure of public corruption in the country. The indices \(i\) and \(t\) denote correspondingly a country and a time period from the pooled cross-section-time-series dataset.

The specification (3) allows for different intercepts across countries units \(a_{0i}\), but assumes the time-invariant countries’ fixed effects and same slopes \(a_j, j = 1,..7\) across countries in the sample (dynamic homogeneity)\(^5\).

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\(^5\) I tested for possible dynamic heterogeneity (which if present, would bring inconsistent GMM and first difference estimates) using F test, as explained for example in Canova (2007, pp. 288-325). F-statistics comparing \(R^2\)s for restricted regression (3) vs unrestricted regression, formed by cross-products of all explanatory variables in (3) with dummies for cross-section units (countries), \(F = \frac{(R^2_u - R^2_r)}{(1-R^2_u)/(N_T-n_2)}\) was equal to 0.71, with \(n_2 = Nk, n_2 = k, k\) -number of regressors in (3). This preliminary test suggests
Furthermore, I evaluate the effect of corruption on the level of public debt in the dynamic setup by the model of the form:

\[ BY_{i,t} = \beta_1 BY_{i,t-1} + \beta_2 U_{i,t} + \beta_3 DY_{i,t} + \beta_4 RB_{i,t} + \beta_5 PI_{i,t} + \beta_6 PP_{i,t} + \beta_7 COR_{i,t}, \quad (4) \]

where \( BY \) is central government debt to GDP ratio, \( U \) is unemployment rate, \( DY \) - GDP growth, and \( RB \) - calculated debt service cost.

Given the dynamic and panel structure of the models (3) and (4), I use the Arellano-Bond linear dynamic panel-data estimator (see for example, Cameron and Trivedi (2009, pp. 763-768), Kennedy (2008, pp.281-296) for inference), which eliminates the countries’ fixed effect by first differencing, and then deals with endogenous lagged dependent variable by applying the appropriate set of the instruments.

The instruments include the lagged values of the dependent and explanatory variables, and are chosen so that possible endogeneity of some of the regressors (such as unemployment rate and political factors) is taken into account. Arellano-Bond linear dynamic panel-data estimator deliver consistent estimates if the errors are serially uncorrelated. The results discussed below confirm validity of the estimator applied in the scope of the considered model.

2.1 Data

I take the annual central government debt to GDP ratio as a measure of public debt of the country, available from OECD dataset. The annual unemployment rates, nominal interest rates, interest paid on debt are taken from OECD database as well. The GDP growth rates are calculated given the real GDP taken from the Penn World Tables. As a proxy of political instability I consider the number of mayor cabinet changes from the Pippa Norris dataset. The measure of political polarization in reported by The Quality of Government Dataset Codebook 2010. Inflation rate, as calculated by the World Development Indicators, was taken from The Quality of Government Dataset Codebook 2010.

that null hypothesis of equality of the coefficients over the cross section cannot be rejected (Canova, 2007). Given the nonstandard distribution of \( F \)-ratio in this case, and its weak efficiency compared with other estimators, the conclusions of this pre-test should be considered with precaution.
There are several commonly used datasets on the measures of public corruption\textsuperscript{6}. As was concluded by Alesina, Campante and Tabellini (2008), all of them are highly correlated and persistent, therefore it is not principal which measure to use. I will rely on the Corruption Perception Index from the Transparency International reports, available for years 1995-2009. This index measures the overall extent of corruption (frequency and/or size of bribes) in the \textit{public and political} sectors and thus represent the measure exactly of the variable which I need for the support of the government corruption-government debt hypothesis. For the robustness test I also reestimate the model with the alternative measure of public corruption, calculated by the World Bank and available in The Quality of Government Dataset Codebook 2010. The conclusions are not affected by the change of the corruption variable\textsuperscript{7}.

For the choice of the countries to be included in the estimation sample some criteria is needed. I select the most developed countries in the world, for which all the necessary data is available. As a criteria I use the list of \textit{Development Assistance Committee members} which includes 23 most advanced countries\textsuperscript{8}. The countries considered are listed in the appendix A.

Therefore, the panel data includes in total 23 countries over years 1995-2007 (for earlier dates corruption indices are not available).

The detail description of the data is given in appendix A; summary statistics is given in the Table A.1. in the appendix A.

\subsection*{2.2 Results}

The results for fixed-effect Arellano-Bond estimates for change in debt and level of debt dependent variables are presented in the Table 1. In all specifications corruption measures (either the one calculated by Transparency International or the one calculated by the World Bank) are significant and influence debt accumulation in the expected direction.

\textsuperscript{6}Such as ICRG, Control of Corruption index from Kaufman, Kraay and Mastruzzi’s (2005), Corruption Perception Index from Transparency International, etc.

\textsuperscript{7}Appendix A describes in detail the political disagreement and corruption measures used in the estimation, as well as some alternative proxies for these variables; the correlation between the different measures of political disagreement is about 65%, and between the different measures of public corruption about 95%.

\textsuperscript{8}Development Assistance Committee members is a group of the world’s major donor countries that discuss issues surrounding development aid and poverty reduction in developing countries (Wikipedia).
Table 1: Estimation Results, Dependent variables: Change in public debt to GDP ratio; Debt to GDP ratio

<table>
<thead>
<tr>
<th>Dependent: D.DEBT</th>
<th>GMM (1)</th>
<th>GMM (2)</th>
<th>Dependent: DEBT</th>
<th>GMM(3)</th>
<th>GMM(4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>L.D.DEBT</td>
<td>.321**</td>
<td>.341**</td>
<td>L.DEBT</td>
<td>.910**</td>
<td>.753**</td>
</tr>
<tr>
<td></td>
<td>(.066)</td>
<td>(.083)</td>
<td></td>
<td>(.032)</td>
<td>(.034)</td>
</tr>
<tr>
<td>D.GDP growth</td>
<td>-.182**</td>
<td>-.207**</td>
<td>GDP growth</td>
<td>-.502**</td>
<td>-.611**</td>
</tr>
<tr>
<td></td>
<td>(.079)</td>
<td>(.069)</td>
<td></td>
<td>(.117)</td>
<td>(.182)</td>
</tr>
<tr>
<td>D.Unemployment</td>
<td>.987**</td>
<td>.856**</td>
<td>Unemployment</td>
<td>.547**</td>
<td>.827**</td>
</tr>
<tr>
<td></td>
<td>(.153)</td>
<td>(.181)</td>
<td></td>
<td>(.133)</td>
<td>(.228)</td>
</tr>
<tr>
<td>D.RDEBT</td>
<td>.341**</td>
<td>.288*</td>
<td>RDEBT</td>
<td>.295</td>
<td>1.205**</td>
</tr>
<tr>
<td></td>
<td>(.147)</td>
<td>(.156)</td>
<td></td>
<td>(.233)</td>
<td>(.290)</td>
</tr>
<tr>
<td>Corruption</td>
<td>-.1.016**</td>
<td>-.932**</td>
<td>Corruption</td>
<td>-.486**</td>
<td>-3.843**</td>
</tr>
<tr>
<td></td>
<td>(.373)</td>
<td>(.424)</td>
<td></td>
<td>(.245)</td>
<td>(1.541)</td>
</tr>
<tr>
<td>Polit instability</td>
<td>.310</td>
<td></td>
<td>Polit instability</td>
<td>.131</td>
<td>.320</td>
</tr>
<tr>
<td></td>
<td>(.404)</td>
<td></td>
<td></td>
<td>(.429)</td>
<td>(.385)</td>
</tr>
<tr>
<td>Polit polarization</td>
<td>-.235</td>
<td></td>
<td>Polit polarization</td>
<td>-.477</td>
<td>-2.64</td>
</tr>
<tr>
<td></td>
<td>(.300)</td>
<td></td>
<td></td>
<td>(.289)</td>
<td>(.307)</td>
</tr>
</tbody>
</table>

N Observations 245 211 N Observations 197 82
Wald -test 189.17 188.69 Wald -test 4091.45 3121.08
Sargan test, Pr > chi2 0.6413 0.5848 Sargan test, Pr > chi2 0.0457 0.6569
Errors autocorr, ord1 0.0021 0.0021 Errors autocorr, ord1 0.0212 0.1041
Errors autocorr, ord2 0.8618 0.8993 Errors autocorr, ord2 0.5185 0.2849

The estimation technic: Arellano-Bond dynamic panel-data estimation; GMM (1),(2),(3) use public corruption index from the Transparency International Reports; GMM(4) uses the measure of public corruption from the World bank; the reported errors are from robust estimation; ** = significant at the 5% significance level, * = significant at the 10% significance level.

That is, the higher public corruption in the country, the higher is public debt in that country, other things being equal. Note, however, that the same cannot be said about the political instability and political polarization variables. Both turn out to be insignificant in all model specifications. This result is in accordance with de Haan and Sturm (1997), who found that government debt is not related to the political power dispersion index. Moreover, the political polarization coefficient has a negative sign, which is contrary to the hypothesis that higher political polarization increases the public debt levels.

The political instability, however, has an expected sign. This is in accordance with the theory developed here, that the political instability and political corruption are the two mutually enhancing outcomes, and does not imply that the political authorities disagree about some aspect of the public policy.

Therefore, it can be concluded, that there exists some evidence in favor of the hypothesis that political corruption defines suboptimally high government debt levels. The next
section builds a simple model based on this hypothesis and consistent with the empirical evidence presented above.

3 The Model

This section develops a simple theoretical model consistent with the empirical facts reported in the section above. The model features traditional approach to the optimal fiscal policy: the economy consists of the government and identical households; the households consume and save in the form of financial (government bonds) and physical (capital) assets; the function of the government is to tax households optimally and to use tax revenues and possibly debt issues to optimally provide public goods. The government is discretionary. It is not able to follow a fiscal plan developed for a long period of time; instead, it optimally deviates from that plan whenever it is beneficial to do so (every period). This paper restricts analysis only to the set of Markov perfect equilibria. The main justification to exclude the complete set of the sustainable equilibria from the consideration are the following: 1 - reputation mechanisms in the same way as commitment may not be accessible by the government (argument from Klein and Rios-Rull, 2003); 2 - the Markov strategies prescribe the simplest form of behavior that is consistent with rationality (argument from Maskin and Tirol, 2002). I consider the simplest possible sequence of events in every period: the government and households simultaneously make their choices about the variables which they can control.

To incorporate public corruption, I make the following assumptions (in line with the claims about the empirical facts discussed above):

- The government is not benevolent. It cares about the utility of the households, but also wants to maximize its utility while being in the power.

- All authorities that may be elected in the given country are equally corrupted.

- The level of corruption is exogenously given.

\textsuperscript{9}Alternative sequence of events, when the government acts as a Stalcelberg leader, results in the same qualitative conclusions.
The corruption is modelled as a choice by the government of some part of the economy’s output for its own consumption. The weight the government imposes on the expropriated consumption depends on the degree of the public corruptness of the country, and is given exogenously. Similarly, the weight on the traditional public consumption, and the total factor productivity are exogeously given and may differ across countries. These three parameters will be calibrated given the data on the advanced OECD economies, and the model outcomes be compared with the actual debt levels observed in the developed world. The performance of the model is discussed in the next section.

Below, the structure of the economy and the decisions of economic agents are described in more detail.

The problem of the households given the policy of the government

The households are identical, they live infinite periods of time, consume every time period, save in the form of financial and physical assets, and supply labor inelastically. Aggregate labor is normalized to $1^{10}$. The households are indifferent between the two forms of assets because the no arbitrage condition equating the rates of return holds in this economy. The optimization problem of a representative household, given the expected fiscal policy of the government, as reflected in income taxes $\tau$, government expenditures $g$, and issues of government bonds $b$, and given the aggregate stock of physical capital $k$, may be written in a recursive form as follows:

\[
v(a, k, b) = \max_{c,a'} \{ u(c, g) + \beta v(a', k', b') \}
\]

\[
s.t.
\]

\[
c + a' = a + (1 - \tau)(w(k) + R(k)a),
\]

\[
k' = H(k, b, b', \tau),
\]

\[
b' = B(k, b),
\]

\[
\tau = \Upsilon(k, b),
\]

\[
(5)
\]

(6)

(7)

(8)

\footnotesize{\textsuperscript{10}}This model disregards possible influence of growing population on debt levels, as modelled in Diamond (1965). Figure A4 in Appendix A shows that there is little evidence that changes in public debt depend on population growth in OECD countries.
Where \( c \) denotes private consumption of a representative household, \( a \) and \( a' \)- it’s current and next period level of assets consisting of private capital and government debt holdings, \( R(k) \) - gross return on assets and \( w(k) \) - wage rate of a representative household; \( \beta \) is a discount factor. The policy of the government is expected to be conducted according to \( \Upsilon(k, b), G(k, b, b', \tau) = \hat{g} \), and \( B(k, b) \), the aggregate stock of physical capital is expected to evolve according to \( H(k, b, b', \tau) \). In equilibrium, all expected functions coincide with the actually implemented ones.

The instantaneous utility function of the households \( u(c, g) \) is assumed to satisfy the concavity and Inada conditions.

The first-order condition combined with Envelope condition at an interior solution of the households’s problem dictates:

\[-u_c + \beta u'_c(1 + (1 - \tau')R(k')) = 0.\] (9)

Let \( c = C(a, k, b) \), and \( a' = A(a, k, b) \) denote the solution to (5).

The problem of the competitive firms is static:

\[\max_{k,l} f(k, l) - wl - rk - \delta k\] (10)

\[\text{f.o.c. : } r(k) = f_k(k) - \delta, w(k) = f(k) - f_k(k)k.\]

The no arbitrage condition requires equalization of returns to physical and financial assets. Therefore

\[R(k) = r(k) = f_k(k) - \delta.\] (11)

The problem of the government

The government is partially benevolent in the sense that it aims to maximize utility of the households. However, it is also corrupted in the sense that it aims to maximize its utility while being in the power. The maximization problem of the government combines both objectives:
\[ U(c, g, \hat{g}) = u(c, g) + \gamma \hat{u}(\hat{g}), \]  
(12)

where \( \gamma \) reflects the degree of corruptness of the government. The total government expenditures are split between those going to the public, and those expropriated by the public officials (and unobserved by the public):

\[ G = g + \hat{g}. \]  
(13)

The problem of the government is to set the income taxes and issue public debt optimally, taking as given the household’s consumption function, the law of motion of the aggregate capital stock of the economy, and the policy of future governments.

The government budget constraint is:

\[ G = \tau(w(k) + r(k)(k + b)) + b' - (1 + r(k))b. \]  
(14)

The aggregate resource constraint of the economy is:

\[ k' + G + c = f(k) + (1 - \delta)k. \]  
(15)

**Definition:**

A recursive economic equilibrium for government policy rules \( \{\tau, \hat{g}, b'\} \), is a set of functions \( \{v(a, k, b), H(k, b, b', \tau), G(k, b, b', \tau), C(a, k, b), A(a, k, b)\} \) such that

1. Functions \( \{v(a, k, b), C(a, k, b), A(a, k, b)\} \) solve the household’s problem (5) given functions \( \{H(k, b, b', \tau), G(k, b, b', \tau), \tau, \hat{g}, b'\} \).

2. Assets market clears: \( A(a, k, b) = H(k, b, b') + b' \) - the asset portfolio of the representative household in every period consists of the physical capital available in the economy and the government bonds.

3. Government budget constraint is satisfied: \( G(k, b, b', \tau) = \tau(w(k) + r(k)(k + b)) + b' - (1 + r(k))b. \)

Note that now private consumption may be equivalently rewritten as a function of aggregate physical capital and public debt only: \( C(k, b) \), and the latter notation will be used in the rest of the paper.

Further discussion will be concentrated more on the problem of the government.
3.1 Markov-perfect equilibrium

The problem of the government is to choose the income taxes and the government debt issues given the expected reaction of households, captured by their choice of the private consumption, and given the evolution of the aggregate capital stock of the economy:

\[ V(k, b) = \max_{g, b'} \left\{ U(c, g, \hat{g}) + \beta V(k', b') \right\} \]

\[ s.t. \]

\[ k' = k + b + (1 - \tau)(f(k) - \delta k + r(k)b) - b' - C(k, b), \]

\[ G = \tau(f(k) - \delta k + r(k)b) + b' - (1 + r(k))b, \]

\[ G = g + \hat{g}. \]

Under the notion of Markov perfect equilibrium the policy of the government depends only on the current states of the economy, which are \( b \) and \( k \). The policy functions of the government in equilibrium will be those expected by the households:

\[ b' = B(k, b), \tau = \Upsilon(k, b), \]

From the government and feasibility constraints of the economy define the aggregate savings and public consumption functions:

\[ H(k, b, b', \tau) = k + b + (1 - \tau)(f(k) - \delta k + r(k)b) - b' - C(k, b). \]

\[ G(k, b, b', \tau) = \tau(f(k) - \delta k + r(k)b) + b' - (1 + r(k))b, \]

Given the households’ consumption function \( C(k, b) \), as defined by the household’s optimality condition (9), the problem of the government can be formulated recursively:

\[ \{ B(k, b), \Upsilon(k, b), \hat{G}(k, b) \} \in \arg\max_{b', \tau, \hat{g}} U(C(k, b), G(k, b, b', \tau) - \hat{g}, \hat{g}) \]

\[ + \beta V(H(k, b, b', \tau), b'). \]

In this study I will concentrate only on the differentiable Markov perfect equilibria.

**Definition:**
An interior differentiable Markov perfect equilibrium is a value function $V$, and differentiable policy functions $B, \Upsilon, \hat{G}$, such that

1. For all $k$ and $b$, policy functions solve the government maximization problem,

$$\{B(k, b), \Upsilon(k, b), \hat{G}(k, b)\} \in \text{argmax}_{\nu, \tau, \hat{g}} U(C(k, b), G(k, b', \tau) - \hat{g}, \hat{y})$$

$$+ \beta V(H(k, b, b', \tau), b'),$$

where

$$G(k, b, b', \tau) = \tau (f(k) - \delta k + r(k)b) + b' - (1 + r(k))b,$$

$$H(k, b, b', \tau) = k + b + (1 - \tau)f(k) - \delta k + r(k)b - b' - C(k, b).$$

2. For all $k$, and $b$, the first order condition of household’s problem is satisfied,

$$u_c(C(k, b)) \equiv \beta u_c(C(H(k, b, B(k, b), \Upsilon(k, b)), B(k, b))$$

$$(1 + (1 - \Upsilon(H(k, b, B(k, b), \Upsilon(k, b)), B(k, b)))(f(k)(H(k, b, B(k, b), \Upsilon(k, b))) - \delta),$$

3. For all $k$ and $b$, value function satisfy the functional equation:

$$V(k, b) = U(C(k, b), G(k, b, B(k, b), \Upsilon(k, b)) - \hat{G}(k, b), \hat{G}(k, b)) +$$

$$\beta V(H(k, b, B(k, b)), B(k, b)).$$

The alternative way of defining equilibrium, when the government problem is solved subject to the first-order conditions of the household problem, is given in appendix B.

The Optimality Conditions (see derivations in appendix C):

the Generalized Euler Equations:

$$U_g = \beta [U'_c C'_k + U'_g G'_k + U'_g (1 + f'_k - \delta - C'_k - G'_k)],$$

$$U_y = U_y + \beta [U'_c - U'_g] C'_y.$$
where

\[ G'_k = \tau(b', k')(f_{k'} - \delta + r_k(k')b') - r_k(k')b' + \tau_k(b', k')(f(k') - \delta k' + r(k')b'), \]

and the equalities that must be satisfied at optimum:

\[
u_c(c(b, k)) = \beta u'_c(c(b', k'))[1 + (1 - \tau(b', k'))(f_k(k') - \delta)],
\]

\[ k' = (1 - \delta)k + f(k) - C(k, b) - G, \]

\[ G = \tau(k, b)(f(k) - \delta k + r(k)b) + b'(k, b) - (1 + r(k))b, \]

\[ G = g + \dot{g}, \quad r(k) = f_k(k) - \delta. \]

The Generalized Euler Equations (25) have the following interpretation: the first one sets optimal taxes to equate the marginal value of raised public spending through the increased taxation to the marginal value of investing in physical capital. The second one sets public debt issues to equate the marginal value of increase in public debt level to the marginal value of increase in taxes.

The equations (25) and (26) characterize the politico-economic equilibrium for this economy, and can be used to solve for unknown policy functions. The solution method and equilibrium outcomes are discussed in the section 4.

### 3.2 Steady States

From the optimality conditions, and given the results of numerical computations, the availability of two stable steady states arises in the infinite horizon economy model: the one without distortionary taxation and with positive holdings of large government assets (when \( u_c = u_g \)) - the solution identical to the outcome of the corresponding Ramsey problem in the full commitment case; and the one with positive government debt and income taxes in equilibrium (when \( C_b = 0 \)). Taking into account that positive taxes and debt levels is a more realistic description of the current fiscal policy of the majority of the countries in the world, the subsequent analysis is only concentrated on the second steady state, with distortionary taxation. This steady state cannot be obtained from the corresponding Ramsey problem with the government functioning under the full commitment.
4 Debt Levels and Corruption

This section will use the model developed above to examine the relationship between the debt and corruption levels in the countries characterized by the (near) steady state growth path. To facilitate further discussion, I will now impose a particular form on the utility function, as well as define the technology.

Consider the utility function of the government of the CES form\textsuperscript{11}:

\begin{equation}
U(c, g, \hat{g}) = \ln(c) + \varphi \ln(g) + \tilde{\gamma} \ln(\hat{g})
\end{equation}

The weights $\varphi$ and $\tilde{\gamma}$ on public and expropriated public consumption can be calibrated given the data for a particular country.

The technology is Cobb-Douglas:

\begin{equation}
y = Ak^a,
\end{equation}

where $A$ is a "TFP" parameter, that can be normalized to match the output in the particular country.

4.1 The Interaction between Public Consumption and Expropriated public Expenditures

Given the utility form $U(c, g, \hat{g}) = u(c, g) + \tilde{\gamma}u(\hat{g})$, and the condition $G = g + \hat{g}$, the optimal allocation of $g$ and $\hat{g}$ on the part of the government requires:

\begin{equation}
U_g = U_{\hat{g}}.
\end{equation}

For the functional form considered in this paper, the equality of marginal utility of public vs expropriated consumption means:

\begin{equation}
\varphi g^{-1} = \tilde{\gamma} \hat{g}^{-1},
\end{equation}

\begin{equation}
G = g + \hat{g}
\end{equation}

\textsuperscript{11}Utility functions, separable in all arguments, give quantitatively similar results for elasticities of $c, g, \hat{g}$ different from 1.
\[
\left( \frac{\bar{\gamma}}{\varphi} \right) g = \hat{g},
\]
\[
G = \frac{\varphi + \bar{\gamma}}{\varphi} g.
\]
\[
g = \frac{\varphi}{\varphi + \bar{\gamma}} G, \hat{g} = \frac{\bar{\gamma}}{\varphi + \bar{\gamma}} G.
\]

Denote:
\[
\Gamma = \frac{\varphi + \bar{\gamma}}{\varphi}
\]

then
\[
U_g = \frac{\Gamma}{G} = U_{\hat{g}} = \frac{\Gamma - 1}{G}.
\]

The total government expenditures are split proportionally between spending enhancing social utility and spending expropriated by the corrupted government. Higher degree of corruption $\bar{\gamma}$ leads to less public goods available for household.

4.2 The Effect of Corruption

Under a mild assumption which holds for a wide range of calibration parameters, the effect of the level of corruption $\bar{\gamma}$ on the steady state with distortionary taxation may be characterized by the proposition 1 stated below.

Assumption 1. assume that $C_k > f_k - \delta$, or, equivalently, $G_k > 0$.

This assumption insures that increase in aggregate capital has positive net effect (due to increase in tax base minus drop in taxes due to higher capital) on public spending.

Lemma 1. Under assumption 1, $1 - \beta(1 + f_k - \delta) + \beta C_k > 0$, $1 - \beta(1 + f_k - \delta) < 0$.

Proof: Comes from the Euler equation of the household, evaluated at the steady state with distortionary income taxation, under assumption 1.

Proposition 1: Given government policy, at the steady state with positive income taxes,
\[
k_\gamma < 0, c_\gamma < 0, \tau_\gamma > 0, \text{G}_\gamma > 0, b_\gamma > 0.
\]
Proof: is relegated to appendix C.

That is, the higher is the level of public corruption, the lower is the economy’s capital, output and private consumption, and the higher is the level of public debt, expenditures and income taxes.

The intuition behind this result is quite simple. Suppose at some period $t$ the economy is hit by the permanent rise in public corruption level. In the considered model this means the government would start spending more on public (and expropriated public) goods. Given the state of the economy, Markov strategy of the government would require increase in newly issued debt to satisfy budget constraint with higher expenditure part. From the feasibility constraint of the economy, higher public spending would crowd out investment, and thus decrease capital stock and output next period. Next period lower output would lead to lower private consumption. In the new steady state income taxes would be higher, as a function of new and lower aggregate capital.

Given that the model predicts positive influence of public corruption on the public debt levels, it can be used in an attempt to replicate the public debt to GDP shares in the countries characterized as "close to their steady state growth", given the public corruption levels and other macroeconomic indicators for these countries.

4.3 Parametrization and Calibration

This subsection describes how the model parameters are linked to the corresponding available macroeconomic data in the set of the selected countries. Similarly to the empirical part, only the most developed OECD economies are considered. Moreover, I drop from the discussion here several outliers such as Japan, South Korea, Australia and Luxembourg. These economies have either too different from the average in the sample debt levels or too different from the average GDP levels, and therefore complicate the calibration of several model parameters, which are based on the average over the sample values. Thus, the total number of the countries used for the evaluation of the model performance is 19.

The model is defined by the following set of parameters:

- technology related: $A_i, a_i$, where $i = 1, ..19$, denotes the country.
- parameters of the utility function: $\varphi_i, \sigma, \tilde{\gamma}_i$.
- the discount rate and depreciation: $\beta_i, \delta_i$.

I have evaluated the model with different capital shares $\alpha_i$, taken from Caselli and Feyrer (2007). The special role devoted to the value of this parameter comes from the conjecture, that the capital shares by themselves, when combined with the levels of GDP and the shares of public expenditures, may explain the debt levels in the developed countries. However, the model without corruption (that is, the model of Ortigueira and Pereira, 2009) with $a_i$ and $\beta_i$ different for every country does not deliver the public debt levels consistent with those observed in reality. In fact, the effect of the structural parameters $(a_i, \beta_i)$, when these parameters are calculated from the data, on the the model performance is both insignificant and of the wrong sign, when the model outcomes are compared with the data. Therefore, the estimation below uses the averages of $a$ and $\beta$ for the sample of countries considered.

So, parameters which are taken to be the same for all countries, and prescribed the conventionally accepted values are: $\beta, \delta, \sigma, a$.

The proxy of the weight on the expropriated public consumption $\gamma_i$ can be extracted from the data for every country in the sample. So, the parameters given and fixed from the data are:

$$\beta, \delta, \sigma, a, \gamma_i.$$  

The parameters left to be calibrated are the weight on the public expenditures, and the TFP factor:

$$\varphi_i, A_i.$$  

The calibration targets are the government consumption to GDP ratio and the relative level of GDP correspondingly:

$$\varphi_i \rightarrow \frac{\bar{g}}{y_i} A_i \rightarrow y_i.$$  

Given these parameters, the debt levels generated by the model are then compared with the actual debt to GDP ratios in the considered 19 OECD member states.

---

12As these authors explain, these estimates of $\alpha$ "compute the capital share as one minus the labor share in GDP. In turn, the labor share is employee compensation in the corporate sector from the National Accounts, plus a number of adjustments to include the labor income of the self-employed and noncorporate employees".
As the analysis performed in this paper assumes that the country under consideration is in the steady state, the following measures of the "steady state" output, government expenditures and debt shares are considered:

**Output:**

1. Take the country’s average GDP per capita over the years 1980-2007, for each country in the sample: 
   \[
   \bar{Y}_i = \frac{\sum T Y_{it}}{T}, \quad i = 1, \ldots, N, \quad \text{where } Y_{it} \text{ is GDP per capita for country } i \text{ in the year } t, \quad N = 19 \text{ is the number of countries, } T = 27 \text{ - the number of time periods.}
   \]

2. Calculate the average of the averages over the whole sample: 
   \[
   \bar{Y} = \frac{\sum_i N \bar{Y}_i}{N} = \frac{\left(\sum_i N \bar{Y}_i\right)}{N}.
   \]

3. Re-scale the calculated average of averages \(\bar{Y}\) to 1: 
   \[
   \bar{y} = \frac{\bar{Y}}{\bar{Y}} = 1.
   \]

4. For every country calculate the relative average GDP per capita by re-scaling: 
   \[
   y_i = \frac{Y_i}{\bar{y}}.
   \]

**Government expenditures to GDP shares:**

Take the country’s average government consumption to GDP shares over the years 1980-2007, for each country in the sample: 
\[
\bar{g}_{yi} = \frac{\sum T g_{it} Y_{it}}{T}, \quad i = 1, \ldots, N, \quad N = 19, \quad T = 27,
\]
where \(g_{it} Y_{it}\) is the government consumption to GDP share for country \(i\) in the year \(t\).

**Debt to GDP shares:**

Take the country’s average public debt to GDP shares over the years 1980-2007, for each country in the sample: 
\[
\bar{b}_{yi} = \frac{\sum T b_{it} Y_{it}}{T}, \quad i = 1, \ldots, N, \quad N = 19, \quad T = 27,
\]
where \(b_{it} Y_{it}\) is the central government debt to GDP share for country \(i\) in the year \(t\).

Then, \(\varphi_i\) and \(A_i\) are chosen for every country so, that the government expenditures shares \(\bar{g}_{yi}\) and relative outputs \(y_i\) generated by the model are matched with those calculated from the data as described above.

Corruption measure in the model is calculated as a *minimum* of the corruption measure from the data, over the period when this measure is available (1995-2007): 
\[
CPI_i = Min(Corruption_{it}), \quad i = 1, \ldots, N, \quad N = 19, \quad T = 13.
\]
The minimum is taken instead of the average to preclude underestimation of corruption in the highly corrupted countries.

The two corruption measures are considered (for robustness check): International Transparency corruption perception index from Transparency International Reports, and
the “Control of Corruption” from the World Bank Governance indicators.

Given that these indices take values in the range (0; 10), and (0, 2.5) correspondingly, the re-scaling to the range (0,1) is necessary for the application to the model considered. Moreover, the fit of the model proved to be better for the quadratic function of the expropriated expenditures given the corruption perception index. Therefore, the parameter used in the model is:

\[ \tilde{\gamma}_i^1 = (1 - 0.1 * CPI)^2, \]
\[ \tilde{\gamma}_i^2 = (1 - 0.4 * CC)^2, \]

for the first and second measure correspondingly.

Table 2 proposes a summary of parameters and their values, together with the sources.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a)</td>
<td>0.29</td>
<td>Caselli and Feyrer (2007)</td>
</tr>
<tr>
<td>(\beta)</td>
<td>0.94</td>
<td>data on average real interest rate over the sample</td>
</tr>
<tr>
<td>(\delta)</td>
<td>0.11</td>
<td>set to match average debt share in average country</td>
</tr>
<tr>
<td>(\tilde{\gamma}_i)</td>
<td>(1 - \frac{\text{CorruptionData}}{\text{Max(CorruptionData)}})^2</td>
<td>data on public corruption</td>
</tr>
<tr>
<td>(\sigma)</td>
<td>1</td>
<td>assumption</td>
</tr>
<tr>
<td>(\varphi_i)</td>
<td>[0.091; 0.409]</td>
<td>set to match average government expenditure share</td>
</tr>
<tr>
<td>(A_i)</td>
<td>[0.661; 1.126]</td>
<td>set to match average output</td>
</tr>
</tbody>
</table>

Note, that the depreciation rate is consistent with the average investment share observed in developed countries during the last two decades (till 2007), and that its value is such, that given the "average country" with the average level of output \(\bar{y} = 1\), average level of government expenditures \(\bar{g} = \left(\frac{\bar{g}}{\bar{y}}\right) = \sum_i \frac{g_i}{Y_i}/N\), and average corruption index \(\bar{\gamma} = \sum_i \tilde{\gamma}_i/N\), the average debt share \(\bar{b}/\bar{y}\) produced by the model with parameters \(\bar{g}, \bar{g}, \bar{\gamma}, a, \beta, \delta, \sigma\) is matched with the average debt to GDP in the sample of observed countries: \(\sum_i b_i/y_i/N\).
The values of country specific data, incorporated in the model are given in Table 3.

<table>
<thead>
<tr>
<th>Country</th>
<th>( \bar{x}_1 )</th>
<th>( \bar{x}_2 )</th>
<th>( y_i )</th>
<th>( g/y_i )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Austria</td>
<td>0.082</td>
<td>0.073</td>
<td>1.084</td>
<td>0.125</td>
</tr>
<tr>
<td>Belgium</td>
<td>0.225</td>
<td>0.218</td>
<td>1.019</td>
<td>0.154</td>
</tr>
<tr>
<td>Canada</td>
<td>0.025</td>
<td>0.068</td>
<td>1.083</td>
<td>0.141</td>
</tr>
<tr>
<td>Denmark</td>
<td>0.004</td>
<td>0.022</td>
<td>1.034</td>
<td>0.182</td>
</tr>
<tr>
<td>Finland</td>
<td>0.012</td>
<td>0.011</td>
<td>0.912</td>
<td>0.176</td>
</tr>
<tr>
<td>France</td>
<td>0.136</td>
<td>0.232</td>
<td>0.958</td>
<td>0.171</td>
</tr>
<tr>
<td>Germany</td>
<td>0.072</td>
<td>0.084</td>
<td>1.007</td>
<td>0.127</td>
</tr>
<tr>
<td>Greece</td>
<td>0.384</td>
<td>0.920</td>
<td>0.757</td>
<td>0.137</td>
</tr>
<tr>
<td>Ireland</td>
<td>0.096</td>
<td>0.192</td>
<td>0.911</td>
<td>0.116</td>
</tr>
<tr>
<td>Italy</td>
<td>0.491</td>
<td>0.899</td>
<td>0.941</td>
<td>0.126</td>
</tr>
<tr>
<td>Netherlands</td>
<td>0.019</td>
<td>0.042</td>
<td>1.054</td>
<td>0.174</td>
</tr>
<tr>
<td>New Zealand</td>
<td>0.005</td>
<td>0.017</td>
<td>0.774</td>
<td>0.149</td>
</tr>
<tr>
<td>Norway</td>
<td>0.044</td>
<td>0.062</td>
<td>1.381</td>
<td>0.136</td>
</tr>
<tr>
<td>Portugal</td>
<td>0.197</td>
<td>0.331</td>
<td>0.623</td>
<td>0.127</td>
</tr>
<tr>
<td>Spain</td>
<td>0.323</td>
<td>0.343</td>
<td>0.828</td>
<td>0.121</td>
</tr>
<tr>
<td>Sweden</td>
<td>0.012</td>
<td>0.029</td>
<td>0.964</td>
<td>0.235</td>
</tr>
<tr>
<td>Switzerland</td>
<td>0.025</td>
<td>0.030</td>
<td>0.924</td>
<td>0.066</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>0.052</td>
<td>0.086</td>
<td>1.020</td>
<td>0.166</td>
</tr>
<tr>
<td>United States</td>
<td>0.078</td>
<td>0.233</td>
<td>1.320</td>
<td>0.098</td>
</tr>
<tr>
<td>Average</td>
<td>0.080</td>
<td>0.140</td>
<td>1.000</td>
<td>0.144</td>
</tr>
</tbody>
</table>

The question is how much of observed public debt shares the model is able to explain, given these characteristics of the countries under study. The answer is proposed after a brief description of the numerical strategy.

### 4.4 Numerical algorithm

The solution of the model was obtained by the two different methods, the global and the local one, which delivered very close estimates. The reported results, however, are calculated by the local method of approximation at the steady state, due to significant gain in the speed of calculations by this method.

The local method of approximation relies on the approximation of unknown functions by the polynomials using only the steady state information, as explained in Klein, Krusell, Ríos-Rull (2008). Namely, given the unknown functions
and the steady state conditions

\[ b' = b, k' = k, \]

the solution to the government problem may be approximated by evaluating the optimality conditions (25), and (26) at the steady state with the unknown functions defined as:

\[ b' = \sum_{i}^{n} \sum_{j}^{n} a_{b ij} k^{i} b^{j}, \quad \tau = \sum_{i}^{n} \sum_{j}^{n} a_{\tau ij} k^{i} b^{j}, \quad c = \sum_{i}^{n} \sum_{j}^{n} a_{c ij} k^{i} b^{j}, \]

(35)

with \( n \) being the order of approximation, and \( a_{b ij}, a_{\tau ij}, a_{c ij} \) the coefficients that can be found by differentiating the equations (25), and (26) the necessary number of times with respect to the states \( k \) and \( b \).

This method delivers quite close results for second, third and fourth order approximation, as well as close to the approximation of functions (34) by (35) by the global method, based on projections of first order conditions (25), and (26), and described in more detail in appendix D.

### 4.5 Results

The results of the steady state model evaluation, given the set of calibrated parameters discussed above, are presented in the Figure 2. Figure 3 reports the regression lines obtained from the model versus the ones from the data, of the averages of debt levels regressed on the corruption indices, for the two alternative sources of corruption measure. Note, that the World Bank measure gives a slightly better fit. In general, the model augmented with corruption still slightly underestimates the debt levels in the highly indebted countries and overestimates the debt levels in the countries characterized by the low public debts.

<table>
<thead>
<tr>
<th>OECD</th>
<th>Data</th>
<th>Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>MEAN (B/Y)</td>
<td>0.520</td>
<td>0.538</td>
</tr>
<tr>
<td>STD (B/Y)</td>
<td>0.239</td>
<td>0.199</td>
</tr>
</tbody>
</table>
The results do not change significantly when the different time period is considered (excluding years 2008-2009 when debt levels soared due to the financial crisis). However, the model performs much worse with the attempt to replicate the debt levels in the rest of the OECD countries. The reason is, that the "new" developed states, such as for example Poland, Hungary, Slovakia and Czech Republic, have significantly lower GDP and public debt levels when compared with the Development Assistance Committee members, and cannot be considered as those operating near their steady state path.

Figure 2 shows that the public debt in Spain is significantly overestimated, which may be a signal that either Spain has not reached its steady state development path or this economy is affected to the higher extent, that other considered states, by the factors omitted in the estimation.
Among the highly-indebted countries the model does not manage to replicate the public debt share in Belgium, due to its relatively low public corruption indices. Given its high simplicity, the model leaves disregarded many other factors, which may affect the public debt accumulation, besides the public corruption. The next section considers one possible extension which takes into account the political instability, defined as a political turnover, effect on the public debt accumulation. However, as can be found below, the incorporation of political changes does not affect significantly the success of the model.

Consider other predictions of the model, given the calibrated data on output and government spending. In particular, besides public debt level, the model delivers private consumption and income taxes, given the level of public corruption in the country. In accordance with proposition 1, the model predicts lower consumption and higher taxes when the level of public corruption in the country is high. However, the data does not seem to obey this rule. Table 4 reports the correlation coefficients between the variable as predicted by the model, and the variable observed in the data.

<table>
<thead>
<tr>
<th>Variable</th>
<th>$B/Y$</th>
<th>$C/Y$</th>
<th>$G/Y$</th>
<th>$TR/Y$</th>
<th>$Y$</th>
<th>Corruption</th>
</tr>
</thead>
<tbody>
<tr>
<td>$Correlation(Var_{Data}, Var_{Model})$</td>
<td>0.765</td>
<td>-0.279</td>
<td>1.000</td>
<td>-0.106</td>
<td>1.000</td>
<td>0.968</td>
</tr>
</tbody>
</table>

While output and public spending coincide because of calibration strategy, and there is a strong positive relationship between public debt levels in the model and in the data, the private consumption and tax revenues in the model correlate negatively with those observed in the data. According to the model, higher corruption provokes higher taxes, through decrease in aggregate capital and through the negative relationship between capital and taxes. In reality the relationship between income taxation and aggregate capital may be more complicated. In particular, when higher public corruption crowds out investment because of higher public spending, the government might decide to decrease income taxes to attract more labor force (which is assumed exogenous in the model) as a substitute of capital in the production process. Once the negative correlation of tax revenues in the model and in the data is accepted as a result of omission of other factors such as labor, the effect on private consumption turns out to be defined by the direction of
change in tax revenues (see Figure 4 below). In the model consumption does not depend directly on income taxes, because of simultaneous choice of taxes by the government and consumption by the households. However, consumption decreases with higher income taxes, because of positive effect of capital on consumption, and negative effect of capital on taxes. The negative relationship between taxes and private consumption is observed in reality as well.

![Figure 4. Private consumption versus tax revenues, model and data.](image)

Table 5: Correlation coefficients between the variables in the model and in the data

<table>
<thead>
<tr>
<th></th>
<th>$B/Y$</th>
<th>$C/Y$</th>
<th>$G/Y$</th>
<th>$T/R/Y$</th>
<th>$Y$</th>
<th>Corruption</th>
</tr>
</thead>
<tbody>
<tr>
<td>$B/Y$</td>
<td>1</td>
<td>0.202</td>
<td>0.196</td>
<td>0.125</td>
<td>-0.418</td>
<td>0.708</td>
</tr>
<tr>
<td>$C/Y$</td>
<td>0.999</td>
<td>1</td>
<td>-0.311</td>
<td>-0.632</td>
<td>-0.302</td>
<td>0.421</td>
</tr>
<tr>
<td>$G/Y$</td>
<td>0.110</td>
<td>0.104</td>
<td>1</td>
<td>0.760</td>
<td>-0.263</td>
<td>-0.215</td>
</tr>
<tr>
<td>$T/R/Y$</td>
<td>0.993</td>
<td>-0.994</td>
<td>0.085</td>
<td>1</td>
<td>0.060</td>
<td>-0.292</td>
</tr>
<tr>
<td>$Y$</td>
<td>-0.416</td>
<td>0.411</td>
<td>-0.263</td>
<td>-0.474</td>
<td>1</td>
<td>-0.375</td>
</tr>
<tr>
<td>Corruption</td>
<td>0.864</td>
<td>-0.871</td>
<td>-0.283</td>
<td>0.886</td>
<td>-0.361</td>
<td>1</td>
</tr>
</tbody>
</table>

Table 5 proposes the correlation coefficients between the variables in the data (above the main diagonal of the table), and the correlation coefficients between the variables in the model. Again, the only contradiction between the relationships observed in the data versus those in the model are for private consumption and tax revenues (the contradictory signs are in bold). However, once the possibility of positive relationship between taxes and
output is taken into account, the derived behavior of consumption in the model accords with the data.

4.6 Counterfactual Exercise

The previous subsection described the success of the model in replicating public debt shares in developed countries, given public corruption, output levels and government expenditures shares in these countries. This subsection recalculates public debt levels predicted by the model, given public corruption measures in the countries and assuming that the countries are characterized by the same TFP factors and same preferences for public consumption. That is, the parameters $\varphi$ and $A$ are now considered the same for all the countries and chosen so as to match the average output and average government expenditure share of output over the whole sample of the countries considered.

$$\varphi_i = \varphi \to \frac{\bar{y}}{y}, A_i = A \to \bar{y}, \text{ for } \forall \ i = 1, .. 19.$$ 

The performance of the model under such calibration strategy does not differ significantly from the case when output and public expenditures shares in the model coincide with those observed in the data. Figure 5 below reports the regression lines of public debt levels versus public corruption obtained from the model as compared with the regression from the data. The correlation coefficients between the variables produced by the model and observed in the data are presented in Table 6.
Correlation between tax revenues in the model and in the data is still negative and may be explained by the logic outlined in the previous subsection. Now additional inference can be made about the predictions of the model about the behavior of output and government expenditures of the country, given this country’s public corruption measure. Correlation between GDP in the model and in the data is about 40%, which supports the hypothesis that higher public corruption has negative influence on economic growth. However, the effect of public corruption on public spending, as predicted by the model, is opposite to what seems to occur in reality. Again, the contradiction may be due to omission of some other wedge in the government maximization problem, such as, for example, labor choice. In the simple model discussed in this paper, the only trade-off the government faces when it decides on how much of public goods to expropriate, is between allocation of public goods for its own usage or for the households, and the degree of necessary taxation and public debt issues. Extensions of the model, including productive public capital, endogenous labor, or some other additional choice variables could certainly improve its performance in replicating variables other that public debt. However, as the main target of this study is to explain public debt shares in developed countries, and the simple model considered till now delivers satisfactory results, no further extensions on the structure of the economy are viewed as necessary.

Next subsection proposes a robustness check, consisting of the application of the model considered above to the different set of the economies, namely, the states of USA.

### 4.7 Debt and Corruption in the US States

This subsection applies the model developed above to the alternative set of economies, namely, the states of USA. Each of the states of the US is characterized by some degree of independence of local authorities, local budget, legislation, and local governance, and satisfy the requirement of the (near) steady state development path. Given the otherwise
relatively homogenous characteristics of the states of US, they constitute an ideal sample for the robustness check of the results reported for OECD countries.

The calibration is proceeded in the same way as before. Given the data on GDP and government expenditures for each state of the USA, $\varphi_i, A_i$ are set so, that the model generates output and government expenditures same as in the data. Then, the debt levels from the model are compared with those in the data.

The economic indicators for the USA are available from the CENSUS dataset. It reports the total state and local government expenditures by state. The measure of public consumption was constructed, similar to Barro (1990), by subtracting the expenditures on public investment, transfers, education and defence (the last item is zero in the state and local budgets) from the total government expenditures. I use the cross-section data on GDP, government expenditures and public debt, total of the state and local values, for the year 2002.

The USA data sources do not report any indices of public corruption by state. As a measure of public corruption, they use the number of convictions of the state and local public officials in a year. Given the evident shortcomings of this measure (the estimates are biased downwards, may be affected by the political factors), I tried to find an alternative measure. The only available alternative is an "Integrity Index" of the states by Better Government Association (BGA), which ranks the states according to the estimates of the quality of their legislature as a way of protection against the public corruption. Surprisingly, the correlation between the BGA measure of corruption and the one, obtained from the number of convictions, is negative. As the Corporate Crime Reporter (2004) explains, "if a public official wants to violate his or her trust, the laws don’t stand in the way". Therefore, I use the number of convictions (sum over the decade 1993-2002), normalized by the state population in 2002:

$$\bar{\gamma}_i = \frac{\# \text{ of convictions}}{\text{population}}, \; i = 1, .. 50.$$

The average and std. deviation values for the data incorporated into the model is presented in the table below.
The next table reports the summary statistics as produced by the model versus the data. The model does not reproduce perfectly the debt level in each particular state. However, as can be seen from the Figure 6, the regression line, fitting the public debt levels in the USA states, when taken from the model, coincides almost perfectly with the line obtained from the data.

<table>
<thead>
<tr>
<th></th>
<th>Data</th>
<th>Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>MEAN (B/Y)</td>
<td>0.159</td>
<td>0.158</td>
</tr>
<tr>
<td>STD (B/Y)</td>
<td>0.027</td>
<td>0.038</td>
</tr>
</tbody>
</table>

Figure 6. The regression lines of model vs data debt shares on the corruption levels for the USA states.

Note, that this subsection considers an absolutely different measure of corruption as the previous ones, and still finds a positive relationship between the public corruption and public debt share. That is, given that public corruption is an unobservable and difficult to measure phenomenon, the relative public debt levels might signal the relative differences in the corruptness of the public officials in the regions (countries) of investigation.

4.8 Debt Levels, Corruption, and Political Turnover

Given the special attention that the literature devotes to the political factor of the public debt accumulation, this section incorporates political instability, defined as political
turnover, in the model developed above. Under political instability it is meant that there are (frequent) changes in the authorities, namely re-elections, resulted in the change of political parties composing the government.

The standard way of modeling political instability in the scope of the environment studied in this paper is through introduction of probability of re-election and definition of the value functions of the current incumbent in case of re-election and in case of losing the power (see Alesina and Tabellini, 1990). The simplest way of combining the political instability with the existence of public corruption, as modeled here, is to define the utility of the non-reelected party in the same way as that of the representative citizen, that is, the non-reelected authority loses the possibility to enjoy the extra rents from the corrupted activities. However, the solution of the model with political instability, formulated in such a way, produces the controversial result that the higher political turnover leads to lower public debt levels in equilibrium. The intuition behind the failure of such a model, with the utility of the non-elected politicians coinciding with the utility of normal citizens, is that in reality the politicians might do precautionary savings, or insure in some other way, such as legislation, continuation of their access to the extra rents, for the case of not being reelected, and therefore, enjoy the higher utility levels that the other citizens even after losing the power.

Therefore, instead of modeling different preferences for a looser and a winner party, I incorporate political turnover in the model discussed in the section 3 in the same way as in Kumhof and Yakadina (2006). The incumbent party realizes that it is in the power for the finite period of time. As a consequence, the government discounts the future by the higher rate that the rest of the country’s inhabitants. Then, the discount factor in the problem of the government is adjusted by the expected time-horizon of the current authorities. This time-horizon is related to the probability of reelection in the following way:

$$yio = \frac{1}{1 - P},$$

where $yio$ is the (expected) number of years in office of the current government officials, $P$ - the probability of reelection. The problem of the government is modified to:
\[ V(k, b) = \max_{\tau, \hat{g}, \hat{b}} \{ U(c, g, \hat{g}) + \beta PV(k', b') \} \]  
\[ \text{s.t.} \]
\[ k' = k + b + (1 - \tau)(f(k) - \delta k + r(k)b) - b' - C(k, b), \] 
\[ G = \tau(f(k) - \delta k + r(k)b) + b' - (1 + r(k))b, \]
\[ G = g + \hat{g}. \]  

The data on probability of reelection for the considered here OECD members is taken from Brender and Drazen (2008)\textsuperscript{13}, and reproduced in the table below. Given that re-elections usually take place once in four years on average, the probabilities reported below, when incorporated in the model, are reevaluated to the annual frequency, that is:

\[ P_{\text{Model}} = P_{\text{Data}}^{1/4}. \]

<table>
<thead>
<tr>
<th>Country</th>
<th>Probability of reelection; source: Brender and Drazen (2008)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Country</td>
<td>Australia</td>
</tr>
<tr>
<td>P</td>
<td>9/13</td>
</tr>
<tr>
<td>Country</td>
<td>Finland</td>
</tr>
<tr>
<td>P</td>
<td>0.75</td>
</tr>
<tr>
<td>Country</td>
<td>Italy</td>
</tr>
<tr>
<td>P</td>
<td>1/6</td>
</tr>
<tr>
<td>Country</td>
<td>Spain</td>
</tr>
<tr>
<td>P</td>
<td>4/5</td>
</tr>
</tbody>
</table>

The table and figures below illustrate the success of the model with corruption augmented by the presence of political turnover. As was already mentioned, adding political turnover does not improve the fit of the model with corruption. This may be due to omitting other factors significantly influencing public debt accumulation, and because of large correlation between the public corruption and political instability measures.

<table>
<thead>
<tr>
<th>OECD with P Data Model</th>
<th>MEAN (B/Y)</th>
<th>STD (B/Y)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data</td>
<td>0.520</td>
<td>0.239</td>
</tr>
<tr>
<td>Model</td>
<td>0.553</td>
<td>0.176</td>
</tr>
</tbody>
</table>

\textsuperscript{13}The data for Finland and Switzerland was not available, so I considered the conventional P=0.75.
Uncertainty and Dynamics

The discussion of all the previous sections is carried out under the assumption that there is no uncertainty in the world. This section shows that adding the uncertainty would not change any of the conclusions reported above. The irrelevance of the shocks on the long-run outcomes of the considered model is due to stationarity of the fiscal variables: government debt, physical capital and income taxes. Many theoretical considerations suggest that US public debt contains a unit root, for example Barro (1979), Aiyagari, Marcet, Sargent and Seppälä (2002). However, Bohn (1998) argues that US debt-to-GDP ratio is mean-reverting, when controlled for war-time spending and cyclical fluctuations. The conclusions of this paper take serious the arguments of Bohn (1998), and rely on the fact that the debt-to-GDP ratios in the considered developed countries are stationary.
This section introduces aggregate uncertainty to the model, and characterizes the
dynamics of the fiscal variables around the steady state in the short run.

Consider the "steady state" of one of the countries studied in the previous section, say
the USA. Given the results of the calibration (without political instability), the values of
the macroeconomic variables and parameters for this country are:

<table>
<thead>
<tr>
<th>Table 8: The US Economy &quot;steady state&quot; values</th>
</tr>
</thead>
<tbody>
<tr>
<td>$y$</td>
</tr>
<tr>
<td>1.32</td>
</tr>
</tbody>
</table>

The total factor productivity and the public corruption measure are the two potential
causes of the aggregate uncertainty in the model. In the data for the US economy, the
correlation between GDP growth and the change in public corruption is equal to -0.23.
So, the stochastic processes for the total factor productivity ($A$) and public corruption
($\bar{\gamma}$) should be negatively correlated. For expositional purposes of this section consider the
stochastic process for $A$ to be given by:

$$\ln A_t = (1 - \rho) \ln A + \rho \ln A_{t-1} + \varepsilon, \quad \varepsilon \sim N(0, \sigma^2),$$

with $\rho = 0.91$ and $\sigma = 0.007$ (the parameters generally considered in the literature).
Define $\bar{\gamma}_t$ as\(^{14}\):

$$\bar{\gamma}_t = \bar{\gamma} + \bar{\gamma}(A - A_t).$$

Given these stochastic processes, the policy functions of the government will now
depend on an additional state variable, which is the state of productivity, $A_t$. It is
necessary to make an assumption about the market structure in the considered economy.
Assume without loss of generality, that public bonds are not state contingent\(^{15}\) ($b_{t+1}$ is a

\(^{14}\) Considering the separate stochastic process for $\bar{\gamma}$ would not change the conclusions. The assumption
of perfect correlation between $\bar{\gamma}$ and $A$ is made only for simplification.

\(^{15}\) As was shown by Grechyna (2009), the market structure does not matter for the stochastic behavior
of fiscal variables in the Markov perfect equilibrium.
function of $A_t, k_t, b_t$, while the income taxes are set given the state of the nature in the current period.

The solution for a stochastic Markov perfect equilibrium is found by the projection method, as described by Judd (1992). The details of the numerical algorithm are proposed in the appendix D.

The Figure 9 below represents the impulse-responses to one standard deviation increase in the total factor productivity (and corresponding fall in the preferences for public corruption). A positive economic shock leads to growth in output and physical capital, as well as to decline in the debt-to-GDP ratio. Note, however, that after the initial fall, the government debt and income taxes return to the initial value, and even grow for the several subsequent periods, returning in the long-run to their levels before the productivity shock.

![Figure 9. The impulse-responses to one standard deviation increase in the total factor productivity.](image)

To compare the performance of the model with the data, I plot the impulse-responses generated by the US data for 1980-2007 and the impulse-responses for the data generated by the model. While having a persistent response, the public debt-to-GDP series return to their initial value prior to shock, after approximately a decade.

The lack of the data does not allow to analyze the responses of the fiscal variables to a shock to public corruption. But as long as the positive shock to public corruption may be considered as a negative shock to total productivity (see the proposition 1), the short-run
effect of a temporary increase in public corruption is easily predicted.

![Figure 10. The impulse-responses for the US data (on the left) and for the data generated by the model (on the right).](image)

The analysis of this section suggests, that, assuming there were no permanent structural changes in the economic uncertainty, that would lead to a shift in the public debt pattern, the conclusions of the previous section hold regardless of the presence of cyclical fluctuations and temporary economic shocks.

6 Conclusions

The simple model developed in this paper is able to deliver the suboptimally high (up to 100% of GDP) debt levels in the countries characterized by significant corruption of the public officials, while it prescribes positive moderate (about 50% of GDP) public debt levels in the countries with low or absent public corruption. When applied to a sample of most advanced countries, the model predicts the public debt shares quite close to those actually observed. The empirical evidence presented confirms the plausibility of the higher public corruption - higher public debt hypothesis.

The conclusions of this paper may be used as a bulk for legislative modifications of the public policy fundamentals, aimed to decrease the possibilities of public corruption of the government officials. This work suggests that such modifications, among other welfare improving consequences for the developed economies, would lead to the substantial drop in the public debt levels in the long run.
The results reported here may be viewed both as alternative and as supplementary to the political disagreement arguments used in the previous studies as an explanation of the public debt levels in the high-income countries.

The presented framework could be extended in several promising directions. For example, endogenizing labor choice would add the household’s trade-off between consumption and leisure, thus affecting the optimal income taxation and the way of financing rent-seeking public activities. One would expect that endogenous labor choice would lead to higher public debt levels in the economy studied in this paper, other things being equal and given that the substitution effect on leisure choice is larger than its income effect. In that case the government would not be able to tax households by the same amount as in inelastic labor case, so it would have to rely more on public debt accumulation to finance its corrupt activities.

Another possible extension would be to extend the analysis of the economy under the aggregate uncertainty. In particular, the degree of correlation between the public corruption and economic growth, the issue not explored in this paper, could be analyzed, and might add new insights on the fluctuations of the fiscal variables in the short and medium term.

References


Appendix

A. Empirical Facts

Figure A1. Average Government Debt-to-GDP ratios in the OECD countries.

Figure A2. Composition of average government expenditures for Italy by years of political changes.
Figure A3. Total government expenditures by composition. Source: OECD.

Figure A4. Growth in debt/GDP as a function of growth in population, OECD countries.

Data used in the Empirical Estimation

The list of the countries included in the estimation:

Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Japan, South Korea, Luxembourg, Netherlands, New Zealand, Norway,
Portugal, Spain, Sweden, Switzerland, United Kingdom, United States.

Table A.1. Summary Statistics of the variables used in the regression

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean</th>
<th>Std</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>debt</td>
<td>48</td>
<td>30</td>
<td>0.82</td>
<td>164</td>
</tr>
<tr>
<td>polit_polarization</td>
<td>1.14</td>
<td>0.90</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>growthGDP</td>
<td>2.36</td>
<td>2.64</td>
<td>-12</td>
<td>11</td>
</tr>
<tr>
<td>polit_instability</td>
<td>0.41</td>
<td>0.56</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>Unemployment</td>
<td>6.98</td>
<td>3.40</td>
<td>1.5</td>
<td>19.5</td>
</tr>
<tr>
<td>Debt_Service</td>
<td>2.04</td>
<td>1.74</td>
<td>-1.96</td>
<td>10.2</td>
</tr>
<tr>
<td>Corruption</td>
<td>7.69</td>
<td>1.60</td>
<td>2.99</td>
<td>9.98</td>
</tr>
<tr>
<td>Corruption1</td>
<td>1.67</td>
<td>0.59</td>
<td>0.21</td>
<td>2.57</td>
</tr>
</tbody>
</table>

Measures of Public Corruption (from The Quality of Government Dataset Codebook if not mentioned otherwise; the variables with asterisk denote the ones used in the estimation):

- **ti_cpi** (denoted as Corruption in the estimation table) Corruption Perceptions Index

  The CPI focuses on corruption in the public sector and defines corruption as the abuse of public office for private gain. The surveys used in compiling the CPI tend to ask questions in line with the misuse of public power for private benefit, with a focus, for example, on bribe-taking by public officials in public procurement. The sources do not distinguish between administrative and political corruption. The CPI Score relates to perceptions of the degree of corruption as seen by business people, risk analysts and the general public and ranges between 10 (highly clean) and 0 (highly corrupt).

- **wbgi_gee** Government Effectiveness - Estimate

  “Government Effectiveness” combines into a single grouping responses on the quality of public service provision, the quality of the bureaucracy, the competence of civil servants, the independence of the civil service from political pressures, and the credibility of the government’s commitment to policies. The main focus of this index is on “inputs” required for the government to be able to produce and implement good policies and deliver public goods.

- **wbgi_rle** Rule of Law - Estimate

- **wbgi_cce** (denoted as Corruption in the estimation table) Control of Corruption - Estimate

  “Control of Corruption” measures perceptions of corruption, conventionally defined as the exercise of public power for private gain. The particular aspect of corruption mea-
sured by the various sources differs somewhat, ranging from the frequency of “additional payments to get things done”, to the effects of corruption on the business environment, to measuring “grand corruption” in the political arena or in the tendency of elite forms to engage in “state capture”.

Measures of Political Instability and Disagreement (from The Quality of Government Dataset Codebook if not mentioned otherwise; the variables with asterisk denote the ones used in the estimation):

*van_comp* Competition

The competition variable portrays the electoral success of smaller parties, that is, the percentage of votes gained by the smaller parties in parliamentary and/or presidential elections. The variable is calculated by subtracting from 100 the percentage of votes won by the largest party (the party which wins most votes) in parliamentary elections or by the party of the successful candidate in presidential elections. The variable thus theoretically ranges from 0 (only one party received 100 % of votes) to 100 (each voter cast a vote for a distinct party).

*wbgi_pse* Political Stability - Estimate

“Political Stability” combines several indicators which measure perceptions of the likelihood that the government in power will be destabilized or overthrown by possibly unconstitutional and/or violent means, including domestic violence and terrorism.

*dpi_gf* Government Fractionalization

Government fractionalization measures the probability that two randomly chosen deputies from among the government parties will be of different parties.

*dpi_opf* Opposition Fractionalization

Opposition fractionalization measures the probability that two randomly chosen deputies belonging to the parties in the opposition will be of different parties.

*dpi_tf* Total Fractionalization

Total fractionalization measures the probability that two randomly chosen deputies in the legislature belong to different parties.

*polit_instability* (denoted as Polit. instability in the estimation table) - Number of mayor cabinet changes within a year (Pippa Norris dataset).
dpi_polariz* (denoted as Polit. polarization in the estimation table) Maximum Difference of Orientation

The maximum difference between the left-right-center orientation of the chief executive’s party and the placement of the three largest government parties and the largest opposition party. Is coded (0) if the Legislative Index of Political Competitiveness (dpi_lipc) or the Executive Index of Political Competitiveness (dpi_eipc) are less than 6 (elections are not competitive), and if the chief executive’s party has an absolute majority in the legislature. Ranges between 0 and 2.

Below the correlation coefficients of the corruption and political measures are reported; the variables with asterisk denote the ones used in the estimation output reported in the main text.

<table>
<thead>
<tr>
<th>Correlation in the Corruption Measures</th>
<th>ti_cpi*</th>
<th>wbgi_gpee</th>
<th>wbgi_rle</th>
<th>wbgi_cce*</th>
</tr>
</thead>
<tbody>
<tr>
<td>ti_cpi*</td>
<td>1.0000</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>wbgi_gpee</td>
<td>0.8821</td>
<td>1.0000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>wbgi_rle</td>
<td>0.9138</td>
<td>0.9328</td>
<td>1.0000</td>
<td></td>
</tr>
<tr>
<td>wbgi_cce*</td>
<td>0.9542</td>
<td>0.9219</td>
<td>0.9537</td>
<td>1.0000</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Correlation in the measures of political disagreement</th>
<th>dpi_gf</th>
<th>dpi_opf</th>
<th>dpi_tf</th>
<th>dpi_polariz*</th>
<th>van_comp</th>
<th>wbgi_pse</th>
</tr>
</thead>
<tbody>
<tr>
<td>dpi_gf</td>
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B. Alternative definition of Markov Perfect Equilibrium and Optimality Conditions

This formulation is equivalent to the one in the main text (see Klein, Krusell and Ríos-Rull 2008).

The problem of the government may be written as:

\[
\max_{k', b', \tau, \tilde{g}} U(c, G - \tilde{g}, \tilde{g}) + \beta V(k', b'),
\]
\[-u_c + \beta u_c'[1 + (1 - \tau')(f_k(k') - \delta)] = 0 : \text{denote } \eta(.) = 0 \]

\[G = \tau(f(k) - \delta k + rb) + b' - (1 + r)b,\]

\[c = k + b + (1 - \tau)(f(k) - \delta k + rb) - b' - k'.\]

Call the policy functions of the government in equilibrium to be:

\[b' = B(k, b), \tau = \Upsilon(k, b),\]

then the competitive equilibrium conditions from the household problem yield a stationary decision rule for the private consumption:

\[c = C(k, b).\]

The first-order condition from the household problem now can be rewritten in terms of the defined functions as follows:

\[\eta(c, c', H(k, c, b, b', \tau), \Upsilon(H(k, c, b, b', \tau), b')) = 0,\]

which characterizes the household behavior for the current period for any arbitrary policy of the current government given that the government follows \(B(.), \Upsilon(.)\) and thus implement \(c\), where

\[H(k, c, b, b', \tau) = k + b + (1 - \tau)(f(k) - \delta k + rb) - b' - c.\]

From the government constraint define the aggregate private consumption function:

\[G(k, b, b', \tau) = \tau(f(k) - \delta k + rb) + b' - (1 + r)b,\]

Given the perception that future governments will follow some tax and debt policies \(\Upsilon(k, b)\) and \(B(k, b)\), which in turn induces future household behavior given by \(c\), the problem of the current government can be written recursively as:

\[V(k, b) = \max_{c,b',\tau} U_{gov}(c, G(k, b, b', \tau) - \hat{g}, \hat{g}) + \beta V(H(k, c, b, b', \tau), b') \quad s.t.\]
\[ \eta(c, c', H(k, c, b, b', \tau), \Upsilon(H(k, c, b, b', \tau), b')) = 0. \]

An interior Markov perfect equilibrium is a set of policy functions \( H, B, \Upsilon, \) and value function \( V, \) such that for all \( K, \) and \( B: \)

1. Given the value function, policy functions solve the government maximization problem:

\[
\{C(k, b), B(k, b), \Upsilon(k, b)\} = \arg\max_{c, b', \tau, \hat{g}} U_{gov}(c, G(k, b, b', \tau) - \hat{g}(k, b, b', \tau), \hat{g}(k, b, b', \tau))
\]

subject to
\[
\eta(c, c', H(k, c, b, b', \tau), \tau; C(k, b), B(k, b), \Upsilon(k, b)) = 0, \\
G(k, b, b', \tau) = \tau(f(k) - \delta k + rb) + b' - (1 + r)b, \\
H(k, k', b, b', \tau) = k + b + (1 - \tau)(f(k) - \delta k + rb) - b' - c.
\]

2. Given the policy functions, value function satisfy the functional equation:

\[
V(k, b) = U_{gov}(C(k, b), G(k, b, B(k, b), \Upsilon(k, b)) - \hat{g}(\cdot), \\
\hat{g}(\cdot) + \beta V(H(k, C(k, b), b, B(k, b), \Upsilon(k, b)), B(k, b)).
\]

The functions \( C(b, k), B(b, k), \) and \( \Upsilon(b, k) \) are assumed to be continuous and continuously differentiable.

First order conditions:

\[
[k'] : U_c C_k + U_g G_k + \beta V_{k'} + \lambda \eta_{k'} = 0 \\
[b'] : U_c C_b + U_g G_b + \beta V_{b'} + \lambda \eta_{b'} = 0 \\
[\tau] : U_c C_\tau + U_g G_\tau + \lambda \eta_\tau = 0
\]

Derivative of value function w.r.t. states + Envelope conditions \( (V_{k'} = V_{b'} = 0) : \)

\[
V_k = U_c C_k + U_g G_k + \lambda \eta_k \\
V_b = U_c C_b + U_g G_b + \lambda \eta_b
\]
\[ \eta = -u_c(C(k, b, \tau, b', k')) + \beta u_c'(C(k', b', \tau'(b', k'), B(b', k'), H(b', k'))[1 + (1 - \tau'(b', k'))(f_k(k') - \delta)] = 0 \]

\[ \eta_{\tau} = -u_c C_{\tau} \]

\[ \eta_k = -u_c C_k \]

\[ \eta_b = -u_c C_b \]

\[ \eta_{k'} = -u_c C_{k'} + \beta u_c'(C'_{k'} + C'_{k'} H_{k'} + C'_{b'} B_{k'} + C'_{\tau'} \tau'_{k'})[1 + (1 - \tau'(b', k'))(f_k(k') - \delta)] + \beta u_c'(1 - \tau'(b', k'))f_{k,k'} - \beta u_c' \tau'_{k'}(f_k(k') - \delta) \]

\[ \eta_{b'} = -u_c C_{b'} + \beta u_c'(C'_{b'} + C'_{b'} H_{b'} + C'_{y'} B_{b'} + C'_{\tau'} \tau'_{b'})[1 + (1 - \tau'(b', k'))(f_k(k') - \delta)] + \beta u_c' \tau'_{b'}(f_k(k') - \delta). \]

Then, given that \( C_{\tau} = -G_{\tau}, C_{b'} = -G_{b'} = -1, C_{k'} = -1, G_{k'} = 0, C_k = 1 - \delta + f_k - G_k: \)

\[ \lambda = \frac{u_c - u_g}{u_{cc}}, \]

\[ V_b = 0, \]

\[ V_k = u_g(1 - \delta + f_k). \]

\[ V_{b'} = 0, \]

\[ V'_{k'} = u_{b'}'(1 - \delta + f_{k'}). \]

From first order conditions:

Substituting in the last two expressions back into first order conditions w.r.t. \( k', b' \) gives the two generalized Euler equations:

\[ -U_c + \beta u_{b'}'(1 - \delta + f'_{k'}) + \frac{u_c - u_g}{u_{cc}} \eta_{k'} = 0 \]

\[ -U_c + U_g + \frac{u_c - u_g}{u_{cc}} \eta_{b'} = 0 \]

where
\[
\eta_{k'} = u_{cc} + \beta u'_{c,c'}(C'_{k'} + C'_{k''}k''_{k'} + C'_{b'}b''_{k'})[1 + (1 - \tau'(b', k'))(f_k(k') - \delta)] + \\
\beta u'_{c,c'}(1 - \tau'(b', k'))f_{k'k'}(f_k(k') - \delta),
\]
\[
\eta_{\nu} = u_{cc} + \beta u'_{\nu,c'}(C'_{b'} + C'_{k''}k''_{b'} + C'_{\nu'}b''_{b'})[1 + (1 - \tau'(b', k'))(f_k(k') - \delta)] + \\
-\beta u'_{\nu,c'}(f_k(k') - \delta).
\]

C. Proofs

Derivation of the Necessary Optimality Conditions for the Definition of Markov Perfect Equilibrium (25), and (26)

From the household’s optimization problem

\[
u_c(c(b, k)) = \beta u'_{c,c'}(c(b', k'))[1 + (1 - \tau')(f_k(k') - \delta)].
\]

From the government optimization problem:

\[
[b'] : \quad U_g(G_{\nu'} - \tilde{g}_{\nu'}) + U_{\tilde{g}_{\nu'}} - \beta V'_{k'}G_{\nu'} + \beta V'_{b'} = 0,
\]
\[
[\tau] : \quad U_gG_{\tau} - \beta V'_{k}G_{\tau} = 0,
\]
\[
[\tilde{g}] : \quad U_g - U_{\tilde{g}} = 0,
\]

\[
[b'] : \quad U_gG_{b'} - \beta V'_{k'}G_{b'} + \beta V'_{b'} = 0,
\]
\[
[\tau] : \quad (U_g - \beta V'_{k'})G_{\tau} = 0.
\]

From the feasibility constraint, the case of positive private consumption requires: \(G_{\tau} \neq 0\).

Combining with the Envelope Theorem:

\[
V_k = U_cC_k + U_g(G_k - \tilde{g}_k) + U_{\tilde{g}}\tilde{g}_k + \beta V'_{k'}(1 + f_k - \delta - C_k - G_k) + \beta V'_{b'}b'_k = \\
U_cC_k + U_gG_k + U_{\tilde{g}}G_{\tilde{g}}b'_k + \beta V'_{k'}(1 + f_k - \delta - C_k - G_k) - \beta V'_{b'}G_{b'}b'_k + \beta V'_{b'}b'_k = \\
U_cC_k + U_gG_k + \beta V'_{k'}(1 + f_k - \delta - C_k - G_k) + U_{\tilde{g}}G_{\tilde{g}}b'_k - \beta V'_{k'}G_{b'}b'_k + \beta V'_{b'}b'_k = 0 \text{ from f.o.c.}
\]
\[
V_b = U_c C_b + U_g G_b + \beta V_{k'}'(-C_b - G_{bV}) + U_g G_{bV}' b'_b - \beta V_{k'}' G_{bV} b'_b + \beta V_b' b'_b,
\]

\[
V_k = U_c C_k + U_g G_k + \beta V_{k'}'(1 + f_k - \delta - C_k - G_k),
\]

\[
V_b = U_c C_b + U_g G_b + \beta V_{k'}'(-C_b - G_b).
\]

Forward the latter two equations one period, and plugging the government optimality conditions:

\[
V_{k'}' = 0,
\]

\[
\beta V_{k'}' = U_g,
\]

obtain the Generalized Euler Equations (25)\[\blacksquare\].

**Proof of Proposition 1:**

Using conclusions of Conjecture 1 from the main text, the generalized Euler and Euler equations at steady state may be simplified to:

\[
U_g = \beta \left( U_c C_k + U_g (1 + f_k - \delta - C_k) \right),
\]

\[
1 = \beta (1 + (1 - \tau)(f_k - \delta)).
\]

Thus the equalities that must be satisfied at optimum, with imposed steady state condition \(k = k', b = b'\) are:

\[
U_g = \beta \left( U_c C_k + U_g (1 + f_k - \delta - C_k) \right),
\]

\[
1 = \beta (1 + (1 - \tau)(f_k - \delta)),
\]

\[
f(k) = \delta k + c + G,
\]

\[
G = \tau (f(k) - \delta k + (f_k - \delta)b) - (f_k - \delta)b.
\]

Or

\[
U_g(f(k) - \delta k - c) = \beta \left( U_c C_k + U_g (f(k) - \delta k - c)(1 + f_k - \delta - C_k) \right),
\]

\[
1 = \beta (1 + (1 - \tau)(f_k - \delta)),
\]

\[
f(k) - \delta k - c = \tau (f(k) - \delta k + (f_k - \delta)b) - (f_k - \delta)b.
\]
These three equations define $k$, $b$, $c$, $\tau$ at the steady state. Given that at the steady state with distorting taxation private consumption is a function of one variable - physical capital, and given that marginal property to consume for this economy is defined as $C_k$, $0 < C_k < 1$, and is positively related to the derivative of private consumption with respect to physical capital: $C_k = C_k a k^{-a-1}$, the following inequality holds:

$$C_k = C_k(k) > 0.$$ 

Therefore, given level of public corruption $\bar{\gamma}$,

$$U_g(f(k) - \delta k - C(k)) = \beta \left( U_z(C(k))C_k + U_g(f(k) - \delta k - C(k))(1 + f_k - \delta - C_k) \right),$$

$$f(k) - \delta k - C(k) = (1 - \frac{1 - \beta}{\beta(f_k - \delta)})(f(k) - \delta k + (f_k - \delta)b) - (f_k - \delta)b.$$ 

Define a system of two equations in two unknowns: $k$ and $b$.

Plugging the functional forms of utility:

$$\varphi \Gamma / (f(k) - \delta k - C(k)) = \beta / (1/(C(k))C_k + \varphi \Gamma / (f(k) - \delta k - C(k))(1 + f_k - \delta - C_k)),$$

$$f(k) - \delta k - C(k) = (1 - \frac{1 - \beta}{\beta(f_k - \delta)})(f(k) - \delta k + (f_k - \delta)b) - (f_k - \delta)b.$$ 

Consider the first equation:

$$\varphi \Gamma C(k) = \beta (C_k(k)(f(k) - \delta k - C(k)) + \varphi \Gamma C(k)(1 + f_k(k) - \delta - C_k(k))),$$

which implicitly defines physical capital as a function of level of public corruption:

$$F(\bar{\gamma}, k(\bar{\gamma})) = \varphi \Gamma C(1 - \beta(1 + f_k - \delta - C_k)) - \beta C_k(f(k) - \delta k - C) = 0.$$ 

Applying implicit function theorem:

$$\frac{dk}{d\bar{\gamma}} = -\frac{\varphi \Gamma C(1 - \beta(1 + f_k - \delta - C_k))}{\varphi \Gamma C_k(1 - \beta(1 + f_k - \delta - C_k)) - \varphi \Gamma C \beta (f_k - C_k - \beta C_k(k)(f(k) - \delta k - C) - \beta C_k(f_k - \delta - C_k))}$$

From Lemma 1 in the main text, and using definition of $\Gamma$, the nominator is positive.

Consider the denominator:

$$\varphi \Gamma C_k(1 - \beta(1 + f_k - \delta - C_k)) - \varphi \Gamma C \beta (f_k - C_k - \beta C_k(k)(f(k) - \delta k - C) - \beta C_k(f_k - \delta - C_k)$$

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First term is positive by assumption. Second and third terms give together:

\[-\varphi \Gamma C \beta (f_{kk} - C_{kk}) - \beta C_{kk} (f(k) - \delta k - C) =
\]
\[-\varphi \Gamma C \beta f_{kk} + \beta C_{kk} (\varphi \Gamma C - (f(k) - \delta k - C)) =
\]
\[-\varphi \Gamma C \beta f_{kk} + \beta C_{kk} (\varphi \Gamma C - G).
\]

$G$ may be expressed using the generalized Euler equation evaluated at the steady state:

\[ U_g = \beta \left( U_c C_k + U_g (1 + f_k - \delta - C_k) \right) \]

from where:

\[ G = \frac{\varphi \Gamma C (1 - \beta (1 + f_k - \delta - C_k))}{\beta C_k}. \]

Plugging this expression for $G$ back into the sum of second and third terms:

\[-\varphi \Gamma C \beta f_{kk} + \beta C_{kk} (\varphi \Gamma C - G) =
\]
\[-\varphi \Gamma C \beta f_{kk} + \beta \varphi \Gamma C C_{kk} \frac{-1 + \beta (1 + f_k - \delta)}{\beta C_k} > 0,
\]

given that the production function $f(k)$ is concave and that $-1 + \beta (1 + f_k - \delta) < 0$ (see Lemma 1) at the steady state with positive distortionary taxation.

So, the first three terms of the denominator are positive expressions. The fourth one

\[-\beta C_k (f_k - \delta - C_k) \]

is positive by assumption 1.

Therefore,

\[ \frac{dk}{d\gamma} = -\{+\} < 0, \]

that is, higher public corruption leads to lower capital accumulation and therefore lower economic growth.

Given that at the steady state consumption is a function of capital, with $C_k > 0$,

\[ \frac{dC}{d\gamma} = C_k \frac{dk}{d\gamma} < 0. \]

Given the expression defining the steady state income taxes:

\[ \tau = 1 - \frac{1 - \beta}{\beta (f_k - \delta)}, \]

\[ \frac{d\tau}{d\gamma} = \frac{(1 - \beta) f_{kk} dk}{\beta (f_k - \delta)^2 d\gamma} > 0. \]
Given the expression for public expenditures and using again assumption 1:

\[ G = f(k) - \delta k - C, \]
\[ \frac{dG}{d\gamma} = (f_k - \delta - C_k) \frac{dk}{d\gamma} > 0. \]

Finally, to find out how the steady state government debt depends on the level of corruption, consider the second equation of the system above defining \( k \) and \( b \):

\[ f(k) - \delta k - C(k) = (1 - \frac{1 - \beta}{\beta(f_k - \delta)})(f(k) - \delta k + (f_k - \delta)b) - (f_k - \delta)b. \]

or:

\[ b = \frac{\beta}{1 - \beta} \left( (1 - \frac{1 - \beta}{\beta(f_k - \delta)})(f(k) - \delta k) - (f(k) - \delta k - C) \right) \]

\[ \frac{db}{d\gamma} = \frac{\beta}{1 - \beta} \left( (f_k - \delta)(1 - \frac{1 - \beta}{\beta(f_k - \delta)}) + (f(k) - \delta k) \frac{1 - \beta}{\beta(f_k - \delta)^2} - f + \delta + C_k \right) \frac{dk}{d\gamma} > 0, \]

given that \( C_k < 1, f(k) - \delta k > k(f_k - \delta) > 0. \]

\[ \text{D. Numerical Algorithm} \]

Here the description of the global approximation method is proposed. The solution obtained by this method for the no uncertainty case does not differ significantly from the solution obtained by the local method and reported in the main text. The initial guess for the case with uncertainty is taken from the steady approximation by the local method.

The system (25), and (26) is approximated globally by Galyorkin projection method around the steady state in a number \( n \times n \times n \) of grid points.

The unknown functions are approximated by three-dimensional Chebyshev polynomials of second order:

\[ c_t = \Psi^1(b_t, k_t, s_t), \quad \tau_t = \Psi^2(b_t, k_t, s_t), \quad b_{t+1} = \Psi^3(b_t, k_t, s_t), \]

where \[ \Psi^J(b_t, k_t) = \sum_{i=0}^{n_1} \sum_{j=0}^{n_2} \sum_{h=0}^{n_3} a^J_{ijh} T_i(b_t)T_j(k_t)T_h(s_t), \quad J = c, \tau, b, \]

\[ T_0(b_t) = 1, T_1(b_t) = b_t, T_2(b_t) = 2b_tT_1(b_t) - T_0(b_t), \quad J = 2, \ldots, \]
on the grid \([b_t; k_t; s_t]: [b_{ss} \pm 0.1b_{ss}; k_{ss} \pm 0.1k_{ss}; [A - 3\sigma_A; A + 3\sigma_A]],\) where \(\sigma_A = \frac{\sigma}{\sqrt{1 - \rho^2}}\), with polynomials evaluated on the grid rescaled to zeros of Chebyshev polynomials. The unknown coefficients \(a^J, J = c; \tau; b,\) are found by imposing the requirement that the system of optimality conditions holds exactly on the \(n \times n \times n\) grid points. Expectations appearing in the Euler and generalized Euler equations are approximated by Gauss-Hermite quadrature. The accuracy check relies on the calculation of the Euler equation errors which lie (for the no uncertainty case) in the interval \((10^{-5}; 10^{-14})\) and their sign alternates between positive and negative.