Government time preferences and national debt

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Abstract

Democracy restricts the tenure of influential policymakers, rendering political time horizons shorter than those of ordinary market participants. This feature gives rise to a discrepancy between the government's time rate of discount and the market interest rate, inducing budget a deficit bias. Governments for which this discrepancy exceeds a certain cut-off level will drive their economies to insolvency. The presence of risk premium mitigates the insolvency prospects by increasing the range of government's discount rates at which the economy remains solvent, while economic growth exacerbates insolvency prospects by decreasing this range.

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1 Introduction

The average gross national debt of advanced economies currently exceeds 100 percent of GDP, following a rise from about 40 percent three decades ago (IMF 2013). The literature offers a variety of explanations. One explanation views the government budget as a common pool exploited by competing groups of voters and the political failure resembles the market failure that prevails in the exploitation of common-pool resources (see Weingast et al. 1981, Velasco 2000, Krogstrup and Wyplosz 2010). Other explanations include debt as a strategic device used by the incumbent party to limit the range of policies available to another party when it resumes power, intergenerational redistribution motives, intra-generational distribution conflicts, and various forms of voters-politicians interaction (see Persson and Svensson 1989, Alesina and Tabellini 1990, Persson and Tabellini 1999, Drazen 2000, and references therein).

This work shows that excessive government impatience, as measured by the discrepancy between the government's time rate of discount and the interest rate at which the government borrows, is a potent driver of systematic budget deficit bias. Far from being coincidental, this discrepancy stems from short time horizons of politicians inherent in democratic systems, as crisply explained in:

> Politicians themselves have, for the most part, short time horizons. For most of them, each election presents a critical point, and the primary problem they face is getting past this hurdle. ...... This is not to say that politicians never look beyond the next election in choosing courses of action, but only that such short-term considerations dominate the actions of most of them. Such features are, of course, an inherent and necessary attribute of a democracy. But when this necessary attribute is mixed with a fiscal constitution that does not restrain the ordinary spending and deficit creating proclivities, the result portends disaster. (Buchanan and Wagner

1977, p. 166.)

Empirical evidence on the link between political time horizons and public debt is reported in Roubini and Sachs (1989) and Grilli et al. (1991). The former constructed an indicator of political fragmentation in a group of OECD countries, based on the number of parties, and found that government tenure significantly affects public debt. The latter found that longer-lived governments have smaller deficits. This link persists in time, as the following figure reveals. The figure plots gross national debt (as % of GDP) in 2012 against average government tenure for 24 advanced economies. The purpose of this work is to explain the underlying mechanism.

Figure 1: Gross national debt in 2012 (% GDP) against average government tenure for 24 advanced democracies. Average government tenure is calculated based on DPI2012's data (Keefer, 2012); gross national debt data are taken from IMF's World Economic Outlook Database, October 2013 (the data are listed in Appendix A).

Time preferences are parsimoniously modeled as discount rates and a government's time rate of discount is inversely related to the length of the period it expects to hold power. A glance at Figure 1 reveals that, in advanced democracies, this period rarely exceeds 10 years – shorter than the planning horizons of ordinary market participants. As a result, governments' discount rates often exceed market interest rates. We show how this discrepancy generates a budget deficit bias and the ensuing public debt buildup. Moreover, if the government's time rate of discount exceeds the market interest rate at which it borrows by a certain margin, debt will reach the insolvency bound at a *finite time*.

Risk premium, demanded by concerned creditors at high debt-to-GDP ratio, mitigates the budget deficit bias for the simple reason that it increases the interest rate at which the government borrows, thus shrinking the gap from the government's time rate of discount. Economic growth, on the other hand, often exacerbates debt accumulation. The reason is that growth alters borrowing incentives in a way that motivates transfers from (wealthier) future generations to the present. As a result, the bound on the discrepancy between the government's time rate of discount and the interest rate (on its debt) above which the country is doomed to become insolvent changes in such a way that, ceteris paribus, a growing economy is more likely to reach the insolvency bound than its stationary counterpart.

If the government's discount rate is smaller than the market interest rate, the country becomes a net saver, eventually reaching an (exogenous) excessive saving limit. If the discount rate neither falls below the market interest rate nor exceeds it too much, equilibrium will be reached at a debt-to-GDP ratio between the insolvency and excessive saving bounds.

That differences in impatience across agents underlie borrowing-lending patterns is well known (see, e.g., Ljungqvist and Sargent 2004, Section 17.4). It is also known that democratically elected politicians behave more impatiently in their official role than as ordinary market participants (as the above passage explains). This work shows how the latter phenomenon drives national debt. Effects of government impatience on public debt were recently studied by Aguiar et al. (2014), focusing on the role of inflation credibility in governments' decisions to inflate away some of the debt. In the present work all economic processes are real and defaults are assumed prohibitively costly, thus not taken as a viable course of action in the future by (yet perfectly solvent) governments.

To focus sharply on effects of impatient politicians, we consider a democracy consisting of infinitely-lived, homogenous electorate and a deterministic stream of government income. The only deviation from benevolence is due to the government impatience over and above that of the representative voter, and this deviation is shown to be a potent driver of budget deficit.

The next section presents the model's basic ingredients, explains why politicians in democratic societies tend to behave more impatiently in their official role than when engaged in ordinary market transactions, and shows how this excessive impatience generates a budget deficit bias. Section 3 introduces risk premium and shows that it has a self-correcting role but may not be solvency-proof. Section 4 incorporates economic growth and shows that growth exacerbates debt buildups by motivating transfers from (wealthier) future generations to the present. Section 5 concludes and the appendix presents data (of Figure 1) and proofs.

2 The basic setup

We begin with a simple model of government spending, where the government faces an exogenous stream of income and uses it to finance its expenses, of which some are mandatory and some discretionary.[1] Let $y(t)$, $t \geq 0$, denote the discretionary part of the income stream, i.e., total income minus mandatory expenses (henceforth income and discretionary income are used interchangeably). The deterministic income flow $y(t)$ is assumed positive and fluctuates around a constant value (growth will be considered in Section 4). The value at time t of the income stream from time t onward is

$$Y(t) = \int_t^\infty y(\tau)e^{-r(\tau-t)}d\tau, \tag{2.1}$$

where r is the market interest rate facing the government, assumed constant.

The government's discretionary expenditure (budget) at time t is

$$b(t) = y(t) - x(t) \geq 0, \tag{2.2}$$

where $x(t) \leq y(t)$ is the budget surplus (if positive) or deficit (if negative). A budget $b \geq 0$ generates the instantaneous utility $u : \mathbb{R}_+ \mapsto \mathbb{R}$, satisfying

$$u'(\cdot) > 0, \quad u''(\cdot) < 0, \quad \text{and} \quad \lim_{b\to\infty} u'(b) = 0. \tag{2.3}$$

The utility $u(\cdot)$ reflects the preferences of the budget decision-makers, namely

[1]Mandatory and discretionary spending may vary from country to country, based on cultural, institutional and political considerations; see, e.g., the mandatory-discretionary breakdown of USA's 2013 budget in http://www.nytimes.com/interactive/2012/02/13/us/politics/2013-budget-proposal-graphic.html.

the country's polity, and accounts for households' (voters') preferences via their effect on elections outcomes. In a democratic society, thus, the polity's instantaneous utility will resemble that of a representative household (voter).

A budget policy $\{b(t) \geq 0, \, t \geq 0\}$ generates the payoff

$$\int_0^\infty u(b(t))e^{-\rho t}dt, \tag{2.4}$$

where ρ is the polity's time rate of discount (impatience). Unlike $u(\cdot)$, which (for reasons mentioned above) is likely to represent households' preferences, there are good reasons for ρ to exceed the market discount rate. This is so because ρ is inversely related to the government's time horizon.[2] In democracies, politicians' time horizon coincides, more or less, with the term they expect to remain in office and is substantially shorter than the horizon of ordinary market participants (see Figure 1).

The budget surpluses/deficits accumulate to form the outstanding debt $D(t)$ and the latter evolves in time according to

$$\dot{D}(t) = rD(t) - x(t). \tag{2.5}$$

A budget deficit ($x(t) < 0$) requires borrowing and the government can

[2]This property can be illustrated by the following simple example. Let T represent the (random) time remaining in office and suppose that T is distributed exponentially (with a constant hazard rate m): $F_T(t) = 1 - e^{-mt}$ with $E\{T\} = 1/m$. Let ρ_0 be the representative household's utility discount rate. Assuming that the polity's utility is $u(b(t))$ while in office and zero otherwise, its objective is

$$E\left\{\int_0^T u(b(t))e^{-\rho_0 t}dt\right\} = \int_0^\infty u(b(t))e^{-\rho t}dt,$$

where E is expectation with respect to T and $\rho = \rho_0 + m = \rho_0 + 1/E\{T\}$.

borrow freely at the market rate r as long as

$$D(t) \leq Y(t). \tag{2.6}$$

If (2.6) is violated, the country's net worth

$$W(t) = Y(t) - D(t) \tag{2.7}$$

becomes negative. Now, $W(t)$ satisfies

$$W(t+s) \leq e^{rs} W(t), \ s \geq 0, \tag{2.8}$$

equality holding if the entire income is used to service the debt from time t onward (i.e., $x(t+\tau) = y(t+\tau)$ for all $\tau \geq 0$).[3] Thus, a negative net worth today implies that future net worths will become ever more negative and the government will not be able to pay the interest on its debt, let alone the principal, even when its entire income is allocated to service the debt now and forever. Under such circumstances, borrowing becomes impossible, as no (private) creditors will be willing to lend at any rate.

The country, thus, becomes insolvent when $W(t) = Y(t) - D(t) < 0$ and (2.6) is referred to as the insolvency constraint. Barring defaults,[4] (2.8) implies that the insolvency limit $W = 0$ is trapping, in that debt cannot be reduced below $Y(t)$ and the entire income is doomed to service the debt

[3]To verify (2.8), integrate (2.5) from t to $t+s$ to obtain $D(t+s)e^{-r(t+s)} - D(t)e^{-rt} = -\int_t^{t+s} x(\tau)e^{-r\tau}d\tau \geq -\int_t^{t+s} y(\tau)e^{-r\tau}d\tau$, where the inequality follows from $x(\tau) \leq y(\tau)$. Noting (2.1), $\int_t^{t+s} y(\tau)e^{-r\tau}d\tau = e^{-rt}\left[Y(t) - e^{-rs}Y(t+s)\right]$ and the inequality can be expressed as $e^{-rs}D(t+s) - D(t) \geq e^{-rs}Y(t+s) - Y(t)$, which noting (2.7) gives (2.8).

[4]In this work defaults are not considered a viable course of action. This is the case, for instance, when the ensuing penalty, due to retaliatory actions such as trade sanctions and expropriating of assets abroad (see Reinhart and Rogoff 2009), is prohibitively high.

forever (i.e., $b(t+\tau) = 0$ for all $\tau \geq 0$). A question arises regarding whether a, yet perfectly solvent, government (with $W(0) > 0$) will intentionally reach insolvency ($W = 0$) when it is fully aware of the consequences? The answer, it is shown below, is in the affirmative when the government's discount rate exceeds the market interest rate.

A negative debt occurs when the accumulated surpluses exceed (in current value) the accumulated deficits, in which case the country is a net lender. However, lending cannot be extended without limit (see, e.g., Ljungqvist and Sargent 2004, p. 225) and it is expedient in the present context to impose this constraint in terms of the country's net worth as

$$W(t) = Y(t) - D(t) \leq \bar{W}, \tag{2.9}$$

where the excessive saving limit $\bar{W}$ is finite.

A budget policy is feasible if $x(t) \leq y(t)$, or equivalently $b(t) \geq 0$, and $D(t) \in [Y(t) - \bar{W}, Y(t)]$ for all $t \geq 0$. The optimal policy is the feasible policy that maximizes (2.4) subject to (2.5), given $W(0) = Y(0) - D(0) > 0$. Let $W^*(t)$, $t \geq 0$, represent the optimal net worth process and $D^*(t) = Y(t) - W^*(t)$ the corresponding debt path.

Define

$$\hat{W} = \begin{cases} \bar{W} & \text{if } \rho < r \\ W(0) = Y(0) - D(0) & \text{if } \rho = r \\ 0 & \text{if } \rho > r \end{cases} \cdot \tag{2.10}$$

Then (see proof in Appendix C):

Proposition 1. *Suppose (2.3) holds. Then: (i) $W^*(t)$ converges monoton-*

ically to a steady state at $\hat{W}$ from any initial state $W(0) \in (0, \bar{W}]$. (ii) If $\rho < r$, the steady state $\bar{W}$ will be reached at a finite time. (iii) If $\rho = r$, the steady state is entered instantly (at the initial time) and the optimal policy is to maintain the constant budget $b = rW(0)$. (iv) If $\rho > r$, the country is doomed to reach the insolvency limit $\hat{W} = 0$ at a finite time or asymptotically (as $t \to \infty$), depending one whether $u'(0)$ is finite or infinite, respectively.

The interest rate r reflects the time preferences of market participants, in that in equilibrium it equals the utility discount rate of a representative household (Ramsey 1928). A case can be made for a benevolent polity that freely chooses the discount rate to set $\rho = r$. The optimal policy in this case is to maintain a constant budget $b(t) = b = rW(0) = r[Y(0) - D(0)]$. Thus, recalling that $x(t) = y(t) - b(t)$, when income is low (during recession periods), $x(t)$ is appropriately reduced by borrowing and running a budget deficit, and during boom periods a surplus $x(t) > 0$ occurs. This property stems from the diminishing marginal utility of budget, which operates to smooth out the budget trajectory over time (Barro 1979).

The case $\rho > r$ occurs when the government's time horizon is shorter than the planning horizon of (most) market participants. In this case the country is doomed to reach the insolvency limit $W = 0$. Moreover, when $u'(0)$ is finite (a likely property given that the government income is net of the mandatory spending), the insolvency brink will be reached at a finite time.

3 Risk premium

In actual practice, a government will encounter difficulty borrowing at the riskless rate r long before it reaches a zero net worth. As soon as investment in the country's debt is perceived by potential creditors as not perfectly safe, they will demand a premium above the riskless rate. Consequently, the interest rate at which the government borrows includes a risk premium that depends on the debt-income ratio (see Schmitt-Grohé and Uribe 2003, for an explanation and possible specification). To simplify the presentation, a constant income stream $y(t) = y$ is assumed. Normalizing y to unity implies that the surplus/deficit $x(t)$, the budget $b(t) = 1 - x(t)$ (cf. equation (2.2)), and the ensuing debt $D(t)$ are all measured as income shares (in this section, "debt" and "debt-income ratio" are used interchangeably).

The government borrows by issuing short-term bonds whose price includes a risk premium, denoted h, that depends on the debt-income ratio. As long as $D(t)$ does not exceed some critical income share, no risk is perceived (by potential lenders) and $h = 0$. Above this threshold, h increases at an increasing rate. Without loss of generality, the threshold debt above which the risk premium is positive is assumed zero. Thus, $h(\cdot)$ satisfies

$$h(D) = 0 \ \text{ for } D \leq 0; \ \ h'(D) > 0 \text{ and } h''(D) > 0 \ \text{ for } D > 0. \tag{3.1}$$

The function $h(\cdot)$ varies from country to country and reflects (potential lenders) beliefs of the risk associated with servicing the debt.

The interest cost of a debt D is $[r + h(D)]D$ and debt evolves in time according to

$$\dot{D}(t) = [r + h(D(t))]D(t) - x(t). \tag{3.2}$$

Let $\bar{D}$ be the debt level satisfying

$$[r + h(\bar{D})]\bar{D} = 1. \tag{3.3}$$

Since $x(t) \leq 1$ (recalling the normalization $y = 1$), at debt level $\bar{D}$, the interest cost $[r + h(\bar{D})]\bar{D}$ consumes the entire income and any increase in debt above $\bar{D}$ implies that the debt will increase indefinitely (the right-hand side of (3.2) remains positive even when $x(t) = 1$), in which case the government becomes insolvent. In actual practice, as soon as debt reaches $\bar{D}$, borrowing becomes impossible (no lender will be found), implying that

$$D(t) \leq \bar{D}. \tag{3.4}$$

The insolvency bound $\bar{D}$ is trapping in that once the debt-income ratio reaches $\bar{D}$, the government must allocate the entire income to cover the interest cost now and forever. Will a perfectly solvent government reach the insolvency limit $\bar{D}$ while acting optimally when it is fully aware of the consequences? The answer, it is shown below, is in the affirmative but it requires a more impatient government than in the riskless case: the polity's impatience rate ρ should exceed the risk-adjusted interest rate $r + \psi(\bar{D})$, where $\psi : [\underline{D}, \bar{D}] \mapsto \mathbb{R}_+$, defined by

$$\psi(D) = h(D) + h'(D)D, \tag{3.5}$$

is the marginal risk premium cost.

A negative debt means that the country is a net lender and the lower bound $\underline{D} = (Y - \bar{W})/y \leq 0$ applies (see discussion of $\bar{W}$ above equation (2.9)), i.e.,

$$D(t) \geq \underline{D}\,. \tag{3.6}$$

The budget management problem can be formulated as

$$\max_{x(t)\leq 1} \int_0^\infty u(1-x(t))e^{-\rho t}dt \tag{3.7}$$

subject to (3.2) and $D(t) \in [\underline{D}, \bar{D}]$, given $D(0) \in [\underline{D}, \bar{D})$. Define

$$\hat{D} = \begin{cases} \underline{D} & \text{if } \rho < r \\ \min(D(0), 0) & \text{if } \rho = r \\ \psi^{-1}(\rho - r) \in (0, \bar{D}] & \text{if } r < \rho \leq r + \psi(\bar{D}) \\ \bar{D} & \text{if } \rho > r + \psi(\bar{D}) \end{cases} \tag{3.8}$$

where $D(0)$ is the initial debt. The optimal debt process $D^*(t)$ is characterized in the following proposition (the proof is presented in Appendix D):

Proposition 2. *Suppose (2.3) and (3.1) hold. Then: (i) $D^*(t)$ converges monotonically to a steady state at $\hat{D}$ from any initial debt $D(0) \in [\underline{D}, \bar{D})$. (ii) If $\rho < r$, the steady state $\hat{D} = \underline{D}$ will be reached at a finite time. (iii) If $\rho = r$ then: if $D(0) \leq 0$, the steady state $\hat{D} = D(0)$ is entered instantly; if $D(0) > 0$, the steady state $\hat{D} = 0$ will be reached asymptotically (as $t \to \infty$). (iv) If $r < \rho \leq r + \psi(\bar{D})$, the steady state $\hat{D} = \psi^{-1}(\rho - r) \in (0, \bar{D}]$ will be reached asymptotically. (v) If $\rho > r + \psi(\bar{D})$, the insolvency limit $\hat{D} = \bar{D}$ will be reached at a finite time or asymptotically as $u'(0)$ is finite or infinite, respectively.*

As expected, the risk premium plays no role when $\rho < r$, in which case debt is negative (or will eventually turn negative) and the risk premium vanishes. When $\rho \geq r$, the risk premium effects are pronounced. Consider first the case $\rho = r$, where the polity's impatience ρ coincides with the riskless market rate

r. In this case, no debt with a positive risk (i.e., $h(D) > 0$) will prevail in the long-run. If the initial debt is nonpositive, the optimal policy is to retain debt at its initial level (by running a balanced budget). If the initial debt $D(0)$ is positive, debt will be gradually reduced, approaching zero asymptotically (as $t \to \infty$).

When $\rho > r$, the equilibrium debt is positive, but as long as $\rho < r + \psi(\bar{D})$, debt will not reach the insolvency limit $\bar{D}$. If $\rho \geq r + \psi(\bar{D})$, the equilibrium debt equals the insolvency limit $\bar{D}$ and insolvency will be reached at a finite time if the inequality is strong ($\rho > r + \psi(\bar{D})$) and $u'(0)$ is finite (since the discretionary income is net of the mandatory expenses, a finite $u'(0)$ is plausible).

Comparing with the results of Section 2, it is seen that the risk premium function $h(\cdot)$ mitigates the tendency of politicians to drive their country to the brink, in that the critical polity's discount rate ρ above which the country will sooner or later reach the insolvency limit is higher with risk premium than without. As a market phenomenon, the risk premium is thus a self-correcting mechanism, though may not be solvency-proof.

4 Growth

We turn now to examine effects of exogenous economic growth on public debt buildup.[5] Suppose the economy grows at a constant rate $g > 0$:

$$y(t) = e^{gt}, \tag{4.1}$$

[5]There may also be a causality link running from debt to growth (see Reinhart et al. 2012), which is not considered here.

where the normalization $y(0) = 1$ is used. Total debt is $D(t)$ and

$$d(t) = D(t)e^{-gt} \tag{4.2}$$

is the debt-income ratio. Likewise, $b(t)$ and $x(t)$ represent, respectively, the budget and surplus/deficit at time t, expressed as income shares, so the total budget is $b(t)e^{gt}$, the total surplus/deficit is $x(t)e^{gt}$ and $b(t) = 1 - x(t)$.

The risk premium function $h(\cdot)$ is the same as in the stationary case (specified in (3.1)), with the debt-income ratio d as its argument:

$$h(d) = 0 \ \text{ for } \ d \leq 0; \ h'(d) > 0 \ \text{ and } \ h''(d) > 0 \ \text{ for } \ d > 0. \tag{4.3}$$

The interest cost associated with a (total) debt $D(t)$ is $[r_g + h(d(t))]D(t)$ and $D(t)$ evolves in time according to

$$\dot{D}(t) = [r_g + h(d(t))]D(t) - x(t)e^{gt}, \tag{4.4}$$

where r_g is the (riskless) interest rate (which may differ from its stationary economy counterpart r, hence the subscript g). Differentiating (4.2) with respect to time, using (4.4), gives

$$\dot{d}(t) = [r_g - g + h(d(t))]d(t) - x(t). \tag{4.5}$$

Noting (4.5), the insolvency limit $\bar{d}$ of the debt-income ratio is defined by

$$[r_g - g + h(\bar{d})]\bar{d} = 1. \tag{4.6}$$

Since $x(t) \leq 1$, when $d(t) = \bar{d}$, the interest payments consume the entire income and any debt above $\bar{d}$ will increase without bound. Thus, no borrowing is possible at $\bar{d}$ (no lender will be found) and

$$d(t) \leq \bar{d}. \tag{4.7}$$

A negative d occurs when the country becomes a net lender. In a growing global economy, potential lending increases at the rate g and equals $\underline{D}e^{gt}$, where $\underline{D} = (Y - \bar{W})/y$ (see equation (3.6)). Thus,

$$d(t) \geq \underline{d} = \underline{D}. \tag{4.8}$$

The utility flow generated by the budget $(1 - x(t))e^{gt}$ takes the isoelastic form

$$\frac{((\zeta + 1 - x(t))e^{gt})^{1-\eta} - 1}{1 - \eta} = \frac{(\zeta + 1 - x(t))^{1-\eta} e^{-(\eta-1)gt} - 1}{1 - \eta}$$

where $\eta > 0$ is the elasticity of marginal utility (the inverse of the intertemporal elasticity of substitution) and $\zeta \geq 0$ is a nonnegative parameter.[6] (The logarithmic form is used when $\eta = 1$.) The payoff is

$$\int_0^\infty \frac{(\zeta + 1 - x(t))^{1-\eta}}{1 - \eta} e^{-(\rho + (\eta - 1)g)t} - \frac{1}{(1 - \eta)\rho} \ ,$$

which, using

$$u(b) = \frac{(\zeta + b)^{1-\eta}}{1 - \eta} \tag{4.9}$$

[6]The role of ζ is to allow a violation of the Inada condition $\lim_{b \to 0} u'(b) = \infty$, which is plausible when b represents discretionary budget.

and ignoring the constant term, can be expressed as

$$\int_0^\infty u(1 - x(t))e^{-(\rho+(\eta-1)g)t}. \tag{4.10}$$

A feasible budget policy satisfies $x(t) \leq 1$ at all times. The optimal policy is the feasible policy that maximizes (4.10) subject to (4.5) and $d(t) \in [\underline{d}\,, \bar{d}]$, given $d(0) \in [\underline{d}\,, \bar{d})$.

The marginal cost of risk corresponding to $d(t)$ is

$$\psi(d) = h(d) + h'(d)d. \tag{4.11}$$

Define $\hat{d}$ by:

$$\hat{d} = \begin{cases} \underline{d} & \text{if } \ \rho < r_g - \eta g \\ \min(d(0), 0) & \text{if } \ \rho = r_g - \eta g \\ \psi^{-1}(\rho + \eta g - r_g) \in (0, \bar{d}] & \text{if } \ r_g - \eta g < \rho \leq r_g - \eta g + \psi(\bar{d}) \\ \bar{d} & \text{if } \ \rho > r_g - \eta g + \psi(\bar{d}) \end{cases} \tag{4.12}$$

The optimal debt process $d^*(t)$ is characterized in (the proof is presented in Appendix E):

Proposition 3. *Suppose (4.3) and (4.9) hold. Then:* (i) *$d^*(t)$ converges monotonically to a steady state at $\hat{d}$ from any initial debt $d(0) \in [\underline{d}, \bar{d})$.* (ii) *If $\rho < r_g - \eta g$, the steady state $\hat{d} = \underline{d}$ will be reached at a finite time.* (iii) *If $\rho = r_g - \eta g$ then: if $d(0) \leq 0$, the steady state $\hat{d} = d(0)$ is entered instantly; if $d(0) > 0$, the steady state $\hat{d} = 0$ will be reached asymptotically (as $t \to \infty$).* (iv) *If $r_g - \eta g < \rho \leq r_g - \eta g + \psi(\bar{d})$, the steady state $\hat{d} = \psi^{-1}(\rho + \eta g - r_g) \in (0, \bar{d}]$*

will be reached asymptotically. (v) *If* $\rho > r_g - \eta g + \psi(\bar{d})$, *the insolvency limit* $(\hat{d} = \bar{d})$ *will be reached at a finite time or asymptotically as* $\zeta > 0$ *(*$u'(0)$ *is finite) or* $\zeta = 0$ *(*$u'(0)$ *explodes) , respectively.*

Comparing with the results of the stationary case (Section 3), economic growth affects insolvency prospects in two ways. First it changes the (riskless) interest rate from r to r_g. Second, it changes the condition characterizing the equilibrium debt-income ratio $\hat{d}$ (note, in particular, the conditions under which the insolvency limit is reached, i.e., $\hat{d} = \bar{d}$). The equilibrium interest rate satisfies (Ramsey 1928) $r_g = \rho_0 + \eta g$, thus $r_g = r + \eta g$, where r is the equilibrium interest rate in a stationary economy ($g = 0$) and ρ_0 is the representative household's utility discount rate. Substituting $r_g = r + \eta g$ in (4.6) and comparing with (3.3), one verifies that $\bar{d} < \bar{D}$ if $\eta > 1$, $\bar{d} = \bar{D}$ if $\eta = 1$ and $\bar{d} > \bar{D}$ if $\eta < 1$.

A stationary economy is doomed to reach the insolvency limit $\bar{D}$ when $\rho > r + \psi(\bar{D})$ (Proposition 2(v)). The corresponding condition for a growing economy, according to Proposition 3(v), is $\rho > r_g - \eta g + \psi(\bar{d}) = r + \psi(\bar{d})$. Thus, the effect of growth on insolvency prospects boils down to the relation between $\psi(\bar{D})$ and $\psi(\bar{d})$. In particular, $\eta > 1$ implies $\bar{d} < \bar{D}$ and $\psi(\bar{d}) < \psi(\bar{D})$, in which case growth exacerbates the insolvency prospects by lowering the upper bound on the polity's discount rate ρ above which reaching the insolvency limit is inevitable. When $r + \psi(\bar{d}) < \rho < r + \psi(\bar{D})$, the same polity will drive a growing economy ($g > 0$) to the insolvency brink but will retain a stationary economy ($g = 0$) perfectly solvent. This situation is depicted in Figure 2.

The explanation for this result rests on the role of η as a measure of aversion to intergenerational inequality. The introduction of growth means that

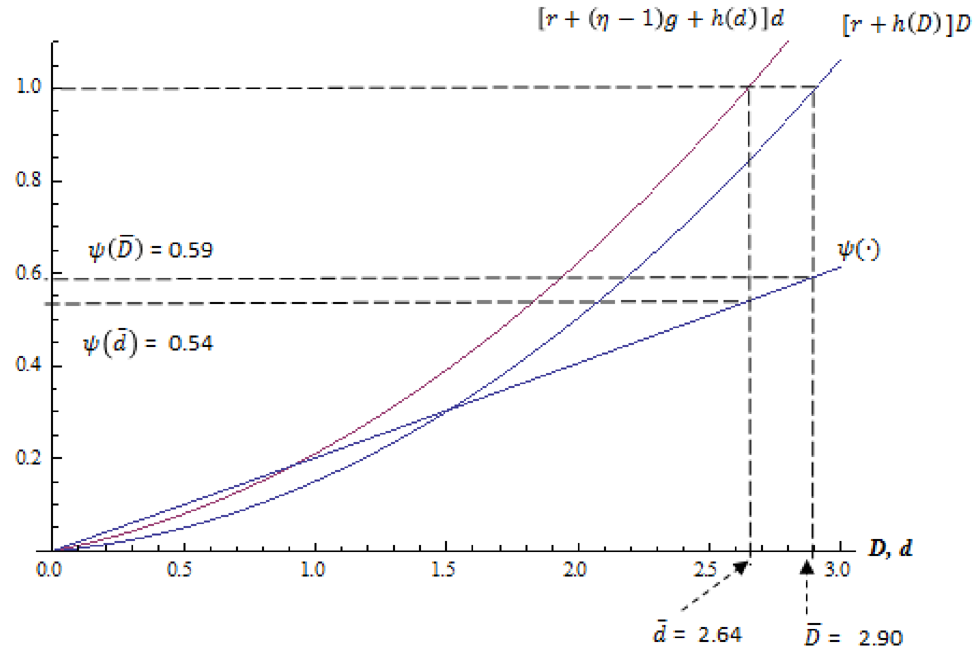

Figure 2: The curves $[r+h(D)]D$ and $[r+(\eta-1)g+h(d)]d$ correspond to stationary and growing economies, respectively, with an exponential $h(\cdot)$ and parameters $r = 0.05$, $\eta = 4$ and $g = 0.02$. $\bar{D}$ and $\bar{d}$ solve, respectively, $[r + h(\bar{D})]\bar{D} = 1$ and $[r + (\eta-1)g + h(\bar{d})]\bar{d} = 1$, giving $\bar{D} = 2.90 > \bar{d} = 2.64$ and $\psi(\bar{D}) = 0.59 > \psi(\bar{d}) = 0.54$. A polity with a discount rate ρ that falls between $r+\psi(\bar{d})$ and $r+\psi(\bar{D})$, i.e., $0.59 < \rho < 0.64$, would drive the growing economy to the insolvency limit $\bar{d}$ at a finite time but retain the stationary economy perfectly solvent (below $\bar{D}$).

future generations will be richer, and high aversion to intergenerational inequality (high η) induces redistribution from (wealthier) future generations to the present; such a redistribution, which takes the form of borrowing, pushes an economy further towards the insolvency limit. The magnitude of η is a subtle (and contested) issue (see Stern 2008, and references cited therein); empirical evidence suggests $\eta > 1$ (Hall 1988).

5 Concluding comments

Observed debt processes in advanced democracies attest to a systematic budget deficit bias and the literature identifies a number of culprits. This work focused on the role of short time horizon of politicians relative to that of ordinary market participants, which gives rise to a discrepancy between the government time rate of discount and the interest rate at which the government borrows. It was found that (i) this discrepancy gives rise to a budget deficit bias and above a certain cut-off level portends insolvency, (ii) the presence of a risk premium (that depends on the debt-to-GDP ratio) mitigates insolvency prospects, and (iii) economic growth exacerbates debt buildup by motivating transfer from (wealthier) future generations to the present.

A question arises as to why voters put up with (i.e. elect and re-elect) deficit prone politicians. Indeed, recent literature models political processes as a dynamic game between voters and politicians in a variety of situations (Battaglini and Coate 2008, Yared 2010, Song et al. 2012, and references they cite). Within this framework, Lizzeri (1999) showed that in some situations rational voters reward myopic politicians, i.e., vote for candidates that credibly commit (if elected) to a myopic redistribution of resources. The underlying cause of this result is the uncertain election outcome, which indirectly affects to shorten political horizons. The possibility that policy myopia prevails in an equilibrium of a game played between voters and political candidates has also been demonstrated by Aidt and Dutta (2007). These authors distinguish between short-term and long-term public spending and define a policy that is biased (relative to some social reference) towards short-term public investment as myopic. Aidt and Dutta (2007), then, characterize the conditions under which rational voters allow for policy myopia. While mechanisms that limit the election probability of opportunistic politicians have been proposed (see Gersbach 2004), incorporating such mechanisms within election processes in actual practice remains a challenge.

A more direct response to chronic budget deficits has been the use of deficit and debt limits, such as the European Union's Stability and Growth Pact (SGP) and the United States' debt ceiling. The deterrence role of such limits is questionable when they can easily be relaxed.[7] A partial remedy to this time-inconsistency problem entails the use of supernational ceiling rules, such as the SGP or IMF-imposed rules, that are beyond the scope of individual governments (see Krogstrup and Wyplosz 2010). This approach is straightforward when international arrangements already exist but could be harder to implement from scratch only for the purpose of imposing budget discipline.

Another response to the budget deficit bias is to exploit the capacity of democracy in transparency and information disclosure. Legislations with detrimental budgetary impacts could be evaluated and disclosed to the public by an independent, unbiased agency, inducing lawmakers to reconsider before casting their vote. Examples include the "Wisepersons' committees to inform the general public," in Denmark, Sweden and the Netherlands (see Krogstrup and Wyplosz 2010) and Israel's Posterity's Commission ('*Netzivut Ha'dorot Ha'baim*') formed by the Knesset (parliament) in order to monitor impacts on future generations of legislative processes (regrettably, this commission was abolished in 2010).

Delegation of certain responsibilities to professional civil servants (e.g., the

[7] This is an example of the "rules vs.discretion" dilemma (Kydland and Prescott 1977), where optimal policies are time-inconsistent and time-consistent policies are suboptimal. In the present context, external ex-ante rules are updated ex-post by short-sighted politicians.

authority to set monetary policy) is a common response to political failure in general and short-termism in particular. Fiscal policy is arguably the most pronounced manifestation of political priorities and should be determined by elected politicians, but civil servants should have the authority to impose certain limits when a polity (borrowing from the passage in the introduction) "....does not restrain the ordinary spending and deficit creating proclivities."

Appendix

Appendix A contains the data of Figure 1 and appendixes B - E present proofs of the propositions. The proofs make use of the general results of Tsur and Zemel (2014); a detailed version is available in Tsur (2012).

A Data of Figure 1

Table A.1: The data of Figure 1. The average government tenure is the average length of chief executive terms during the period 1975-2012, calculated based on the variable YRSOFFC of the World Bank's DPI2012 Database (see Keefer 2012). This variable measures, for each year, the number of years the current chief executive has been in office and allows calculating the terms of all chief executives during 1975-2012. The gross national debt data are taken from IMF's World Economic Outlook Database, October 2013 (http://www.imf.org/external/pubs/ft/weo/2013/02/weodata/weoselgr.aspx).

	Average government tenure: 1975-2012 (years)	Gross national Debt: 2012 (% GDP)
Australia	6.33	27.86
Austria	7.00	74.08
Belgium	5.83	99.78
Canada	7.17	85.29
Switzerland	4.11	49.19
Cyprus	8.67	85.82
Germany	9.50	81.90
Denmark	5.43	45.64
Spain	6.33	85.90
Finland	4.38	53.56
France	3.17	90.23
UK	5.43	88.81
Greece	4.50	156.86
Ireland	4.11	117.40
Iceland	4.63	99.08
Israel	3.89	68.20
Italy	3.25	126.98
Japan	2.75	238.03
Netherlands	7.40	71.26
Norway	4.63	34.12
New Zealand	6.00	37.77
Portugal	3.89	123.80
Sweden	4.20	38.27
USA	5.43	102.73

B A useful property

The proofs will make use of the following property. Consider the infinite-horizon, autonomous problem

$$\max_{q(t)\in\mathcal{A}\subset\mathbb{R}} \int_0^\infty f(Q(t),q(t))e^{-\rho t}dt$$

subject to

$$\dot{Q}(t) = g(Q(t),q(t))$$

and $\underline{Q} \leq Q(t) \leq \bar{Q}$, given $Q(0) \in (\underline{Q},\bar{Q})$, where $f(\cdot,\cdot)$ and $g(\cdot,\cdot)$ satisfy properties (2.3) in Tsur and Zemel (2014). It is assumed that the problem admits an optimal solution (not necessarily unique) and there exists a function $M : [\underline{Q},\bar{Q}] \mapsto \mathcal{A}$, satisfying

$$g(Q,M(Q)) = 0\ \forall\, Q \in [\underline{Q},\bar{Q}].$$

Define $L : [\underline{Q},\bar{Q}] \mapsto \mathbb{R}$ by

$$L(Q) = \frac{f_q(Q,M(Q))}{g_q(Q,M(Q))}[\rho - g_Q(Q,M(Q))] + f_Q(Q,M(Q)), \tag{B.1}$$

where subscripts Q and q indicate, respectively, partial derivatives with respect to Q (the first argument) and q (the second argument). Then:

Property 1. (i) *The optimal* $Q(t)$ *process converges monotonically to a steady state* $\hat{Q} \in [\underline{Q},\bar{Q}]$ *from any initial* $Q(0) \in (\underline{Q},\bar{Q})$, *and* (ii)

$$\hat{Q} = \begin{cases} \bar{Q} & \text{if } L(Q) > 0\,\forall Q \in [\underline{Q},\bar{Q}] \\ L^{-1}(0) & \text{if } L(Q) \text{ crosses zero once from above on } [\underline{Q},\bar{Q}] \\ \underline{Q} & \text{if } L(Q) < 0\,\forall Q \in [\underline{Q},\bar{Q}] \end{cases}. \tag{B.2}$$

Proof. The proof of (i) is based on the observation that optimal state trajectories of (a single state) infinite-horizon, autonomous problems are monotonic. Thus, if the state is bounded, the optimal path must converge to a steady state (see Tsur and Zemel 2014). Part (ii) is a restatement of Corollary 1 of Tsur and Zemel (2014, p. 167). □

C Proof of Proposition 1

Proof. Equations (2.1), (2.2) and (2.5) give

$$\dot{W}(t) = rW(t) - b(t) \tag{C.1}$$

and the budget problem can be reformulated as

$$\max_{b(t)\geq 0} \int_0^{\infty} u(b(t))e^{-\rho t}dt \tag{C.2}$$

subject to (C.1) and $W(t) \in [0, \bar{W}]$, given $W(0) > 0$. This is an infinite-horizon, autonomous problem with a bounded state, thus, according to Property 1, $W^*(t)$ converges to a steady state $\hat{W} \in [0, \bar{W}]$. With W and b corresponding, respectively, to Q and q of Property 1, $u(b)$ and $rW - b$ corresponding, respectively, to $f(Q, q)$ and $g(Q, q)$, and $M(W) = rW$, $L(\cdot)$, defined in (B.1), specializes to

$$L(W) = u'(rW)[r - \rho]. \tag{C.3}$$

(*i*) When $\rho < r$, $L(W) > 0$ for all $W \in [0, \bar{W}]$, implying, noting (B.2), that $\hat{W} = \bar{W}$. Likewise, when $\rho > r$, $L(W) < 0 \,\forall\, W \in [0, \bar{W}]$ implies $\hat{W} = 0$.

The case $\rho = r$ requires some care, since $L(W) = 0$ for all W and equation (B.2) does not identify the steady state. Given that $W^*(t)$ converges to a steady state (Property 1(*i*)), the budget problem can be reformulated as

$$\max_{\{T, b(t)\geq 0\}} \int_0^{T} u(b(t))e^{-\rho t} + e^{-\rho T}u(\hat{b})/\rho$$

subject to (C.1) and $W(t) \in [0, \bar{W}]$, given $W(0) \in (0, \bar{W}]$, where T is the steady state entrance time and

$$\hat{b} = rW(T) \tag{C.4}$$

is the steady state budget. The current-value Hamiltonian for this problem is

$$H(t) = u(b(t)) + \mu(t)(rW(t) - b(t)),$$

where $\mu(t)$ is the current-value costate variable, and necessary conditions for (interior) optimum include

$$u'(b(t)) = \mu(t), \tag{C.5}$$

$\dot{\mu}(t) - \rho\mu(t) = -r\mu(t)$, giving

$$\mu(t) = \mu_0 e^{(\rho - r)t}, \tag{C.6}$$

and the transversality condition (associated with the choice of T)

$$e^{-\rho T}[H(T) - u(\hat{b})] = 0. \tag{C.7}$$

Now, when $\rho = r$, conditions (C.5)-(C.6) imply that $\mu(t) = \mu_0$ and $b^*(t) = b^*$, $t \in [0, T]$, where b^* is constant. Suppose $b^* \neq rW(0)$. Setting $b^* < rW(0)$ implies, noting (C.1), that $W^*(t) = e^{rt}(rW(0) - b^*)/r + b^*/r$ increases and will reach $\bar{W}$ at a finite time. Likewise, when $b^* > rW(0)$, $W^*(t)$ decreases and will reach zero at a finite time. In either case, condition (C.7) implies $H(T) - u(\hat{b}) = 0$ or

$$u(b^*) + u'(b^*)[rW(T) - b^*] - u(\hat{b}) = 0, \tag{C.8}$$

where

$$\hat{b} = \begin{cases} 0 & \text{if } W(T) = 0 \\ r\bar{W} & \text{if } W(T) = \bar{W} \end{cases}. \tag{C.9}$$

Now, when $b^* > rW(0)$, $W(T) = 0$ and $b^* > \hat{b} = 0$; when $b^* < rW(0)$, $W(T) = \bar{W}$ and $b^* < \hat{b} = r\bar{W}$. In both cases (C.8) is violated due to the strict concavity of $u(\cdot)$. Thus, $b^* \neq rW(0)$ cannot be optimal, implying that $b^* = rW(0)$ is the optimal policy, i.e., the steady state $\hat{W} = W(0)$ is entered instantly. This completes the proof of part (i).

(ii) When $\rho < r$, the steady state, according to (i) above, is $\hat{W} = \bar{W}$ and $L(\hat{W}) > 0$. In the terminology of Tsur and Zemel (2014), the steady state is *constrained* (since $L(\hat{W}) \neq 0$) and *non-essential* (since $u'(r\hat{W}) < \infty$). Proposition 4(i) of Tsur and Zemel (2014), then, implies that the steady state will be entered at a finite time.

(iii) When $\rho = r$ it was proven in part (i) above that $\hat{W} = W(0)$ and the steady state is entered instantly.

(iv) When $\rho > r$, $\hat{W} = 0$ and $L(\hat{W}) < 0$. Thus, $\hat{W}$ is a *constrained* steady state (since $L(\hat{W}) \neq 0$) and Proposition 4(i) of Tsur and Zemel (2014) implies that the steady state will be reached at a finite time or asymptotically depending on whether $u'(r\hat{W}) = u'(0)$ is finite (*non-essential*) or infinite (*essential*), respectively. $\square$

D Proof of Proposition 2

Proof. The budget Problem (3.7) is an infinite-horizon, autonomous problem with a bounded state, thus, according to Property 1(i), the optimal state trajectory $D^*(t)$ converges to a steady state $\hat{D} \in [\underline{D}, \bar{D}]$. With D and x corresponding, respectively, to Q and q of Property 1, $u(1-x)$ and $[r+h(D)]D-x$ corresponding to $f(Q,q)$ and $g(Q,q)$, and $M(\cdot)$ of Property 1 specialized to $M(D) = [r+h(D)]D$, the function $L(\cdot)$, defined in (B.1), specializes to

$$u'(1 - [r + h(D)]D)[\rho - r - \psi(D)].$$

Since $u'(1 - [r + h(D)]D) > 0$ for all $D \in [\underline{D}, \bar{D}]$, Property 1 can be applied with

$$L(D) = \rho - r - \psi(D). \tag{D.1}$$

(i) Suppose $\rho < r$. Then, recalling (3.1) and (3.5), $L(D) < 0$ for all $D \in [\underline{D}, \bar{D}]$ and (B.2) implies that the optimal steady state is $\hat{D} = \underline{D}$, as stated in (3.8).

Suppose $\rho = r$. Then, $L(D) < 0$ for $D \in (0, \bar{D}]$ implies, noting (B.2), that $\hat{D} \in [\underline{D}, 0]$. Thus, if $D(0) \leq 0$, it is known from the outset that $D^*(t)$ will remain in the interval $[\underline{D}, 0]$, over which $h(D)$ vanishes. The problem, then, reduces to a riskless problem (zero risk premium) and the proof of Proposition 1 can be repeated (with the obvious modifications) to show that $\hat{D} = D(0)$ and the steady state is entered instantly. If $D(0) > 0$, then $D^*(t)$ must decrease monotonically in order to exit the (non-steady-state) interval $(0, \bar{D}]$ and eventually will reach zero. As soon as debt equals zero, the above argument implies that the steady state has been entered, verifying the $\rho = r$ part of (3.8).

Suppose $r < \rho \leq r + \psi(\bar{D})$. Then, noting (3.1) and (3.5), $L(D) = \rho - r - \psi(D)$ is positive for $D \in [\underline{D}, 0]$ and admits a single root $\hat{D} \in (0, \bar{D}]$, which is crossed (or attained if $\rho = r + \psi(\bar{D})$) from above. Property 1(ii), then ensures that this root $\hat{D}$ is the optimal steady state. Thus, $L(\hat{D}) = \rho - r - \psi(\hat{D}) = 0$ implies $\hat{D} = \psi^{-1}(\rho - r) \in (0, \bar{D}]$, as stated in (3.8).

Suppose $\rho > r + \psi(\bar{D})$. Since $L(D) = \rho - r - \psi(D)$ is non-increasing, $L(D) > 0$ for all $D \leq \bar{D}$. Property 1(ii) then implies that $\hat{D} = \bar{D}$, verifying (3.8) for this case. This completes the proof of part (i).

(ii) When $\rho < r$, noting (i) above, $\hat{D} = \underline{D}$ and $L(\hat{D}) = \rho - r - \psi(\hat{D}) = \rho - r < 0$. Moreover, using (3.2), the steady state budget is $\hat{b} = 1 - \hat{x} = 1 - r\underline{D}$. In the terminology of Tsur and Zemel (2014), the steady state is *constrained* (since $L(\hat{D}) \neq 0$) and *non-essential* (since $u'(\hat{b})$ is finite), implying, by virtue of Proposition $4(i)$ of Tsur and Zemel (2014, p. 168), that the steady state will be entered at a finite time.

(iii) When $\rho = r$, we know from part (i) that $\hat{D} \leq 0$ and $L(\hat{D}) = \rho - r - \psi(\hat{D}) = 0$. Thus, the steady state is *unconstrained* (since $L(\hat{D}) = 0$), implying, by virtue of Tsur and Zemel (2014, Proposition 3), that the steady state entrance time is asymptotic.

(iv) When $r \leq \rho \leq r + \psi(\bar{D})$, we know from (i) that $\hat{D} = \psi^{-1}(\rho - r) \in (0, \bar{D}]$ and $L(\hat{D}) = 0$. The steady state is *unconstrained* (since $L(\hat{D}) = 0$), thus (using again Proposition 3 of Tsur and Zemel 2014) will be entered asymptotically.

(v) When $\rho > r + \psi(\bar{D})$, we know from part (i) that $\hat{D} = \bar{D}$ (the insolvency bound), $L(\hat{D}) = \rho - r - \psi(\hat{D}) > 0$ and $\hat{b} = 1 - \hat{x} = 1 - (r + \bar{D})\bar{D} = 0$ (cf. (3.3)). The steady state $\hat{D}$ is *constrained* (since $L(\hat{D}) \neq 0$) and Proposition $4(i)$ of Tsur and Zemel (2014) implies that the steady state entrance time is finite or infinite as $u'(0)$ is finite or infinite, respectively. □

E Proof of Proposition 3

Proof. The budget problem maximizing (4.10) subject to (4.5) and $d(t) \in [\underline{d}, \bar{d})$, given $d(0) \in [\underline{d}, \bar{d})$, is an infinite-horizon, autonomous problem with a bounded state, thus, according to Property $1(i)$, the optimal state trajectory $d^*(t)$ converges monotonically to a steady state $\hat{d} \in [\underline{d}, \bar{d}]$. With d and x corresponding, respectively, to Q and q of Property 1, the functions $u(1-x)$ and $[r_g - g + h(d)]d - x$ corresponding, respectively, to $f(Q, q)$ and $g(Q, q)$, $M(\cdot)$ of Property 1 specializing to $M(d) = [r_g - g + h(d)]d$, and the discount rate $\rho + (\eta - 1)g$ (instead of ρ), the $L(\cdot)$ function, defined in (B.1), specializes to

$$u'(1 - (r_g - g + h(d))d)[\rho + \eta g - r_g - \psi(d)].$$

Since $u'(1-(r_g-g+h(d))d)>0$ for all $d \in [\underline{d},\bar{d}]$, Property 1 can be applied with

$$L(d)=\rho+\eta g-r_g-\psi(d).$$

With the obvious modifications, the proof proceeds along the same steps as the proof of Proposition 2 and is therefore omitted. $\square$

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