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To shorten or to lengthen?
Public debt management
in the low interest rate
environment

**Alessandro Maravalle,
Łukasz Rawdanowicz**

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ECONOMICS DEPARTMENT

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By Alessandro Maravalle and Łukasz Rawdanowicz

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Abstract/résumé

To shorten or to lengthen? Public debt management in the low-interest rate environment

With still large government debt and interest payments in many OECD countries, actively adjusting debt maturity can help to minimise debt servicing costs. Temporarily lengthening the maturity of new debt issuance may lower debt servicing costs in the longer term and reduce rollover risks if interest rates increase gradually over a prolonged period and to a high level. However, if market interest rates increase fast and stay high, shortening debt maturity would be financially more beneficial though at the cost of higher rollover risks. Illustrative scenarios considered in this paper show that adjusting debt maturity may take several years before producing fiscal savings. They are likely to be moderate at best for most G7 countries, ranging from less than 0.1% to $\frac{1}{3}$ per cent of GDP per year on average, with the exception of Italy where they could be significantly higher. In countries where debt maturity management has small fiscal effects, lengthening the debt maturity may still be pursued to reduce rollover risks.

JEL classification codes: H63

Keywords: public debt management, yield curve, term premia

Raccourcir ou allonger les échéances?

La gestion de la dette publique dans un contexte de faiblesse des taux d'intérêt

Alors que la dette publique et les charges d'intérêts connexes demeurent importantes dans nombre de pays de l'OCDE, une gestion active de la maturité de la dette peut contribuer à minimiser le coût du service de la dette. Un allongement temporaire de l'échéance des nouveaux titres de dette émis est susceptible d'alléger le service de la dette à long terme et de réduire les risques de refinancement si les taux d'intérêt augmentent progressivement sur une période prolongée pour atteindre un niveau élevé. Néanmoins, si la hausse des taux d'intérêt est rapide, marquée et durable, il serait plus bénéfique sur le plan financier de raccourcir l'échéance des titres de dette, au prix toutefois d'un accroissement des risques de refinancement. Les scénarios présentés à titre d'illustration dans ce document montrent qu'il peut s'écouler plusieurs années avant qu'un ajustement des échéances de la dette ne se traduise par des économies budgétaires. Un tel ajustement déboucherait probablement, dans le meilleur des cas, sur des économies budgétaires modérées pour la plupart des pays du Groupe des Sept (G7), allant de moins de 0,1 point à $\frac{1}{3}$ point de PIB par an en moyenne, exception faite de l'Italie, pour laquelle elles sont plus importantes. Reste que dans les pays où la gestion du profil des échéances de la dette a des effets budgétaires limités, une stratégie d'allongement de l'échéance des titres de dette peut être mise en œuvre pour réduire les risques de refinancement.

Codes JEL : H63

Mots Clés : gestion de la dette publique, courbe de rendement, primes à terme

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TO SHORTEN OR TO LENGTHEN? PUBLIC DEBT MANAGEMENT IN THE LOW-INTEREST RATE ENVIRONMENT

By

Alessandro Maravalle and Łukasz Rawdanowicz¹

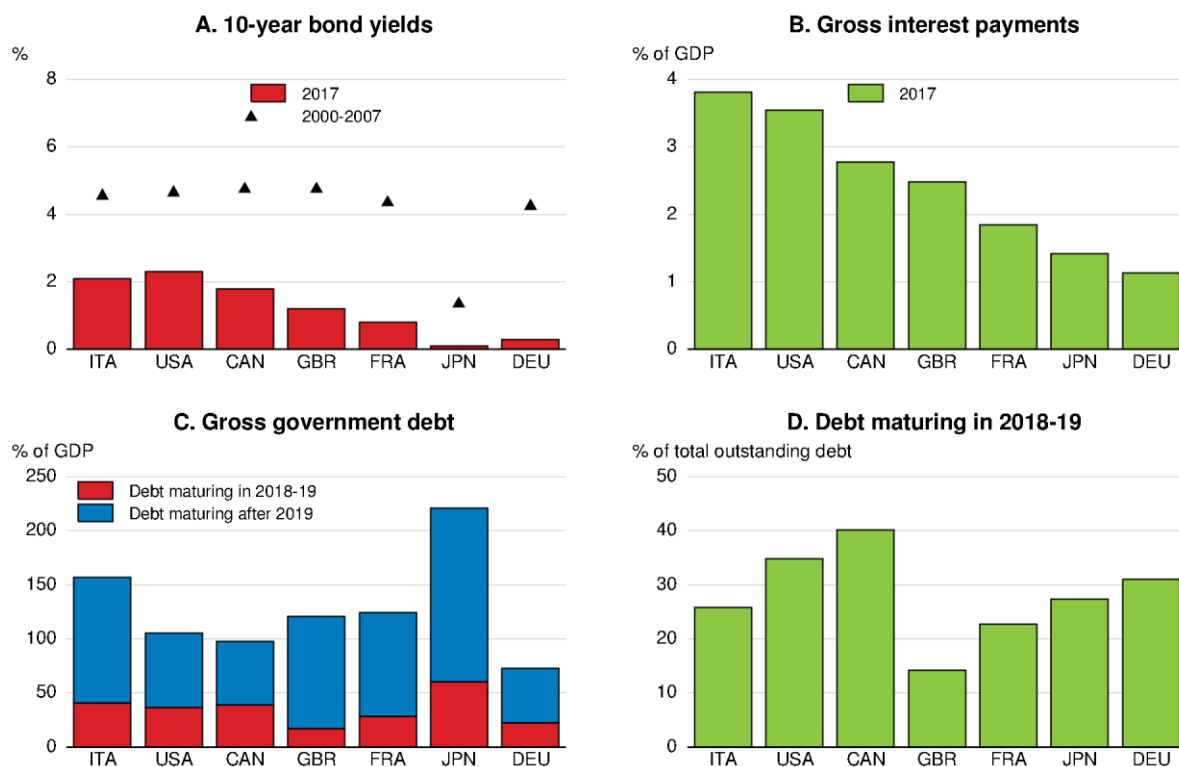
1. Introduction and main findings

In recent years, advanced economies' government bond yields have been at record-low levels, public debt has been high, and in some countries is still increasing, and gross interest payments have remained sizeable, ranging between 2% and 4% of GDP (Figure 1). In this context, lengthening the maturity of public debt may offer a way to lock in current low long-term bond yields and produce fiscal savings. Indeed, many countries have already increased the average remaining maturity of public debt in the past decade (Figure 2). With sizeable amounts of public debt maturing over the next two years (Figure 1), actively adjusting debt maturity may help to minimise debt servicing costs and contribute to maintaining debt sustainability and economic growth.²

This paper outlines the main implications of changing debt maturity for debt servicing costs and presents stylised country-specific simulations for G7 economies to shed light on potential fiscal effects of an active adjustment of debt maturity.

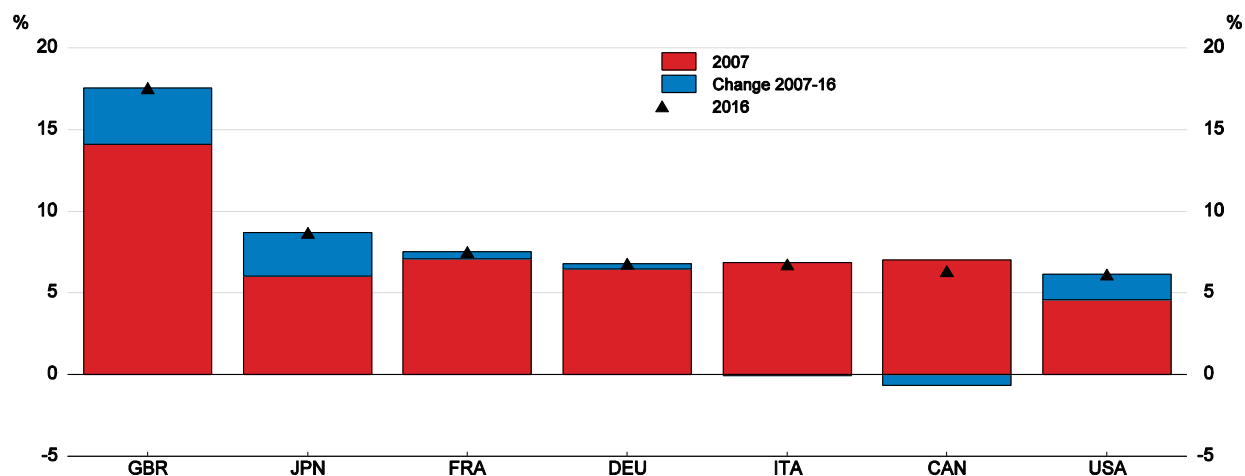
Predicting the size and distribution over time of fiscal benefits of an active adjustment of debt maturity is complicated by uncertainty about the future evolution of yield curves and budget balances, and initial conditions related to the level and maturity structure of public debt. With the current low levels of interest rates and estimated term premia, stylised simulations for G7 countries demonstrate that a temporary lengthening of debt maturity is not likely to bring fiscal benefits, unless the pace of interest rate and term premia normalisation is sufficiently gradual and protracted. Still this reduces rollover risks. Moreover, potential fiscal gains would materialise only with a significant lag, not helping much to lower current budget deficits. In contrast, shortening permanently the debt maturity is beneficial to budgets but entails higher rollover risks. Substantial gains from actively adjusting debt maturity are likely only for countries with high debt and relatively steep yield curves like Italy (and to a much smaller extent the United States and France). In other countries, changing debt maturity does not bring significant fiscal benefits but it could still be motivated by rollover risk considerations.

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1. The authors work at the OECD Economics Department. We would like to thank Sebastian Barnes, Sveinbjörn Blöndal, Fatoş Koç, Gary Mills, Dorothée Rouzet and Sebastian Schich for their useful comments; Jérôme Brezillon, Ane Kathrine Christensen and Sylvie Foucher-Hantala for statistical help; and Aman Johal for final document preparation.
 2. This paper ignores other aspects of active public debt management after primary issuances, such as the use of derivatives, buybacks and exchange operations to achieve cost-risk objectives and to improve secondary market liquidity (OECD, 2005; IMF, 2014). It also abstracts from an active management of government financial assets.

Figure 1. Selected debt-related characteristics of G7 countries

Note: The share of debt maturing in 2018-19 (panel D) is based on the maturity structure of marketable debt as of end-2017. This share is then applied to total outstanding debt as of end-2017, at market prices, in panel C.

Source: Bloomberg; OECD Economic Outlook 102 database; and OECD calculations.

Figure 2. Average remaining maturity of public debt has increased in many countries

Note: Data shown come from the surveys presented in the *OECD Sovereign Borrowing Outlook*. They refer to central government marketable debt. They differ from the debt maturity structure used in simulations below.

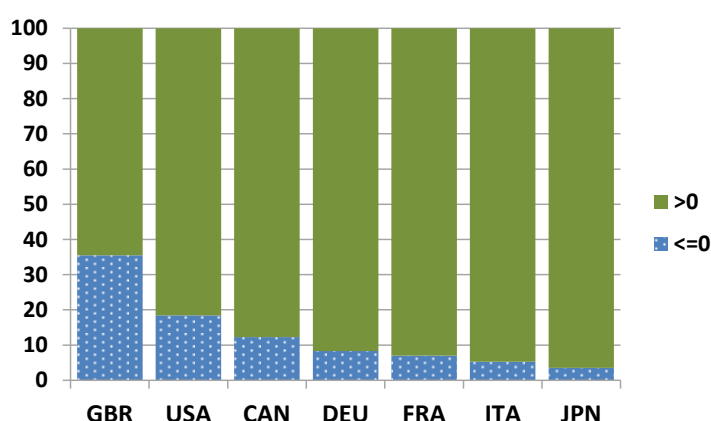
Source: OECD (2017), *Sovereign Borrowing Outlook 2017*.

2. How do changes in government debt maturity affect fiscal spending?

When choosing the maturity of public debt, debt managers consider current and expected yield curves, rollover risks and preferences of investors. In the long term, with an upward-sloping yield curve, which prevails most of the time in the advanced countries (Figure 3), it is always cheaper to finance debt with short maturities.³ However, with a short maturity, more frequent refinancing of larger amounts is needed. This increases the chances that such refinancing will have to be done in adverse market conditions. An adequate supply of both short and long-term government bonds, usually perceived as safe assets, can be crucial for the proper functioning of financial markets and can be in high demand by investors. The considerations about rollover risks and investors' demand, together with the maturity structure of the past debt, may reduce the possibility of adjusting the average debt maturity significantly. Such risk considerations can be particularly important for high-debt countries. The task of debt managers is further complicated by uncertainty about future yield curves and funding needs related to budget balances. In theory, the term structure of interest rates could provide some guidance on the future evolution of interest rates and term premia. However, in practice, estimating expected interest rates and term premia is difficult, especially at longer horizons.⁴ Moreover, market expectations tend to change frequently and are not the best predictors of future developments.⁵

Figure 3. Upward-sloping yield curves are the norm in most G7 economies

The percent of months between 1999 and 2017 with indicated characteristics of the yield curve slope



Note: The slope of the yield curve is defined here as the difference between the monthly average of 10-year government bond yields and the monthly average of the 3-month money market rates. 5% of time in the 1999-2017 period (228 months) equals around 11 months.

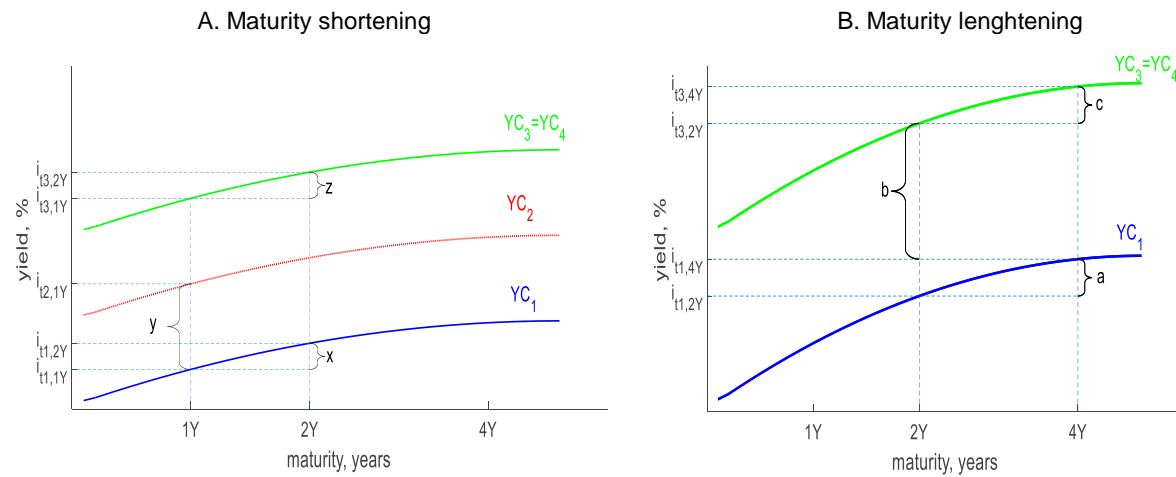
Source: Thomson Reuters; and authors' calculations.

3. The interpretation of an upward-sloping yield curve varies across different theories. For the pure expectations hypothesis, an upward-sloping yield curve is explained by investors expecting stronger inflationary pressures and thus higher short-term interest rate. Under the liquidity preference hypothesis the yield curve could be upward-sloping even with expectations of stable inflation because of a positive liquidity premium associated to longer maturities. For the segmentation hypothesis, instead, the shape of each segment of the yield curve is uniquely determined by the interaction of segment-specific supply and demand.
4. For instance, estimates of US Treasury 10-year term premia from only two models used by the staff in the Federal Reserve System can at times differ materially, by at least 100 basis points (Li et al., 2017).
5. Evidence of time-varying time premia (Backus et al., 2001) and monetary policy surprises (Pérez Quirós and Sicilia, 2002) are two of the factors that make it difficult to predict the future dynamics of the yield curve.

The key fiscal implications resulting from changes in public debt maturity can be illustrated in a simple model that, for the sake of simplicity, assumes an upward shift in the yield curve and abstracts from the size of debt, budget balance, rollover risks and investor preferences (Figure 4). The model assumes that initially a government has to roll over a constant nominal amount of debt indefinitely, implying that future budgets are balanced. A gradual steepening and shifting up of the yield curve is expected during the first three years, with the stabilisation of the yield curve thereafter. The baseline strategy is to issue 2-year bonds, paying $i_{t1,2Y}$ for the first two years, and $i_{t3,2Y}$ for the subsequent years as interest rates are assumed to stay constant from year 3 (i.e. $i_{t3,1Y} = i_{t4,1Y}$).

An alternative strategy is to shorten the maturity of newly issued debt and roll over debt indefinitely with 1-year bonds. During the first two years, this brings fiscal benefits as long as the initial yield curve is upward-sloping and the upward level shift in the second year is not too large, more specifically when the saving in terms of paying lower term premia during the two years exceeds the costs of higher interest rates (i.e. when $2x > y$ in Figure 4). Otherwise, shortening the maturity of debt is costly in these two years. During the subsequent years, the strategy is permanently beneficial as long as the yield curve is upward-sloping (i.e. $z > 0$ in Figure 4). In this case, it is always cheaper to issue shorter-term debt, but at the cost of higher refinancing risks.

Figure 4. Illustrative fiscal effects of changing debt maturity



C. Interest rate determinants of fiscal effects

	Year 1 & 2	Year 3 & 4	Steady-state
Maturity shortening (1-year bonds)	$2 \cdot i_{t1,2Y} - (i_{t1,1Y} + i_{t2,1Y})$ (+): $2x > y$ (-): $2x < y$	$2 \cdot i_{t3,2Y} - (i_{t3,1Y} + i_{t4,1Y})$ (+): $z > 0$	$i_{t3,2Y} - i_{t3,1Y}$ (+): $z > 0$
Maturity lengthening (4-year bonds)	$2 \cdot i_{t1,2Y} - 2 \cdot i_{t1,4Y}$ (-): $a > 0$	$2 \cdot i_{t3,2Y} - 2 \cdot i_{t1,4Y}$ (+): $b > 0$	$i_{t3,2Y} - i_{t3,4Y}$ (-): $c > 0$
	$2 \cdot i_{t1,2Y} + 2 \cdot i_{t3,2Y} - 4 \cdot i_{t1,4Y}$ (+): $a < b$ (-): $a > b$		

Note: (+) / (-) implies fiscal benefits/costs compared with the baseline strategy of issuing 2-year bonds.

Source: Authors.

The opposite alternative strategy is to lengthen the maturity of newly issued debt and roll debt over indefinitely with 4-year bonds. This time, during the first two years, the strategy is costly as long as the initial yield curve is upward-sloping (i.e. $a > 0$ in Figure 4), but can bring savings in years 3 and 4 as long as the yield curve shifts up sufficiently (i.e. $b > 0$ in Figure 4). The net benefit during the first four years will depend on the difference between a and b ; it is likely to be positive with an initial flat yield curve and a large upward level shift of the yield curve in the subsequent years (i.e. $a < b$ in Figure 4). In the long run, lengthening debt maturity permanently is always costly as long as the yield curve is upward-sloping (i.e. $c > 0$ in Figure 4), but it reduces the refinancing risks.⁶

3. The fiscal impact of changing the maturity structure: Country-specific simulations

In view of the principles presented above, the low and flat yield curve, prevailing in recent years in many advanced economies as a result of extraordinarily expansionary monetary policy, provides an incentive to lengthen maturity if interest rates and term premia are expected to rise (i.e. leading to a steepening of the yield curve – large b compared with a in Figure 4). However, predicting fiscal implications of changing government debt maturity is complex as it jointly depends on the size of debt and its maturity structure, the future evolution of primary balances, and the size of and returns from government financial assets. Moreover, the distribution of new debt issuances over time complicates the analysis further. If, for example, borrowing needs are concentrated predominantly in the early years, then the choice of debt maturity of newly issued debt in subsequent years is less relevant.

In order to quantify the potential fiscal effects of changing debt maturity, country-specific stylised simulations calibrated to reflect key actual characteristics of G7 economies are presented for the following three illustrative debt management strategies:

- Permanent lengthening of the debt maturity of newly issued debt by one year compared with the initial country-specific average remaining maturity.
- Temporary lengthening of the debt maturity of newly issued debt by one year, which is considered for all possible durations ranging between 1 and 30 years, given the specific path of interest rates (see below). After the temporary lengthening, the maturity of the newly issued debt reverts back to its initial level. Only the best strategy is selected and shown in terms of the largest cumulative benefit (smallest cumulative loss) by the end of the simulation period.⁷
- Permanent shortening of the debt maturity of newly issued debt by one year compared with the initial country-specific average remaining maturity.

The strategies exclude the possibility of changing the maturity of outstanding debt by early redemptions.

6. In this simple example, fiscal savings and costs occurring at different years are not discounted. With a positive discount rate, cumulated fiscal costs or savings will be reduced, possibly affecting net effects. For a given discount interest rates, the discounted upfront costs of temporarily lengthening debt maturity are going to be reduced by less than discounted long-term benefits.

7. This is done based on the comparison of the results of all possible strategies of temporarily lengthening debt maturity between 1 and 30 years. The exercise assumes a perfect foresight. Thus, it is purely illustrative and not realistic.

While changing the duration of newly issued debt, the share of total debt allocated to maturities of up to one year is kept constant at the initially observed value.⁸ This is to proxy for debt manager preferences to supply enough short-term debt given its safe-asset status and its role in a proper functioning of financial markets. Thus, changes in the maturity structure are done by adjusting shares of debt with maturity 2, 5, 10 and 20 years. For the sake of simplicity, debt is assumed to be issued only in the form of fixed-rate coupon bills and bonds denominated in domestic currency, and the use of interest rate and exchange rate swaps is excluded.⁹ For the initial debt structure, given the scarcity of data, the maturity structure of total government debt is assumed to be the same as the maturity structure of marketable government bonds as of end-2017 based on data from Bloomberg.

The simulations are based on the G7 country-specific initial level and maturity structure of gross general government debt, and initial levels of the general government primary budget balance and financial assets (i.e. as of 2017). Purely illustratively, the primary balance is assumed to follow OECD long-term projections over the simulation period (Guillemette and Turner, 2018). The overall balance is derived from the primary balance and net interest rate payments (Annex 1). Returns on financial assets are based on the effective interest rate from the last available period and changes in the short-term interest rate over the simulation period, abstracting from the possibility of an active management of financial assets. Government financial assets are assumed to remain constant as a share of nominal GDP. New debt is issued at the beginning of each year, incurring interest payments in the same year.

The evolution over the simulation of short and long-term interest rates and nominal GDP growth are derived from a stylised set of equations to ensure consistency between economic growth, inflation and interest rates, assuming term premia to increase gradually from their current historically low levels (Annex 1).

Under the hypothetical assumptions of yield curve steepening and shifting up at a constant pace for the first five years and stabilising afterwards, which is likely with the normalisation of monetary policy, and of the path for primary balances and potential growth (Figure A1.1 in Annex 1), a permanent shortening of the debt maturity renders the highest fiscal benefits for most G7 countries (Figures 5 and 6). This reflects that the assumed initial increase in interest rates is too quick and too large for reaping potential benefits from lengthening the debt maturity (low b in Figure 4). In practice, the average maturity of debt changes only slowly over time as it takes several years for new debt issuances with longer maturity to replace the shorter maturity initial debt (Figure 7). Japan is an exception among the G7 countries as temporary lengthening yields the highest benefits. This stems from the assumption of very flat yield curves during the simulation period (Figure 8), which minimises the initial cost of debt maturity lengthening (very low a in Figure 4).

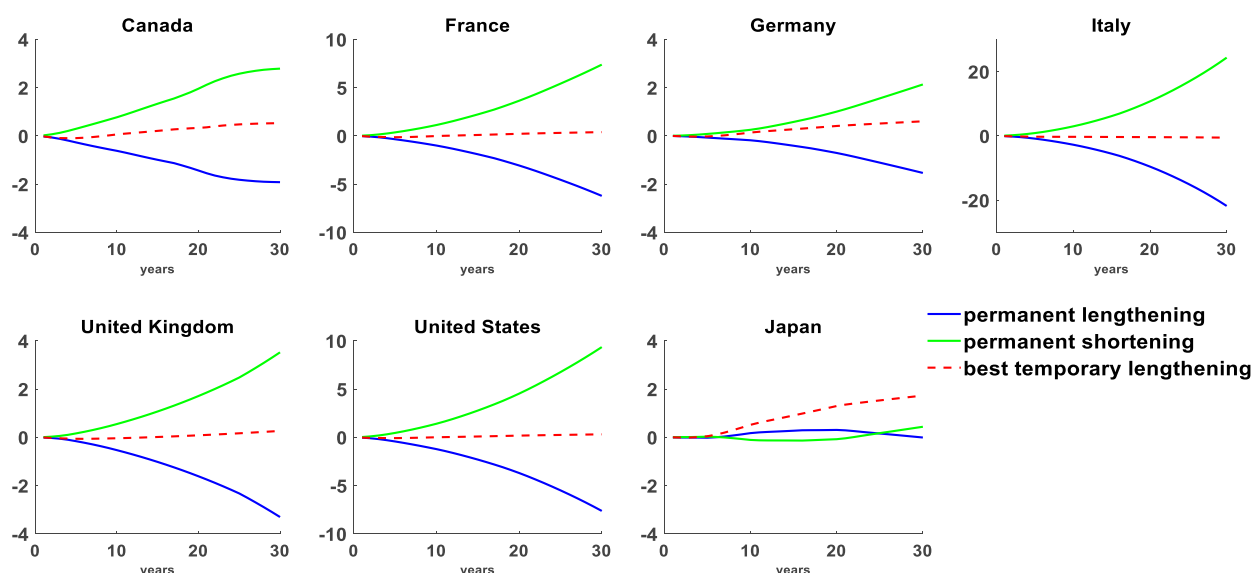
For all G7 countries, as expected, a permanent lengthening of the debt maturity implies cumulative fiscal costs by the end of the simulation, when interest rates have stabilised (Figures 5 and 6). For Canada the fiscal impacts across the three strategies differ slightly from the other countries; both the costs and benefits stabilise over time rather than continuously diverge like in other countries. This is because borrowing needs in Canada dwindle over time due to a fast reduction in government debt induced by the

8. Given the aggregate nature of data on debt maturity used in this paper, the share of debt maturing within one year is likely to be overestimated compared with debt issued with original maturity of at most one year, as it reflects also past debt issued at longer maturities which happened to mature in 2018.

9. In practice, index-linked bonds are very important in the United Kingdom (accounting for around ¼ of outstanding central government debt), moderately important in Canada, France, Germany, Italy and the United States (accounting for around 10%), and negligible in Japan (OECD, 2018). Debt managers in some G7 economies engage in interest rate swaps that can affect debt servicing costs.

combination of assumed fiscal surpluses and large revenues from government financial assets that exceed government debt.

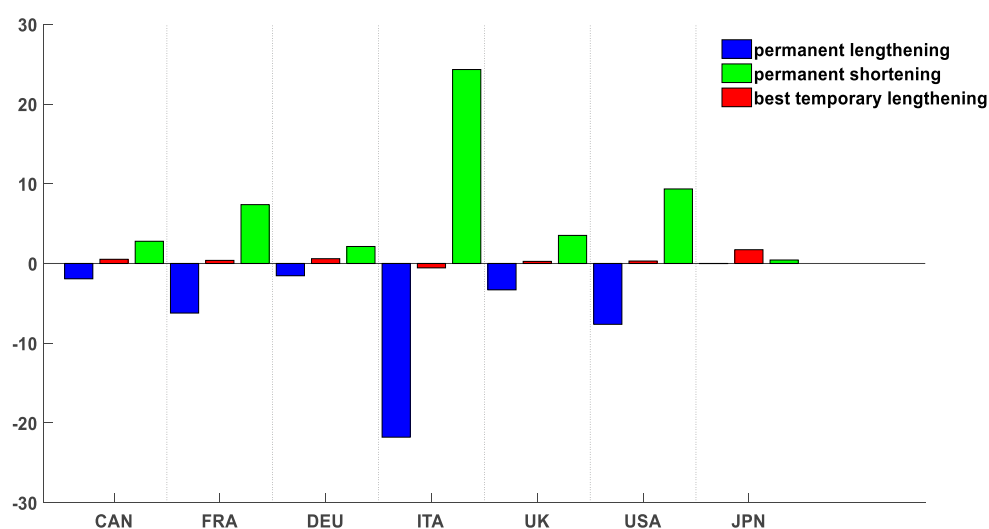
Figure 5. Fiscal impact of changing debt maturity structure
Evolution of cumulative fiscal savings (+) / costs (-), % of GDP (different scales)



Notes: The cumulative fiscal effects are calculated compared with the baseline scenario of keeping the initial debt maturity unchanged. They are expressed as per cent of GDP of each year.

Source: Authors' calculations.

Figure 6. Total cumulative fiscal impact of changing debt maturity structure
Total cumulative fiscal savings (+) / costs (-) after 30 years, % of GDP

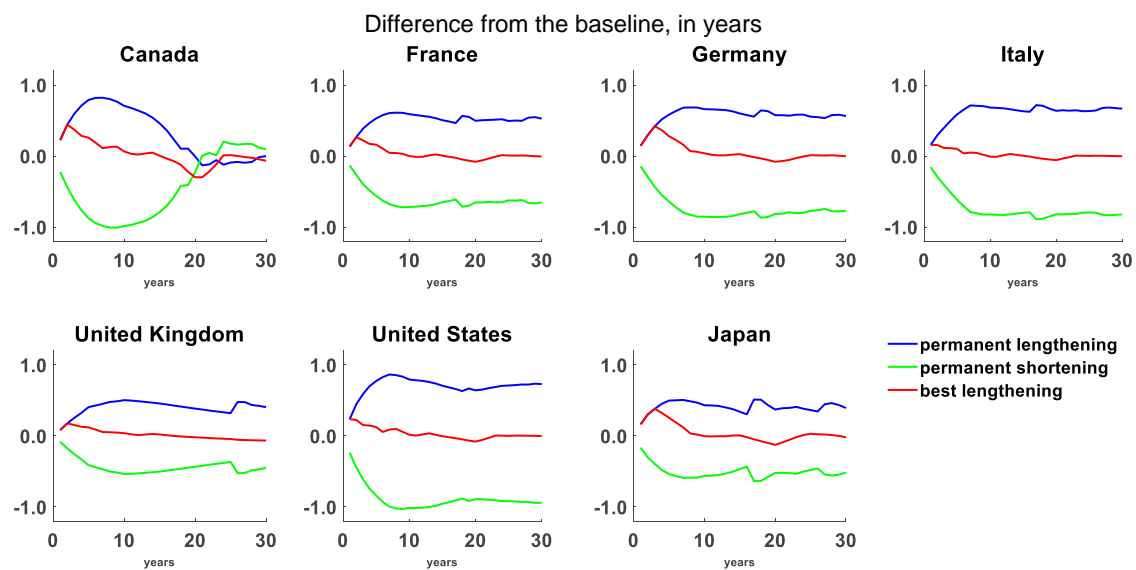


Notes: The cumulative fiscal effects are calculated compared with the baseline scenario of keeping the initial debt maturity unchanged. They are expressed as per cent of GDP of each year.

Source: Authors' calculations.

The size of fiscal savings from changing debt maturity management varies across countries and time. Cumulative benefits are negligible in the first decade in all countries. By the end of the simulation period, they remain very small (around 0.1% of GDP per year on average) in Canada, Germany, Japan and the United Kingdom. The savings are moderate (around 0.3% of GDP per year on average) in France and the United States, and substantial in Italy (around 0.8% of GDP per year on average). Differences in the size of the effects reflect primarily, but not uniquely, differences in the size of the initial debt. Larger effects are observed in countries with higher debt. The largest benefits in Italy stem also from the significantly higher term premia (Figure A1.1 in Annex 1). In Japan, the G7 country with the highest initial debt-to-GDP ratio, benefits from debt maturity management are reduced due to the assumed very flat yield curve which increases by much less than in other countries (Figure 8).

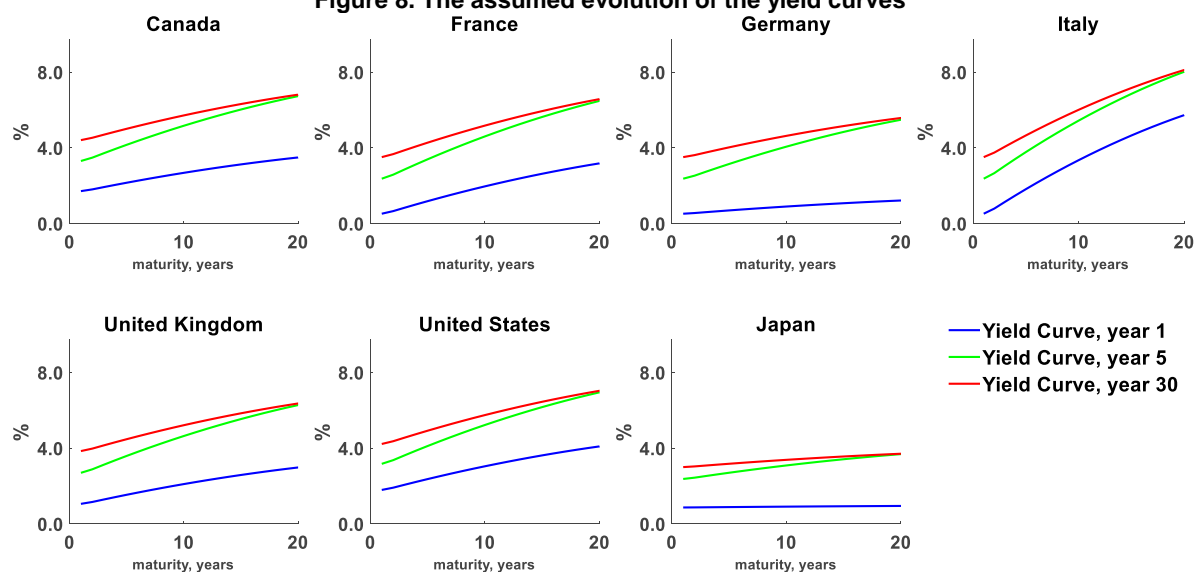
Figure 7. The evolution of average debt maturity



Note: See Annex 1 for details.

Source: Authors' calculations.

Figure 8. The assumed evolution of the yield curves



Source: Authors' calculations.

4. Uncertainty about future interest rates

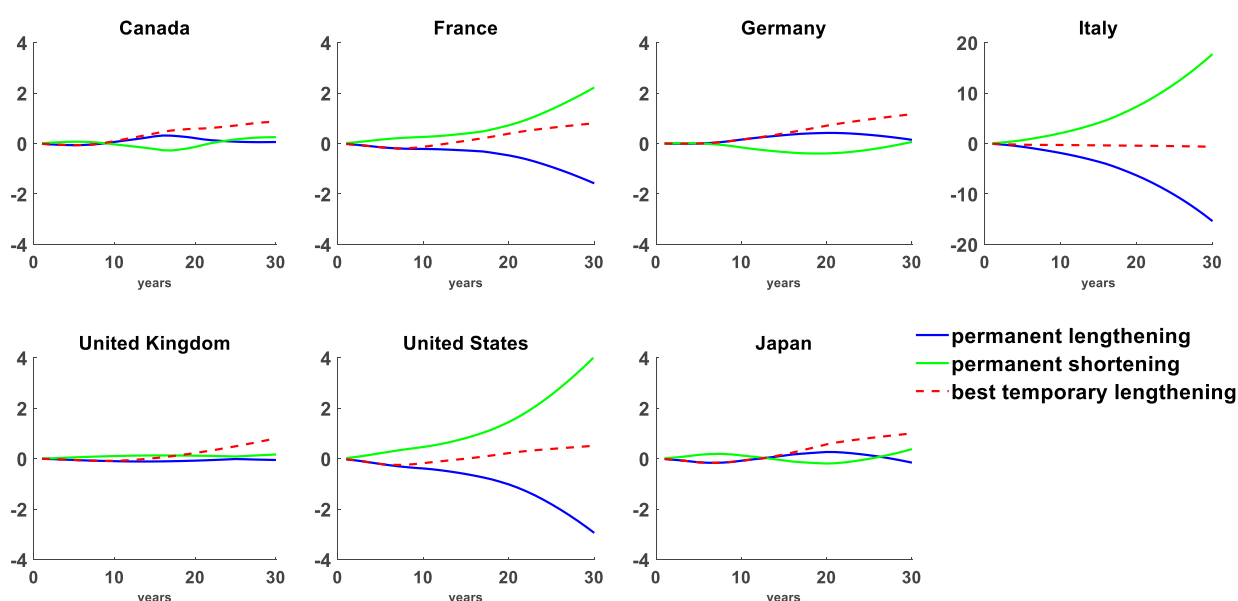
Fiscal effects of adjusting the debt maturity will crucially depend on the future level and the slope of the yield curve, which are notoriously difficult to predict. The current term structure of interest rates usually provides little help in this respect. This uncertainty may discourage debt managers from changing the maturity structure much and make them focus more on rollover risks and on satisfying demand of investors, by constantly supplying bonds with specific maturities. To shed some light on the issue, this section looks at how fiscal effects would change with alternative interest rate paths.

Under the assumption of a slower upward adjustment of the yield curve than assumed in the baseline scenario discussed in the section above, driven by a slower convergence of term premia towards their long-term values (Annex 1), a permanent shortening of debt maturity does not always bring the highest fiscal benefits (Figures 9 and 10). In Canada, Germany, the United Kingdom and Japan, a temporary lengthening of debt maturity provides the highest fiscal benefits. This result is driven by the more gradual adjustment of interest rates and thus the less steep yield curves during the adjustment. This decreases the relative costs of the lengthening of debt maturity (lower a in Figure 4, Panel B). However, the fiscal gains from the temporary lengthening of the debt maturity are negligible and they do not differ much from the fiscal impacts of other strategies. They would be even smaller with lower terminal long-term interest rates compared with the baseline scenario (lower b in Figure 4, Panel B). For France, Italy and the United States, permanent shortening the government debt maturity still provides the highest benefits, though these benefits are significantly reduced compared with the baseline scenario.

Starting from a flat yield curve, a higher level of short-term interest rates in the long term, together with a protracted convergence, would increase the benefits of temporary lengthening of debt maturity. This reflects smaller short-term costs and higher medium-term benefits from fixing low debt servicing costs by issuing longer-term bonds (small a and large b in Figure 4). However, longer-term fiscal benefits of temporary lengthening debt maturity would be altered with normal periodic business cycle fluctuations. They could be higher or lower depending on the amplitude and length of booms and busts.

Figure 9. Fiscal impact of changing debt maturity structure with a slower steepening of the yield curve

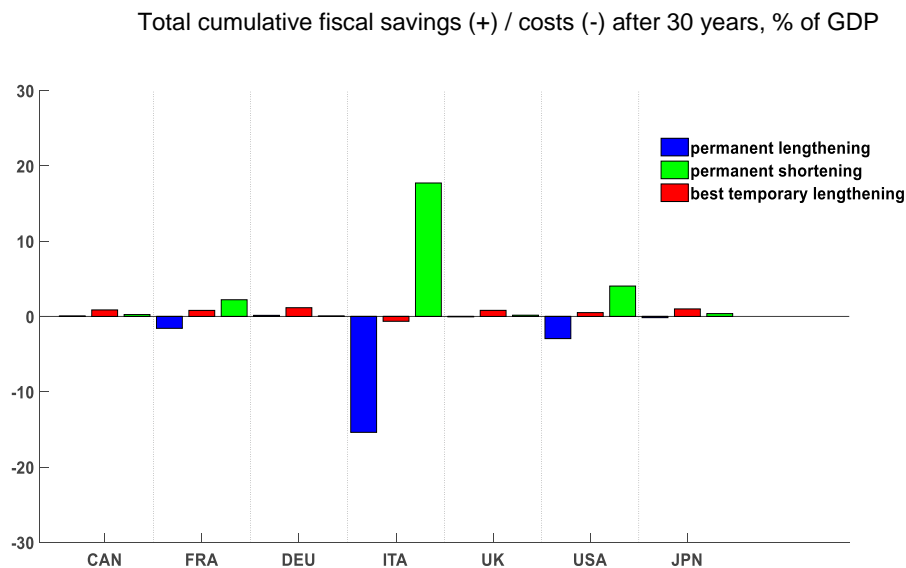
Evolution of cumulative fiscal savings (+) / costs (-), % of GDP



Notes: The cumulative fiscal effects are calculated compared with the baseline scenario of keeping the initial debt maturity unchanged. They are expressed as per cent of GDP of each year.

Source: Authors' calculations.

Figure 10. Total cumulative fiscal impact of changing debt maturity structure with a slower steepening of the yield curve



Notes: The cumulative fiscal effects are calculated compared with the baseline scenario of keeping the initial debt maturity unchanged. They are expressed as per cent of GDP of each year.

Source: Authors' calculations.

5. The trade-off between rollover risks and debt maturity

Rollover risks conventionally refer to unexpectedly high costs of debt issuance or problems with market access (Holler, 2013; IMF, 2014). There is no common definition of rollover risks but frequently they are proxied by the share of debt maturing within one year. Thus, in general, shorter average debt maturity implies higher rollover risks. However, longer-term maturity may also imply periodical (but less frequent) rollover risks if occasionally there are spikes in debt maturing. Overall, rollover risks are related to the size of outstanding debt and thus would be less of a concern for countries with very low total government debt.

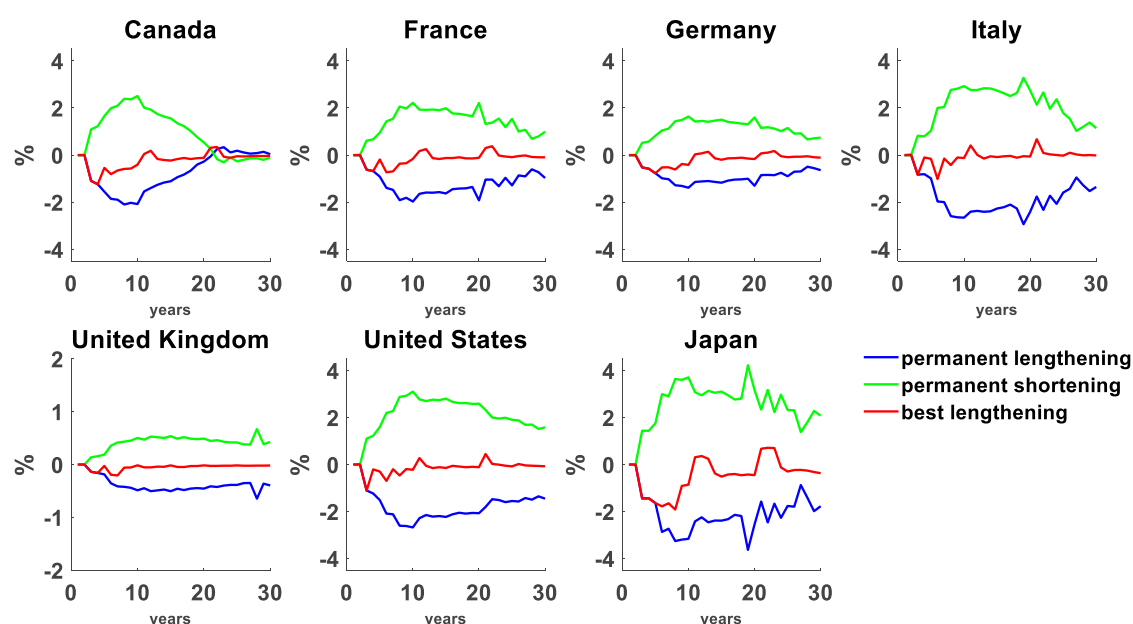
In order to illustrate potential changes in rollover risks stemming from the shortening and lengthening of debt maturity, this section analyses the evolution of the share of debt maturing within one year across the three strategies discussed above for the baseline path of interest rates. Given the assumption of keeping the share of short-term new debt fixed at its initial value (Section 3), this share is driven by the maturity schedule of initial debt as well as the accumulation of debt during the simulation period. A strategy increases rollover risks when the share of debt maturing within one year rises with respect to maintaining the maturity of future debt issuances unchanged at its initial level during the simulation period.¹⁰

For the baseline path of interest rates, debt managers would face a trade-off as permanent shortening of debt maturity both brings long-term fiscal benefits and increases rollover risks (Figure 11). For all the G7 countries but the United Kingdom, this strategy would increase the share of debt maturity of up to one year by between 1.2 and 2.5 percentage points from the average shares ranging between 10% and 15%.

10. The mechanical nature of debt management in these illustrative simulations results in periodic spikes in debt rollovers in the baseline strategy of keeping the average maturity unchanged. In practice, debt managers could avoid this.

Figure 11. Change in rollover risks with alternative debt maturity strategies

Difference in debt maturing within one year compared with the unchanged debt maturity strategy, per cent of GDP



Notes: They are expressed as per cent of GDP of each year.

Source: Authors' calculations.

This would correspond to an increase in annual debt rollover by between 1% and 3% of GDP. In the United Kingdom, the share of debt maturity of up to one year would increase much less, by 0.3% of GDP on average, given the long average maturity in the United Kingdom. Thus, the longer the initial average maturity, the smaller the increase in rollover risks stemming from shortening the maturity of new debt.

6. Conclusions

This paper shows that while shortening debt maturity may in general lower debt servicing payments at the cost of higher rollover risks, a temporary lengthening of debt maturity may be beneficial under some conditions. Fiscal benefits of adjusting public debt maturity crucially depend on the future evolution of the yield curves. Debt maturity lengthening has been suggested in the low-interest rates environment prevailing over the past years. A temporary lengthening is, however, not likely to bring fiscal benefits unless the rate of interest rate normalisation is sufficiently gradual and protracted and interest rates increase significantly in the long term, but it may reduce rollover risks. Moreover, any fiscal gains would materialise only with a significant lag, not helping much to lower current budget deficits. In contrast, as expected, with upward-sloping yield curves, shortening permanently the debt maturity is beneficial but entails higher rollover risks.

Stylised simulations for G7 countries indicate that substantial gains from actively changing debt maturity are likely only for countries with high debt and relatively steep yield curves like Italy (and to a much smaller extent the United States and France). In other countries (including Japan where despite the highest public debt-to-GDP ratio, yield curves are assumed to remain flat), either temporary lengthening or permanent shortening of new debt maturity does not have large fiscal effects. In these countries, changes in debt maturity could still be motivated by rollover risk considerations or accommodating demand from investors.

Further extensions of the simulations are possible. For instance, they could include accounting for the original maturity of maturing bonds, the existence of index-linked bonds and a possible impact of changing supply of bonds of particular maturities on their yields as well as endogenising risk premia with regard to the level of government debt and deficit and rollover risks. These modifications could make simulations more realistic but are unlikely to alter the main findings of this paper in a fundamental way.

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ANNEX 1. STYLISTED MODEL

Stylised simulations to investigate the fiscal impact of active debt management are based on a simple model determining the evolution of short and long-term interest rates, nominal and real GDP growth rates, and budget balances and public debt, with parameters of the equations calibrated on the basis of the OECD long-term projections (Johansson et al., 2013).

Potential growth is exogenous and is assumed to linearly converge towards the 2008-17 average,¹ and the output gap evolves as given by equation 1, inflation being modelled as a Phillips curve in equation 2 and levels of real and nominal GDP are given by identities in equations 3 and 4:

$$\left(\frac{Y_t}{Y_t^{pot}} - \frac{Y_{t-1}}{Y_{t-1}^{pot}}\right) = c_0 \left(\frac{Y_{t-1}}{Y_{t-1}^{pot}} - \frac{Y_{t-2}}{Y_{t-2}^{pot}}\right) + c_1 \left(\frac{Y_{t-1}}{Y_{t-1}^{pot}} - 1\right) \quad (1)$$

$$\pi_t = b_1 \pi_{t-1} + (1 - b_1) \pi^{target} + b_2 \left(\frac{Y_t}{Y_t^{pot}} - 1\right) \quad (2)$$

$$Y_t = Y_{t-1}(1 + g_t / 100) \quad (3)$$

$$Y_t^N = Y_t(1 + \pi_t / 100) \quad (4)$$

where g_t and g_t^{pot} are growth rates of real measured and potential GDP, Y_t and Y_t^N and Y_t^{pot} are levels of real, nominal and potential GDP respectively, π_t is the inflation rate and π^{target} is the inflation target.

Short-term interest rates are determined in line with a Taylor-style monetary policy rule (equation 5) and long-term interest rates are derived from the convolution of future short-term interest rates and term premia (equation 6):

$$IRS_t = a_1 IRS_{t-1} + (1 - a_1)(\pi^{target} + g_t^{pot}) + a_2 \left(\frac{Y_t}{Y_t^{pot}} - 1\right) \quad (5)$$

$$IRL_t = \left(\prod_{s=0}^9 (1 + IRS_{t+s}) / 100\right)^{1/10} + TP_t \quad (6)$$

where IRS is the short-term interest rate, IRL is the yield on 10-year government bonds, and TP is term premia. The term premia up to 2017 are approximated by the difference between the realised 10-year bond yield and the geometric average of the realised or projected from the model short-term interests over the life of the long-term bond. Over the simulation period, the term premia are assumed to linearly converge towards their 2000-17 average over five years and then stabilise at that level.² For the sake of simplicity, they do not account for risk premia (related for instance to debt and deficit levels and rollover risks) and liquidity premia. Each year the yield curve is estimated with a quadratic polynomial given IRS and IRL values, assuming a monotonically increasing and concave function.

-
1. Taking longer averages, for instance starting from 2000, other things being equal, would result in higher steady-state short and long-term interest rates, which could improve fiscal benefits of temporary debt maturity lengthening and reduce fiscal benefits of debt maturity shortening.
 2. Calculating averages starting before 2000 would result in much higher proxies of term premia. This would increase the benefits of debt maturity shortening.

Gross government budget balance and debt follow the standard set of identities:

$$b_t = pb_t - ip_t + ir_t \quad (7)$$

$$ir_t = 0.01 * i_t^R a_t \quad [i_0^R = \frac{100 * ir_0}{a_0} - 100] \quad (8)$$

$$i_t^R = i_{t-1}^R + IRS_t - IRS_{t-1} \quad (9)$$

$$ip_t = \sum_{m=1}^M \sum_{s=t_0}^t D_s^m i_s^m I_s / 100 \quad (10)$$

$$gd_t = gd_{t-1} + b_t + a_t - a_{t-1} \quad (11)$$

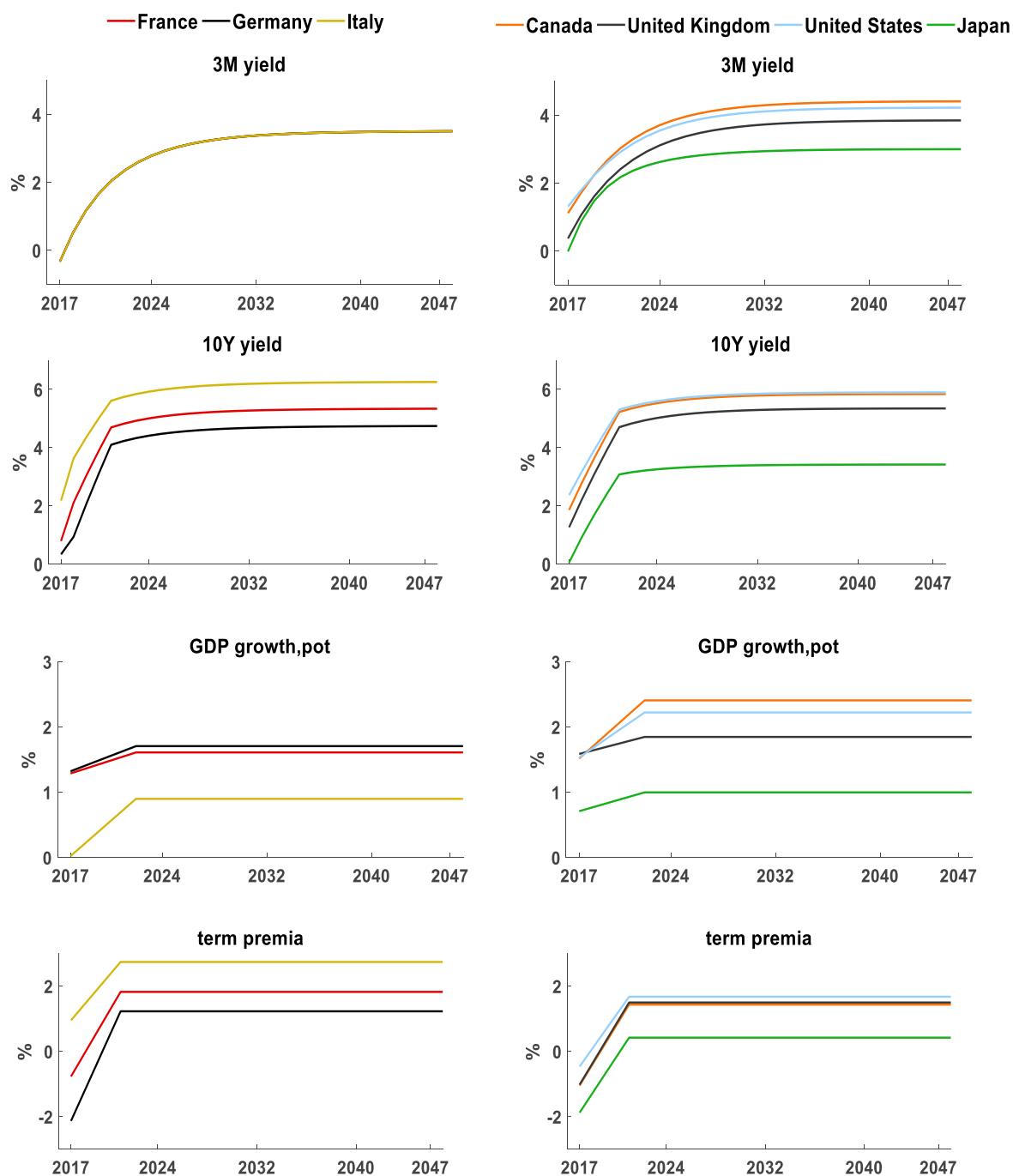
$$gdq_t = \frac{gd_t}{Y_t^N} \quad (12)$$

$$aq_t = aq_{t-1} \quad (13)$$

where b is the overall budget balance, pb is the primary balance, ip is interest payments on gross debt, ir is interest revenues from government financial assets (a), gd and gdq are nominal gross government debt and gross government debt as a percentage of nominal GDP, and aq is government financial assets as a percentage of GDP. The primary balance is exogenous and is assumed to follow OECD long-term projections (Guillemette and Turner, 2018). At any period t , ip_t is a function of past debt D_s^m , where s denotes the period the debt was issued and m denotes its initial maturity, and i_s^m is the annual interest rate associated to that debt. The indicator function I_s specifies if D_s^m has been repaid at time t , and is equal to 0 if $m > t - s$ and 1 otherwise. Finally, ir_t is the implicit return rate on government financial assets, which is assumed to evolve over time as a function of changes in the short-term interest rates.

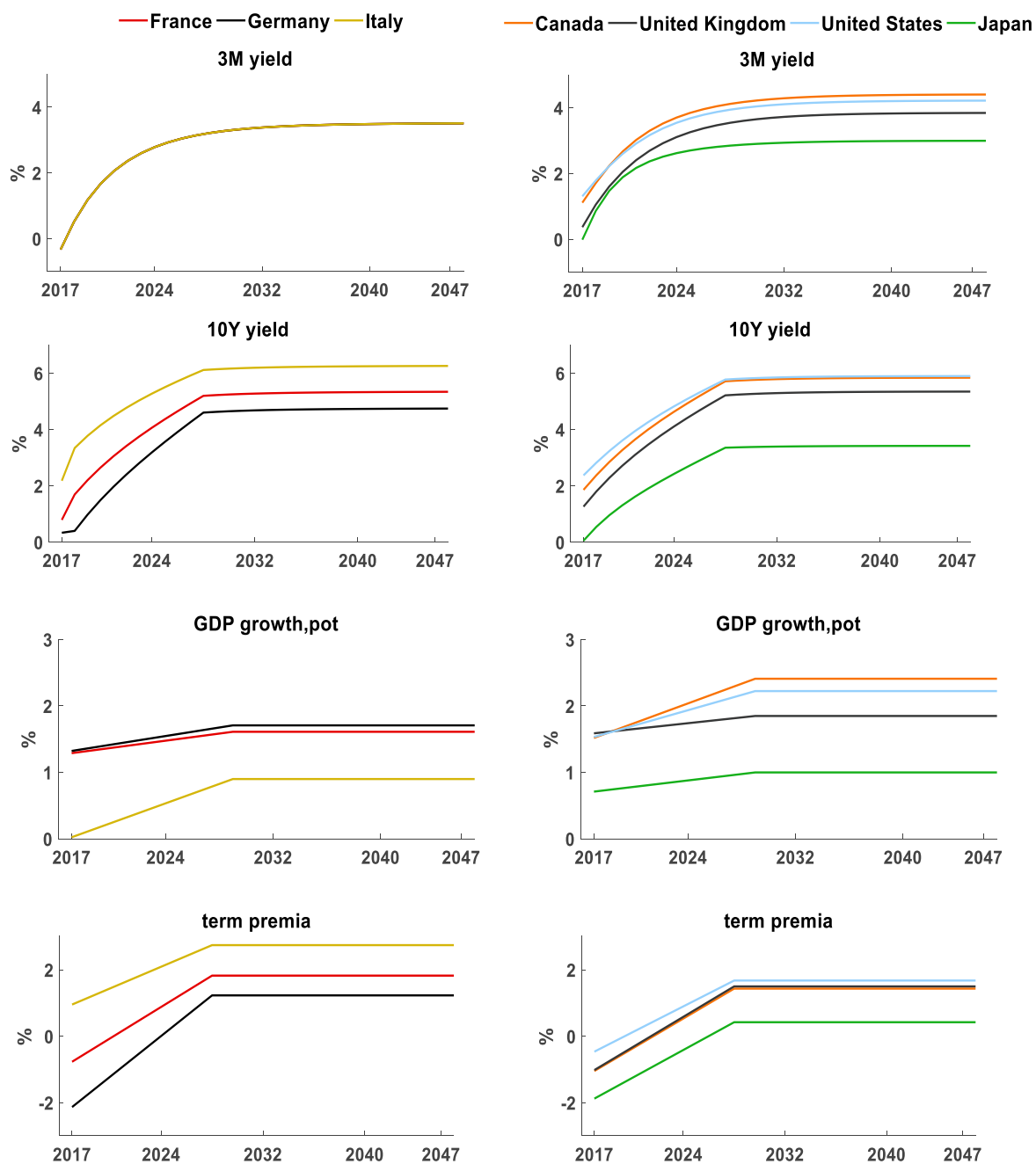
The evolution of the key variables generated from the above simple model is illustrated in Figure A1.1 for the baseline specification. Figure A1.2 shows the evolution of the same variables assuming a protracted (ten instead of five years) convergence of the term premia.

Figure A1.1. Model implied set of macroeconomic variables in the baseline simulation



Note: 3M yield is the same for France, Germany and Italy due to common monetary policy.

Source: Authors' calculations.

Figure A1.2. Model implied set of macroeconomic variables with a slower steepening of the yield curves

Note: 3M yield is the same for France, Germany and Italy due to common monetary policy.

Source: Authors' calculations.