On Deficit Bias and Immigration

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Abstract

How much can governments shift the cost of government expenditure from today's voters to tomorrow's generations of immigrants, without resorting to taxation that is explicitly discriminatory? I demonstrate that if their societies are absorbing continuous flows of new immigrants, we should expect governments that represent the interests of today's population, even if that population is altruistically linked to future generations, to choose policies that shift some portion of the tax burden to the future. This bias in favor of deficit finance is not infinite. Today's population or their descendents, together with future immigrants, ultimately pay the higher taxes necessary to finance the accumulated debt, and live with the additional excess burdens these higher taxes generate. For a given rate of immigration and policy horizon, governments balance the deadweight losses associated with fluctuating tax rates against the benefits that accrue to the initial resident population from shifting part of the burden of financing government expenditure to future immigrant families. To measure the deficit bias, I analyse the dynamic behavior of an optimal growth model with overlapping dynasties and factor taxation, calibrated for the US economy. Models with overlapping infinite-lived dynasties allow for a very clear distinction between natural population growth (an increase in the size of existing dynasties) and immigration (the addition of new dynasties). They also provide an alternative to the strict dichotomy between models with overlapping generations, where agents disregard the impact of their choices on future generations, and the quasi-Ricardian world of infinite-lived dynasties with representative agents that fully participate in both the economy and the political system in every period. The trajectory of the debt burden predicted by the model is a good match for the rise in US Federal government debt since the early 1980's, as well as the increases in debt projected by the Congressional Budget Office over the next few decades.

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1 Introduction

Ordinarily, in an economy in which taxes are distortionary, heavy reliance on deficit finance to fund government expenditure combined with sustained increases in unfunded liabilities, relative to the size of the economy, would be hard to reconcile with the prescriptions of optimal fiscal policy, as the very high tax rates that will ultimately be needed to finance the increasing burden of debt, are associated with exceedingly large excess burdens. Yet it is precisely these types of fiscally imbalanced policies that both national and local governments throughout much of the developed world have been pursuing for decades. This paper examines how the existence of immigrant flows may encourage a government to favor deficit finance and low taxes for long periods of time, even if such policies will eventually necessitate far higher tax rates in the future, to finance the accumulated debt alongside other public expenditures.

In this paper I demonstrate that if their societies are absorbing new immigrants, we should expect governments that represent the interests of today's population to choose policies that shift some portion of the tax burden to the future, even if that population is altruistically linked to future generations. This bias in favour of deficit finance is not infinite. Today's population, or their descendents, will ultimately pay the higher taxes and live with the distortions these higher taxes generate along with the immigrants. Instead, for a given rate of immigration and policy horizon, governments will choose policies that balance the deadweight losses associated with fluctuating tax rates against the benefits that accrue to the initial population and its descendents when they use public debt as a mechanism for shifting some of today's tax burden to future arrivals. The model I build to demonstrate and measure this bias in favour of deficits is a simple optimal growth model with overlapping dynasties, factor taxation and public debt, calibrated for the US economy.

Publicly held net US federal debt has risen during the last three decades from 26% of annual GDP in 1981 to 62% in 2010.[1] It is still rising. Each June, during past few years, the US Congressional Budget Office has produced two different estimates of future spending, revenue and the predicted trajectory of US Federal debt for the decades to come. The first is the Extended Baseline Forecast, which is premised on three main assumptions: that the Federal government will contain entitlement spending, particularly spending on Medicare; that growth in non-entitlement spending will no longer keep pace with the growth in the economy as it has in the past; and that temporary tax cuts which are set to expire will no longer be renewed, even if they have been renewed more than once in the past. Though the population is aging and the bill for Medicare is driving total expenditure higher, the Extended Baseline Forecast for 2011 shows revenue growing as well (Figure 1). Meanwhile, Figure 2 shows the debt as forecast in 2011 increasing but at a slower pace, to 87% of GDP by 2040, rather than more than doubling during these years as it did from 1981 to 2010.

Along with the Extended Baseline Forecast the CBO produces an Alternative Fiscal Scenario. Here the CBO assumes Medicare costs will rise much as they have in the past; that those

[1] Congressional Budget Office, *Long-Term Budget Outlook*, June 2011.

temporary tax cuts which are typically renewed as a matter of course will again not be allowed to expire; and that Federal spending other than Medicare and Social Security will continue to grow at the same rate as the economy. In this scenario, public debt grows along an explosive path. In 2009 the Alternative Fiscal Scenario had the debt burden reaching 223% of GDP by 2040, and 767% of GDP by 2083. The 2010 estimate predicted the debt reaching 233% by 2040 and 947% by 2084. In 2011, the CBO predicted the debt to GDP ratio would reach 195% by 2036, but declined to extrapolate any further, arguing in effect that the economy simply could not sustain a debt burden any higher.[2]

One way to distinguish between the two sets of predictions is that under the Extended Baseline Forecast, while tax revenue so far has proven inadequate to preclude the rise in debt over the previous thirty years, tax rates will rise in the near future in part to pay for entitlements and also to finance interest payments on the higher level of debt. Under the Alternative Fiscal Scenario, the rise in tax rates is postponed indefinitely. Yet unless the US defaults or repudiates its debt, or economic growth rates are far higher than anticipated, in this scenario too, if the debt burden is ever to stabilize, taxes will eventually rise, and possibly by a great deal more. In either case, this pattern of maintaining low rates of taxation over long periods of time, even as the liabilities that will necessitate far higher future taxes to finance them continue to mount, is a puzzle. It contradicts a basic prescription of optimal fiscal policy: keep distortionary tax rates relatively smooth to minimize the overall excess burden they generate.

There is a wide-ranging literature exploring the many reasons why governments, even abstracting from distributional issues, might not adopt first or even second-best fiscal policies. If agents are indifferent to the next generation's welfare, they will of course support policies that shift the burden of funding government expenditure to the future. Even if agents are not indifferent to their children's welfare, but some are bequest-constrained, as in Cukierman and Meltzer (1989), a constituency in favour of deficit finance can emerge. Rogoff (1990) proposed that in a society with asymmetric information, politicians have an incentive to spend more and tax less prior to an election. Voters, according to Rogoff, are not irrational, but lack the opportunity either to directly observe the competence of their leaders, or to judge the appropriateness of the policies they pursue. Similarly, Lizzeri (1999) and Battagliani and Coate (2008) demonstrate that voters or legislators may support benefits for themselves while treating the future tax burden as a commons. Finally, politicians may choose to increase the debt burden while in power as a device to control or tie the hands of possible successor governments, as in Persson and Svensson (1989) and Tabellini and Alesina (1990).

Yet government budgets are not always in deficit, and even when they are, in years when economic growth is sufficiently high the debt burden still declines. The US and most other

[2]The Extended Baseline Forecast for June 2012 shows debt declining steeply over the next few decades, premised on implementation of the full range of tax increases and budget cuts implied by sequestration, but the Alternative Fiscal Scenario remains unchanged. Projections of the debt by the International Monetary Fund show it increasing even faster than the Alternative Fiscal Scenario. See Batini, *et. al.* 2010 and IMF Staff Report for the 2012 Article IV consultation, IMF Country Report No. 12/213.

advanced nations emerged from World War II with extraordinarily high debt burdens that they immediately set about paying down through a combination of primary surpluses, real growth and liquidation though a mixture of high inflation and financial repression (Reinhart and Sbrancia, 2011). Why did governments choose to pay down debts until sometime between the mid-1970's and the early 1980's? As early as 1977, Buchanan and Wagner argued that the widespread adoption of Keynesian analysis provided intellectual cover for policy makers to indulge their inclination to spend but not to tax.[3] An alternative explanation, popular with political commentators and journalists, combines intergenerational conflict and shifting cultural norms. According to this 'selfish generation' hypothesis, today's adults, particularly members of the cohorts born during the post-war baby boom, are less willing to sacrifice for the benefit of future generations, including their own children.[4] My explanation does not rely on intergenerational selfishness, but argues that voters tolerate higher deficit spending only because they understand that their own children will not inherit the burden of it alone, but will share it with future immigrants.

Others before have drawn a possible connection between growing intergenerational imbalances and immigration. To consider how much existing patterns of immigration might ameliorate the fiscal imbalances in the United States, Auerbach and Oreopoulos (1999) consider how much a suspension of all future immigration might exacerbate them. Using a generational accounting framework, their findings suggest only a limited role for immigration. By contrast Bonin *et al.* (2000) find that if the present pattern of immigration to Germany is maintained, the arrival of immigrants does partly reduce, though certainly does not eliminate, fiscal imbalances borne by future generations of natives. Fehr *et al.* (2004) find that doubling immigration rates will only slightly mitigate future tax rises in the European Union, Japan, and the US. Storesletten (2000) found that high-skilled professional workers entering the United States in their early 40's generate such high tax revenue that their arrival alone could rebalance fiscal policy at the time—provided that the number of immigrants rose by 40%, and more crucially, that all of them fit this very narrow profile. Other types of immigrants are not nearly as helpful to public finances, and low-skilled immigrants generate net losses. Storesletten (2004) finds that with its more generous welfare payments, relatively high unemployment and low labor force participation rates that prevail for its immigrants, immigration to Sweden generates a net loss.

The best feature of these last papers is the well articulated age structures of the populations being modeled, something that the overlapping generations structure on which they are based easily accommodates. At the same time these overlapping generations models exclude intergen-

[3]In their view, Keynesians came to dominate economic policymaking soon after the end of World War II, their growing influence culminating in passage of the tax cut of 1964. Nonetheless, in the years that followed the debt burden continued to decline, albeit more slowly. Buchanan and Wagner, 1977, pg 48.

[4]See David Brooks, The Geezers' Crusade, *The New York Times*, February 2, 2010 Tuesday, Pg. 27; Ed Howker and Shiv Malik, 2010, *Jilted Generation*, Icon Books, London; Laurence J. Kotlikoff and Scott Burns, 2004, *The Coming Generational Storm*, MIT Press, Cambridge MA; David Willetts, 2010, *The Pinch*, Atlantic Books, London.

erational altruistic links. In essence everyone in these models begins life as an immigrant—the new-born offspring of a native and newly arrived adult immigrants differ only in the shape and length of their earnings profile. Otherwise, long-run fiscal imbalances affect each of these groups in similar ways. By adopting an overlapping dynasties approach, I assume that if members of one generation already resident in the country benefit from unfunded tax cuts, they can use bequests to share their gain with their descendents, and also compensate them for both the higher tax burden and the additional excess burdens financing the additonal debt will entail.

In Section 2, I present the overlapping dynasties model, which features a continuous inflow of infinite-lived optimizing agents.[5] Government expenditure and debt service are financed by taxation on both capital and labor, as well as new bond issuance. In Section 3, I calibrate the model to match some of the main features of the US economy. If households in the economy are all characterized by utility functions with unit intertemporal elasticities of substitution, and government expenditure is a fixed share of net national product, then in the absence of immigration or accumulated debt, a policy of the second best would equalize long-run tax rates on capital and work. What if the government has already accumulated a stock of debt? Because of the lump-sum character of taxing income from capital in the short run, a policy that temporarily raises these tax rates well above their long-run optimal value in the near term in order to run modest surpluses and redeem part of the debt can generate small improvements in welfare by moving the economy closer to its second-best optimum.[6]

If the economy is absorbing immigrants and is expected to continue absorbing them in the future, but policy-makers remain focused on serving the interests of today's residents, other considerations, particularly the desire to shift part of the burden of government expenditure to future immigrants, can easily overwhelm both the case for factor taxation smoothing and any bias in favor of budget surpluses and debt redemption. Policy makers will choose a path of factor taxation that balances the desired shift in the tax burden from natives to future immigrants, against the efficiency losses generated by deviations from the prescriptions of Ramsey optimal tax policy.

Of course efficiency losses depend on which factors are taxed, as well as the elasticities of their supply and demand. I focus on fluctuations in the tax rate on capital income for two reasons. First, in an optimal growth model, the long-run supply of capital is infinitely elastic, and policies that cause the tax rate associated with capital income to fluctuate will generate the highest deadweight losses. Indeed, if policy makers can use future rises in lump-sum or other non-distortionary taxes to finance higher levels of debt, the deficit bias will not only be larger, but nearly unbounded. Furthermore, I assume that immigrants arrive in their new country without capital—it is spent funding their migration. Together, this implies that the policies I model here represent a lower bound on any deficit bias that might exist. Second, around the time the US Federal debt began its initial post-war ascent—a time when policy makers knew the population was aging and likely to continue accumulating unfunded liabilities, this is the

[5]The original version of the overlapping dynasties model was developed by Weil (1989).

[6]This generalises to a wider class of preferences, but only in the absence of steady state growth.

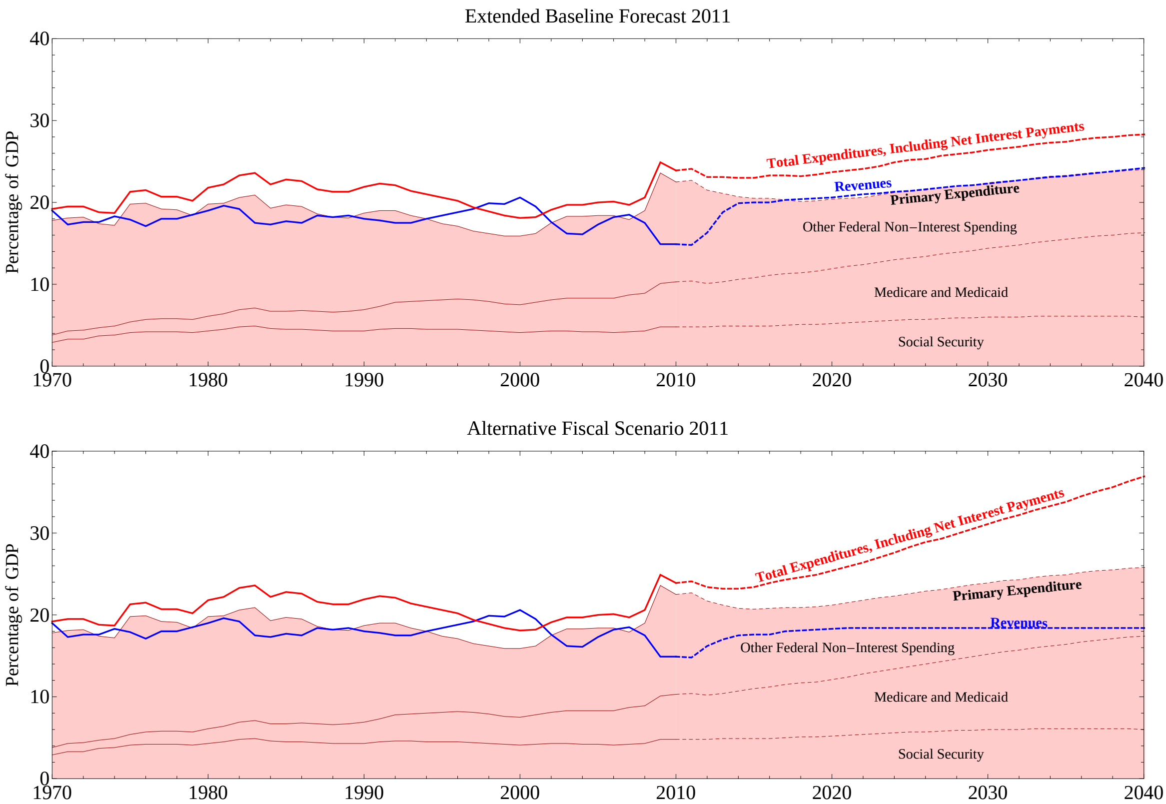

Figure 1: US federal budgets from 1970 to 2010 with forecasts using extended baseline and alternative fiscal scenarios generated by the Congressional Budget Office for 2011 to 2040.

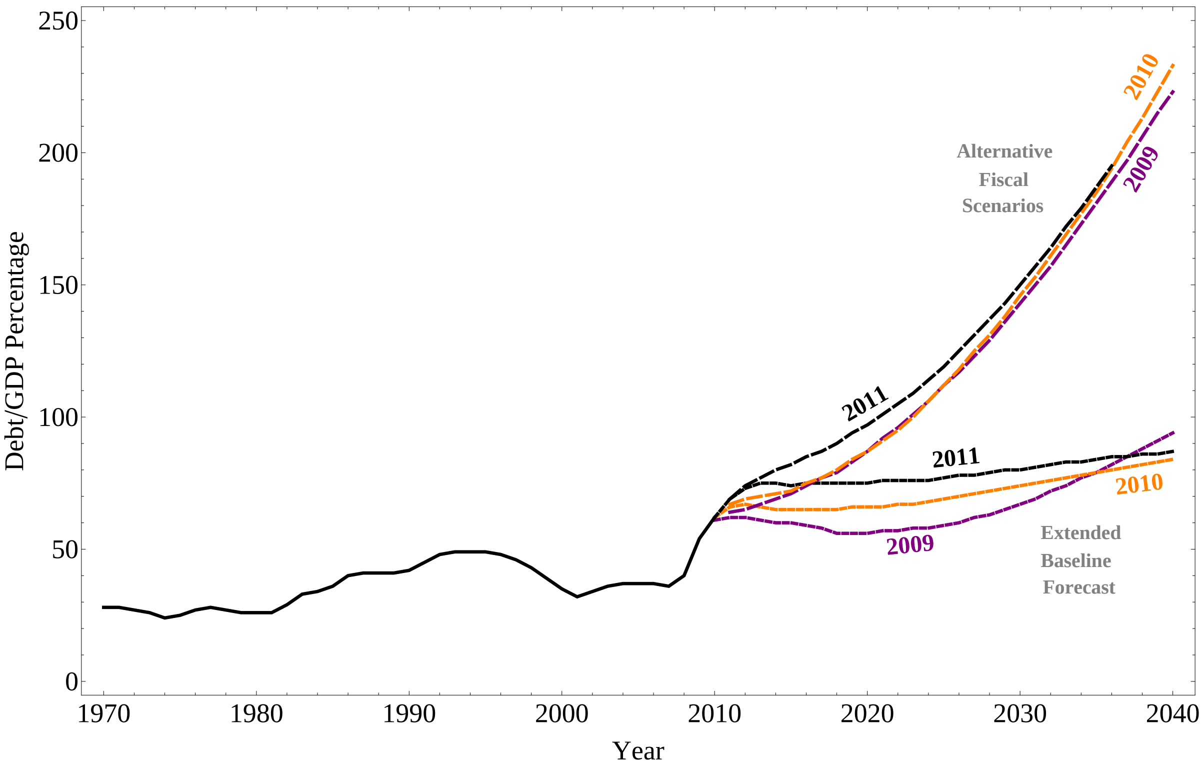

Figure 2: US federal debt held by the public from 1970 to 2010 with forecasts using extended baseline and alternative fiscal scenarios generated by the Congressional Budget Office for 2011 to 2040.

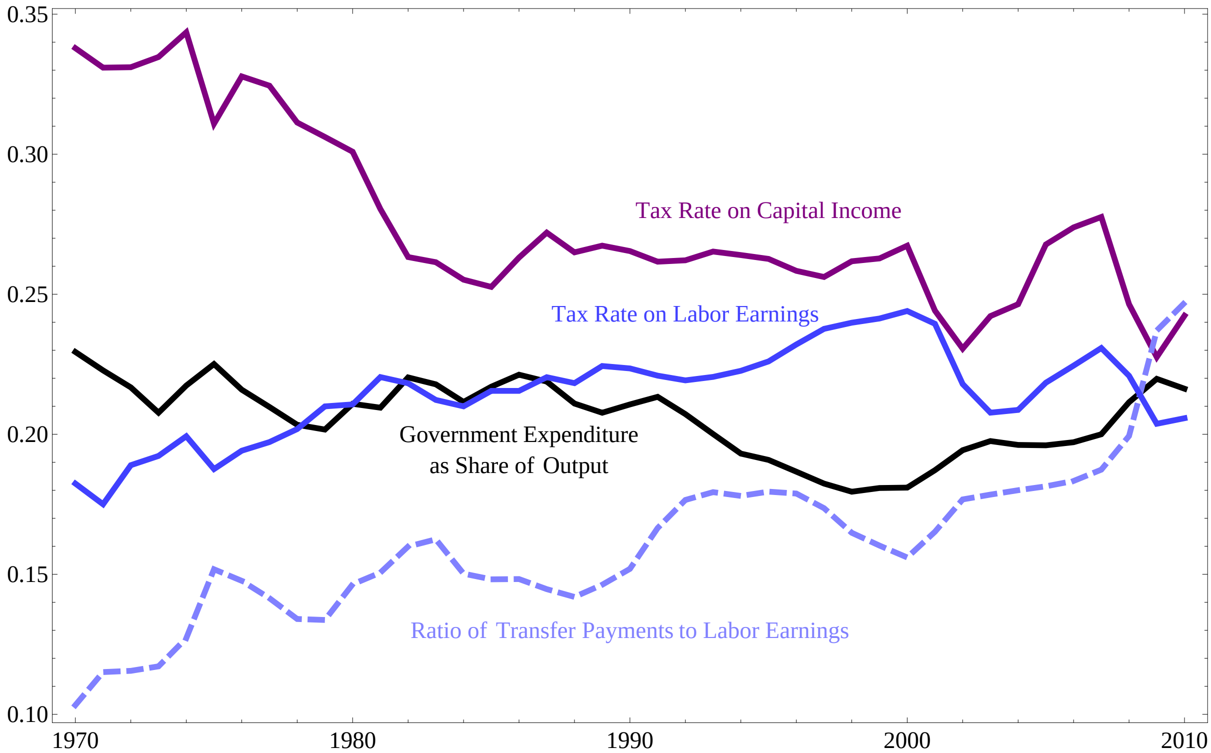

Figure 3: The average rates of tax on income from capital and income from labour earnings in the United States, 1970-2010 are imputed using National Accounts data following the procedure outlined in Gomme and Rupert (2007). Government expenditure (Federal, State and Local), is a share of output, where output includes imputed services from consumer durables.

tax, the one that least impacted most of the growing numbers of recently arrived immigrants, that policy makers chose to lower from an average of 0.326 during the 1970's, to an average of 0.260 in the decades that follow. True, the imputed tax rate on labor earnings rose for most of this period, but the ratio of transfer payments to these same labor earnings more than kept pace. At the same time there is no overall trend to government consumption and investment as a share of net output in Figure 3. Hence, one possible interpretation of US fiscal policy over recent decades is that while government consumption and investment has not been growing any faster than the economy, lost revenues from cuts to the tax on income from capital were replaced by deficit finance, even though it was unlikely that higher taxes on labor earnings would be sufficient to keep pace with the rising burden of transfer payments. What I demonstrate below is that the accelerating pace of immigration, and more importantly its growing importance as source of population growth, could have provided at least some of the motivation for this behavior.

I make no effort to model the migration decision itself. For the United States as well as Western Europe and the rest of the developed world, the marginal supply of potential immigrants from impoverished foreign countries is very large. Furthermore, it is unlikely that even the prospect of inheriting a portion of the growing national debt is likely to deter many people from the world's poorest countries from seeking a better life through migration.

2 The Basic Model

Consider an economy that is closed in every way but one: new people—adult immigrants—are arriving from abroad at a continuous rate of $m(t)$. These new immigrants are founding members of new infinite lived dynasties, each indexed by a value s, the date at which the dynasties' founding member crossed the international frontier to instantaneously join the economy as a worker, consumer, and saver. The economic environment is assumed to be deterministic, and the behavior of each agent including each new immigrant and all of his or her descendants, can be characterized as the maximization of a dynasty's infinite horizon discounted utility function beginning at time s:

$$\max_{c} \int_{s}^{\infty} e^{(\rho-n)(s-t)} \ln c(s,t)\, dt, \tag{1}$$

subject to a time t budget constraint:

$$\dot{a}(s,t) = (1-\tau_h(t))\, w(t)h + ((1-\tau_k(t))\, r(t) - n)\, a(s,t) - c(s,t)\ \forall s,t, \tag{2}$$

and the transversality condition:

$$\lim_{t\to\infty} e^{-\int_s^t ((1-\tau_k(v))r(v)-n)dv} a(s,t) = 0\ \forall s,t, \tag{3}$$

where ρ is the subjective discount rate, n is the rate of natural population growth (the rate at which each dynasty itself is growing), $c(s,t)$ and $a(s,t)$ are consumption and holdings of assets for the members of dynasties of vintage s at time t, and $w(t)$ and $r(t)$ are wages and the rate of return on assets at time t.[7] The assets $a\,(s,t)$ for each household are the sum of holdings of physical capital $k(s,t)$ and government debt $b(s,t)$, and the returns on these assets are taxed at the rate of $\tau_k\,(t)$. Hours worked h are assumed to be constant and common across all households, and earnings are taxed at the rate $\tau_h\,(t)$. The solution to the optimization problem yields the evolution of consumption for each individual dynasty s over time:

$$c\,(s,t) = c\,(s,s)\, e^{\rho(s-t)} e^{\int_s^t (1-\tau_k(v))r(v)dv}. \tag{4}$$

Integrating the first order conditions of the individual maximization problem and the time t budget constraint over time, the consumption rule for dynasty s at time t is:

$$c\,(s,t) = (\rho - n)\,(\omega(t) + a(s,t)\;) \quad \forall s,t. \tag{5}$$

where $\omega(t) = \int_t^\infty e^{-\int_t^u ((1-\tau_k(v))r(v)-n)dv}\,[(1-\tau_h\,(u))\,w(u)h]\,du$ is the present discounted value of net labor income from time t forward.

To simplify the notation, I designate t=0 as the moment the policy we wish to analyze is introduced, and normalize the number of dynasties at that moment to one. Aggregating (5) over all dynasties and differentiating with respect to t, aggregate consumption evolves over time according to:

$$\dot{C}\,(t) = (\rho - n)\left[m\,(t)\,\Omega\,(t) + (1-\tau_k\,(t))\,r(t)\,(\Omega\,(t) + A(t)) + e^{n(t-b)} m\,(t)\,M\,(t)\,a(t,t) - C\,(t)\right], \tag{6}$$

where $C(t) = e^{n(t)} \int_0^t M\,(s)\,m\,(s)\,c(s,t)ds + e^{nt}c(0,t)$, $A(t) = e^{nt}\int_0^t M\,(s)\,m\,(s)\,a(s,t)ds + e^{nt}a(0,t)$, and $\Omega\,(t) = e^{nt}\int_0^t M\,(s)\,m\,(s)\,\omega\,(s,t)\,ds + e^{nt}\omega\,(0,t)$ are aggregate consumption, aggregate assets, and the aggregate present value of future earnings at time t, $M\,(0) = 1$, $M\,(s) = e^{\int_0^s m(v)dv}$ is the number of dynasties that have accumulated by time $s > 0$, and $c(0,t)$, $a(0,t)$, and $\omega(0,t)$ are the time t consumption, assets, and discounted earnings of those dynasties resident in the country at time zero. Rewriting equation (6) in terms of per-capita variables, and distinguishing between physical capital and government debt, yields:

$$\dot{c}\,(t) = (1-\tau_k)\,r(t)c(t) - \rho c\,(t) - (\rho - n)\,m\,(t)\,[b\,(t)\,\beta(t) + k\,(t)\,\kappa(t)]\,, \tag{7}$$

where $c(t) = e^{-nt}\frac{C(t)}{M(t)}$, $b(t) = e^{-nt}\frac{B(t)}{M(t)}$, $k(t) = e^{-nt}\frac{K(t)}{M(t)}$, and $\kappa(t) = \frac{k(t)-k(t,t)}{k(t)}$ is the fractional difference between per-capita physical capital and the physical capital owned by new immigrants at the moment of their arrival, and $\beta(t) = \frac{b(t)-b(t,t)}{b(t)}$ the analogous terms for government debt.

The production function $F : \mathbb{R}^2_{++} \to \mathbb{R}_{++}$ is homogeneous of degree one in aggregate capital and effective labor—the aggregate supply of hours worked $H(t) = e^{nt}M\,(t)\,h$, multiplied by the level of labor augmenting technology $z(t)$. I assume $z(t)$ is growing at the fixed rate x, and rewrite (7) and the per-capita feasibility constraint in terms of the stationary variables $\widetilde{c}(t) = \frac{c(t)}{z(t)}$, $\widetilde{k}(t) = \frac{k(t)}{z(t)}$, $\widetilde{b}(t) = \frac{b(t)}{z(t)}$ and $\widetilde{w}(t) = \frac{w(t)}{z(t)}$:

$$\dot{\widetilde{c}}(t) = [(1-\tau_k)\,r(t) - \rho - x]\,\widetilde{c}(t) - (\rho - n)\,m\,(t)\left[\widetilde{b}\,(t)\,\beta(t) + \widetilde{k}\,(t)\,\kappa(t)\right], \tag{8}$$

[7] I assume complete intergenerational altruism, but otherwise this is most similar to Canova and Ravn's (2000) framework for analyzing the impact of German reunification. By contrast in Zak *et al.* (2002) agents live only two periods and in Storesletten (2000) agents enjoy long but finite lives.

$$\dot{\widetilde{k}}(t) = (1-g(t))\left(F\left(\widetilde{k}(t),h\right) - \delta\widetilde{k}(t)\right) - \widetilde{c}(t) - (x+n+m(t)\kappa(t))\,\widetilde{k}(t), \tag{9}$$

$$\dot{\widetilde{b}}(t) = g(t)\left(F\left(\widetilde{k}(t),h\right) - \delta\widetilde{k}(t)\right) - \tau_h(t)\,\widetilde{w}(t)h - \tau_k r(t)\left(\widetilde{b}(t)+\widetilde{k}(t)\right) - (n+x-r(t)+m(t)\beta(t))\,\widetilde{b}(t), \tag{10}$$

where δ is the depreciation rate of capital and factors receive their marginal products:

$$r(t) = F_K\left(\widetilde{k}(t),h\right) - \delta, \tag{11}$$

$$\widetilde{w}(t) = F_H\left(\widetilde{k}(t),h\right). \tag{12}$$

The present value of future government borrowing is limited by a transversality condition:

$$\lim_{t\to\infty} e^{-\int_0^t (1-\tau_k(v))r(v)dv} B(t), \tag{13}$$

which implies that the time-discounted budget must remain balanced over the long run. In terms of per-capita stationary variables this is:

$$\tilde{b}(0) = \int_0^\infty e^{-\int_0^t (1-\tau_k(v))r(v)dv}\left[\tau_h(t)\tilde{w}(t)h + \tau_k(t)r(t)\tilde{k}(t) - g(t)\left[F\left(\tilde{k}(t),h\right) - \delta\tilde{k}(t)\right]\right]dt. \tag{14}$$

Finally, the production function takes the Cobb-Douglas form:

$$F(K(t), z(t)H(t)) = K(t)^\alpha [z(t)H(t)]^{1-\alpha}.$$

The system (8), (9) and (10), together with the government's budget constraint (14), describes the behavior of the economy, where the products of $m(t)$ and $\kappa(t)$, and $m(t)$ and $\beta(t)$, regulate the impact of immigration on the economy. If $\beta(t)$=0 and $\kappa(t)$=0, new immigrants are identical to members of the already resident population, and changes in the rate of immigration have no effect on per-capita variables in this model.

3 Calibrating the Model

During the 1960's and 1970's immigration rates in the United States were relatively stable, while natural population growth dropped dramatically. From 1961 to 1970, the net rate of migration to the United States averaged 2.01 per thousand, and from 1971 to 1980, it averaged 1.98. At the same time the rate of natural population growth nearly halved, from an average of 10.43 to 6.22. In the next decade the rate of natural population growth had increased slightly, averaging 7.20 between 1980 and 1990, but the net rate of immigration began to climb, averaging 2.75 per thousand. From 1991 to 2000, the average net rate of migration increased again, doubling to 4.58 per thousand while natural population growth began receding once more, averaging 6.28 per thousand. In the first decade of this century natural population growth has continued to decline, averaging 5.75 per thousand between 2001 and 2010, and immigration also decreased to an average of 2.96 per thousand.

My hypothesis is that as the source of population growth has shifted from one driven by the excess of births to deaths in the native population to one increasingly reliant on higher rates of immigration, and subsequent above average birth rates among those newly arrived, a bias in favour of deficit funding on the part of the native population emerges. Though such a change is inevitably driven by subtle shifts in attitudes and a consequent process of gradual adjustment, I find it convenient to choose a specific date as a starting point for this policy in my analysis. The decade beginning in 1981 is when both the drop in the tax rate on income from capital and the rise in the public debt burden coincided with a substantial increase in the rate of immigration. Hence, to calibrate the model, I use long-run averages for the United States economy over the thirty years from 1981-2010.

Following the example of Cooley and Prescott (1995) and Gomme and Rupert (2007), henceforth output Y includes both gross domestic product and the imputed services from consumer durables. This measure of output was on average 8.345% higher than GDP alone. Solving (9) in steady state for the rate of depreciation in terms of the long-run ratios of consumption and capital to output, C/Y and K/Y yields:

$$\delta = \frac{1 - g - C/Y - (n + x + m\kappa)K/Y}{(1-g)\,K/Y} \tag{15}$$

Between 1981-2010, the capital-output ratio K/Y averaged 3.028, consumption as a share of output C/Y averaged 0.619, and the rate at which real per-capita output grew, x, averaged 0.017 per annum. The share of government consumption and investment g out of net output (including services from consumer durables but excluding depreciation of fixed assets) averaged 0.203 between 1981-2010. Finally, the average annual rate of natural population increase, n, was 6.4 per thousand, and the annual net rate of international migration, m, was 3.4 per thousand, yielding an overall rate of population growth of 9.8 per thousand. However, these numbers understate the full contribution new immigrants make to long-run population growth, as they abstract from differences in total fertility rates between natives and immigrants. For example, for the period from 2005-2050, new immigrants and their descendants are predicted to account for 82% of population increase, equivalent to a net migration rate of 8.0 per thousand, assuming the overall rate of population growth remains the same.[8] When determining what fiscal policy is most advantageous for the population already resident in the country, it is important to remember that immigration's role in population growth is far more significant than a comparison of the raw numbers would indicate.

In my analysis, I fix the overall rate of population growth at 9.8 per thousand throughout, and vary the share of that growth generated by immigration. To calibrate the model, I set the rate of migration m to 0.0057, or 5.7 per thousand, and the rate of natural population growth n to 0.0041. That is consistent with new immigrants who arrived between 1980 and 2005 and their US born descendants, accounting for 58% of the 68 million additional people added to the United States population during that period.[9] I assume κ=1 and β=1—immigrants arrive in the United States after having exhausted during their passage whatever capital they may have

[8] Jeffrey S. Passel and D'Vera Cohn, "U.S. Population Projections: 2005–2050," *Pew Research Center, Social and Demographic Reports*, 2008, p. 2.

[9] *Ibid.*

owned, and do not arrive owning US government debt. The overall depreciation rate δ for this economy is 0.0401.

Solving (8) in steady state for the subjective discount rate yields:

$$\rho = n + \frac{((1-\tau_k)(C/Y - (1-\alpha)(1-g)) + ((n+x)(g-\tau_k) + (1-\tau)\kappa m)K/Y)}{(1-g)(m(\beta B/Y + \kappa K/Y) + C/Y)} \frac{C/Y}{K/Y}. \quad (16)$$

As the aim of this work is to explain both the rise in United States public debt over recent decades, as well as its projected increase in the decades to come, I solve for steady state values that are consistent with the ratio of public debt to output in 1981, rather than taking an average across the entire period. At the start of 1981, the stock of US public debt corresponded to 26.1% of GDP, which implies a value for B/Y of 0.2412, in terms of our more broadly defined output. The share of capital in output includes net interest, profits, and rental income, as well as the identical share of proprietors' income. Together they averaged 0.362 over the period. I use that for the value of α. I calculate the tax rate on capital income τ_k using a method similar to Mendoza *et al.* (1994) or Gomme and Rupert (2007), except that here the tax is imposed on returns net of depreciation. The imputed tax rate on capital income averaged 0.315 in the 1960's and 0.322 in the 1970's, and then dropped to an average of 0.265 during the 1980's, 0.262 in the 1990's, and 0.250 in the first decade of the twenty first century. The average rate between 1981 and 2010 was 0.259, but for reasons that will become clear in Section 5, I choose the higher value of 0.29 as the initial steady state value for τ_k when calibrating the model. This implies a subjective discount rate ρ of 0.038 per annum. Setting (8), (9) and (10) equal to zero, and using (11) and (12), the steady state tax rate on labour earnings τ_h, net of transfer payments, is 0.181.

In steady state, the relationship between gross investment flows I and capital stock K is:

$$\frac{I}{Y} = (x + \delta + n + m\kappa)\frac{K}{Y}, \quad (17)$$

which implies an investment to output ratio of just under 0.203. This is somewhat less than the average of 0.226 between 1981 and 2010, derived from US National Income and Product Accounts, if consumer durable purchases are treated as investment. The implied steady state rate of return, net of depreciation is 0.0794. By comparison, the net rate of return on capital, during this period, including imputed services from consumer durables, was 0.07, based on NIPA data.

4 The Upper Bound on Debt

Before considering the dynamic impact of changes in taxation on both the economy and the welfare of the native population, we should consider what fiscal policies are actually feasible in the long term, particularly in relation to shifts in capital taxation. When a government lowers taxation for a given length of time, while holding government expenditure as a share of net output fixed, it accumulates debt that must ultimately be financed by future increases in tax rates. The steeper the initial cut in taxation, or the longer its duration, the larger the debt accumulated in the interim, but because the size of the tax base is endogenous, there is an upper limit to how much debt an economy can finance.

To demonstrate, I set (8), (9) and (10) equal to zero, set the parameters other than immigration equal to their calibrated values, fix the tax rate on labour income, and calculate the combinations of the capital tax rate τ_k and the steady state amount debt/output ratios for rates of immigration of zero, 3.4, 5.7, 8 and 9.8 per thousand.[10] What emerges in Panel (a) of Figure 4 are five monotonically increasing convex curves, corresponding to each rate of immigration, that relate the percentage of debt to GDP to the tax rate on capital necessary to finance it, assuming both the share of net output devoted to government expenditure and the net tax rate on labor earnings remain constant. As the total growth rate of the population is fixed at 9.8 per thousand, the lower the rate of immigration, the higher the concurrent rate of natural population growth. Higher natural population means more descendants per household, and the more households will save for them by accumulating physical capital. Hence the lower the share of immigration in a given rate of population growth, the greater the tax base, and the slightly higher the steady state levels of debt sustainable from the same rate of capital tax.

None of this implies a monotonic relationship between the rate of capital income taxation and the absolute amount of debt it can sustain. For high rates of taxation, the increasing debt to GDP ratios represented by the curves in Panel (a) of Figure 4 are generated not by an increase in the debt numerator, but by an accelerating decline in the GDP denominator as higher levels of capital taxation depress the stock of physical capital.

To understand how much revenue can ultimately be generated by capital taxation, I fix the denominator to be GDP at the level consistent with the initial tax rate on capital income of 0.29, and the initial steady state value of debt at 26.1% of GDP. What emerge in Panel (b) of Figure 4 are Laffer curves—the additional revenue generated by each increment of tax declines as the tax base shrinks, until a maximum amount of revenue and the debt it can finance is arrived at. These Laffer curves reach their peaks at tax rates between 0.791 if the rate of immigration is at the maximum of 9.8 per thousand, and 0.801 if there is no immigration at all.

The tax rates that correspond to the peaks in Panel (b) of Figure 4 are significant, because they represent the effective limits of fiscal policy in this economy. Starting from our initial steady state, a policy that cuts tax rates deeply enough, or for long enough, to accumulate debt higher than between 338.9% of initial GDP (if the source of all population growth is from immigration) and 382.4% of initial GDP (in the absence of all immigration) would not be merely self-defeating, but simply impossible. It also means that we should never expect the observed debt to GDP ratio to exceed between 586% (if the source of all population growth is from immigration) and 666% of GDP (in the absence of all immigration). This is well above the theoretical limit of 195% of GDP by 2036, set by the Congressional Budget Office in its Alternative Fiscal Scenario published in June 2011, but well below the 947% of GDP by 2084

[10]The steady state value of the tax rate on labour τ_h, varies slightly with each rate of immigration, from 0.179 if m=0, 0.178 if m=0.0034, 0.176 if m=0.008 or 0.0098, as well as 0.177 for the baseline case of m=0.0057.

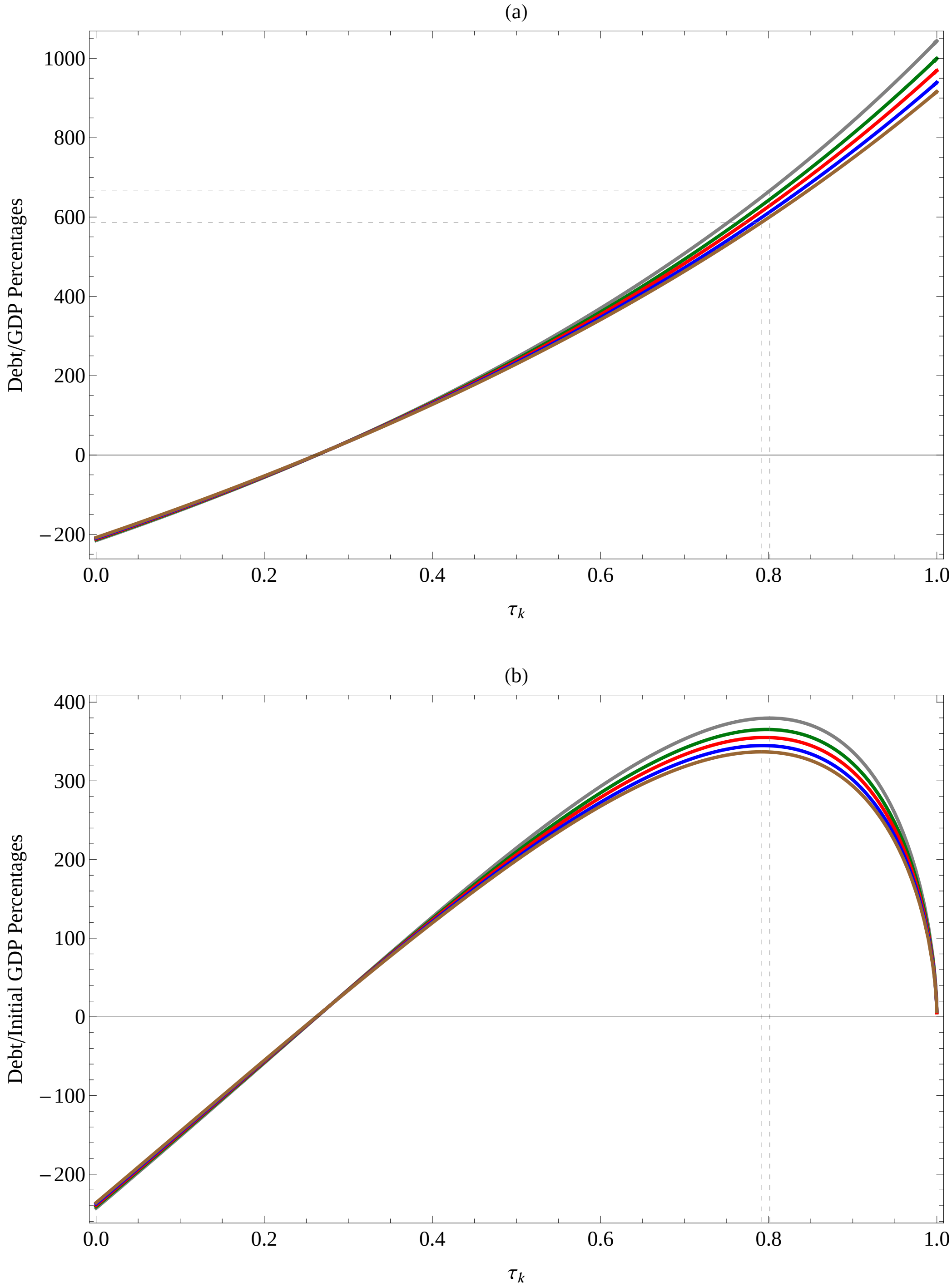

Figure 4: Each solid curve represents the steady state public debt as a percentage of GDP as they relate to the rates of capital taxation τ_k necessary to finance them. The grey curves correspond to no immigration, m=0; the green curves to a per annum immigration rate of 3.4 per thousand, the red curves to a per annum immigration rate of 5.7 per thousand, the blue curves to a per annum rate of 8 per thousand, and the brown curves to to a per annum rate of 9.8 per thousand. In each the overall rate of population growth is set to 9.8 per thousand. Each dashed curve represents the percentage of public debt to GDP where the latter is fixed to its calibrated value corresponding to the initial debt of 26.2% of GDP. The vertical grey dashed lines represent the values of τ_k at which these curves m=0 and m=0.0098 achieve their maxima, and the horizontal grey dashed lines the corresponding steady state public debt as a percentage of GDP.

it predicted in the preceding year. In the next section, I will consider how close to these limits policy makers might choose to go.

5 Deficit Policy and Welfare

In an optimal growth model, the long-run supply of capital is infinitely elastic, so of all the taxes we ordinarily observe, fluctuations in the tax on income from capital have the greatest potential to generate welfare losses. Focusing on the effects of deficit finance necessitated by deferring these taxes to the future provides us with a lower bound for how much rising public debt could be motivated by the rising shares of immigrants in the population.

In keeping with the time scales in Figures 1 and 2, I assume a very high degree of policy stickiness—governments set tax rates to benefit the country's resident population at a given moment, and these remain unchanged for at least a generation, if not longer. An initial perturbation to the tax rate on capital from its starting value of 0.29, lasting T years, is then followed by a permanent change, sufficient to ensure that the impulse responses generated by (8), (9) and (10) exactly satisfy the transversality condition (3) and the government's intertemporal budget constraint (14). That means the new long-run tax rate is set to permanently fund the fixed share of government expenditure in net output, and to finance interest payments on both the stock of pre-existing public debt and any additional public debt that has accumulated in the interim, while the rate of labor taxation remains unchanged.

Assume that at time t=0, the economy is in steady state, with per-capita output, per-capita capital and wages growing at a constant rate, and tax revenue just sufficient to fund the government's expenditures and finance the interest payments on its debt. Furthermore assume that policy makers are free to change the tax rate on capital, $\tau_k(t)$, for a period of T years, but we restrict the tax rate on labor income, $\tau_h(t)$, to remain fixed.

First, policy makers have the option to leave the tax rate as is, and keep the economy in permanent steady state. Second, policy makers can raise the tax on capital income. Since the calibrated tax rate of 0.29 is not enormously high, the result of any small or moderate increase will be years of budget surpluses, with the extra revenue dedicated to redeeming all or part of the existing stock of debt. Once this policy is suspended, the lower debt burden will permit the tax rate on capital to be set permanently lower from year T onwards. Finally, policy makers can choose to lower the tax on income from capital until T, and finance the shortfall in the government's budget by issuing additional debt. This policy too comes to an end at time T, after which the tax rate must rise sufficiently beyond its initial value of 0.29 to finance the interest payments on the additional debt.

Using third-order perturbations to capture the non-linearities in their dynamic paths, I calculate each impulse response to shifts in the initial tax rate from 0.29 to between 0.22 and 0.34 for rates of immigration between zero and 9.8 per thousand, and policy horizons T=30, 40, 50 and 60 years.[11] These impulse responses can then be used to determine the welfare

[11] Though optimal growth models are often analysed using linearisations around a steady state, policy-induced

implications of each policy.[12] But what do we mean by welfare in this context? There is no representative agent or dynasty in this economy, and the number of dynasties is ever-expanding. Whose welfare do I mean? I will focus on the welfare of those people resident in the country at time t=0, when the policy is being determined. It is with maximising the welfare of those people, and not future generations of immigrants that have yet to arrive, that policy makers concern themselves.

It must be emphasized that this is not a mechanism for intergenerational redistribution or conflict. By maximising the welfare of those resident at time t=0, I mean maximization of the intertemporal utility of the infinite-lived dynasties; so policy makers are implicitly concerned not only with the welfare of today's population but with the welfare of all of its descendants. The only people whose interests I assume are ignored are those of the future immigrants yet to arrive in the country at the time when the policy is determined, as well as their descendents.[13]

For a given rate of immigration m and a policy horizon T, I assume the policy maker compares the discounted welfare generated by the evolution of $c(0,t)$, the consumption of a representative dynasty already resident in the country at time t=0 that follows the adoption of the new policy, against the discounted welfare generated by the analogous counterfactual consumption path $\bar{c}(0,t)$, when the baseline policy of budget balance remains in force:

$$\int_0^\infty e^{(n-\rho)t} \ln c\left(0,t\right) dt = \int_0^\infty e^{(n-\rho)t} \ln\left[\left(1+p_{m,T}\right)\bar{c}(0,t)\right] dt. \tag{18}$$

The difference between the two, the welfare effect, is measured as a compensating differential—a permanent fraction $p_{m,T}$ of consumption needed to compensate native households for not deviating from the baseline fiscal policy. Inserting (4) into (18) and solving for $p_{m,T}$ yields:

$$p_{m,T} = \frac{\bar{c}\left(0,0\right)}{c\left(0,0\right)} e^{(\rho-n)\int_0^\infty \int_0^t e^{(n-\rho)t}((1-\tau_k(v))r(v))dvdt - \frac{(1-\bar{\tau}_k)\bar{r}}{(\rho-n)}} - 1 \tag{19}$$

In each panel of Figure 5, labeled T= 30, 40, 50 and 60 years, the grey, green, red, blue and brown curves represent the values of the compensating differentials $p_{m,T}$, when m=0, 0.0034,

changes in welfare can be sensitive to non-linearities in the saddle path. All impulse reponses here are calculated as third order perturbations to capture the non-linearity of consumption, physical capital and the path of public debt as they converge to their new steady state growth path.

[12]The impulse responses for debt, for a particular set of policy choices, are presented in the next section. Qualitatively, the impulse responses representing the behavior of per-capita capital and consumption, and the rate of return to capital, following the implementation of each of these policies, are fairly standard for an optimal growth model. An initial rise [cut] in the tax on capital income causes the net rate of return to capital to decline [increase]. Consumption immediately increases [decreases] and savings decrease [increase], causing capital to gradually decline [rise]. In the years that follow, agents anticipate the future decline [increase] in the tax rate and resume [suspend] saving so by time T, when the tax rate declines [increases] to ensure long-term balance in the government's budget, capital is already above [below] its initial value. Long-run consumption and capital are higher [lower] and the after tax rate of return converges to its initial value.

[13]Even if the policy were re-evaluated in each period, and immigration were the sole source of all population growth, it would take more than seventy years for the accumulated stock of new immigrants who arrive after t=0 to form a majority. Hence policies that serve the interests of the entire population when they are introduced, though not strictly time consistent because of the presence of capital in the economy, do benefit the majority of the population for far longer than the highest value of T in my simulations.

0.0057, 0.008 and 0.0098 respectively, as the rate of capital taxation shifts during the period from 0 to T, from its initial value of 0.29. Figure 6 displays the analogous curves in terms of the long-run consequences of such policies—the accumulated debt as a percentage of GDP in the limit, as the economy converges to its new steady state, compared to where it began with debt at 26.1% of GDP.

In Table 1, I provide a summary of the policies that correspond to the maxima of each curve in Figures 5 and 6. The first column lists the tax rates τ_k during the initial period between time zero and time T when the tax rate changes from 0.29, and the second column the tax rates after time T necessary to finance the new debt burden that has accumulated during the interval. The debt burden at time T is listed in the third column, and its long-run value after the economy has converged is listed in the fourth column. This corresponds to the values on the horizontal axis in Figure 6. The fifth column of Table 1 lists the values of the maximum compensating differentials $p^*_{m,T}$, themselves. Finally, the sixth column is the difference between the value $p^*_{m,T}$ for a given rate of immigration and the value $p_{0,T}$, the compensating differential associated with the same policy we would calculate if we ignored immigration. Graphically this is the vertical distance between the maximum points on each of the green, red, blue and brown curves in Figure 6 and the corresponding point on the grey curve directly below. Since typically, in the absence of immigration, a policy of deficit finance sustained over decades yields a welfare loss, the numbers in column six of Table 1 provide a measure of the extent to which we risk misunderstanding the welfare consequences and motivation behind such policies when we ignore immigration.

Indeed, consider first the shape of the grey curves and what they tell us would be the optimal policy if the economy were not absorbing any immigrants at all. The logic of Harberger's triangle nearly prevails—as in Lucas and Stokey (1983), in their model without capital, the convexity of the excess burden with respect to the tax rate implies the best policy is to smooth the tax rate over time, and not depart from steady state. However there are two reasons why slight deviations from tax smoothing will generate small welfare benefits here. First, the short-run supply of capital is inelastic, so the lump-sum property of taxing it immediately at a higher rate is beneficial, particularly if the additional revenue is applied to a partial redemption of public debt, enabling lower taxes in the future.[14] Second, the model is not calibrated around the Ramsey second-best optimal policy—the tax rate on capital is higher than the share of government expenditure in output.[15] Raising the tax rate from period zero to T means that in the long run the economy will converge closer to a steady state that is Ramsey optimal. These two reasons are why, in the absence of immigration, a policy that raises the tax on capital income in the short run to redeem part of the debt generates a very small welfare benefit.

For example, if the policy horizon is set to $T = 30$, and m=0, a policy that raises the tax

[14]This is a direct implication of *Theorem* 3 in Chamley (1986).

[15]Because government expenditure in not a fixed amount but a fraction g of net output, the second-best long-run optimal policy is not the familiar Chamley-Judd result of eliminating the tax on income from capital and placing the burden of government finance on labor, but rather to set all taxes equal to g.

on capital from 0.29 to 0.295 for thirty years will eventually lower the debt burden from 26.1% of GDP to 19.6%, once the economy has fully converged. That lower debt will be financed by a lower permanent tax rate of 0.283. This reduction of the debt burden generates a very small improvement in welfare, equivalent to a permanent increase in consumption of 2.7×10^{-5} or 0.0027%. The higher the value of T, the longer the policy persists, and the weaker the lump-sum aspect of the initial rise in taxation—what few benefits can be derived from slight declines in both debt and future tax rates is diluted still further. Though the grey curves do rise (almost imperceptibly) above zero to the right of the initial tax rate of 0.29, if the economy is not absorbing immigrants, holding taxes constant and maintaining the debt burden fixed is very close to an optimal policy. Tax cuts that allow debt to rise will always generate welfare losses, and anything but the smallest of temporary rises in taxes to enable a modest redemption of the debt diminishes welfare as well.

If the economy is absorbing even small numbers of immigrants, raising the tax rate initially to accumulate surpluses and facilitate lower taxes after time $t = T$ reduces welfare for the initial population. The curves associated with rates of immigration of 3.4, 5.7, 8.0 and 9.8 all decline monotonically to the right of the initial tax rate of 0.29 in Figure 5, and the initial debt burden of 26.1% in Figure 6. Indeed, the higher the rate of immigration, the more such a policy shifts the tax burden away from future immigrants and towards the initial population—hence the higher the rate of immigration, the steeper declines in welfare the latter will experience. Similarly, the higher the value of T, the more time the policy of surpluses is in force, and the greater the decline in welfare. We should not expect to see economies that are absorbing relatively larger numbers of new immigrants running sustained budget surpluses to enable future reductions in tax.

By contrast, the temporary and partial replacement of taxes with deficit finance, provided it is not too great, has the potential to improve the welfare of the initial population resident at t=0. Of course, if the rate of immigration is relatively modest, and the policy horizon not too long, the benefits are small. The green curves correspond to the measured rate of net migration to the United States when averaged across the last three decades, 3.4 per thousand. For example cutting taxes on income from capital to 0.274 for thirty years generates a benefit to members of the initial population equivalent to a permanent 0.02% increase in consumption. Cut taxes much further and the benefit soon disappears, as the long-run efficiencies associated with a future of high debt and high taxes overwhelms the benefits of shifting part of the tax burden to future immigrants.

However, the benefits of deficit finance rise quickly the more immigrants contribute to population growth. The rate 3.4 per thousand understates the impact of immigration, because it ignores the differences in fertility rates between the native population and new immigrants. If we maintain the policy horizon of T=30, the length of time which corresponds to the period between 1981 to 2010, but raise the rate of immigration to 5.7 per thousand, the rate of immigration used to calibrate the model, a policy of deficit finance can generate a welfare improvement for the initial population equivalent to a 0.09% permanent increase in consumption. This happens when the tax rate on capital income is initially cut to 0.259. As mentioned in Section 3, this is in fact the rate that corresponds to the observed value of τ_k between 1981 and 2010. This is not by chance, the choice of 0.29 as the initial tax rate for calibrating the model was designed to match this observation. However, as it happens, as I will demonstrate in Section 6, the rise in debt thirty years later that the model predicts will accompany this policy is nearly a perfect match for the actual rise in US public debt from the beginning of 1981 to the end of 2010.

Though the difference between 0.02% and 0.09% is substantial—the welfare gains rise in a convex fashion as the rate of immigration increases in Figure 7—it could be argued that a rise in consumption, even if permanent, of less than one tenth of one percent hardly constitutes sufficient motivation for a sustained policy of deficit finance. Yet by not considering immigration, any large deviation from a policy of smoothing taxes and budget balance would seem inexplicable. If we ignore immigration and set m=0, lowering the tax rate for thirty years so that the debt burden ultimately stabilizes at 63.4% of GDP is a policy that generates a welfare loss equivalent to the 0.15% permanent drop in consumption in the last column of Table 1 under $p_{0,T}$. Taken together, the difference between the values of $p^*_{m,T}$ and $p_{0,T}$ represents a mismeasurement of the welfare consequences of this policy, equivalent to 0.24% of permanent consumption. Furthermore, these results assume that the reliance on deficit finance was discontinued from 2010, after which the US shifts permanently to a policy of higher capital taxation that causes the debt to stabilize. If instead the policy horizon is extended to forty years, the difference between $p^*_{m,T}$ and $p_{0,T}$ grows substantially. Now with the rise in taxes postponed till 2020, the maximum achievable welfare benefit rises to the equivalent of a 0.13% increase in consumption, juxtaposed against a 0.22% drop in welfare measured in the absence of immigration. Postpone the shift in policy to 2030 or 2040, and the equivalent rise in welfare is 0.16% and 0.18% and not the welfare loss equivalent to 0.28% and 0.30% of permanent consumption we might assume if we disregard immigration.

And what if the net rate of immigration is not the official 3.4 per thousand that obtained between 1981-2010, or the effective rate of 5.7 that prevailed between 1980-2005 once the difference in fertility between immigrants and natives is factored in, but closer to the 8.0 per thousand effective rate predicted for the years 2005-2050? The welfare maximizing policies will entail even deeper initial tax cuts and and more accelerated accumulation of debt. At this higher rate of immigration and a policy horizon that lasts sixty years, the optimal policy is for the tax rate on capital income to be set to only 0.248. In the long run, the debt will stabilize at 247.4% of GDP, and financing it will necessitate raising the tax rate from the year 2040 onwards to 0.512, but such a policy generates a benefit to the initial population that is equivalent to a 0.38% permanent increase in consumption, rather than the loss of 0.72% that would prevail if the debt were allowed to reach that same ratio to GDP in the absence of immigration. Finally, assume the policy still lasts for sixty years but the source of all population growth is immigration. The optimal policy reduces the tax to only 0.236 and then raises it to 0.587 to help finance the debt, which ultimately stabilizes at 340% of GDP once the economy has coverged. This is associated with a welfare gain equivalent to a 0.59% permanent increase in consumption. Ignore

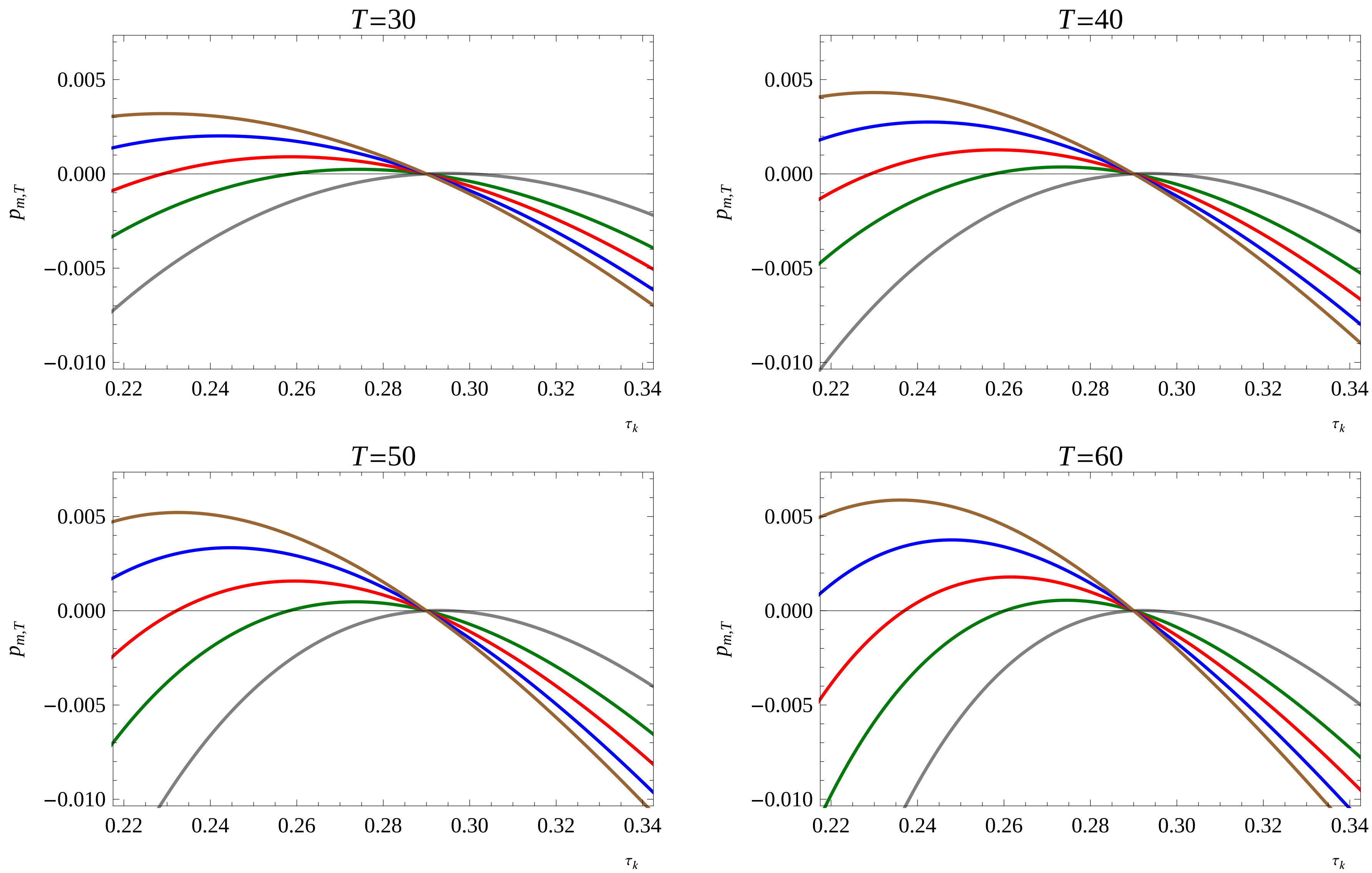

Figure 5: Compensating differentials $p_{m,T}$ for a change in the tax rate on capital income from its initial value of 0.29 for policy horizons of T=30, 40, 50, 60 and the rate of immigration of zero (grey), 3.4 per thousand (green), 5.7 per thousand (red), 8 per thousand (blue) and 9.8 per thousand (brown). Results are only calculated for deficits that are sustainable.

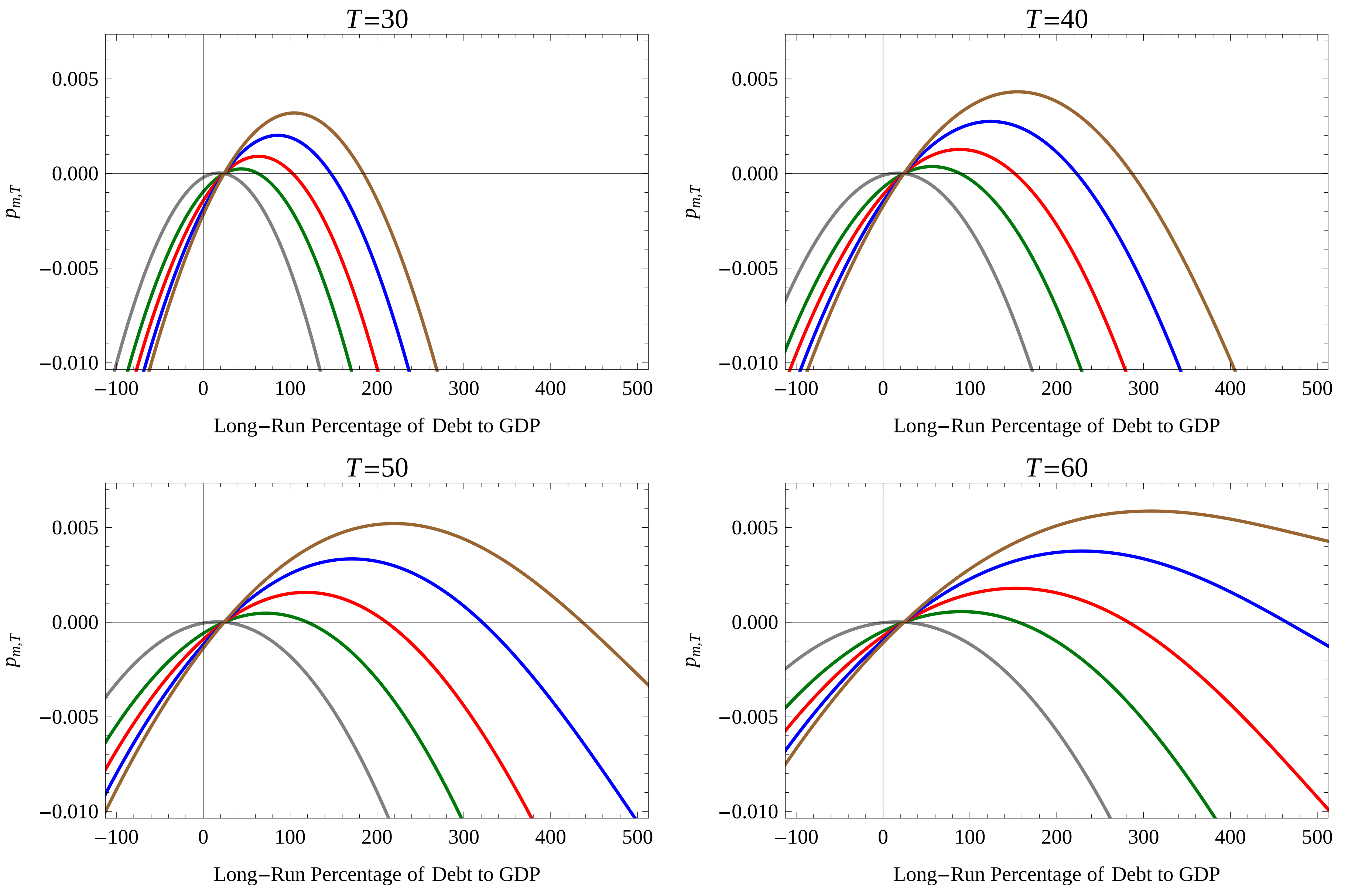

Figure 6: Compensating differentials $p_{m,T}$ for a change in long-run debt from its initial value of 26.1% of GDP, for policy horizons of T=30, 40, 50, 60 and the rate of immigration of zero (grey), 3.4 per thousand (green), 5.7 per thousand (red), 8 per thousand (blue) and 9.8 per thousand (brown). Results are only calculated for deficits that are sustainable.

Rate of Immigration Per Thousand	$\tau_k \ (t < T)$	$\tau_k \ (t \geq T)$	$\frac{b(T)}{GDP(T)}$	$\frac{b(\infty)}{GDP(\infty)}$	$p^*_{m,T}$	$p_{0,T}$
			$T = 30$			
0	0.295	0.283	0.197	0.196	2.7×10^{-5}	0
3.4	0.274	0.313	0.476	0.475	0.0002	−0.0005
5.7	0.259	0.336	0.684	0.685	0.0009	−0.0015
8.0	0.242	0.364	0.8942	0.936	0.0020	−0.0036
9.8	0.229	0.387	1.149	1.139	0.0032	−0.0057
			$T = 40$			
0	0.294	0.281	0.180	0.180	2.1×10^{-5}	0
3.4	0.273	0.329	0.623	0.622	0.0004	−0.0007
5.7	0.258	0.365	0.969	0.963	0.0013	−0.0022
8.0	0.243	0.405	1.345	1.331	0.0028	−0.0047
9.8	0.230	0.441	1.699	1.675	0.0043	−0.0081
			$T = 50$			
0	0.293	0.280	0.171	0.171	1.6×10^{-5}	0
3.4	0.274	0.344	0.773	0.771	0.0005	−0.0008
5.7	0.259	0.399	1.305	1.294	0.0016	−0.0028
8.0	0.245	0.455	1.867	1.839	0.0033	−0.0062
9.8	0.233	0.506	2.408	2.363	0.0052	−0.0110
			$T = 60$			
0	0.292	0.281	0.175	0.175	1.2×10^{-5}	0
3.4	0.275	0.363	0.959	0.955	0.0006	−0.0009
5.7	0.262	0.432	1.651	1.631	0.0018	−0.0030
8.0	0.248	0.512	2.520	2.474	0.0038	−0.0072
9.8	0.236	0.587	3.400	3.343	0.0059	−0.0147

Table 1: Changing the tax rate from its initial value of 0.29 to its welfare maximising value.

immigration and the same policy reduces welfare by the equivalent of lowering consumption by 0.0147. Hence a policy of sustained tax cuts that allows the debt burden to ultimately rise so high would seem inexplicable, if we fail to distinguish carefully between the two sources of population growth.

All of these simulated examples hold the tax rate on labor income fixed. First, since 1981, the imputed tax rates on labor income in the United States have if anything risen slightly—particularly because of increases during the early 1980's in the rates for FICA—and have then been paid out as transfer payments. Furthermore, what I am able to demonstrate here is that even if I confine the analysis to a particularly distortionary type of tax—the tax on returns to capital and bonds—the model can justify significant deficits and the accumulation of debt over time. The welfare results in Table 1 are merely a lower bound on the potential benefit the initial population and its descendents may derive if they are free to let the debt rise quickly, before bequeathing part of it to a new population of immigrants. As we will see in the next section, the behavior of debt as simulated in the model bears a close resemblance to the trajectory of US debt and its predicted evolution in Figure 2.

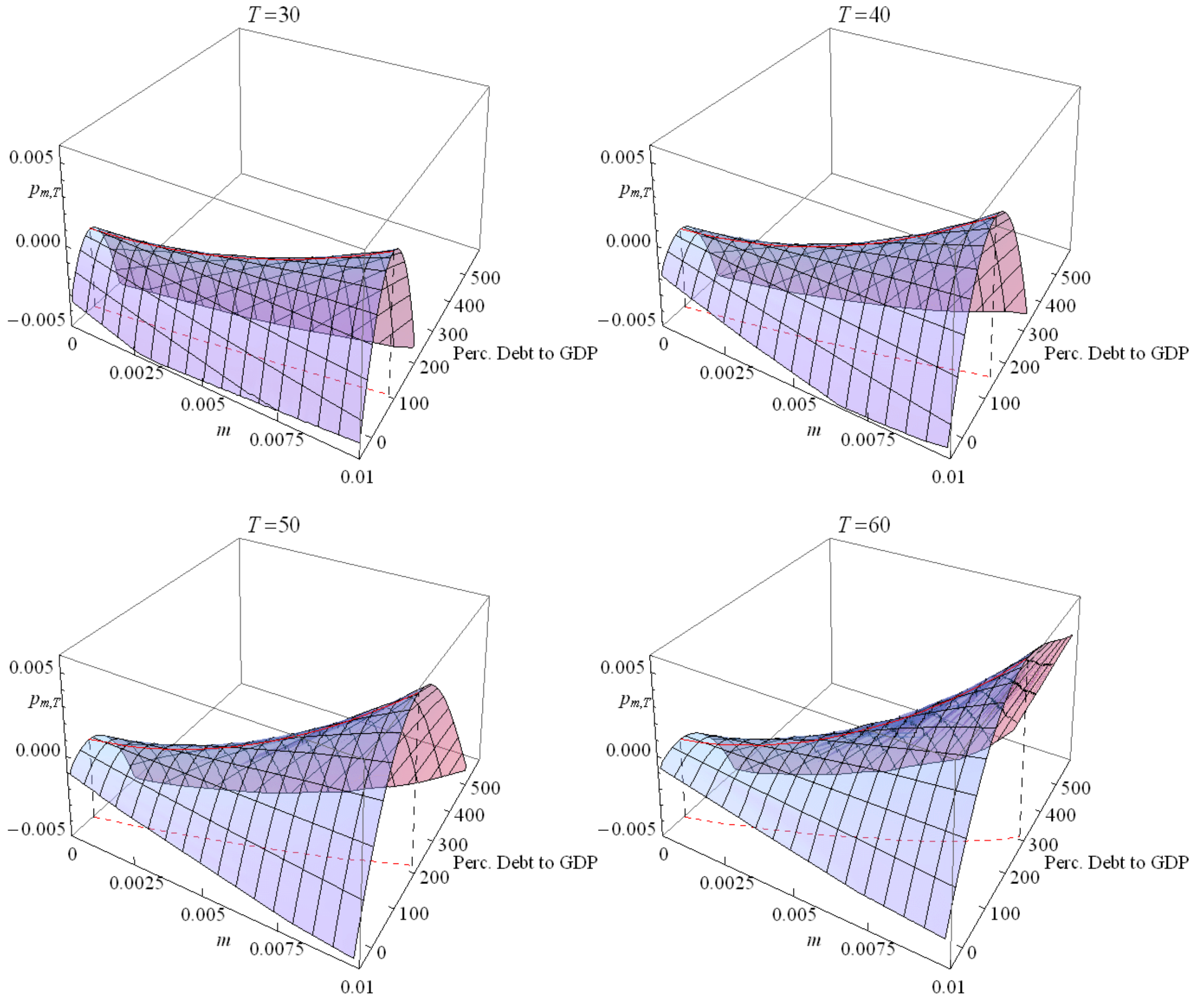

Figure 7: Compensating differentials $p_{m,T}$ for a change in the tax rate on capital income from 0.29 for T=30, 40, 50, 60 and rates of immigration ranging from zero to 9.8 per thousand.

6 Simulating the Trajectory of US Debt

It is of course the case that the trajectory of US debt is the result of decision-making and political processes that are far more dynamic, and far more contingent on unforeseen circumstances, than I assume in my model. What my model demonstrates is merely that *ceteris paribus*, there is likely to be a far greater willingness to defer taxes and rely on deficit spending during periods when immigration is a more prominent component of population growth. Nevertheless, to a surprising degree, the model is able to capture both the steep decline in the tax rate on capital from 1981 onwards in Figure 3, and the subsequent accumulation of debt in Figure 2.

From its entry into World War II at the end of 1941 to the year the war is ended in 1945, the U.S. Federal Government debt as a ratio of GDP climbed from 43.3% to 112.7%.[16] From then on, every year but three (1949, 1954 and 1958) the debt to GDP ratio declined as the US government retired its wartime debt, until the end of 1974, when it reached a postwar low of 24.6%. During the remaining years of that decade, the debt burden was relatively stable.

The year 1981, the year President Ronald Reagan took office, was a turning point. In every one of the subsequent 13 years, the percentage of debt to GDP rose, until it had nearly doubled to 49.5% at the end of 1993. Tax cuts were responsible for an initial decline in revenue. The tax rates on income capital fell, though the tax on labor income partly offset the decline. Overall, Federal government revenue averaged 18.0% of GDP during this period, only slightly less than the 18.2% average during the prior thirteen years. Primary spending by the Federal government, including transfer payments, rose modestly from an average of 18.7% of GDP to 19.2%. Therefore while it is true the US government was running persistent primary budget deficits, initially, the single largest factor contributing to the growth in Federal public debt was the doubling in interest payments from 1.5% to 3.0% of GDP. At first this was largely a by-product of the high interest rates introduced by the Federal Reserve, which reflected its Chairman Paul Volker's desire to lower inflation. Later, as the deficits accumulated, the increased interest payments were driven by the need to finance the growing stock of debt.

The debt burden was stable during 1994 and 1995, and then began to decline—dropping to 33.3% of GDP at the end of 2001. Interest payments tapered off as well, averaging 2.6% during this period, while faster growth in the US economy generated even faster growth in revenues, which averaged 19.8% of GDP during these years. Most importantly, spending declined, particularly on defense. If during the period between 1981 and 1992 defense spending averaged 5.8% of GDP, during the first decade that followed the dissolution of the Soviet Union, defense spending dropped to only 3.6%. The attacks on the United States on September 11, 2001, and the subsequent wars in both Afghanistan and Iraq prompted quick increases in defense spending, though not a resumption of the rates of spending that preceded the end of the Cold War—from 2002 to 2010 spending on defense averaged 4.0% of GDP. At the same time revenue fell sharply, initially because President George W. Bush lowered tax rates, but later as a consequence of the recession that began in 2008.

[16] Data is from Congressional Budget Office, Supplemental Data 2009.

Yet beyond all this, the most important and consistent feature of the US Federal budget during the last few decades is the growth in spending on entitlement programmes, whose main beneficiaries are the elderly. This is particularly the case for Medicare; and unlike the vagaries of war and recession, this growth was completely predictable—a consequence of increasing life expectancy. Yet no effort was made to either modify benefits or increase revenues to balance the growing mountain of future liabilities. Instead, passage of the Medicare Modernization Act at the end of 2003 extended coverage to include the cost of prescription drugs for the elderly from 2006 onward, and further exacerbated the fiscal gap. The decision to leave tax rates low, particularly the tax rate on capital income, and as a consequence to continue to accumulate both formal debt and unfunded liabilities, is a political choice my model is designed to explain.

Official measures of the public debt are at best very partial gauges of the full nature of a government's net liabilities, and the claims these liabilities may make on future taxpayers. The method of Generational Accounting, pioneered by Auerbach, Gokhale and Kotlikoff (1991), addresses some of these deficiencies by replacing the single number of debt with a vector of net tax payments distinguished by birth cohorts. Another option is to assume that absent a change in tax policy, unfunded liabilities will ultimately express themselves as deficits and official borrowing in the future. This is the approach taken by the Congressional Budget Office when it produces the Extended Baseline Forecasts and the Alternative Fiscal Scenarios in Figure 2.

What differentiates the Extended Baseline Forecasts from the Alternative Fiscal Scenarios is to a small degree the pace at which spending, particularly on entitlements, is predicted to grow, but mostly the degree to which taxes are expected to rise to keep pace. The Extended Baseline Forecasts are premised on the assumption that both spending and revenues will evolve according to the letter of current legislation, whereas the Alternative Fiscal Scenarios can best be described as embodying the spirit rather than the letter of current law, and that legislation will be ammended as needed to maintain many of the features of current policy.

For example, comparing the two, expenditure according to the Alternative Fiscal Scenarios rises at a slightly faster pace, as it assumes new legislation to hold down Medicare payments to physicians will be postponed, as it has in the past, and that proposed exchange subsidies for health insurance will be slightly higher than what was in the legislation when it was passed. Furthermore, the Extended Baseline Forecasts assume that discretionary spending will grow at the rate of inflation, whereas the Alternative Fiscal Scenarios assume discretionary spending will grow faster—at the same rate as the economy. However, some of this difference is offset, as the former makes no provision for the planned scaling back of military commitments in Iraq, the wider Persian Gulf region and Afghanistan, whereas the latter incorporates them into its projections.

Again, the biggest differences between the two forecasts are on the revenue side. Not only does the Extended Baseline Scenario assume that in a departure from more than ten years of previous experience, income tax brackets and the threshold for income exempt from the Alternative Minimum Tax, will no longer be adjusted or indexed. In addition, it assumes that all previous changes dating back from 2001 will be suspended in line with the current letter of the law, from 2013 onward. By contrast, the Alternative Fiscal Scenario assumes that previous modifications will be renewed, and that the practice of indexing will continue, so as to prevent a drastic rise in effective income tax rates for millions of US households. Seen in this light, the Extended Baseline Forecasts from 2009 to 2011 are akin to setting the value of T at 30 in the previous section, and assuming that the shift from a regime of low taxes and debt accumulation to higher taxes and stabilization of the debt is about to commence.[17] The Alternative Fiscal Scenario from 2009 to 2012 corresponds to setting the value of T at 60 or higher, and assuming that the US will postpone its fiscal reckoning for several more decades.

So how well does my model capture the last thirty years of accumulating public debt, and match the various projections for the future? In Figure 8, I plot the simulated trajectories of public debt as a fraction of GDP that correspond to the policies which maximize the compensating differentials plotted in Figures 5 and 6, and listed in Table 1, against the historical data and both the Extended Baseline Forecasts and the Alternative Fiscal Scenarios produced from 2009 to 2011, as in Figure 2.

In Figure 8, there are a total of twenty time paths that represent the evolution of debt as a percentage of GDP, corresponding once again to five different rates of immigration, in each of four panels that correspond to the different lengths of time T, during which the government leaves the tax on capital below its long-run rate and runs deficits. First, the grey curves represent the optimal trajectory of debt in the absence of immigration. These show how debt would be expected to gradually decline very slightly, from its initial value of 26.1% of GDP, because in this economy, absent immigration, there is a small bias in favor of front-loading taxes and running a small surplus.

Compare that to the time paths of debt associated with the optimal policies when the immigration rate is 3.4 per thousand, as represented by the green curves. If the policy horizon is set to T=30, debt rises till 2010 before leveling off, but the rise is insufficient to match the overall increase in debt from 1981, and levels off well below not only the predictions of the Alternative Fiscal Scenarios, but the Extended Baseline Forecasts as well. The longer we allow the policy to be extended, the longer debt has to accumulate, and the closer the match to the Extended Baseline Forecasts after 2020 or 2030. Set the value of T to 60 years, and the projected debt in 2040 is a good match. Yet this is only because the Extended Baseline Forecasts level off during the early part of this decade, as tax rates are assumed to rise, while the predicted path generated by this version of the model continues to grow, as it assumes tax rates remain low. Mostly, with the rate of immigration set to 3.4 per thousand, the time path of debt generated by the model underpredicts the history of US debt from 1981 to 2010, as well as both sets of forecasts.

Compare this with the time path when T=30, associated with the rate of immigration of

[17] The provisions of the Budget Control Act of 2011, the so-called 'fiscal cliff' that may or not be implemented in January 2013, comprise a far more radical course, and imply in the Extended Baseline Forecast of 2012 an absolute reduction in the debt burden over the coming decades.

5.7 per thousand, the effective rate of net migration between 1980 and 2005, once differential fertility is considered. Here the debt burden, represented by the red curve in Figure 8, reaches 68% of GDP by 2010, as opposed to its actual value of 62%, before it levels off, much as the Extended Baseline Forecasts do. Setting T=40, and by doing so, extending the assumed policy of deficit finance by a further decade, the red curve corresponding to the rate of immigration of 5.7 per thousand follows the trajectory of the Alternative Fiscal Scenarios till 2020. Extend the policy by a further decade, and it is a reasonable match for the year 2030 as well. With the rate of immigration set to 5.7 per thousand the model predicts that the debt burden will stabilize between the lower bounds defined by the Extended Baseline Forecasts and the upper bounds defined by the Alternative Fiscal Scenarios. In all the simulations, debt rises monotonically from 1981 to 2010 (I make no effort to capture the brief decline in the debt burden between 1996 and 2001).

Consider instead the behavior of the model if the rate of immigration is set to the maximum rate of 9.8 per thousand. This assumption generates the patterns of debt accumulation designated by the brown curve, which rise much too quickly. If T=30, the debt burden reaches 114.9% of GDP by 2010 and then declines slightly, because until the economy converges, interest rates remain low enough to allow the government to devote a small portion of the surge of new revenue it receives to clawing back a small portion of the accumulated debt. Ultimately this revenue is redirected towards financing higher interest payments, and away from any continued redemption of the debt, once the economy has converged. Extending the policy horizon to forty, fifty or sixty years means tax rates need not be driven down as aggressively over a relatively short period to attain the maximum welfare benefit for the initial resident population. Even so, the predicted path of debt exceeds even the path of the 2011 Alternative Fiscal Scenario.

Finally, compare these trajectories to the paths of debt predicted by the model and corresponding to the blue curves, when the rate of immigration is set to 8.0 per thousand. Setting T=30, debt accumulates too quickly, reaching 89.4% of GDP by 2010. Of course this rate of immigration exceeds both the measured rate of net migration from 1981 to 2010, and the rate meant to reflect the contribution immigration made during this period to population growth, 5.7 per thousand. Yet it does reflect the future predicted contribution of immigration to population growth. Extending the policy horizon means the predicted path of the debt ratio measured against GDP will ultimately be higher, but this debt burden accumulates at a slower pace. For T=60, the debt burden reaches 75.6% of GDP by 2010, which is still too high, yet the gap between the model's predicted path for debt and the predictions in the Alternative Fiscal Scenario narrow considerably in the decades that follow, until they nearly coincide in Figure 8 by 2040.

Immigration policy in the United States remains as contentious an issue as fiscal policy, and there is no guarantee that projections of either will materialize in the manner predicted by the Congressional Budget Office or assumed in my model. Nonetheless it is notable that it is the Alternative Fiscal Scenarios, with their seemingly implausible exponential rises in the debt burden, that so closely match what the model predicts the existing population, or the government that represents their interests, will choose if it believes that the future population of new immigrants, and their descendants, will match current forecasts.

7 Immigration and the Deficit Bias in Europe

If immigration does indeed create a bias in favour of deficit finance, there is no reason to assume the phenomenon is isolated to the United States. In many developed countries, the transition from low rates of net migration and high rates of natural population growth to high net migration and low, even negative, rates of natural population growth has been far more extreme. In Figure 9, I plot rates of natural population growth (columns associated with the left-hand scale) and net migration (blue curves associated with the left-hand scale) of twenty-one OECD countries for the years 1960 to 2010, along with yearly public debt in percentage terms, relative to GDP (red curves associated with the right-hand scale).[18] Whereas the primary source of population growth in the developed world, half a century ago, was the difference between births and deaths, now it is net migration. Many countries have also accumulated debt at a much faster pace than the US.

Just as the rise in US public debt between 1981 and 2010 represents but a hint of the much deeper fiscal imbalances that underlie the forecasts for future debt in Figure 2 so too the time paths of gross public debt in Figure 9, do not necessarily capture the rising tide of unfunded liabilities that have accumulated during this period in much of the rest of the developed world. Though the exercise in forecasting performed by the US Congressional Budget Office is unusual—particularly its Alternative Fiscal Scenario—the Office of Budget Responsibility in the UK predicts on the basis of current policy that the debt burden will nearly double during the next fifty years.

Of the twenty one countries that feature in Figure 9, the experience of three southern European countries, Greece, Italy, and Spain, over the last half century is particularly interesting.[19] Of the three, only in Italy had the rate of natural population growth dipped just below ten per thousand by the early 1960's. Yet by the end of the century, in all three countries, the fertility rates of native women plummeted well below replacement, and only increasing life expectancy, and the rising numbers of children born to immigrants, has kept the natural rate of population growth from descending well below zero. If fifty years ago, Greek, Italian, and Spanish workers migrated to Northern Europe, the Americas and Australia in search of higher wages, in the last two decades these countries became important destinations for both economic migrants and refugees.

[18] Data for the US in Figure 2 from the CBO, is publicly held net debt at all levels of government, whereas Figure 9 uses gross debt for central governments as computed for seventy countries by Reinhart and Rogoff (2010).

[19] Portugal is a special case. The natural rate of population growth dropped steeply throughout the 1970's and 1980's as in the rest of Southern Europe, but it experienced an earlier surge of inmigration in the late 1970's as the descendants of Portuguese settlers returned from the colonies made independent in the wake of the military coup in 1974.

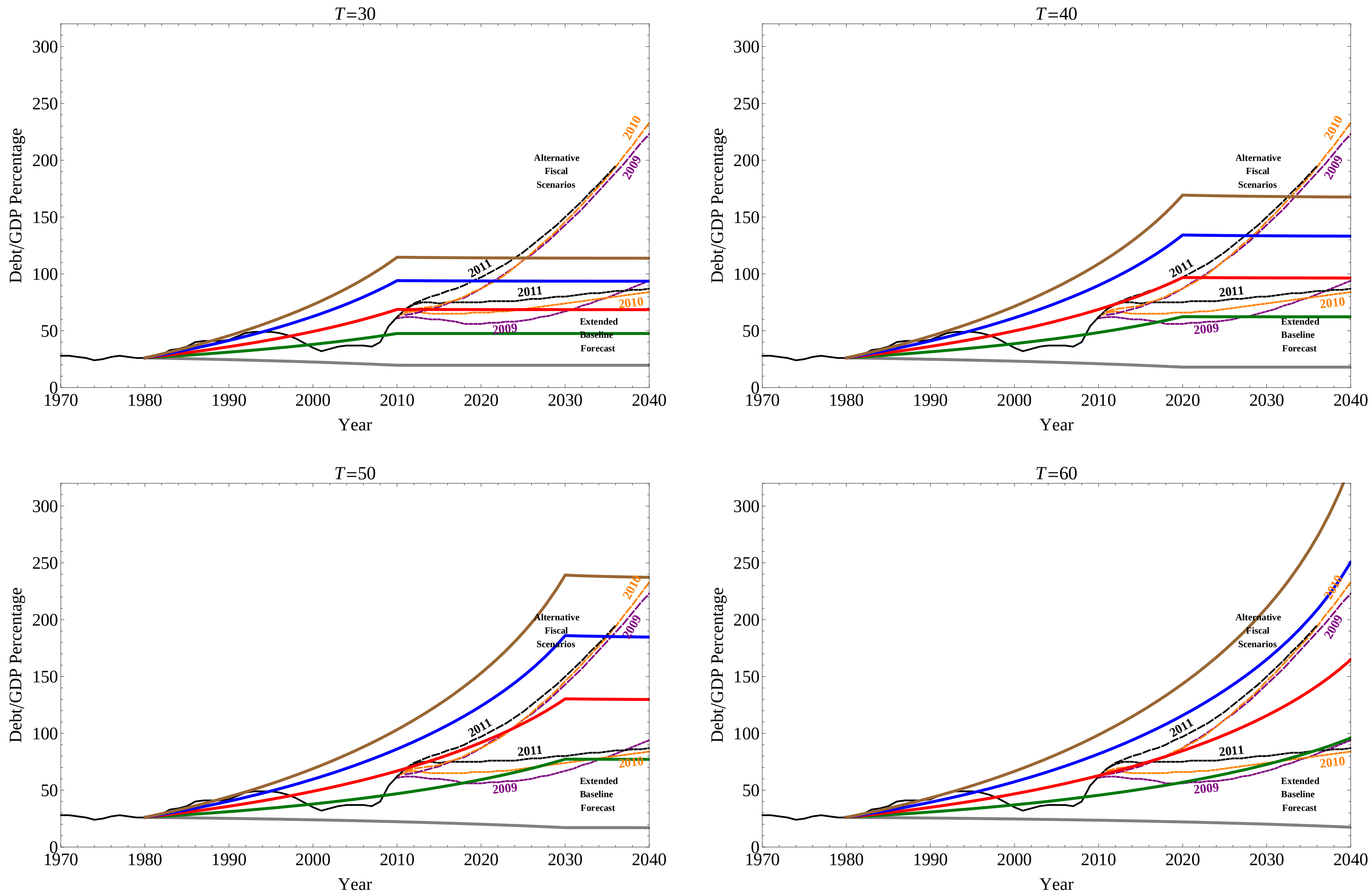

Figure 8: The trajectory of debt for optimal policies corresponding to no immigration (grey) and rates of immigration of 3.4 per thousand (green), 5.7 per thousand (red), 8.0 per thousand (blue) and 9.8 per thousand (brown) against the forecasts of the US Congressional Budget Office.

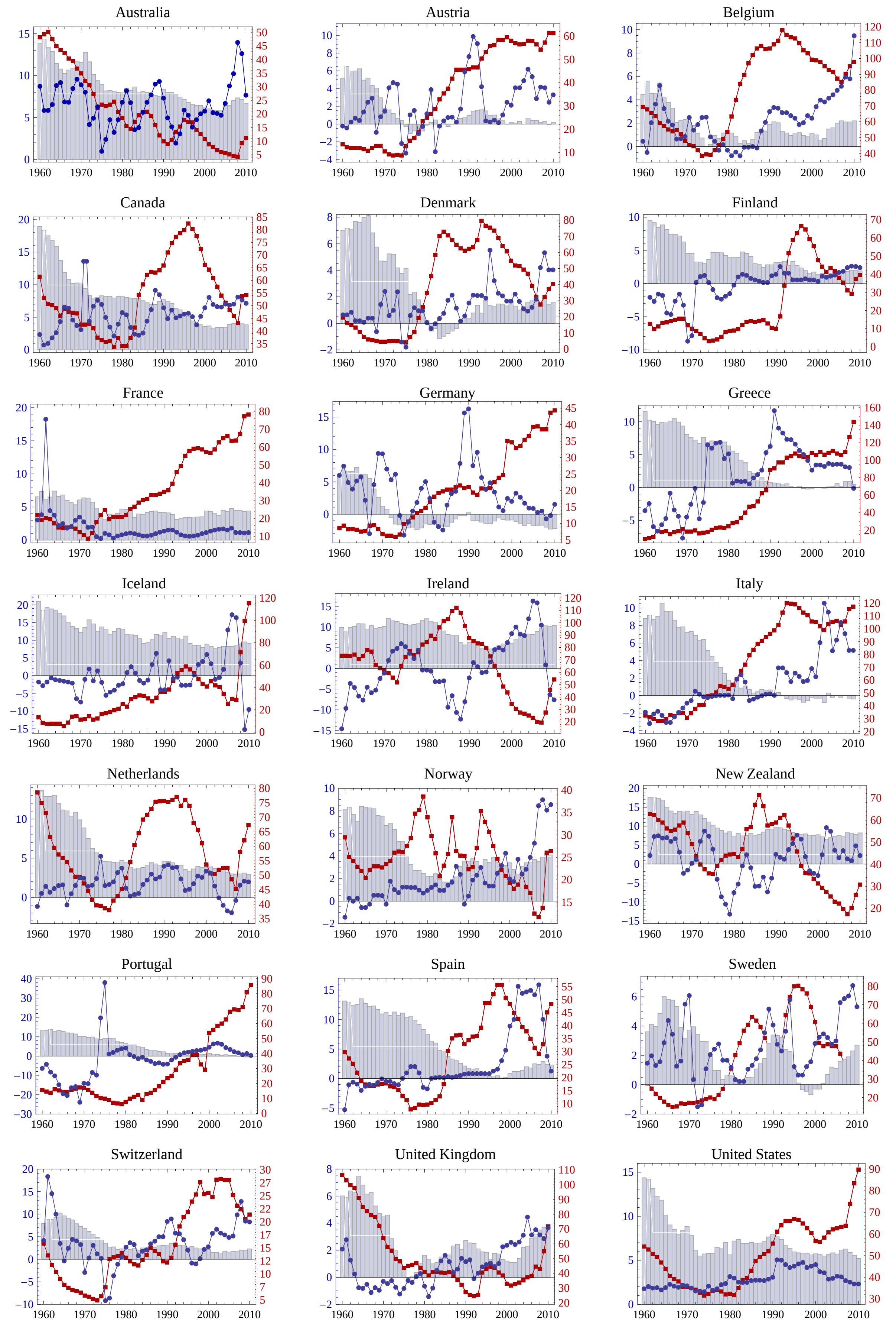

Figure 9: Birth rates, net international migration and central government public debt for 21 OECD countries. Net international migration represented by curve with circles in blue, left-hand scale, annual stock of gross public debt represented by curves with squares in red, right-hand scale. Birth rates represented by bars, also left-hand scale. Sources: OECD supplemented by Australian Bureau of Statistics, Eurostat, Office of National Statistics (UK) and Statistics Denmark for birth and migration data. Debt to GDP from data appendix to Reinhart and Rogoff (2009).

Start with Greece. Hundreds of thousands left Greece in the years after World War II and the Civil War that followed. Emigration from Greece exceeded immigration for the last time in 1974, and 1988 was the last time natural population growth exceeded net migration. In the last few decades, there have been two major waves of net migration to Greece. The first, during the late 1970's, resulted from large numbers of Greek workers returning from Northern Europe, as well as the return of political exiles, after the collapse of the military junta in 1974. The second, beginning in the late 1980's, was largely made up of new immigrants, and particularly after the collapse of the communist regime in Albania at the end of 1990, Albanians have dominated the flow of migrants to Greece. At its high point in 1991, Greece was absorbing immigrants at a rate of over one percent of its population per annum, and by 2011, 11.10% of the total population was foreign-born. Yet examining the share of the population in Greece that was born abroad does not fully capture the remarkable transformation of Greek society. During the ten years between 2000 and 2009, the share of 15-year-olds with at least one foreign-born parent—as measured by participation in the Programme for International Student Assessment (PISA)—has climbed from 10.6% to 17.7% of the total. Whereas only 4.15% of the population aged 65 is foreign-born, the foreign born constitute 19.28% of the population in the high fertility ages of 25-29 (see Figure 10). This means in the decades to come, second generation immigrants are expected to be an increasingly significant fraction of the population.

How much these demographic changes may have motivated the enormous accumulation of Greek public debt that culminated in the crisis and subsequent write-down of debt in 2011 is impossible to determine, particularly given the tumultuous history of Greek political life during the last few decades. Central government debt in Greece reached its lowest point in 1957, when it constituted only 7.5% of GDP. By the end of 1964, on the eve of the first in a series of constitutional crises that began in 1965, debt was 18.5% of GDP. By the end of 1974, after seven and a half years of military rule, debt had declined to 17.5% of GDP. The years that followed the restoration of democratic rule are also years in which the debt burden rose by only modest amounts, and when the rise in net migration, though substantial, was mostly associated with the return home of Greek citizens. The debt burden began to grow rapidly in the 1980's as the decline in the rate of natural population growth accelerated. After 1986, net migration exceeded natural population growth, and as more immigrants continued to arrive during the 1990's and the first years of this century, the debt burden has continued to rise, in spite of the relatively strong growth of the Greek economy during this period.

The year 1964 was the last time the rate of natural population growth in Italy exceeded ten per thousand. By 1993, the number of deaths exceeded births, and only the rising numbers of immigrants—in 2003 they arrived at a rate of more than ten per thousand—kept Italy's population from declining. By 2010, the percentage of children born in Italy that year with two foreign-born parents was close to 14% of all births, and the percentage with at least one foreign-born parent was 19%. In 2011, the foreign born constituted 8.83% of Italy's population, but 16.50% of people aged 25-29, and only 2.25% of those aged 65 and older.

As in Greece, the Italian debt burden began rising prior to the surge of immigration, but coincided with an even steeper decline in the rate of natural population growth. From 1970 to 1979 it rose from 30.9% to 55.0% of GDP, before peaking at 120.1% in 1994. The debt burden declined for a few years but resumed its ascent during the years when immigration was at its highest—reaching 117.4% by 2010. Many factors may have contributed to the accumulation of so much debt over the course of such a relatively short amount of time, but the accumulation of debt outpaced the growth of the economy even in 1988, when GDP grew at a rate of 4.2%.

Spain's experience with mass immigration is the most condensed of the three. It started later, doubling between 1999 and 2000, remained above one percent of the population per annum from 2000 to the onset of the financial crisis in 2008, and averaged just over 15 per thousand between 2001 and 2007. Similarly, the rate of natural population growth was over ten per thousand as late as 1976, but had dropped below one per thousand by 1994. Natural population growth has begun to recover in Spain, but as in Greece and Italy, this is driven by the higher fertility rates of the foreign-born population, which in 2011 accounted for over 23% of the population aged 25-34. During the ten years between 2000 and 2009, the number of 15-year-olds with at least one foreign-born parent has climbed from 5.9% to 15.5%, and it is set to climb much higher, as the bulk of Spain's immigrant population is only now beginning to have children.

Central government debt in Spain, as a percentage of GDP, reached 55.8% in 1997, declined and then climbed again. Yet the decentralized nature of the Spanish state means that much of the fiscal gap occurred at the level of provincial and local governments. To this could be added the fast accumulating debts incurred by politically connected banks that enjoyed implicit public guarantees—the true nature of Spain's fiscal gap during this period is only now becoming apparent. One indication is the percentage of gross external debt to GNP (both public and private). According to Reinhart and Rogoff it rose in Spain from 40.7% in 1996 to 173.9% in 2009.

The stock of public debt is merely an element in the larger portfolio of assets and obligations that governments shift across time. My model assumes rather simplistically that a cut in a specific tax, that on capital income, is what drives this accumulation of debt. This is a tax that falls most heavily on the native population, and the drop in this particular tax provides a reasonable approximation of recent U.S. history. Yet shifts in tax rates are but one way in which society can benefit the population that is resident in the country today, while bequeathing the accumulated debts generated to finance them to the rising number of new and future immigrants. Another way is through the creation of unfunded liabilities, particularly through the mechanism of pay-as-you-go pensions and other old-age entitlements. These transfers, and particularly the expected rise in healthcare costs, are what drives the projected growth in US Federal spending in Figure 1. One alternative measure, generational accounting, provides a means for assessing long-term fiscal policy inclusive of unfunded liabilities and how this burden is shared across the generations. Generational accounts calculated in Auerbach *et al.* (1999) imply future generations in Australia, Denmark and France face fiscal burdens 30 to 50 percent higher than current generations; in Belgium, Norway and the US, 50 to 75 percent higher; in Germany

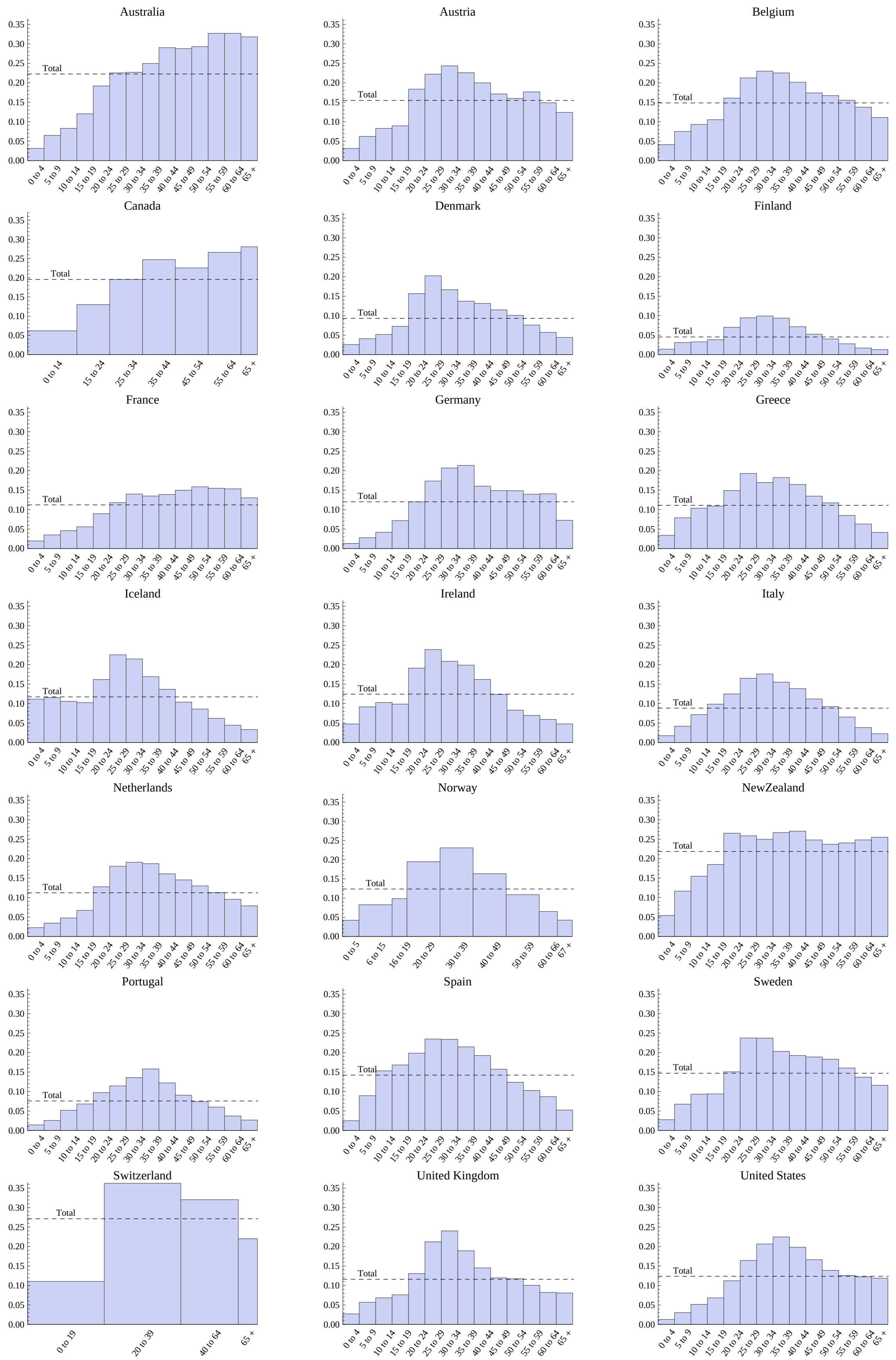

Figure 10: Fraction of population that is foreign-born by age. Data for Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Netherlands, Portugal, Spain, Sweden, United Kingdom is for 2011, *Source*: Eurostat. Data for Australia and Canada is for 2006, *Source*: United Nations Statistical Division. Data for Iceland is for 2012, *Source*: Statistics Iceland. Data for New Zealand is for 2006, *Source*: Statistics New Zealand. Data for Norway is for 2012, *Source*: Statistics Norway. Data for Switzerland is for 2012, *Source*: Swiss Federal Statistical Office. Data for United States is for 2010, *Source*: US Census Bureau.

and the Netherlands 75 percent higher; and in Italy more than 100 percent higher (Canada, New Zealand, and Sweden had policies that are either balanced policies that imply lower future burdens). Work done by Keuschnigg *et al.* (2000) for Austria implies 65 percent.

How much will the waves of newly arrived immigrants or those to follow help to mitigate these imbalances? As mentioned in the Introduction, others before me have drawn a possible connection between immigration and intergenerational imbalances. Chojnicki's (2012) recent findings for France are similar to the conclusions Auerbach and Oreopoulos (1999) reach for the US, and Fehr *et al.* (2004) reach for the European Union, Japan and the US—immigration's role in mitigating fiscal imbalances is positive, but because of differences in life-time incomes between immigrants and natives, very limited. By contrast, Bonin, *et. al.* (2000) for Germany, Collado, *et. al.* (2003) for Spain, and Mayr (2005) and Deeg *et al.* (2009) for Austria, found that immigration could play a substantial role in ameliorating, though not eliminating fiscal imbalances. Furthermore Razin and Sadka (2004) emphasise the need to consider not only the impact of immigrants themselves on fiscal balances, which may be small or even negative, but the potentially larger and positive impact of their descendents as well.

Natives are also the main beneficiaries when public sector employment rapidly increases—immigrants are often ineligible for positions in the civil service or government-owned companies, or lack the required skills or credentials. Returning one last time to the example of Greece, between 1970 to 2008, employment in the Greek public sector more than tripled from 264,000 to 824,000, equivalent to a rate of increase of 3% per annum.[20] During that same time private sector employment increased by less than 30%, from 3 million to 3.8 million.[21] Managerial positions in the Civil Service proliferated as new departments were established. By 2010, over twenty percent of departments within the different Ministries employed a single manager with no subordinates, and ninety percent of departments had fewer than twenty subordinates.[22] Civil servants received 14 monthly salaries a year and a plethora of extra payments.[23] According

[20]Zafiris Tzannatos and Yannis Monogios, "Public sector adjustment amidst structural adjustment in Greece: Subordinate, spasmodic and sporadic," in *Public Sector Adjustments in Europe – Scope, Effects and Policy Issues*, ed. Daniel Vaughan-Whitehead (International Labor Organization, 2012), 143.

[21]*ibid.*

[22]'On average, a ministry has almost five general secretariats or single administrative sectors; each of these has two general directorates; a general directorate has six directorates; and a directorate has four departments. These structures add up to a total of 302 on average per ministry at central level; in addition, a ministry has on average 137 decentralised structures at regional level. Throughout the ministerial services, one department out of five does not have any employees (apart from the head of department); one out of three has one employee or less and a majority has three employees or less...' Organization for Economic Cooperation and Development, Public Governance Reviews. 'Greece: Review of the Central Administration', December 2011, Paris: OECD, 56.

[23]"There was a monthly allowance of 690 euros paid to 420 employees in the Greek Telecommunications Organization for 'warming-up car engines'. Another allowance of 420 euros was paid to 1,987 employees in the National Railways Organization for 'washing their hands'. A 'propeller allowance' of 840 euros was paid to 653 coastguards. The 'antenna bonus allowance' of 1,120 euros was paid to 329 employees at the Athens-Piraeus Electric Railways Company. A 'folder transferring allowance' of 290 euros was provided to 6,800 office workers. A 'bus handing over' allowance of 450 euros was paid to 1,100 workers. An allowance for 'timely handling of cases' of 595 euros was provided to employees at the Ministry of Justice, and a 'fax services allowance' of 870

to IMF estimates, prior to the 2010 reforms, the overall wage premium for workers in the public sector was 32%, and 11% when controlling for education, gender, age, etc.[24] Given the employment protections Greek law afforded civil servants, this increase in public sector employment could be interpreted as yet another unfunded liability, alongside the swelling debt and the mounting obligations to its growing number of pensioners, that would have fallen solely on the shoulders of existing voters and their descendents had it not been for the swelling ranks of first and second generation immigrants. It remains a matter of conjecture whether Greek voters would have resisted more forcefully the practices that led to their sovereign debt crisis were it not concurrant with such a relatively sudden and unprecedented shift in the composition of the population. Yet it bears remembering that Greece was not a closed and secretive society, and the debt was not accumulated by an unaccountable autocrat. From 1975, as the Greek state borrowed heavily to finance this largesse, Greece held regular elections, there were orderly transfers of power between the two largest parties, and there was a lively free press.

The desire to shift resources between immigrants and natives is surely not the only reason that public debt has increased so dramatically in so many countries. In fact, countries with the largest foreign-born populations, but long experience absorbing mass immigration, have been the least affected by the recent sovereign debt crisis. These include not only Australia, Canada and New Zealand, but France and Germany as well. What those countries that have encountered so much difficulty in recent years have in common is not the overall size of the foreign born population, but the fact that it arrived so quickly and at a time when natural population growth had dropped to zero or lower. That is what may have provided some of the motivation behind the heavy reliance on deficit finance.

8 Conclusion

It is very unlikely that voters, or their representatives, are deliberately choosing policies that carefully weigh the costs and benefits of deficit finance, as rates of migration change, in the manner of the model. However, it is not too hard to imagine that concerns about the rising burden of debt, and its impact on the next generation, are less likely to be as persuasive at a time when citizens are watching the composition of their societies being transformed so quickly.

That people voting for a set of tax policies in one period may not be exactly the same people who must pay these taxes in the next is not an uncommon feature in models associated with dynamic fiscal policy. What is different here is that by adapting the Weil (1989) framework, I provide an alternative to the strict dichotomy between models with overlapping generations,

euros to 657 employees at the Electrical Power Corporation. An 'annual canteen allowance' of 120 euros was paid to all staff at the Greek Petroleum Group, although there was an in-house restaurant where food was provided free of charge. It is said that there was even a provision for an allowance 'for not getting any other allowances'." Tzannatos and Monogios (2012), 146-147.

[24] International Monetary Fund (2011), Greece: Fourth Review under the Stand-By Arrangement and Request for Modification and Waiver of Applicability of Performance Criteria, Country Report No. 11/175, July 2011, Washington DC: IMF, 34.

where agents disregard the impact of their choices on future generations, and the quasi-Ricardian world of infinite-lived dynasties in which agents are assumed to fully participate in both the economy and the political system in every period. Because taxation here is distortionary, gone also is the option to simply choose the tax that redistributes the most income to those who can organize the most votes, while abstracting from deadweight loss. As recent experience has shown, prolonged reliance on defict finance has real consequences—the higher rates of future taxation in my model are only one possible outcome, and clearly not the most dire.

My contention is that immigration creates a bias in favor of deficit finance, though this argument could be turned on its head; deficit finance is what generates a preference for accomodating more immigrants. This is certainly possible, though because the welfare effects in Table 1 and in Figure 7 are increasing and convex in the rate of immigration, and as demonstrated in Ben-Gad (2004), the effect of immigration itself on factor returns generates an immigration surplus for the native population that is also convex, we are left to wonder why immigration is not considerably higher. Perhaps one reason does follow directly from the model—the faster immigrants arrive, the more natives may want the government to issue bonds to cover immediate government expenditure, but also the greater the risk that the immigrants will acquire the political power to repudiate that very same debt.[25]

There are a number of possible extensions of this work. One is to endogonise the labor supply. Doing so would incorporate distortions from labor taxation into the model, and generate a more meaningful distinction between these taxes and government tranfers.[26] I also assume a relatively high degree of policy-stickiness rather than allow the policies to be continuously re-evaluated in a time-consistent manner. The ever-expanding number of agents participating in the economy raises all sorts of technical challenges to deriving time-consistent policies.

One last issue is emigration. At any given moment, migration flows at the national level tend to be one-way—only occasionally do we observe so-called 'replacement migration' in which a country absorbs significant numbers of new workers, even as its own native-born workers move elsewhere. Emigration could create a bias in favor of surpluses—tax people before they leave—but only if the rate of emigration does not exceed a certain threshold. If enough people are leaving, or anticipate they will, they may opt to avoid taxing themselves, and leave behind their share of the public debt to those who remain. Of course, at the sub-national and local level simultaneous flows of inmigration and outmigration are the normal consequence of churning in the labor market. One implication is that as people become more mobile, we may expect the different regions within federal states and localities to acquire higher debt and unfunded liabilites.

[25] One paper in which the rate of immigration is endogenously determined by voters in the destination country is Dolmas and Huffman (2004). In their stylised three-period model, natives who are heterogenous in initial wealth vote in the first period on the number of immigrants to admit, and in the second period vote together with the new immigrants on the amount of redistribution to implement in the third.

[26] This is not as trivial a step as it seems. The heterogeneity in asset holdings means that as long as immigrants arrive, the income effects dominate substitution effects and drive down the supply of labor for the initial population, until it reaches a zero lower bound. See Ben-Gad (2004).

References

[1] Auerbach, Alan J., Jagadeesh Gokhale and Laurence J. Kotlikoff. 1991. "Generational Accounts—A Meaningful Alternative to Deficit Accounting." *Tax Policy and the Economy 5*: 55-110.

[2] Auerbach, Alan J. and Philip Oreopoulos. 1999. "Analyzing the Fiscal Impact of U.S. Immigration." *American Economic Review* 89 (2): 176-180.

[3] Batini, Nicoletta, Giovanni Callegari, and Julia Guerreiro. 2011. "An Analysis of U.S. Fiscal and Generational Imbalances: Who Will Pay and How?" IMF Working Paper, WP/11/72. Washington D.C.

[4] Battaglini, Marco, and Stephen Coate. 2008. "A Dynamic Theory of Public Spending, Taxation, and Debt." *American Economic Review* 98 (1): 201-236.

[5] Ben-Gad, Michael. 2008. "Capital-Skill Complementarity and the Immigration Surplus." *Review of Economic Dynamics* 11 (2): 335-365.

[6] Ben-Gad, Michael. 2004. "The Economic Effects of Immigration—a Dynamic Analysis." *Journal of Economic Dynamics and Control* 28 (9): 1825-1845.

[7] Bonin, Holger, Bernd Raffelhüschen and Jan Walliser. 2000. "Can Immigration Alleviate the Demographic Burden?" *FinanzArchiv/Public Finance Analysis* 57 (1): 1-21.

[8] Brooks, David. 2010. The Geezers' Crusade, *The New York Times*, February 2, 2010 Tuesday, Pg. 27.

[9] Buchanan, James and Richard E. Wagner. 1977. *Democracy in Deficit.* New York: Academic Press.

[10] Canova, Fabio and Morten O. Ravn. 2000. "The Macroeconomic Effects of German Unification: Real Adjustments and the Welfare State." *Review of Economic Dynamics* 3 (3): 423-460.

[11] Chamley, Christophe. 1986. "Optimal Taxation of Capital Income in General Equilibrium with Infinite Lives." *Econometrica* 54 (3): 607-22.

[12] Chojnicki, Xavier, Frédéric Docquier and Lionel Ragot. 2011. "Should the US have Locked Heaven's door? Reassessing the Benefits of Postwar Immigration." *Journal of Population Economics* 24 (1): 317–359.

[13] Chojnicki, Xavier. 2012. "The Fiscal Impact of Immigration in France: A Generational Accounting Approach. Working Paper no. 2012-11, CEPII.

[14] Collado, M. Dolores, Iñigo Iturbe-Ormaetxe and Guadalupe Valera. 2004. "Quantifying the Impact of Immigration in the Spanish Welfare State." *International Tax and Public Finance* 11 (3): 335-353.

[15] Cooley, Thomas F., and Edward C. Prescott. 1995. "Economic Growth and Business Cycles." *Frontiers of Business Cycles Research*, edited by Thomas F. Cooley. Princeton: Princeton University Press.

[16] Cukierman, Alex and Allan H. Meltzer. 1989. "A Political Theory of Government Debt and Deficits in a Neo-Ricardian Framework." *American Economic Review* 79 (4): 713-732.

[17] Deeg, Veronika, Christian Hagist and Stefan Moog. 2009. "The fiscal outlook in Austria: an evaluation with Generational Accounts." *Empirica* 36 (4): 475–499.

[18] Dolmas, Jim, and Gregory W. Huffman. 2004. "On the Political Economy of Immigration and Income Redistribution." *International Economic Review* 5 (4): 1129-1168.

[19] Fehr, Hans, Sabine Jokisch and Laurence J. Kotlikoff. 2004. "The Role of Immigration in Dealing with the Developed World's Demographic Transition." *FinanzArchiv/Public Finance Analysis* 60 (3): 296-324.

[20] Gomme, Paul and Peter Rupert. 2007. "Theory, Measurement and Calibration of Macroeconomic Models." *Journal of Monetary Economics* 54 (2): 460-497.

[21] Howker, Ed and Shiv Malik. 2010. *Jilted Generation*. London: Icon Books.

[22] International Monetary Fund. 2011. Greece: Fourth Review under the Stand-By Arrangement and Request for Modification and Waiver of Applicability of Performance Criteria, Country Report No. 11/175. Washington DC.

[23] Judd, Kenneth L. 1985. "Redistributive Taxation in a Simple Perfect Foresight Model." *Journal of Public Economics* 28 (1): 59–83.

[24] Kotlikoff, Laurence J. and Scott Burns. 2004. *The Coming Generational Storm*. Cambridge MA: MIT Press.

[25] Kotlikoff, Laurence J. and Scott Burns. 2004. *The Coming Generational Storm*. Cambridge, MA: MIT Press.

[26] Keuschnigg, Christian, Mirela Keuschnigg and Reinhard Koman, Erik Lüth and Bernd Raffelhüschen. 2000. "Public Debt and Generational Balance in Austria." Economics Series 80, Vienna: Institute for Advanced Studies.

[27] Lizzeri, Alessandro. 1999. "Budget Deficits and Redistributive Politics." *Review of Economic Studies* 66 (4): 909-928.

[28] Lucas, Robert E. and Nancy L. Stokey. 1983. "Optimal Fiscal and Monetary Policy in an Economy without Capital." *Journal of Monetary Economics* 12 (1): 55-93.

[29] Mayr, Karin. 2005. "The Fiscal Impact of Immigrants in Austria – A Generational Accounting Analysis." *Empirica* 32 (2): 181–216.

[30] Mendoza, Enrique G. and Assaf Razin and Linda L. Tesar. 1994. "Effective Tax Rates in Macroeconomics: Cross-country Estimates of Tax Rates on Factor Incomes and Consumption." *Journal of Monetary Economics* 34 (3): 297-323.

[31] Organization for Economic Cooperation and Development. 2011. "Public Governance Reviews. 'Greece: Review of the Central Administration." Paris: OECD.

[32] Passel, Jeffrey S. and D'Vera Cohn. 2008. "U.S. Population Projections: 2005–2050." *Pew Research Center, Social and Demographic Reports*. Washington D.C.

[33] Persson, Torsten, and Lars E. O. Svensson. 1989. "Why a Stubborn Conservative Would Run a Deficit: Policy with Time-Inconsistent Preferences." *Quarterly Journal of Economics* 104 (2): 325-345.

[34] Razin, Assaf and Efraim Sadka. 2004. "Welfare Migration: Is the Net Fiscal Burden a Good Measure of Its Economic Impact on the Welfare of the Native Born Population?" Working Paper no. 10682, NBER, Cambridge, MA.

[35] Reinhart, Carmen M., and M. Belen Sbrancia. 2011. "The Liquidation of Public Debt." Working Paper no. 16893, NBER, Cambridge, MA.

[36] Reinhart, Carmen M. and Kenneth S.. Rogoff. 2009. *This Time is Different*. Princeton: Princeton University Press.

[37] Rogoff, Kenneth S. 1990. "Equilibrium Political Budget Cycles." *American Economic Review* 80 (1): 21-36.

[38] Storesletten, Kjetil. 2000. "Sustaining Fiscal Policy Through Immigration." *Journal of Political Economy* 108 (2): 300-323.

[39] Storesletten, Kjetil. 2003. "Fiscal Implications of Immigration: A Net Present Value Calculation." *Scandinavian Journal of Economics* 105 (3): 487-506.

[40] Tabellini, Guido and Alberto Alesina. 1990. "Voting on the Budget Deficit." *American Economic Review* 80 (1): 37-49.

[41] Tzannatos, Zafiris and Yannis Monogios. 2012. "Public Sector Adjustment Amidst Structural Adjustment in Greece: Subordinate, Spasmodic and Sporadic," *Public Sector Adjustments in Europe – Scope, Effects and Policy Issues*, edited by Daniel Vaughan-Whitehead. International Labor Organization.

[42] Weil, Philippe. 1989. "Overlapping Families of Infinitely-Lived Agents." *Journal of Public Economics* 38 (2): 183-198.

[43] Willetts, David. 2010. *The Pinch*. London: Atlantic Books.

[44] Zak, Paul J., Yi Feng, Jacek Kugler. 2002. "Immigration, fertility, and growth." *Journal of Economic Dynamics and Control* 26 (4): 547-576.

Appendix: Derivation of the Law of Motion for Consumption (8)

Each dynasty maximisies

$$\max_c \int_s^\infty e^{(\rho-n)(s-t)} \ln c(s,t)\, dt$$

s.t.

$$\dot{a}(s,t) = (1-\tau_h(t))\, w(t)h + ((1-\tau_k(t))\, r(t) - n)\, a(s,t) - c(s,t) \ \forall s,t$$

$$\frac{\partial H}{\partial c} : \frac{e^{(\rho-n)(s-t)}}{c(s,t)} = \lambda(s,t) \tag{A.1}$$

$$\frac{\partial H}{\partial a} : \lambda(s,t)\left((1-\tau_k(t))\, r(t) - n\right) = -\dot{\lambda}(s,t) \tag{A.2}$$

Integrating (A.2)

$$\lambda(s,t) = \lambda(s,s) e^{-\int_s^t ((1-\tau_k(v))r(v)-n)dv}$$

Insert (A.1):

$$c(s,t) = c(s,s)\, e^{(\rho-n)(s-t)} e^{\int_s^t ((1-\tau_k(v))r(v)-n)dv} \tag{A.3}$$

Differentiate (A.1) with respect to t:

$$-(\rho-n)\, e^{(\rho-n)(s-t)} = \dot{\lambda}(s,t) c(s,t) + \dot{c}(s,t)\, \lambda(s,t) \tag{A.4}$$

Insert (A.1) and (A.2) into (A.4):

$$\dot{c}(s,t) = ((1-\tau_k(t))\, r(t) - n)\, c(s,t) - (\rho-n)\, c(s,t)$$

Integrating the present value of the intertemporal budget constraint:

$$\begin{aligned} & \int_t^\infty \left[e^{-\int_s^u ((1-\tau_k(v))r(v)-n)dv} \dot{a}(s,u) - e^{-\int_s^u ((1-\tau_k(v))r(v)-n)dv} \left((1-\tau_k(u))\, r(u) - n\right) a(s,u) \right] du \\ = & \int_t^\infty e^{-\int_s^u ((1-\tau_k(v))r(v)-n)dv} (1-\tau_h(u))\, w(u)h du - \int_t^\infty e^{-\int_s^u ((1-\tau_k(v))r(v)-n)dv} c(s,u) du \end{aligned} \tag{A.5}$$

$$\begin{aligned} & e^{-\int_s^u ((1-\tau_k(v))r(v)-n)dv} \dot{a}(s,u) - e^{-\int_s^u ((1-\tau_k(v))r(v)-n)dv} (1-\tau_k(u))\, (r(u) - n)\, a(s,u) \\ = & \frac{\partial \left[e^{-\int_s^u ((1-\tau_k(v))r(v)-n)dv} a(s,u) \right]}{\partial u} \end{aligned}$$

$$\begin{aligned} & \int_t^\infty e^{-\int_s^u ((1-\tau_k(v))r(v)-n)dv} \dot{a}(s,u) du - \int_t^\infty e^{-\int_s^u ((1-\tau_k(v))r(v)-n)dv} (1-\tau_k(u))\, (r(u) - n)\, a(s,u) du \\ = & \int_t^\infty \frac{\partial \left[e^{-\int_s^u ((1-\tau_k(v))r(v)-n)dv} a(s,u) \right]}{\partial u} du \end{aligned}$$

Since:

$$\int_t^\infty \frac{\partial \left[e^{-\int_s^u ((1-\tau_k(v))r(v)-n)dv} a(s,u) \right]}{\partial u} du = e^{-\int_s^u ((1-\tau_k(v))r(v)-n)dv} a(s,u) \mid_t^\infty,$$

and

$$\begin{aligned} & \int_t^\infty \frac{\partial \left[e^{-\int_s^u ((1-\tau_k(v))r(v)-n)dv} a(s,u) \right]}{\partial u} du \\ = & \lim_{u\to\infty} e^{-\int_s^u ((1-\tau_k(v))r(v)-n)dv} a(s,u) - e^{-\int_s^t ((1-\tau_k(v))r(v)-n)dv} a(s,t), \end{aligned}$$

and from the transversality condition:

$$\lim_{u\to\infty} e^{-\int_s^u((1-\tau_k(v))r(v)-n)dv} a(s,u) = 0,$$

therefore:

$$\begin{aligned}
&\int_t^\infty e^{-\int_s^u((1-\tau_k(v))r(v)-n)dv} \dot{a}(s,u) - \int_t^\infty e^{-\int_s^u((1-\tau_k(v))r(v)-n)dv} \left(1-\tau_k\left(u\right)\right)\left(r(u)-n\right) a(s,u) \\
= \quad & -e^{-\int_s^t((1-\tau_k(v))r(v)-n)dv} a(s,t)
\end{aligned}$$

Substituting this into (A.5):

$$\begin{aligned}
-e^{-\int_s^t((1-\tau_k(v))r(v)-n)dv} a(s,t) \quad = \quad & \int_t^\infty e^{-\int_s^u((1-\tau_k(v))r(v)-n)dv} \left(1-\tau_h\left(u\right)\right) w(u)hdu \\
& -\int_t^\infty e^{-\int_s^u((1-\tau_k(v))r(v)-n)dv} c(s,u)du
\end{aligned} \tag{A.6}$$

Rearranging (A.6):

$$\begin{aligned}
\int_t^\infty e^{-\int_s^u((1-\tau_k(v))r(v)-n)dv} c(s,u)du \quad = \quad & \int_t^\infty e^{-\int_s^u((1-\tau_k(v))r(v)-n)dv} \left(1-\tau_h\left(u\right)\right) w(u)hdu \\
& +e^{-\int_s^t((1-\tau_k(v))r(v)-n)dv} a(s,t)
\end{aligned} \tag{A.7}$$

Form (A.3):

$$\frac{c\left(s,u\right)}{c\left(s,t\right)} = \frac{e^{(\rho-n)(s-u)}e^{\int_s^u((1-\tau_k(v))r(v)-n)dv}}{e^{(\rho-n)(s-t)}e^{\int_s^t((1-\tau_k(v))r(v)-n)dv}}$$

and therefore:

$$c\left(s,u\right) = c\left(s,t\right) e^{(\rho-n)(t-u)} e^{\int_t^u((1-\tau_k(v))r(v)-n)dv}. \tag{A.8}$$

Substitute (A.8) into (A.7):

$$\begin{aligned}
& \int_t^\infty e^{-\int_s^u((1-\tau_k(v))r(v)-n)dv} c\left(s,t\right) e^{(\rho-n)(t-u)} e^{\int_t^u((1-\tau_k(v))r(v)-n)dv} du \\
= \quad & \int_t^\infty e^{-\int_s^u((1-\tau_k(v))r(v)-n)dv} \left(1-\tau_h\left(u\right)\right) w(u)hdu + e^{-\int_s^t((1-\tau_k(v))r(v)-n)dv} a(s,t)
\end{aligned}$$

$$\begin{aligned}
& c\left(s,t\right) e^{-\int_s^t((1-\tau_k(v))r(v)-n)dv} \int_t^\infty e^{(\rho-n)(t-u)} du \\
= \quad & \int_t^\infty e^{-\int_s^u((1-\tau_k(v))r(v)-n)dv} \left(1-\tau_h\left(u\right)\right) w(u)hdu + e^{-\int_s^t((1-\tau_k(v))r(v)-n)dv} a(s,t)
\end{aligned}$$

$$c\left(s,t\right) = \left(\rho-n\right)\left(\int_t^\infty e^{-\int_t^u((1-\tau_k(v))r(v)-n)dv} \left(1-\tau_h\left(u\right)\right) w(u)hdu + a(s,t)\right)$$

Define:

$$\omega(t) \equiv \int_t^\infty e^{-\int_t^u((1-\tau_k(v))r(v)-n)dv} \left(1-\tau_h\left(u\right)\right) hw(u)du$$

Yields the consumption rule:

$$c\left(s,t\right) = \left(\rho-n\right)\left(\omega(t)+a(s,t)\right) \tag{A.9}$$

Aggregate Variables:

$$\begin{aligned}
C(t) &= e^{nt}\left(\int_0^t M\left(s\right) m\left(s\right) c(s,t)ds + M\left(0\right) c(0,t)\right) \\
K(t) &= e^{nt}\left(\int_0^t M\left(s\right) m\left(s\right) k(s,t)ds + M\left(0\right) k(0,t)\right) \\
B(t) &= e^{nt}\left(\int_0^t M\left(s\right) m\left(s\right) b(s,t)ds + M\left(0\right) b(0,t)\right) \\
\Omega\left(t\right) &= e^{nt}\left(\int_0^t M\left(s\right) m\left(s\right) ds + M\left(0\right)\right) \omega\left(t\right)
\end{aligned}$$

Aggregating (A.9):

$$C(t) = (\rho - n)\left(\Omega\left(t\right) + K(t) + B(t)\right)$$

$$\Omega\left(t\right) = \frac{C(t)}{\rho - n} - K(t) - B(t) \tag{A.10}$$

Differentiating with respect t:

$$\dot{C}(t) = (\rho - n)\left(\dot{\Omega}\left(t\right) + \dot{K}(t) + \dot{B}(t)\right) \tag{A.11}$$

$$\begin{aligned}
\Omega\left(t\right) &= e^{nt}\left(\int_0^t M\left(s\right) m\left(s\right) ds + M\left(0\right)\right)\omega(t) \\
\dot{\Omega}\left(t\right) &= ne^{nt}\left(\int_0^t M\left(s\right) m\left(s\right) ds + M\left(0\right)\right)\omega(t) \\
&\quad + e^{nt} M\left(t\right) m\left(t\right)\omega(t) + e^{nt}\left(\int_0^t M\left(s\right) m\left(s\right) ds + M\left(0\right)\right)\dot{\omega}(t) \\
\dot{\Omega}\left(t\right) &= n\Omega\left(t\right) + e^{nt} M\left(t\right) m\left(t\right)\omega(t) + e^{nt} M\left(t\right)\dot{\omega}(t)
\end{aligned}$$

$$\begin{aligned}
\dot{\omega}(t) &= \int_t^\infty \left(\left(1-\tau_k\right) r(t) - n\right) e^{-\int_t^u ((1-\tau_k)r(v)-n)dv}\left(1 - \tau_h\left(u\right)\right) w(u) h du - \left(1 - \tau_h(t)\right) w(t) h \\
\dot{\omega}(t) &= \left(\left(1-\tau_k\right) r(t) - n\right)\int_t^\infty e^{-\int_t^u ((1-\tau_k)r(v)-n)dv}\left(1 - \tau_h\left(u\right)\right) w(u) h du - \left(1 - \tau_h(t)\right) w(t) h \\
\dot{\omega}(t) &= \left(\left(1-\tau_k\right) r(t) - n\right)\omega(t) - \left(1 - \tau_h(t)\right) w(t) h
\end{aligned}$$

$$\dot{\Omega}\left(t\right) = n\Omega\left(t\right) + e^{nt} M\left(t\right) m\left(t\right)\omega(t) + e^{nt} M\left(t\right)\dot{\omega}(t)$$

$$\dot{\Omega}\left(t\right) = n\Omega\left(t\right) + e^{nt} M\left(t\right) m\left(t\right)\omega(t) + e^{nt} M\left(t\right)\left[\left(\left(1-\tau_k\right) r(t) - n\right)\omega(t) - \left(1 - \tau_h(t)\right) w(t) h\right]$$

$$\Omega\left(t\right) = e^{nt}\left(\int_0^t M\left(s\right) m\left(s\right) ds + M\left(0\right)\right)\omega(t)$$

$M\left(t\right) = \int_0^t M\left(s\right) m\left(s\right) ds + M\left(0\right) = M\left(0\right) e^{\int_0^t m(v)dv}$

$$\dot{\Omega}\left(t\right) = n\Omega\left(t\right) + m\left(t\right)\Omega\left(t\right) + \left(\left(1-\tau_k(t)\right) r(t) - n\right)\Omega\left(t\right) - e^{nt} M\left(t\right)\left(1 - \tau_h(t)\right) w(t) h$$

$$\dot{\Omega}\left(t\right) = m\left(t\right)\Omega\left(t\right) + \left(1-\tau_k(t)\right) r(t)\Omega\left(t\right) - e^{nt} M\left(t\right)\left(1 - \tau_h(t)\right) w(t) h$$

$$\dot{\Omega}\left(t\right) = m\left(t\right)\Omega\left(t\right) + \left(1-\tau_k(t)\right) r(t)\Omega\left(t\right) - \left(1 - \tau_h(t)\right) w(t) H$$

Insert (A.10):

$$\dot{\Omega}\left(t\right) = \left(\left(1-\tau_k(t)\right) r(t) + m\left(t\right)\right)\left(\frac{C(t)}{\rho - n} - K(t) - B(t)\right) - \left(1 - \tau_h(t)\right) w(t) H \tag{A.12}$$

Market Clearing Condition:

$$\dot{K}(t) = \left(1 - g(t)\right)\left(F\left(K(t), z(t)H\right) - \delta K(t)\right) - C(t) + e^{nt} M\left(t\right) m\left(t\right) k(t,t) \tag{A.13}$$

Government's Budget Constraint:

$$\dot{B}(t) = g(t)\left(F\left(K(t), z(t)H\right) - \delta K(t)\right) - \tau_h(t) w(t) H - \tau_k(t) r(t)\left(K\left(t\right) + B\left(t\right)\right) + r(t) B(t) + e^{nt} M\left(t\right) m\left(t\right) b(t,t) \tag{A.14}$$

Insert (A.12), (A.13) and (A.14) into (A.10):

$$\begin{aligned}\dot{C}(t) &= (\rho-n)\Bigg[\left(\left(1-\tau_k(t)\right)r(t)+m\left(t\right)\right)\left(\frac{C(t)}{\rho-n}-K(t)-B(t)\right)-\left(1-\tau_h(t)\right)w(t)H \\ &+\left(1-g(t)\right)\left(F\left(K(t),z(t)H\right)-\delta K(t)\right)-C(t)+e^{nt}M\left(t\right)m\left(t\right)k(t,t) \\ &+g(t)\left(F\left(K(t),z(t)H\right)-\delta K(t)\right)-\tau_h(t)w(t)H-\tau_k(t)r(t)\left(K\left(t\right)+B\left(t\right)\right)+r(t)B(t)+e^{nt}M\left(t\right)m\left(t\right)b(t,t)\Bigg]\end{aligned}$$

$$\begin{aligned}\dot{C}(t) &= \left(\left(1-\tau_k(t)\right)r(t)+m\left(t\right)\right)\left(C(t)-\left(\rho-n\right)K(t)-\left(\rho-n\right)B(t)\right)-\left(\rho-n\right)\left(1-\tau_h(t)\right)w(t)H \\ &+\left(\rho-n\right)\left[\left(F\left(K(t),z(t)H\right)-\delta K(t)\right)-C(t)+e^{nt}M\left(t\right)m\left(t\right)k(t,t)\right] \\ &+\left(\rho-n\right)\left[-\tau_h(t)w(t)H-\tau_k(t)r(t)\left(K\left(t\right)+B\left(t\right)\right)+r(t)B(t)+e^{nt}M\left(t\right)m\left(t\right)b(t,t)\right]\end{aligned}$$

The production function is homogenous degree 1:

$F=F_kK+F_hH$

$r=F_k-\delta$

$w=F_h$

$F=\left(r+\delta\right)K+F_hH$

$$\begin{aligned}\dot{C}(t) &= \left(\left(1-\tau_k(t)\right)r(t)+m\left(t\right)\right)\left(C(t)-\left(\rho-n\right)K(t)-\left(\rho-n\right)B(t)\right)-\left(\rho-n\right)w(t)H \\ &+\left(\rho-n\right)\left[\left(r(t)+\delta\right)K(t)+wH-\delta K(t)-C(t)+e^{nt}M\left(t\right)m\left(t\right)k(t,t)\right. \\ &\left.+-\tau_k(t)r(t)\left(K\left(t\right)+B\left(t\right)\right)+r(t)B(t)+e^{nt}M\left(t\right)m\left(t\right)b(t,t)\right]\end{aligned}$$

$$\begin{aligned}\dot{C}(t) &= \left(\left(1-\tau_k(t)\right)r(t)+m\left(t\right)\right)\left(C(t)-\left(\rho-n\right)K(t)-\left(\rho-n\right)B(t)\right) \\ &+\left(\rho-n\right)\left[\left(r(t)\right)K(t)+r(t)B(t)-C(t)+e^{nt}M\left(t\right)m\left(t\right)k(t,t)\right. \\ &\left.+-\tau_k(t)r(t)\left(K\left(t\right)+B\left(t\right)\right)+e^{nt}M\left(t\right)m\left(t\right)b(t,t)\right]\end{aligned}$$

$$\begin{aligned}\dot{C}(t) &= \left(\left(1-\tau_k(t)\right)r(t)+m\left(t\right)\right)C(t) \\ &-\left(\rho-n\right)\left(\left(1-\tau_k(t)\right)r(t)+m\left(t\right)\right)K(t) \\ &-\left(\rho-n\right)\left(\left(1-\tau_k(t)\right)r(t)+m\left(t\right)\right)B(t) \\ &+\left(\rho-n\right)\left[r(t)K(t)+r(t)B(t)-C(t)+e^{nt}M\left(t\right)m\left(t\right)k(t,t)\right. \\ &\left.+-\tau_k(t)r(t)\left(K\left(t\right)+B\left(t\right)\right)+e^{nt}M\left(t\right)m\left(t\right)b(t,t)\right]\end{aligned}$$

$$\begin{aligned}\dot{C}(t) &= \left(\left(1-\tau_k(t)\right)r(t)+m\left(t\right)\right)C(t) \\ &-\left(\rho-n\right)\left[C(t)+m\left(t\right)K(t)+m\left(t\right)B(t)-e^{nt}M\left(t\right)m\left(t\right)k(t,t)-e^{nt}M\left(t\right)m\left(t\right)b(t,t)\right]\end{aligned}$$

$$\begin{aligned}\dot{C}(t) &= \left(\left(1-\tau_k(t)\right)r(t)-\rho+m\left(t\right)+n\right)C(t) \\ &-\left(\rho-n\right)\left[m\left(t\right)K(t)+m\left(t\right)B(t)-e^{nt}M\left(t\right)m\left(t\right)k(t,t)-e^{nt}M\left(t\right)m\left(t\right)b(t,t)\right]\end{aligned}$$

$$\dot{c}\left(t\right)=\frac{\dot{C}\left(t\right)}{e^{nt}M\left(t\right)}-\left(n+m\left(t\right)\right)c\left(t\right)$$

$$\begin{aligned}\dot{c}\left(t\right) &= \left(\left(1-\tau_k(t)\right)r(t)-\rho+m\left(t\right)+n\right)\frac{C(t)}{e^{nt}M\left(t\right)} \\ &-\left(\rho-n\right)\frac{m\left(t\right)K(t)+m\left(t\right)B(t)-e^{nt}M\left(t\right)m\left(t\right)k(t,t)-e^{nt}M\left(t\right)m\left(t\right)b(t,t)}{e^{nt}M\left(t\right)} \\ &-\left(n+m\left(t\right)\right)c\left(t\right)\end{aligned}$$

$$C(t) = e^{nt} M(t)\, c(t)$$
$$K(t) = e^{nt} M(t)\, k(t)$$
$$B(t) = e^{nt} M(t)\, b(t)$$
$$\dot{c}(t) = \left(\left(1-\tau_k(t)\right) r(t) - \rho\right) c(t) - (\rho - n)\, m(t) \left[k(t) + b(t) - k(t,t) - b(t,t)\right]$$

Define: $\kappa(t) = \frac{k(t)-k(t,t)}{k(t)}$ and $\beta(t) = \frac{b(t)-b(t,t)}{b(t)}$ yields equation (7).

$$\widetilde{c}(t) = \frac{c(t)}{z(t)}$$
$$\dot{\widetilde{c}}(t) = \frac{\dot{c}(t)}{z(t)} - \frac{c(t)}{z(t)^2}\dot{z}(t)$$
$$\dot{\widetilde{c}}(t) = \frac{\dot{c}(t)}{z(t)} - \widetilde{c}(t)x$$

yields (8).

Appendix: Derivation of the Law of Motion for Capital (9) and Government Debt (10)

Insert (A.13) into:

$$\dot{\widetilde{k}}(t) = \frac{1}{z(t)}\left[\frac{\dot{K}(t)}{e^{nt}M(t)} - (n + m(t))\,k(t)\right] - \widetilde{k}(t)x$$

yields (9) and insert (A.14) into:

$$\dot{\widetilde{b}}(t) = \frac{1}{z(t)}\left[\frac{\dot{B}(t)}{e^{nt}M(t)} - (n + m(t))\,b(t)\right] - \widetilde{b}(t)x$$

yields (10).

Appendix: Derivation of Government's Intertemporal Budget Constraint (14)

Integrate the discounted value of (A.14)

$$\begin{aligned} & \int_0^{\infty} \dot{B}(t) e^{-\int_0^t (1-\tau_k(v)) r(v) dv} dt - \int_0^{\infty} (1-\tau_k(t)) r(t) B(t) e^{-\int_0^t (1-\tau_k(v)) r(v) dv} dt \\ = & \int_0^{\infty} g(t) \left[F\left(K(t), z(t) H\right) - \delta K(t) \right] e^{-\int_0^t (1-\tau_k(v)) r(v) dv} dt \\ & - \int_0^{\infty} \tau_h(t) w(t) H e^{-\int_0^t (1-\tau_k(v)) r(v) dv} dt \\ & - \int_0^{\infty} \tau_k(t) r(t) K\left(t\right) e^{-\int_0^t (1-\tau_k(v)) r(v) dv} dt \end{aligned}$$

The left hand side of the equation:

$$e^{-\int_0^t (1-\tau_k(v)) r(v) dv} \dot{B}(t) - e^{-\int_0^t (1-\tau_k(v)) r(v) dv} \left(1-\tau_k\left(t\right)\right) r(t) B(t) = \frac{\partial \left[e^{-\int_0^t (1-\tau_k(v)) r(v) dv} B(t) \right]}{\partial t}$$

$$\int_0^{\infty} e^{-\int_0^t (1-\tau_k(v)) r(v) dv} \dot{B}(t) du - \int_0^{\infty} e^{-\int_0^t (1-\tau_k(v)) r(v) dv} \left(1-\tau_k\left(t\right)\right) r(t) B(t) dt = \int_0^{\infty} \frac{\partial \left[e^{-\int_s^t (1-\tau_k(v)) r(v) dv} B(t) \right]}{\partial t} dt$$

$$\int_0^{\infty} e^{-\int_0^t (1-\tau_k(v)) r(v) dv} \dot{B}(t) du - \int_0^{\infty} e^{-\int_0^t (1-\tau_k(v)) r(v) dv} \left(1-\tau_k\left(t\right)\right) r(t) B(t) dt = e^{-\int_0^t (1-\tau_k(v)) r(v) dv} B(t) \mid_0^{\infty}$$

$$\int_0^{\infty} e^{-\int_0^t (1-\tau_k(v)) r(v) dv} \dot{B}(t) dt - \int_0^{\infty} e^{-\int_0^t (1-\tau_k(v)) r(v) dv} \left(1-\tau_k\left(t\right)\right) r(t) B(t) dt = \lim_{t \to \infty} e^{-\int_0^t (1-\tau_k(v)) r(v) dv} B(t) - B(0)$$

From the transversality condition: $\lim_{t \to \infty} e^{-\int_0^t (1-\tau_k(v)) r(v) dv} = 0$

$$\int_0^{\infty} e^{-\int_0^t (1-\tau_k(v)) r(v) dv} \dot{B}(t) - \int_0^{\infty} e^{-\int_s^t (1-\tau_k(v)) r(v) dv} \left(1-\tau_k\left(t\right)\right) r(t) B(t) = -B(0)$$

Therefore:

$$\begin{aligned} B(0) = & \int_0^{\infty} \tau_k(t) r(t) K\left(t\right) e^{-\int_0^t (1-\tau_k(v)) r(v) dv} dt \\ & + \int_0^{\infty} \tau_h(t) w(t) H e^{-\int_0^t (1-\tau_k(v)) r(v) dv} dt \\ & - \int_0^{\infty} e^{-\int_0^t (1-\tau_k(v)) r(v) dv} g(t) \left[F\left(K(t), z(t) H\right) - \delta K(t) \right] dt \end{aligned}$$

$$B(0) = \int_0^{\infty} e^{-\int_0^t (1-\tau_k(v)) r(v) dv} \left[\tau_k(t) r(t) K\left(t\right) dt + \tau_h(t) w(t) H dt - g(t) \left[F\left(K(t), z(t) H\right) - \delta K(t) \right] \right] dt$$

Dividing both sides by $z\left(t\right) e^{nt} M\left(t\right)$ yields (14).

Appendix: Derivation of the Welfare Effect (19)

$$\int_0^\infty e^{(n-\rho)t}\ln c\,(0,t)\,dt=\int_0^\infty e^{(n-\rho)t}\ln\left[\left(1+p_{m,T}\right)\overline{c}(0,t)\right]dt$$

$$\int_0^\infty e^{(n-\rho)t}\ln c\,(0,t)\,dt=\int_0^\infty e^{(n-\rho)t}\ln\left(1+p_{m,T}\right)dt+\int_0^\infty e^{(n-\rho)t}\ln\overline{c}(0,t)dt$$

$$\ln\left(1+p_{m,T}\right)\int_0^\infty e^{(n-\rho)t}dt=\int_0^\infty e^{(n-\rho)t}\ln c\,(0,t)\,dt-\int_0^\infty e^{(n-\rho)t}\ln\overline{c}(0,t)dt$$

$$\frac{\ln\left(1+p_{m,T}\right)}{\rho-n}=\int_0^\infty e^{(n-\rho)t}\ln c\,(0,t)\,dt-\int_0^\infty e^{(n-\rho)t}\ln\overline{c}(0,t)dt$$

$$\frac{\ln\left(1+p_{m,T}\right)}{\rho-n}=\int_0^\infty e^{(n-\rho)t}\ln\frac{c\,(0,t)}{\overline{c}(0,t)}dt$$

Insert (A.9) for s=0, and for the counterfactual path $\overline{c}(0,t)$=$\overline{c}\,(0,0)\,e^{((1-\overline{\tau}_k)\overline{r}-\rho)t}$:

$$\frac{\ln\left(1+p_{m,T}\right)}{\rho-n}=\int_0^\infty e^{(n-\rho)t}\ln\left[\frac{c\,(0,0)\,e^{\int_0^t((1-\tau_k(v))r(v)-\rho)dv}}{\overline{c}\,(0,0)\,e^{((1-\overline{\tau}_k)\overline{r}-\rho)t}}\right]dt$$

$$\frac{\ln\left(1+p_{m,T}\right)}{\rho-n}=\int_0^\infty e^{(n-\rho)t}\ln\left[\frac{c\,(0,0)\,e^{\int_0^t(1-\tau_k(v))r(v)dv}}{\overline{c}\,(0,0)\,e^{(1-\overline{\tau}_k)\overline{r}t}}\right]dt$$

$$\frac{\ln\left(1+p_{m,T}\right)}{\rho-n}=\int_0^\infty e^{(n-\rho)t}\ln\left[\frac{c\,(0,0)}{\overline{c}\,(0,0)}e^{\int_0^t(1-\tau_k(v))r(v)dv}e^{-(1-\overline{\tau}_k)\overline{r}t}\right]dt$$

$$\frac{\ln\left(1+p_{m,T}\right)}{\rho-n}=\int_0^\infty e^{(n-\rho)t}\left(\ln\left[\frac{c\,(0,0)}{\overline{c}\,(0,0)}\right]+\ln\left[e^{\int_0^t(1-\tau_k(v))r(v)dv}e^{-(1-\overline{\tau}_k)\overline{r}t}\right]\right)dt$$

$$\begin{aligned}\frac{\ln\left(1+p_{m,T}\right)}{\rho-n}&=\int_0^\infty e^{(n-\rho)t}\ln\left[c\,(0,0)\right]dt+\int_0^\infty e^{(n-\rho)t}\int_0^t\left(1-\tau_k\left(v\right)\right)r(v)dvdt\\&\quad-\int_0^\infty e^{(n-\rho)t}\ln\left[\overline{c}(0,0)\right]dt-\int_0^\infty e^{(n-\rho)t}\left(1-\overline{\tau}_k\right)\overline{r}tdt\end{aligned}$$

$$\begin{aligned}\frac{\ln\left(1+p_{m,T}\right)}{\rho-n}&=\ln\left[c\,(0,0)\right]\int_0^\infty e^{(n-\rho)t}dt+\int_0^\infty e^{(n-\rho)t}\int_0^t\left(1-\tau_k\left(v\right)\right)r(v)dvdt\\&\quad-\ln\left[\overline{c}(0,0)\right]\int_0^\infty e^{(n-\rho)t}dt-\int_0^\infty e^{(n-\rho)t}\left(1-\overline{\tau}_k\right)\overline{r}tdt\end{aligned}$$

$$\begin{aligned}\frac{\ln\left(1+p_{m,T}\right)}{\rho-n}&=\frac{\ln c\,(0,0)}{n-\rho}+\int_0^\infty e^{(n-\rho)t}\int_0^t\left(1-\tau_k\left(v\right)\right)r(v)dvdt\\&\quad-\frac{\ln\overline{c}(0,0)}{n-\rho}-\left(1-\overline{\tau}_k\right)\overline{r}\int_0^\infty e^{(n-\rho)t}tdt\end{aligned}$$

$$\begin{aligned}\frac{\ln\left(1+p_{m,T}\right)}{\rho-n}&=\frac{\ln c\,(0,0)}{n-\rho}+\int_0^\infty e^{(n-\rho)t}\int_0^t\left(1-\tau_k\left(v\right)\right)r(v)dvdt\\&\quad-\frac{\ln\overline{c}(0,0)}{n-\rho}-\frac{\left(1-\overline{\tau}_k\right)\overline{r}}{\left(n-\rho\right)^2}\end{aligned}$$

$$\begin{aligned}\ln\left(1+p_{m,T}\right)&=\ln\overline{c}(0,0)-\ln c\,(0,0)+(\rho-n)\int_0^\infty e^{(n-\rho)t}\int_0^t\left(1-\tau_k\left(v\right)\right)r(v)dvdt\\&\quad-\frac{\left(1-\overline{\tau}_k\right)\overline{r}}{\left(\rho-n\right)}\end{aligned}$$

$$\ln\left(1+p_{m,T}\right) = \ln\frac{\overline{c}(0,0)}{c\left(0,0\right)}+(\rho-n)\int_0^\infty e^{(n-\rho)t}\int_0^t\left(1-\tau_k\left(v\right)\right)r(v)dvdt - \frac{\left(1-\bar{\tau}_k\right)\bar{r}}{(\rho-n)}$$

$$1+p_{m,T}=e^{\ln\frac{\overline{c}(0,0)}{c(0,0)}}e^{(\rho-n)\int_0^\infty e^{(n-\rho)t}\int_0^t(1-\tau_k(v))r(v)dvdt-\frac{(1-\bar{\tau}_k)\bar{r}}{(\rho-n)}}$$

which yields (19):

$$p_{m,T}=\frac{\overline{c}(0,0)}{c\left(0,0\right)}e^{(\rho-n)\int_0^\infty e^{(n-\rho)t}\int_0^t(1-\tau_k(v))r(v)dvdt-\frac{(1-\bar{\tau}_k)\bar{r}}{(\rho-n)}}-1$$

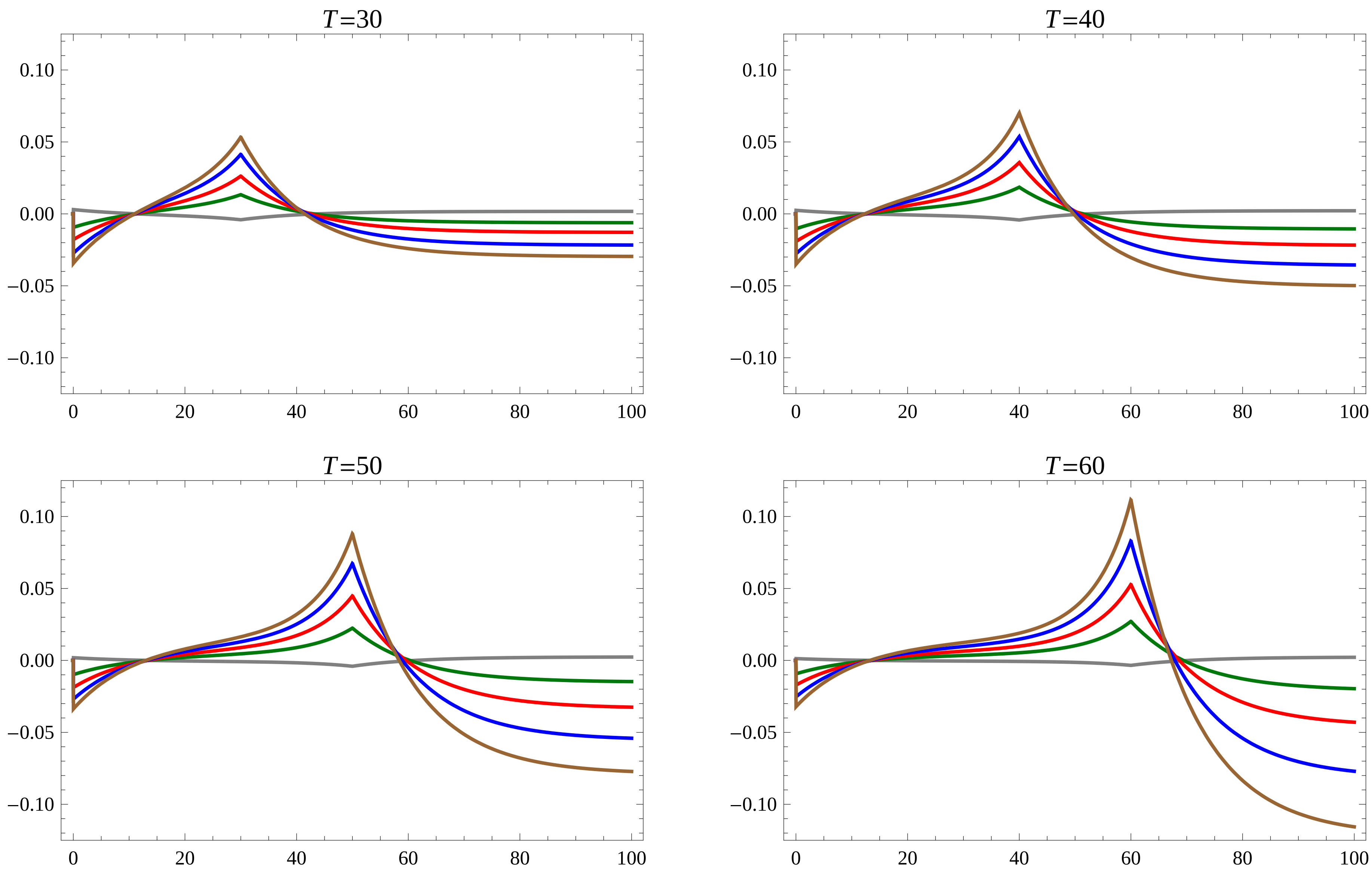

Figure A1: The impulse responses for consumption as fractional deviations for optimal policies corresponding to no immigration (grey) and rates of immigration of 3.4 per thousand (green), 5.7 per thousand (red), 8.0 per thousand (blue) and 9.8 per thousand (brown).

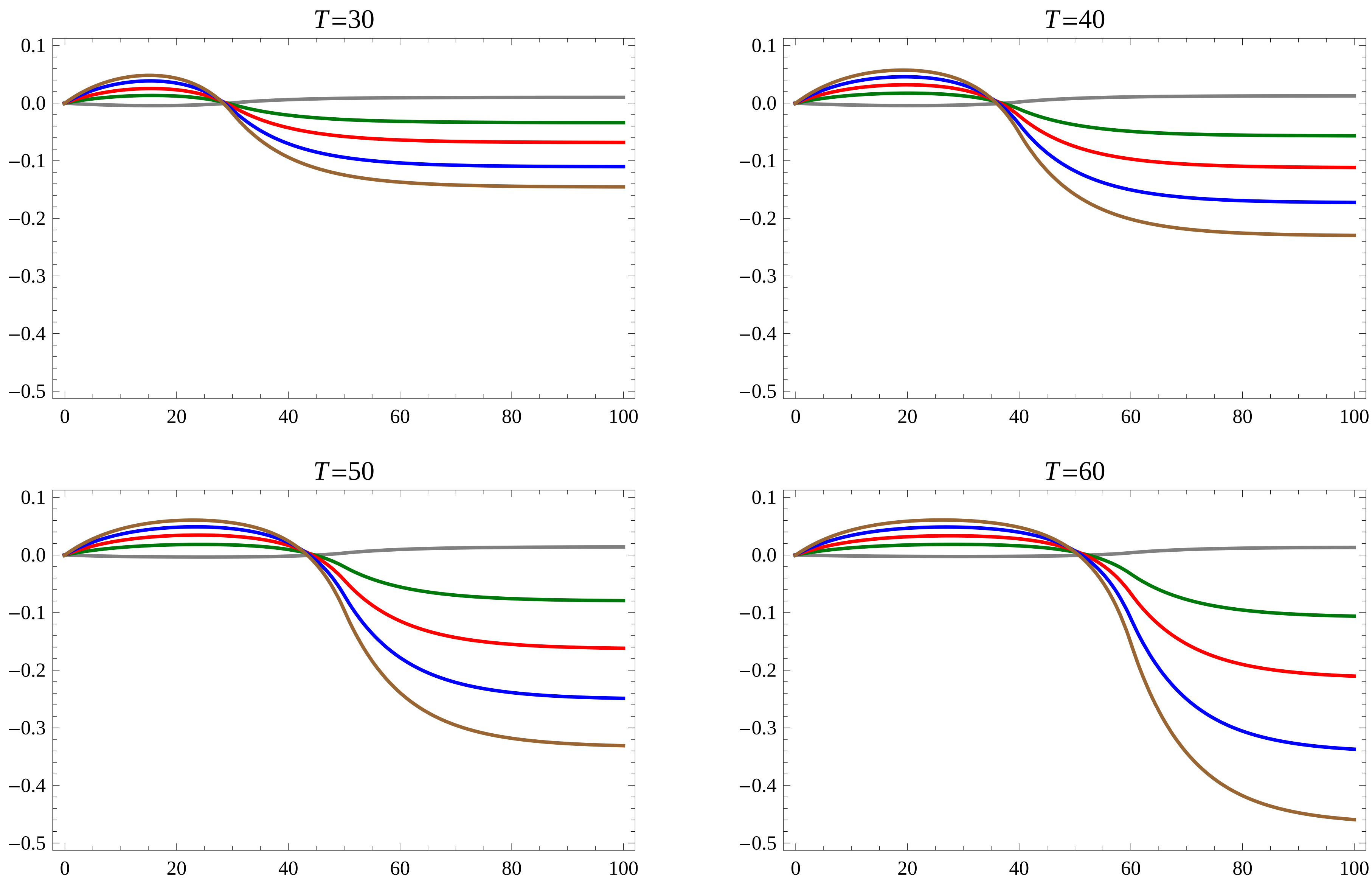

Figure A2: The impulse responses for capital as fractional deviations for optimal policies corresponding to no immigration (grey) and rates of immigration of 3.4 per thousand (green), 5.7 per thousand (red), 8.0 per thousand (blue) and 9.8 per thousand (brown).

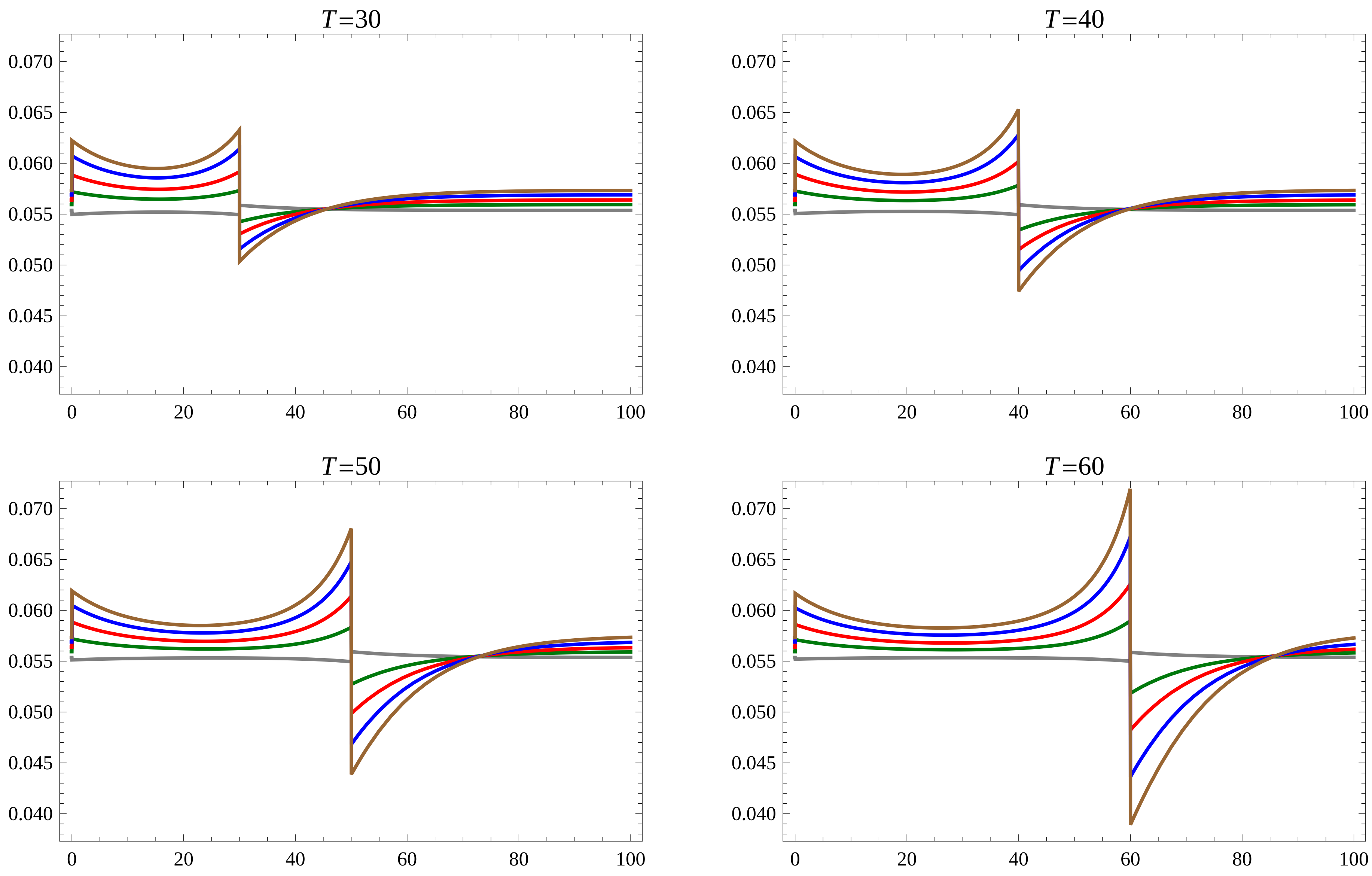

Figure A3: The impulse responses for capital as fractional deviations for optimal policies corresponding to no immigration (grey) and rates of immigration of 3.4 per thousand (green), 5.7 per thousand (red), 8.0 per thousand (blue) and 9.8 per thousand (brown).