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Wage Growth and the Measurement of Social Security's Financial Condition

by

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Abstract

Government spending on the elderly is projected to increase rapidly as the population ages and the baby-boomers retire. A chief concern is the continued viability of entitlement programs such as Social Security. Lawmakers, budget analysts, and the public pay considerable attention to the Social Security Trustees' economic growth projections because they believe that higher growth would significantly reduce the program's actuarial deficit. This belief is validated by the Social Security Administration's calculations that show a smaller 75-year actuarial deficit when real wage growth is assumed to be faster.

In recent years, however, economists have drawn attention to the merits of measuring Social Security's financial status over periods extending beyond the next 75 years. And since 2003, the Social Security Trustees have added estimates of the program's finances measured in perpetuity in their annual reports. However, sensitivity analysis examining the impact of various assumptions on the system's financing are not reported over the infinite term. First, this paper shows analytically that faster wage growth may *reduce* Social Security's actuarial balance when measured in perpetuity if the decline in the ratio of workers to retirees is projected to continue beyond the first 75 years. Second, it analytically evaluates and reports stylized calculations of the impact of real wage growth and demographic change – including time-varying rates of change based on official projections for the US economy – on Social Security's actuarial balance in a multi-period setting. Third, it uses the SSASIM actuarial model of Social Security financing to estimate the degree to which increased wage growth could negatively affect the system's actuarial balance.

These results raise questions both about conventional wisdom regarding how improved wage growth would affect Social Security's financing, as well as about how commonly used measures of Social Security's financing capture those effects.

1. Introduction

It is often argued in both policy circles and the popular media that faster economic growth could significantly reduce Social Security's long-term funding imbalance.[1] If, as many argue, Social Security Trustees' projections for economic growth are unduly pessimistic, policymakers may ignore calls for policies to reform the system in the belief that faster economic growth will "bail us out." However, Social Security's financial status is normally analyzed under a truncated horizon of 75 years. Does the positive association of faster economic growth with improvement in the system's actuarial balance survive under longer horizons? If not – that is, if faster economic growth fails to improve or even worsens Social Security's actuarial balance over very long horizons – failure to enact reforms to make the system sustainable would be a more serious lapse than many policymakers and budget analysts realize.

The current Social Security benefit formula indexes workers' earnings through age 60 for wage growth when calculating their average indexed monthly wage (AIME), which is the basis for computing Social Security benefits.[2] Benefits are calculated at retirement by applying a progressive formula to the AIME, so that a larger fraction of pre-retirement earnings are replaced by Social Security benefits for low wage workers compared to higher earners. Post-retirement, benefits are increased annually with the Consumer Price Index to maintain their purchasing power. Each worker cohort's retirement benefits -- as calculated when its members retire -- reflect that cohort's higher labor productivity and wages during its lifetime compared to that of

[1] See, for instance, Gordon (2003); Baker (1996); Weller and Rassell (2000); Baker and Weisbrot (1999); and Hall (2005). For contrasting views, see Penner (2003); Davis (2000); Biggs (2000). Note that this paper does not comment on the appropriateness of the wage growth projections made by the Social Security Trustees or other agencies. For analysis of the Trustees' projections, see the 1999 and 2003 Technical Panel reports, as well as General Accounting Office (2000).

[2] This is done to place past earnings on par with current ones by inflating the former at the rate of nominal wage growth during the intervening years. This accounts for both economy-wide general price inflation and real wage growth that occurred during those years. Disability benefits are calculated in a similar way, though with adjustments for decreased time in the labor force.

the immediately preceding cohort. Thus, average benefits for succeeding cohorts of retirees will tend to rise at the rate of average wages. And for each cohort, once the benefit level is established, its purchasing power is maintained by allowing the dollar amount to grow at the rate of general price inflation.

Actuarial balance is the most prominent of a number of measures that the Social Security Trustees use to assess the program's long-term finances. It equals the present value of the system's annual net income expressed as a percentage of payrolls over the measurement period.[3] As described by the Trustees,

> *"…actuarial balance is a measure of the program's financial status for the 75-year valuation period as a whole. It is essentially the difference between income and cost of the program expressed as a percentage of taxable payroll over the valuation period. This single number summarizes the adequacy of program financing for the period."*

While the Trustees have traditionally measured actuarial balance over 25, 50 and 75 years, the 75-year measure receives the most attention in policy debates. The 2005 Trustees Report projects a 75-year actuarial deficit of 1.92 percent of taxable payrolls. This deficit has a commonly applied policy interpretation:

> *"When the actuarial balance is negative, the actuarial deficit can be interpreted as the percentage that would have to be added to the current law income rate in each of the next 75 years, or subtracted from the cost rate in each year, to bring the funds into actuarial balance."*[4]

Under this interpretation, the actuarial deficit indicates the size of an immediate and permanent payroll tax increase – 1.92 percentage points, from 12.40 percent to 14.32 percent of wages up to

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[3] More specifically, the Trustees measure actuarial balance over a measurement period as the net value of the initial trust fund balance, the present value of income, the present value of costs, and the present value of scheduled benefits in the final year of the measurement period. This last amount is to satisfy the requirement that the ratio of trust fund assets to benefit payments in the final year equal 100 percent.

[4] Board of Trustees (2005), p. 10

the taxable limit – that would be sufficient to restore the program to actuarial balance over 75 years, though not necessarily thereafter.[5]

Given how past wages enter into the calculation of Social Security benefits, it is easy to understand why many people believe that faster economic growth would improve the system's financial outlook. Benefits paid to current retirees are indexed only to inflation, rather than to nominal wage growth (which generally exceeds inflation by the growth rate of real labor productivity). Thus, faster growth in real productivity and wages would cause an immediate increase in the tax base and, therefore, in revenues, but would increase benefit payments only after a delay as working generations that experienced faster wage growth retire and claim benefits in the future. If the increase in wage growth were permanent, the annual cost rate – projected benefits as a percent of the projected tax base through the calculation horizon – would permanently decline relative to a lower wage growth scenario. Thus, cash balances relative to the payroll base would improve in every following year.

The Trustees' Annual Report for 2005 shows that over a 75-year horizon, this improvement in annual balances would carry over to an improvement in Social Security's actuarial balance. Assuming an increase in real wage growth from a baseline of 1.1 percent per year to 1.6 percent, the 75-year actuarial balance would improve by 0.53 percentage points, from a deficit of 1.92 percent of payroll to a deficit 1.39 percent. This analysis lends credence to the

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[5] It should be noted, however, that actuarial balance is not the sole "finite horizon" measure used to assess Social Security's finances. For example, the Social Security Trustees also report measures of "close actuarial balance." See the Board of Trustees (2005), p. 60. The Social Security Administration's Office of the Chief Actuary have suggested additional measures, including cash balances and trust fund ratios in specific years and the direction of both at the close of a measurement period. See Goss (1999) and Chaplain and Wade (2005).

widely shared view that faster economic growth would significantly *reduce* Social Security's projected actuarial deficit. We label this as the "traditional" view.[6]

In recent years Social Security analysts have increasingly focused on very long term financing with the policy goal being solvency that can be sustained well beyond the traditional 75-year scoring period – often termed "sustainable solvency." [7] The Trustees note that

> *Even a 75-year period is not long enough to provide a complete picture of Social Security's financial condition…. Overemphasis on summary measures for a 75-year period can lead to incorrect perceptions and to policy prescriptions that do not move toward a sustainable system. Thus, careful consideration of the trends in annual deficits and unfunded obligations toward the end of the 75-year period is important. In order to provide a more complete description of Social Security's very long-run financial condition, this report also includes summary measures for a time period that extends to the infinite horizon.*[8]

Proponents of longer-term measures argue that focusing on 75-year solvency alone can distort policy decisions; the 1999 Technical Panel, for instance, argued that "When reformers aim only for 75-year balance, … they usually end up in a situation where their reforms only last a year before being shown out of 75-year balance again."[9] For that reason, analysts have begun to calculate the Social Security program's finances beyond 75 years.[10] Beginning with the 2003 Report, Social Security's Trustees have published data on system financing measured over the infinite term. The main rationale for the infinite horizon measure is that it gives the fullest view of the total assets and obligations of the Social Security program. The Department of the Treasury notes that

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[6] Although economic growth is a broader concept than real wage growth, the two are generally understood to occur concomitantly, at least in public debates about Social Security financing.

[7] See 1994-96 Advisory Council; 1999 Technical Panel; 2003 Technical Panel; 2005 Trustees Report;

[8] Board of Trustees (2005), p. 12

[9] 1999 Technical Panel, p. 37.

[10] For example, see Gokhale and Smetters (2003), and Auerbach, Gale, and Orzag (2004). In infinite horizon calculations, cash flows are projected into the future until the present value sums of future dollar flows (benefits, taxes, the tax base, and so on) become stable (asymptote to a finite value).

> *"…a 75-year projection is incomplete. For example, when calculating unfunded obligations, a 75-year horizon includes revenue from some future workers but only a fraction of their future benefits. In order to provide a complete estimate of the long-run unfunded obligations of the programs, estimates should be extended to the infinite horizon..*[11]

Since then, measures of very long term financing, both for social insurance programs and the federal budget in general, have gained increasing prominence in policy discussions.[12]

Calculations of long-term financing measures suggest that the traditional view may be an artifact of calculating Social Security's actuarial balance under a truncated projection horizon of 75-years. In particular, such limited-horizon measures reduce the effect of a projected decline in the worker-to-beneficiary ratio over the very long-term. Under perpetuity calculations, the conclusion that faster wage growth improves Social Security's actuarial balance could be reversed when the decline in the worker-to-beneficiary ratio is assumed to continue beyond the next 75 years. This result arises because a declining worker-to-beneficiary ratio magnifies the future impact of faster wage growth on Social Security's cost rate and widens the gap between the present value of its outlays and revenues to yield a *larger* actuarial deficit.

Exploring the sensitivity of Social Security's actuarial balance to individual economic assumptions involves examining its response to changes in one (economic or demographic) parameter at a time. However, altering the real wage growth assumption raises the question of "model consistency." Faster real wage growth could not occur isolated from changes in other

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[11] Department of the Treasury (2004), p. 88

[12] Greenspan (2003) discusses the advantages of the related approach of accrual accounting for Social Security; Walker (2003) discussed "one possible approach would be to calculate the estimated discounted present value of major spending and tax proposals as a supplement to, not a substitute for, the CBO's current 10-year cash flow projections." Senator Joseph Lieberman (D-Conn.) has introduced legislation (S. 1915, The Honest Government Accounting Act of 2004) that would calculate 75-year and infinite horizon net present value measures on a government-wide basis. The Social Security Advisory Board's 2003 Technical Panel on Assumptions and Methods praised the Trustees' inclusion of measures of system financing in perpetuity and recommended that they be given greater prominence in the Report.

relevant economic variables. For example, faster wage growth may be the result of technological progress, which increases the productivity of both capital and labor, and could be associated with higher interest rates. In that case, Social Security's (risk free) rate of interest could also be higher with accompanying effects on actuarial balance.

If the increase in the government's interest rate associated with faster real wage growth were sufficiently large, bigger future Social Security outlays would receive a smaller weight in present-value calculations, potentially confirming the traditional view. However, because interaction of faster wage growth with a declining worker-to-beneficiary ratio worsens Social Security's long-term actuarial balance under a constant discount rate, such a worsening may persist despite a simultaneous increase in the government's interest rate – up to a limit. With the actuarial balance calculation calibrated to U.S. demographics and real wage growth, it can be shown that faster wage growth would generate larger actuarial deficits for a range of Social Security interest rates.

This paper analyzes the effect of increased economic growth on Social Security solvency measured in perpetuity.[13] Using a stylized model, we first show analytically that it is possible for faster wage growth to reduce the system's actuarial balance measure in a simple pay-as-you-go program, provided that the ratio of workers to beneficiaries is declining. We then examine these results under a variety of demographic and interest rate conditions. Next, using the SSASIM actuarial model we show that such a decline in Social Security's infinite-term actuarial balance is plausible under demographic and economic conditions projected for the United States, even

[13] Admittedly, a change in economic growth over the long term would be associated with changes in other variables involved in measuring Social Security's financial status -- such as wage growth, demographic change, capital returns, and discount rates. This paper does not attempt to capture the interrelationships between these variables in a dynamic general equilibrium setting. Rather, it is limited to examining the impact of higher productivity and real wage growth on "static" measures of the program's financial condition that are traditionally used by the Social Security Administration and the program's Trustees.

though the same wage growth rate would improve the program's 75-year actuarial balance and the measure of sustainable solvency. The paper closes with a discussion of the results' meaning for Social Security financing and for the measures of solvency commonly applied to it.

2. A Simple Model of Social Security Financing

The following builds a stylized model of a pay-as-you-go Social Security program. Initial specifications are deliberately simplified for the purpose of better communicating the core insights, with increasing complexity and realism added as the model is developed.

First consider a program in which each beneficiary is paid a benefit equal to a constant percentage of the average wage in that year. The actuarial balance for such a program is herein defined as the present value of taxes minus the present value of benefits, expressed as a percentage of the present value of future payrolls.

$$AB = \frac{PVTaxes - PVBenefits}{PVPayroll} . \qquad (1)$$

This is the familiar equation in which the summarized cost rate is subtracted from the summarized income rate. This stylized measure of actuarial balance differs from that applying to the true Social Security program primarily in that it excludes the initial value of the trust fund.[14]

Measured in perpetuity, the present value of taxes can be expressed as

$$PVTaxes = \tau w_0 \sum_{t=0}^{\infty} N_t G^t R^{-t} , \qquad (2)$$

where

[14] Actuarial balance as measured by the Social Security Trustees includes the initial trust fund balance and a requirement that the final year trust fund balance be equal to 100 percent of outlays in that year. To keep the derivations as simple as possible, the formulation of the actuarial balance [equation (1)] in the text assumes those amounts to be zero.

τ (tau) = the payroll tax rate;

w_0 = the average wage at time zero;

N_t = the population of workers at time t;

G = a compound real wage growth factor equal to $(1+g)$, where g equals the annual rate of real wage growth; and

R = an interest factor equal to $(1+r)$, where r equals the real interest rate;

The present value of benefits is equal to

$$PVBenefits = w_0 \beta_0^{-1} \rho \sum_{t=0}^{\infty} N_t G^t B^{-t} R^{-t} \ , \qquad (3)$$

where

ρ (rho) = a constant replacement rate of the average current wage;

β_0 (beta) = the worker-beneficiary ratio at time zero; and

B = a reduction factor equal to $(1-b)$ where b equals a constant percentage rate of decline in the worker-beneficiary ratio.

The present value of payrolls can be expressed as

$$PVPayrolls = w_0 \sum_{t=0}^{\infty} N_t G^t R^{-t} \ . \qquad (4)$$

Equation (3) shows that the present value of total benefits paid at time t is a function of a constant replacement rate, the initial values of wages, (the inverse of) the worker-beneficiary ratio, and changes in the worker population, wages, worker-beneficiary ratio, and accumulated interest between time zero and time t. For purposes of clarity, the values of G^t and B^{-t} would be greater than 1 so long as real wages are rising and the worker-beneficiary ratio falling (g, $b > 0$); the value of R^{-t} would be less than 1 so long as the real interest rate is positive ($r>0$).

Note that equation (3) assumes that current benefits are a function of *current* wages. That is, there is no lag between realizing higher wages and higher Social Security benefits. This relationship would obtain if Social Security benefits were dependent on past wages indexed for wage growth throughout a retiree's lifetime. Although this is not true for Social Security in reality, examining its implications is helpful for developing intuition about results when this assumption is dropped.

The variables in equation (3) affect *PVBenefits* in the following ways: a higher value of *g* means that wages would be higher in each future period. Because benefits depend on contemporaneous wages by assumption, *PVBenefits* would be larger. Note that if *g* were larger, each term under the summation sign in equation (3) would also be larger. Hence, the entire term would be larger. The same is true for *PVTaxes* in equation (2). Furthermore, if the t^{th} term in *PVBenefits* increases by x percent as a result of an increase in *g*, so would the t^{th} term in *PVTaxes*. Both taxes and benefits would, therefore, increase in the same proportion under a higher value of *g*.

Likewise, if the worker-beneficiary ratio declines (that is, if *b* were larger), there would be more beneficiaries per worker in the future, implying a larger *PVBenefits* relative to *PVTaxes* at each given value of *g*. That is because a change in *b* affects the former but not the latter. In contrast, increases in the real interest rate (*r*) means that future benefit payments, taxes, and wages are all discounted more heavily -- implying proportionate reductions in *PVBenefits, PVTaxes,* and *PVPayrolls*. These relationships are stated as

Proposition 1: *Assuming 1) that the replacement rate is constant and 2) that current benefits depend on current wages:*

i) An increase in real wage growth leads to a proportionate increase in PVBenefits and PVTaxes;

ii) A faster decline in the worker-beneficiary ratio increases PVBenefits relative to PVTaxes;

iii) An increase in the real interest rate leads to a proportionate reduction in PVBenefits and PVTaxes; and

iv) An increase in real wage growth leads to a proportionate increase in PVPayrolls and PVBenefits, while an increase in the real interest rate leads to a proportionate reduction in both.

Using equations (2), (3) and (4), the actuarial balance defined in equation (1) can be expressed as

$$AB = \frac{\tau N_0 w_0 \sum_{t=0}^{\infty} G^t R^{-t} - N_0 w_0 \rho \beta_0^{-1} \sum_{t=0}^{\infty} B^{-t} G^t R^{-t}}{N_0 w_0 \sum_{t=0}^{\infty} G^t R^{-t}},$$

where, for simplicity, we assume that the total worker population remains constant over time at N_0. The expression for AB can be can be simplified to

$$AB = \tau - \frac{\rho \beta_0^{-1} \sum_{t=0}^{\infty} B^{-t} G^t R^{-t}}{\sum_{t=0}^{\infty} G^t R^{-t}} = \tau - \Omega. \tag{5}$$

Equation (5) says that the actuarial balance is equal to the tax rate minus the summarized cost rate (Ω), where both revenues and costs are expressed as a percentage of payrolls. The assumption of a constant worker population but a declining worker-to-beneficiary ratio obviously implies a growing total population.

We next explore the question of the impact of faster wage growth on the actuarial balance under several cases using alternative parametric assumptions, progressively making the model more realistic.

Case A. Constant Worker-Beneficiary Ratio

This case assumes $b=0$, which implies that the age structure of the population remains constant over time. If so, $B^{-t}=1$ for all future periods t, and this term is eliminated from equation (5). That allows for the simplified expression for the actuarial balance:

$$AB = \tau - \rho\beta_0^{-1}. \qquad (6)$$

Equation (6) is intuitively easy to understand: The system receives τ cents per worker. For it to be balanced, τ cents must be sufficient to pay benefits to the number of beneficiaries per worker (β_0^{-1}).[15] Note that the compound wage growth term G^t is also eliminated from the expression for AB, implying that in this simplified model wage growth (g), does not influence the actuarial balance.

Proposition 2: *With an unchanging population structure (b=0) and with current benefits being proportional to current wages, the Social Security system's actuarial balance is unchanged in response to a change in the rate of real wage growth.*

That is, in this simplified setting, a Social Security system that is initially in (out of) balance will remain in (out of) balance to the same degree regardless of the rate of real wage growth.

Case B: Declining Worker-Beneficiary Ratio

Now consider the case where $b>0$—that is, where the worker-beneficiary ratio declines over time. First, all other things equal, this will reduce the actuarial balance of the system. With

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[15] For instance, if the replacement rate were 32 percent and the worker-to-retiree ratio were 2, the tax rate required for a zero actuarial balance would be 16 (32×2^{-1}).

$b>0$, B^{-t} [$=1/(1-b)^t$] must be larger than 1.[16] Compared to the cost rate under Case A, a positive b increases the numerator in the second term of equation (5) and makes the system's costs as a percentage of payrolls larger, thereby reducing actuarial balance.

Proposition 3: *Other things equal, a faster rate of decline, b, in the worker-beneficiary ratio is associated with a smaller (and more negative) actuarial balance.*

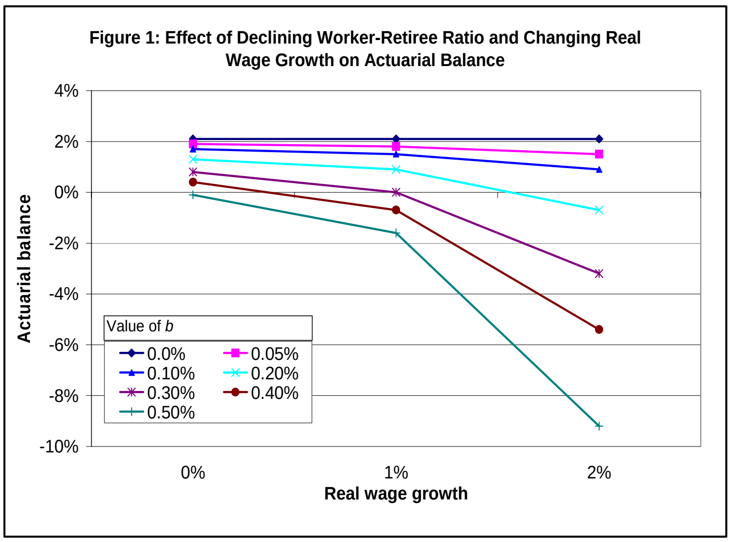
Moreover, when the worker-beneficiary ratio is falling (that is, when $b>0$), the actuarial balance is not neutral with regard to changes in wage growth (g). If $b>0$, then $B^{-t}>1$ for each value of t. In this case, a larger value of g causes a disproportionate change in the numerator of the second term in equation (5) compared to its denominator, again causing the actuarial balance to change.

Proposition 4: *When the worker-retiree ratio is declining (b>0), increased economic growth reduces the actuarial balance (makes it more negative).*

A formal proof of Proposition 4 is provided in Appendix A. However, the proof is intuitively clear from equation (5). As stated earlier, $B^{-t}>1$ when $b>0$. That means any increase in g must result in a larger increase in the numerator of the second term of equation (5) compared to the increase in the denominator. That, in turn, means an increase in g increases the summarized cost rate and reduces the system's actuarial balance. The intuition underlying Proposition 4 is quite straightforward: If the population of retirees is growing, the population of workers is constant, and retirement benefits are determined by current wages, faster wage growth would cause benefit outlays to grow faster than payrolls.

[16] For instance, if b were 2% and t were 5 years, then β^{-t} would be equal to $1/(1 -.02)^5$, or 1.11.

Figure 1 illustrates Propositions 3 and 4 by calculating actuarial balance for a range of values of the parameters *b* and *g*. The model is designed to be in actuarial balance in perpetuity when annual wage growth (*g*) is 1 percent and the rate of annual decline (*b*) in the worker-beneficiary ratio is 0.3 percent, roughly the rate projected for the current Social Security program over the very long term.[17] From this base, we alter both the rate of decline of the worker-beneficiary ratio (from a low of zero percent to a high of 0.5 percent) and the rate of real wage growth, from zero percent through 2 percent.



When the worker-beneficiary ratio is stable (*b=0*), changing the assumed rate of real wage growth has no effect on the actuarial balance. With a declining worker to beneficiary ratio (*b*>0), however, the actuarial balance (*AB*) declines when real wage growth occurs faster. Figure 1 shows that, consistent with Proposition 3, a higher value of *b* results in a lower level of *AB* (for each given level of *g*). In addition, consistent with Proposition 4, when *b>0*, an increases in *g* reduces *AB* whereas a reduction in *g* increases *AB*. Furthermore, *AB* becomes more sensitive to changes in *g* at larger values of *b*. Thus, in a pure pay-as-you-go program in which benefits are based on current average wages, increased economic growth reduces actuarial balance calculated in perpetuity so long as the worker-retiree ratio is declining.

[17] The steady-state decline at the end of the 75-year period is roughly 0.24 percent annually; the rate of decline in the early part of the 75-year period, which has a disproportionate value in actuarial balance calculations, is significantly higher.

Case C: Benefits Dependent on Current Wages and Wages Lagged One Period

Equation (3) for *PVBenefits* bears an important distinction from the current Social Security program in that it pays benefits as a percentage of *current* average wages alone whereas the Social Security program's benefits depend upon *past*, or lagged, wages. As a result, an immediate increase in wages, and thus tax revenues, would not lead to an immediate increase in benefits. This lag in translating wage growth to benefit growth underlies the common belief that system financing unequivocally improves in response to faster economic growth.

Equation (3) is re-written below to express the current benefit as an equally weighted function of current wages and wages 1 period ago. This makes benefits at time *t* a function of wages at time *t* and *t-1*.

$$PVBenefits = \frac{1}{2} w_0 \rho \beta_0^{-1} \sum_{t=0}^{\infty} N_t B^{-t} G^t R^{-t} + \frac{1}{2} w_0 \rho \beta_0^{-1} \sum_{t=0}^{\infty} N_t B^{-t} G^{t-1} R^{-t}$$

$$= \frac{1}{2} w_0 \rho \beta_0^{-1} \sum_{t=0}^{\infty} N_t (1+G^{-1}) B^{-t} G^t R^{-t} \ . \qquad (3a)$$

Given (3a), equation (5) for actuarial balance can be rewritten as

$$AB = \tau - \frac{\rho \beta_0^{-1} \sum_{t=0}^{\infty} B^{-t} (1+G^{-1}) G^t R^{-t}}{2 \sum_{t=0}^{\infty} G^t R^{-t}} = \tau - \frac{1}{2}(1+G^{-1})\Omega \, . \qquad (5a)$$

With a stable worker-retiree ratio (*b=0*), equation (6) can be simplified to

$$AB = \tau - \frac{1}{2} \rho \beta_0^{-1} (1+G^{-1}) \ . \qquad (6a)$$

This expression of the actuarial balance clarifies why many people believe that increased economic growth will improve system financing. Because G^{-1} declines as wage growth increases, higher wage growth reduces the cost rate, $(1/2)\rho\beta_0^{-1}(1+G^{-1})$, relative to the revenue rate, τ, and improves the system's financing. This leads to

Proposition 5: *Assuming 1) a stable worker-to-beneficiary ratio (b=0) and 2) dependence of benefits on lagged wages, faster wage growth reduces the cost rate and improves the system's actuarial balance.*

The above discussion clarifies that when benefits are a function of lagged wages, faster wage growth has a differential impact on *PVBenefits* and *PVTaxes*. This becomes clear by comparing equations (5) and (5a).

The obvious next question concerns the impact of faster wage growth (*g*) on the actuarial balance when the worker-to-beneficiary ratio is declining -- that is, the sign of the derivative *dAB/dG* when *b>0.*

Appendix B shows that the expression for *dAB/dG* for the case of *b>0* can be written as

$$\frac{dAB}{dG} = -\omega(1+G^{-1})G^{-1}\Omega\left[Z - \frac{G^{-1}}{1+G^{-1}}\right], \tag{7}$$

where Ω is the summarized cost rate as defined in equation (5) above and *Z* equals the net increase in Ω arising from a change in *G*. (As discussed earlier, an increase in *G* would lead to a larger increase in the numerator of the second term of equation (5) compared to the increase in the denominator because each B^{-t} term in the numerator exceeds 1.) The term *Z* in equation (7) [which is defined in equation A6 in Appendix A] equals the net increase in the numerator of the second term in equation (5) compared to the denominator due to an increase in *G*. The term *Z* is a function of *b, Z(b),* with the properties: (i) that Z≥0 when *b*≥0, with equality holding when *b*=0; and (ii) that Z increases monotonically with *b*. Thus, Z in equation (7) captures the impact of the worker-to-retiree ratio on the change in the actuarial balance due to a change in the growth rate (*dAB/dG*).

What is equation 7 telling us? It is simply a combination of Propositions 4 and 5. Proposition 4 revealed that with retirees forming a larger fraction of the population over time, faster wage growth increases Social Security's cost rate and *worsens* the system's actuarial balance. Proposition 5 shows that under dependence of benefits on lagged wages, faster wage growth *improves* the system's actuarial balance. Equation 7 shows that the change in the actuarial balance is determined by the balance of these opposing forces. Appendix B shows that setting *b*=Z=0 in Equation (7) yields the result of Proposition 5, namely that

$$\frac{dAB}{dG} = \frac{1}{2} G^{-2} \Omega > 0 \,. \qquad (8)$$

Equation (7) also clarifies that setting *b>0* (which implies Z>0) could change the sign of *dAB/dG* from positive to negative—by flipping the sign of the term in the square brackets. That is, a sufficiently rapid decline in the worker-to-beneficiary ratio could result in Proposition 4's effect dominating that of Proposition 5. That would cause the system's actuarial balance to become smaller (more negative) in response to a change in the wage growth rate (*g*), contrary to the popular belief that higher wage growth improves Social Security's finances.

Case D: Benefits Dependent on Wages in Several Earlier Periods

In practice, current Social Security benefit outlays are not just a function of wages one period ago, but of wages often as many as 40 periods prior. That's because although the Social Security benefits of those retiring today are wage indexed – that is, depend on current wages – the benefits of older cohorts alive today were based on wages from several periods ago (that prevailed in their periods of retirement) and now grow only with prices rather than wages. For example, Social Security benefits of older retirees (say, those aged 92 who retired when they were age 62) are determined by the wage level of 30 periods ago whereas those of younger retirees (say, those aged 67 today who retired when they were age 62) depend on the wage level from just 5 years ago. Appendix C shows that if past wages entering the actuarial balance formula are equally weighted, the actuarial balance can be expressed as

$$AB = -\frac{1}{N+1}\gamma(G)G^{-1}\Omega\left[Z + \frac{(N+1)G^{-(N+1)}}{1-G^{-(N+1)}} - \frac{G^{-1}}{1-G^{-1}}\right] \tag{9}$$

where $\gamma(G)$ summarizes the dependence of benefits on past wages. Again, as Appendix C shows, the basic conclusions of Proposition 5 above would be preserved. That is, whether $dAB/dG \lesseqgtr 0$ depends on the balance of two opposing forces. For values of *g* and *b* where the two forces are exactly balanced, $dAB/dG=0$. For other combinations of *g* and *b*, $dAB/dG\neq 0$, meaning it would be either negative or positive. This yields

Proposition 6: *When current benefits are an equally weighted function of wages in the current period and N earlier periods, for each given value of* $g=g^*$, *there exists a value of* $b^*=b(g^*)$ *where* $dAB/dG=0$, *with* $dAB/dG>0$ *when* $b<b(g^*)$ *and* $dAB/dG<0$ *when* $b>b(g^*)$.[18]

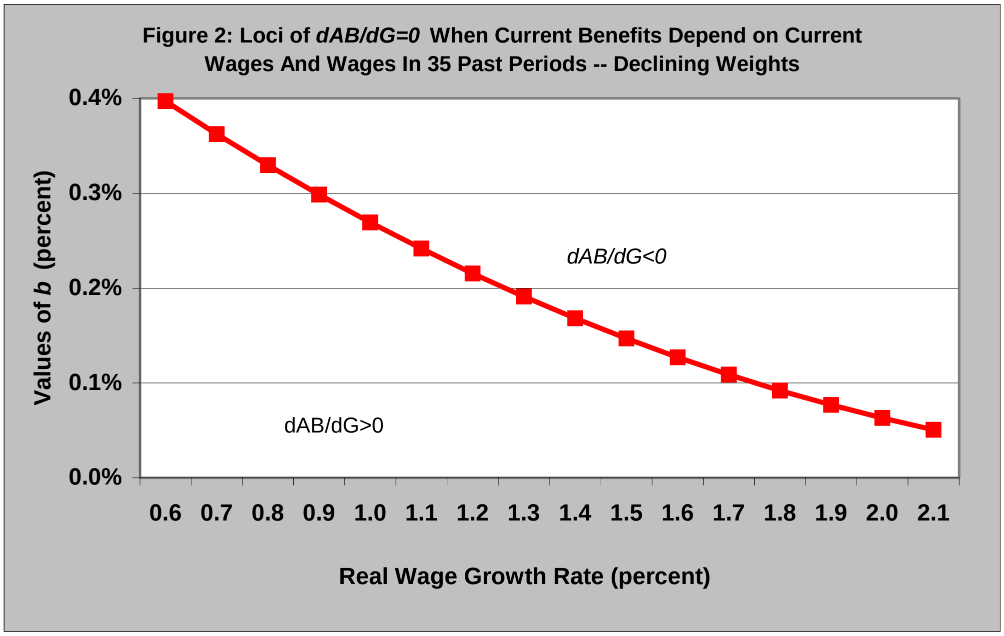
It is obvious that equally weighting past wages in the actuarial balance formula is inappropriate because mortality reduces the sizes of older cohorts whose benefits are determined by wages further back in the past. Hence, actuarial balance should be calculated using declining weights calibrated to the age distribution of cohort sizes over time. Applying smaller rather than equal weights to wage levels further back in the past implies that the force of Proposition 5

[18] To keep the development of these propositions simple, we use equal weighting of current and past wages in the derivations shown in the Appendix C. However, sub-section E below shows the results obtained from assuming declining population weights for wage terms earlier in the past.

(whereby actuarial balance improves in response to faster wage growth) diminishes relative to that of Proposition 4 in determining the change in actuarial balances with respect to a change in real wage growth. Because a larger share of total benefits would be paid to relatively younger retirees, faster wage growth would result in larger benefit outlays more quickly. Consequently, the combinations of g and b values at which $dAB/dG = 0$ would be different compared to the case of equal weighting.

Figure 2 shows locus (that is, combinations of the wage growth rate g, and the rate of decline in the worker-to-beneficiary ratio, $b(g)$) for which $dAB/dG = 0$. The calculations assume: τ (payroll tax rate)=12.4%; w_0 (initial real wage)=1; N_t=N_0 (population of workers at time t)=1; r (interest rate)=3%; ρ (benefit replacement rate)=35%; β_0 (initial worker-beneficiary ratio)=3.33; and N (the number of past wage periods that enter into the benefit formula)=35. In Figure 2, the locus is calculated under the assumption of declining weights for wages further back in the past. The weights are calculated based on population shares of those aged 65 and older that would arise under age-specific conditional mortality rates for those aged 65 and older.[19]

[19] Mortality rates provided by the Social Security Administration are used in calculating the weights.



The derivative of actuarial balance with respect to *G*, *dAB/dG*, is negative for combinations of *b* and *g* that lie in the north east direction relative to the locus. That is, higher wage growth would reduce actuarial balance under these circumstances. For wage growth rates approximating current rates in the United States – about 1 percent per year – values of $b^*=b(g^*)$ are very small – about 0.2 percent -- making it quite likely that $dAB/dG<0$ when *b* values are calibrated to U.S. demographics.

Case E: Calibration To U.S. Demographic Projections

Figure 3 shows projected values of the worker-beneficiary ratio for the United States.[20] It shows that the ratio is expected to decline sharply during the next three decades followed by a much more gradual decline after the baby-boom generation transitions into retirement and passes away.

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[20] All demographic projections are taken from the Social Security Administration. See http://www.ssa.gov/OACT/TR/TR05/lrIndex.html (noted as of January 6, 2005).

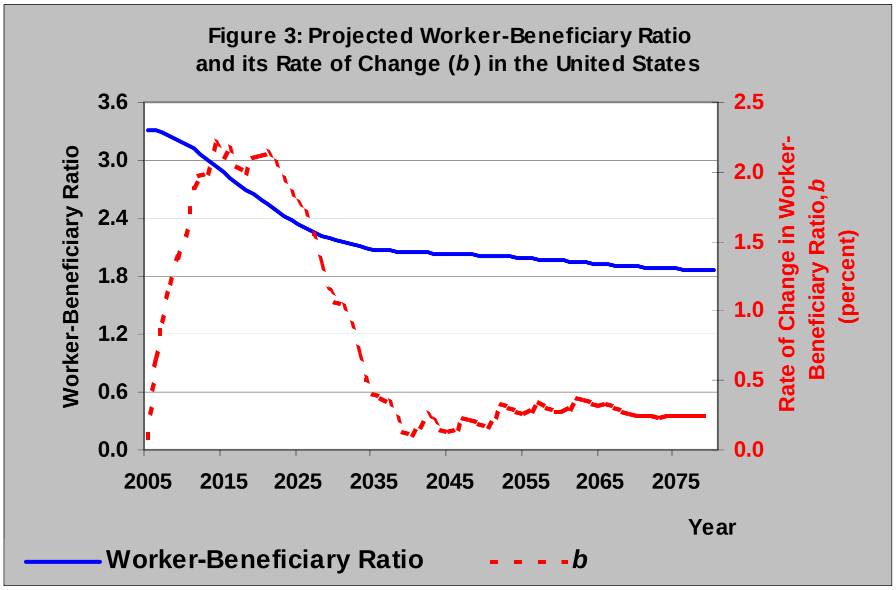
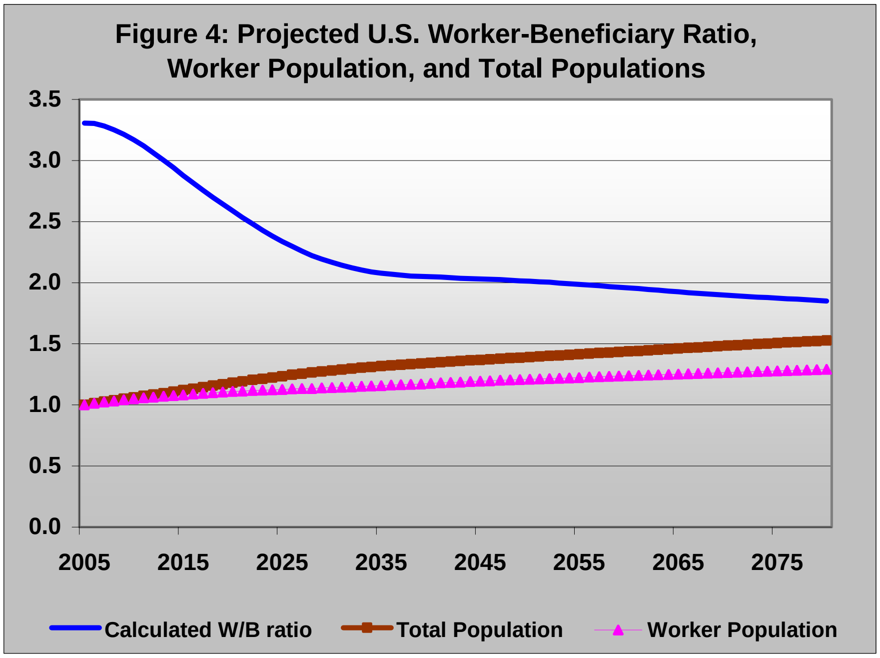


Figure 3 also shows the corresponding projected time-varying rate of decline (b) in the worker-to-beneficiary ratio. The values of b are generally quite large compared to the values in Figure 2 at which $dAB / dG = 0$ when real wage growth equals 1 percent.

Note that while the worker-to-beneficiary ratio is projected to decline, this decline would take place alongside a *growing* projected population in the United States. Figure 4 shows the Social Security Administration's projection of the population of workers and that of workers plus retirees, both normalized to their population sizes in 2005. That Figure indicates that a projected decline in the worker-to-beneficiary ratio does not involve a stagnant worker population as assumed earlier. Rather, both populations are projected to grow in absolute size in the United States. A declining worker-to-beneficiary ratio means just that the fraction of the total (and growing) population that would be in the workforce is expected to decline over the next 75 years.



Incorporating U.S. demographic projections into the actuarial balance calculations (and assuming that the rate of decline in the worker-to-beneficiary ratio is constant at its terminal value beyond the year 2080) yields values for dAB/dG of 0.29 when g=1.1 percent and −1.75 when g=1.6 percent. The values of AB at those two values of g are −3.2 percent and −4.1 percent respectively.[21] That is, although the immediate marginal contribution of faster growth is positive at g=1.1 percent, it rapidly becomes negative as values of g are increased to cumulatively yield a smaller (more negative) actuarial balance when g=1.6 percent.

[21] This stylized model of Social Security financing excludes many details of the actual Social Security program, including the income taxation of benefits, scheduled increases in the normal retirement age, survivor and disability benefits and actuarial reductions for early retirement. Its actuarial balance estimate should not, therefore, be expected to closely approximate the official estimate of the Social Security's Board of Trustees based on much more detailed calculations. We regard the estimate of a 3.2 percent actuarial deficit under intermediate growth and interest rate assumptions as quite reasonable in comparison with the official estimate of 3.5 percent.

As Table 1 shows, restricting actuarial balance calculations to just 75 years would suggest the opposite conclusion: A larger value of real wage growth (g) produces an (algebraically) larger actuarial balance and positive values of dAB/dG. For example, using the baseline discount rate of 3 percent and real wage growth rate of 1.1 percent, the 75-year horizon yields an actuarial balance of just −1.5 percent, a much smaller deficit than the −3.2 percent obtained under the calculation in perpetuity. In addition, increasing the growth rate to 1.6 percent per year, the 75-year actuarial balance becomes algebraically larger (less negative)—1.1 percent.

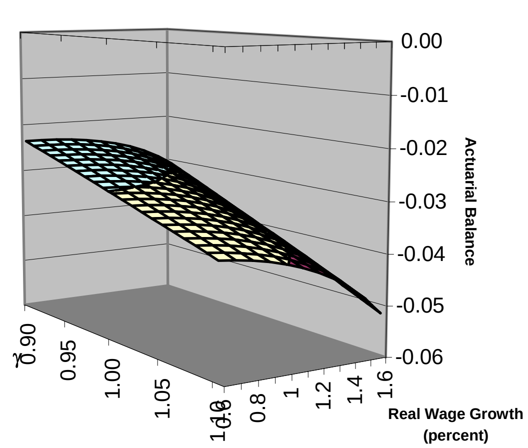
Table 1: Actuarial Balance and Change in Response to Change in Productivity Growth and Discount Rates

Discount Rate (%)	Projection Horizon	Real Wage Growth Rate (%)	Actuarial Balance, *AB*(%)	*dAB/dG*	Local Elasticity, $\lvert\varepsilon\rvert$
2.7	∞	1.1	-4.0	-0.582	0.023
2.7	∞	1.6	-5.9	-5.657	0.327
2.7	75	1.1	-1.6	1.783	0.028
2.7	75	1.6	1.2	1.669	0.021
3.0	∞	1.1	-3.2	0.292	0.009
3.0	∞	1.6	-4.1	-1.748	0.070
3.0	75	1.1	-1.5	1.761	0.026
3.0	75	1.6	-1.1	1.645	0.018
3.3	∞	1.1	-2.7	0.749	0.020
3.3	∞	1.6	-3.1	-0.314	0.010
3.3	75	1.1	-1.3	1.742	0.023
3.3	75	1.6	-1.0	1.624	0.016

Table 1 also shows that under perpetuity calculations, the (negative) response of actuarial balance to increases in wage growth rates is very large when present values are calculated with smaller discount rates. This is as expected because smaller discount rates increase the weight on dollar flows in the distant future relative to weights on dollar flows in the immediate future, making future benefit obligations larger in present value relative to earlier payroll tax-payments.

Next, we investigate the impact on actuarial balance of a slightly faster or slower decline in the U.S. worker-beneficiary ratio when the calculation horizon is infinite. Figure 5 shows the actuarial balance for different values of a parameter, γ (gamma), applied to the time-varying values of *b* shown in Figure 3. For example, γ=0.9 would imply a slower decline in the worker-to-beneficiary ratio over time whereas γ=1.1 would imply a faster rate of decline in that ratio. Figure 5 shows the values of *AB* for values of γ ranging from 0.9 to 1.1 and values of wage growth (*g*) between 1.1 percent and 2.1 percent (that is, values of G ranging from 1.011 to 1.021). Figure 5 shows that at all levels of wage growth, actuarial balance is smaller (more negative) when the worker-to-beneficiary ratio is assumed to decline faster (γ>1). Moreover, Figure 5 shows that for each rate of decline in the worker-beneficiary ratio, there is a rate of productivity/wage growth at which the actuarial balance is maximized. At γ=1, the rate of real wage growth that maximizes actuarial balance is much smaller, only around 0.5 percent—closer to that under the Social Security Trustees' "high-cost" assumptions. Under calculations in perpetuity, increasing real wage growth would, according to the figure, reduce Social Security's actuarial balance given projected demographic changes in the United States.[22]

Figure 5: Actuarial Balance for Alternative Rates of Decline in the Worker-Beneficiary Ratio and Real Wage Growth



[22] Again, we remind readers that measurement of Social Security's finances is conducted under a "static" framework (see footnote 13).

3. Wage Growth, Social Security Cash Flows, and Present Value Calculations

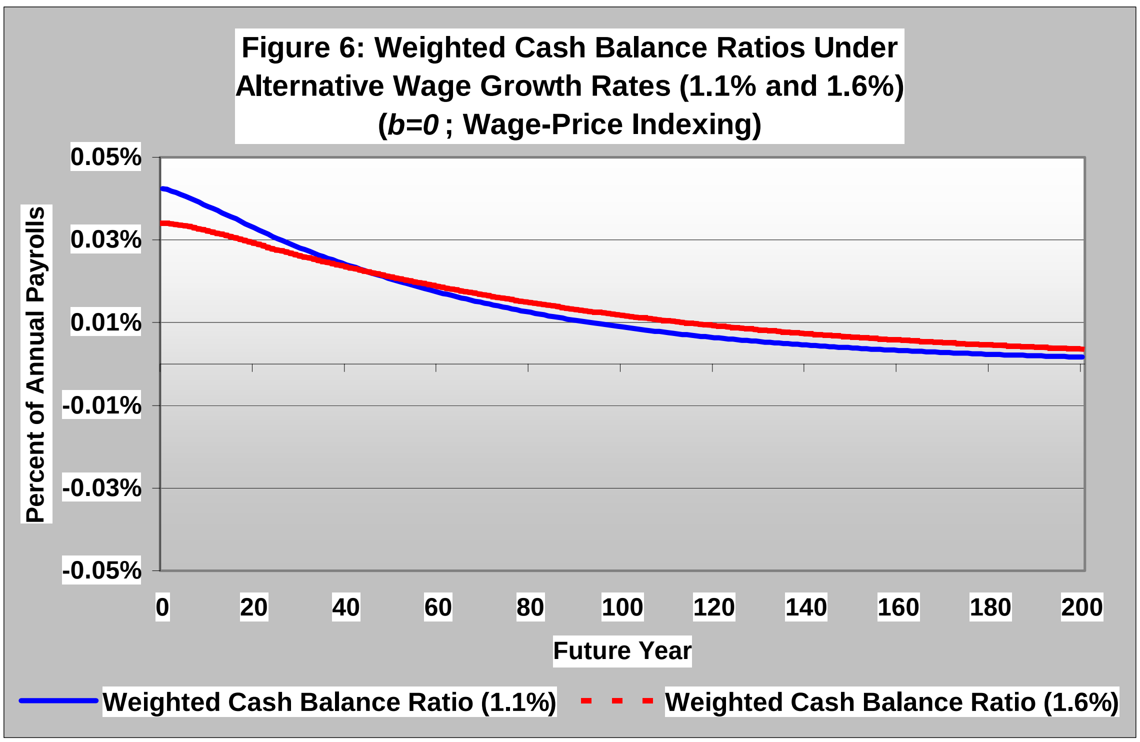
The previous sections results show that under stylized calculations calibrated to features of the U.S. Social Security system, faster growth could worsen the infinite horizon actuarial balance. This result can be explained in a different way by examining the impact of faster growth on Social Security's cash balances over time. Appendix D shows that with benefits partially dependent on wages from several past periods, the actuarial balance can be expressed as:

$$AB = \sum_{t=0}^{\infty} \frac{Cash\ Balance_t}{Payrolls_t} \frac{PVPayrolls_t}{\sum_{t=0}^{\infty} PVPayroll_t} = \sum_{t=0}^{\infty} \frac{\left[\tau G^t - \rho \beta_0^{-1} \omega \gamma(G) B^{-t} G^t\right]}{G^t} \frac{G^t R^{-t}}{\sum_{t=0}^{\infty} G^t R^{-t}}, \qquad (10)$$

where $\omega\ \gamma(G)$ captures the impact of past wages levels on current benefits, $G=1+g$, and $B=1-b$ as before (see section 2).

Equation (10) shows that wage growth affects the component terms in different ways. First (as Appendix D clarifies), it changes annual balances in every future year. The calculations shown below indicate that under reasonable parameter choices, annual cash balances improve with wage growth – indicating that the dependence of benefits on past wages (the effect of Proposition 5 in Section 2 above) generally dominates in annual cash balance calculations. Second, however, faster wage growth alters the present-value weights applicable to the annual balances in different future years. Note, that the present value weights depend on the net discount factor, $G^t R^{-t}$, representing the difference between the rate of real wage growth and the real interest rate. A larger value of G implies a smaller net discount rate. Hence, faster wage growth reduces the weighting of annual balances in the near future and increases that on balances in the distant future. The net impact of these two effects determines the change in the actuarial balance.

The crucial question is: What happens to these two effects of faster growth under alternative rates of decline in the worker-to-beneficiary ratio? Consider Figure 6, which shows prospective weighted annual cash-flow balance ratios when *b=0*, indicating a stable population age structure, under two alternative values of real wage growth (*g*) of 1.1 percent and 1.6 percent. The sum of these annual ratios represents the actuarial balance over the period. Increasing *g* from 1.1 percent to 1.6 percent increases (un-weighted) cash balances throughout the future.



That shift in the growth rate, however, reduces the weights, $G^t R^{-t} / \sum_{t=0}^{\infty} G^t R^{-t}$ on cash balance ratios in the near future but increases those on cash balance ratios in the distant future. (Appendix D provides a detailed explanation of why this occurs.) As a result, despite the increase in early-years' cash balance ratios, early-years' weighted cash balance ratios actually become smaller. Figure 6 shows that, under the parameters of the calculation, the reduction in cash balance ratios due to faster growth does not persist beyond the first 44 years. In years 45 and later, weighted cash balance ratios are larger with g=1.6 percent compared to those when g=1.1. Those larger future weighted cash balance ratios improve the system's infinite-horizon actuarial balance—that is, the cumulative sum of weighted cash balance ratios throughout the future.

Figure 7, repeats Figure 6 but for *b*>0, indicating a declining worker-retiree ratio. Values of *b* are, again, calibrated to those of the U.S. economy as shown in Figure 3. Shifting from the stable demographics of Figure 6 to U.S. demographics has a large first order impact on the actuarial balance (as noted in Proposition 3 earlier).

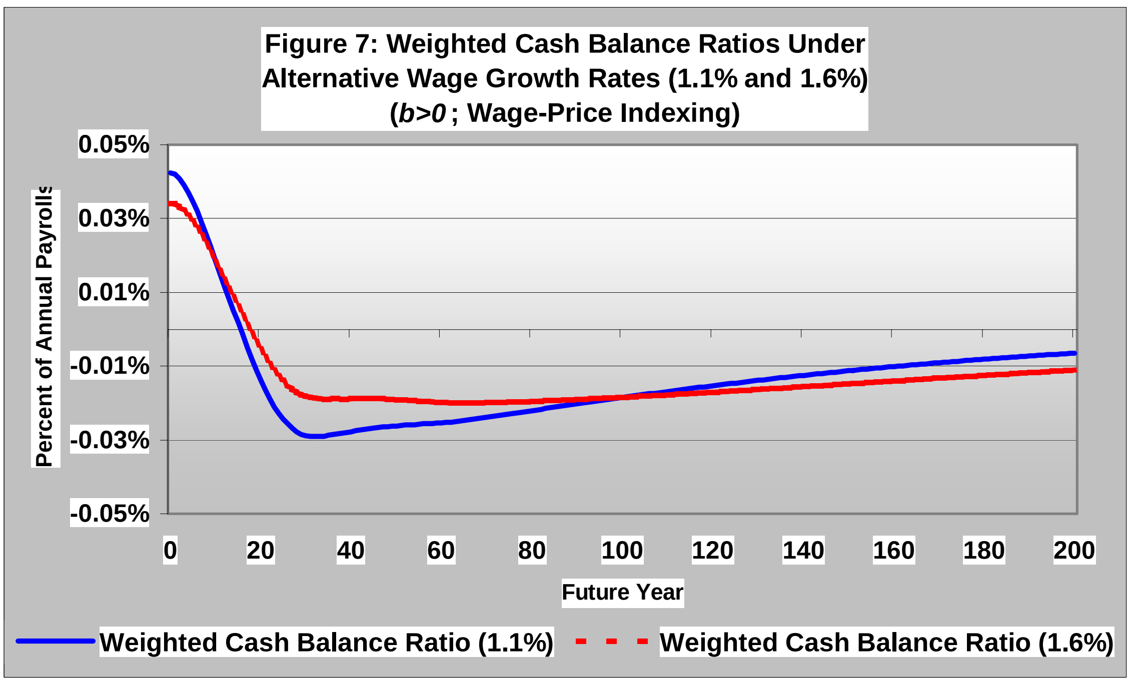


Figure 7: Weighted Cash Balance Ratios Under Alternative Wage Growth Rates (1.1% and 1.6%) (*b>0* ; Wage-Price Indexing)

With *b*>0, annual balance ratios move from initial surpluses to rapidly increasing future deficits and the transition to deficits occurs quite rapidly – when the demographic transition is especially quick as reflected by the high values of *b* during the next few decades (see Figure 3). However, as is clear from Proposition 4 and equation 10, the declining worker-to-beneficiary ratio (as captured by the parameter *B*) acts as a drag on the improvement in annual cash balance ratios arising from faster wage growth. This is evident from Figure 7 in which weighted annual cash-balance ratios when *g*=1.6 percent become larger than those under *g*=1.1 percent during the early years, but do not remain larger forever as under Figure 6. Rather, a second crossover occurs at year-95, after which weighted cash-balance ratios are smaller (more negative) when *g*=1.6 percent than when *g*=1.1 percent.

It should be noted that the change in the weights attached to different years' cash balances is *identical* in both cases (Figure 6 with *b*=0 and Figure 7 with *b*>0). The difference in the results stems from the different time profiles of cash-balance ratio improvements triggered by the shift to faster wage growth—where annual improvements are not as large when *b*>0 as under *b*=0. The smaller improvement in cash balance ratios under faster wage growth leads to the decline in the infinite-horizon actuarial balance: from −3.2 when *g*=1.1 percent to −4.1 when *g*=1.6 percent (see the case with a 3 percent discount rate and infinite horizon calculation shown in Table 1).

Thus, a declining worker-beneficiary ratio imposes a "demographic drag" that limits the improvement in annual cash balance ratios and worsens the overall actuarial balance when calculated in perpetuity. It is easy to see that the actuarial balance would not decline if it were calculated under a 75-year time horizon. That's because, the larger weighted deficits beyond the terminal year would be excluded from the calculation.

4. Model Consistency in Evaluating the Sensitivity of Actuarial Balance

In this section, we consider the issue of "model consistency" when exploring the response of actuarial balance to faster wage growth. The standard criticisms levied against the sensitivity analysis presented in the Social Security trustees' annual reports is that exploring the implications of changing a single factor while holding other inputs constant is inappropriate and the analysis cries out for a general equilibrium framework. For example, faster real wage growth that, perhaps, results from better economic policies, would be accompanied by a different constellation of economic (and, perhaps, demographic) outcomes. Replicating the static approach to analyzing Social Security's finances used by most government scoring agencies, could be subject to the same criticism: Faster wage growth could be accompanied, for example, by higher interest rates as technological shocks increases both labor and capital productivity.

There are two responses to these criticisms. First, a general equilibrium framework requires explicit specification of the policies that would be used to close the government's intertemporal budget constraint. The Trustees' analysis of Social Security finances imposes no such budget constraint. When the objective is to measure an existing budget gap, general equilibrium modeling is naturally precluded: Social Security is presumed to continue paying scheduled benefits even though revenues are inadequate.

Second, impending demographic change in the United States is likely to increase future capital intensity (a declining pool of workers relative to the pool of retirees owning sizable wealth) would tend to dampen interest rate increases arising from technological changes that improve capital and labor productivity. On the other hand, economic agents may demand higher returns on savings in an environment of higher growth but also greater economic volatility. The standard approach to estimating the government's interest rate under uncertainty suggests equating it to the rate of time preference (say, 1 percent per year) plus the product of two items: the inverse of the degree of risk aversion and the standard deviation of productivity growth. However, there is no consensus in the economic growth literature on the size of the appropriate risk aversion parameter.

Here, we simply calculate the range of interest rates that support an inverse relationship between wage growth and Social Security's actuarial balance. For example, calculations using the stylized model under Case E above show that increasing real wage growth rates from 0.6 percent per year to 1.6 percent per year the actuarial balance declines from −3.0 percent to −4.1 percent. However, simultaneously increasing the government's interest rate from 2.6 percent to 3.2 percent would leave the actuarial balance unchanged at −3.0 percent.[23]

In addition to interest rate uncertainties, the results obtained showing worsening infinite-term actuarial balance in response to higher wage growth depend crucially on assuming that the decline in the worker-to-beneficiary ratio continues indefinitely after the 75th year. Of course, assuming continuing declines in the worker-retiree ratio for the entire future implies that Social Security benefits would be financed by workers comprising an ever smaller fraction of the population.[24] Although gradually increasing longevity and a gradual but continuing decline in fertility is not inconceivable for a number of decades beyond the next 75 years, the assumption of declining worker-retiree ratios in perpetuity is difficult to defend.

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[23] Under the steady state relationship $r=\rho+(x/\theta)$, where the rate of time preference (ρ) is assumed to equal 1 percent, productivity growth rate alternatives (x) ranging between 0.6 percent and 1.6 percent per year and interest rate alternatives (r) ranging between 2.6 and 3.2 percent per year are consistent with intertemporal elasticities of substitution (θ) between 0.27 and 1.0. These values of θ span the range of values estimated in the economics literature. However, note that this relationship characterizes a steady state whereas the U.S. economy is undergoing a sizable transition.

[24] We remind readers that a declining share of the worker population in the total population is consistent with both populations growing over time.

To explore this issue, we calculate the infinite term actuarial balance under alternative assumptions regarding the period beyond 75 years for which the worker-to-retiree ratio would continue to decline. In other words, we assume $b_t=b_{75}$ for $75 \leq t \leq S$ and $b_t=0$ for $t>S$ for alternative values of S (see Table 2). The calculations show that the infinite-term actuarial balance under wage growth of 1.6 percent per year is smaller (implying that the actuarial deficit is larger) than that under wage growth of 1.1 percent per year when the assumption of $b_t=b_{75}$ is dropped after just another 20 years beyond the next 75 years (S>95). Thus, although the negative impact of higher wage growth on the infinite-term actuarial balance requires the assumption of a continued decline in the worker-to-beneficiary ratio, it does not appear necessary to maintain that assumption for more than a few years beyond the conventional horizon of 75 years.

5. Simulations Under A Detailed Model of Social Security--SSASIM

Table 2: Infinite Term Actuarial Balance Under Alternative Horizons for Continued Decline in the Worker-to-Beneficiary Ratio

S	Infinite Term Actuarial Balance Under Alternative Wage Growth Rate Assumptions	
	1.1 percent	1.6 percent
85	-2.51	-2.47
95	-2.61	-2.61
105	-2.70	-2.74

Source: 2005 Social Security Trustees Report, Table VI.D.4

These simple demonstrations of the impact of wage growth on Social Security's actuarial balance capture the essence of the current Social Security program – wherein current benefits are based on past wages – but do not capture the full details of Social Security financing.

In this section we utilize the SSASIM (Social Security and Accounts Simulator) model developed and maintained by the Policy Simulation Group. This model was developed during the 1994-1996 Advisory Council on Social Security under contract with a number of organizations, including the Social Security Administration, and has been regularly updated since then.[25] The SSASIM model has two modes of calculating system financing: a cell-based actuarial mode designed to replicate the results from the Social Security Administration's actuaries and a fully microsimulation-based mode similar to that utilized by the Congressional Budget Office. The results reported below were produced using SSASIM's cell-based mode, though simulations using the microsimulation-based mode produce qualitatively similar results. It should be noted, however, that results from the SSASIM model do not constitute official findings from the Social Security Administration's actuaries and official estimates may differ.

A. SSASIM Performance Relative to SSA Estimates

The Social Security Trustees report results from sensitivity analyses conducted on a number of demographic and economic factors. These factors are shifted by a pre-set amount from their mid-point projections to examine how increasing or reducing their values affects system financing over 75 years. Table 3 reports the Trustees' findings on the sensitivity of the actuarial balance with respect to wage growth: Increasing the ultimate rate of real wage growth from 1.1 percent to 1.6 percent increases the 75-year actuarial balance by 0.53 percent of payroll. As expected, system solvency

Table 3: Social Security Trustees Sensitivity Analysis of Real Wage Growth on 75-year Actuarial Balance

	Assumed ultimate rate of real wage growth	
Percent of taxable payroll	1.1 percent	1.6 percent
Summarized income rate	13.87	13.74
Summarized cost rate	15.79	15.13
Actuarial balance	-1.92	-1.39

Source: 2005 Social Security Trustees Report, Table VI.D.4

[25] For details, see Holmer (2005); www.polsim.com

is improved through a decline in the summarized cost rate (the ratio of the present value of benefit outlays plus administrative expenses to the present value of taxable payrolls).[26]

Although the SSASIM model does not use real wage growth as a direct input, changes to assumed rates of productivity growth increase wage growth and impact system financing. The SSASIM baseline productivity growth assumption of 1.6 percent is consistent with that assumed by Social Security's Trustees and the model produces a 75-year actuarial deficit of 1.92 percent of taxable payroll, also consistent with the Trustees' projections. In the SSASIM model, increasing the assumed rate of annual productivity growth from 1.6 to 2.1 percent (which corresponds to an increase in the real wage growth rate from 1.1 percent to 1.6 percent), produces very similar results. The 75-year actuarial deficit is reduced from 1.92 to 1.42 percent of taxable payroll—an improvement of 0.50 percentage points which is quite close to the 0.53 percentage point improvement reported by the Trustees.

Since 2003, the annual Social Security Trustees Report has published estimates of system financing in perpetuity. The 2005 Report estimated the program's actuarial deficit in perpetuity as 3.5 percent of taxable wages, meaning that an immediate and permanent payroll tax increase of 3.5 percentage points would be sufficient to maintain program sustainability under the Trustees' intermediate economic and demographic assumptions.[27] However, the Report does not conduct sensitivity analysis for changes in economic or demographic factors measured over an infinite horizon, as it does for solvency measured over the traditional 75-year horizon.

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[26] This improvement emerges despite a *decline* in the summarized income rate (defined as the value of the trust fund plus the present value of tax revenues expressed as a percentage of the present value of taxable payrolls). The decline in the summarized income rate occurs primarily because the initial value of the trust fund, while unchanged in dollar terms, falls relative to the larger present value of taxable payrolls under the high growth scenario. Another minor reason for the decline in the summarized income rate is that part of the program's revenue is derived from income taxes levied on benefit payments. Because benefits increase with a lag, so do those income tax revenues.

[27] Board of Trustees, Section IV.B.5.

When the system's solvency is measured in perpetuity, the SSASIM model produces a revenue shortfall equal to 3.53 percent of the present value of payrolls – very close to the (rounded) 3.5 percent projected by the Trustees.[28]

B. SSASIM's Perpetuity Estimate of Sensitivity of Actuarial Balance to Productivity Growth

The SSASIM model projects that increasing the rate of productivity growth from 1.6 percent to 2.1 percent would *increase* Social Security's actuarial deficit from 3.5 percent to 3.7 percent of taxable payroll (that is, reduce it's actuarial balance as defined in equation (5) in Section 2 from –3.5 percent to –3.7 percent). The reason for this is two-fold: economic growth increases costs by *more* than it increases payrolls, and increases income *less* than the increase in payrolls.

Table 4: Impact of Productivity Growth on Infinite Term Income, Cost and Payrolls

	Productivity growth		
$ trillions present value (percent of payroll)	1.6 percent	2.1 percent	Percent change
Income	$44.52 (13.72%)	$60.30 (13.59%)	35.44%
Cost	$55.97 (17.25%)	$76.80 (17.29%)	37.21%
Payroll	$324.49	$444.00	36.83%

Source: Authors' calculations based on SSASIM model.

SSASIM model calculations show that the summarized cost rate increases from 17.25 percent of payroll in the base case to 17.29 percent of payroll in the high-growth scenario (see Table 4). SSASIM results indicate that the program's income rate declines from 13.72 to 13.59 percent of

[28] Note that the infinite horizon simulation in SSASIM was conducted using slightly different mortality assumptions than the 75-year forecast. The baseline 75-year projection in SSASIM assumes annual mortality reductions of 0.83 percent, versus 0.71 percent assumed by the Trustees, due to differences in how the SSASIM model incorporates changes to mortality. For the infinite horizon simulations, mortality reduction was returned to the 0.71 percent ultimate rate assumed by the Trustees. However, using consistent mortality assumptions between the 75-year and infinite horizon simulations does not change the outcome of altering the productivity assumption.

payroll in response to faster wage growth.[29] The net impact of these two changes is a decline in the system's actuarial balance from −3.53 to −3.70 percent. Note that the actuarial balance would have declined even if we had ignored the change in the income rate traceable to the reduced ratio of the existing trust fund relative to the increase in the present value of payrolls arising from faster productivity growth.

The reason for the worsening of the actuarial balance can be traced to the opposing effects identified in Proposition 6 of section 2: A direct actuarial-balance-increasing effect of the lagged dependence of benefits on wages versus the opposite effect due to a decline in the worker-beneficiary ratio. The SSASIM model's estimate of a worsening actuarial balance under faster productivity growth suggests that the latter effect dominates the former under an assessment of Social Security's finances in perpetuity.

Figure 8 is similar to Figure 7 above, but utilizes SSASIM (rather than stylized model) results to illustrate the annual cash balances entering the actuarial balance calculation of equation (10).[30] Recall that in equation (10), the actuarial balance is expressed as the weighted average of annual balance ratios, with weighting determined by the ratio of each year's discounted payroll to the present value of all payrolls over the measurement period.

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[29] As outlined earlier, much of this is because of the decline in the fixed initial value of the trust fund relative to the larger tax base. SSASIM uses an initial trust fund balance of $1.553 trillion (differing slightly from the $1.501 value in the 2005 Trustees Report). This amount is equal to 0.48 percent of payroll under the baseline scenario, but only 0.35 percent of payroll when productivity growth is increased from 1.6 percent to 2.1 percent.

[30] The actual profiles of annual cash balance ratios are different in Figure 7 compared to Figure 6 because the SSASIM model incorporates tax, benefit, and demographic features relevant for the Social Security program in much greater detail than the stylized model of Section 2.

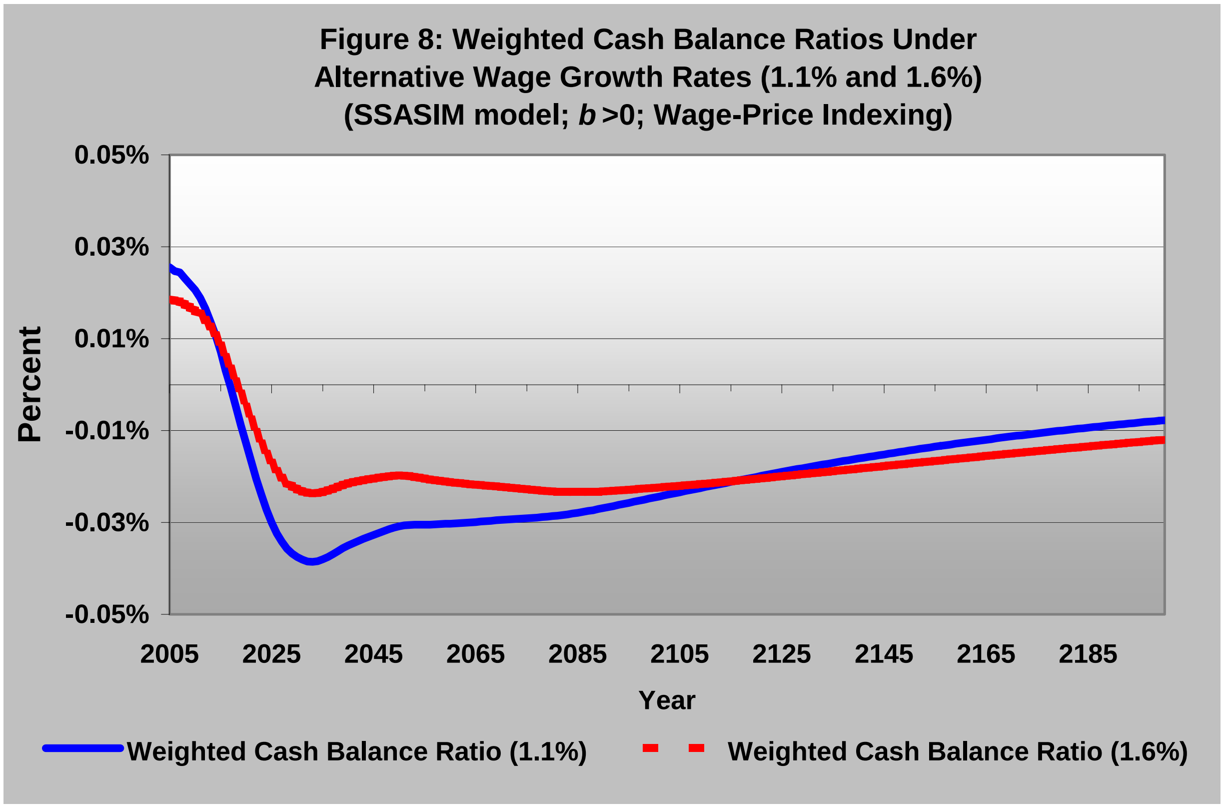

Figure 8 illustrates that for roughly the next 115 years, the cash flow effect would dominate the weighting effect -- that is, payroll-weighted annual deficits would be smaller under a 1.6 percent wage growth rate than under a 1.1 percent rate. After that period, however, annual improvements in annual cash balance ratios with g=1.6 percent are insufficient and weighted cash balances become more negative than under g=1.1 percent. Hence, the infinite-horizon actuarial balance is smaller under the faster wage growth assumption. Figure 8 also clarifies the seemingly contradictory result that faster wage growth improves actuarial balance over 75 years but reduces it in perpetuity. The smaller weighted deficits that emerge under faster wage growth during the short term in included in the limited-horizon calculation but the larger future weighted deficits that emerge under faster wage growth are excluded.

6. Discussion and Conclusion

This paper shows that faster wage growth could exert a significant impact on Social Security's measured actuarial balance on an annual basis, over truncated scoring periods, and under perpetuity measures of the program's sustainability. Measured over 75 years, increases in real wage growth can be expected to improve the Social Security's actuarial balance on a roughly one-for-one basis: An increase in real wage growth from 1.1 to 1.6 percent annually could be expected to reduce program's cash deficit in the 75^{th} year by roughly 22 percent, a significant reduction in system costs.[31] However, stylized calculations calibrated to U.S. demographics and calculations using a detailed model of the program's operations suggest that faster economic growth would negatively impact aggregate system financing as measured by the infinite-horizon actuarial balance.

These counterintuitive findings raise questions of interpretation. As noted above, increased wage growth improves (un-weighted) annual balance ratios in every subsequent year. This leads to a ready policy interpretation: Were solvency achieved by increasing payroll taxes every year to match rising cost rates, a faster wage growth would require smaller increases in payroll tax rates in all future periods. While increased wage growth would push a greater share of individuals' earnings to later in life, where they would be subject to higher tax rates, their lifetime tax rates would still decline when wage growth increases.[32] This produces the seemingly contradictory result that outcomes for individuals improve while the program's actuarial balance declines.

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[31] The Social Security Administration's Office of the Chief Actuary uses the reduction in the cash deficit in the final year of the 75-year period as a proxy measure for a reform proposal's improvement to the program's cash flows. See, for instance, Chaplain and Wade (2005).

[32] Defined as the present value of total taxes as a percentage of the present value of total earnings

In interpreting these results, it is important to recall that actuarial balance is a measure of *system* financing, not of the treatment of individuals participating in the system. Individual treatment is commonly analyzed through internal rates of returns, money's worth ratios, the net present values of taxes and benefits, and other measures.[33] Increased wage growth could have different effects on individuals based upon the measure applied. Although the projected actuarial deficit is commonly interpreted in policy terms, and from this policy interpretation inferences are made regarding the treatment of individuals, actuarial balance is simply a measure of the program's total net income relative to total payrolls over a given period of time.

These results show that with higher wage growth, a larger share of total future payrolls must be devoted to the program to pay scheduled benefits. This occurs because wage growth increases future payrolls and, in combination with projected demographic changes in the United States, also increases the system's future costs. In particular, a larger share of total payrolls will occur during future periods in which costs are higher.

This effect can be seen in equation (10) above and in the illustrative figures. The weights calculated in the second term of (10) denote the share of payrolls (in present value terms) that would bear a particular annual tax rate increase under a pay-as-you-go approach to achieving solvency. Hence, the seemingly contradictory result that the actuarial balance worsens (becomes more negative) but annual cash balance ratios improve (become less negative) in each future year can be explained as follows.

Note that Table 1's infinite-horizon actuarial deficit under wage growth of 1.1 percent and discount rate of 3.0 percent equaled 3.2 percent. Also note that the time series of annual (unweighted) cash deficit ratios increases over time when the calculations are calibrated to

[33] See, for instance, Nichols, et al (2006).

projected U.S. demographic change. Increasing wage growth to 1.6 percent reduces the (un-weighted) annual cash deficits in each future year—although, again, the times series of annual deficit ratios – that is, the annual pay-as-you-go tax rate increases require for maintaining solvency – increases over time. However, faster wage growth (1.6 percent) also increases the share of payrolls (in present value) on which the pay-as-you-go tax rate increase must be more than 3.2 percent (and reduces the share of payrolls on with the pay-as-you-go tax rate hike must be less than 3.2 percent). That implies the average unit of payroll (in present discounted value) must bear a tax rate larger than 3.2 percent – the average under 1.1 percent wage growth. This reconciles the apparent contradiction mentioned earlier.

Some may be tempted to conclude that because the actuarial deficits increase whereas the annual balance ratios decline with faster wage growth, the former may be an inferior measure of Social Security's finances because it does not reflect the reduction in costs to individual participants under a pay-as-you-go approach to solvency.   However, one must also consider that although the annual pay-as-you-go tax rate increases applied to all future individuals would be smaller under faster wage growth, the share (and absolute dollar amount) of total payrolls that would be subject to a higher tax rate hike (compared to the average rate hike under the slower growth scenario) would be larger. Although not explicitly calculated (or calculable), the application of larger than average tax rate hikes on a larger amount of total payrolls under a pay-as-you-go approach may generate greater economic distortions. Indeed, if it is at all feasible to pre-fund the larger benefit entitlements that a faster wage growth would confer on future generations, tax-smoothing arguments would suggest that achieving solvency by imposing a uniform (although higher) tax rate increase on all future cohorts would become even more important under a faster assumed wage growth.[34] However, it should be re-emphasized that although the actuarial balance is considered to be a measure of system financing as a whole, how different cohorts would fare under faster wage growth would depend on the type of measure used and the type of reform implemented to achieve solvency.

This paper provides new information regarding how economic growth affects the Social Security program's finances, and raises questions on how different measures capture those effects. Faster economic growth is obviously desirable because it would help improve citizens' living standards and provide additional resources with which to address growing entitlement costs. However, given Social Security's tax and benefit structure, faster real wage growth would not necessarily improve, and may worsen, Social Security's finances as measured by the traditional actuarial balance calculated in perpetuity.

[34] It can be argued that a gradually rising tax rate would smooth generational burdens more effectively, because tax smoothing would imply higher internal rates of return for future cohorts, who would live and thus collect benefits longer than current cohorts. However, these results would likely hold under a gradually rising tax rate. Such a policy would be distributionally equivalent to applying a constant tax rate increase while indexing future benefits for changes in longevity; under this latter policy there is no reason to believe that the effects outlined above would not hold.

Appendix A

Proof of Proposition 4

Equation (5) in the text is:

$$AB = \tau - \frac{\rho\beta_0^{-1}\sum_{t=0}^{\infty} B^{-t}G^{t}R^{-t}}{\sum_{t=0}^{\infty} G^{t}R^{-t}} = \tau - \frac{N}{D} = \tau - \Omega\,, \tag{A5}$$

where *R=(1+r)*; *G=(1+g); B=(1–b);* and it is assumed that the numerator is well defined—that is *G/BR<1*.

Note: $D = \sum_{t=0}^{\infty} G^{t}R^{-t}$;

$$dD = \sum_{t=0}^{\infty} tG^{t-1}R^{-t}dG = G^{-1}\sum_{t=0}^{\infty} tG^{t}R^{-t}dG\,;$$

$$N = \rho\beta_0^{-1}\sum_{t=0}^{\infty} B^{-t}G^{t}R^{-t} \quad ;$$

and

$$dN = \rho\beta_0^{-1}\sum_{t=0}^{\infty} tB^{-t}G^{t-1}R^{-t}dG = G^{-1}\rho\beta_0^{-1}\sum_{t=0}^{\infty} tB^{-t}G^{t}R^{-t}dG\,.$$

Thus,

$$\frac{dAB}{dG} = -\frac{d\Omega}{dG} = -\frac{DdN - NdD}{D^2} = -\Omega\left[\frac{dN}{N} - \frac{dD}{D}\right]$$

$$= -\Omega\left[\frac{\left[G^{-1}\rho\beta_0^{-1}\sum_{t=0}^{\infty} tB^{-t}G^{t}R^{-t}\right]}{\rho\beta_0^{-1}\sum_{t=0}^{\infty} B^{-t}G^{t}R^{-t}} - \frac{\left[G^{-1}\sum_{t=0}^{\infty} tG^{t}R^{-t}\right]}{\left[\sum_{t=0}^{\infty} G^{t}R^{-t}\right]}\right]$$

$$= -G^{-1}\Omega\left[\frac{\left[\sum_{t=0}^{\infty} tB^{-t}G^{t}R^{-t}\right]}{\sum_{t=0}^{\infty} B^{-t}G^{t}R^{-t}} - \frac{\left[\sum_{t=0}^{\infty} tG^{t}R^{-t}\right]}{\left[\sum_{t=0}^{\infty} G^{t}R^{-t}\right]}\right] = -G^{-1}\Omega Z\,. \tag{A6}$$

We know that $G^{-1}>0$ and $\Omega>0$ (cost is positive). In equation (A6), Z>0 when $b>0$ (see the Proof A below). That yields the result $[dAB/dG]<0$ when $b>0$.

Proof A:

To prove: Z $= \left[\frac{\left[\sum_{t=0}^{\infty} tB^{-t}G^{t}R^{-t}\right]}{\sum_{t=0}^{\infty} B^{-t}G^{t}R^{-t}} - \frac{\left[\sum_{t=0}^{\infty} tG^{t}R^{-t}\right]}{\left[\sum_{t=0}^{\infty} G^{t}R^{-t}\right]}\right] \geq 0$ when $b\geq 0$ (with equality holding if $b=0$). That is,

$$\left[\sum_{t=0}^{\infty} tB^{-t}G^{t}R^{-t}\right]\left[\sum_{t=0}^{\infty} G^{t}R^{-t}\right] \geq \left[\sum_{t=0}^{\infty} tG^{t}R^{-t}\right]\left[\sum_{t=0}^{\infty} B^{-t}G^{t}R^{-t}\right] \tag{A7}$$

Writing $G^{t}R^{-t}=x_t$, equation (A7) can be expressed as

$$\left[\sum_{t=0}^{\infty} tB^{-t}x_t^2\right] + \sum_{i=0}^{\infty} iB^{-i}x_i\sum_{j=0}^{\infty} x_j\Bigg|_{i\neq j} \geq \left[\sum_{t=0}^{\infty} tB^{-t}x_t^2\right] + \sum_{i=0}^{\infty} ix_i\sum_{j=0}^{\infty} B^{-j}x_j\Bigg|_{i\neq j}\,.$$

Eliminating the first terms on each side of the inequality, we get

$$\sum_{i=0}^{\infty} iB^{-i}x_i \sum_{j=0}^{\infty} x_j \Big|_{i\neq j} \geq \sum_{i=0}^{\infty} ix_i \sum_{j=0}^{\infty} B^{-j}x_j \Big|_{i\neq j}.$$

In the proof, we assume the opposite (that is, replace ≥ with <) and show that doing so leads to a contradiction:

Assume $\sum_{i=0}^{\infty} iB^{-i}x_i \sum_{j=0}^{\infty} x_j \Big|_{i\neq j} < \sum_{i=0}^{\infty} ix_i \sum_{j=0}^{\infty} B^{-j}x_j \Big|_{i\neq j}$. (A8)

Select any pair of terms in equation (A8) where, $i=n$ and $j=m$, in the first, and $i=m$ and $j=n$ in the second. Without loss of generality, assume $m<n$.

For this pair, the left hand side of (A8) equals $nB^{-n}x_n x_m + mB^{-m}x_m x_n$, and the right hand side equals $nx_n B^{-m}x_m + mx_m B^{-n}x_n$

Expression (A8) implies checking if $nB^{-n}x_n x_m + mB^{-m}x_m x_n < nx_n B^{-m}x_m + mx_m B^{-n}x_n$ for each such pair of terms.

That is, whether $nB^{-n} + mB^{-m} < nB^{-m} + mB^{-n}$;

Multiplying all terms by B^m, check whether $nB^{-(n-m)} + m < n + mB^{-(n-m)}$;

or $B^{-(n-m)}(n-m) < n-m$.

However, given that $B^{-1} \geq 1$ when $b \geq 0$, this inequality cannot be true since $m<n$ by assumption. Because the contradiction applies to all pairs of terms *i, j* [*(n,m)* and *(m,n)* with $m<n$], it applies to equation (A8) in its entirety. Hence, $Z \geq 0$ when $b \geq 0$ (with equality holding when $b=0$).

Moreover, Z is a monotonically increasing function of *b*. This follows from the fact that $B^{-1}=[1/(1-b]$ is a monotonically increasing function of *b*.

Appendix B

Proof of Proposition 6

Suppose current benefits are determined by wages in two periods -- the current period and 1 period ago. Assume that each period's wages receive the same weight, ω=0.5, in the benefit formula. Equation (A5) would be modified to:

$$AB = \tau - \frac{\rho\beta_0^{-1}\omega(G^0 + G^{-1})\sum_{t=0}^{\infty} B^{-t}G^t R^{-t}}{\sum_{t=0}^{\infty} G^t R^{-t}} = \tau - \omega(1+G^{-1})\Omega = \tau - \omega\left[\frac{1-G^{-2}}{1-G^{-1}}\right]\Omega, \qquad \text{(A9)}$$

where ω=0.5, *G=(1+g),* and *B=(1–b)*. Thus,

$$\frac{dAB}{dG} = -\omega\left[\left[\frac{1-G^{-2}}{1-G^{-1}}\right]\frac{d\Omega}{dG} + \Omega\left[\frac{1-G^{-2}}{1-G^{-1}}\right]\left[\frac{2G^{-3}}{1-G^{-2}} - \frac{G^{-2}}{1-G^{-1}}\right]\right] \qquad \text{(A10)}$$

Using the result from equation (A6) that $\frac{d\Omega}{dG} = G^{-1}\Omega Z$ and simple algebraic manipulations yields

$$\frac{dAB}{dG} = -\omega(1+G^{-1})G^{-1}\Omega\left[Z - \frac{G^{-1}}{1+G^{-1}}\right], \qquad \text{(A11)}$$

where Z is as defined in Proof A above. Note that when *Z=1* when *b=0*. Hence,

$$\lim_{b \to 0} \frac{dAB}{dG} = \omega G^{-2}\Omega > 0\,. \qquad \text{(A12)}$$

When current benefits are a function of current wages and wages one period ago, there exists some value, b^* of *b*, such that $[dAB/dG]\big|_{b=b^*} = 0$. For $b>b^*$, faster wage growth causes the actuarial balance to decline.

Appendix C

We generalize the case of Appendix B by assuming that the current benefit level is based on the current wage and wages in *N* past periods. We also assume that each period's wage receives an equal weight ω=*1/(N+1)*. Then, the expression for AB becomes

$$AB = \tau - \frac{\rho\beta_0^{-1}\omega\left(\sum_{i=0}^{N} G^{-i}\right)\sum_{t=0}^{\infty} B^{-t}G^{t}R^{-t}}{\sum_{t=0}^{\infty} G^{t}R^{-t}} = \tau - \omega\left(\sum_{i=0}^{N} G^{-i}\right)\Omega = \tau - \omega\gamma(G)\Omega\,, \qquad \text{(A13)}$$

where $\gamma(G) = \left[\frac{1-G^{-(N+1)}}{1-G^{-1}}\right]$.

Then,

$$\frac{dAB}{dG} = -\omega\Omega[\gamma(G)G^{-1}Z + \gamma'(G)]$$

$$= -\omega\gamma(G)G^{-1}\Omega\left[Z + \frac{(N+1)G^{-(N+1)}}{1-G^{-(N+1)}} - \frac{G^{-1}}{1-G^{-1}}\right] \qquad \text{(A14)}$$

Equation (A14) (which is identical to equation (A11) when N=1) shows that a result similar to that of Appendix B holds: When current benefits are a function of current and wages in N earlier periods, some value $b=b^{**}$ exists for which $[dAB/dG]\big|_{b=b^{**}} = 0$. For $b>b^{**}$, higher growth causes the actuarial balance to decline.

Appendix D

Equation (A13) of Appendix C

$$AB = \tau - \frac{\rho\beta_0^{-1}\omega\left(\sum_{i=0}^{N} G^{-i}\right)\sum_{t=0}^{\infty} B^{-t}G^{t}R^{-t}}{\sum_{t=0}^{\infty} G^{t}R^{-t}} \tag{A13}$$

can also be expressed as

$$= \frac{\tau\sum_{t=0}^{\infty} G^{t}R^{-t}}{\sum_{t=0}^{\infty} G^{t}R^{-t}} - \frac{\rho\beta_0^{-1}\omega\left(\sum_{i=0}^{N} G^{-i}\right)\sum_{t=0}^{\infty} B^{-t}G^{t}R^{-t}}{\sum_{t=0}^{\infty} G^{t}R^{-t}}.$$

Letting $\gamma(G)=\left(\sum_{i=0}^{N} G^{-i}\right)$, simple manipulation allows the actuarial balance to be expressed as

$$AB = \sum_{t=0}^{\infty} \frac{\left[\tau G^{t} - \rho\beta_0^{-1}\omega\gamma(G)B^{-t}G^{t}\right]}{G^{t}} \frac{G^{t}R^{-t}}{\sum_{t=0}^{\infty} G^{t}R^{-t}}. \tag{A15}$$

Equation (A15) (which corresponds to equation (10) in the text) shows that the actuarial balance is a weighted sum of the ratio of annual net cash flows $(\tau G^{t} - \rho\beta_0^{-1}\omega\gamma(G)B^{-t}G^{t})$ to annual payrolls G^{t} (the "annual cash balance ratio"), where the weight equals $G^{t}R^{-t}/\sum_{t=0}^{\infty} G^{t}R^{-t}$.

In annual-cash-balance-ratio term, the dependence of benefits on lagged wages is captured in the term $\gamma(G)$ and ω=1/(N+1), with N being number of past years' wages that factor into the benefit determination (Note: *N* depends on the age of the oldest cohort alive relative to the age of retirement).

One feature of equation (A15) is that faster growth implies a smaller value of $\gamma(G)$ – and, therefore, smaller annual cost and cash balance rates. Call this the annual balance effect. A second feature of equation (A15) is that faster wage growth also implies larger weights on annual balances accruing in the more distant future. Note that the denominator in $G^t R^{-t} / \sum_{t=0}^{\infty} G^t R^{-t}$ also grows larger, but because it's an average over all future years, it grows at a slower rate than the numerator $G^t R^{-t}$ when t is large. Call this the weighting effect.

Hence, if the out years are deficit years, (a) those deficits will be smaller because of the annual balance effect but (b) will become more important in the present value calculation because of the weighting effect. The net effect on the actuarial balance could be negative.

As Proposition 6 in the text shows, whether actuarial balance is reduced with faster wage growth depends on the rate at which the worker-beneficiary ratio declines over time.

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