A Tradeoff between the Output and Net Foreign Asset Effects of Pension Reform

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Abstract

We use an overlapping generations model of a small open economy with perfect capital mobility to evaluate the long-term effects of pension reforms on output and net foreign assets. We compare reforms that achieve similar fiscal targets and show the existence of a trade-off. Reforms that increase the retirement age have an expansionary effect on output, but a negative effect on the net foreign asset position. In contrast, reforms that cut pension benefits improve the net foreign asset position but have no output effect. Only mixed reforms that increase the retirement age *and* cut pension benefits sufficiently can boost both output and net foreign assets.

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I. INTRODUCTION

The debate over pension reform has been traditionally framed by concerns over the long-term financial viability of pay-as-you-go pension systems and fiscal sustainability more broadly (Lindbeck and Persson, 2003). Reforms that increase the retirement age or reduce pension benefits are conducive to more resilient fiscal positions. Their effects on countries' output and external positions, however, are less evident.

Since the early 2000s, the rise of persistent global current account imbalances prompted concerns about the sustainability of external positions in many economies (Obstfeld, 2012). The decline in net foreign asset positions (increase in net external indebtedness) could become unsustainable, requiring potentially abrupt and costly adjustments.[1] Since the global financial crisis, current account imbalances have narrowed significantly but have not reversed. Thus, net foreign asset positions continue to diverge and remain a major concern (IMF, 2014).

In this paper, we address the following question: what are the effects of different pension reforms on output and the net foreign asset position of a country? We use an overlapping generations model of a small open economy with perfect capital mobility to compare the long-term effects of reforms that achieve similar fiscal targets. We show the existence of a trade-off. Reforms that increase the retirement age have an expansionary effect on output, but a negative effect on the net foreign asset position. In contrast, reforms that cut pension benefits improve the net foreign asset position but have no output effect. Only mixed pension reforms that increase the retirement age *and* cut pension benefits sufficiently can boost both output and net foreign assets.

II. THE MODEL

The open economy is populated by overlapping generations of finitely-lived households, an infinitely-lived government, and atomistic firms. Households and the government can borrow

[1] Historical episodes of current account reversals often involve sharp domestic currency depreciations, output losses, and disruptions in financial markets and institutions (Edwards, 2005; and Obstfeld and Rogoff 2005).

funds from (or invest funds in) international capital markets at a prevailing interest rate. Time is continuous and the economy is in a stationary state characterized by no population or productivity growth.

A. Households

Households consume and accumulate assets during their lifetime, work during their youth, and retire when old. The utility of a household is given by $U = \int_0^L u[c(s)] \cdot e^{-\beta s} \cdot ds$, where L is life length, $c(s)$ denotes consumption at age s, and β is the subjective discount rate.[2] The household's flow budget constraint is given by $\dot{a}(s) = r \cdot a(s) + H(s) - c(s),$ where $a(s)$ denotes the assets held by the household at age s, a dot indicates derivative with respect to time, and r is the interest rate. $H(s)$ stands for household's income, which is given by:

$$H(s) = \begin{cases} w - \tau & \text{for} \quad 0 \le s \le R \\ b & \text{for} \quad R < s \le L \end{cases},$$

where the household supplies one unit of labor time instantaneously and inelastically during its work life, R is the retirement age ($0 < R < L$), w is the wage rate per unit of labor, τ is a payroll tax, and b is the pension benefit. In what follows we abstract away from labor market efficiency effects associated with pension reforms and focus only on saving effects.[3]

Assumption 1. *The net of tax wage earning is greater than the pension benefit:* $w - \tau > b$.

The household's intertemporal budget is obtained by integrating the flow constraint and assuming that the household is born with no assets and dies with no debt, i.e. $a(0) = a(L) = 0$

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[2] As the economy is stationary, we suppress the subscript that indicates a generation's birth time when denoting household-specific variables. The instantaneous utility function is assumed to be strictly increasing and concave, i.e. $u'(c) > 0,$ and $u''(c) < 0.$

[3] These two dimensions have been traditionally emphasized in the pension reform literature; see Lindbeck and Persson (2003) and the papers cited therein.

("no inheritance or bequest" conditions):[4]

$$\int_0^L c(s)\cdot e^{-rs}\cdot ds=\int_0^R (w-\tau)\cdot e^{-rs}\cdot ds+\int_R^L b\cdot e^{-rs}\cdot ds=\left(\frac{1}{r}\right)\cdot\left\{(w-\tau)\cdot\left(1-e^{-rR}\right)+b\cdot e^{-rR}\cdot\left(1-e^{-r(L-R)}\right)\right\};$$

it holds when the present value of consumption equals the present value of net wage and pension income.

The household maximizes its utility by choosing consumption and asset holdings subject to the intertemporal budget constraint. It takes as given the interest rate, the wage rate, the pension benefit, the retirement age, and the no inheritance or bequest conditions. The first order optimality conditions imply $u'[c(s)]=\lambda\cdot e^{(\beta-r)\cdot s}$. Assuming for simplicity that $\beta=r$, the household's optimal profile of consumption by age is constant and given by

$c=(w-\tau)\cdot\frac{\left(1-e^{-rR}\right)}{\left(1-e^{-rL}\right)}+b\cdot\left[1-\left(\frac{1-e^{-rR}}{1-e^{-rL}}\right)\right]$, whereby the household consumes its permanent income—a weighted average of the net wage income earned during the working life, and the pension income received during retirement (both in present value). Assumption 1 implies that the household saves during the working life and dissaves during retirement; hence, the household's optimal profile of asset holdings by age exhibits a tent shape.[5]

Population born at any time t is normalized to 1. Thus, the size of the total population is L, employment is R, and aggregate consumption is given by $C=L\cdot c$. The aggregate amount of household assets, evaluated at the optimal consumption level, is given by:

$$A^h=\int_0^R\left(\frac{w-\tau-c}{r}\right)\cdot\left(e^{rs}-1\right)\cdot ds+\int_R^L\left(\frac{c-b}{r}\right)\cdot\left[1-e^{-r(L-s)}\right]\cdot ds=\frac{(w-\tau-b)}{r}\cdot\left[L\cdot\left(\frac{1-e^{-rR}}{1-e^{-rL}}\right)-R\right].$$

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[4] The no-ponzi game condition prevents the household from dying indebted: $a(L)\geq 0$. In addition, utility maximization and the non-satiation property of the utility function (always increasing in consumption) imply that a household will never choose to die with strictly positive asset holdings: $a(L)\leq 0$. Hence, $a(L)=0$.

[5] The household's optimal profile of asset holdings by age is obtained by solving the first order differential equation $\dot{a}(s)=r\cdot a(s)+H(s)-c$ (where c is the optimal consumption) and imposing the initial and terminal conditions $a(0)=a(L)=0$. The solution is given by: $a(s)=\left(\frac{w-\tau-c}{r}\right)\cdot\left(e^{rs}-1\right)$ for $0\leq s\leq R$ and $a(s)=\left(\frac{c-b}{r}\right)\cdot\left(1-e^{-r(L-s)}\right)$ for $R<s\leq L$.

B. Firms

Perfectly competitive firms maximize profits using the Cobb-Douglas production function $Y = \left(K^f\right)^\alpha \cdot \left(N^f\right)^{1-\alpha}$. Firms' first order conditions for profit maximization with respect to labor (N^f) and capital (K^f) are given by $w = (1-\alpha)\cdot\left(\frac{K^f}{N^f}\right)^\alpha$ and $r = \alpha\cdot\left(\frac{N^f}{K^f}\right)^{1-\alpha}$.

C. Government

The government collects payroll taxes to finance pension benefits, and the budget is always balanced: $\int_0^R \tau \cdot ds = \tau \cdot R = \int_R^L b \cdot ds = b\cdot(L-R).$ Pension policies are defined by the choice of two of the three parameters τ, b, and R; the third one is endogenously determined to satisfy the budget constraint.

D. Equilibrium: Definition

For a constant international interest rate, a (stationary) equilibrium is defined as a set of allocations for households and firms, prices, and government variables, that simultaneously place all households and firms on their optimizing paths, ensure that the government budget constraint is satisfied, and clear all markets. The market clearing conditions determine the equilibrium employment (N), where $N = N^f = R$; the economy's stock of capital (K), where $K = K^f$; and the economy's net foreign assets (A^*), where $A^h = A^* + K$.[6]

E. Equilibrium Characterization

Plugging the equilibrium employment condition $N = R$ into the firms' first order conditions, aggregate capital and output can be expressed as linear functions of the retirement age:

[6] When the economy is in a stationary equilibrium, there is no accumulation of net foreign assets; hence, the current account balance is zero. The aggregate flow constraint is given by $\dot{A}^* = 0 = Y - C + r\cdot A^*$, where the first two terms in the right-hand side equal the trade balance, and the last term is the net factor income from abroad.

$K = \alpha \cdot R \cdot \left(\frac{\alpha}{r}\right)^{\frac{1}{1-\alpha}}$ and $Y = \alpha^{\alpha} \cdot R \cdot \left(\frac{\alpha}{r}\right)^{\frac{\alpha}{1-\alpha}}$; thus, the equilibrium wage rate is uniquely determined by the international interest rate: $w = \alpha^{\alpha} \cdot (1-\alpha) \cdot \left[\frac{\alpha}{r}\right]^{\frac{\alpha}{1-\alpha}}$. In addition, given the government's budget constraint $b = \frac{\tau \cdot R}{L-R}$, the pension benefit is an increasing and convex function of the retirement age (for a given tax τ).[7] Plugging the government budget constraint into the aggregate household assets function, the latter can be written as follows:

$$A^h(R,\tau) = \frac{1}{r} \cdot \left[w - \tau \cdot \left(\frac{L}{L-R}\right)\right] \cdot \left[L \cdot \left(\frac{1-e^{-rR}}{1-e^{-rL}}\right) - R\right].$$

Note that for a given tax τ, assumption 1 is satisfied if and only if the retirement age is sufficiently low: $R < L \cdot (1 - \frac{\tau}{w}) = \overline{R}$. Hence, we restrict our analysis to "feasible" values of R that are in the range $(0, \overline{R})$. Lemma 1 discusses the properties of the $A^h(R,\tau)$ function. (Proofs are shown in the Appendix.)

Lemma 1. *For a given tax τ, the aggregate household assets function $A^h(R,\tau)$ is: a) positive for all the interior feasible values of R, when $R \in (0, \overline{R})$; b) equal to 0 when R approaches its boundary feasible values: $\lim_{R \to 0} A^h = \lim_{R \to \overline{R}} A^h = 0$; and c) increasing and concave in R for all $R \in (0, R_m]$, and decreasing (either concave or convex) in R for all $R \in [R_m, \overline{R})$, where R_m denotes the value of R at which $A^h(R,\tau)$ achieves its maximum.*

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[7] As shown in Figure 1 (bottom quadrant), the pension benefit increases at an increasing rate as the retirement age increases. Intuitively, the collection of taxes grows linearly in R and the pension benefit would also grow linearly if the retired population remained constant. However, the retired population ($L-R$) declines as R increases; hence, the pension benefit per retiree can increase more than linearly without violating the government budget constraint.

For a given tax level τ_0, Figure 1 shows K, Y, $A^h(\tau_0)$, and b as functions of the retirement age. Point E_0 represents an initial stationary equilibrium for the economy, in which R_0 is the retirement age and b_0 is the pension benefit that satisfy the government budget constraint. In this equilibrium, the amount of household assets (A_0^h) is larger than the domestic capital stock (K_0); hence, the net foreign asset position of the economy is positive (A_0^*).

The amount of net foreign assets $A^*(\tau_0)$ as a function of the retirement age is represented by the vertical distance between the $A^h(\tau_0)$ curve and the K line. The function $A^*(\tau_0)$ is non-monotonic in the retirement age, increasing for $R \in (0, R_m^*)$ and decreasing for $R \in (R_m^*, \overline{R})$, where R_m^* is the value of R at which the slopes of the $A^h(R, \tau_0)$ curve and the K line are equal.

Denote by $A^h(R,b)$ the aggregate household assets as a function of the retirement age and the pension benefit.[8] For a given pension benefit, assumption 1 is satisfied for $R > \dfrac{b \cdot L}{w} = \underline{R}$.

Lemma 2 discusses the properties of the $A^h(R,b)$ function.

Lemma 2. *For a given pension benefit b, the aggregate household assets function $A^h(R,b)$ is convex in R, $\dfrac{\partial^2 A^h(R,b)}{\partial R^2} < 0$, and satisfies $\lim_{R \to L} \dfrac{\partial A^h(R,b)}{\partial R} < 0$. If R^* is the value of R such that $\dfrac{\partial A^h(R^*,b)}{\partial R} = \alpha \cdot \left(\dfrac{\alpha}{r}\right)^{\frac{1}{1-\alpha}}$, then $R^* > R_m^*$.*

Assumption 2. *At the initial equilibrium, the retirement age satisfies $R_0 > R^* > R_m^*$.*

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[8] Note that $A^h(R,b)$ and $A^h(R,\tau)$ are different functions, and only the latter is shown in Figure 1. For a precise relation between these functions, see the proof of lemma 2.

As the condition $A^{*}=A^{h}-K$ holds, lemma 2 and assumption 2 guarantee that, at the initial equilibrium, the net foreign asset functions $A^{*}(R_0,\tau)$ and $A^{*}(R_0,b)$ are both decreasing in the retirement age.

III. Effects of Pension Reforms

We compare two pension reforms that either increase the retirement age or cut pension benefits in order to achieve a similar reduction in the tax τ.[9]

A reform that increases the retirement age from R_0 to R_1, holding the pension benefit constant at b_0, results in a movement from point E_0 to point E_1 in Figure 1. To maintain the government's budget balance, the tax declines from τ_0 to τ_1, shifting the household sector assets curve from $A^{h}(\tau_0)$ to $A^{h}(\tau_1)$. (Lemma 2 and assumption 2 guarantee that $\frac{\partial A^{h}(R_0,b)}{\partial R}<\alpha\cdot\left(\frac{\alpha}{r}\right)^{\frac{1}{1-\alpha}}$, i.e. point E_1 is below point P, where the line connecting the points E_0 and P is parallel to the K line.) As the reform increases aggregate employment, it boosts the domestic capital stock from K_0 to K_1, and output from Y_0 to Y_1. The buildup in domestic capital is financed with external debt issuance—as perfect capital mobility equalizes the marginal productivity of capital and the international interest rate—and the stock of net foreign assets declines from A_0^{*} to A_1^{*}.

A reform that cuts pension benefits from b_0 to b_2, holding the retirement age constant at R_0, is shown as a movement from point E_0 to point E_2 in Figure 1. The tax declines from τ_0 to τ_2 (where $\tau_2=\tau_1<\tau_0$), shifting the household assets curve from $A^{h}(\tau_0)$ to $A^{h}(\tau_2)$. Aggregate capital and output remain unchanged, and the amount of household assets increases from A_0^{h} to A_2^{h}, inducing an increase in net foreign assets from A_0^{*} to A_2^{*}. These results are summarized in the following proposition.

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[9] Reforms achieve similar reductions in the tax paid by individual households at each time instant. However, the lifetime taxes paid by individual households, and the total tax collection by the government ($\tau\cdot R$) can vary across reforms, depending on whether or not the retirement age is changed.

Proposition 1. *Under assumptions 1 and 2, there is a tradeoff between the long-term output and net foreign asset effects of pension reforms that achieve similar fiscal targets: a) reforms that increase the retirement age have an expansionary effect on output, but a negative effect on net foreign assets; b) reforms that cut pension benefits improve the net foreign asset position but have no output effect.*

Figure 2 shows the tradeoff between the output and net foreign asset effects of pension reforms explicitly, where E_0, E_1, and E_2 indicate pre- and post-reform equilibria following the notation used in Figure 1.

Define mixed pension reforms as those that both increase the retirement age and cut pension benefits, and consider the subset of mixed reforms that achieve the fiscal target $\tau_2 = \tau_1$.

In Figure 1, point P represents the unique pension reform that achieves the fiscal target $\tau_2 = \tau_1$, increases output, and has no effect on net foreign assets. Implementation of this reform requires increasing the retirement age from R_0 to R_P and reducing the pension benefit from b_0 to b_P.

Corollary 1. *For a given fiscal target, only mixed pension reforms that increase the retirement age and cut pension benefits sufficiently (by an amount greater than $b_0 - b_P$) can boost both output and net foreign assets.*

All reforms corresponding to the segment of the $A^h(\tau_1 = \tau_2)$ curve between (but excluding) the points E_2 and P increase both output and net foreign assets. To achieve these results, the pension benefit cut must be greater than $b_0 - b_P$. In Figure 2, the output and net foreign asset effects of mixed pension reforms that achieve the fiscal target $\tau_2 = \tau_1$ are represented by the segment of the curve between (but excluding) the extreme points E_1 and E_2. Corollary 1 highlights the segment of the curve between the points E_2 and P, where output and net foreign assets are increased simultaneously.

Figure 1. Effects of Pension Reforms

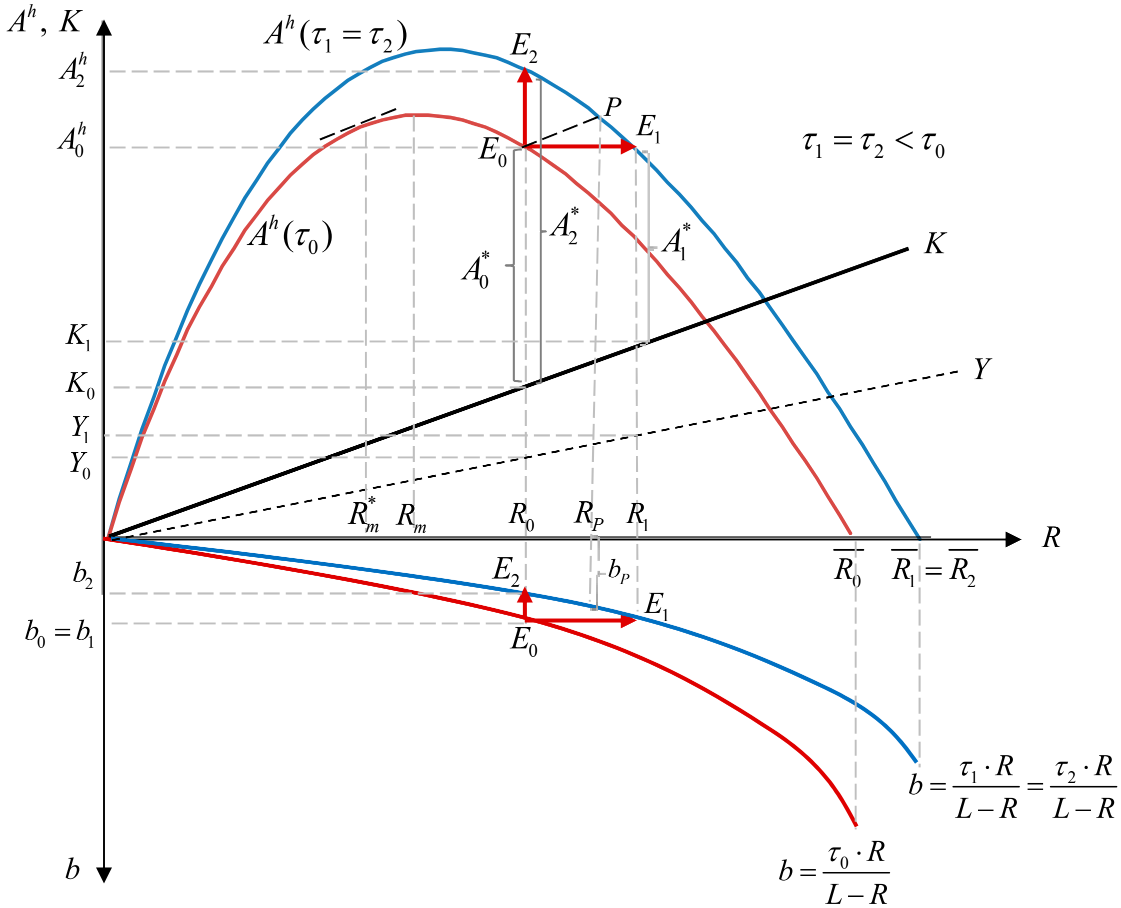
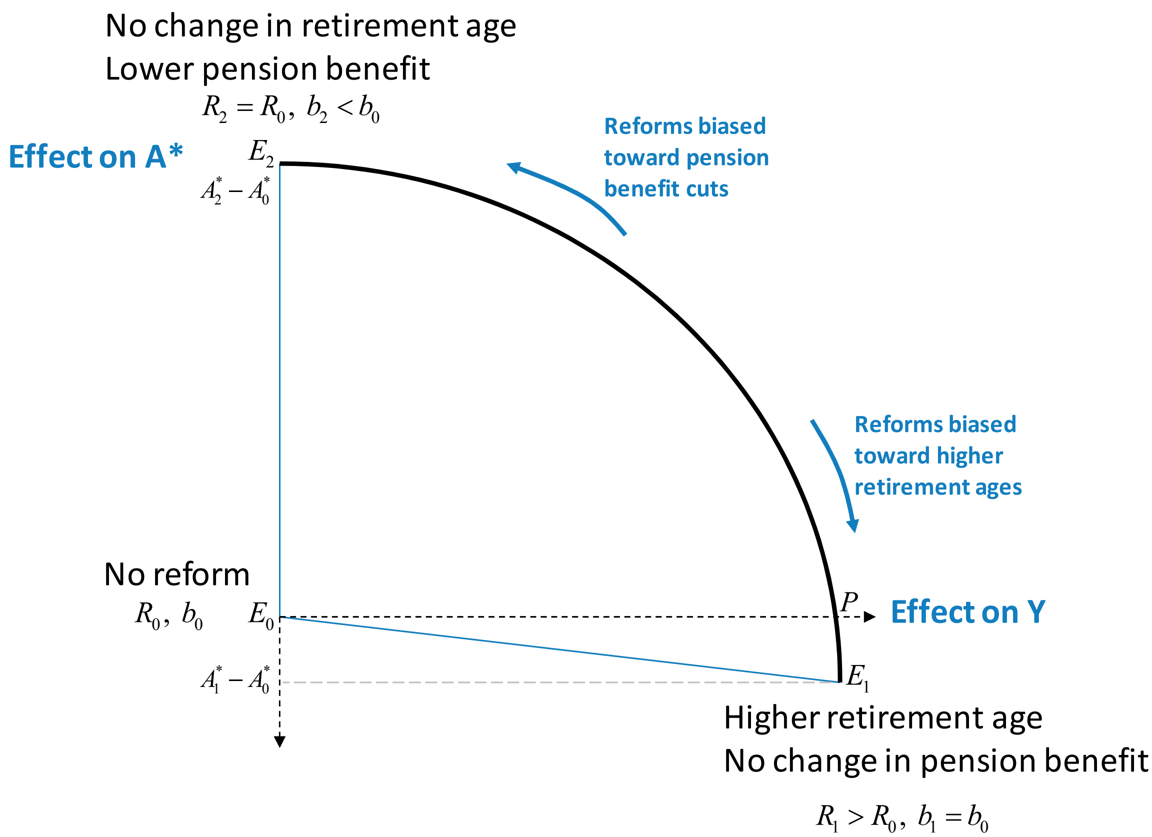


Figure 2. A Tradeoff between the Output and Net Foreign Asset Effects of Pension Reforms



APPENDIX. PROOFS

Proof of Lemma 1.

a) In the function $A^h(R,\tau)$, the first factor $w-\tau\cdot\left(\frac{L}{L-R}\right)>0$ for all $R\in(0,\overline{R})$; this follows directly from assumption 1 (which is satisfied if and only if $R<L\cdot(1-\frac{\tau}{w})$). The second factor $L\cdot\left(\frac{1-e^{-rR}}{1-e^{-rL}}\right)-R>0$ for all $R<\overline{R}<L$. Hence $A^h(R,\tau)>0$ for all $R\in(0,\overline{R})$.

b) The first derivative of $A^h(R,\tau)$ with respect to R is given by:

$$\frac{\partial A^h}{\partial R}=-\frac{\tau\cdot L}{r\cdot(L-R)^2}\cdot\left[\frac{L\cdot\left(1-e^{-rR}\right)}{\left(1-e^{-rL}\right)}-R\right]+\left(\frac{1}{r}\right)\cdot\left(w-\frac{\tau\cdot L}{L-R}\right)\cdot\left[\frac{r\cdot L\cdot e^{-rR}}{\left(1-e^{-rL}\right)}-1\right].$$ Since

$\lim_{R\to 0}\left(\frac{\partial A^h}{\partial R}\right)=\frac{(w-\tau)}{r}\cdot\left[\frac{r\cdot L}{1-e^{-rL}}-1\right]>0$ (note that $\frac{r\cdot x}{1-e^{-rx}}-1>0$ for $x>0$), the function A^h is increasing in R when R approaches 0. In addition,

$\lim_{R\to \overline{R}}\left(\frac{\partial A^h}{\partial R}\right)=-\frac{\tau\cdot L}{r\cdot\left(L-\overline{R}\right)^2}\cdot\left[\frac{L}{1-e^{-rL}}-\frac{\overline{R}}{1-e^{-r\overline{R}}}\right]\cdot\left(1-e^{-r\overline{R}}\right)<0$; thus, the function A^h is decreasing in R when R approaches $\overline{R}$. Note that in the expression for $\frac{\partial A^h}{\partial R}$, the first term in the right hand side is always negative, and the second term can be either positive or negative depending on the value of R (the function $\frac{r\cdot L\cdot e^{-rR}}{1-e^{-rL}}-1$ is decreasing in R and becomes negative for values sufficiently close to L).

c) The second derivative of $A^h(R,\tau)$ with respect to R is given by:

$$\frac{\partial^2 A^h}{(\partial R)^2}=-\frac{2\cdot\tau\cdot L}{r\cdot(L-R)^3}\cdot\left[\frac{L\cdot\left(1-e^{-rR}\right)}{\left(1-e^{-rL}\right)}-R\right]-\frac{2\cdot\tau\cdot L}{r\cdot(L-R)^2}\cdot\left[\frac{r\cdot L\cdot e^{-rR}}{\left(1-e^{-rL}\right)}-1\right]-\left(w-\frac{\tau\cdot L}{L-R}\right)\cdot\frac{r\cdot L\cdot e^{-rR}}{\left(1-e^{-rL}\right)}.$$

The first and third terms in the right hand side are non-positive; the second term is negative for all $R<R_m$, but it becomes positive as the value of R approaches L. Cases in which the

second term is positive and more than offsets the sum of the first and third terms (in absolute value) cannot be ruled out. For example, the function A^h becomes convex when R approaches $\overline{R}$, and $\overline{R}$ approaches L. In this case, $\lim_{R \to \overline{R}} \left(w - \frac{\tau \cdot L}{L - R} \right) = 0$; the first and third terms in the expression for $\frac{\partial^2 A^h}{(\partial R)^2}$ equal 0, and the second term is positive. Thus, $\frac{\partial^2 A^h}{(\partial R)^2} > 0$.

Proof of Lemma 2.

The function $A^h(b,R)$ and its first and second derivatives with respect to R are given by:

$$A^h(b,R) = \frac{1}{r} \cdot \left[w - b \cdot \frac{L}{R} \right] \cdot \left[L \cdot \left(\frac{1 - e^{-rR}}{1 - e^{-rL}} \right) - R \right];$$

$$\frac{\partial A^h(b,R)}{\partial R} = \frac{b \cdot L^2}{r \cdot R^2} \cdot \frac{\left[1 - e^{-rR} \cdot (1 + r \cdot R) \right]}{\left(1 - e^{-rL} \right)} + \frac{w}{r} \cdot \left[\frac{r \cdot L \cdot e^{-rR}}{1 - e^{-rL}} - 1 \right];$$

$$\frac{\partial^2 A^h(b,R)}{(\partial R)^2} = -\left(w - \frac{b \cdot L}{R} \right) \cdot \left(\frac{L \cdot r \cdot e^{-rR}}{1 - e^{-rL}} \right) - \frac{2 \cdot b \cdot L^2}{r \cdot R^3} \cdot \frac{\left[1 - e^{-rR} \cdot (1 + r \cdot R) \right]}{\left(1 - e^{-rL} \right)} < 0.$$

The first derivative could be positive or negative: the first term is always positive, but the second term becomes negative for R values that are sufficiently high. As the second derivative is always negative, the function is strictly convex.

The first derivative can also be expressed as follows:

$$\frac{\partial A^h(b,R)}{\partial R} = \left(\frac{1}{r} \right) \cdot \left(w - \frac{b \cdot L}{R} \right) \cdot \left[\frac{r \cdot L \cdot e^{-rR}}{1 - e^{-rL}} - 1 \right] + \frac{b \cdot L}{r \cdot R} \cdot \left[\frac{L \cdot \left(1 - e^{-rR} \right)}{R \cdot \left(1 - e^{-rL} \right)} - 1 \right].$$

In the limit, when R approaches L, $\lim_{R \to L} \left(w - \frac{b \cdot L}{R} \right) \cdot \left[\frac{r \cdot L \cdot e^{-rR}}{1 - e^{-rL}} - 1 \right] < 0$ and $\lim_{R \to L} \left[\frac{L \cdot \left(1 - e^{-rR} \right)}{R \cdot \left(1 - e^{-rL} \right)} - 1 \right] = 0$. Hence, $\lim_{R \to L} \frac{\partial A^h(b,R)}{\partial R} < 0$.

The following "envelope" condition can be used to establish a relation between the derivatives of the functions $A^h(R,b)$ and $A^h(R,\tau) = A^h[R, \tau(b,R)]$:

$$\frac{\partial A^h\left(R,b\right)}{\partial R}=\frac{\partial A^h\left(R,\tau\right)}{\partial \tau}\cdot\frac{\partial \tau(R,b)}{\partial R}+\frac{\partial A^h\left(R,\tau\right)}{\partial R};$$

$$\frac{\partial A^h\left(R,b\right)}{\partial R}-\frac{\partial A^h\left(R,\tau\right)}{\partial R}=\frac{b\cdot L^2}{r\cdot\left(L-R\right)}\cdot\left[\frac{L\cdot\left(1-e^{-rR}\right)}{R\cdot\left(1-e^{-rL}\right)}-1\right]>0.$$

At the point $R=R_m^*$, $\frac{\partial A^h\left(R_m^*,b\right)}{\partial R}>\frac{\partial A^h\left(R_m^*,\tau\right)}{\partial R}=\alpha\cdot\left(\frac{\alpha}{r}\right)^{\frac{1}{1-\alpha}}$ (slope of K line in Figure 1) .

The convexity of the function $A^h(R,b)$ implies that if R^* is the value of R such that

$\frac{\partial A^h(R^*,b)}{\partial R}=\alpha\cdot\left(\frac{\alpha}{r}\right)^{\frac{1}{1-\alpha}}$, then $R^*>R_m^*$.

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