Online Appendices (not intended for publication)
A Proofs

It is convenient to first present a lemma specifying how much taxes are lowered in the case of capturing assets and shifting contributions.

**Lemma 1.** If $\theta_{t-1} = 2$ and $\theta_t = 1$, i.e., asset capture and shifting of contributions occurs (denoted by superscript $AC$), lump-sum taxes $\Upsilon_t$ in period $t$ are lowered by

$$\Delta \Upsilon^A_t = \tau F w_t \left( \frac{3 + r + 2g}{3(1 + g)} - \frac{r - g}{3(1 + r)} \right) > 0. \text{ (A.1)}$$

*Proof.* According to (7) and (8), for $\theta_{t-1} = 2$ and $\theta_t = 1$, $f_{1,t}^F = 0$ and $f_{2,t}^F = (1 + r)\tau F w_{t-1}$. From equation (4), the government balance adjusts by:

$$-\sum_j \Delta \Upsilon^A_t = \sum_{j=1}^{J-1} (f_{j,t} + \tau F w_t) - \frac{(1 + g)(1 + r)\tau F w_{t-1} - (1 + g)(1 + g)\tau F w_{t-1}}{1 + r}.$$  

Using that the total population size alive is 3 and that $w_t = w_{t-1}(1 + g)$,

$$-3\Delta \Upsilon^A_t = (1 + r)\tau F w_{t-1} + (1 + 1)\tau F w_t - \frac{(r - g)(1 + g)\tau F w_{t-1}}{1 + r}.$$  

Simplifying

$$-3\Delta \Upsilon^A_t = \tau F w_t \left( \frac{3 + r + 2g}{1 + g} - \frac{r - g}{1 + r} \right) > 0. \text{ □}$$

**Lemma 2.** If $\theta_{t-1} = 2$ and $\theta_t = 0$, i.e., social security is abandoned completely (denoted by superscript $A$), lump-sum taxes $\Upsilon_t$ in period $t$ are lowered by

$$\Delta \Upsilon^A_t = \frac{3 + r + 2g}{3(1 + g)} \tau F w_t > 0. \text{ (A.2)}$$

*Proof.* If $\theta_{t-1} = 2$ and $\theta_t = 0$, then $f_{1,t}^F = 0$ and $f_{2,t}^F = (1 + r)\tau F w_{t-1}$. From equation (4), the government balance adjusts by:

$$-\sum_j \Delta \Upsilon^A_t = \sum_{j=1}^{J-1} (f_{j,t} + \tau F w_t).$$  

Using that the total population size alive is 3 and that $w_t = w_{t-1}(1 + g)$, and simplifying:

$$-3\Delta \Upsilon^A_t = \frac{3 + r + 2g}{1 + g} \tau F w_t > 0 \text{ □}$$
Proposition 1:

Proof. Abandoning social security implies zero social security contributions and zero benefit payments. Hence, the PAYG pillar disappears.

- The intertemporal budget constraint of a young individual born in period \( t \) is:
  
  \[
  c_{1,t} + \frac{c_{2,t+1}}{(1+r)} + \frac{c_{3,t+2}}{(1+r)^2} = (1-\tau)w_t - \Upsilon_t + \frac{(1-\tau)w_{t+1} - \Upsilon_{t+1}}{(1+r)} + \frac{b^P_{t+2} - \Upsilon_{t+2}}{(1+r)^2}.
  \]

  The resource effect for a young person in period \( t \) of abolishing the PAYG pillar of social security is given by
  
  \[
  \tau w_t + \frac{\tau(1+g)w_t}{(1+r)} - \frac{b^P_{t+2}}{(1+r)^2} = \frac{(2+r+g)(1+r) - (2+g+g)(1+g)}{(1+r)^2} \tau w_t.
  \]

  This expression is positive if \( r > g \). Hence, young agents would benefit from abandoning PAYG social security, because diverting their contributions into private savings yields a higher rate of return. Thus, young agents vote to abandon it.

- The budget constraint of a middle-aged individual can be expressed as
  
  \[
  c_{2,t} + \frac{c_{3,t+1}}{(1+r)} = (1+r)a_1,t-1 + (1-\tau)w - \Upsilon_t + \frac{b^P_{t+1} - \Upsilon_{t+1}}{(1+r)}.
  \]

  The resource effect of abolishing social security would be given by:
  
  \[
  \tau w_t - \frac{b^P_{t+1}}{(1+r)} = \frac{r - 1 - 2g}{1+r} \tau w_t,
  \]

  which is negative if \( r < 1 + 2g \). Therefore, for plausible values of \( r \) and \( g \), middle-aged agents lose from abandoning PAYG social security, so they vote to keep it.

- The budget constraint of an old individual can be expressed as \( c_{3,t} = (1+r)a_2,t-1 + b^P_t - \Upsilon_t \).

  Abandoning social security implies a loss of resources of \( b^P_t > 0 \). Thus old agents would lose from abandoning PAYG social security. Thus old agents vote to keep it.

- Old and middle-aged agents outnumber the young, so the PAYG system is stable.

\( \blacksquare \)
Proposition 2:

Proof. We show that keeping the system intact cannot be an equilibrium outcome.

- The budget constraint of a young individual is:

\[
c_{1,t} + \frac{c_{2,t+1}}{(1+r)} + \frac{c_{3,t+2}}{(1+r)^2} = (1-\tau)w_t - \Upsilon_t + \frac{(1-\tau)w_{t+1} - \Upsilon_{t+1}}{(1+r)} + \frac{b_{t+2} - \Upsilon_{t+2}}{(1+r)^2},
\]

and asset capture lowers their retirement benefit by

\[
\Delta b_{t+2} = (r-g)(3+2g+r)\tau^F w_t.
\]

Compare the loss in terms of social security benefits with the taxes reduced (\(\Delta \Upsilon_{tAC}\)) as per equation (A.1). The young individual supports asset capture if:

\[
\Delta \Upsilon_{tAC} > \Delta b_{t+2} \iff (3 + 2g)(3 + 2g + r) > (r-g)(1+g)(3+2g+r) + (r-g)(1+r)(1+g),
\]

which holds for all \(r, g > 0\). \(^{33}\)

- The budget constraint of a middle-aged individual is expressed as

\[
c_{2,t} + \frac{c_{3,t+1}}{(1+r)} = (1+r)a_{1,t-1} + (1-\tau_t)w_t - \Upsilon_t + \frac{b_{t+1} - \Upsilon_{t+1}}{(1+r)},
\]

and assets capture lowers their retirement benefit by

\[
\Delta b_{t+1} = \frac{(r-g)(2+r+g)}{1+g} \tau^F w_t.
\]

Analogously to the young individual, we use equation (A.1) to compare the gain from lowered taxes due to the asset capture with the decline in retirement benefits:

\[
\Delta \Upsilon_{tAC} > \frac{\Delta b_{t+1}}{1+r} \iff (1+r)(3+r+2g) > (r-g)(7+3r+4g).
\]

The above inequality depends on the magnitude of \(r-g\). \(^{34}\)

- Finally, the budget constraint of an old individual is

\[
c_{3,t} = (1+r)a_{2,t-1} + b_t - \Upsilon_t.
\]

As asset capture does not affect their retirement benefit (\(\Delta b_t = 0\)), using Lemma 1 it is clear that the old gain from asset capture.

Summarizing, old and young individuals vote to capture assets, so even if middle-aged individuals vote against asset capture, they are outvoted. Hence, a system with a funded pillar is not politically stable.

\[\square\]

\(^{33}\)The computations yield a third-order polynomial in both \(r\) and \(g\), which takes positive values for \(r > 0\) and \(g > 0\).

\(^{34}\)If \(r-g\) is sufficiently small, the middle-aged individual votes to capture assets, otherwise they are in favor of maintaining the funded arrangement as it is. Note that a small difference between \(r\) and \(g\) is equivalent to a small gain of having a funded social security over having a PAYG system.

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Proposition 3:

Proof. We will show that voting results in the following rule for social security: \( \theta_t = \theta(\theta_{t-1}) = 1 \) for \( \theta_t \in \{1, 2\} \). Recall that we assumed that, once a social security pillar has been abolished, it cannot be re-introduced, i.e. \( \theta_t = \theta(\theta_{t-1}) \in \{0, 1, 2\} \) for \( \theta_{t-1} = 2, \theta_t = \theta(\theta_{t-1}) \in \{0, 1\} \) for \( \theta_{t-1} = 1 \) and \( \theta_t = \theta(\theta_{t-1}) \in \{0\} \) for \( \theta_{t-1} = 0 \). We demonstrate that the proposed equilibrium is an equilibrium indeed by resorting to the "one-shot deviation principle", i.e. for \( \theta_{t-1} \in \{1, 2\} \) an agent finds a one-shot deviation from \( \theta_t = \theta(\theta_{t-1}) = 1 \) not optimal.

Case of \( \theta_{t-1} = 2 \).

Using the one-shot deviation principle we demonstrate the voting outcomes summarized in Table A.1. The table reports the majority voting outcomes for pairs of policies pitched against each other. The tables shows that regardless of the sequence in which pairs of arrangements are put to majority vote, the eventual outcome is always that voters choose to capture assets and shift contributions.

<table>
<thead>
<tr>
<th>policies</th>
<th>age and outcome</th>
<th>( j = 1 )</th>
<th>( j = 2 )</th>
<th>( j = 3 )</th>
<th>Voting outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>no capture ( \theta_t = 2 ) vs capture ( \theta_t = 1 )</td>
<td>( \theta_t = 1 )</td>
<td>( \theta_t = 2 )</td>
<td>( \theta_t = 1 )</td>
<td>( \theta_t = 1 )</td>
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</tr>
<tr>
<td>abandon ( \theta_t = 0 ) vs capture ( \theta_t = 1 )</td>
<td>?</td>
<td>( \theta_t = 1 )</td>
<td>( \theta_t = 1 )</td>
<td>( \theta_t = 1 )</td>
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</tr>
<tr>
<td>abandon ( \theta_t = 0 ) vs no capture ( \theta_t = 2 )</td>
<td>?</td>
<td>( \theta_t = 2 )</td>
<td>( \theta_t = 2 )</td>
<td>( \theta_t = 2 )</td>
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</table>

- No asset capture, i.e. \( \theta_t = 2 \), versus asset capture \( \theta_t = 1 \).

Given the proposed equilibrium policy \( \theta_t = \theta(\theta_{t-1}) = 1 \) for \( \theta_{t-1} \in \{1, 2\} \), the one-shot deviation from this is to not capture assets in period \( t \), but capture them instead in period \( t + 1 \). We demonstrate that the deviation reduces welfare for a majority of the cohorts currently alive.

- The budget constraint of a young individual is expressed as:

\[
c_{1,t} + \frac{c_{2,t+1}}{(1+r)} + \frac{c_{3,t+2}}{(1+r)^2} = (1-\tau)w_t - \gamma_t + \frac{(1-\tau)w_{t+1} - \gamma_{t+1}}{(1+r)} + \frac{b_{t+2} - \gamma_{t+2}}{(1+r)^2}.
\]

Capturing assets in the next period instead of the current period raises the future retirement benefits of the young by

\[
\Delta b_{t+2} = (1+g)(r-g)r^F w.
\]

Since taxes are lowered in period \( t + 1 \) rather than in period \( t \), the present value of the reduction in taxes shrinks by \(-(-\Delta \gamma_{t}^{AC}) + \frac{-\Delta \gamma_{t+1}^{AC}}{1+r}\). Combining with equation (A.1) and simplifying:

\[
-(-\Delta \gamma_{t}^{AC}) + \frac{-\Delta \gamma_{t+1}^{AC}}{1+r} + \frac{\Delta b_{t+2}}{1+r} < 0 \iff 1+g < 1+r,
\]

which holds for all \( r > g > 0 \). Higher retirement benefits due to postponing asset capture do not compensate for the postponement of the tax cut. Thus, the young individuals prefer asset capture.
- Old individuals prefer asset capture in period \( t \), so as to benefit from the tax reduction, instead of asset capture in the next period \( t + 1 \) after they have died.

- The budget constraint of a middle-aged individual is

\[
c_{2,t} + \frac{c_{3,t+1}}{(1 + r)} = (1 + r) a_{1,t-1} + (1 - \tau_t) w_t - \Upsilon_t + \frac{b_{t+1} - \Upsilon_{t+1}}{(1 + r)}.
\]

Postponing asset capture raises their retirement benefit by

\[
\Delta b_{t+1} = (r - g)(2 + r + g) \tau^F w.
\]

We need to compare this with the loss of postponing the reduction in taxes:

\[
-(-\Delta Y^A_t) + \frac{-\Delta Y^{AC}_{t+1}}{1 + r} + \frac{\Delta b_{t+1}}{(1 + r)} > 0 \iff 2 + 2g + 2rg > 2g^2.
\]

Hence, for \( 1 + 2g > r > g \) middle-aged individuals vote not to capture assets.

- With young and old individuals voting in favor of asset capture in period \( t \) instead of period \( t + 1 \), the outcome of the vote is asset capture in period \( t \).

- Complete abandonment of social security, i.e. \( \theta_t = 0 \), versus asset capture only, i.e. \( \theta_t = 1 \).

Again, we demonstrate that the deviation reduces welfare for a majority of the cohorts currently alive.

- The budget constraint of a young individual is

\[
c_{1,t} + \frac{c_{2,t+1}}{(1 + r)} + \frac{c_{3,t+2}}{(1 + r)^2} = (1 - \tau_t) w_t - \Upsilon_t + \frac{(1 - \tau_{t+1}) w_{t+1} - \Upsilon_{t+1}}{(1 + r)} + \frac{b_{t+2} - \Upsilon_{t+2}}{(1 + r)^2}.
\]

Equations (A.1) and (A.2) imply that complete dismantling of social security affects the present discounted value of the young’s resources as:

\[
-\Delta Y^A_t - (-\Delta Y^{AC}_t) + \tau w_t + \frac{\tau w_{t+1}}{(1 + r)} - \frac{b_{t+2}}{(1 + r)^2} = \frac{(r - g)}{3(1 + r)^2} \tau^F w + \frac{(2 + r + g)(1 + r)}{(1 + r)^2} - \frac{2(1 + g)}{(1 + r)^2} \tau w.
\]

Since \( r > g \), the young individual prefers to capture assets rather than abandon social security entirely.

- The budget constraint of a middle-aged agent can be expressed as

\[
c_{2,t} + \frac{c_{3,t+1}}{(1 + r)} = (1 + r) a_{1,t-1} + (1 - \tau) w_t - \Upsilon_t + \frac{b_{t+1} - \Upsilon_{t+1}}{(1 + r)}.
\]

The difference is, using equations (A.1) and (A.2):

\[
-\Delta Y^A_t - (-\Delta Y^{AC}_t) + \tau w_t - \frac{b_{t+1}}{(1 + r)} = \frac{(r - 1 - 2g)}{(1 + r)} \tau^P w + \frac{r - 3 - 4g}{3(1 + r)} \tau^F w.
\]

Hence, for \( r < 1 + 2g \) middle-aged individuals prefer to capture assets rather than to abandon social security completely.
The budget constraint of an old individual is $c_{3,t} = (1 + r)a_{2,t-1} + b_t - \Upsilon_t$. In comparison with the middle-aged, the old do not benefit from abolishing the contribution payment in return for giving up their PAYG retirement benefit and, hence, they also prefer to capture assets and shift contributions rather than to abandon social security completely.

- We conclude that the outcome of the vote between capturing assets and diverting contributions versus abandoning social security completely is the former.

- Keeping both pillars intact, i.e. $\theta_t = 2$, versus complete abandonment of social security $\theta_t = 0$.

We now compare two one-shot deviations. The first one is to not capture assets in period $t$ and the second one is to completely abandon social security in period $t$. Recall that once social security is completely abandoned, it cannot be restored.

- The budget constraint of a young individual is given by:

$$c_{1,t} + \frac{c_{2,t+1}}{1 + r} + \frac{c_{3,t+2}}{(1 + r)^2} = (1 - \tau)w_t - \Upsilon_t + \frac{(1 - \tau)w_{t+1} - \Upsilon_{t+1}}{1 + r} + \frac{b_{t+2} - \Upsilon_{t+2}}{(1 + r)^2}.$$ 

Completely abandoning social security in period $t$ means that they lose future retirement benefits and future lower taxation, but gain by not paying contributions in period $t$ and $t+1$ as well as from lower taxes in period $t$. Using equations (A.1) and (A.2), their budget constraint is affected as follows:

$$\tau w_t + \frac{\tau w_{t+1}}{1 + r} - \frac{b_{t+2}}{(1 + r)^2} + \left( -\Delta \Upsilon^A_t \right) - \frac{(-\Delta \Upsilon^AC_{t+1})}{(1 + r)} = \tau^F w_t \left( \frac{r(3 + r) - g(3 + 2g - r)}{(1 + r)^2} \right) + \tau^P w_t \left( \frac{r(3 + r) - g(3 + 2g - r)}{(1 + r)^2} \right),$$

which is positive for $r > g$, hence young agents prefer abandoning social security completely to capturing assets.

- The budget constraint of a middle-aged individual is

$$c_{2,t} + \frac{c_{3,t+1}}{1 + r} = (1 + r)a_{1,t-1} + (1 - \tau_t)w_t - \Upsilon_t + \frac{b_{t+1} - \Upsilon_{t+1}}{1 + r}.$$ 

Completely abandoning the social security in period $t$ means that they lose future retirement benefits and future lower taxation, but gain by not paying contributions in period $t$ as well as experiencing lower taxes in period $t$. Using equations (A.1) and (A.2), the budget constraint is affected as follows:

$$\tau w_t - \frac{b_{t+1}}{1 + r} + \left( -\Delta \Upsilon^A_t \right) - \frac{(-\Delta \Upsilon^AC_{t+1})}{(1 + r)} = \tau^F w_t \left( \frac{r(3 + r) - g(3 + 2g - r)}{(1 + r)^2} \right) + \tau^P w_t \left( \frac{r(3 + r) - g(3 + 2g - r)}{(1 + r)^2} \right).$$

Since $0 < g < r < 1 + 2g$, this expression implies that middle-aged individuals prefer to capture assets rather than abandon social security altogether.

- The old clearly prefer keeping both pillars intact to abandoning social security completely.
We conclude that the voting outcome is to keep both pillars versus abandoning social security completely.

The case of $\theta_{t-1} = 1$.

It follows from Proposition 1 that voting results into $\theta_t = \theta(\theta_{t-1}) = 1$ for $\theta_{t-1} = 1$. 

$\square$
B Calibration

This appendix provides further detailed information on the inputs used in the calibration.

Figure B.1: Number of 20-year-old arriving in each period (upper left), one year survival probability over time for a selected cohort (upper right), age structure of population in the initial steady state (lower left) and labor-augmenting technological progress (lower right).

Source: Demographic forecasts until 2080 are based on EUROSTAT, the rate of technological progress is based on the forecasts of the Ageing Working Group of the Economic Policy Committee and the European Commission, and the total factor productivity data represented by the thick solid line are from the OECD. The latter are smoothed by a moving-average for the cyclical component.

Figure B.2: Distribution of $\omega$ multipliers for individual productivity

Note: Estimates of the distribution are obtained using data from the Structure of Earnings Survey, wave of 1998.
Figure B.3: Interest rate and growth rate of total wage bill when continuing with PAYG-DB (left panel) and in transition to two-pillar DC

\[\text{Note: The figure depicts the model-based paths for the interest rate and the growth rate of the total wage bill for the case with intra-cohort homogeneity; the left-hand panel for continuing with PAYG-DB and the right-hand panel for a transition to two-pillar DC social security. The analogous figures with intra-cohort heterogeneity are virtually identical and are available upon request.}\]
C Derivation of the welfare effect of reform

Cohorts alive at the time of the reform

The remaining lifetime utility of an individual of type \( \kappa \) who is \( j \) years old in period \( t \) can be written as:

\[
V_{j,\kappa,t} = \sum_{s=0}^{J-j} \delta^s \pi_{j+s,t+s} u (c_{j+s,\kappa,t+s}^j, l_{j+s,\kappa,t+s}).
\]  

(C.3)

Define \( V_{j,\kappa,t}^S \) and \( V_{j,\kappa,t}^R \) as the remaining lifetime utilities of such an individual under respectively the status-quo and the reform scenarios:

\[
V_{j,\kappa,t}^S = \sum_{s=0}^{J-j} \delta^s \pi_{j+s,t+s} u (c_{j+s,\kappa,t+s}^S, l_{j+s,\kappa,t+s}),
\]

\[
V_{j,\kappa,t}^R = \sum_{s=0}^{J-j} \delta^s \pi_{j+s,t+s} u (c_{j+s,\kappa,t+s}^R, l_{j+s,\kappa,t+s}).
\]

where \( c_{j+s,\kappa,t+s}^S \) and \( l_{j+s,\kappa,t+s} \) are consumption and labor in the status-quo scenario and similarly \( c_{j+s,\kappa,t+s}^R \) and \( l_{j+s,\kappa,t+s} \) refer to consumption and labor in the reform scenario. The welfare effect \( W_{j,\kappa,t} \) that brings the remaining lifetime utility of a \( \kappa \)-type individual of age \( j \) under the reform scenario to the remaining lifetime utility under the status-quo scenario is given by:

\[
\sum_{s=0}^{J-j} \delta^s \pi_{j+s,t+s} \left( u (1 - W_{j,\kappa,t}) c_{j+s,\kappa,t+s}^R, l_{j+s,\kappa,t+s}^R \right) = \sum_{s=0}^{J-j} \delta^s \pi_{j+s,t+s} \left( u (1 - W_{j,\kappa,t}) c_{j+s,\kappa,t+s}^R, l_{j+s,\kappa,t+s}^R \right).
\]  

(C.4)

For a logarithmic utility function we can rewrite the left-hand side (LHS) of equation (C.4) as follows:

\[
LHS = \sum_{s=0}^{J-j} \delta^s \pi_{j+s,t+s} \left[ \ln \left( (1 - W_{j,\kappa,t}) c_{j+s,\kappa,t+s}^R \right) + \phi \ln \left( l_{j+s,\kappa,t+s}^R \right) \right] = \sum_{s=0}^{J-j} \delta^s \pi_{j+s,t+s} \left[ \ln (1 - W_{j,\kappa,t}) + \ln \left( c_{j+s,\kappa,t+s}^R \right) + \phi \ln \left( l_{j+s,\kappa,t+s}^R \right) \right] = V_{j,\kappa,t}^R + \ln (1 - W_{j,\kappa,t}) \sum_{s=0}^{J-j} \delta^s \pi_{j+s,t+s}
\]

Substituting into equation (C.4) we obtain:

\[
\ln (1 - W_{j,\kappa,t}) \sum_{s=0}^{J-j} \delta^s \pi_{j+s,t+s} = V_{j,\kappa,t}^S - V_{j,\kappa,t}^R.
\]

Therefore, the welfare effect can be expressed as:

\[
W_{j,\kappa,t} = 1 - \exp \left\{ \frac{V_{j,\kappa,t}^S - V_{j,\kappa,t}^R}{\sum_{s=0}^{J-j} \delta^s \pi_{j+s,t+s}} \right\}.
\]  

(C.5)
Cohorts born after the reform  For an individual of $\kappa$ type who arrives into the economy in period $t' \geq t$ the welfare gain from the reform can analogously and straightforwardly be derived as:

$$W_{1,\kappa,t'} = 1 - \exp \left\{ \frac{V_{1,\kappa,t'}^S - V_{1,\kappa,t'}^R}{\sum_{s=0}^{J-1} \delta_s^{\kappa} \pi_{1+s,t'+s}} \right\}. \quad (C.6)$$
D Introduction of two-pillar DC social security in 1999

The emergence of a two-pillar DC social security arrangement in 1999 can be rationalized as the outcome of a vote in which individuals weigh a number of factors. First, progressing longevity would imply higher PAYG-DB benefits relative to the alternative of a DC arrangement, *ceteris paribus*. Second, with a PAYG-DB system increasing longevity would require a permanent subsidy from the government, because a longer life at retirement would raise the amount of retirement benefits to be paid out. The resulting deficit would need to be financed with higher consumption taxes and debt according to the fiscal rule given by equation (22). Replacement by a DC scheme would eventually render social security balanced, producing lower taxes in the long run when compared with continuation of PAYG-DB. Third, with the return on assets exceeding the growth rate of the wage bill, the benefits paid out by the funded social security pillar would exceed those paid out of the component of the PAYG-DB pillar that is replaced by the funded pillar. Fourth, during the transition period to the two-pillar DC scheme, a deficit would emerge in social security, necessitating a transitory increase in taxes, which would be smoothed by a transitory increase in the public debt. Finally, there would be general equilibrium effects, stemming from an adjustment in private voluntary savings and in the labor supply. The tighter link between contributions and benefits in the DC system would strengthen labor supply, thereby increasing social security benefits.

We discuss first the case in which intra-cohort heterogeneity is absent. Replacing a PAYG-DB social security system with a DC system with partial funding has different effects across cohorts. Overall there is a majority among those alive in 1999 in favor of this reform – see Figure D.4. Based on welfare evaluations, which account for direct and general equilibrium effects, we can demonstrate which cohorts are in support of turning the PAYG-DB system into a DC system with partial funding. The retired are sheltered from the reform in any case and they benefit from the fact that introducing a DC system strengthens the incentives for labor supply (see Figure D.5). The increase in the wage bill raises the indexation rate of the social security benefits. The same is the case for the elderly workers who thus also benefit from the reform. The calculation for younger cohorts is more complicated. These cohorts enjoy the benefit from the higher return on the funded pillar relative to the part of the PAYG-DB it replaces. However, they are negatively affected by the fact that consumption taxes have to be raised for a while, since directing some of the contributions to the funded pillar necessitates fiscal adjustment in order to pay for the elders’ retirement benefits. Moreover, the shift of part of the PAYG-DB to PAYG-DC has a negative effect on the benefits obtained from the PAYG part of social security, because the switch results into a balanced social security, while at the moment of the reform the original PAYG-DB system already features a deficit that will be growing further with rising life expectancy. This deficit is reduced by a corresponding reduction of retirement benefits from the new PAYG-DC pillar, which is only partially compensated by the increase in benefits coming from the return on the funded pillar dominating the growth rate of the wage bill. The reform eventually improves welfare for newborn cohorts at the moment of their birth. They benefit from increased overall efficiency and lower taxation.

Partial funding eventually raises the welfare gains from having the two-pillar DC system instead of the pure PAYG-DB system. Figure D.5 depicts for each year the percentage of individuals who
benefit from the reform in 1999 when compared with maintaining the single-pillar DB scheme. The losing cohorts pass away over time, whereas the newborn benefit from increased overall efficiency and lower taxation. Eventually, all cohorts alive at a given moment would benefit from the reform. The aggregate long-term welfare effect of the reform amounts to 1%, so that if all losers were compensated by the winners, the latter would on net still gain (i.e., a Kaldor-Hicks welfare improvement).

Figure D.4: Distribution of the welfare effects by cohort from introducing two-pillar DC system in 1999

Note: Lines depict welfare effect in terms of percent increase in the remainder of lifetime consumption relative to continuation of the PAYG-DB system for each cohort, which is indicated by the birth year, at the moment of the reform. Of the future-born the figure thus depicts the effect over the full lifetime. The solid line obtains in the absence of intra-cohort heterogeneity, while the other lines correspond to the presence of intra-cohort heterogeneity. Here, the dispersion within each non-solid line reflects the heterogeneity of welfare effects across productivity types.

We turn now to the case of intra-cohort heterogeneity. The driving force behind differences in the evaluation of the reform across the subcohorts are differences in the discount factor $\delta_c$. In the long run all subcohorts gain due to lower taxation. Among the transition cohorts, i.e., those younger than 40 years in 1999, nearly all subcohorts experience a decline in welfare due to lower overall social security benefits and higher taxation. Exempted from the decline in welfare are the most patient transition subcohorts among the transition cohorts.

Differences in the individual productivity endowment have virtually no effect on the reform evaluation – see the plots of welfare in Figure D.4. This also implies that there is no room for coalition building across cohorts based on individual productivity endowments, such as between the elderly and high-productivity individuals in the transition cohorts; tax and general equilibrium effects dominate.
Notes: Results from simulations with intra-cohort homogeneity. Those for intra-cohort heterogeneity are virtually the same. The left-hand panel depicts as a function of the tax rule the percent of subcohorts living in each period who gain from introducing the two-pillar DC social security, as described above. Hence, for each year on the horizontal axis it gives the percent of political support for the reform that took place in 1999 versus continuing with single-pillar PAYG-DB. The solid black line, denoted as ‘standard fiscal rule’ refers to the fiscal rule as described by equation (22) and parametrized in Table 1. The first alternative specification considers instantaneous consumption tax adjustment (denoted as ‘pure $\tau_c$’). Combining equation (20) and (21), with $D_{t+1} = D_t$ we have:

$$\tau_{c,t} = \frac{G_t + \text{Subs}_t + r_t D_t - \tau_{l,t} [ (1 - \tau) w_t L_t + \sum_{k=1}^K \sum_{j=1}^J b_{j,k,t} Y_{j,k,t} ] - \sum_{k=1}^K \sum_{j=1}^J N_{j,k,t} (\tau_{k,t} r_t a_{j,k,t} + \check{\Upsilon}_t) \sum_{k=1}^K \sum_{j=1}^J N_{j,k,t} c_{j,k,t}}{\sum_{k=1}^K \sum_{j=1}^J N_{j,k,t} c_{j,k,t}}.$$  

The second alternative considers full accommodation through public debt keeping the consumption tax rate initially unchanged. Subsequently, after the transition cohorts have passed away debt is gradually reduced using the fiscal rule described in equation (22) (denoted as ‘debt’). We trigger adjustment in consumption taxes as soon as $D_t$ exceeds 90%. Third, we study slower tax adjustment than described in Table 1 by setting parameter $g_D$ to 0.03 in the fiscal rule (22) (denoted as ‘slow tax adjustment’), and faster tax adjustment by setting parameter $g_D$ to 0.07 in (22) (denoted as ‘fast tax adjustment’). The right-hand panel depicts the decomposition of the overall effect of a switch from PAYG-DB to a two-pillar DC scheme into an effect attributable to a switch from PAYG-DB to single-pillar PAYG-DC and an effect attributable to the introduction of a funded pillar.

The role of productivity differences.$^{35}$

This latter finding points to the relevance of the fiscal adjustments accompanying social security reforms: if lump-sum taxes were used to finance the transition costs of the reform, the utility of the elderly cohorts would be harmed, leading them to oppose the reform. However, the fiscal rule portrayed in equation (22) partly raises consumption taxes, but mostly smooths the costs of the reform to the future cohorts via the public debt. Overall, the cohort distribution of these welfare effects is such that in 1999 approximately 54.7% of the population living at the moment of the reform would support it; see the left panel of Figure D.5.

To disentangle the effect of a switch from PAYG-DB to a two-pillar DC scheme into an effect attributable to a switch from DB to DC and an effect attributable to the introduction of a funded pillar, we run an additional simulation with $\tau^P = \tau$ and $\tau^F = 0$. Subtraction of the resulting welfare effect from the overall welfare effect of the switch to the two-pillar DC scheme yields the welfare

$^{35}$Earlier literature on introducing (redistributive) social security has studied coalition formation between elderly and low-productivity young agents, who have a common interest in a highly redistributive arrangement. For example, see Tabellini (1991).
effect of the introduction of the funded pillar. The right-hand panel of Figure D.5 depicts the decomposition for intra-cohort homogeneity. For intra-cohort heterogeneity, the results are virtually identical. The welfare effect of introducing a funded pillar starting from a single-pillar PAYG-DC scheme is negative for all cohorts born until approximately 2010, after which it becomes positive for all subsequently-born cohorts, indicating that eventually the gains from a faster-growing and larger economy exceed the costs of financing the transitory deficit in public social security.

Figure D.6 depicts the development of the interest rate and the consumption tax rate for the three cases under intra-cohort homogeneity: maintaining the initial single-pillar PAYG-DB, the single-pillar PAYG-DC and the two-pillar DC. The corresponding figure under intra-cohort heterogeneity is essentially identical. Single-pillar PAYG-DB features the lowest capital stock, hence is responsible for the highest interest rate. Vice-versa, the highest capital stock under the two-pillar DC regime is responsible for the lowest interest rate. A single-pillar DC forces individuals to save more, in order to make up for the loss of retirement benefits compared to single-pillar DB. However, the additional savings do not make up for the absence of a funded pillar, hence the interest rate in this case is in-between that of the other two cases. The growing deficit under the single pillar PAYG-DB regime produces a strong increase in the consumption tax rate relative to that in the other two cases.

Figure D.6: Interest rates (left) and consumption tax rates (right) under the DB and DC social security

Notes: "FDC" denotes the two-pillar DC system with partial funding, while "DC" denotes a DC system financed entirely on a PAYG basis. "DB" denotes a DB system fully based on PAYG financing. The initial steady state is always the PAYG-DB system. Each line denotes a separate simulation on an economy with the same initial steady state. In the scenarios of a change to DC (with or without funding) the reform is introduced in 1999. The transition is gradual, as described in Section 3.4 in the main text.
E Macroeconomic effects of reducing the funded pillar of social security

We discuss the effects of capturing social security assets in 2012. This year is suitable for illustration purposes, because around this date most of the countries that earlier introduced partially-funded DC systems started to unfund their social security systems. Results for alternative years for the vote to unfund social security are available upon request.

The impact of the three analyzed policies on social security benefits differs. Policy 1 redirects contributions from the funded pillar to the PAYG-DC pillar. This shift lowers the benefits for two reasons. First, because the interest rate exceeds the growth rate of the wage bill, during working age entitlements in the PAYG pillar accumulate at a lower rate than value of the assets in the funded pillar. Second, benefits-in-payment from the PAYG pillar are also indexed at a rate lower than benefits paid from the funded pillar. Under Policy 2, a one-off asset capture, social security benefits fall for cohorts working during the asset capture. However, because the asset capture is one-off, Policy 2 has no long-run effects. Under Policy 3, the effects of Policy 1 and Policy 2 add up and, hence, social security benefits are lower than under either Policy 1 or Policy 2. The trajectories of the total social security benefit payouts and the deviations from the status-quo of the current two-pillar DC scheme are depicted in Figure E.7. The interest rate and wage rate under the current two-pillar DC scheme are depicted in Figure B.3, while the effects of a policy shift away from the current two-pillar DC scheme are found in Figure E.8.

In addition to the effect on social security benefits, there is an effect through taxes. The shift of contributions under Policy 1 results in a temporarily lower consumption tax rate. Similar to Policy 1, under Policy 2, the deficit is reduced in the PAYG pillar, which benefits current cohorts as it allows to reduce the consumption tax rate. Under Policy 3, as the effects of Policy 1 and Policy 2 add up, the decline in the consumption tax rate is larger than under either of the alternative policies. The trajectories of the consumption tax rate and its deviation from the status-quo of maintaining the two-pillar DC are depicted in Figure E.7.

Lower benefits due to the reduction of the funded pillar result in higher voluntary savings. However, since voluntary savings are taxed and cannot be converted into an annuity at retirement age, this increase fails to make up for the effect of the reduction of the funded pillar on the capital stock – see Figure 6. Nevertheless, with the reaction of private voluntary savings, there is an increase in the overall amount of capital income taxation, because social security assets were not subject to such taxation.

The impact on the labor supply is twofold. First, lower consumption taxes distort less the intra-temporal choice between consumption and leisure, which tends to increase the labor supply. Second, due to the shift away from funding, social security contributions yield a lower return in terms of future benefits, hence the incentive to work is reduced. Depending on which of the effects is stronger, the labor supply rises or falls. For Policy 1 the second effect dominates. The labor supply drops rapidly at the time of introducing the policy change. For Policy 2 the first effect is stronger, and the labor supply rises or falls. For Policy 3 the effects add up, and the labor supply rises or falls.

Recall that the return on the annuity exceeds the interest rate, because the funded pillar assets of individuals who die remain in this pillar.
supply increases. In the case of Policy 3, the effect of lower consumption taxes dominates initially, as the decline in taxes is largest in the initial years after the reversal of the original reform, but over time this effect is overtaken by the effect of the distortion associated with the second effect; see Figure 6.

The interest rate and the wage rate under the status-quo of the two-pillar DC scheme were already depicted in Figure B.3, while the effects of the policy shift are found in Figure E.8. The lower capital stock under Policies 1 and 3 compared to Policy 2 results into a higher interest rate under the former.

Figure E.8: Adjustments in the interest rate $r_t$ (left) and the wage rate $w_t$ (right)

Notes: the interest rate is expressed as the difference relative to the baseline of two-pillar DC (in percentage points). The wage rate is expressed as a ratio relative to the baseline of two-pillar DC. Reported are the results from a vote in 2012. Policy 1 is a permanent shift of contributions from the funded to the PAYG pillar. Policy 2 is a one-off capture of the funded-pillar assets. Policy 3 combines Policies 1 and 2. The results for alternative voting years are available upon request.
Figure E.7: The effect of unfunding on social security benefits and fiscal variables

(a) social security benefits
(b) social security benefits (percent relative to baseline)
(c) $\tau_c$ rate (percent)
(d) $\tau_c$ rate (percentage point relative to baseline)
(e) debt share in GDP (percent)
(f) debt share (percentage point relative to baseline)

Notes: results from a vote in 2012, individuals are uniform within birth cohort. The results from an alternative voting year are available upon request. “No policy changes” and “baseline” refers to the current two-pillar DC scheme. Policy 1 is a permanent shift of the contributions from the funded pillar to the PAYG pillar. Policy 2 is a one-off capturing of the assets accumulated in the funded pillar. Policy 3 combines Policy 1 and Policy 2. The top left panel depicts the total social security benefits paid out in a given year in model units, while the top right panel depicts the deviation from the baseline of no policy change in percent.
Intra-cohort heterogeneity: macroeconomic and welfare effects

This appendix reports the relevant tables and figures for the case in which we allow for intra-cohort heterogeneity.

Table F.2: Political support for the three alternatives to the current two-pillar DC

<table>
<thead>
<tr>
<th>Year of vote</th>
<th>2012</th>
<th>2162</th>
<th>2192</th>
<th>final steady state</th>
</tr>
</thead>
<tbody>
<tr>
<td>Political support in % of those alive</td>
<td>Against two-pillar DC</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>for Policy 1 - shifting contributions (permanent)</td>
<td>98</td>
<td>100</td>
<td>100</td>
<td>Model with intra-cohort heterogeneity</td>
</tr>
<tr>
<td>for Policy 2 - capturing assets (one-off)</td>
<td>54</td>
<td>64</td>
<td>64</td>
<td></td>
</tr>
<tr>
<td>for Policy 3 - combination of Policies 1 and 2</td>
<td>100</td>
<td>98</td>
<td>98</td>
<td></td>
</tr>
<tr>
<td>Long-term welfare effect of Policy 1</td>
<td>-0.34%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Long-term welfare effect of Policy 2</td>
<td>0.00%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Long-term welfare effect of Policy 3</td>
<td>-0.34%</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: see Notes to Table 3.

Figure F.9: The effect of a successful vote against the current two-pillar DC on retirement benefits and taxes in the presence of intra-cohort heterogeneity

Note: See Notes to Figure E.7.
Figure F.10: Welfare effects and its decomposition of a policy change for a vote in 2012 by birth year and with intra-cohort heterogeneity

(a) Policy 1: shifting contributions (permanent)
(b) Policy 2: capturing assets (one-off)
(c) Policy 3: combination of Policy 1 and Policy 2

Notes: see Figure 7.
Figure F.11: Welfare effects and its decomposition of a policy change for a vote in 2192 by birth year and with intra-cohort heterogeneity

(a) Policy 1: shifting contributions (permanent)

(b) Policy 2: capturing assets (one-off)

(c) Policy 3: combination of Policy 1 and Policy 2

Notes: see Figure 7.
Figure F.12: The effect of reducing the funded pillar on retirement benefits and fiscal variables in the presence of intra-cohort heterogeneity

Notes: results from a vote in 2012 with intra-cohort heterogeneity. Further, see Notes to Figure E.7.
Figure F.13: Adjustments in capital $K_t$ (left) and labor supply $L_t$ (right) in the presence of intra-cohort heterogeneity

Notes: measures expressed in terms of ratio relative to baseline of two-pillar DC. Reported are the results from a vote in 2012. The results for alternative voting years are available upon request.

Figure F.14: Adjustments in the interest rate $r_t$ (left) and the wage rate $w_t$ (right) in the presence of intra-cohort heterogeneity

Notes: the interest rate is expressed as the difference relative to the baseline (in percentage points). The wage rate is expressed as a ratio relative to the baseline. Reported are the results from a vote in 2012. The results for alternative voting years are available upon request.
G The effects on poverty

We also show the aggregate effects on both absolute and relative poverty. We define relative poverty as consumption below 60% of current median consumption in any given year. We define absolute poverty as consumption below 60% of consumption in the initial PAYG-DB steady state (adjusting for technological progress and population change). The evolution of the poverty measures is displayed in Figure G.15.

Figure G.15: Evolution of poverty

![Graphs of poverty measures](image)

(a) relative poverty: all  
(b) relative poverty: elderly

(c) absolute poverty: all  
(d) absolute poverty: elderly

**Note:** relative poverty is defined as the fraction of the population with consumption below 60% of median consumption in a given year, while absolute poverty is defined as the fraction of the population with consumption below 60% of median consumption in the initial steady state. Old-age poverty measures the fraction of poor elderly as a share of the total group of elderly. Policy 1 is a permanent shift of the contributions from the funded pillar to the PAYG-DC pillar. Policy 2 denotes a one-off capturing of the assets accumulated in the funded pillar. Policy 3 combines Policies 1 and 2.

Poverty, both absolute and relative, would increase the least if the PAYG-DB system was continued. This is because the majority of the poor households are in old-age: the higher retirement benefits under the PAYG-DB system imply that a larger fraction of them can afford sufficient consumption.

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37 That is, we scale back quantities by the amount of technological progress and the change in the size of population relative to the initial steady state.
Moreover, the higher consumption tax under this system implies lower average consumption, hence fewer households falling below the relative poverty threshold.

The shift from PAYG-DB to single-pillar PAYG-DC has a strong positive effect on the share of old-age households that cannot afford consumption above 60% of the median in a given year. Hence, relative poverty among this group and, therefore, the population at large, rises strongly. There are two driving factors here. The main driving factor is the fall in social security benefits.

The direct consequence of the asset capture under Policy 2 is a decline of overall consumption, relative to the current two-pillar DC scheme. Overall consumption falls, because consumption needs to be given up to stem the fall in social security benefits. This decline lowers the threshold above which a household is no longer defined as poor, hence relative poverty declines. The development of relative poverty under Policies 1 and 3 is very similar to that under Policy 2.