



Propagation and smoothing of shocks in alternative social security systems[☆]

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ABSTRACT

Even with well-developed capital markets, there is no private market mechanism for trading between current and future generations. This generates a potential role for public old-age pension systems to spread economic and demographic shocks among different generations. This paper evaluates how different systems smooth and propagate shocks to productivity, fertility, mortality and migration in a realistic OLG model. We use reductions in the variance of wealth equivalents to measure performance, starting with the existing U.S. system as a unifying framework, in which we vary how much taxes and benefits adjust, and which we then compare to the existing German and Swedish systems. We find that system design and shock type are key factors. The German system and the benefit-adjustment-only U.S. system best smooth productivity shocks, which are by far the most important shocks. Overall, the German system performs best, while the Swedish system, which includes a buffer stock to relax annual budget constraints, performs rather poorly. Focusing on the U.S. system, reliance solely on tax adjustment fares best for mortality and migration shocks, while equal reliance on tax and benefit adjustments is best for fertility shocks.

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1. Introduction

While the main function of old-age pension systems is to provide resources to elderly retirees, these systems can satisfy many other important government functions as well. Indeed, in circumstances where access to capital markets is good and many individuals can, alone or in conjunction with private employers, save for retirement, broad-based public pension systems may not be needed simply to provide retirement income and their other functions may take on greater prominence. One such function is the allocation and spreading of economic and demographic shocks among generations. Even with well-developed capital markets and informal family arrangements, there is no private market mechanism for trading between current and future generations, leaving government policy as the only broad-based option.

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A range of government policies, including national debt management, infrastructure investment, and public education expenditures, have important intergenerational consequences, but the size and variety of public pension schemes make them a natural place to focus for intergenerational policy.

Like private defined-contribution pension arrangements, funded defined-contribution public pension schemes result in one particular allocation of economic and demographic shocks among generations. For example, a demographic shock that leads to one age cohort being large relative to others will lead that cohort to experience relatively low lifetime wages (because of its high labor supply) and relatively low rates of return on its retirement saving (because of its high demand for retirement assets). But public schemes may deviate from the defined-contribution approach with respect to two criteria: asset accumulation and determination of contributions and benefits. With respect to the first criterion, systems may adhere to some form of strict pay-as-you-go (PAYG) approach, or to a more flexible approach that allows a fluctuation in the system's financial assets or liabilities within some stable range. With respect to the second criterion, systems may adjust either contributions or benefits to maintain financial stability, and when adjusting benefits may adjust them immediately or in the future.

This paper relates to a large literature that studies how aggregate and idiosyncratic risks are shared in models with inter-generational

linkages, starting with [Diamond \(1977\)](#).¹ Our main contribution to this literature is to analyze how specific demographic and economic shocks policymakers are concerned about propagate through different versions of public pension systems currently employed or proposed in different countries.

Two earlier papers ([Auerbach and Lee, 2009, 2011](#)) studied a variety of existing and hypothetical unfunded arrangements. These included the actual and hypothetical Swedish systems, the actual German system, and three stable variants of the existing U.S. social security system, evaluated according to a variety of welfare criteria, such as internal rates of return and an approximation of expected utility. Our findings, particularly in the second paper, suggested that the methods of spreading shocks across generations can have significant effects on welfare. But questions remain about the channels through which these effects operate.²

Understanding the effects of an existing or proposed system on welfare is, ultimately, our objective in studying the spreading of shocks. However, we would also like to understand why certain systems seem to perform better in the welfare dimension and how other potential systems would perform in response to different patterns of shocks. Our past welfare analysis was based on empirically estimated demographic and economic stochastic processes for the United States, but patterns in the future or in other countries may differ; it would be useful to have a more general picture of how different systems perform in response to different types and patterns of shocks. Using the stochastic modeling approach of our previous work, by looking only at the particular shocks of interest, one at a time, is difficult because each type of shock has complex economic effects and channels that cannot be determined without an explicit general equilibrium model. Thus, we utilize a modified version of the [Auerbach and Kotlikoff \(1987\)](#) dynamic general-equilibrium OLG model that incorporates realistic patterns of fertility and mortality and shocks to productivity, fertility, mortality and migration. While this model is well adapted for our purposes, it is worth highlighting some limitations of our analysis.

One issue concerns the fact that, although we model the responses of the economy to a range of shocks, the model is effectively deterministic, in the sense that households do not anticipate the shocks and respond to them after they occur. In particular, due to the complexity of our model economy and the particular counterfactuals we study, we abstract from modeling aggregate or idiosyncratic uncertainty. Although recent studies have made substantial progress in incorporating aggregate shocks into realistic large-scale OLG models, these models are still too limited to deal with our setting. For instance, [Hasanahodzic and Kotlikoff \(2013\)](#) incorporate aggregate productivity shocks in a large-scale OLG model with a Social Security system that is simpler than ours and does not incorporate demographic changes. [Ríos-Rull \(2001\)](#) on the other hand incorporates stochastic population changes but does not include government and hence cannot study the role social security plays in propagating or smoothing of these shocks. The latter study, like much of the literature analyzing aggregate shocks such as [Krueger and Kubler \(2006\)](#) and [Ludwig and Reiter \(2010\)](#), also analyzes such shocks using a quadratic approximation of the full rational expectations equilibrium around a deterministic steady state.

Other studies incorporate idiosyncratic risks but not aggregate uncertainty. The models by [Hong and Ríos-Rull \(2007\)](#) and [Nishiyama and Smetters \(2007\)](#) for example feature a simplified version of social

security and idiosyncratic demographic shocks, but no aggregate uncertainty. The latter study finds that even allowing for idiosyncratic shocks “significantly increases the complexity of the model and the required computation time from several hours to typically several days per simulation.” While we do incorporate uncertainty with respect to mortality in our model, we couple it with an assumption of complete annuity markets, so that household saving decisions are not affected.

One limitation of our study is therefore the absence of precautionary savings as an element of the household’s intertemporal optimization, and we leave such an analysis to future research. However, it is worth pointing out that since our study focuses on the comparison of the dynamic responses across different social security systems, it is not obvious whether and to what extent the existence of precautionary savings would change these relative comparisons. A second limitation, associated with the absence of idiosyncratic uncertainty, is that while we can and do evaluate the spreading of shocks across generations, we cannot analyze risk-sharing within generations. Finally, in studying shocks around the steady state of an economy, we limit our consideration to shocks that, though potentially of very long duration, are not permanent.

Our analysis yields several interesting results. First, for our calibration based on U.S. historical experience, productivity shocks are the most important source of welfare volatility, so success at smoothing such shocks could be quite valuable. Yet no system is particularly effective at smoothing productivity shocks, because the tax cuts or benefit increases that positive productivity shocks make feasible generally aid cohorts already gaining from the productivity shock. However, among variants of the U.S. social security system, reliance on benefit adjustment smooths such shocks most effectively, as retirees’ direct gains from the shocks themselves are smaller than are those of workers.

Adjustments in response to fertility shocks, the second most important shocks, are more effective when relying on a mix of tax and benefit adjustments, because cohorts hurt by the initial shock in different ways (a decline in wages from an increased labor force vs. reduced consumption due to larger families) are helped differentially by tax and benefit adjustments. For mortality and migration shocks, which in our calibration are the least important and generate roughly equal amounts of volatility in well-being, tax adjustments are better at smoothing, because these shocks affect workers most – migration shocks because of increased labor-market competition, mortality shocks because of less need for resources among the elderly. Also, social security has a greater ability to smooth shocks in these cases than for productivity and fertility shocks, because the initial effects of the shocks themselves are less widespread.

An important lesson from our analysis is that, even where smoothing is possible, some combinations of tax and benefit adjustments fail to smooth shocks. In fact, some social security systems actually concentrate the effects of shocks for certain parameterizations and shocks. For example, while reliance primarily on tax adjustments effectively smooths the migration shock, this is not the case when the primary adjustment is through benefits.

Finally, considering the performance of the German and Swedish systems, we find that the German system performs well overall relative to the U.S. system, successfully combining tax and benefit adjustments in smoothing different shocks. The Swedish system, on the other hand, performs rather poorly except in the case of the fertility shock, even though it alone has a buffer stock mechanism that relaxes the requirement of short-run cash-flow balance.

2. The model

The model we use is adapted from that laid out in [Auerbach and Kotlikoff \(1987, chapter 11\)](#) and used subsequently by [Auerbach et al. \(1989\)](#) to evaluate the economic effects of public pension systems in several countries. That original model was a perfect foresight, dynamic general equilibrium model with variations in fertility that permitted analysis of the interactions of demographic transitions and different public pension systems. However, several modifications are needed to

¹ This literature is too large to summarize adequately here and we refer the reader to the excellent surveys by [Feldstein and Liebman \(2002\)](#) and [Attanasio et al. \(2016\)](#). Two more recent extensions of the overlapping generations (OLG) framework developed by [Diamond \(1977\)](#) worth mentioning in our context are [Shiller \(1999\)](#) and [Bohn \(2009\)](#), who show that public pension systems can reduce consumption risk of all generations.

² Other studies that analyze specific designs of public pensions include [Matsen and Thøgersen \(2004\)](#), who investigate the optimal mix between PAYG and fully funded systems, [Krueger and Kubler \(2006\)](#), who study the welfare benefits of a minimum pension, and [Ludwig and Reiter \(2010\)](#), who ask how pension systems perform in smoothing fertility shocks.

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