

# Redistribution of Nominal Wealth and the Welfare Cost of Inflation\*

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## Abstract

This paper considers the revaluation of nominal wealth as a channel for aggregate and welfare effects of inflation. In a calibrated OLG model, an inflation episode is viewed as an unanticipated shock to the wealth distribution that hurts old lenders and helps young borrowers. While the redistribution shock is zero-sum, households respond asymmetrically, which generates a decrease in labor supply as well as an increase in savings. Although inflation-induced redistribution has a persistent negative effect on output, it improves the weighted welfare of domestic households.

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# 1 Introduction

An immediate consequence of an unanticipated change in the price level is redistribution: inflation lowers the real value of nominal assets and liabilities, and thereby redistributes wealth from lenders to borrowers. Recent literature on the real effects and welfare costs of inflation has paid little attention to redistribution effects. While representative-agent models provide no scope for redistribution at all, existing studies with heterogeneous agents focus on the effect of inflation on cash balances alone, which make up only a minor fraction of all nominal assets.<sup>1</sup>

This paper provides a quantitative study of the redistribution effect of inflation. We ask what would happen if the United States were to enter another inflation episode such as the one experienced during the 1970s. We emphasize the role of money as a unit of account: inflation affects *all* nominal asset positions, not just cash positions. As a result, even moderate inflation leads to substantial wealth redistribution.

Since wealth changes induce agents to adjust their behavior over the entire life cycle, the effects on individuals are persistent. Moreover, the responses of losers (old lenders) and winners (young borrowers) do not cancel out, so that aggregates react as well. The magnitude of the aggregate effects is comparable to those in representative-agent models with monetary frictions, but the effects arising from redistribution persist long after the end of the inflation episode.

We also find that the welfare effect on domestic households arising from redistribution is the opposite of what standard monetary models generate: inflation-induced redistribution leads to a *positive* effect on weighted aggregate welfare. Financial innovation and foreign borrowing have recently increased the potential welfare gains from inflation, to the point that these gains are now substantially larger than conventional estimates of the welfare cost of inflation. We conclude that redistribution is a key channel for the impact of inflation on household behavior, economic aggregates, and welfare.

We arrive at our conclusions by performing the following thought experiment. Suppose an economy is initially in a low-inflation regime, as is the case for the US today. Suppose further that an episode of moderate inflation, such as the 1970s, occurs. If all real effects of inflation are due to redistribution (that is, the only role of money is to serve as a unit of account in the credit market), who gains and who loses, and what economic effects arise?

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<sup>1</sup>There is an old tradition in monetary economics that does focus on redistribution—see Fisher (1933) for a classic contribution.

To answer these questions, we employ a deterministic neoclassical growth model. Households differ by age and skill to generate a heterogeneous population. The other important players in credit markets—the business, government, and foreign sectors—are also present. The model is calibrated so that its balanced growth path matches key aggregate ratios, as well as properties of the wealth and income distribution.

Since the model is designed to isolate the effects of inflation that are generated by wealth redistribution, we abstract from monetary frictions. Instead, an inflation episode is modeled as an unanticipated zero-sum redistribution of real wealth. The magnitude of the redistribution shock is calibrated to the present-value gains and losses from a ten-year inflation episode that were calculated by Doepke and Schneider (2005) for different sectors and groups of households.

Even though redistribution shocks are zero-sum, they have aggregate effects, because net borrowers (winners) and net lenders (losers) respond differently. Empirically, the key asymmetry in nominal positions is that net borrowers tend to be younger than net lenders. This asymmetry gives rise to two life-cycle effects. First, a reduction in the labor supply of the young winners (that is, an increase in their consumption of leisure motivated by an increase in wealth) is not offset by an increase in labor supply by the old losers, since the latter are retired. Second, an increase in the savings of the young winners is not fully offset by a decrease in the savings of the old losers, since young households spread any gain or loss over more remaining periods of life than old households.

In our calibrated model, the first effect causes aggregate labor supply to decline by up to 1.5 percent in the decade after the inflation episode. The second effect increases the capital stock by up to 0.8 percent above trend three decades after the inflation episode. The net result is a decline in output over the first three decades after the shock of up to 0.8 percent relative to trend, followed by a smaller temporary increase.

The effects on the welfare of individual cohorts are large. Retirees lose the most and experience a decrease in their consumption of up to 12 percent relative to the balanced growth path. Among the winners, consumption of the young middle-class cohorts increases by up to 6 percent. Overall, domestic households gain at the expense of foreigners. Using standard weighted welfare measures, we find that the aggregate welfare effect of inflation on domestic households is positive. This would be true even if foreigners were not affected by inflation, since the redistribution effect tends to level the overall wealth distribution. However, the losses incurred by foreigners substantially increase the positive

welfare effect.

An individual's welfare is affected not only by the direct change in assets brought about by the redistribution shock, but also by the reaction of fiscal policy. Fiscal policy must adjust in some dimension in an inflation episode, since the reduction of real government debt presents the government with a windfall gain. Apart from the baseline case of an increase in government spending, we consider different ways for the government to rebate its gain to households. Income tax cuts tend to further favor young winners. If the government increases social security transfers, in contrast, most of the old losers from inflation can be fully compensated. Hence, fiscal policy plays a key role in determining how many losers and winners from inflation there are overall.

In the next section, we review the literature. Section 3 presents the theoretical framework. The model parameters as well as the redistribution shock are calibrated to data in Section 4. In Section 5, we use the calibrated model to analyze the economic implications of an inflation shock. Section 6 concludes.

## 2 Related Literature

One of the redistribution effects that underlies our results is the surprise revaluation of nominal government debt. This effect is also the focus of Bohn's (1988) study of fiscal policy. Bohn considers a stochastic model with incomplete markets where government debt is nominal. Nominal debt provides insurance against the effects of economic fluctuations on the government's budget. A negative productivity shock leads to an increase in the price level (through the quantity equation), and thereby deflates the value of existing government debt. This windfall enables the government to continue to provide its services without being forced to raise taxes in the downturn. Nominal debt therefore serves as a mechanism that implements event-contingent insurance.<sup>2</sup>

Persson, Persson, and Svensson (1998) are also interested in the effect of inflation on government finances. For the case of Sweden, they conduct a thought experiment that is similar in spirit to ours: what would be the present value change in the government budget, as of 1994, if there was a permanent 10 percentage point increase in inflation? They find a sizeable effect, about as large as 1994 GDP. However, most of this effect is accounted

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<sup>2</sup>See also Bohn (1990b) for some empirical evidence on this mechanism, and Bohn (1990a, 1991) on open-economy extensions.

for by incomplete indexation of the tax and transfer system, as opposed to the direct devaluation of government debt. Despite the large positive impact on the government's budget, the authors conclude that the net social gains of the inflation policy are likely to be negative. Burnside, Eichenbaum, and Rebelo (2003) examine the fiscal implications of currency crises in three middle-income countries. They find that devaluation of the dollar value of government debt is a more important source of depreciation-related government revenue than seigniorage, which is the source emphasized by most standard currency crisis models. Neumeyer and Yano (1998) document the effects of U.S. monetary shocks on other countries that arise from cross-border holdings of nominal assets, and argue that during the 1980s these were especially large for Latin American countries.

A connection between inflation and the wealth distribution can also arise through asymmetric incidence of the inflation tax. Erosa and Ventura (2002) observe that poor households hold more cash relative to other financial assets than rich households do. They rationalize this fact in a monetary growth model where access to credit markets is costly. The poor then pay a disproportionate share of the inflation tax and are hurt more by inflation. Since inflation acts like a nonlinear consumption tax—with higher rates for the poor—it also encourages precautionary savings and thereby leads to higher concentration of wealth. Albanesi (2002) derives a positive correlation between inflation and inequality in a similar model, where the inflation tax rate is set in a political bargaining game. Since the poor are more vulnerable to inflation, their bargaining power is weak and the rich succeed in implementing high inflation. The key difference between the inflation tax literature and our paper is that the former deals with the effect of anticipated inflation on cash holdings. In contrast, we are concerned with unanticipated shocks on all nominal asset holdings, of which cash holdings are only a small part.

Our study is also related to a large literature on the link between the earnings and wealth distributions in the US. The key stylized fact that this literature has wrestled with is that the distribution of wealth is much more concentrated than that of earnings (see Budría Rodríguez, Díaz-Giménez, Quadrini, and Ríos-Rull 2002 for an overview of the stylized facts). Both models with dynastic households (for example, Aiyagari 1994, Krusell and Smith, Jr. 1998, Quadrini 2000) and life-cycle models (Hubbard, Skinner, and Zeldes 1995, Huggett 1996) have been explored. More recently, several papers have combined features of these two setups by accommodating both life-cycle concerns for saving and altruism (for example, Castañeda, Díaz-Giménez, and Ríos-Rull 2003, De Nardi 2004, Laitner 2001).

The model used here is simpler than those in most of the above studies in that households face no uncertainty. In particular, idiosyncratic labor income risk, the typical source of heterogeneity in the literature, is absent from our setup. Instead, all earnings heterogeneity is due to differences in deterministic skill profiles across types of households, and wealth inequality is partly generated by preference heterogeneity. We choose a different modeling strategy in order to be able to calibrate the model to observed features of specific groups of households, as opposed to aggregate moments of the earnings and wealth distribution. At the same time, our model shares several broad themes with existing studies. One is the importance of bequests for generating a group of rich households that holds most of aggregate wealth. In our model, agents with high earnings also have a greater ‘warm glow’ taste for transfers to their children. This may be viewed as a simplified version of the setups in Carroll (2000) and De Nardi (2004), who employ preferences where bequests are a luxury good. A second model feature that helps reconcile the different properties of the earnings and wealth distribution is the presence of a social security system.

Our model has two features that are not staples of the wealth distribution literature. One is the explicit treatment of durables (both consumer durables and houses), which allows a distinction between financial and nonfinancial wealth. In addition, we assume that labor supply is endogenous, and we calibrate both earnings and wealth observations to a cross section of SCF data. In this respect, we follow Castañeda, Díaz-Giménez, and Ríos-Rull (2003). In contrast, most other studies work with an exogenous earnings process estimated from panel data.<sup>3</sup>

### 3 The Model

This section introduces an theoretical framework that can be used to assess the economic implications of redistribution shocks. We use an overlapping generations model in which people differ both by age and by “type,” where the types will later be calibrated to different groups of households in the US population. Apart from predicting the reaction of firms and consumers, the model will also allow us to explore the role of government behavior. We use the model as a laboratory to explore different reactions of the government to this windfall, such as lower taxes, higher government expenditures, or increased social security.

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<sup>3</sup>We do not use panel data since, unfortunately, common panel data sets contain little information about rich households, who are particularly prominent owners of nominal assets.

## Preferences

We consider an overlapping-generations economy in which consumers live for  $N + 1$  periods, from 0 to  $N$ , and derive utility from durable and non-durable consumption. Every period, a cohort of size one is born. The utility function of a household of type  $i$  born at time  $s$  is:

$$\sum_{t=s}^{s+N} \beta_i^t u_i(c_{i,s,t}, d_{i,s,t}, 1 - l_{i,s,t}) + v_i(b_{i,s}), \quad (1)$$

where  $c_{i,s,t}$  is non-durable consumption,  $d_{i,s,t}$  are houses (consumer durables),  $l_{i,s,t}$  is labor supply,  $1 - l_{i,s,t}$  is leisure, and  $b_{i,s}$  is the bequest left to the next generation.<sup>4</sup> Preferences for bequests are of the “warm-glow” type, that is, parents derive utility directly from the bequest given to their children, as opposed to the children’s utility.

The consumer receives a bequest in the first period of life, works for the first  $N - 1$  periods, and is retired during the last two periods. During retirement, the consumer receives a social security benefit from the government. Utility is maximized subject to the following budget constraints:

$$c_{i,s,s} + d_{i,s,t} + a_{i,s,s+1} = (1 - \tau_s) w_s \phi_{i,0} l_{i,s,s} + b_{i,s-N}, \quad (2)$$

$$c_{i,s,t} + d_{i,s,t} + a_{i,s,t+1} = (1 - \delta) d_{i,s,t-1} + R_t a_{i,s,t} + (1 - \tau_t) w_t \phi_{i,t-s} l_{i,s,t} \quad (3)$$

$$\text{for } s < t < s + N - 1,$$

$$c_{i,s,s+N-1} + d_{i,s,s+N-1} + a_{i,s,s+N} = (1 - \delta) d_{i,s,s+N-2} + R_{s+N-1} a_{i,s,s+N-1} + tr_{s+N-1}, \quad (4)$$

$$c_{i,s,s+N} + p_{s+N} d_{i,s,s+N} + b_{i,s} = (1 - \delta) d_{i,s,s+N-1} + R_{s+N} a_{i,s,s+N} + tr_{s+N-1}. \quad (5)$$

Here  $a_{i,s,t}$  are savings,  $R_t$  is the interest rate,  $tr_{s+N-1}$  is a social security transfer,  $w_t$  is the wage, and  $\phi_{i,t-s}$  is an age- and type-specific skill parameter. Notice that the social security transfer is indexed by the first period of retirement, and is the same in both periods of retirement. In the last period, instead of buying houses outright, consumers rent the houses at price  $p_{s+N}$ . The rental units are owned by other households as part of their assets  $a_{i,s,t}$  and the price of renting adjusts such that the return on owning houses is equal to the return on other assets. Equivalently, we could have assumed that rental services are supplied by a competitive industry that borrows money to build and rent out houses.

<sup>4</sup>The explicit treatment of durables allows us to distinguish financial and nonfinancial wealth. The importance of durables for understanding life cycle patterns in consumption and wealth has been stressed by Fernández-Villaverde and Krueger (2001).

We assume that young people buy houses, since otherwise the model could not match the observations that a large fraction of the population has positive net worth, but negative financial assets. At the same time, we assume that old people rent, so that we do not have to introduce additional assumptions on what happens to the houses of people after they die.

In a frictionless environment, owning a house and renting in a competitive market are equivalent. For a part of our analysis, however, we are going to assume that households face a borrowing constraint. In particular, households are only able to borrow up to a fixed fraction  $\psi$  of the value of their houses:

$$a_{i,s,t} \geq -\psi d_{i,s,t}. \quad (6)$$

As long as  $\psi < 1$ , a financially-constrained household would be better off renting housing services instead of buying, as long as the housing market is competitive. We still maintain the assumption that young households buy their houses, because this is the prevalent situation in the data. This choice could be formally justified by introducing additional frictions (such as tax advantages) that favor buying over renting.

### *Technology*

There is a competitive industry that produces the (nondurable) consumption good from physical capital  $K$ , intangible capital  $E$ , and efficiency units of labor  $L$  according to the production function:

$$Y_t = z_t (K_t^\rho E_t^{1-\rho})^\alpha L_t^{1-\alpha}.$$

Output can be transformed into either type of capital or into the durable consumption good (houses) without adjustment costs. Both  $K_t$  and  $E_t$  are owned by households and rented to firms. Productivity  $z_t$  grows at the exogenous and constant rate  $g$ :

$$z_{t+1} = (1 + g)z_t.$$

Firms rent physical and intangible capital at the common rental rates  $R_t$ , and the depreciation rates are  $\delta_K$  and  $\delta_E$ . In equilibrium, both types of capital have the same expected return. If in addition the two depreciation rates are the same, the two types of capital can be aggregated, and the model economy behaves just like the usual model with labor and physical capital only. Even in this situation, introducing intangible capital is useful for calibrating the model; in particular, we will be able to independently match the ratio of

business capital  $K_t$  to output and the return to capital to data.

Firms' first-order conditions equate the marginal product on either type of capital to its rental rate and the marginal product of labor to the wage rate. Due to the absence of arbitrage, the net returns on both types of capital must also be equal to the interest rate. We thus have:

$$R_t = 1 - \delta_k + z_t \alpha \rho \frac{Y_t}{K_t}, \quad R_t = 1 - \delta_E + z_t \alpha (1 - \rho) \frac{Y_t}{E_t}, \quad w_t = z_t (1 - \alpha) \frac{Y_t}{L_t}. \quad (7)$$

### *Government and Foreigners*

There is a government which taxes labor income and issues debt to finance social security transfers, general government expenditures  $G_t$ , and interest on existing government debt  $B_{t-1}$ . The labor tax  $\tau_t$  is linear, does not depend on the type of the worker, and may vary over time. The social security system consists of lump-sum payments  $tr_{t-1}$  and  $tr_t$  to every adult who retired in period  $t - 1$  and  $t$ , respectively. The period budget constraint of the government is:

$$B_t + \tau_t w_t L_t = R_{t-1} B_{t-1} + G_t + tr_{t-1} + tr_t. \quad (8)$$

Notice that the size of each cohort of retirees is one, so that population size does not enter on the right-hand side of the budget constraint. We do not assume that the government is benevolent or maximizes any particular objective function. Instead, our strategy will be to calibrate government behavior in the balanced growth path to US observations, and then explore the consequences of different government policies in reaction to an inflation shock.

In addition to the domestic consumers, we also allow for the possibility that foreigners are investing in the domestic market. Similar to our treatment of the government, the behavior of the foreigners will be taken as exogenous. Later on, the asset holdings of the foreigners will be calibrated to the net nominal position of the rest of the world. The assets held by foreigners in period  $t$  will be denoted  $a_{F,t}$ . In the model economy, net exports are given by interest payments to foreigners minus new foreign investment in domestic assets.

This completes the description of the main elements of our model. In Appendix A, we provide the remaining market-clearing conditions, specify the rental market for houses, and formally define an equilibrium.

## *Redistribution Shocks*

A redistribution shock is an unanticipated zero-sum redistribution of assets among the agents in the economy that displaces the economy from its balanced growth path. In particular, suppose that the economy is still on the balanced growth path in period  $t$ . The redistribution takes place among financial assets saved in period  $t$  for period  $t + 1$ . The generations affected by redistribution are thus all generations alive at the beginning of  $t + 1$ . Since the shock is unanticipated, it does not affect decisions in period  $t$ . Agents begin period  $t + 1$  with the asset position after the redistribution shock took place, and adjust their behavior accordingly. We concentrate on a one-time shock: no further redistribution takes place after period  $t + 1$ , and agents do not expect future redistributions. This approach is designed to isolate the wealth effect of redistribution on individuals' behavior.

The economic effects of the redistribution shock can be assessed by comparing the adjustment path after the shock with the balanced growth path. When computing the adjustment path, we have to take a stand on the behavior of the government and the foreigners after the shock. Unlike households and firms, whose behavior is ruled by utility and profit maximization, the decisions of government and foreigners are taken as exogenous in the model. We assume simple parametric decision rules on the part of these agents, and explore the sensitivity of the results to the government's and foreigners' behavior by experimenting with different rules.

More specifically, in the analysis below we assume that the government and foreigners target the ratio of their net asset position to GDP, either holding this ratio constant, or adjusting it at a constant rate towards the original balanced growth path. In the case of the government, we also have to determine how the different components of the government's budget (tax revenue, pension payments, government expenditures) adjust. In the quantitative analysis below we explore a number of different assumptions on this point.

Within the theoretical model, we do not take a stand on the origin of the redistribution shock, or the precise way how it is implemented. In the case of an inflation shock that we analyze below, a more direct interpretation could be given if we distinguished between nominal and real assets, which are affected differentially by inflation. Such an extension, however, would not change the predictions of the model. Since there is no uncertainty in the model, there is no meaningful distinction between nominal and real. If we formally introduced both types of assets, and both were held in positive quantities, agents

would be indifferent between them in any equilibrium, so that *any* profile of nominal positions could be maintained as an equilibrium outcome. In particular, there would be one equilibrium where the nominal asset positions exactly reproduce the redistribution vector calibrated in Section 4 below, given an unanticipated change in the unit of account of suitable size. However, no further insights would be gained from this formal exercise.<sup>5</sup>

## 4 Calibration

### 4.1 Model Parameters

To calibrate the model, we use statistics on aggregates as well as the cross section of households in the US. We specify household heterogeneity in the model to match the empirical analysis of nominal positions in Doepke and Schneider (2005). That paper sorts households, by age of the household head, into six cohorts: households under 35, 35–45, 45–55, 55–65, 65–75, and over 75. Consistent with this breakdown of the data, we assume that a model period lasts ten years, with the youngest cohort corresponding to ages up to 35 and the oldest cohort comprising those aged 75 and above.

For every age group, Doepke and Schneider (2005) isolate the top 10 percent of households by net worth and call them the ‘rich’. The non-rich households are then sorted by the amount of debt they owe. Those non-rich households whose market value of debt is above the median for non-rich households are labeled the ‘middle class’, while the rest makes up the ‘poor’. Table 5 provides some justification for the labels: it shows that the resulting middle class households have significantly higher earnings than the poor households. In the model, the three groups are distinguished by their earnings profile, their time preference, and by their preference for leisure and bequests.

In order to choose values for household, technology, and government parameters, we select a set of target moments. The parameter values are chosen such that the balanced growth path of our economy matches each of these statistics. In most cases, there is no

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<sup>5</sup>Of course, it would be a much harder exercise to match the empirical nominal position profiles using a *stochastic* model with nominal and real assets, in which an inflation shock is expected with some low probability. Constructing such a model is beyond the scope of this paper. Nevertheless, given that, as long as the profiles are matched, the resulting redistribution would be the same, we conjecture that most of the findings from our model would carry over to a more complicated setting. In particular, the post-inflation predictions would be unchanged if after the realization of the shock there were no further uncertainty.

one-to-one relationship between a moment and a particular model parameter. Nevertheless, it is helpful to distinguish three sets of moments, one for each sector. For households, the preference parameters and households' skill profiles determine the extent of consumption smoothing over time and across the three goods (nondurable consumption, houses, and leisure). We use data on labor earnings, wealth profiles, and aggregate statistics to guide our parameterization. The technology parameters determine the accumulation of tangible and intangible capital in the business sector. Here we target the labor share, the return on capital, and the ratios of depreciation and business capital to GDP. Finally, government behavior is calibrated in order to match the ratios of tax revenues, social security spending, and public debt to GDP.

### *Preferences and Skill Profiles*

A key requirement for the functional form of the utility function is to be consistent with balanced growth. We therefore choose the following period utility function:

$$u_i(c_t, d_t, 1 - l_t) = \frac{(c_t^{1-\sigma_i}(1 - l_t)^{\sigma_i})^{1-\gamma}}{1 - \gamma} + \eta \frac{d_t^{1-\nu_i}}{1 - \nu_i},$$

and the utility derived from bequests is given by:

$$v_i(b) = \xi_i \frac{b^{1-\epsilon_i}}{1 - \epsilon_i}.$$

The Cobb-Douglas specification of preferences over consumption and leisure is standard in the real business cycle (RBC) literature. We also follow the RBC literature in choosing the weight of leisure  $\sigma_i$  to match average labor supply to a target of 40 percent of the time endowment (in other words, a working adult works an average of 40 hours per week out of a total of 100 "disposable" hours, i.e., excluding sleep and basic maintenance). The parameter is allowed to vary across groups so that we can match labor supply for each group individually. Specifically, if all groups placed the same weight on leisure, the rich group would work too little relative to the data because of their higher wealth, which would also lead to widely different labor supply elasticities in the different groups.<sup>6</sup> The elasticity parameters  $\gamma$ ,  $\nu_i$ , and  $\epsilon_i$  govern risk attitudes and the intertemporal elasticity of

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<sup>6</sup>In the calibrated model, the Frisch labor supply elasticity at average hours is essentially identical across types, varying from 0.97 for the middle type to 1.00 for the rich type. These elasticities are within the range of existing empirical estimates, see Browning, Hansen, and Heckman (1999). In particular, the values are well below estimates for the elasticity of female and aggregate labor supply, but exceed estimates for males, which is appropriate since the model is formulated at the level of households.

substitution. We set  $\gamma$  to the standard value of  $\gamma = 2$ . Balanced growth then governs the remaining choices,  $\nu_i = \epsilon_i = 1 - (1 - \sigma_i)(1 - \gamma)$ .

The utility weight  $\eta$  determines the expenditure share of durables (which we interpret as houses). To match  $\eta$  to data, we take two different targets into account: the ratio of residential capital to physical capital in NIPA (which is 1.44 in 1989), and the ratio of nonfinancial wealth to net worth in the SCF data (58 percent in 1989). The valuation procedures used in these two data sources are not mutually consistent, so we cannot match both statistics at the same time. As an intermediate target that takes account of both numbers, we target a ratio of 1.8 for durables to physical capital, which results in a 36 percent share of durables in net worth.

The parameter  $\xi_i$  determines the expenditure share of bequests. In the data, bequests are highly concentrated among the richest groups of the population; the vast majority of people do not receive significant bequests at all. For example, Gale and Scholz (1994) reports that only 3.7 percent of households interviewed for the SCF in 1986 had received an inheritance, and households leaving or receiving inheritances had a net worth that is far above average. We therefore assume that only rich people care about bequests, setting  $\xi_p = \xi_m = 0$ . To calibrate  $\xi_r$ , we follow De Nardi (2004) and target the transfer wealth ratio, which is the fraction of total net worth accounted for by transfers from other households, including bequests and inter-vivos transfers (but not college payments). Using the estimate of Gale and Scholz (1994), we target a transfer wealth ratio of 60 percent.

The time preference parameters  $\beta_i$  determine the amount of capital accumulation in the economy, the steepness of lifetime asset and consumption profiles, and the relative net worth of different types of households. We therefore use three different targets to set the  $\beta_i$ : the ratio of the measured capital stock to output in the business sector, which was 1.55 in 1989, the ratio of rich-to-middle-class net worth, which was 12.64 in the 1989 SCF, and the ratio of middle-to-poor net worth, which was 1.94. To match these targets, we have to assume that the rich type is significantly more patient than the other types. This follows because the rich have a steeper asset profile, and their share of total wealth is much higher than their share of labor earnings.<sup>7</sup>

The skill parameters  $\phi_{i,n}$  are chosen such that the cross-section of labor earnings in the balanced growth path of the model matches observed earnings in the 1989 SCF. Notice that because the balanced growth rate is positive, the cross-section of earnings is not iden-

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<sup>7</sup>See also Carroll (2000).

tical to the lifetime profile of earnings for a given type. In particular, the lifetime profile is steeper than the cross-section profile, since wages rise over time. Before we can match model earnings to data, a couple of steps are necessary to ensure a consistent measurement of earnings in model and data. In the SCF, we observe labor earnings, business income, and private business wealth and other financial wealth for each type and cohort. The model does not distinguish between private business and other financial assets; business wealth in the data is therefore interpreted as a part of overall financial wealth in the model. Here, however, a potential measurement problem arises. Since in the model there is just one type of financial asset, by definition business wealth has the same rate of return as any other type of financial wealth. In the data, however, we see that the implied returns on private business wealth (the ratio of business income to business wealth) greatly exceeds the return on other financial assets. We deal with this inconsistency by assuming, perhaps realistically, that part of what is labeled as business income in the SCF should actually be interpreted as labor income, since it is derived from running the private business. We therefore construct earnings targets by adding observed labor income and business income that exceeds the income implied by the return on financial assets in the model. This adjustment is important to match the earnings of the rich, who derive a large part of their income from private business. Using  $e_{i,n}$  for the SCF earnings of type  $i$  and cohort  $n$ ,  $bi_{i,n}$  for business income,  $bw_{i,n}$  for business wealth, and  $R$  for the rate of return, the earnings targets  $\hat{e}_{i,n}$  are:

$$\hat{e}_{i,n} = e_{i,n} + [bi_{i,n} - (R - 1)bw_{i,n}].$$

The average level of earnings in the economy is a scale factor. We therefore normalize the skills of the youngest poor cohort to one, and choose the  $\phi_{i,n}$  to match the ratio of the earnings of each type and cohort to the earnings of this group. Table 5 displays the (relative) earnings targets.

### *Technology Parameters*

The only non-standard aspect of our technology is the presence of intangible capital. Since investment in intangible capital is not measured as investment in NIPA, production  $Y_t$  and measured output are not identical concepts in our economy. To link model output and measured output in the balanced growth path, we use the resource constraint of the economy:

$$C_t + I_t^k + I_t^h + G_t = Y_t - I_t^e.$$

We equate the right-hand side to the NIPA GDP for the business sector. This output is either consumed or invested in physical (household or business) capital. As mentioned earlier, the ratio of business capital to measured output is matched to data by choosing the time preference parameters of consumers. Given this ratio, the share of intangible capital  $1 - \rho$  determines the equilibrium rate of return. Given our other calibration choices, we find that setting  $\rho = 0.5$  leads to a return of 8.25 percent per year, which is close to the 8.4 percent real annual return on the US stock market computed by Jagannathan, McGrattan, and Scherbina (2000) for the period 1945–1999. If we did not allow for intangible capital, the model would imply a much higher, counterfactual return. The share parameter  $\alpha$  determines the fraction of output going towards compensation of capital and labor. Once again, we cannot match  $\alpha$  to the capital share directly due to the presence of unmeasured output. The measured labor share of our economy is given by  $w_t L_t / (Y_t - I_t^e)$ , which we match to the observed value of 0.66 in the data. The depreciation rate on physical capital can be inferred directly from NIPA. Given the observed NIPA rate for the business sector, we select 7 percent per year, or  $\delta_k = 1 - (1 - 0.07)^{10}$ . We also impose that all depreciation rates are identical, so that  $\delta = \delta_e = \delta_k$ . Finally, the growth rate  $g$  of TFP is set to 2 percent per year, which approximates the average growth rate of the real output per person in the US economy over the past century.

#### *Behavior of the Government and Foreigners*

The government parameters to be calibrated are the labor tax rate  $\tau_t$ , the social security transfer  $tr_t$ , and general government spending  $G_t$ . Given these choices, the interest rate and productivity growth rate pin down the ratio of government debt  $B_t$  to GDP in the balanced growth path. We choose  $\tau$  to match the ratio of tax revenues to measured GDP to its observed value of one-third. The social security transfer  $tr_t$  is chosen to match the ratio of social security transfers to measured GDP, which is seven percent. Finally,  $G_t$  is chosen to target the ratio of government debt to GDP. Our target measure of government debt is the net nominal position of the government.<sup>8</sup>

Finally, we need to calibrate the asset holdings of foreigners. Consistent with the calibration to a balanced growth path, we assume that foreign asset holdings grow at the same

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<sup>8</sup>An alternative strategy would be to choose  $G_t$  to target the ratio of (non-social-security) government spending to GDP. However, following this strategy would lead to a counterfactually low ratio of government debt to GDP. The reason for this discrepancy is that the model has just one rate of return, which is targeted to match average stock market returns. Since in the real world government debt has a lower return than equity, we cannot match the government spending ratio and the debt ratio at the same time. For our redistribution exercise, it is important for the model to have a realistic ratio of public debt to private debt, which is why we target the debt-to-GDP ratio.

rate as output. The level of foreign assets is calibrated to the net nominal position of the rest of the world in 1989, which is 15.25 percent of measured GDP. The complete model parameterization is summarized in Table 6.

## 4.2 The Redistribution Shock

To calibrate the redistribution shock, we use evidence on household nominal positions in 1989 and 2001. In Doepke and Schneider (2005), we document the distribution of nominal assets and liabilities in the United States, combining data from the Survey of Consumer Finances (SCF) and the Flow of Funds Accounts (FFA).<sup>9</sup> To capture the maturity structure of nominal positions, we construct *nominal payment streams*: using data on interest rates and maturities for several broad asset classes, we determine, for every household in the SCF, a certain net payment stream that the household expects to receive in the future. The market value of the household's nominal position in 1989 can be calculated by discounting its nominal payment stream with the 1989 nominal term structure. Its gain or loss from an inflation episode is obtained by revaluing the payment stream.

In particular, we estimate the gain or loss encountered if the 1973-82 inflation episode were to return at the end of the benchmark 1989. If this were to happen, the magnitude of any redistribution would depend on how quickly expectations and portfolios adjust during the episode. We do not take a stand on expectations and adjustment, but instead posit two scenarios that provide upper and lower bounds for the redistribution effect of inflation. We provide a brief discussion of these calculations here; a more formal description is contained in the appendix.

Our upper bound is a *Full Surprise* scenario: there is a one-time jump in the price level at the end of 1989, but the nominal term structure does not change. We choose the jump equal to the difference in cumulative inflation between the decades 1973-82 and 1989-1998, an increase of about 54%. Since the term structure is assumed not to change, the present value gains and losses can be computed by multiplying each position with a constant factor. Quantitatively, the *Full Surprise* case delivers an upper bound on present value gains or losses during the ten year inflation episode: we are effectively assuming that households do not react at all to inflation. Qualitatively, the *Full Surprise* case is special

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<sup>9</sup>Here we include not only direct nominal asset holdings and debt, but also nominal assets held indirectly (such as ownership of shares in a mutual fund that holds nominal bonds) and debt owed indirectly (for example, through ownership of a business that in turn has issued nominal debt).

since positions of different maturity all experience the same proportional gain or loss. This feature would also obtain if there was a sequence of surprise changes.

Our second scenario assumes that in 1989 there is a surprising *announcement* of a new, higher, inflation path, namely the inflation observed 1973-82. The announcement is assumed to immediately shift the nominal term structure up. In particular, suppose that the real term structure can be read off realized real interest rates 1989-1998 and does not change as a result of the announcement. We take the post-announcement nominal term structure as the real term structure plus 1973-82 (cumulative) inflation. Present value gains and losses are computed by discounting the nominal payment streams with the new nominal term structure and comparing the resulting new market value to the old 1989 market value.

Quantitatively, this second scenario delivers a lower bound for gains and losses, since nominal wealth invested in a given instrument in 1989 is protected from any inflation that occurs once the instrument has matured. For example, wealth invested in one year bills will only be affected by inflation over the first year: if it is reinvested after one year, this happens at the higher interest rate induced by the announcement. In other words, the scenario implicitly assumes that investors index their positions as soon as they mature. We thus refer to it as the *Indexing ASAP* scenario. Qualitatively, the *Indexing ASAP* is special in that it affects longer positions more than short positions.

#### *Redistribution across Households*

Table 1 summarizes the redistribution of wealth across sectors, stated as a percent of GDP. Table 3 considers redistribution within the household sector for the benchmark year 1989, with gains and losses of the different household types stated as a fraction of total losses incurred by the household sector. Taken together, these tables deliver two vectors of gains and losses relative to GDP—one for *Full Surprise* and one for the *Indexing ASAP* scenario—which we can plug into the model as redistribution shocks.

The redistribution effects are sizeable. A coalition of relatively old households lose between 7 and 18 percent of GDP. About three quarters of the loss are born by the top 10 percent of the wealth distribution, who hold a lot of long-term fixed-income securities. However, poor agents who hold most of their savings as deposits are also vulnerable to inflation. Within each wealth category, the largest losses are born by the oldest households, who are already in retirement. Within the household sector, the main winners are young middle-class households who bought a home and have large fixed-rate mortgages.

About half of the total gains in the redistribution accrue to this group. The remainder goes to the government, which also benefits at the expense of the foreign sector; the revaluation of government debt yields between 5 and 14 percent of GDP.

### *Mapping the Shock into the Model*

We map the redistribution totals in Tables 1 and 3 into a redistribution vector in the model by matching (for each group) the ratio of the total wealth gain or loss to measured GDP between model and data.<sup>10</sup> In the household sector, the losses or gains of the cohort up to age 35 affect the initial assets of the cohort 35–44, losses and gains from 35–44 affect initial assets at age 45, and so on. The youngest cohort under 35 starts with zero assets, and therefore does not experience a change in its initial assets. The young rich, however, may receive a different bequest because of the impact on their parents. The level of government debt and net asset holdings of foreigners are changed as well. Since in the model the last cohort dies at age 85, there is no cohort whose initial assets are affected by the gains and losses of the cohort aged 75–85. For simplicity, we disregard the redistribution occurring in this age group.<sup>11</sup>

## **5 Findings from the Model**

In this section, we use the calibrated model to assess the economic implications of the wealth redistribution triggered by an unanticipated inflation episode. As discussed above, we model the arrival of inflation as a redistribution shock that displaces the economy from its balanced growth path. The direction and amount of the redistribution that we feed into the model has been calibrated Section 4.2. As can be seen from Table 1, the government is a major winner in the redistribution. We thus need to take a stand on how it will adjust its behavior. If tax rates and real government spending do not change, the government budget will be in surplus, and the real value of government debt will decline even further. Alternatively, the government could use the extra revenue to raise government spending or to lower taxes. In our benchmark experiment, the government uses the extra revenue

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<sup>10</sup>The redistribution in Table 1 does not add up exactly to zero because of data limitations; in each case, we adjust the gain of the government to ensure a zero-sum redistribution.

<sup>11</sup>To maintain a zero-sum redistribution, we reduce the gain of the government by the amount of losses in this cohort. We have also tried an alternative procedure in which the last cohort is interpreted as “open ended” and receives a larger total redistribution. The results were very similar to baseline approach. The main difference is a larger decline in the old cohorts’ consumption, with little effect on aggregates.

to raise government spending. The real value of government debt returns to its steady-state value, so that we do not induce permanent effects solely by imposing them on the reaction of the government. Alternative government policies will be considered below. We also have to take a stand on the behavior of foreign investors, who also lose from inflation. We treat the foreigners similarly to the government, that is, we assume that the real value of the foreigners' assets returns to the steady state over time.<sup>12</sup>

### *The Impact on Households*

We begin describing the impact of the inflation shock by looking at individual groups of households, leaving aggregates for later. Our baseline results are for the version of the model without a borrowing constraint. Figure 2 shows the impact on the consumption of each cohort that is alive at the time of a *Full Surprise* inflation shock. Consumption is displayed as a percentage deviation from consumption in the balanced growth path. Each panel shows the reaction of each cohort over their entire life cycle, and periods are labeled by their midpoint. For the cohort 75–85, for example, the inflation shock hits only in the last period. The graph therefore shows a zero effect until age 70 (that is, the decade 65–74), because for the oldest cohorts those ages are reached before the inflation shock. The middle-class cohorts 35–54 enjoy the largest positive effect, with a gain in consumption of up to six percent relative to the balanced growth path. These cohorts have a relatively large amount of debt (mainly mortgages to finance houses), and inflation lowers the real value of this debt. The pre-retirement cohort of the middle class (up to age 64) and the rich 35–44 also gain, but to a lesser degree. Finally, the youngest cohort of the poor and the middle class are winners as well, albeit for a different reason. These cohorts are not directly affected by redistribution, but they gain from general equilibrium price effects. In particular, a decline in total labor supply leads to a rise in wages.

All other types and cohorts lose from the inflation shock. The young rich lose because they receive a smaller bequest; the others lose because they hold nominal assets that decline in real value. The oldest cohort of the poor takes the largest hit, with a decline in consumption in excess of 12 percent. The old are disadvantaged in two different ways. First, they hold large amounts of nominal assets, which exposes them to inflation. Second, they are at the end of their life cycle, which implies that they cannot smooth the impact on consumption by lowering savings. The impact on consumption of durables or houses

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<sup>12</sup>Using other assumptions (such as a permanent reduction in the foreigners' assets) made little difference to the results, mainly because in the 1989 calibration the holdings of foreigners were still relatively low relative to GDP. For both government and foreigners, we assume that 50 percent of the gap to the pre-inflation net nominal position is closed per decade.

(not shown) is very similar to the impact on consumption: once again the young middle class wins, while the old, the rich, and the poor lose relative to the balanced growth path.

Figure 3 shows the impact on labor as a percentage deviation from average labor supply in the balanced growth path. With the exception of retired households, who have lost this margin of adjustment, the losers from inflation compensate for the impact by working more, while the winners (the middle class) enjoy more leisure. Notice that the cohorts with the largest increase in labor supply are the pre-retirement cohorts age 55–64 of the poor and the rich. These households have to use their “last chance” of adjusting, while younger households are able to smooth their adjustment over several decades.

Figure 4 shows the impact on savings. What is striking about this figure is the size of the effects. The middle class 35–44 increase their savings by more than 25 percent of their average savings in the balanced growth path, while the poor 65–74 experience a decline of more than 25 percent. Another interesting observation is that while from age 45 on the reaction of the rich and the poor are quite similar, in the youngest cohort it is the poor and the middle class who behave very similarly. The reason is that in the youngest cohort only the rich are directly affected by inflation through receiving a smaller bequest. The poor and the middle class only react to changing prices.

### *The Impact on Aggregates*

Figure 5 displays the effect on economic aggregates. Here period 0 is the impact period, and effects are displayed for the first five decades after the shock. The change in the interest rate is displayed in basis points, and the effect on the other variables is given as a percentage deviation from the balanced growth path. In each panel, the solid line corresponds to the *Full Surprise* experiment discussed so far. In absolute terms, aggregates move a lot less than type- and cohort-specific variables, indicating that the individual effects partially offset each other. Nevertheless, a clear pattern emerges, which can be related to the individual characteristics of borrowers and lenders in the economy. The first notable feature is a persistent decline in labor supply. This decline is driven by the middle class, who profit from a positive wealth effect and choose to enjoy more leisure. The decline of labor supply is partially offset by the rich and the poor. The net effect is still negative, however, since a large fraction of the losers from inflation are retirees, who are unable to adjust their labor supply. Therefore, the age structure of gainers and losers from inflation is key for the aggregate effect on labor supply.

The evolution of the capital stock is driven by life-cycle effects as well. The capital stock

increases for two decades after the impact of the shock. The relatively young gainers from inflation increase their savings, while the older losers have a smaller decrease in savings, since they are closer to the end of the life cycle. The capital stock continues to increase over the first decades, because the losers reach the end of their life cycle before the gainers do. The middle-class gainers from inflation are still alive after twenty years, and their additional savings account for the high capital stock in this period. The effect is reversed when the middle class cohorts who initially had the largest gains reach the end of their life cycle. After a number of decades, none of the cohorts that were directly affected by the inflation shock remain, and the aggregate effects begin to peter out.

The net impact on output is a decline of up to 0.8 percent relative to the balanced growth path during the first three decades, and an increase of up to 0.25 percent thereafter. Notice that while the effects are moderate in magnitude, they are extremely persistent. Given an average decline of about 0.6 percent relative to the balanced growth path over the first twenty years, the cumulative amount of output lost is large. In addition, the output effect is on the same order of magnitude as what is generated by representative-agent models with monetary frictions. For example, Cooley and Hansen (1989) find that in a standard cash-in-advance model with stochastic money supply, a permanent increase in inflation from 0 to 10 percent reduces steady-state output by about 0.8 percent (with a cash-in-advance constraint that requires that the equivalent of one month of consumption has to be held in cash). Notice that we consider a smaller experiment (a one-decade-long shock that adds an average of 5 percent inflation per year), and our effects arise from redistribution only.

So far, we have only considered the *Full Surprise* inflation experiment. Under the alternative *Indexing ASAP* assumption, assets and liabilities with maturities below ten years are affected less by inflation, since nominal interest rates are assumed to adjust to the new expected inflation path right away. As Table 1 shows, under this assumption the net loss of the household sector is only 3.1 percent of GDP, instead of 8.1 percent under the *Full Surprise* assumption. Despite the lower total amount of redistribution, the economic effects of an *Indexing ASAP* inflation shock are not just a scaled-down version of the *Full Surprise* shock. The reason is that the maturity structure of assets and liabilities differs across sectors and groups of households.

In Figure 5, the effects of the *Indexing ASAP* experiment are given by the dotted lines. The responses still have a similar shape, but are generally smaller. The initial impact on output declines to 0.25 percent, but it is more persistent than in the *Full Surprise* case.

Additional insights can be gained if we decompose the overall redistribution experiment into two components: redistribution among households, and redistribution among the household sector as a whole and the government and foreigners. Figure 5 shows what happens in the *Full Surprise* experiment if we only redistribute among households in the same amount as before, but isolate the government and foreigners from the redistribution. In terms of labor supply and output, this households-only redistribution leads to an even larger labor supply and output effect. The reason is that if the government receives its windfall, the households are poorer, while the demand for government consumption increases. Both effects increase labor supply. Turning to capital, results are changed only by a small degree under the households-only redistribution. This is different under the *Indexing ASAP* assumption, where in the households-only experiment the capital stock increases (relative to full redistribution). The reason for this discrepancy is related to the maturity structure of nominal assets in the different sectors. Most short-term borrowing and lending takes place within the household sector, while the government has a large amount of long-term debt. In the *Indexing ASAP* scenario, where redistribution affects mostly long-term nominal assets, the windfall of the government is a much larger component of overall redistribution than in the *Full Surprise* scenario. From the perspective of the households, the government's windfall is a loss of wealth, which tends to depress savings. Consequently, removing this loss has a large impact in the *Indexing ASAP* scenario. In contrast, in the *Full Surprise* scenario results are mostly driven by the life-cycle effects of redistribution within the household sector.

We repeated both experiments in versions of the model with a binding borrowing constraint, i.e., consumers can only borrow up to fraction  $\psi$  of the value of their houses. We experimented with a variety of values for  $\psi$ , but found that in each case the results were virtually the same as in the model without financial constraints. Intuitively, a borrowing constraint will change the reaction of households who are right at the constraint when the inflation shock hits. Since these households are borrowers, they gain from inflation; that is, the real value of their debt declines. Compared to an unconstrained household, a constrained household will spend a larger fraction of the windfall on additional consumption in the impact period, since consumption was previously limited by the constraint. At the same time, there will also be a larger increase in leisure, since a constrained household tends to increase labor supply to overcome the restriction. Quantitatively, however, these effects turn out to be small. The reason is that only the youngest households are financially constrained, and these households account for only a small part of the overall

effects.

### *Alternative Government Policies*

The purpose of our model is to gauge how the economy reacts to the redistribution of wealth induced by an inflation episode. While the model makes precise predictions about the reaction of the household sector, we had to make assumptions about the reaction of the government, which is a major beneficiary of the inflation-induced redistribution. The question arises whether our results are sensitive to alternative assumptions about the government's reaction to the inflation windfall. To evaluate the role of the government, we computed outcomes under a variety of scenarios concerning the reaction of the government.

In our model, apart from increasing government spending, the government may put additional funds to two alternative uses: it could lower taxes, or it could increase social security spending. The top panel in Figure 6 compares the impact on output across the three possible "pure" policies, i.e., the entire windfall is used either to increase general spending, increase social security, or lower income taxes. In each case, we use the *Full Surprise* scenario; effects are qualitatively similar, but smaller, in the *Indexing ASAP* case. We maintain the assumption that real government debt returns to its original steady state. The shape of the impact on aggregate output is remarkably similar across the three policies. In each case, output initially declines due to the negative effect on labor supply, and later increases due to the increased capital stock. Throughout the entire transition, output is highest if taxes are lowered, and lowest if pensions are increased. The intuition is that lowering taxes lowers distortions at the labor-leisure margin, which increases output. Subsidizing pensioners, in contrast, lowers incentives for saving.

So far, we have taken as given that the effect of wealth redistribution on the government is transitory, i.e., real government debt returns to its original steady state. However, the government could also decide to permanently keep government debt at its lower post-inflation value, which would allow either a permanent increase in spending or a permanent decrease in taxes. The bottom panel of Figure 6 displays the output effect of the three possible reactions in this scenario. Since the economy now converges to a different balanced growth path, permanent effects on output arise. Lowering taxes leads to the largest increase—about two percent of output in the steady state. Thus, in the long run, lowering taxes increases output more than increasing government spending. Raising pensions has almost no long-run effect. Since pensions are paid late in life, in this case the lower

government debt is counteracted by lower private saving.

### *Welfare Implications*

While the redistribution numbers computed in Section 4.2 give us a good indication of who gains and who loses from inflation, they are not sufficient to determine the overall welfare effect on each group. Households are also affected by the reaction of the government to inflation, as well as by general equilibrium price changes. To gauge the impact of inflation on group-specific welfare, Table 7 compares the utility of each type and cohort of consumer alive in the impact period to balanced-growth utility in the *Full Surprise* scenario under the three possible government policies, with government debt returning to steady state. Table 8 provides the same information for the *Indexing ASAP* case. For ease of interpretation, the numbers are expressed as equivalent proportional variations in consumption (both nondurable and durable). For example, an entry of -1.00 would indicate that the utility of the household in the inflation scenario is equivalent to the utility gained from the balanced growth allocation, with consumption and housing scaled down by one percent until the end of the life cycle. For people from the poor and middle groups who have reached the final period of their life, the welfare number is exactly equal to their percentage change in consumption. For younger people, this is not the case, because they can also adjust leisure, and the old rich can adjust bequests. We also display a weighted welfare criterion that places equal weight on each group alive in the impact period.<sup>13</sup> We discuss the results for the *Full Surprise* case first; qualitatively, the results under the *Indexing ASAP* assumption are similar.

The welfare calculations show that government policy determines the direction of the welfare effect for a number of groups of households. In the baseline experiment with an adjustment in government expenditure, a majority of households lose from inflation. Specifically, for all but one of the groups the sign of the welfare change is equal to the sign of the direct redistribution effect in Table 2. The exception consists of the young and poor households, whose small direct loss is more than offset by wage increases, which are driven by the reduction in aggregate labor supply. The middle class aged 35–45 gains most from inflation with a positive effect slightly above 11 percent relative to the balanced

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<sup>13</sup>While a formal political economy analysis is beyond the scope of this paper, our individual and aggregate welfare measures correspond to the objective functions of two commonly used political economy models, and in this sense indicate the “political popularity” of inflation. Under majority voting, each voter picks the platform which yields higher utility. In this case, each group’s political preferences can be read off the sign of the group-specific welfare effect. Probabilistic voting (see Persson and Tabellini 2000) introduces noise to voting decisions, and it can be shown that voting outcomes are equivalent to maximizing a weighted welfare function of the same type as our aggregate welfare measure.

growth path, while the oldest cohort of the poor suffers the largest welfare loss of over 12 percent. In this scenario, there is a direct link between redistribution and welfare, because the government uses its windfall to increase government spending, which does not enter anybody's utility.

The situation is different, however, if the government rebates its windfall to the households. In particular, if government spending is adjusted through increasing pensions, a majority of households gain from the redistribution shock, including most of the poor. The oldest group among the poor, which suffers a 12 percent welfare loss if the adjustment is through government spending, now experiences a gain of 0.3 percent. For a number of groups (including this one) the direct loss through the revaluation of their assets is more than offset by the compensating higher pension payments. Thus, while the poor as a group experience a negative direct redistribution effect, this loss turns out to be easy to compensate, precisely because it does not take much in terms of transfers to improve the well-being of the poor. From a political economy perspective, we conclude that the government can adopt simple fiscal policies in reaction to an inflation shock which imply that the shock benefits a majority. Thus, policymakers may be tempted to inflate the economy not just because they take some direct interest in the fiscal position of the government, but also because such a policy may actually have wide support if the losers from inflation receive some compensation.<sup>14</sup>

The temptation of inflation becomes even more apparent when we consider the weighted welfare measure, which is positive in each case. Three effects are at work here. First, the economy as a whole experiences a net gain, because inflation deflates the wealth of foreigners. Second, a reduction in government debt also registers as a welfare gain, since Ricardian equivalence does not hold in our OLG-economy with distortionary taxation. Third, inflation redistributes wealth from the rich to the middle class and to some of the poor. Since the rich have the lowest marginal utility, this redistribution also has a positive impact on the weighted welfare measure.

We can gauge the relative importance of the taxation of foreigners by computing results for an otherwise identical experiment that leaves the real value of the foreign asset hold-

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<sup>14</sup>It is intriguing to observe that the US inflation episode in the 1970s started right after social security was first indexed to inflation in 1972. While this policy change is unlikely to have been the main cause of the episode, it certainly lowered the political cost of inflation, and therefore may help explain why it took a decade until inflation was brought under control. In fact, the formula for the cost-of-living adjustment of social security was originally specified incorrectly. The retirees were actually overcompensated for inflation until 1978 (see Duggan, Gillingham, and Greenlees 1996), so real pensions rose as a result of inflation, just as in our "Pensions Adjust" policy experiment.

ings intact. In other words, redistribution takes place only between domestic households and the government, while the rest of the world is protected from inflation. To balance the total redistribution, we assign a smaller gain to the government. In this scenario, the overall welfare effect remains positive, but is smaller. In the *Full Surprise* case with government debt returning to the steady state, the weighted welfare effects are 0.17 if government spending adjusts, 0.99 when taxes adjust, and 0.98 when pensions are raised. In the spending experiment, the exclusion of foreign debt has almost no effect on welfare. The reason is that neither government spending nor the consumption of foreigners enter utility, so that the taxation of foreigners makes little difference to the domestic households if the government consumes all the gains. In the tax and pensions experiments, the implicit taxation of foreigners contributes slightly more than 50 percent of the overall welfare effect. The welfare effect is also positive if neither foreigners nor the government are affected by inflation, i.e., if we consider redistribution among consumers only. Here the welfare numbers are the same as the ones we got previously under the assumption that government spending adjusts.

The welfare effects are similar if we work under the alternative assumption that government debt does not return to the steady state. Even though we saw that making permanent changes to debt and taxes can have a sizable effect on output in the balanced growth path, this is of little relevance to the initial generations. The results are also qualitatively unchanged if we consider the *Indexing ASAP* scenario. Individual welfare effects are generally smaller due to the reduced redistribution volume, but duration effects are important. For the poor, for example, losses are much smaller under the *Indexing ASAP* scenario relative to *Full Surprise*, since most of their nominal assets are short term. For the rich as well as for the government and foreigners, the difference between the two scenarios is smaller. Once again, the weighted welfare effect is positive in each scenario.

When interpreting these results, one has to keep in mind that our model isolates only the welfare implications of the redistribution effect of an inflation shock. The traditional literature on the welfare cost of inflation, in contrast, builds on monetary frictions (from which we abstract), and finds that inflation lowers welfare. At the same time, the size of the effects is generally shown to be small, so that the positive effects arising from redistribution that we document here are likely to dominate. To give a concrete example, the estimates by Lucas (2000) imply that a *permanent* rise in inflation from zero to five percent lowers welfare in steady state by the equivalent of about 0.5 percent of consumption.<sup>15</sup>

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<sup>15</sup>The welfare cost of inflation is larger in economies where money is held to smooth consumption, and

The inflation shock that underlies our experiments is smaller, since it is transitory: inflation increases by about five percent over a single ten-year period. Even so, as long as the government's windfall is not used to increase government spending (which does not enter utility), in every scenario the positive welfare effect arising from redistribution is at least twice as large in absolute value as Lucas' welfare cost estimate. In the *Full Surprise* scenario, the positive welfare effect exceeds two percent for both the tax rebate and pension policies. Thus, even when we take into account standard estimates of the welfare cost of inflation arising from monetary frictions, the conclusion remains that under suitable government policies, the overall welfare effect of an unanticipated inflation shock is positive and large.

#### *Results for Baseline Year 2001*

Doepke and Schneider (2005) document substantial changes in the net nominal positions of different sectors of the US economy over the last 15 years. Most importantly, there has been a large decline in the net nominal position of the household sector, and a corresponding increase in the position of the rest of the world. We repeated our experiment with redistribution numbers generated from data in 2001 to gauge how important these changes are for the effects of inflation. To make results comparable, we used the same model calibration as before (apart from the asset positions of the rest of the world and the government, which were adjusted to their 2001 values).

Figure 7 shows the impact on economic aggregates for the 2001 experiment. Qualitatively and quantitatively, the effects are very similar to 1989 results. Important differences do arise, however, when we consider the welfare implications. The weighted welfare measures now show a bigger positive effect of up to 3.13 percent in the *Full Surprise* scenario with an adjustment in taxes (0.33 if spending adjusts, and 3.04 with an adjustment in pensions. The numbers for the gradual experiment are 0.21, 1.62, and 1.53 in the spending, taxes, and pension scenarios). The main reason for this larger effect is the increased net nominal position of the rest of the world. The devaluation of assets owned by foreigners is a windfall from the perspective of domestic households. The importance of foreigners can be gauged by recomputing the experiment under the assumption that foreigners are isolated from inflation (as if, counterfactually, foreigners only held inflation-indexed bonds). The weighted welfare effects in the spending, tax, and pension experiments are 0.21, 0.47, and 0.45 percent in the *Indexing ASAP* scenario, and 0.33, 0.52, and 0.52 percent

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there is a lack of other liquid assets that can serve this function (see Imrohoroglu and Prescott 1991 and Imrohoroglu 1992).

in the *Full Surprise* scenario. Thus, under the assumption that the government uses its windfall to either rebate taxes or raise pensions, the inflation tax on foreigners accounts for between 70 and 85 percent of the overall welfare effects.

In summary, across all our experiments we find that inflation-induced redistribution has a positive effect on standard weighted welfare measures. Even if we abstract from the fact that foreigners hold a sizable amount of domestic nominal assets, these positive effects are large enough to outweigh standard estimates of the welfare cost of inflation arising from monetary frictions. The large recent increase in foreigners' holdings of domestic, dollar-denominated debt, however, has made inflation an even more attractive proposition from a US perspective. In effect, foreigners are currently lending large amounts of funds to the US at terms of repayment that are under control of the US Federal Reserve System. Even moderate taxation of these funds through an increase in inflation of about 5 percent per year would result in substantial welfare gains for US households.<sup>16</sup>

## 6 Conclusions

The goal of this paper was to examine the importance of wealth redistribution as a channel for real effects of inflation. Building on empirical work in Doepke and Schneider (2005), we have computed the wealth redistribution that would be induced by a moderate inflation episode such as the 1970s. We find that even moderate inflation leads to sizeable redistribution of wealth. The wealth effects of inflation induce highly persistent effects on both individual welfare and aggregate economic activity. The main source of aggregate effects is that borrowers are younger than lenders. Standard life cycle considerations imply that the responses of young winners and old losers are not offsetting.

Discussion of optimal monetary policy in the US is often based on models with monetary frictions, where inflation causes inefficiencies and therefore lowers welfare. Our model

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<sup>16</sup>While these findings depend on the specific distribution of nominal assets and liabilities that we documented for the US, there is evidence to suggest that similar features may have played a role in other historical inflation episodes. For example, concerning the German hyperinflation of 1923, Holtfrerich (1986) finds that the distribution of wealth was leveled, with the rich losing the most and the gains being concentrated in the middle class. Moreover, "a significant proportion of creditor's losses arising out of the inflation was borne by foreigners who had taken up creditor positions in marks. The losses these suffered were of at least the same order of magnitude as German Reparation Payments between 1919 and 1923." (p. 333). Thus, despite the severe economic disruption caused by the hyperinflation, the distributional impact may have been among the key factors that rendered inflation attractive.

abstracts from frictions to isolate the distributional effects of inflation. Based on US data, we show that the redistribution caused by an inflation episode tends to increase the welfare of domestic households on average. This conclusion arises for two reasons. First, inflation imposes a tax on foreigners who hold domestic nominal assets. If the foreign net nominal position is positive, inflation creates a windfall from the perspective of domestic households. Second, inflation tends to redistribute income from the relatively rich to the relatively poor, which is also registered as an improvement by standard weighted welfare measures.

Our findings therefore lead to some doubts regarding the conventional wisdom that low inflation is always in the best interest of the domestic population. There is a sizable fraction of the US population which would stand to gain if another inflation episode such as the one in the 1970s were to occur. As more and more nominal assets are held by foreigners, this fraction of the population continues to grow. Currently, the potential welfare gains from taxing foreigners' nominal assets through a moderate increase in inflation easily outweigh standard estimates of the welfare cost of inflation. The current widespread optimism regarding continued low inflation in the foreseeable future may be misplaced.

We do not mean to suggest that policymakers should use inflation systematically to achieve distributional purposes. Clearly, a systematic policy of this kind would be impossible to implement, since redistribution arises only to the extent that inflation is unanticipated. At the same time, if the potential gains from inflation through redistribution are large, policymakers may find it more difficult to resist the temptation of inflation. Being aware of the potential redistribution effect may be important even if controlling inflation is the ultimate aim.

To this end, our analysis may provide a useful starting point for future research into the political economy of inflation. One of our key findings is that the cohort welfare effects are highly sensitive with respect to the fiscal policy regime followed by the government. If the government simply raises general spending, only the young middle class experiences a net gain from inflation, so that inflation would not be widely popular. If the windfall is used to raise pensions, however, the poor as well as the old middle class are compensated for all their losses, and most groups, apart from the very rich, stand to gain from inflation. As we discuss above, during the 1970s the US did have a policy of compensating retirees, since social security pensions were (perhaps inadvertently) over-indexed to inflation starting in 1972. Our results suggest that this policy may have contributed to the political sustainability of inflation. In future research, we plan to explore the role of fiscal

policies and redistribution effects in other historical inflation episodes.

## A Definition of an Equilibrium

It simplifies notation to define aggregate consumption, domestic assets, investment, and net exports in the economy:

$$\begin{aligned}
C_t &= \sum_i \mu_i \sum_{s=t-N}^t c_{i,s,t}, \\
A_t &= \sum_i \mu_i \sum_{s=t-N}^t a_{i,s,t}, \\
I_t^h &= \sum_i \mu_i \sum_{s=t-N}^t [d_{i,s,t} - (1 - \delta)d_{i,s-1,t-1}], \\
I_t^k &= K_{t+1} - (1 - \delta_k)K_t, \\
I_t^e &= E_{t+1} - (1 - \delta_k)E_t, \\
NX_t &= R_t a_{F,t} - a_{F,t+1}.
\end{aligned}$$

where  $\mu_i$  is the size of group  $i$ , and we have  $\sum_i \mu_i = 1$ . For the definition of an equilibrium, we also have to be more specific about the rental price of houses, and the amount of assets committed to housing the old. The houses rented by the old people are part of the stock of assets owned by other households. The rental price of houses adjusts such that the return to investing in houses for rent is equal to the interest rate. If the rent is  $p_t$  per unit, investing in one house requires  $1 - p_t$  per unit today for a return of  $1 - \delta$  tomorrow. The returns are therefore equalized if:

$$\frac{1 - \delta}{1 - p_t} = R_{t+1},$$

or:

$$p_t = 1 - \frac{1 - \delta}{R_{t+1}}. \quad (9)$$

The amount of assets committed to housing the old is given by:

$$D_t = (1 - p_t) \sum_i \mu_i d_{i,t-N,t} = \frac{1 - \delta}{R_{t+1}} \sum_i \mu_i d_{i,t-N,t}.$$

**Definition 1 (Equilibrium)** *An equilibrium consists of a sequence of prices  $\{w_t, R_t, p_t\}$ , household allocations  $\{c_{i,s,t}, d_{i,s,t}, a_{i,s,t}, l_{i,s,t}, b_{i,s}\}$ , foreigners' assets  $\{a_{F,t}\}$ , firm decisions  $\{Y_t, K_t, E_t, L_t\}$ , and government decisions  $\{B_t, \tau_t, G_t, tr_t\}$  such that:*

1. Given prices, the households' decisions maximize utility (1) subject to the budget constraints (2)-(5) and the borrowing constraint (6).
2. Given prices, firms maximize profits, i.e., (7) is satisfied.
3. The government budget constraint (8) is satisfied in every period.
4. The rental market clears, i.e., (9) holds.
5. The goods market clears in every period:

$$C_t + I_t^k + I_t^e + I_t^h + G_t + NX_t = Y_t.$$

6. The labor market clears in every period:

$$L_t = \sum_i \sum_{s=t-N}^t \phi_{i,t-s} l_{i,s,t}.$$

7. The asset market clears in every period:

$$A_t + a_{F,t} = K_t + E_t + D_t + B_t.$$

## B Computation of Gains and Losses from Inflation

It is convenient to represent the computations underlying both of our scenarios as adjustments to the nominal term structure, holding the real term structure fixed.<sup>17</sup> Let  $i_t^n$  and  $r_t^n$  denote the total yields on  $n$ -year nominal and indexed zero-coupon bonds, respectively, in the benchmark year  $t$ . Suppose that the Fisher equation holds ex ante in the benchmark year, so that  $\pi_t^n = i_t^n - r_t^n$  is cumulative expected inflation. Let  $\tilde{\pi}_t^n$  denote the new inflation path realized from  $t$  to  $t+n$ . The inflation factors for our baseline experiments with benchmark year 1989 are depicted in Figure 1. We take the real interest rate to be equal to the nominal rate minus realized CPI inflation, with the 2003 inflation rate used for expectations beyond 2003.<sup>18</sup> The initial expectations  $\pi_t^n$  are shown as the dashed black line starting in 1989. To obtain the new inflation path, we replace the first ten years of inflation implicit in  $\pi_t^n$  by realized inflation starting in 1973. The resulting cumulative new path  $\tilde{\pi}_t^n$  is shown as the solid grey line starting in 1989.

<sup>17</sup>The assumption that real interest rates do not move with redistribution is in line with the calibrated model in Section 5 below, where the redistribution shock has only a small effect on the real interest rate.

<sup>18</sup>An alternative would be to estimate a time series model for inflation and use the forecast from that model. However, since inflation is very persistent, the results would be rather similar, at least after the high inflation of the 1980s.

Under *Indexing ASAP*, the new inflation path is announced at the end of the benchmark year. The nominal yield curve thus immediately adjusts to  $\tilde{v}_t^n = r_t^n + \tilde{\pi}_t^n$ . To determine gains and losses, we revalue the payment streams associated with bonds and fixed rate mortgages using this new yield curve. Consider a position that promises a single payment  $\nu_{t+k}$  in year  $t+k$ . The percentage loss on this position is  $1 - e^{-(\tilde{\pi}_t^k - \pi_t^k)}$ . The difference between cumulative inflation paths (given by the difference between the solid grey and dashed black lines in Figure 1) is steeply increasing in maturity. This reflects the fact that the *Indexing ASAP* scenario allows for implicit adjustment by agents towards indexed portfolios. To see this, let  $\tilde{v}_{t+k}^{10-k}$  and  $r_{t+k}^{10-k}$  denote the  $(10-k)$ -year nominal and indexed forward interest rates quoted at  $t$ , respectively and let  $\tilde{\pi}_{t+k}^{t+10}$  denote cumulative expected inflation from  $t+k$  to  $t+10$ . Since the Fisher equation holds after the announcement, the present value of the position can be rewritten as:

$$e^{-\tilde{v}_t^k} \nu_{t+k} = e^{-\tilde{v}_t^{10}} \left( \nu_{t+k} e^{\tilde{v}_{t+k}^{10-k}} \right) = e^{-(r_t^{10} + \tilde{\pi}_t^{10})} \left( \nu_{t+k} e^{(r_{t+k}^{10-k} + \tilde{\pi}_{t+k}^{10-k})} \right) = e^{-r_t^{10}} \left[ \left( e^{-\tilde{\pi}_t^k} \nu_{t+k} \right) e^{r_{t+k}^{10-k}} \right].$$

In other words, once the payment is due at  $t+k$ , it may be thought of as reinvested at the forward rate  $\tilde{v}_{t+k}^{10-k}$  which fully incorporates future inflation. Equivalently, in real terms, once the loss or gain from inflation up to  $t+k$  has been realized, reinvestment takes place at the real rate.

The simplest way to think about the *Full Surprise* scenario is that all positions are multiplied by the same factor,  $e^{-(\tilde{\pi}_t^{10} - \pi_t^{10})}$ . It thus represents revaluation in hypothetical situations where either the ten-year inflation occurs in one day, or, equivalently, where agents are not allowed to touch their portfolios for ten years. To see that similar outcomes are possible with rebalancing but repeated surprises, consider again the present value of a position that pays  $\nu_{t+k}$  at date  $t+k$ . As under *Indexing ASAP*, the investor will take a loss as the real value of the payment at  $t+k$  falls to  $e^{-\tilde{\pi}_t^k} \nu_{t+k}$ . Now suppose the payment is reinvested. Since agents hold on to their original inflation expectations  $\pi_t^k$  as the inflation episode unfolds, the spot nominal interest rate on a  $(10-k)$ -year zero-coupon bond quoted at  $t+k$  is  $i_{t+k}^{10-k}$ , which is unchanged from the forward rate quoted in the bond market at  $t$ . This interest rate does not offer full protection against the new inflation path  $\tilde{\pi}_{t+k}^{10-k}$ ; there will be an additional surprise loss on the position after reinvestment. The present value can be written as:

$$e^{-r_t^{10}} \left[ \left( e^{-\tilde{\pi}_t^k} \nu_{t+k} \right) e^{(i_{t+k}^{10-k} - \tilde{\pi}_{t+k}^{10-k})} \right] = e^{-(\tilde{v}_t^k + [\tilde{\pi}_{t+k}^{10-k} - \pi_{t+k}^{10-k}])} \nu_{t+k} =: e^{-(\tilde{v}_t^k + s_t^k)} \nu_{t+k}.$$

The cumulative inflation factor for the *Full Surprise* experiment is represented by the dotted black line in Figure 1. The *Full Surprise* loss depends on the difference between the dotted and dashed black lines and has two parts. First, there is the loss under *Indexing ASAP*. For all payments due after ten years, this part makes up for the whole loss—there is no difference between the two experiments for long-term positions. In addition, there is the surprise loss  $s_t^k := \tilde{\pi}_{t+k}^{10-k} - \pi_{t+k}^{10-k}$ , incurred through reinvestment of short-term positions. It depends on the difference between the dotted black and solid grey lines and

is decreasing in maturity—there are more surprise losses when reinvesting shorter term positions. Overall, the proportional loss on all positions is  $s_t^{10}$ .

Since the period length in our valuation framework is one year, the above discussion applies directly only to positions with maturity of one year or longer. We make analogous calculations for shorter claims. Under *Indexing ASAP* we assume that positions in deposits, non-mortgage loans and short term paper—all valued at par in our valuation exercise—can be adjusted within the first year of the inflation episode. The idea is that while it typically takes some time before loans can be repriced or deposits can be withdrawn, agents will try to earn a different interest rate as soon as possible. We devalue the par values by a six-month inflation surprise. Similarly, we devalue adjustable-rate mortgages with a one-year inflation surprise. This captures the fact that, for most ARMs, adjustment can only occur at specific times. Under the *Full Surprise* experiment, all positions are multiplied by the same surprise inflation factor, namely  $s_t^{10} = \tilde{\pi}_t^{10} - \pi_t^{10}$ . By analogy, we also multiply deposit, non-mortgage loan, and ARM positions by that factor.<sup>19</sup>

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<sup>19</sup>We assume indexing even on instruments for which current interest rates are zero, such as some checkable deposits. This is in line with the role of the *Indexing ASAP* scenario as a lower bound.

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	Government		Rest of World		Households					
					Total		Losses		Gains	
1989	<b>+14.1</b>	+5.2	<b>-6.7</b>	-2.3	<b>-8.1</b>	-3.1	<b>-17.5</b>	-6.6	<b>+9.4</b>	+3.5
2001	<b>+15.9</b>	+6.7	<b>-13.4</b>	-5.8	<b>-3.4</b>	-1.9	<b>-12.0</b>	-6.0	<b>+8.6</b>	+4.1

Net Gain from **Full Surprise** and Indexing ASAP Experiments.

Table 1: Redistribution across Sectors, 1989 and 2001, in Percent of GDP

Age	Poor		Middle		Rich	
<35	<b>-6.4</b>	-0.3	<b>+60.9</b>	+22.2	<b>+5.8</b>	+1.5
35–45	<b>-3.9</b>	-2.1	<b>+20.7</b>	+8.7	<b>-1.7</b>	-1.4
45–55	<b>-5.9</b>	-1.7	<b>+5.5</b>	+2.2	<b>-3.1</b>	-2.2
55–65	<b>-12.5</b>	-2.9	<b>-0.8</b>	-0.1	<b>-7.1</b>	-2.7
65–75	<b>-13.3</b>	-2.0	<b>-8.9</b>	-2.5	<b>-7.2</b>	-3.3
>75	<b>-14.3</b>	-1.0	<b>-16.5</b>	-2.0	<b>-11.4</b>	-4.7

Net Gain from **Full Surprise** and Indexing ASAP Experiments.

Table 2: Redistribution in 1989, in Percent of Net Worth

Age	All		Poor		Middle		Rich	
	-47	-49	-22	-14	+32	+41	-57	-76
<35	<b>+27</b>	+24	<b>-1</b>	-1	<b>+22</b>	+21	<b>+6</b>	+4
35-45	<b>+14</b>	+12	<b>-2</b>	-2	<b>+20</b>	+22	<b>-4</b>	-8
45-55	<b>-5</b>	-12	<b>-3</b>	-2	<b>+6</b>	+6	<b>-8</b>	-16
55-65	<b>-28</b>	-24	<b>-8</b>	-5	<b>-1</b>	0	<b>-19</b>	-19
65-75	<b>-30</b>	-29	<b>-7</b>	-3	<b>-6</b>	-5	<b>-17</b>	-21
>75	<b>-25</b>	-20	<b>-1</b>	-1	<b>-9</b>	-3	<b>-15</b>	-16

Net Gain from **Full Surprise** and Indexing ASAP Experiments.

Table 3: Redistribution in 1989, Group Totals, in Percent of Total Loss of Household Sector

Age	Poor		Middle		Rich	
<35	<b>-7.1</b>	-4.0	<b>+101.7</b>	+54.1	<b>+2.5</b>	+2.4
35-45	<b>-4.1</b>	-2.5	<b>+27.8</b>	+15.1	<b>+1.0</b>	+0.4
45-55	<b>-6.2</b>	-2.9	<b>+9.0</b>	+1.9	<b>-1.4</b>	-1.4
55-65	<b>-9.6</b>	-3.7	<b>+2.1</b>	-1.1	<b>-5.4</b>	-2.9
65-75	<b>-12.4</b>	-3.6	<b>-0.1</b>	-1.0	<b>-6.4</b>	-3.2
>75	<b>-11.8</b>	-1.6	<b>-10.5</b>	-2.5	<b>-7.1</b>	-3.4

Net Gain from **Full Surprise** and Indexing ASAP Experiments.

Table 4: Redistribution in 2001, in Percent of Net Worth

	<35	35-45	45-55	55-65
Rich	3.41	7.07	5.80	4.25
Middle Class	2.34	3.42	3.65	2.00
Poor	1.00	1.91	1.72	0.87

Table 5: Relative Earnings Targets

Preferences		Skills			Technology	Government
$\gamma = 2$	$\phi_{r,0} = 2.59$	$\phi_{m,0} = 2.39$	$\phi_{p,0} = 1.03$	$\alpha = 0.41$	$\tau = 0.5$	
$\sigma_r = 0.66$	$\phi_{r,1} = 5.15$	$\phi_{m,1} = 2.96$	$\phi_{p,1} = 1.52$	$\rho = 0.5$	$tr = 0.03$	
$\sigma_m = 0.71$	$\phi_{r,2} = 6.13$	$\phi_{m,2} = 3.11$	$\phi_{p,2} = 1.49$	$\delta = 0.52$	$G/Y = 0.24$	
$\sigma_p = 0.70$	$\phi_{r,3} = 8.10$	$\phi_{m,3} = 2.35$	$\phi_{p,3} = 1.13$	$\delta_K = 0.52$		
$\eta = 0.23$	$\phi_{r,4} = 0$	$\phi_{m,4} = 0$	$\phi_{p,4} = 0$	$\delta_E = 0.52$		
$\xi_r = 0.04$	$\phi_{r,5} = 0$	$\phi_{m,5} = 0$	$\phi_{p,5} = 0$	$1 + g = 1.02^{10}$		
$\beta_r = 1.35$						
$\beta_m = 0.61$						
$\beta_p = 0.66$						

Table 6: Calibrated Parameter Values

Age	Spending Adjusts			Taxes Adjust			Pensions Adjust		
	Poor	Middle	Rich	Poor	Middle	Rich	Poor	Middle	Rich
<35	0.62	0.61	-1.66	3.77	3.87	-0.57	0.64	0.62	-1.45
35-44	0.09	11.05	2.73	3.67	14.55	3.60	0.37	11.21	2.86
45-54	-1.05	10.02	-2.33	1.64	13.02	-1.98	-0.25	10.51	-2.19
55-64	-3.17	3.12	-3.40	-1.84	4.71	-3.22	-0.39	4.72	-3.20
65-74	-9.92	-0.78	-5.42	-9.79	-0.57	-5.25	2.86	6.62	-4.90
$\geq 75$	-12.45	-6.67	-4.97	-12.19	-6.32	-4.43	0.29	0.96	-4.65
Total		0.17			2.28			2.24	

Table 7: Welfare Effects based on Redistribution in 1989 for Different Fiscal Policies, *Full Surprise* Experiment, Public Debt Returns to Steady State

Age	Spending Adjusts			Taxes Adjust			Pensions Adjust		
	Poor	Middle	Rich	Poor	Middle	Rich	Poor	Middle	Rich
<35	0.16	0.16	-0.67	1.43	1.47	-0.25	0.17	0.16	-0.59
35-44	-0.10	3.91	0.72	1.36	5.35	1.07	0.01	3.98	0.76
45-54	-0.69	4.13	-1.37	0.40	5.36	-1.26	-0.39	4.31	-1.33
55-64	-0.95	1.26	-1.97	-0.42	1.91	-1.93	0.12	1.87	-1.90
65-74	-2.32	-0.18	-1.95	-2.27	-0.11	-1.90	2.83	2.80	-1.74
≥ 75	-1.94	-1.88	-2.20	-1.81	-1.73	-1.98	3.23	1.22	-2.06
Total		0.22			1.09			1.01	

Table 8: Welfare Effects based on Redistribution in 1989 for Different Fiscal Policies, *Indexing ASAP* Experiment, Public Debt Returns to Steady State

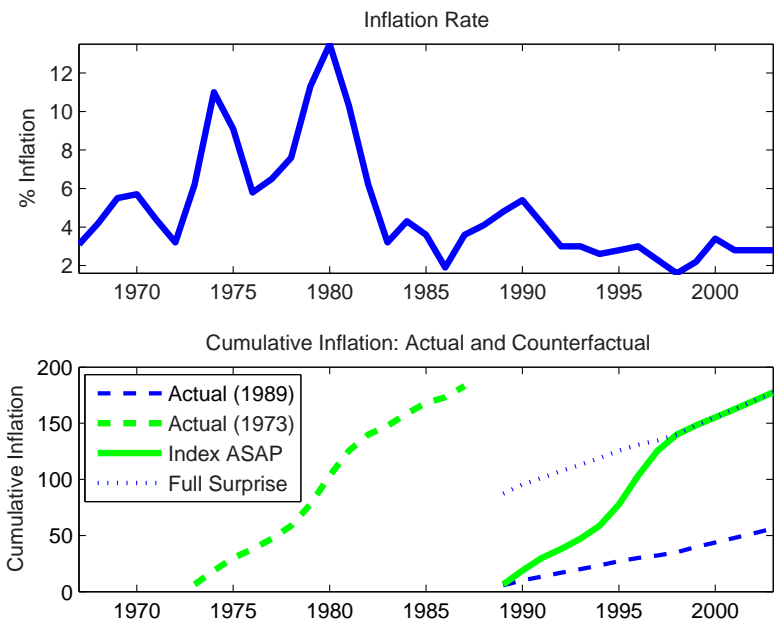


Figure 1: Inflation Expectation Factors for Redistribution Experiments

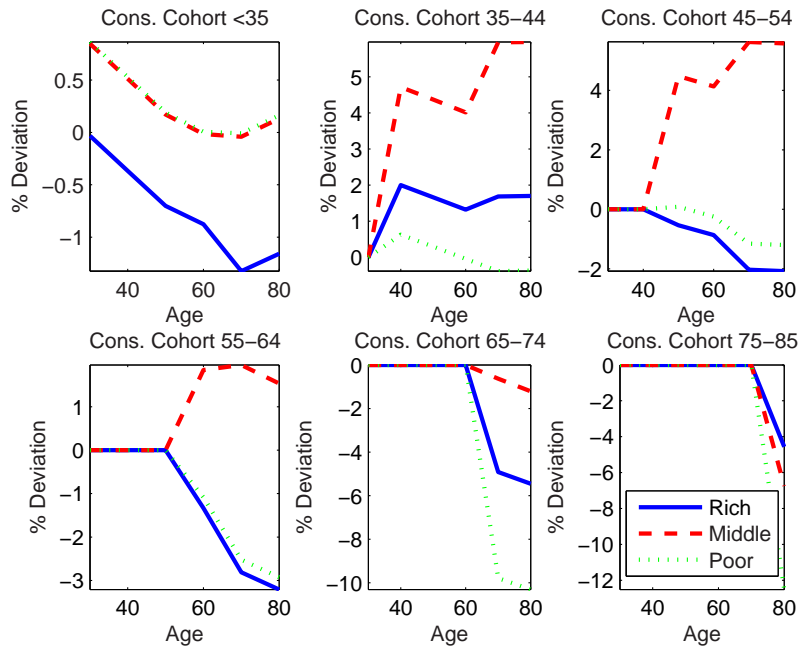


Figure 2: Impact on Lifetime Consumption, in Percent Deviation from Balanced Growth Path, based on Redistribution in 1989, *Full Surprise* Experiment

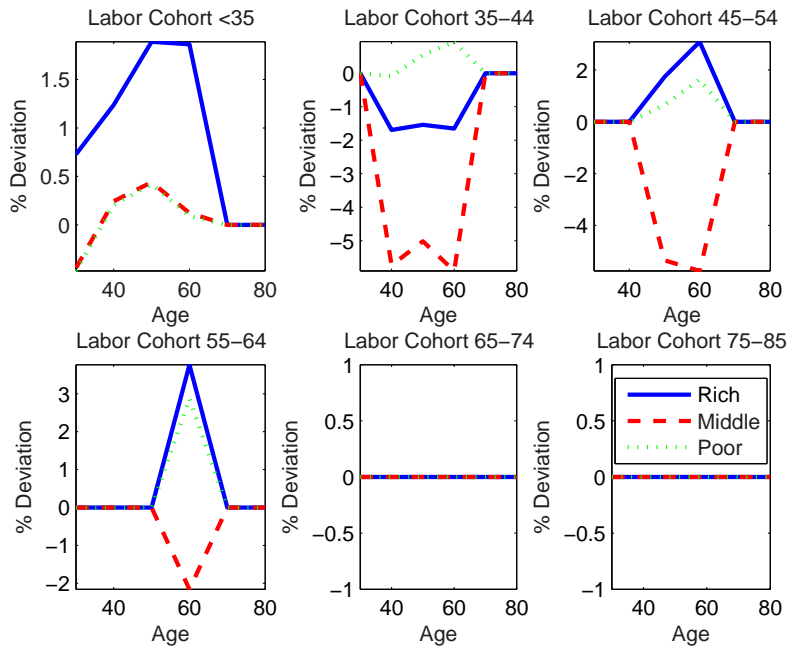


Figure 3: Impact on Lifetime Labor Supply, in Percent Deviation from Average Labor Supply on Balanced Growth Path, based on Redistribution in 1989, *Full Surprise* Experiment

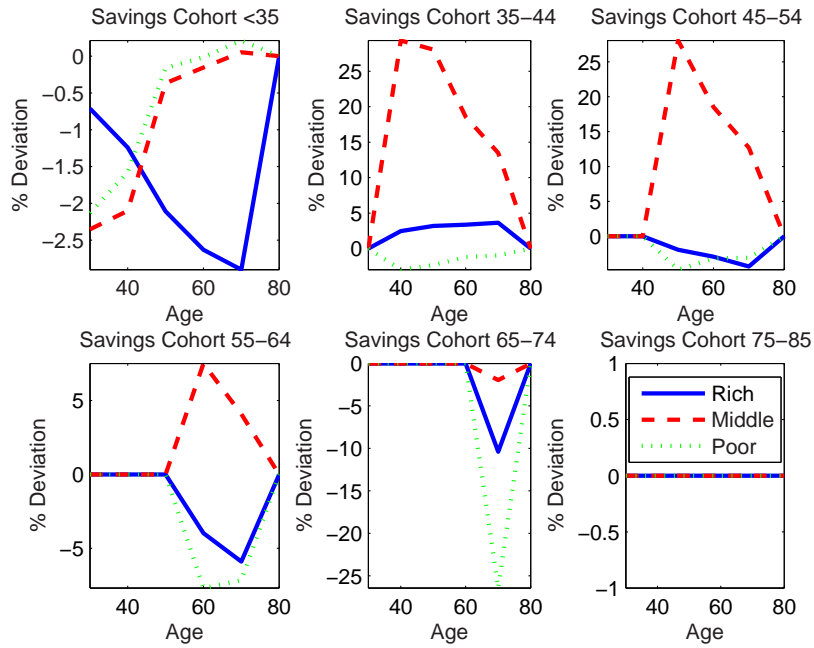


Figure 4: Impact on Lifetime Savings, in Percent Deviation from Average Savings on Balanced Growth Path, based on Redistribution in 1989, *Full Surprise* Experiment

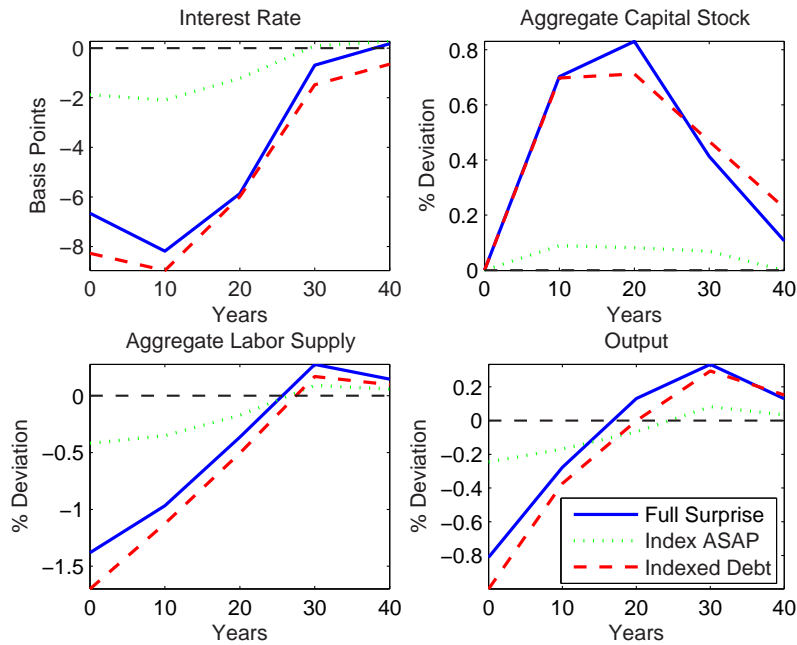


Figure 5: Impact on Economic Aggregates, in Basis Points (Interest Rate) and Percent Deviation from Balanced Growth Path (other Variables), based on Redistribution in 1989

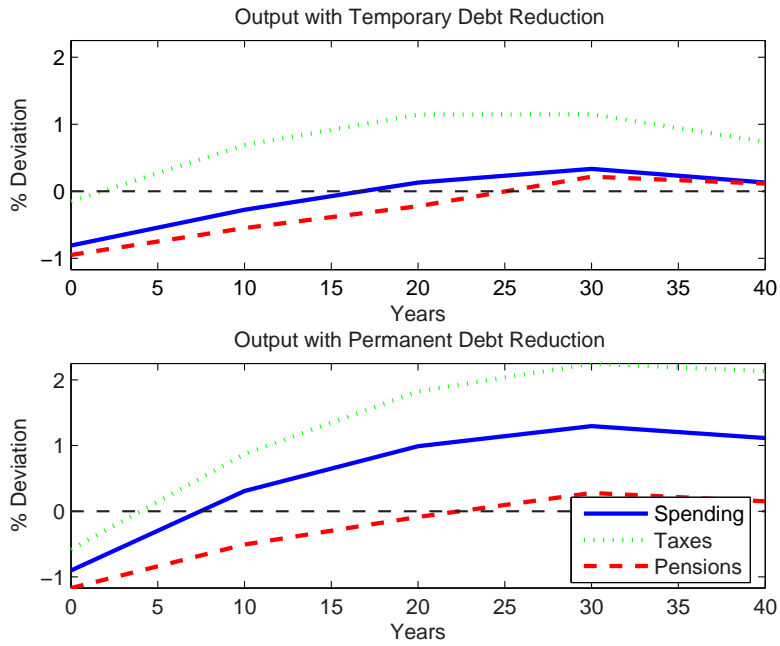


Figure 6: Impact on Aggregate Output by Policy Experiment, in Percent Deviation from Balanced Growth Path, based on Redistribution in 1989, *Full Surprise* Experiment

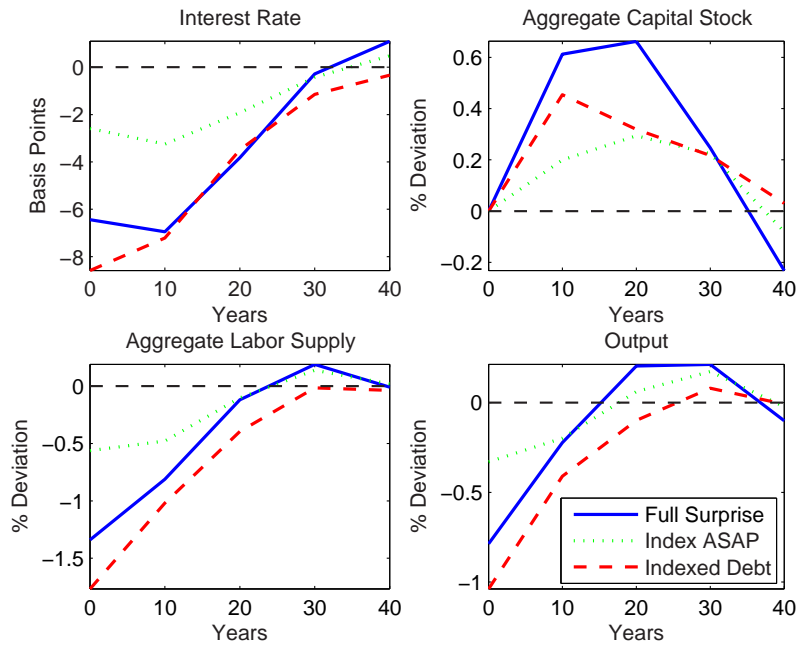


Figure 7: Impact on Economic Aggregates, in Basis Points (Interest Rate) and Percent Deviation from Balanced Growth Path (other Variables), based on Redistribution in 2001