Real Effects of Inflation: the Role of Redistribution through Nominal Debt *

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Abstract

This paper analyzes the effects of inflation through changes in the value of nominal assets. Nominal positions in the U.S. economy are documented for different sectors as well as age and wealth groups of households. The redistribution brought about by a moderate inflation episode is estimated and a calibrated OLG model is used to assess the long-term response of the economy under alternative fical policy rules. Redistribution takes the form of "ends-against-the-middle:" the middle class gains at the cost of the rich and poor. In addition, inflation favors the young over the old. The amount of redistribution is sizeable, and highly persistent real effects arise both at the individual and at the aggregate level.

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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. There is an old tradition in monetary economics that views redistribution as central for understanding both the real effects and the welfare costs of inflation.[1] More recently, redistribution through nominal debt has received little attention. On the one hand, modern quantitative analysis of the effects of inflation usually relies on representative-agent models. In such models there is no scope for redistribution – real effects of inflation instead derive from transaction constraints or nominal rigidities. On the other hand, heterogeneous agent models with money typically consider redistribution due to the effect of inflation on cash balances alone. However, cash makes up only a small fraction of nominal assets in the US economy.

This paper provides a quantitative study of the redistribution effects of inflation. We emphasize the role of money as a unit of account: inflation affects *all* nominal asset positions, not just cash positions. We find that even moderately high inflation leads to substantial redistribution of wealth. In particular, the young middle class gains at the expense of rich, poor and elderly households. Inflation also reduces the real value of government debt, as well as foreigners' net nominal assets. The wealth effects of inflation induce agents to adjust behavior over their whole life cycle. This gives rise to highly persistent responses at both the individual and the aggregate level. The magnitude of the aggregate effects is comparable to that in representative-agent models with standard monetary frictions. The welfare costs and benefits to individual groups of households are substantial.

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 U.S. today. Suppose an episode of moderate inflation, such as the 1970s, were then to occur. We want to know who would gain and who would lose during this episode, and what the resulting aggregate effects are. We answer these questions in three steps. First, we document nominal asset and liability positions in the U.S. economy for various groups of households, as well as the government and foreign sectors. Second, we es-

[1]See for example Fisher (1933).

timate the redistribution of wealth generated by a moderate inflation episode under various assumptions on agents' expectations of—and adjustment to—inflation during the episode. Third, we use a calibrated overlapping-generations model to assess aggregate effects and welfare costs under different scenarios for fiscal policy.

To determine nominal positions, we combine data from the Flow of Funds Accounts (FFA) and the 1989 and 2001 Surveys of Consumer Finances (SCF). We consider not only directly held nominal assets and liabilities, but also indirect nominal positions due to shares in investment intermediaries and the ownership of firms. For most securities, the data consist of accounting numbers that are difficult to interpret economically and compare across securities. We thus construct, for every major class of securities and agent position, the associated stream of future nominal payments. We then restate all positions at market value. This approach also allows us to estimate the duration of agents' positions, which matters for gauging the effects of partially anticipated inflation.

We document several stylized facts on net nominal positions that are crucial for understanding redistribution effects of inflation. First, indirect debt positions through equity holdings are an important part of households' overall nominal position. Second, foreigners are a major net nominal lender, especially in the last 15 years. Once indirect debt positions are taken into account, foreigners now hold more U.S. nominal assets than domestic households. Third, in the cross-section of households, young middle class cohorts with mortgage debt are the only important net nominal borrowers. Young rich and poor households, as well as the elderly at all income levels, are net nominal lenders.

We perform most of our inflation experiments for a benchmark low inflation year, 1989. We compute real gains and losses resulting from a change in the unit of account. The size of that change is motivated by the US experience of the 1970s: we consider a return of the ten-year inflation episode 1973-82. Our experiments are calibrated to capture different scenarios for how agents adjust expectations and portfolios during the episode. This leads us to interval estimates for gains and losses of different sectors and groups of agents. For the benchmark year 1989, a coalition of very rich, poor and old households loses a total of $6.6 - 17.6\%$ of GDP in present value terms. Roughly one half of this loss benefits middle class agents under the age of 45, who receive a gift worth up to 60% of mean cohort net worth. The remainder goes to the government, which altogether gains between 5.2% and 14.1% of GDP through a reduction in the market value of its net debt. Among losers, the poor give up more as a fraction of net worth, because they hold relatively less equity and more nominal assets than the rich. When we repeat the experiments for the benchmark year 2001, the government's gain is similar, but the main loser is now the rest of the world, with losses between 5.8% and 13.4% of GDP.

To assess the aggregate effects of redistribution, we employ a fairly standard deterministic neoclassical growth model with overlapping generations. The model is designed to exhibit the same dimensions of heterogeneity as our empirical analysis: agents differ by age as well as by skills and preferences, which gives rise to different income, debt, and wealth profiles. The model is calibrated so that its steady state equilibrium matches key aggregate ratios as well as properties of the wealth and income distribution. To explore the economy's response to an inflation episode, we treat the transfer of real wealth computed in our redistribution exercise as an unanticipated shock.

The model is designed to isolate the redistribution effects of inflation, and therefore abstracts from monetary frictions. Instead, aggregate effects of inflation derive from two sources: direct wealth effects on the different groups of households, and the response of fiscal policy. Fiscal policy must adjust in some dimension, since the reduction of real government debt presents the government with a windfall gain. We use our model to explore the response of the economy for a number of different fiscal policy rules: the government may use the real gain on its debt to increase spending, cut taxes, or increase social security transfers, and it may or make not make the debt reduction permanent.

Even though the redistribution shock is zero-sum, aggregate effects arise because net borrowers (winners) and net lenders (losers) respond differently. The key asymmetry in nominal positions is that net borrowers tend to be younger than net lenders. This gives rise to two basic 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 and do not adjust labor supply. 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 do old households.

In our calibrated model, the first effect makes aggregate labor supply decline by up to one and a half percent in the decade after the inflation episode. The second effect increases the capital stock up to 0.8 percent above the steady state three decades after the inflation episode. In the baseline case, the net result is a decline in output over the first three decades after the shock of up to 0.8 percent relative to steady state, followed by a temporary increase in output by up to 0.2 percent.[2] This qualitative pattern is robust across the different policy rules we consider. Quantitatively, lowering taxes in response to the inflation shock results in the smallest decline in output, while increasing pensions leads to the largest decline.

The effects on the welfare of individual cohorts are large. Retirees lose the most and experience a decrease in their consumption of up to 20 percent relative to steady state. In contrast, the young middle class cohorts receive the equivalent of a 5% permanent increase in consumption. Domestic households together also gain at the expense of foreigners. Indeed, according to standard weighted welfare measures, the aggregate welfare effect of inflation on domestic households is positive. It is particularly large in experiments with the benchmark year 2001, since foreigners became the main group of net nominal lenders in the 1990s.[3]

Throughout, we emphasize that redistribution effects depend – not only quantitatively, but also qualitatively – on how quickly agents adjust to inflation. In our experiments, we distinguish surprise inflation episodes, during which the duration of positions is irrelevant, from gradual inflation episodes, where gains and losses are relatively larger on positions of longer duration. The main result here is that gradual inflation episodes hurt foreigners and rich domestic households relatively more. In-

[2]These magnitudes are comparable to the results from representative agent models. For example, Cooley and Hansen (1989) find that, in a standard RBC model augmented by a cash-in-advance constraint (which requires that the equivalent of one month of consumption has to be held in cash), a permanent increase in inflation from 0 percent to 10 percent (a larger experiment than what we consider) induces a steady-state reduction in output of about 0.8 percent.

[3]While these findings depend on the specific distribution of nominal assets and liabilities in a country, evidence suggests that similar features may have played a role in historical episodes of high inflation. 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 on 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).

deed, foreign and rich investors hold more long term bonds than domestic poor and middle class households, who hold more short-term deposits. In addition, foreign and rich investors hold more equity. As a result, they have more indirect short-term debt – a lot of business debt is short term, as are deposit-type claims on the financial system. At the same time, the indirect long-term position is small, since mortgages and corporate debt tend to cancel. Gains due to indirect debt are thus due to short-term debt and are smaller in gradual inflation episodes.

We also show how financial innovation has recently changed the real effects of inflation in important ways. First, inflation risk has become more evenly distributed. On the one hand, more widespread equity ownership has provided more gains through indirect debt to the poor. On the other hand, securitization has reduced the maturity mismatch in the financial system, and hence shifted the risk of gradual inflation from shareholders to bondholders. This has further reduced the strong exposure of the rich to such risk. Second, all savers have become more vulnerable to inflation. Indeed, there has been a shift to more long term nominal positions since 1980, driven in part by securitization of mortgages and perhaps also by the increase in indirect holdings. In our experiments, we find that losses under *Indexing Asap* are much closer to the *Full Surprise* losses for 2001 than they are for 1989 – recent changes in financial structure make it harder for agents to adjust quickly to inflation.

The paper is organized as follows. The next section reviews the literature. Section 3 presents the distribution of nominal assets and liabilities in the U.S. economy. Section 4 quantifies the effect of an inflation shock. Section 5 presents and calibrates the theoretical model, which is used in Section 6 analyze the economic implications of an inflation shock. Section 7 concludes.

2 Related Literature

Existing literature on redistribution effects of inflation has focused on the incidence of the inflation tax on cash holdings. This issue plays a minor role in our analysis, since redistribution mostly derives from revaluation of long term nominal assets. The inflation tax studies of Erosa and Ventura (2002) and Albanesi (2002) also complement our paper in the sense that they concentrate on the distributional consequences of anticipated inflation, while we focus on unexpected changes in the price level. Erosa and Ventura (2002) observe that poor households tend to hold a much larger fraction if financial assets in the form of cash than rich households. They then study the consequences of inflation in a monetary growth model where households can use either cash or credit for transactions. Transaction costs for accessing the credit market render credit too costly for the poor, who end up using cash for most of their purchases. Comparing across steady states with different inflation rates, the poor pay a disproportional portion of the inflation tax and are relatively worse off when the inflation rate is high. [4]

Compared to Erosa and Ventura (2002) (who take inflation as given and explore its distributional consequences) Albanesi (2002) reverses direction and asks whether inequality can explain how the inflation tax is set in the first place. Again the poor are particularly vulnerable to inflation. However, the extent of their vulnerability varies and rises with income inequality. Both the income tax and the inflation tax are set in a political bargaining game between rich and poor households. Rich households prefer higher inflation and a lower income tax, since the inflation tax affects mostly the poor. In countries where poor households are vulnerable to inflation, they have a weak bargaining position, and consequently inflation is high in equilibrium. The model implies a positive correlation between inequality and average inflation that is confirmed by cross-country data.

A different aspect of the redistributive effect of inflation is explored by Persson, Persson, and Svensson (1998), who concentrate on the government's incentive to inflate the economy in order to reduce government debt. Using Sweden as an example, they assess the impact of a persistent rise in inflation by 10 percentage points from 1994 onwards on the government's finances, as well as the social costs of such an inflationary policy. The authors find the effect of this inflation change on the government's finances to be quite large, roughly equivalent to GDP in 1994 in present value. However, most of this effect is accounted for by incomplete indexation of the tax and transfer system, as opposed to the direct devaluation of government debt. Despite

[4]If households face uncertainty about their future income, an additional interaction between average inflation and saving behavior arises. Since the inflation tax hits mostly the poor, it acts like a nonlinear consumption tax. If inflation is high, consumers place even more weight on the risk of becoming poor, which raises precautionary savings among the relatively rich. Through this savings effect high inflation leads to a higher concentration of wealth.

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.

Our paper is also related to the large literature on the link between the earnings and wealth distributions in the U.S. 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-Gimenéz, 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-Gimenéz, and Ríos-Rull (2003), De Nardi (2002), Laitner (2001)).

Our model 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. Partly for this reason, we rely more on differences in preferences to match features of the 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 agents 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 (2002), who employ preferences where bequests are a luxury good. A second model feature that helps reconcile the different properties of earnings and wealth is the presence of a social security system.

Our model also has two features that are not staples of the wealth distribution literature. One is the explicit treatment of durables (both consumer durables and houses), that allows a distinction between 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). In addition, we assume that labor supply is endogenous and that both earnings and wealth are calibrated to a cross section of SCF data. In this respect, we follow Castañeda, Díaz-Gimenéz, and Ríos-Rull (2003). In contrast, most other studies work with an exogenous earnings process estimated off panel data. Unfortunately, common panel data sets underrepresent rich households, who are particularly prominent owners of nominal assets.

An important, yet elusive, question beyond the scope of this paper is why nominal assets are used in the first place. By indexing interest rates to realized inflation, the redistributive effects discussed in this paper could be easily eliminated, thereby reducing risk for anyone owning nominal assets. Yet we do observe that most borrowing and lending is done in nominal terms. Recent experiments with inflation-indexed government bonds in the U.S. and the U.K. have not met expectations, and nominal borrowing continues to be the norm. While there is no comprehensive theory explaining the use of nominal assets, a number of authors propose partial explanations. In Bohn (1988), nominal government 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.

3 Nominal Assets and Liabilities in the U.S. Economy

By "nominal" assets and liabilities we mean those denominated in U.S. dollars. We define the net nominal position of an agent (for example, a sector or an individual household) as the market value of nominal assets minus the market value of nominal liabilities. We include all indirect nominal positions due to claims on investment intermediaries and the ownership of firms.

3.1 Indirect Nominal Positions and Valuation

An *investment intermediary* is a financial intermediary that issues only one type of claim, namely shares. Examples are mutual funds, bank investment trusts and defined contribution pension funds. Indirect asset holdings of an agent through an investment intermediary can be calculated by assigning a fraction of the intermediary's portfolio to the agent. In contrast, firms—whether financial or nonfinancial—are typically financed with both debt and equity. The net nominal position of a firm then contributes to the indirect nominal position of its owners through its effect on the value of equity.

We first isolate the net nominal position not due to equity. We define the *zero leverage net nominal position* $NNP(0)$ as the sum of directly held nominal assets plus nominal assets held through investment intermediaries less nominal liabilities. If all firms in the economy held only real assets (such as physical and intangible capital) and had no nominal debt, then an agent's $NNP(0)$ would be his true net nominal position.

Throughout, we consider nominal assets at market value. For simplicity, we abstract from uncertainty. Let $\nu^i = \left(v^i_{t,s}\right)_{s=1}^{\infty}$ denote an agent's stream of future nominal net payments expected as of the end of year t. Every net payment $\nu^i_{t,s}$ includes (i) face values of bonds held at t that mature in s, (ii) coupon payments due at s on all coupon bonds held at t that mature at s or later. The net payment is also net of (iii) amortization and interest payments due in s on mortgages and other debt owed in t. Let $i_{t.s}$ denote the continuously compounded nominal yield to maturity, at the end of of year t, on a zero coupon bond that pays off one dollar at the end of year s. The zero leverage net nominal position at market value is

$$NNP^i(0) = \sum_{s=1}^{\infty} \exp\left(-i_{t,s}s\right) \nu^i_{t,s}.$$

To quantify the indirect nominal position due to equity, we adopt a frictionless approach to the valuation of the aggregate business sector. Let *net equity* denote the market value of all equity claims on U.S. businesses not held by other U.S. businesses. Net equity is thus held by households, nonprofit organizations, foreigners, or the U.S. government. We assume that it is equal to the value of real assets held by firms minus firms' net nominal debt position at market value:

$$\begin{aligned} \text{Net Equity} &= \text{Real Assets of business sector} \\ &\quad + NNP(0) \text{ of business sector.} \end{aligned}$$

It is convenient to define the *net nominal leverage ratio* λ

$$\lambda = -\frac{NNP\,(0)\ \text{of business sector}}{\text{Net Equity}}. \tag{1}$$

This ratio is similar to a debt-equity ratio. However, it differs from conventional measures because (i) it only incorporates nominal claims, and (ii) debt is net of all nominal assets, including nominal assets held indirectly through investment intermediaries.

For every dollar invested in the stock market, an agent now has an indirect nominal position due to equity of $-\lambda$ dollars. His net nominal position is therefore

$$NNP\,(\lambda) = NNP\,(0) - \lambda\ \text{(Equity held)}$$

This position summarizes exposure to purely nominal events in the economy. Changes in the price level affect the real value payments that enter $NNP\,(0)$. In addition, changes in inflation expectations affect the nominal yield curve and hence change both the direct position and the leverage ratio. The only part of financial wealth that is not affected by inflation or changes in inflation expectations is the claim on real business assets, which is equal to $(1 + \lambda)$ (Equity held).

3.2 Sectoral Nominal Positions

Our sectoral calculations are based on the Flow of Funds Accounts of the United States (FFA), which provide a detailed breakdown of the assets and liabilities of the household, business and government sectors, as well as various types of financial intermediaries. We use quarterly data from 1952:1 to 2002:1. We calculate nominal positions in three steps. First, we classify balance sheet items into "nominal", "real" and "equity". We also correct positions where we find FFA conventions not to be economically meaningful. For example, we do not count goodwill as a financial asset, and we treat the current value of defined benefit pension funds as an asset of the plan sponsor, rather than the beneficiary. Further details are described in the appendix.

The second step is to calculate the market value of all outstanding nominal assets. Since the FFA present data only in terms of face value, we estimate market value using interest rate data. This is done separately for several broad classes of bonds and loans and the results are presented below. Finally, in the third step we collect equity holdings and zero leverage net nominal positions for all sectors. Here equity in corporations and in noncorporate business is treated separately. Using net nominal leverage ratios λ, defined in (1) for the aggregate corporate and noncorporate sectors, we then derive net nominal positions for households, the government and the rest of the world.

Market Value of Bonds

We begin by estimating, for every class of bonds and for every year, the stream of all future coupon and face value payments on bonds in that class outstanding in that year. Details of this step are provided in the appendix. Given an estimated payment stream, the market value of all outstanding bonds can be calculated by discounting the payment stream using a zero coupon yield curve. The ratio of market to face value for every class of bonds serves as adjustment factor that can be applied to the holdings of economic agents in the FFA to derive their positions at market value.

To illustrate the typical shape of these factors, Figure 1 plots the market value adjustment factors for Treasury and corporate bonds over the period 1967-2001. The figure shows that the conversion to market value "matters". To arrive at an economically sensible number for the value of an agent's bond portfolio, one should add or subtract up to 20 percent of the FFA par value number. As would be expected, the pattern of adjustment broadly follows the low frequency movement in the level of U.S. interest rates, which trended up until around 1982 and have been trending down since then. In periods of rising interest rates, bonds issued in the past at low coupon rates are worth less than their face value. In contrast, when rates are falling, bonds issued in the past at high coupon rates trade at prices above par.

Market Value of Mortgages

Our basic strategy for mortgages is the same as that for bonds: we begin with an estimate of future payments due on all outstanding contracts in a given year, and calculate market value by discounting with the zero coupon yield curve. However, the estimation of payments is more complicated, because we take into account adjustable rate mortgages (ARMs) as well as mortgage refinancing. We value ARMs at par. This assumes that the interest rate adjusts instantaneously to offset anticipated changes in interest rates. We also assume that a vintage of fixed rate mortgages is refinanced whenever the current rate on new mortgages falls below the rate at which the vintage was originated. The recursive construction of payments thus tracks not only the gradual amortization of different vintages, but also their respective share of ARMs and current interest rate, as detailed in the appendix.

We derive two sets of adjustment factors. To adjust the positions of mortgage lenders in the FFA, we calculate an aggregate factor, plotted in Figure 1. The behavior of this factor is similar to those for bonds. The aggregate factor averages over mortgages of different vintages, which is reasonable to adjust the position of a lender, such as a commercial bank, that holds a diversified portfolio of mortgages. In contrast, the typical household will have only one mortgage loan. If this mortgage has a fixed rate, its market value will depend on when exactly the loan was taken out. For this reason, we also calculate market value adjustment factors for mortgages by vintage. These adjustment factors are used below to revalue mortgage positions of households in the SCF. We verify in the appendix that our algorithm is consistent with information on the cross section of interest rates, maturities and ARM shares in the SCF.

Market Value of Other Debt

Apart from mortgages, the major categories of debt in the FFA are bank loans to businesses as well as "consumer credit", which includes credit card debt and also installment loans that are not mortgages. Most loans to businesses are made under loan commitment and are frequently repriced. According to the 2002 Survey of Loan Officers, more than 90 percent of outstanding loans to businesses are expected to be repriced in under one year. In line with our treatment of adjustable rate mortgages, we treat these loans as protected against movements in interest rates and value them at par. We use the same convention for consumer credit. This is natural for credit card debt, which is very short term. In addition, it treats flexible rate consumer loans are the same way as adjustable rate mortgages. The convention is less appropriate for fixed rate installment credit. It will become clear below that consumer credit as a whole is a small source of redistribution, so that an error in its treatment can only have small quantitative effect on our results.

The Size and Duration of Nominal Positions

We summarize the results of this section in two figures. Figure 2 displays the evolution of *net* nominal positions from 1952 to 2002, as a fraction of GDP. The top left panel tracks aggregate positions; the other panels provide a breakdown into key classes of instruments. Here the item ”short instruments and loans ”collects short term claims such as deposits and commercial paper together with non-mortgage loans. The instruments in this class mostly have maturity (or time to repricing) of less than one year. The panel on ”bonds”aggregates government debt, corporate bonds and collateralized mortgage obligations. The scale is the same across all four panels, so that the positions in the instrument panels sum to those in the top left (aggregate) panel.

In every panel, the three black lines depict the $NNP(\lambda)$ of the three important non-business sectors: U.S. households, the U.S. government sector, and the rest of the world. Here the government position consolidates the Treasury, the Federal Reserve System, state and local governments, and government-sponsored retirement funds.[5] Since the $NNP(\lambda)$s already contain indirect positions through claims on business, they add up to the discrepancy of the FFA plus the holdings of nonprofit organizations, which together are close to zero. To illustrate the importance of indirect positions, the grey lines show the $NNP(0)$ of the household sector as well as the financial system and the nonfinancial (corporate plus noncorporate) business sector. The total indirect position of the household sector is then given by the difference between the solid black and solid grey lines. This position is negative—households are indirect debtors—and makes up to 25 percent of GDP.

Figure 3 depicts the size and duration of *gross* nominal positions. The left hand panels show assets and liabilities for households and businesses. Since households are indirect debtors, the asset panel only contains one line for households - their directly held nominal assets. In contrast, the liability panel distinguishes between direct and indirect debt. The right hand panels in Figure 3 plot the *modified duration* of sectoral assets and liabilities, that is, the derivative of the logarithm of the position with respect to a parallel shift in the yield curve. For coupon bonds, modified duration is a common measure of ”effective ”maturity—it equals the value-weighted average of the maturities of the different payments (coupons and principal) promised by the bond. We apply the same principle to positions more generally here. In our framework, it is

[5]See the appendix for a detailed description of our sectors and how they relate to the FFA classification.

straightforward to calculate duration, since we have a record of all future payments promised at a point in time by every class of instruments.

Financial Innovation and Globalization since 1980

It is apparent from Figures 2 and 3 that there was a structural break in US nominal positions around 1980. This break is reflected in four stylized facts. First, *nominal claims began to grow much more quickly in 1980*. From 1952 to 1980, household and financial system assets increased slowly from about 80 to about 100 percent of GDP. There was a similar slow increase in household and business debt, offset somewhat by a reduction in government debt. Since 1980, government, financial sector and direct household nominal liabilities , each relative to GDP, have almost doubled. The only sector that has not experienced this large an increase in nominal positions in nonfinancial business.

Second, *over the last 20 years, foreigners have become important net creditors*. In fact, once indirect positions are taken into account, the rest of the world is now the major net creditor among end-user sectors, while the government is the major net debtor and the net position of US households has been tending towards zero. The "rest of the world"sector contains foreign private investors, but also foreign institutions, particularly foreign banks. Its role was negligible through the early 1980s. In the last 20 years, foreigners have built a net nominal positions of close to 25 percent of GDP. This position consists about equally of bond and mortgage holdings, while short instruments are less important on net. Mortgage holdings reflect not only direct issues by foreign banks, but also indirect ownership of mortgage through equity claims on US banks.

The third stylized fact is that *longer maturity claims have become more important for intersectoral borrowing and lending*. In particular, consider the net positions of households and the financial system. Figure 2 shows clear trend breaks in net mortgage and bond positions for both sectors, while the net short positions remain stable and actually decline in the 1990s. This fact reflects two developments in the financial system. On the one hand, households have been increasingly saving for retirement through pension plans and mutual funds. Their resulting indirect nominal holdings are more tilted towards long term bonds than traditional direct holdings of deposits. On the other hand, securitization of mortgage markets has implied that a lot of mortgages are now financed by bond issues. According to Figure 2, the financial system was traditionally a net holder of bonds and mortgages, and a net issuer of short instruments. However, it became a net issuer of bonds around 1985 and had bonds worth 40 percent of GDP outstanding in 2000. About half of these bonds are collateralized mortgage obligations backed by loans in federally related mortgage pools. Since net outstanding short debt of the financial system decreased in the 1990s, it is apparent that the surge in mortgage lending was mostly financed by bonds.

Finally, the last 25 years have witnessed a *reduction in the maturity mismatch of the financial system*. Traditional banks had long term assets and short term liabilities: Figure 3 illustrates that, before 1980, the modified duration on financial system assets was fairly stable at around 4 years, whereas that on liabilities was typically just below 2 years. Since 1980, the duration of liabilities has been steadily increasing and is now at over 3 years, whereas there has not been much change in the duration of assets. This development—again a result of securitization—directly affects the indirect position of shareholders. In Figure 2, domestic shareholders' indirect position due to different instruments can be read off from the difference between the solid black and grey lines. Shareholders are always long in mortgages and short in short term instruments. However, the recent increase in their indirect mortgage position has been offset by a substantial short positions in bonds. As a result, the portion of their net position that is subject to a maturity mismatch has declined. This will be crucial for understanding redistribution due to inflation below.

3.3 The Cross Section of Household Nominal Positions

We obtain data on the cross section of portfolio holdings from the Survey of Consumer Finances (SCF). The observation unit in the SCF is a household. In our benchmark year, 1989, the survey covers 3143 households, and weights are provided to produce U.S. aggregates. The sample design is well-suited for our purposes since it oversamples rich households who hold most assets. In all our calculations, we use the weights provided by the SCF to weight observations within an SCF implicate, and we average across the five implicates. We use 1989 as our benchmark year because it was a low inflation year in which the rest of the world was not yet that important. We also report below results for the 2001 SCF.

Age and Wealth Groups

We are interested in heterogeneity along three dimensions: age, wealth and use of credit markets. Households are first sorted, by age of the household head, into six cohorts: households under 35, 35-45, 45-55, 55-65, 65-75, and over 75. For each cohort, we refer to the top 10 percent of households by net worth as 'rich' households. The non-rich households are then sorted by the amount of debt they owe. We refer to those non-rich households whose market value of debt is above the median for non-rich households as the "middle class", and to the remainder as the "poor". Table 1 presents the three groups. The middle class households are indeed richer than the poor in terms of net worth. We show below that their earnings are also significantly higher. This motivates the labels.

Net Financial Positions

Household portfolio positions are summarized in the stylized balance sheet in Table 2. We present average positions for the U.S. populations as a whole, as well as for our three groups. All positions contain direct holdings as well as indirect holdings through investment intermediaries, and they are derived from household holdings at market value. Since the SCF, like the FFA, records bonds and loans at par value, we use the adjustment factors from the previous subsection to convert to market value. The appendix contains further details on our calculations. It also explains how we adjust the leverage ratios from our FFA analysis for use in our SCF calculations to account for discrepancies in nominal positions across the two datasets.

Durables are an important asset for most households. Our durables item equals all nonfinancial assets recorded by the SCF minus business wealth. It contains mostly real estate, but also consumer durables. All durable goods produce service flows that are part of nonbusiness GDP. In our model below, this will be what distinguishes durables from other real assets. To make explicit the special role of durables, we define the *net financial position* as

$$\begin{aligned} NFP &= \text{Net Worth} - \text{Durables} \\ &= \text{Equity held} + NNP\,(0) \\ &= \text{(Equity held)}\ \ (1+\lambda) + NNP\,(\lambda) \\ &= \text{Real Business Assets}\ + NNP\,(\lambda) \end{aligned}$$

The equity position in Table 2 contains not only direct and indirect holdings of public equity, but also the value of private ownership claims on private businesses recorded by the SCF. Since we do not distinguish explicitly between corporate and noncorporate equity here, net nominal positions are calculated using a single number for the net nominal leverage ratio of the entire business sector.

Results

Table 3 already summarizes the main differences across the three wealth groups. The middle class hold 70 % of wealth in durables, partly financed with debt. In contrast, the poor and rich have little debt and less durables. The rich instead invest more in equity, whereas the poor hold more nominal assets. Table 3 now provides a breakdown of durables, net financial and net nominal positions by age as well as wealth and also details the components of the net nominal position. For every cohort, the average cohort position has been normalized by cohort net worth. The durables and net financial position numbers are inputs to the calibration of our model, while the nominal positions contain determine the redistribution caused by a switch to a moderate inflation regime.

Naturally, net financial and net nominal positions are smaller for younger cohorts. However, *very few cohorts have negative net nominal positions*. Only middle class households under 55 as well as the youngest rich cohort stand to gain from inflation. These nominal borrower cohorts typically have large mortgage positions that are used to finance stocks of durables in excess of net worth. Among the net lender cohorts, there are important differences in the allocation of nominal assets. In particular, *elderly rich households tend to keep their nominal savings in (longer term) bonds, whereas the elderly poor rely much more on short instruments such as deposits*. Another feature of the rich is that indirect debt due to equity holdings reduces significantly reduces their net nominal positions of the rich at all ages. The elderly middle class are quite similar to the poor in terms of retirement savings choices, although they hold somewhat more equity and bonds and less short instruments.

4 Inflation and Redistribution

We are interested in the redistribution effects of a switch to a moderate inflation regime. In particular, we would like to estimate, for every sector or cohort of households, the gain or loss encountered—in present value terms—if the inflation experience of the decade 1973-1982 were to return, beginning at the end of a given benchmark year. Both the scale and the nature of redistribution depend crucially on how quickly agents adapt to the new inflation regime. On the one hand, the sooner agents anticipate the higher inflation and adjust their portfolios accordingly, the smaller will be any wealth effects. On the other hand, portfolio adjustment can protect short-term positions more effectively than long-term positions. As a result, faster adjustment implies comparatively larger effects on agents whose positions have longer duration. In this paper, we do not take a stand on how exactly expectations are formed and portfolios are adjusted during an inflation episode. Instead, we construct two scenarios that provide bounds on redistribution and illustrate the qualitative implications of adjustment.

As a lower bound scenario, suppose that the entire new inflation path is announced immediately at the end of the benchmark year. Bond markets will then adjust immediately and higher expected inflation will be reflected in higher nominal interest rates. The new present value of nominal positions can be calculated by discounting agents' expected payment streams with the new nominal term structure. We call this scenario *Indexing Asap*, because agents implicitly adjust as soon as possible to fully indexed portfolios. Indeed, the loss on a position in one-year bonds, say, is only the change in present value of a payment promised for next year. There is no loss on future one-year investments made during the ten year inflation episode. In other words, money due from one-year investments is protected from inflation that occurs after the first year.[6] The lack of inflation surprises after the initial announcement makes the *Indexing Asap* scenario a lower bound for the absolute value of actual gains and losses. In addition, it implies that agents with longer duration positions experience relatively larger gains and losses.

[6]For the wealth effects we are interested in, it does not matter how exactly agents achieve inflation protection for short positions. In practice, one could imagine reinvestment at a higher nominal interest rate or at the real interest rate, or alternatively earlier consumption. It is also irrelevant how the loss on longer term positions is realized—since there is perfect foresight after the initial announcement, the wealth effects are the same whether bonds are sold at a loss early or whether they are held to maturity.

Our upper bound scenario is that neither inflation expectations nor portfolio positions change with respect to the benchmark year during the moderate inflation episode. At all times during the episode, the inflation observed so far is perceived to have been a temporary anomaly, things are expected to return to normal the following year and portfolio positions remain "frozen". This *Full Surprise* scenario thus captures repeated inflation surprises, a common feature of actual inflation episodes. In addition, the percentage present value change is now the same for all portfolio positions, regardless of maturity. This change is determined by the difference in cumulative ten-year inflation between the 1973-1982 decade and the decade following the benchmark year. It follows that under the *Full Surprise* scenario, gains and losses are not only larger than under *Indexing Asap*, but also do not discriminate among agents with different portfolio duration. We now describe more precisely how gains and losses are computed in each case and then present the precise numbers used below.

Computation and Interpretation of Gains and Losses

It is convenient to represent the computations underlying both of our scenarios as adjustments to the nominal term structure. Let $\imath_t^n$ and r_t^n denote the total yields on n-year nominal and indexed zero-coupon bonds, respectively, in the benchmark year t. Suppose for simplicity that the Fisher equation holds ex ante in the benchmark year, so that $\pi_t^n = \imath_t^n - r_t^n$ 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 4. 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. [7] The initial expectations π_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 π_t^n by realized inflation starting in 1973. The resulting new cumulative new path $\tilde{\pi}_t^n$ is shown as the solid grey line starting in 1989.

Under *Indexing Asap*, the new inflation path is announced at the end of the benchmark year. The nominal yield curve thus immediately adjusts to $\tilde{\imath}_t^n = r_t^n + \tilde{\pi}_t^n$. 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

[7] 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 for the time after the high inflation of the 1980s.

payment in year $t+k$,ν_{t+k} say. The percentage loss on this position is $1-e^{-\left(\tilde{\pi}_t^k-\pi_t^k\right)}$. The difference between cumulative inflation paths is the difference between the solid grey and dashed black lines in Figure 4 and 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 $\tilde{i}_{t+k}^{10-k}$ 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

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

In other words, once the payment is due at $t+k$, it may be thought of as reinvested at the forward rate $\tilde{i}_{t+k}^{10-k}$ 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, $e^{-\left(\tilde{\pi}_t^{10}-\pi_t^{10}\right)}$. 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 off ν_{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 π_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}, the forward rate already 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

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

The cumulative inflation factor for the *Full Surprise* experiment is represented by the dotted black line in Figure 4. 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 purely 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 mortgage 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.

Redistribution across Sectors

Figures 5 and 6 plot redistribution over time under the *Full Surprise* and *Indexing ASAP* scenarios, respectively. Both figures show aggregate effects as well as redistribution by class of instrument, following the structure of the positions plots in Figure 2. The years on the x-axis now represent benchmark years for the start of a hypothetical moderate inflation episode. Since the hypothetical inflation path is realized inflation from 1973-1982, the implied redistribution for the benchmark year 1973 is zero in both figures. In the *Full Surprise* case, all positions for a benchmark year t are scaled by the same surprise factor s_t^{10}. Since the late 1980s, this factor has been approximately constant and implies a loss of roughly 45% per position. The top right panel of Figure 6 also illustrates the key difference between our two experiments: under *Indexing Asap*, there is virtually no redistribution due to short instruments.

Among end-users, the government is the only winner, while the rest of the world (ROW) and domestic households lose. With net debt levels as high as in the 1990s, the government would gain at least 5% and up to 20% of GDP from a return of the 1970s. As of the late 1990s, inflation has become an elegant way to default on net foreign debt. A return of the 1970s now would amount to a gift from the ROW of at least 7% and up to 13% of GDP. Indirect positions contribute to overall redistribution in important ways, especially since 1980. At the high business debt levels of the late 1990s, the indirect gain via the stock market effectively offsets the direct net loss made by households. Since not all households are stockholders, this suggests further redistribution within the household sector, to be discussed below.

There are two interesting facts driven by duration. First, *foreigners tend to bear a larger share of losses in a gradual inflation episode*. Indeed, the duration of the ROW position has typically been longer than that of domestic households. Figure 2 shows that while domestic households are net lenders in short term instruments and net creditors in (long term) mortgage markets, the opposite is true for the ROW. The negative net short position of the ROW reflects short term paper issued in the US by foreign financial institutions as well as indirect short debt due to equity in US businesses. As a result of these differences in duration, the ROW loses relatively more under *Indexing Asap*, where short positions are not revalued. Comparison of the top left panels in the figures shows that this effect is especially striking for the period 1982-1993. During this period, the ROW would have paid for more than half of the government's gain under the *Indexing Asap* scenario, but for less than 40% under the *Full Surprise* scenario.

A second fact is that *shareholders gain little in gradual inflation episodes, except recently after securitization had shifted more inflation risk to bondholders*. This highlights again the transformation of the financial system over our sample. In the traditional banking environment of the 1950s and 1960s, anticipated inflation would have implied losses on banks' fixed rate mortgages and bond portfolios that could not be offset by gains on short liabilities. Since the corporate debt market was relatively small, the losses of the financial system cause a loss on shareholders' overall indirect position. This explains why shareholders would have lost from our *Indexing Asap* experiment in the

1960s (the solid black line is below the solid grey line during that time). In contrast, in the 1980s and 1990s, losses on mortgages are partly offset by gains on mortgage-backed securities. The increase in corporate debt of the late 1990s finally implies significant gains to shareholders from anticipated inflation.

Redistribution across Households

Tables 4 and 5 summarize the redistribution across groups of households based on SCF data for our benchmark year 1989. Tables 6 and 7 contain the corresponding numbers for the 2001 SCF. All tables report the effects under both *Full Surprise* and *Indexing ASAP*. In Tables 4 and 6, cohort gains and losses are stated in percent of mean group net worth, whereas in Tables 4 and 6, they are stated as a fraction of total losses incurred by the household sector. The latter two tables thus make gains and losses directly comparable across cohorts and and serve as the basis for the "redistribution shocks"to be explored below in the context of our model. In addition, Table 8 provides more insight into the *Indexing Asap* experiments by comparing the durations of different investments. These numbers can be interpreted as (approximate) percentage gains or losses in response to a one percent permanent change in inflation.

As a general rule, *inflation benefits young and middle class households, while it hurts old, poor and rich households*. The gains to the young middle class arise mostly from debt relief on fixed rate mortgages. There is a smaller debt relief effect for the young rich, who have less debt as a percentage of net worth. To provide further perspective on magnitudes, net worth in 1989 was equal to 85% and 212% of annual earnings for the youngest and 2nd youngest middle class cohorts, respectively. Therefore, each of these cohorts gains at least 19% and up to about one half of annual earnings. In 2003 dollars, the youngest middle class cohort gains between $9,100 and $21,200, whereas the 35-46-year-olds gain between $13,300 and $36,200. In aggregate terms, Table 5 shows that the four winner cohorts receive a transfer of 3.5% – 9.4% of GDP. The two youngest middle class cohorts pocket about 80% of this amount.

Who exactly pays for the losses depends crucially on the duration of cohorts' portfolio and hence also on whether inflation is gradual. Since duration patterns have also changed over time, consider first the effects for our benchmark year, 1989. Table 4 shows that *the rich suffer relatively more from anticipated inflation, whereas the poor are hurt more by surprise inflation*. Relative to net worth, the poor retirees lose most under the *Full Surprise* experiment, which hurts their saving deposits. The rich retirees hold a smaller share of their portfolio in nominal assets, so that their *Full Surprise* loss is smaller than that of the middle class and poor retirees. However, to the extent that the rich do hold nominal assets, they invest more in long term bonds. As a result, the *Indexing Asap* experiment hurts the rich retirees *more*, in percent of net worth, than either the poor or the middle class. Of course, on aggregate the old rich households lose the most—the rich over 55 years of age together account for 60% of total losses, or $4\% - 10.5\%$ of GDP. In 2003 dollars, the typical loss for a rich retiree below 75 years of age is between $100,000 and $218,000.

The numbers for 2001 preserve the effect that anticipated inflation favors the poor, but also show that *the distribution of losses has recently become considerably more equal, especially when inflation is gradual*. In percent of net worth, the poor now lose more than the rich under both experiments, the lone exception being the oldest cohort under *Indexing Asap*. In aggregate terms, the rich's share in total losses under *Indexing Asap* fell from 76% to 63% between 1989 and 2001, while the share of the poor rose from 14% to 22%. Under *Full Surprise*, the effects are smaller but go in the same direction: while the share of the rich remained constant at 59% of total losses, the share of the poor increased from 22% to 29%. The difference is mainly made up by the poor aged 45-75, who are the most important poor savers.[8]

Several developments in the financial system contribute to broader sharing of inflation risk. First, *equity ownership has become more widespread*. By 2001, equity as a fraction of assets had increased to 21%, 19%, and 48% for the poor, middle and rich groups, respectively, a 10 percentage point increase when compared to Table 2. The stock market gains in the *Full Surprise* case are thus shared more evenly among the three wealth groups. Due to an increase in business debt, gains due to indirect debt are also larger in 2001. For example, the 55-65-year old rich lose 9.7% of net worth on their direct holdings under *Full Surprise*, but gain 4.3% on their equity positions, for a total loss of only 5.4% of net worth. The poor of the same age cohort lose 11.9% of net worth on their direct holdings but still gain 2.3% on their equity positions, for a

[8]The difference does not appear to be due to changes in demographics or cohort wealth distributions. The ratios of rich to poor net worth for the 3rd through 5th cohorts were 24, 18 and 21, respectively, in 1989, while they were 26, 24 and 17, respectively, in 2001. For working savers, the wealth distribution thus became more unequal, while inflation losses became more equal. In addition, the distribution of losses across generations is quite similar in the two benchmark years.

total loss of 9.6%. In contrast, in 1989 the same rich cohort won 1.5% through equity, while the corresponding poor cohort won only 0.6%.

Moreover, *reduction of maturity mismatch in the financial system and the increase in long term business debt have increased shareholder gains from gradual inflation episodes*. Comparison of Tables 5 and 7 shows that shareholders actually lose in 1989 under *Indexing Asap*, while they gain in 2001. Since the rich hold more equity, this turnaround also serves to make losses more evenly distributed. Finally, the aggregate shift out of short savings instruments into longer term bonds has affected all wealth group in similarly and has therefore *not* contributed to a shift of inflation risk. However, it has made the household sector as a whole more sensitive to gradual inflation. For example, *Indexing Asap* losses of poor savers aged 45-75 were about 20% of their *Full Surprise* losses in 1989, but the ratio was one third in 2001. The same ratio for the rich rose from one hald to two thirds. We thus conclude that *financial innovation has both increased and distributed the risk of gradual inflation episodes*.

5 The Model

5.1 Setup

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:

$$\sum_{t=s}^{N+s} \beta_i^t u_i(c_{i,s,t}\, , \; d_{i,s,t}\, , \; 1 - l_{i,s,t}) + v_i(b_{i,s}), \tag{2}$$

where $c_{i,s,t}$ is non-durable consumption, $d_{i,s,t}$ are houses (consumer durables), $1 - l_{i,s,t}$ is leisure, and $b_{i,s}$ is the bequest left to the next generation. 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 maximizes utility subject to the following budget constraints in the first, middle, and last periods:

$$
\begin{aligned}
c_{i,s,s} + d_{i,s,t} + a_{i,s,s+1} =& (1-\tau_s) w_s \phi_{i,0} l_{i,s,s} + b_{i,s-N} && (3) \\
c_{i,s,t} + d_{i,s,t} + a_{i,s,t+1} =& (1-\delta) d_{i,s,t-1} + R_t a_{i,s,t} + (1-\tau_t) w_t \phi_{i,t-s} l_{i,s,t} && (4) \\
c_{i,s,N+s} + p_{N+s} d_{i,s,N+s} + b_{i,s} =& (1-\delta) d_{i,s,N+s-1} + R_{N+s} a_{i,s,N+s} && (5) \\
& + (1-\tau_{N+s}) w_{N+s} \phi_{i,s,N} l_{i,s,N+s} + tr_{N+s}.
\end{aligned}
$$

Here $a_{i,s,t}$ are savings, R_t is the interest rate, tr_{N+s} 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 agents receive a bequest from their parents in the first period of life. In the last period, instead of buying houses outright, consumers rent the houses at price p_{N+s}. 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. 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 with the houses of dead people. In a frictionless environment, owning a house and renting in a competitive market are equivalent.

For a part of our analysis, we are going to assume that households face a borrowing constraint. In particular, households are only able to borrow up to a fixed fraction ψ of the value of their houses:

$$a_{i,s,t} \geq -\psi d_{i,s,t}. \tag{6}$$

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, which 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:

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

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 δ_K and δ_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 intangibles is useful for calibrating the model. When intangibles are present, the total value of all firms $K + E$ is higher than the amount of physical capital K. The same is typically true in the data, i.e., the total equity value of corporations and the noncorporate business sector deviates from the amount of physical capital measured in NIPA. Intangibles allow us to match the value of private equity holdings and the aggregate ratio of physical capital to output at the same time.

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. By the absence of arbitrage, the net returns on both types of capital must also be equal to the interest rate. We thus have:

$$R_t = 1 - \delta_k + z_t \alpha \rho \frac{Y_t}{K_t}, \tag{7}$$

$$R_t = 1 - \delta_E + z_t \alpha \left(1 - \rho\right) \frac{Y_t}{E_t}, \tag{8}$$

$$w_t = z_t \left(1 - \alpha\right) \frac{Y_t}{L_t}. \tag{9}$$

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 τ_t is linear, does not depend on the type of the worker, and may vary over time. The social security system consists of a lump-sum payment tr_s to every retired adult. The period budget constraint of the government is:

$$B_t + \tau_t w_t L_t = R_{t-1} B_{t-1} + G_t + tr_t. \tag{10}$$

Notice that population size does not enter the right-hand hand side of the budget constraint, since the size of each cohort is normalized to one. 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 steady state to U.S. 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.

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 μ_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:

$$p_t = 1 - \frac{1-\delta}{R_{t+1}}. \tag{11}$$

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. *Households maximize utility* (2) *subject to the budget constraints* (3)-(5) *and the borrowing constraint* (6).

2. *Firms maximize profits, i.e.,* (7)-(9) *are satisfied.*

3. *The government budget constraint* (10) *is satisfied in every period.*

4. *The rental market clears, i.e.,* (11) *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:*

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

5.2 Calibration

Consistent with the breakdown of the financial data presented in Section 3, we calibrate the model under the assumption that there are three different types of consumers, which we will call "the rich," "the poor," and "the middle class." 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, firm 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. For the most part, there is no obvious one-to-one relationship between a moment and a 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 profiles of labor earnings, asset profiles from the SCF, and aggregate data to guide our parameterization. Second, the technology parameters α, ρ, δ_K and δ_E determine the accumulation of tangible and intangible capital in the business sector. We target the return on capital, the value of firms and the ratio of capital and wages to GDP. Taxation and government spending parameters are calibrated in order to match the ratios of general government spending, social security spending, and government debt to GDP.

We first describe the functional forms chosen for calibration, then describe the calibration strategy for each sector of the economy in more detail, and finally summarize all our calibration choices.

Functional Forms for Utility

We choose the following functional form for utility:

$$u_i(c_t, d_t, 1 - l_t) = \frac{\left(c_t^{1-\sigma_i}(1 - l_t)_i^{\sigma}\right)^{1-\gamma}}{1 - \gamma} + \eta \frac{d_t^{1-\nu}}{1 - \nu}.$$

We allow the weight of leisure σ_i to vary across the different types of agents. This flexibility is needed to match average labor supply across the groups. Specifically, if all groups placed the same weight on leisure, the rich people would work too little relative to the data because of their higher wealth. The utility is chosen to be Cobb-Douglas in consumption in leisure in order to allow for a balanced growth path with constant aggregate labor supply over time. The utility derived from bequests is:

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

Once again, we allow for the possibility that the groups place different weight on bequests. This is necessary since in the data bequests are highly concentrated among households with high wealth, indicating that bequests are a luxury good (see the discussion in De Nardi (2002)).

Preference Parameters

The elasticity parameters γ, ν, and ϵ govern risk attitudes and the intertemporal elasticity of substitution. We set $\gamma = 2$, a standard value used in many studies, and impose $\gamma = \nu = \epsilon$. The utility weights η and ξ_i determine expenditure shares on durables (houses) and bequests. To match η 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). We therefore set our target in the middle of the two statistics, targeting a ratio of durables to physical capital of 1.8, which results in a 36 percent share of durables in net worth. Bequests are highly concentrated among the richest groups of the population; the vast majority of people do not receive significant bequests at all. Gale and Scholz (1994) reports that only 3.7 percent of households interviewed for the SCF in 1986 have received an inheritance. Households leaving or receiving inheritances have 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 ξ_r, we follow De Nardi (2002) 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). Gale and Scholz (1994) estimate this number to be 60 percent in the U.S., which is our chosen target for ξ_r.

The share of leisure σ_i in utility determines the work time as a fraction of total time for each type. Assuming that an adult (before retirement) works an average of 40 hours per week out of a total of 100 "disposable" hours (that is, excluding sleep and basic maintenance), we set the target for each type to 40 percent.

The last preference parameters that need to be calibrated are the discount factors β_i. The average degree of time patience determines the amount of capital accumulation in the economy. The relative size of each type's discount factor determines the relative net worth across groups, as well as the steepness of consumption and net worth profiles. We therefore use three different targets to set the β_i: the ratio of the measured capital stock to GDP, 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.

Earnings Profiles

The skill parameters $\phi_{i,n}$ are chosen to match the cross-section of earnings in the balanced growth path of the model to observed earnings in the 1989 SCF. Notice that because the model economy is on a balanced growth path with a positive growth rate, the cross-section of earnings is not identical 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 of steps are necessary to make the two consistent. In the SCF, we observe labor earnings, business income, as well as 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 therefore has to be interpreted as a part of overall financial wealth in the model. Here, however, a 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) much 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 is actually a a part of labor earnings, related to work in the private business. Specifically, we construct earnings targets by adding any business income in the data that exceeds the income implied by the return on financial assets in the model to observed earnings. 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:

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

Since the poor have little business wealth, this transformation makes little difference to their earnings. The rich, however, derive a large part of their income from business, so that adjusting the target is important.

The average level of earnings in the economy is a scale factor, and therefore irrelevant. We therefore normalized the skills of the youngest poor cohort to one, and choose the $\phi_{i,n}$ to match the ratio of each type's and cohort's earnings to the earnings of this group:

$$\frac{\phi_{i,n}(1-l_{i,n})}{1-l_{p,0}} = \frac{\hat{e}_{i,n}}{\hat{e}_{p,0}}.$$

Notice that the chosen skill profile not only depends on the relative earnings, but also on the relative labor supply in the model.

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 is 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 corporate) capital.

The ratio of physical capital to measured output is calibrated by choosing the time preference parameters of consumers to the observed capital/output ratio. 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 U.S. stock market computed by Jagannathan, McGrattan, and Scherbina (2000) for the period 1945-1999.

The share parameter α determines the fraction of output going towards compensation of capital and labor. Once again, we cannot match α to the capital share directly due to the presence of unmeasured output. The measured labor share of our economy is given by:

$$\frac{w_t L_t}{Y_t - I_t^e},$$

which we match to the observed value of 0.66 in the data by choosing α.

The depreciation rate on physical capital can be inferred directly from NIPA. Given the annual NIPA rate of x% 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.

The Government and Foreigners

The government parameters to be calibrated are the labor tax rate τ_t, the social security transfer tr_t, and general government spending G_t. Given these choices, the rate of return R and the productivity growth rate g pin down the amount of government debt B_t in the balanced growth path. In particular, since in the balanced growth path B_t grows at rate g, we have:

$$\left(\frac{R}{1+g} - 1\right) B_t = \tau w_t L_t - G_t - tr_t.$$

We choose τ to match the ratio of tax revenues to measured GDP to its observed value. The transfer tr_t is chosen to match the ratio of social security transfers to measured GDP. Finally, G_t is chosen to target the ratio of government debt to GDP. Our measure of government debt is the net nominal position of the government, as computed in Section 3.

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 that the model has a realistic ratio of public debt to private debt, which is why we target the debt to GDP ratio.

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 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 GDP.

Summary of Parameter Values

Table 9 displays the (relative) earnings targets, and Table 10 shows the chosen parameter values.

6 Results

6.1 The Inflation Experiment

We now want to use our model to assess the economic implications of the wealth redistribution induced by an unanticipated inflation episode. We model the arrival of inflation as an unanticipated shock that displaces the economy from steady state. The basis for redistribution is Table 5, which implies gains and losses relative to GDP for all cohorts and classes. Suppose the economy is in steady state in period t. We then take the inflation episode to be the beginning of period $t+1$. The relevant announcement of inflation expectations for our exercises occurs at the end of period t. In other words, decisions in period t are not affected by inflation, whereas agents begin period $t+1$ with the asset position after the inflation shock took place. The generations affected by redistribution are all generations alive at the beginning at $t+1$.

More formally, we apply the redistribution total in Table 5 for type i and cohort n as a change to the beginning-of-period assets of cohort $n+1$. The losses or gains of the cohort up to 34 affects the initial assets of the cohort 35–44, losses and gains from 35-44 affects 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. In addition, all three types are affected indirectly through the general equilibrium effect of the inflation shock on prices.

Since in the model the last cohort dies at age 84, there is no cohort whose initial assets are affected by the gains and losses of the cohort aged 75-84. For simplicity, we disregard the redistribution occurring in this age group. Alternatively, we could interpret the last cohort as "open ended" and assign a larger total redistribution to this cohort. The results from this procedure are very similar to our approach. The main difference is a larger decline in consumption of the old; aggregates are affected only through changes in bequests.

¿From Table 5, the government is a major winner in the redistribution. We thus need to take a stand on how it adjusts its behavior. If tax rates and real government spending do not change, the government budget will be in surplus, and the real (and nominal) value of government debt will fall even further. Alternatively, the government could use the extra revenue to raise government spending or lower taxes. In our benchmark experiment, the government uses the extra revenue 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 similar to the government, i.e., we assume that the real value of the foreigners' assets returns to the steady state.[9]

[9] Using other assumptions (such as a permanent reduction in the foreigners' assets) made little

Figure 7 shows the impact on the consumption for 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. The middle class cohorts from 35 to 54 enjoy the largest positive effect. These cohorts have a relatively large amount of debt, mainly for financing 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 from 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 20 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 of consumption by lowering savings.

Figure 8 shows that the impact on housing consumption is qualitatively similar to the impact on nondurable consumption. The differences are explained by the fact that nondurable consumption interacts with leisure in the utility function, while housing does not. Figure 9 shows the impact on labor as a percentage deviation from average labor supply in the balanced growth path. With the exception of retired households, 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 from 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 10 shows the impact on savings, once again as a percentage deviation from the average in the balanced growth path. What is striking about this figure is the size of the effects. The middle class from 34-44 increases their savings by about 30 percent of their average savings in the steady state, while the poor from 65-74 experience a

difference to the results, mainly because in the 1989 calibration the holdings of foreigners were still relatively low relative to GDP.

decline in savings of about 40 percent of average savings. Another interesting observation is that while from age 45 on the rich are similarly affected as the poor, in the youngest cohort the poor and the middle class 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.

Figure 11 shows the effects on economic aggregates as percentage deviations from the balanced growth path. 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 and 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, and 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 stock. 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 effect increases over the first two periods, because the losers reach the end of their life cycle before the gainers do. The middle-class gainers from inflation are still alive in period 3, 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 effect on output is a decline of up to 0.9 percent 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 0.5 percent relative to the balanced growth path over the first 30 years, the total amount of output lost is large, since the negative effect lasts for 30 years.

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 5 shows, under this assumption the total net loss of the household sector is only 5.0 percent of GDP, instead of 14.4 percent under the "Full Surprise" assumption. Despite the lower total amount of redistribution, the economic effects of an "Indexing ASAP" inflation shock are not a scaled-down version of the "Full Surprise" shock. The reason is that the maturity structure of assets and liabilities differs across types and cohorts.

Figures 12 and 13 show the impact of the "Indexing ASAP" inflation experiment on cohort consumption and aggregates. The aggregate effect on labor supply and output has the same sign as before, but the magnitude is reduced. The initial reaction of the capital stock, however, is reversed. The aggregate change in the capital stock is determined by the tradeoff of two different effects. The household sector as a whole loses wealth, while the government gains. The loss of the household sector tends to lower savings through a standard income effect. This negative income effect counteracted by a life-cycle effect: The groups of households that gain from inflation are young, and therefore have a higher propensity to save. In the "Full Surprise" case, the life-cycle effect dominates, resulting in a net increase in savings and the capital stock. In the "Indexing ASAP" experiment, the government still has large gains, since government debt has a relatively long maturity. The redistribution volume across households, however, decreases much more, since short-term debt and assets are hardly affected in the "Indexing ASAP" scenario. Therefore, in the new experiment the overall wealth effect dominates, and the capital stock declines.

We also repeated both experiments in versions of the model with a binding borrowing constraint, i.e., consumers can only borrow up to fraction ψ of the value of their houses. We experimented with a variety of values for ψ, 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 a 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 quite small. The reason is that only the youngest households are financially constrained, and these households account only for a small part of the overall effects.

6.2 Alternative Government Policies

The purpose of our model is to gauge how the economy reacts to the redistribution of wealth induced by an inflationary 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.

As a starting point, it is useful to consider a world in which the government is isolated from the distributionary effects of inflation, as would be the case if the government only issued inflation-indexed bonds. Figure 14 shows the aggregate effects of inflation if wealth is redistributed across consumers as before in the "indexing ASAP" scenario, while the real value of the government's debt is unchanged (this also implies that the aggregate losses of the household sector are proportionally smaller). Compared to Figure 13, we see that labor supply and output decline even further if the government is not affected by redistribution. The intuition for this result is that in Figure 13 we assumed that the government converts a part of its gains (through devalued debt) into higher government spending. This "government spending boom" offsets a part of the decreased output resulting from lower labor supply of the young middle class. Without this offsetting factor, the aggregate effects in Figure 14 are larger. We also see that the capital stock now increases after the inflation shock. Since the government is no longer affected, there is no overall wealth effect for the household sector, and the life-cycle effect dominates once again.

In our model, apart from increasing government spending, the government can put additional funds to two alternative uses: it could lower taxes, or it could increase social security spending. Figure 15 compares outcomes 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. We maintain the assumption that spending is such that real government debt returns to its original steady state.

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. Lowering taxes leads to the highest output level, while increasing pensions does worst. The intuition is that lowering taxes lowers distortions, which increases output. Subsidizing pensioners, in contrast, lowers incentives for saving. The main conclusion from Figure 15 is that the aggregate effects are surprisingly robust to different reactions of the government.

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. Figure 16 displays the output effect of the three possible reactions in this scenario. Since the economy now converges to a different steady state, permanent effects on output arise. Lowering taxes leads to the largest increase of about 2.0 percent of output in steady state. Thus, in the long run lowering tax distortions increases output more that 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. The output effects in the initial period are similar to the case of a transitory policy change displayed in Figure 15.

6.3 Welfare Implications

While the redistribution numbers computed in Section 4 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 general equilibrium price changes. To gauge the impact of inflation on the welfare of each group, Table 11 compares the utility of each type and cohort of consumer alive in the impact period to steady state utility in the full surprise scenario with government debt returning to steady state. For ease of interpretation, the numbers are expressed as equivalent proportional variations in consumption and leisure. 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 by steady state consumption, housing, and leisure all scaled down by one percent until the end of the life cycle. We also display a weighted welfare criterion that places equal weight on each group alive in the impact period.

The welfare calculation show that the specific reaction of the government determines the sign 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 loses from inflation. If the government uses the windfall to increase pension payments, however, a majority of households gains, since the older cohorts who would otherwise lose are being compensated. The weighted welfare measure is positive in each case. Two effects are at work here. First, the domestic households experience a net gain, because inflation deflates the wealth of foreigners. More importantly, however, inflation redistributes wealth from the rich to the middle class and some of the poor. Since the rich have the lowest marginal utility, the weighted welfare measure registers this redistribution as a net gain. We can gauge the relative importance of the two effects by computing results for an otherwise identical experiment that leaves the value of the foreign asset holdings intact. In other words, redistribution takes places only between domestic agents and the government, while the rest of the world is protected from inflation. In this scenario, the overall welfare effect remains positive, but is smaller. In the gradual case with government debt returning to the steady state, the weighted welfare effects are 0.11 if government spending adjusts, 0.29 when taxes adjusts, and 0.28 when pensions are raised. In the spending experiment the exclusion of foreign debt therefore makes little difference. The reason is that government spending does not enter utility, just as the consumption of foreigners. In the tax and pensions experiment, the implicit taxation of foreigners does contribute a significant fraction of the overall welfare effect, though it still less than half in both cases.

The welfare effects look very similar if we work under the alternative assumption that government debt does not return to the steady state, see Table 12. Even though we saw that making permanent changes to debt and taxes can have a sizable effect on output in the steady state, this is of little relevance to the initial generations. The effects under gradual inflation (Tables 13 and 14) are smaller, but qualitatively the same as in the full surprise case.

6.4 Results for 2001

We saw in Section 3 that there have been substantial changes in the net nominal positions of different sectors of the U.S. 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 position of the rest of the world, which was adjusted to its 2001 value).

Figures 17 and 18 show the impact on cohort consumption and economic aggregates for the 2001 experiment under the "full surprise" scenario. Qualitatively and quantitatively, the effects are very similar to 1989 results. We can see some differences, however, if we look at the welfare calculations in Tables 15 and 16. The weighted welfare measures now show a bigger positive effect of up to 1.35 percent in the full surprise scenario with an adjustment in pensions. 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 agents. The importance of foreigners can be gauged be recomputing the experiment that foreigners are isolated from inflation (as if, counterfactually, foreigners only held inflation indexed bonds). The weighted welfare effect in the spending, tax, and pension experiments are 0.10, 0.21, and 0.21 percent in the gradual scenario, and 0.13, 0.21, and 0.21 percent in the full surprise scenario. Thus, under the assumption that the government uses its windfall to either rebate taxes are raise pensions, the inflation tax on foreigners accounts for between 70 and 85 percent of the overall welfare effects. Clearly, relative to earlier periods the recent increase in foreigners' holdings of domestic, dollar-denominated debt has made inflation a much more attractive proposition from a U.S. perspective.

7 Conclusions

The goal of this paper was to examine the importance of wealth redistribution as a channel for real effects of inflation. We have documented the distribution of nominal assets and liabilities in the U.S. economy, and we have used those numbers to compute 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 reponses 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 abstracts from frictions to isolate the distributional effects of inflation. From the point of view of domestic households, the aggregate welfare effect of inflation then becomes positive. 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 agents. 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 appears to a sizeable fraction of the population which would stand to gain if another inflation episodes 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. The current widespread optimism regarding continued low inflation in the foreseeable future may be misplaced.

Our analysis may also provide a useful starting point for future research into the political economy of inflation. From this perspective, an interesting finding is that the cohort welfare effects are highly sensitive with respect to the policy regime followed by the government. For example, 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. However, if the windfall is used to raise pensions, the poor as well as the old middle class are effectively compensated for all their losses, and mosts group apart from the very rich stand to gain from inflation.

For example, it is interesting that the U.S. 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 made inflation less costly in political terms, 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 Bohn 1992), so real pensions rose as a result of inflation.

A Details on the Flow-of-Funds and SCF Data

Our computations are based on the June 2002 release of the Flow of Funds Accounts (Federal Reserve Statistical Release Z.1: Flow of Funds Accounts of the United States. Board of Governors of the Federal Reserve System, Washington D.C.).

A.1 Consolidation of Sectors

Table A.5 is a list of sectors and classes of financial institution for which the FFA supplies aggregate data. We calculate direct and indirect net nominal positions for four *end-user* sectors: households, the government, the rest of the world, and non-profit organizations. The calculation uses direct nominal positions of all sectors and institutions. Among institutions, the key distinction is between those that have only one class of liabilities and those that have several classes. We call the former group investment intermediaries.

Investment Intermediaries

The most important investment intermediaries are mutual funds (MF), money market mutual funds (MMMF), bank investment trusts and private defined contribution (DC) pensions plans.[10] The single class of liabilities of these institutions is fund

[10] A breakdown of private pension assets into DC and defined benefit (DB) pension plans is available only since 1984. Before that time, we postulate that a constant share equal to the 1984 number was DC.

shares. We thus assign nominal positions of investment intermediaries directly to their shareholders. For MMMFs and MFs, these shareholders include other intermediaries, in particular DC plans and trusts. However, cross-holdings between MMMFs and MFs are negligible. We can therefore proceed sequentially: we first reassign mutual fund nominal assets to other intermediaries as well as all end users, and then in a second step reassign pension and trust assets to households.

In recent years, life insurance companies have increasingly offered investment risk pass-through products such as variable annuities, in addition to their more traditional nominal liabilities. Life insurers are required by law to keep a *separate account* for assets that back pass-through claims. We therefore treat the separate account as a separate investment intermediary - gains and losses accrue to pension reserve holders at life insurance companies, rather than to stockholders in these companies. Since the FFA does not distinguish between life insurers' separate and general accounts, we use data on account composition from the Life Insurers Fact Book, published by the American Council of Life Insurers, for the 1990s.

Rest of the World

Our rest of the world (ROW) sector combines the FFA's ROW sector as well as two classes of financial institutions that are wholly foreign-owned.[11] First, for foreign banking offices in the US, the FFA provides a detailed table of positions. Second, funding corporations set up by foreign institutions to issue commercial paper in the US are part of the FFA's funding corporations sector, where they are lumped together with nonbank financial holding companies and custodial accounts for reinvested collateral associated with securities-lending operations. The commercial paper issued by foreign-controlled funding corporations is either used to finance foreign banking offices, or is to raise funds that are then transferred to the foreign parent. We thus construct a *foreign funding corporations* sector. Its assets are equal to miscellaneous claims on foreign banking offices minus foreign direct investment in funding corporations and its liabilities are equal to sufficient commercial paper to balance the books.

Business

Our business sector comprises all FFA sectors and groups of institutions not already mentioned. From the point of view of the end-user and, in particular, household positions, it is not important whether an institution is a corporation or not. The nonfinancial business sector thus contains the FFA nonfarm, noncorporate business, farm business as well as nonfinancial corporate sectors. The distinction between nonfinancial and financial sectors is also immaterial for the end-user calculations, because we cannot distinguish between holdings of financial and nonfinancial equity. However,

[11] Foreign direct investment that represents partial ownership of US businesses is part of the assets of the FFA ROW sector and is discussed below

it is useful for interpreting aggregate redistribution effects caused by indirect nominal positions. The financial business sector contains US commercial banks, other (that is, non-life) insurance companies, closed-end and exchange-traded funds, brokers and dealers, savings institutions, credit unions, the government-sponsored enterprises, finance companies, mortgage companies and REITs. In addition, it contains the general account business of life insurers, and funding corporations that are not foreign-controlled.

We also assign assets and liabilities of federally related mortgage pools to the financial sector. We assume that mortgage pools are financed entirely by pass-through mortgage-backed securities. The FFA do not distinguish investments in securities backed by mortgages in federally related pools from what they call "government agency bonds". To allocate the mortgage-backed securities, we assume that a dollar held in the FFA's agency bonds is split between mortgage-backed and other agency bonds proportionately to outstanding quantities. Our assumption of full pass-through implies that shareholders of the financial sector take neither gains or losses on pool mortgages from inflation—any changes in the value of pool mortgages is born by holders of the collateralized mortgage obligations (CMOs). The convention of counting CMOs as bonds issued by the financial sector and already securitized mortgages as held by the financial sector highlights the role of securitization and facilitates our discussion of the distribution of losses. For other (that is, not federally related) issuers of asset-backed securities, the FFA aggregates commercial paper backed by, say, credit card receivables with longer term mortgage backed securities. We treat the liabilities of this FFA sector as commercial paper or corporate debt, depending on how they is classified by the FFA.

A.2 Classification of Assets

We classify balance sheet items into "nominal", "real"and "equity". We assume that loans and fixed income securities are nominal, unless the Flow of Funds Guide provides information to the contrary. Securities denominated in foreign currency are classified as real. Domestic corporate equity, and ownership of noncorporate business is classified as equity. There are three sets of claims where classification is not obvious: foreign equity positions, defined benefit pension assets and the FFA's "miscellaneous financial assets and liabilities".

Foreign Equity Positions

The FFA ROW table lists foreigners' portfolio equity positions in the US. We add to this foreign direct investment not in foreign banking offices or funding corporations to define the ROW's equity holdings. To be consistent with our treatment of equity at market value, we use data on the market value of foreign direct investment from the BEA's Survey of Current Business, available since 1982. We do not have comprehensive data on dollar denominated claims of foreign corporations. For simplicity, we thus treat foreign equity and foreign direct investment by US investors abroad as entirely real, hence ignoring indirect net nominal positions of US investors through dollar-denominated claims issued by foreign corporations. For our benchmark year 1989 (and more generally all years except the late 1990s), foreign equity holdings are in any case relatively small.

Pensions

We deviate from the FFA in our treatment of defined benefit (DB) pension assets. In the FFA, pension plan holdings are included on the asset side of household balance sheets. With this convention, nominal assets in DB pension plans would contribute to households' nominal position. This would imply that households themselves bear all losses that the pension fund incurs from inflation. In contrast, we view defined-benefit plans as a real tax-transfer system, together with an endowment, the returns on which can be spent on transfers. The plan sponsor, i.e. a firm or a part of the government, is responsible for delivering a real flow of transfer payments. This view seems reasonable given that most plans specify benefits in terms of a replacement rate for wages at retirement. Since wages increase with inflation, future benefits are effectively indexed, at least over the medium run that is of interest to us. In many cases, this is reinforced by explicit inflation protection of payments after retirement.

With this assumption, gains and losses from inflation incurred by the pension funds accrue to the plan sponsor. For a private plan, a shortfall in the endowment due to inflation thus directly hurts the shareholders of sponsoring firm. Similarly, for a government-sponsored plan, the shortfall resembles an increase in net government debt. To capture these redistributions, we make three adjustments to the positions derived from FFA balance sheets. First, we add nominal assets in private DB pension funds to the net nominal position of businesses. Second, we reduce net government debt by nominal assets in DB funds for government employees. Finally, we subtract all pension claims from the asset side of households' balance sheet.

Unidentified Miscellaneous Items

The FFA nonfinancial corporate business sector has a large amount of unidentified miscellaneous assets and liabilities. In the late 1990s, unidentified items account for up to 20% of total assets and liabilities. The FFA determines unidentified items as residuals that result from subtracting all identifiable categories from total assets and liabilities reported by corporations (see Board of Governors of the Federal Reserve System (2000), p. 233). For the net nominal position of the nonfinancial sector, it is important whether these items represent nominal positions that lead to redistribution due to inflation, or rather accounting items that are effectively real. Numbers from

Compustat suggest substantial scope for the latter possibility. For example, goodwill acquired through takeovers or mergers made up 9% of total assets of Compustat Industrial firms in 2000. since there is no identifiable financial claim on another party corresponding to assets like goodwill, we omit all unidentified miscellaneous assets and liabilities from our calculations.

A.3 Valuation

We now describe in detail how we estimate the streams of payments for various types of bonds and loans that are at the heart of the adjustment.

Market Value of Bonds

Most government-issued bonds, such as Treasury bonds, municipal bonds and agency securities, are coupon bonds, issued at various maturities. For Treasury bonds, data on the maturity distribution of outstanding bonds held by the private sector is available from the U.S. Treasury. In contrast, we have no detailed information on the maturity distribution of corporate and municipal bonds. Knowing the maturity distribution is arguably less important for these bonds, since most issues have always had relatively long maturities. We proceed by assuming that all new issues of corporate and muni bonds have maturities of 10 and 20 years, respectively. This should give a reasonable approximation for the maturity distribution of outstanding bonds. In contrast, for Treasury securities, bills with maturity of one year or less make up a large - and changing - fraction of debt, so that it is particularly useful to have data on the maturity distribution.

We want to use our assumptions about maturity and the series of outstanding face values from the FFA to construct time series for new issues of bonds. To do so, we need to impose initial conditions. We have maturity data for Treasuries since 1967 and we assume that the 1967 maturity structure was being replicated in all earlier years. We also assume that before 1952, where our FFA numbers start, the total outstanding quantity was being replicated for each class of bonds. Starting from the initial distributions of bond vintages, it is then straightforward to recursively calculate series of new issues, every year retiring old bonds and inferring new issues from the change in outstanding face values. With this procedure, initial conditions strongly affect the results in the early years of the sample, and hence may induce some error there. However, their effect diminishes over time. As we move towards 1989, which will be the benchmark year for our calibrations, the results are mostly driven by observables.

The next step is to determine the series of future coupon payments for each vintage of bonds. We assume that bonds with maturity longer than one years are issued at par. For Treasuries, where we consider issues of different maturities, we take the coupon rates to be the appropriate Treasury constant maturity yields prevailing in the issue year. For corporate and muni bonds, we set coupon rates equal to the Moody's Aaa rate and the yield on the Fed's index of state and local bonds, respectively. For Treasury securities with maturity equal to one year or less. we assume that they are issued at a discount, and we use the prevailing six month zero coupon yield to discount them. In addition to the above coupon bonds, there is a set of short term liquid assets. The FFA distinguish checkable deposits, time and savings deposits, open market paper, various types of payables (trade payables, taxes payable etc.), various types of receivables (trade receivables, pension contribution receivables, insurance receivables etc.), as well as security repurchase agreements. We value all of these assets at par.

Market Value of Mortgages

To estimate payments on mortgages, we use data on mortgage rates, average maturity and the share of adjustable rate loans in new contracts from the Federal Housing Finance Board (FHFB), as well as the series of outstanding face value for all mortgages from the FFA. Unfortunately, data on the adjustable rate share in new mortgages are available only starting in 1982. As shown in Figure 19 these data show a high share of adjustable rate immediately after the high inflation experience of the late 1970s and early 1980s, and a steadily decreasing share thereafter. We thus conjecture that the share of adjustable rate mortgages was highly correlated with inflation even before 1982. We postulate the shape indicated in Figure 19: we set the share to its historical low of 12% up to the mid 1970s and let it increase in small steps so that it joins the actual series in 1982. We check this assumption using SCF data on mortgages in our benchmark 1989: we verify that the 1989 share of the face value of ARM mortgages in total face values from our FoF calculation matches the corresponding number calculated from the SCF.

In our calculations, we take the maturity of all new contracts in a given year to be equal to the average maturity reported by the FHFB. We assume that fixed and adjustable rate mortgages are amortized according to the same scheme. At any point in time, every vintage of mortgages is associated with its own current interest rate. When a vintage is created, its current rate is the mortgage rate on new issues from the FHFB. We assume that a vintage is refinanced whenever the market rate on new mortgages drops below the current rate of the vintage, and that refinancing does not change the maturity of the vintage. To determine amortization on outstanding vintages in a given year, we calculate annual mortgage payments for every outstanding vintage using its current rate and remaining maturity. For the given year, amortization is determined as if the current interest rate were in place until maturity. The amortization scheme thus changes with every refinancing.

We check whether our assumptions on refinancing produce sensible results by comparing the distributions of interest rates across vintages with the interest rates reported by the SCF for 1989. Table A.5 lists mean interest rates and years since the last refinancing for our middle class cohorts, who are the most important mortgage borrowers. There is some evidence of lower rates on old fixed rate mortgages that were locked in before the high interest period in the early 1980s, as well as on very young mortgages. Nevertheless, all rates are within two percentage points of each other. Our FoF calculation imply a current rate of 9.8% for the 1989 vintage, 9.0% for the 1978-1988 vintages (this the 1987 rate, obtained by refinancing), and slightly lower rates for vintages 1977 and older. While this might understate the rates paid by younger cohorts, probably because we do not take refinancing costs into account, we conclude that our rule does not induce significant bias in valuation.

To construct series of outstanding face values and new issues for both types of mortgages, we again need to impose initial conditions. As for bonds, we assume that 1952 was a 'steady state', where the outstanding mortgage debt was being replicated, with the same maturity for all new issues, the same mortgage rate, and the same share of adjustable rate contracts. Starting from this initial distribution, we recursively calculate time series for outstanding fixed and floating rate mortgage debt, for each year amortizing all old vintages of mortgages and inferring the quantity of new contracts from the change in total face value. Given series of new fixed rate contracts and mortgage rates, we then calculate, for every year *and every vintage,* the stream of payments yet to be made on the mortgage. The nominal yield curve can again be used to compute the market value of these payments. Since we are assuming that rates are set to keep the market value of adjustable rate mortgages always at par value, the adjustment factor per dollar of face value is simply the sum of the market value of fixed rate loans and the face value of adjustable rate loans, divided by the face value of all mortgages.

A.4 SCF Variables

For the SCF tables, households are sorted into groups first by age, and then, conditioning on age, by wealth and debt, as described in the text. The overall rich group is then simply the union, over cohorts, of the rich group from every cohort, and similarly for the middle and poor households. Since younger households are on average poorer, our rich group is somewhat poorer than the top 10% of the overall U.S. wealth distribution. Nevertheless, the statistics are by and large quite similar.

To arrive at Table 2, we first group SCF financial asset holdings into seven categories: directly held bonds, directly held equity, money market mutual funds, mutual funds, pension assets, IRAs, life insurance, as well as "various short term assets". The latter category includes checking accounts, saving accounts, and certificates of deposits. We then assume that for every dollar of directly held bonds recorded in the SCF, a household holds the well-diversified portfolio of bonds directly held by the FFA household sector. We thus multiply the individual household's bond position with the appropriate market adjustment factor for bonds. Similarly, for every dollar of claims on a particular type of investment intermediary recorded in the SCF, we assume that the households owns a share in the portfolio held by all intermediaries of that type in the FFA.

We also break down holdings in IRAs using FFA data. The FFA does not provide exact holdings in IRAs, but records assets in these accounts as direct holdings. However, there is a supplemental table that indicates at which institutions the IRAs are held. We assume that accounts held at commercial banks, savings institutions and credit unions are in the form of savings deposits. The bulk of IRA assets are at mutual funds, life insurance companies, or in "other self-directed accounts". We assume that assets at life insurers are part of life insurers' separate accounts and that other self-directed accounts have the same composition as DC pension funds. Given these assumptions and the composition of investment intermediary portfolios, we construct a portfolio of assets corresponding to the average dollar held in an IRA.

Our 'durables' item equals all nonfinancial assets recorded by the SCF minus business wealth. Here business wealth is defined as follows. For businesses in which the household has an active interest, it contains net equity if the business were sold today, plus loans from the household to the business, minus loans from the business to the household. For businesses in which the household does not have an active interest, business wealth contains the market value of the interest. The fact that loans to and from the business are likely to be nominal could introduce a bias in our exercise, at least for the rich agents who hold most of the business wealth. However, loans to and from a business that is controlled by the household can be renegotiated at little cost. They are thus likely to be state-contingent and work more like equity. Combining public equity and business wealth into a single equity position avoids dealing with the different treatment of private equity in the SCF and FFA data. In the FFA, corporate equity contains closely held shares that are not publicly traded, and it is not possible to separate private and public equity. We thus use a λ that is derived after consolidating corporate and noncorporate business.

A.5 Reconciliation of FFA and SCF Positions

Our calculation of indirect holdings due to claims on investment intermediaries and equity makes sense only if the aggregate nominal positions in the SCF and FFA data are reasonably close. Antoniewicz (1997) provides a detailed analysis of discrepancies between the two data sets. She suggests a number of adjustments to the FFA numbers, after which the discrepancies for most nominal assets are relatively small. Exceptions are pension assets, time deposits and private equity. The SCF does not provide numbers on DB pension assets. This is natural, since survey respondents usually do not know what these assets are: they only know contributions and expected benefits. This is in line with our view of DB pensions as a tax system. Our adjustment to the FFA-based calculations described in the previous subsection thus also brings our numbers in line with the SCF. Time and savings deposits recorded by the FFA are usually higher than in the SCF, while at the same time the value of closely held shares is larger in the SCF than in the FFA. This appears to be a general issue that has no obvious explanation. For our base year 1989, the discrepancies are both around $1trn. They thus cancel out and leave overall households assets roughly equal across the two datasets.

Discrepancies in aggregate positions, even if they leave total assets unchanged, will typically change nominal leverage. To obtain consistent results, we thus have two options: We can either adjust the FFA leverage ratio, or the SCF individual $NNP(0)$ positions. Assuming that the FFA numbers are correct is essentially assuming that SCF survey respondents misstated their positions or that the weights designed to make the SCF representative are incorrect. In contrast, assuming that the SCF numbers are correct, is essentially assuming that FFA measurement of business financial assets has problems. Since household positions in the FFA are residuals, this indirectly leads to a mismeasurement of household positions. We adopt the second assumption here. We recalculate households' aggregate net nominal position based only on SCF assets and liabilities. We adjust the positions of other sectors to retain zero net supply of nominal claims. For most FFA instruments, it is straightforward to identify the broad sector that is the counterparty to a households' position. If the counterparty cannot be uniquely identified, we assume that lending and borrowing sectors are matched proportionately. The adjustment leads to changes in the leverage ratio and aggregate net nominal positions, on the order of a few percent of GDP. For this reason, the aggregate positions and redistribution numbers in the tables for 1989 and 2001 do not coincide exactly with their counterparts in the aggregate FFA-based figures.

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Age	<35	35-45	45-55	55-65	65-75	>75
NW (mean)	49	162	278	308	291	242
NW (90%)	121	330	546	642	551	396
Size (%)	30	21	15	14	12	8
Rich						
NW (mean)	347	968	1,824	1,919	2,014	1,736
Middle						
NW (mean)	26	100	158	143	128	146
Poor						
NW (mean)	7	42	76	109	97	28

NOTE: Moments of net worth ($000s) and cohort sizes (percent of total population) by age, 1989 SCF.

Table 1: The Rich, the Poor, and the Middle Class

	Assets				Liabilities			
	All	Rich	Middle	Poor	All	Rich	Middle	Poor
Durables	51	39	71	61				
Equity	27	40	10	12				
Nominal	20	21	19	27				
Debt					13	7	30	4
Net Worth					87	93	66	97

NOTE: Selected balance sheet items for whole population as well as Rich, Middle and Poor households, in percent of respective group assets, 1989 SCF.

Table 2: Balance Sheet

Age	<35	35-45	45-55	55-65	65-75	>75	<35	35-45	45-55	55-65	65-75	>75
	Averages						Rich					
Durables	96.3	71.0	60.1	53.0	43.7	37.7	55.8	44.3	43.4	42.7	33.0	30.7
NFP	3.7	29.0	39.9	47.0	56.3	62.3	44.2	55.7	56.6	57.3	67.0	69.3
Equity	35.4	33.8	31.9	27.3	31.6	28.6	45.1	45.5	43.2	35.9	43.4	37.0
Net Short	-1.7	5.1	6.3	11.6	12.9	18.3	4.2	7.1	5.9	11.4	10.1	11.9
Bonds	10.2	11.6	9.9	11.0	10.8	14.4	8.7	11.6	10.0	10.8	11.3	18.0
Mortgages	-46.7	-23.3	-10.3	-4.7	-1.4	-0.3	-21.9	-10.3	-4.8	-2.5	-0.8	-0.1
NNP (0)	-38.2	-6.4	5.9	17.9	22.3	32.4	-9.0	8.4	11.1	19.7	20.6	29.8
Ind. Debt	-3.4	-3.3	-3.1	-2.6	-3.0	-2.7	-4.3	-4.4	-4.1	-3.4	-4.2	-3.7
NNP (.07)	-41.6	-9.7	2.8	15.3	19.3	29.7	-13.3	4.0	7.0	16.3	16.4	26.1
	Middle						Poor					
Durables	225.8	127.4	97.3	83.7	66.4	50.1	53.9	76.2	67.2	54.5	59.9	61.8
NFP	-125.8	-27.4	2.7	16.3	33.6	49.9	46.1	23.8	32.8	45.5	40.1	38.2
Equity	10.5	17.3	12.0	11.9	10.7	10.3	24.2	12.0	16.6	14.0	8.1	3.1
Net Short	-20.7	2.4	6.1	7.0	14.7	31.9	4.9	1.5	8.8	18.0	22.8	29.3
Bonds	13.9	10.9	10.5	11.0	11.0	7.9	12.4	13.4	7.9	11.9	8.3	3.8
Mortgages	-131.6	-59.0	-28.0	-14.9	-4.4	-1.0	-0.3	-4.8	-1.5	0.0	0.0	0.0
NNP (0)	-138.4	-45.7	-11.3	3.0	21.3	38.8	17.0	10.1	15.1	29.9	31.1	33.1
Ind. Debt	-1.0	-1.7	-1.2	-1.2	-1.0	-1.0	-2.3	-1.1	-1.6	-1.4	-0.8	-0.3
NNP (.07)	-139.4	-47.4	-12.4	1.8	20.3	37.8	14.7	9.0	13.5	28.5	30.3	32.8

Table 3: Asset Positions (% net worth)

Government (% $NNP\ (\lambda)$)	**+43.7**	+23.3
Rest of the World (% $NNP\ (\lambda)$)		
Capitalists (% Mkt Value)	**+4.2**	-2.7
Households (% Net Worth)	**-2.5**	-1.5

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

NOTE: Net gain from **Full Surprise** and Indexing Asap experiments in % of net worth, based on 1989 SCF.

Table 4: Redistribution 1989 (% Net Worth)

Govmt (% GDP)	**+14.1**	+5.2
ROW (% GDP)	**-6.7**	-2.3

Households	net loss		loss		gain	
% GDP	**-8.1**	-3.1	**-17.5**	-6.6	**+9.4**	+3.5

Households (% total loss)

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

NOTE: Net gain from **Full Surprise** and Indexing Asap experiments, based on 1989 SCF.

Table 5: Redistribution 1989 (Aggregates)

Government (% $NNP\ (\lambda)$)	**+44.8**	+19.0
Rest of the World (% $NNP\ (\lambda)$)		
Capitalists (% Mkt Value)	**+8.8**	+2.8
Households (% Net Worth)	**-1.0**	-0.6

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

NOTE: Net gain from **Full Surprise** and Indexing Asap experiments in % of net worth, based on 2001 SCF.

Table 6: Redistribution 2001 (% Net Worth)

Govmt (% GDP)	**+15.9**	+6.7
ROW (% GDP)	**-13.4**	-5.8

Households	net loss		loss		gain	
(% GDP)	**-3.4**	-1.9	**-12.0**	-6.0	**+8.6**	+4.1

Households (% total loss)

	All		Poor		Middle		Rich	
All	**-30**	-27	**-29**	-22	**+56**	+58	**-57**	-63
<35	**+22**	+26	**-1**	-1	**+21**	+22	**+2**	+5
35-45	+**30**	+33	**-2**	-2	**+29**	+33	**+3**	+2
45-55	**+2**	-13	**-5**	-5	**+14**	+6	**-7**	-14
55-65	**-26**	-26	**-7**	-6	**+2**	+3	**-21**	-23
65-75	**-34**	-31	**-11**	-7	**-1**	-2	**-22**	-22
>75	**-24**	-16	**-3**	-1	**-9**	-4	**-12**	-11

NOTE: Net gain from **Full Surprise** / Indexing ASAP experiments, based on 2001 SCF.

Table 7: Redistribution 2001 (Aggregates)

Investment	1989	2001
Government Bonds	5.43	5.19
Corporate Bonds	4.99	5.47
Mortgages	5.30	6.79
Corporate Equity	2.33	0.85
Noncorporate Equity	1.60	1.85
Mutual Funds	4.06	2.57
DC Pension Assets	2.59	2.60

Table 8: Average Duration of Assets

Type	1	2	3	4
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 9: Target Earnings

Preferences	Skills			Technology	Government
$\gamma = 2$	$\phi_{r,0} = 2.38$	$\phi_{m,0} = 2.32$	$\phi_{p,0} = 1.03$	$\alpha = 0.41$	$\tau = 0.5$
$\nu = 2$	$\phi_{r,1} = 4.97$	$\phi_{m,1} = 2.90$	$\phi_{p,1} = 1.51$	$\rho = 0.5$	$tr = 0.03$
$\epsilon = 2$	$\phi_{r,2} = 6.28$	$\phi_{m,2} = 3.07$	$\phi_{p,2} = 1.46$	$\delta = 0.52$	$G/Y = 0.24$
$\sigma_r = 0.66$	$\phi_{r,3} = 9.28$	$\phi_{m,3} = 2.33$	$\phi_{p,3} = 1.07$	$\delta_K = 0.52$	
$\sigma_m = 0.73$	$\phi_{r,4} = 0$	$\phi_{m,4} = 0$	$\phi_{p,4} = 0$	$\delta_E = 0.52$	
$\sigma_p = 0.78$	$\phi_{r,5} = 0$	$\phi_{m,5} = 0$	$\phi_{p,5} = 0$	$1 + g = 1.02^{10}$	
$\eta = 0.03$					
$\xi_r = 0.007$					
$\xi_m = 0$					
$\xi_p = 0$					
$\beta_r = 1.60$					
$\beta_m = 0.62$					
$\beta_p = 0.62$					

Table 10: Calibrated Parameter Values

	Spending			Taxes			Pensions		
Age	Poor	Middle	Rich	Poor	Middle	Rich	Poor	Middle	Rich
< 35	0.31	0.28	-0.47	1.67	1.61	-0.11	0.32	0.28	-0.40
$35-44$	0.15	4.33	1.04	1.74	5.67	1.29	0.28	4.40	1.10
$45-54$	-0.35	4.00	-0.97	0.91	5.16	-0.95	0.01	4.12	-0.92
$55-64$	-1.42	1.33	-1.37	-0.76	1.96	-1.40	-0.09	1.97	-1.30
$65-74$	-5.33	-0.33	-2.07	-5.29	-0.29	-2.09	1.53	2.78	-1.88
≥ 75	-7.10	-2.98	-1.81	-7.02	-2.87	-1.66	0.21	0.40	-1.71
Total		0.07			0.95			1.02	

Table 11: Welfare Effects, Full Surprise, Return to Steady State

	Spending			Taxes			Pensions		
Age	Poor	Middle	Rich	Poor	Middle	Rich	Poor	Middle	Rich
< 35	0.45	0.39	-0.79	1.69	1.60	-0.22	0.66	0.48	-0.47
$35-44$	0.24	4.37	0.71	1.54	5.51	1.09	0.79	4.66	1.01
$45-54$	-0.33	3.97	-1.25	0.63	4.88	-1.09	0.69	4.51	-1.03
$55-64$	-1.44	1.27	-1.57	-0.98	1.72	-1.52	0.55	2.24	-1.41
$65-74$	-5.33	-0.37	-2.18	-5.32	-0.36	-2.18	-0.12	1.95	-2.06
≥ 75	-7.07	-2.97	-1.83	-7.05	-2.94	-1.78	-2.24	-0.80	-1.83
Total		0.05			0.81			1.07	

Table 12: Welfare Effects, Full Surprise, New Steady State

Age	Spending			Taxes			Pensions		
	Poor	Middle	Rich	Poor	Middle	Rich	Poor	Middle	Rich
< 35	0.07	0.07	-0.18	0.64	0.62	-0.03	0.08	0.07	-0.15
$35-44$	-0.01	1.56	0.28	0.65	2.14	0.38	0.03	1.58	0.30
$45-54$	-0.28	1.67	-0.55	0.26	2.17	-0.55	-0.15	1.74	-0.53
$55-64$	-0.44	0.54	-0.76	-0.16	0.80	-0.79	0.08	0.78	-0.74
$65-74$	-1.19	-0.07	-0.72	-1.18	-0.06	-0.74	1.49	1.21	-0.65
≥ 75	-1.03	-0.82	-0.78	-1.00	-0.77	-0.72	1.75	0.54	-0.74
Total		0.11			0.48			0.46	

Table 13: Welfare Effects, Gradual, Return to Steady State

Age	Spending			Taxes			Pensions		
	Poor	Middle	Rich	Poor	Middle	Rich	Poor	Middle	Rich
< 35	0.13	0.11	-0.31	0.65	0.62	-0.08	0.22	0.15	-0.17
$35-44$	0.02	1.58	0.15	0.57	2.08	0.30	0.24	1.69	0.26
$45-54$	-0.27	1.67	-0.66	0.14	2.06	-0.61	0.13	1.88	-0.57
$55-64$	-0.44	0.51	-0.85	-0.25	0.71	-0.84	0.34	0.90	-0.78
$65-74$	-1.20	-0.09	-0.77	-1.20	-0.09	-0.78	0.84	0.87	-0.72
≥ 75	-1.03	-0.82	-0.79	-1.01	-0.81	-0.77	0.81	0.06	-0.79
Total		0.10			0.43			0.49	

Table 14: Welfare Effects, Gradual, New Steady State

	Spending			Taxes			Pensions		
Age	Poor	Middle	Rich	Poor	Middle	Rich	Poor	Middle	Rich
< 35	0.27	0.24	-0.38	2.04	1.98	0.12	0.27	0.25	-0.29
$35-44$	0.15	2.87	0.13	2.24	4.68	0.52	0.32	2.96	0.21
$45-54$	-0.35	4.08	-0.12	1.32	5.61	-0.07	0.16	4.35	-0.04
$55-64$	-1.67	2.19	-0.94	-0.78	3.01	-0.97	0.23	3.09	-0.83
$65-74$	-3.24	0.26	-1.75	-3.19	0.31	-1.78	5.45	4.36	-1.50
≥ 75	-7.97	-0.30	-1.70	-7.89	-0.16	-1.51	1.70	3.94	-1.56
Total		0.13			1.30			1.35	

Table 15: Welfare Effects, 2001, Full Surprise, Return to Steady State

	Spending			Taxes			Pensions		
Age	Poor	Middle	Rich	Poor	Middle	Rich	Poor	Middle	Rich
< 35	0.12	0.11	-0.20	1.01	0.98	0.05	0.12	0.11	-0.15
$35-44$	0.03	1.50	0.24	1.08	2.43	0.43	0.12	1.55	0.28
$45-54$	-0.25	2.23	-0.08	0.59	3.02	-0.07	-0.01	2.36	-0.04
$55-64$	-0.79	0.44	-0.72	-0.36	0.87	-0.75	0.12	0.88	-0.67
$65-74$	-1.25	-0.34	-0.89	-1.23	-0.32	-0.92	3.07	1.75	-0.77
≥ 75	-2.17	-0.32	-0.81	-2.12	-0.25	-0.72	2.35	1.84	-0.75
Total		0.10			0.69			0.69	

Table 16: Welfare Effects, 2001, Gradual, Return to Steady State

Sector	Table	Number
Households	Households and nonprofit organizations	B.100
Government	Consolidated federal, state, and local	L.106c
	Government employee retirement funds	L.120
	Monetary authority	L.108
Rest of the World	Rest of the world	L.107
	Foreign banking offices in U.S.	L.111
	U.S. funding subsidiaries	L131
Investment Intermediaries	Money market mutual funds	L.121
	Mutual funds	L.122
	Bank personal trusts and estates	L.116
	Private pension funds	L.119
	Life insurance companies (separate account)	L.117
Nonfinancial Business	Nonfarm nonfinancial corporate business	B.102
	Nonfarm noncorporate business	B.103
	Farm business	L.104
Financial business	US-chartered commercial banks	L.109
	Saving institutions	L.114
	Credit unions	L.115
	Life insurance companies (general account)	L.117
	Other insurance companies	L.118
	Closed-end and exchange traded funds	L.123
	Government-sponsored enterprises	L.124
	Federally related mortgage pools	L.125
	Issuers of asset-backed securities	L.126
	Finance companies	L.127
	Mortgage companies	L.128
	Real estate investment trusts	L.129
	Security brokers and dealers	L.130
	Funding corporations (except foreign)	L.131

Table 17: Tables in the Flow of Funds Accounts

Age	<35	35-45	45-55	55-65	65-75
Fixed rate mortgage holders					
Year last refinanced	1985	1982	1979	1977	1975
Interest rate	10.3	9.9	9.0	9.0	8.7
AR mortgage holders					
% all par values	32	31	25	20	10
% with 1 yr adj. interval	76	71	60	62	54
Year last refinanced	1986	1985	1984	1985	1978
Original interest rate	9.9	10.6	9.9	10.9	10.4
Current interest rate	8.8	9.3	8.6	10.7	8.7

Table 18: Cohort means of interest rates and year of last refinancing as well as within-cohort share of adjustable rate mortgages in total outstanding par values and within-cohort share of adjustable rate mortgages with a one-year adjustment interval, middle class cohorts, 1989 SCF.

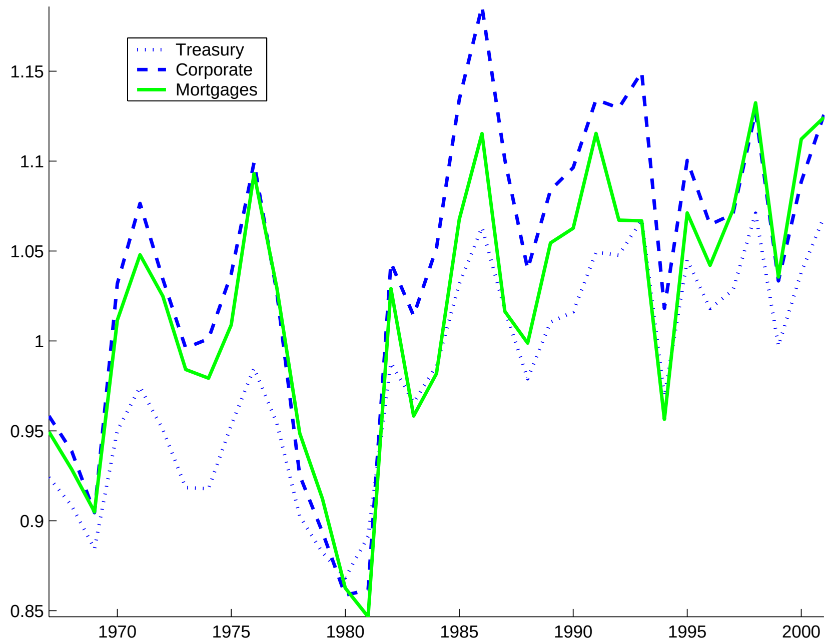

Figure 1: Market Value Adjustment Factors

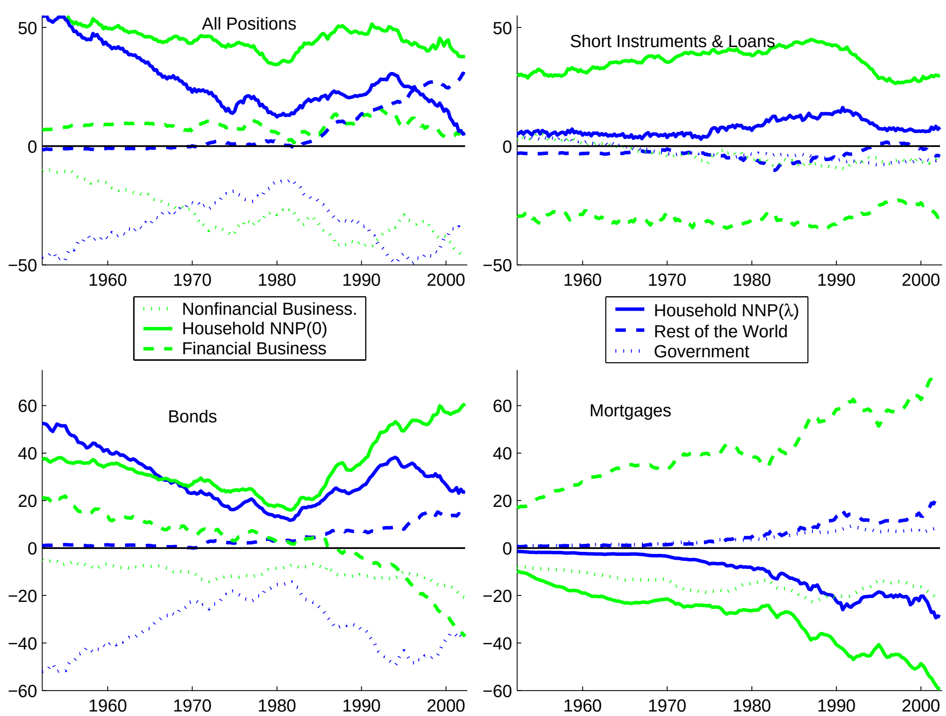

Figure 2: Net Nominal Positions, Aggregates and by Instrument, % GDP.

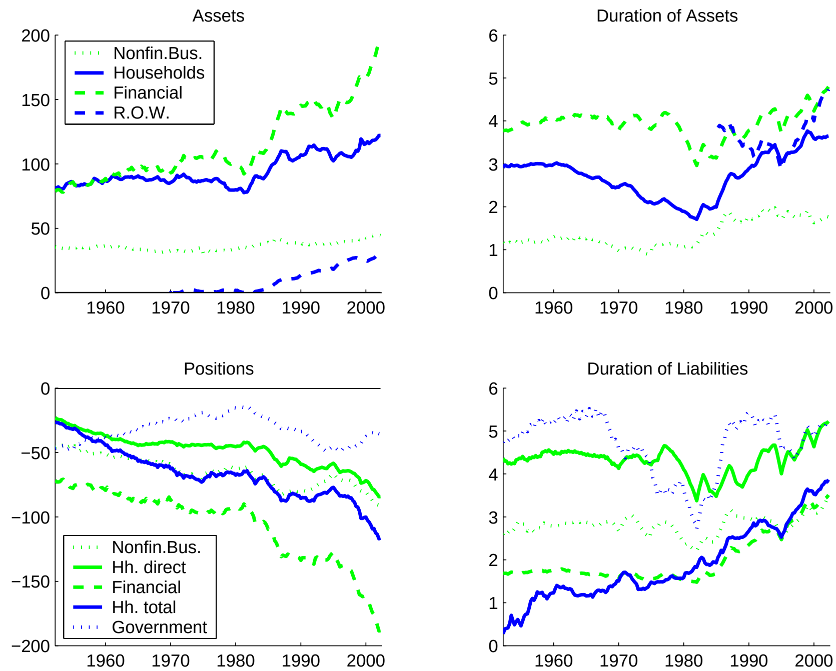

Figure 3: Gross Nominal Positions (%GDP) and Duration (Years).

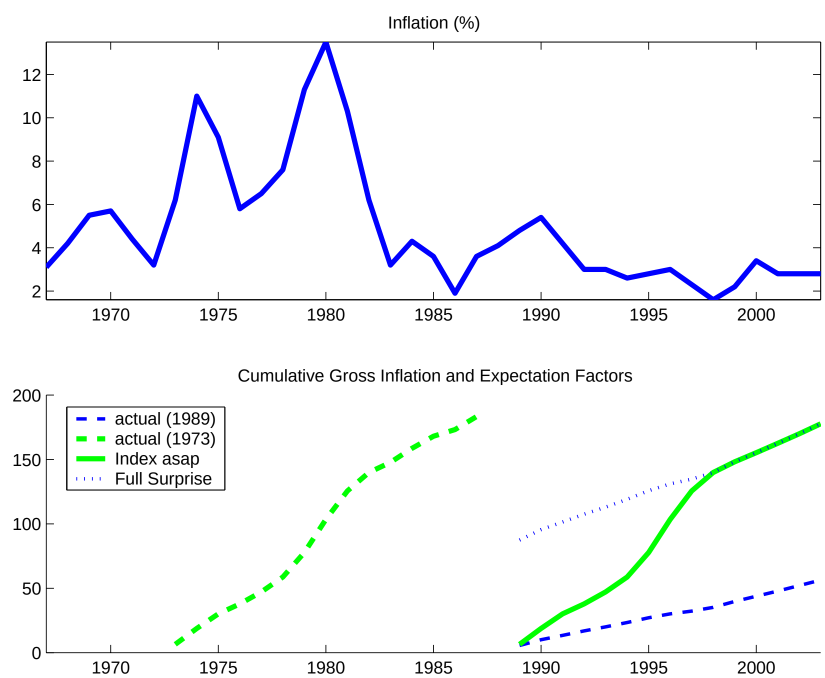

Figure 4: Inflation expectation factors for redistribution experiments

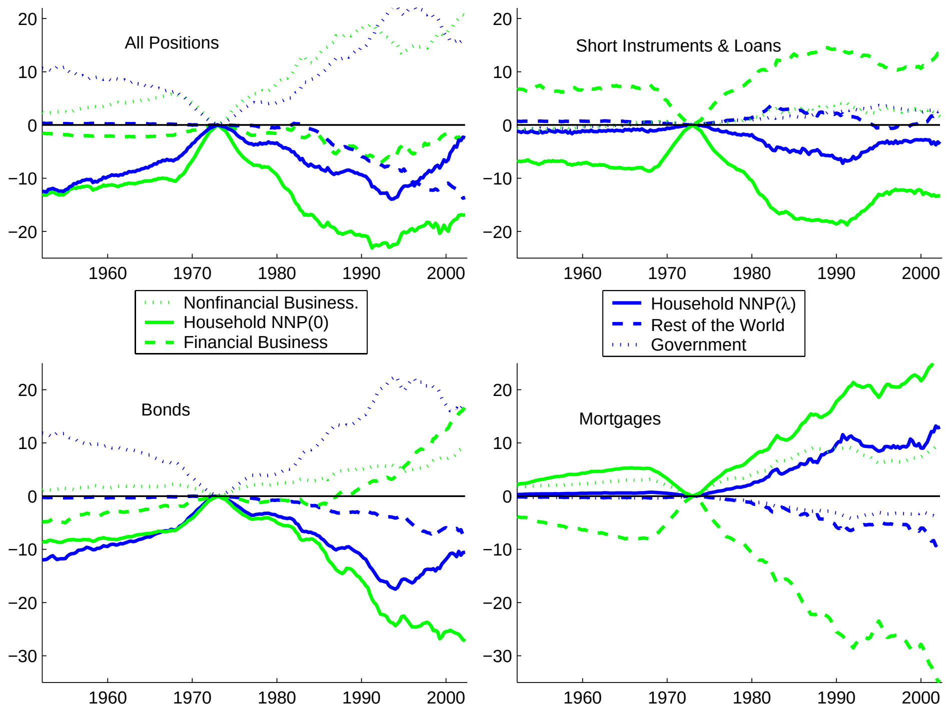

Figure 5: Redistribution over time, Full Surprise, % GDP

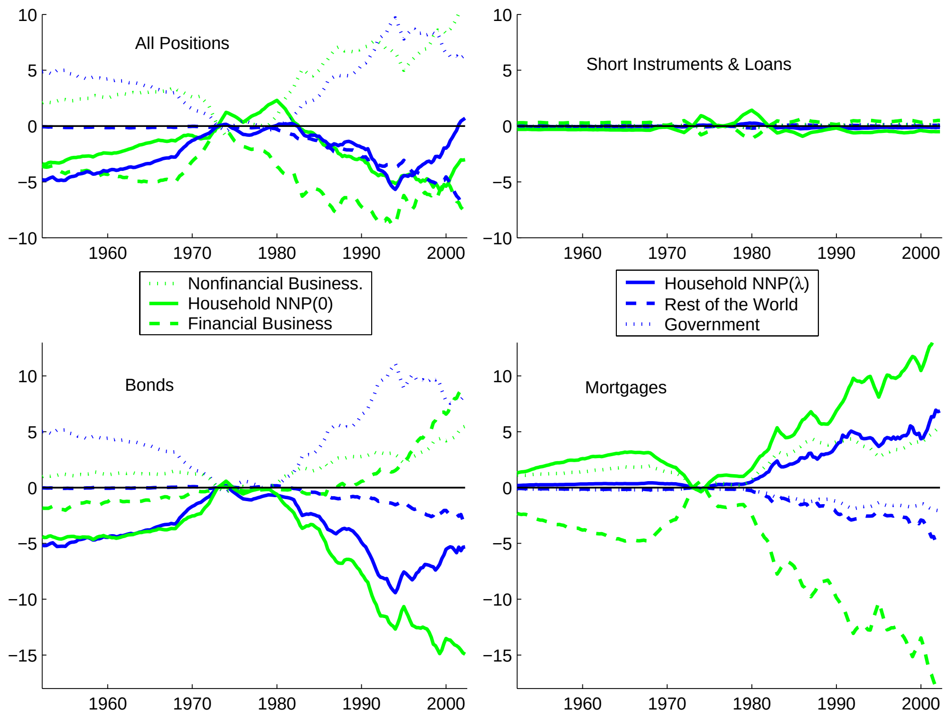

Figure 6: Redistribution over time, Indexing Asap, % GDP

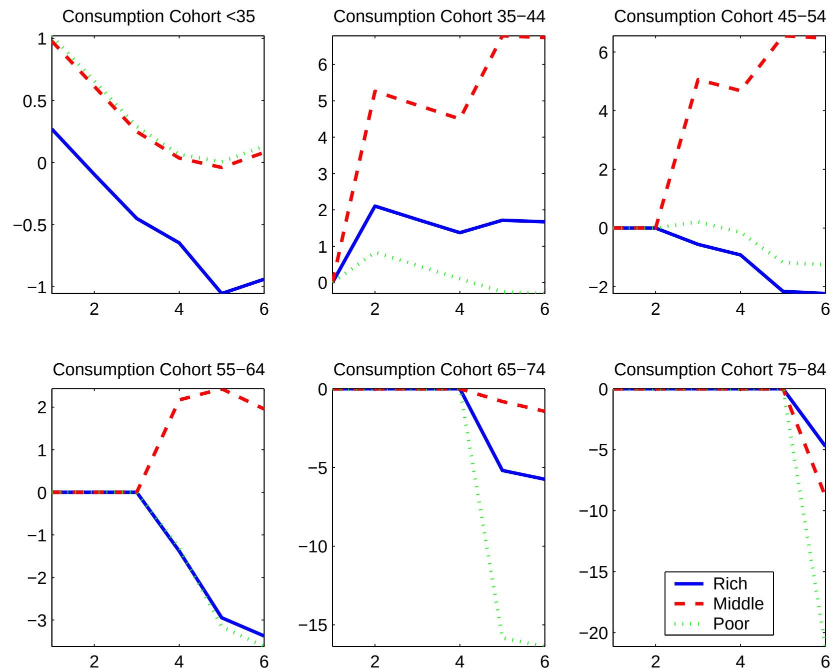

Figure 7: Impact on Consumption, "Full Surprise"

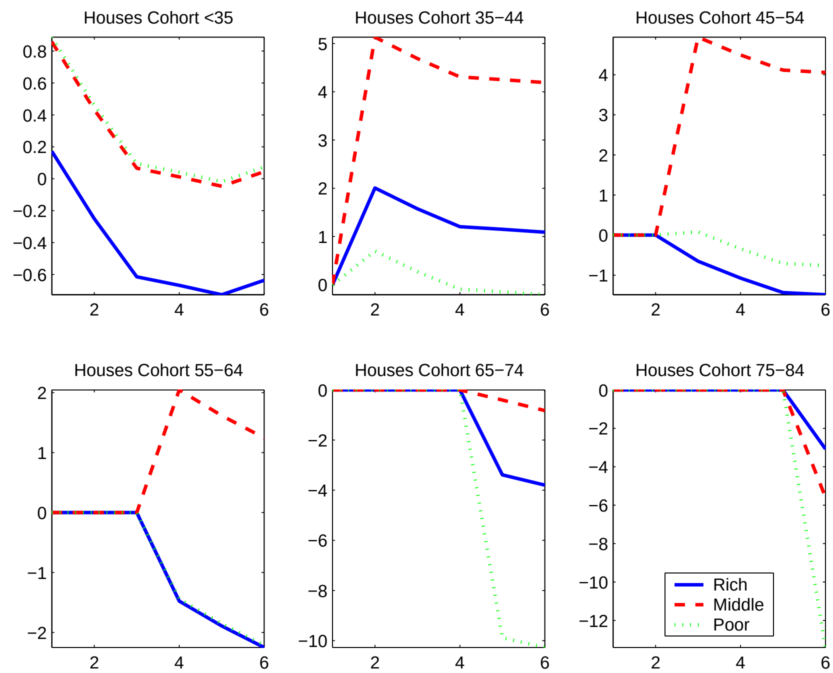

Figure 8: Impact on Housing Consumption, "Full Surprise"

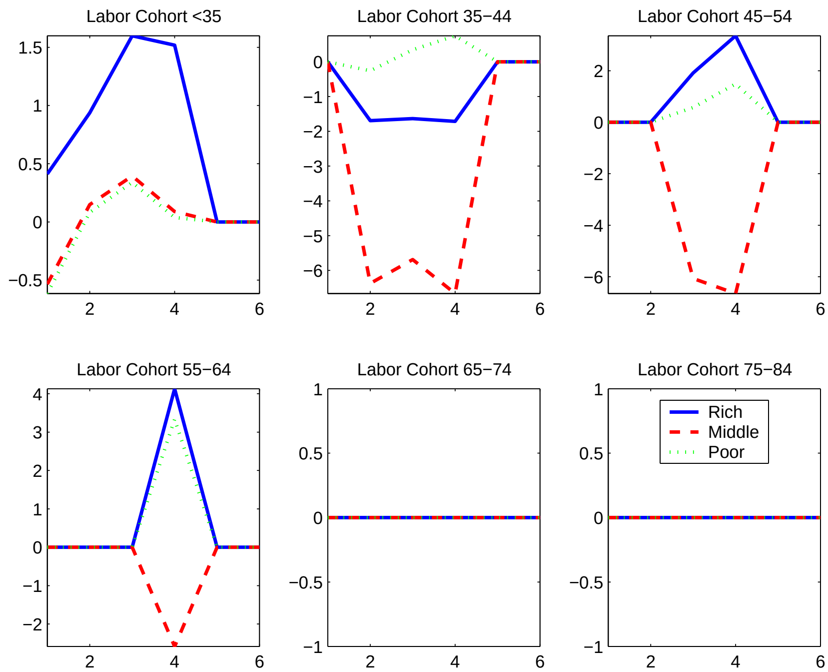

Figure 9: Impact on Labor, "Full Surprise"

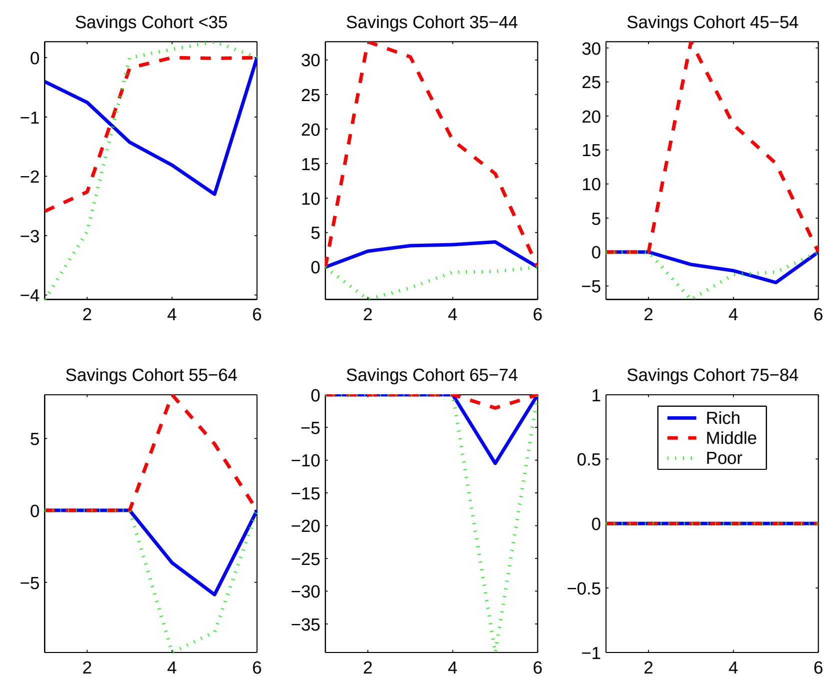

Figure 10: Impact on Savings, "Full Surprise"

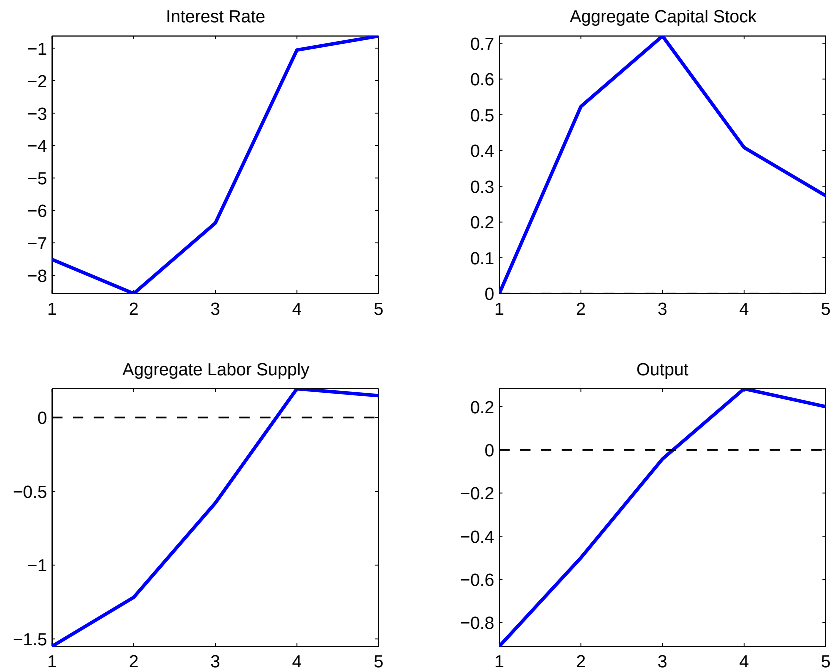

Figure 11: Impact on Economic Aggregates, "Full Surprise"

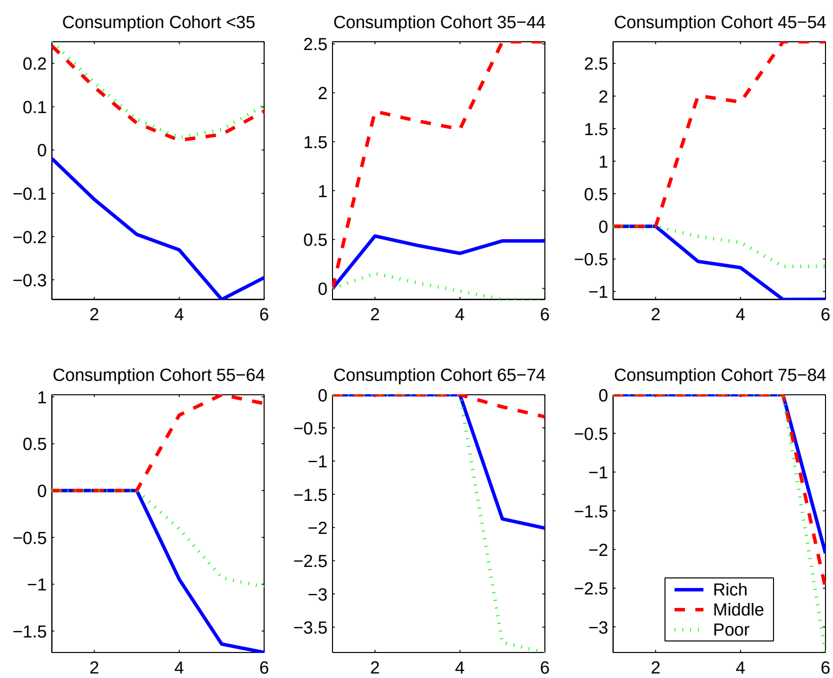

Figure 12: Impact on Consumption, "Indexing ASAP"

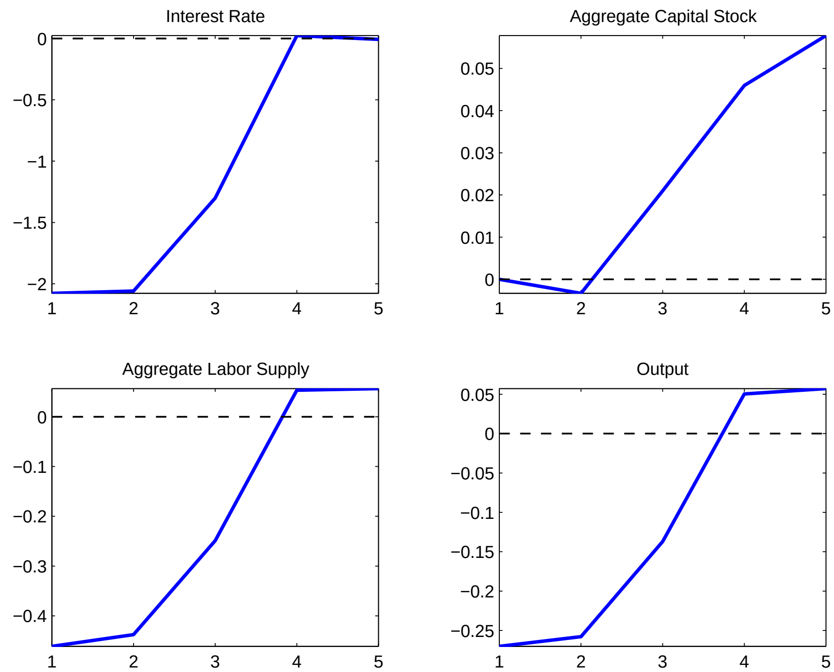

Figure 13: Impact on Economic Aggregates, “Indexing ASAP”

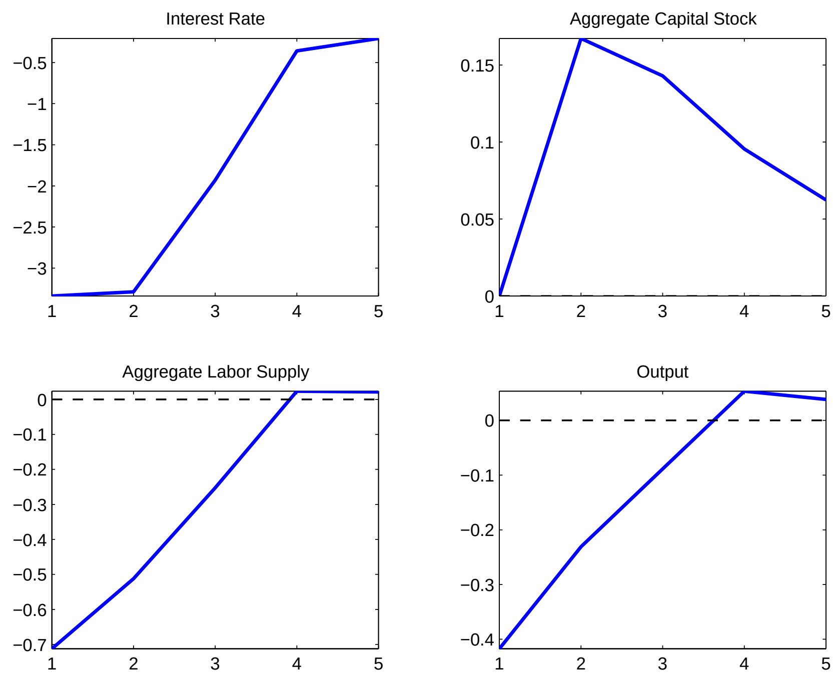

Figure 14: Impact on Economic Aggregates, “Indexing ASAP,” Indexed Government Debt

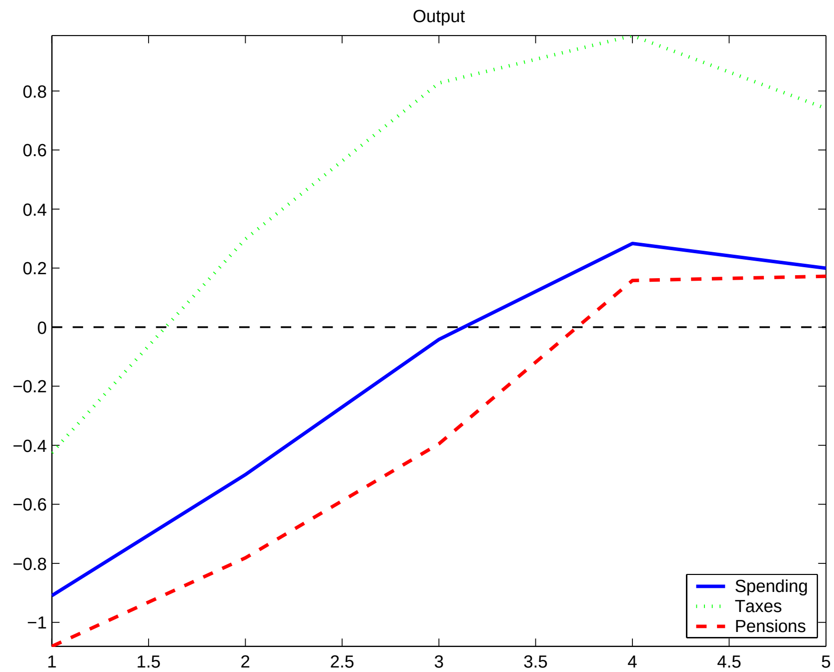

Figure 15: Impact on Economic Aggregates, “Full Surprise,” Different Policies

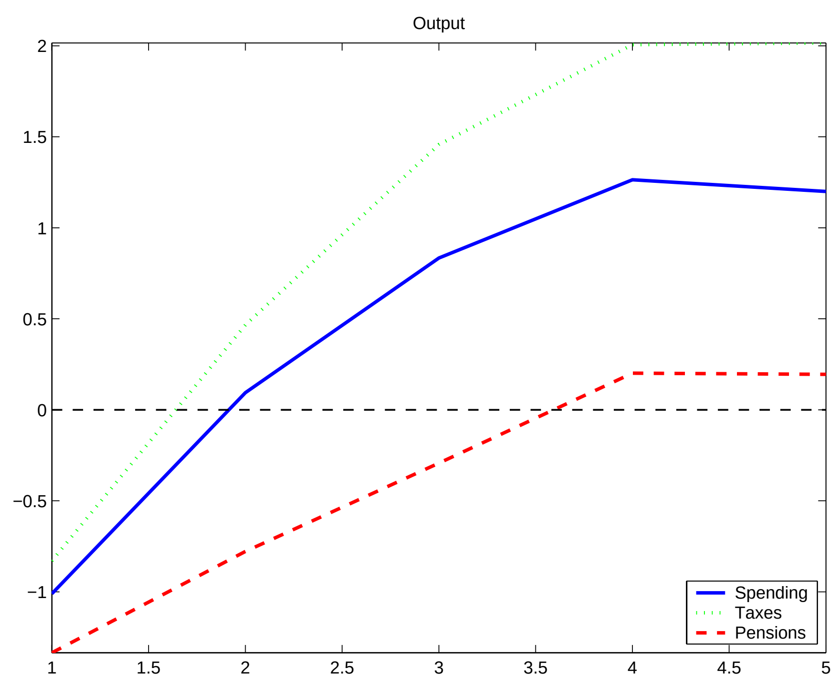

Figure 16: Impact on Economic Aggregates, “Full Surprise,” Different Policies, Permanent Effects

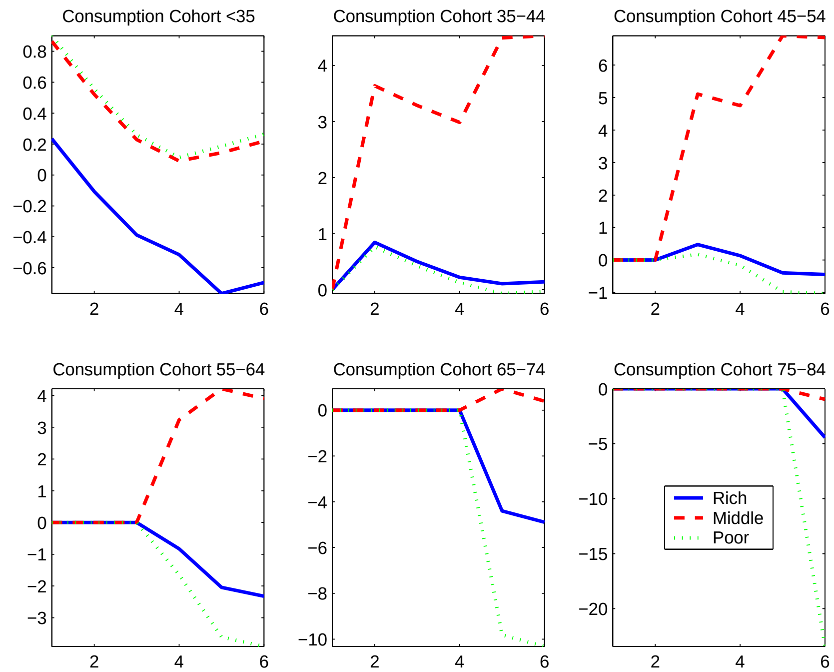

Figure 17: Impact on Consumption, “Full Surprise,” 2001

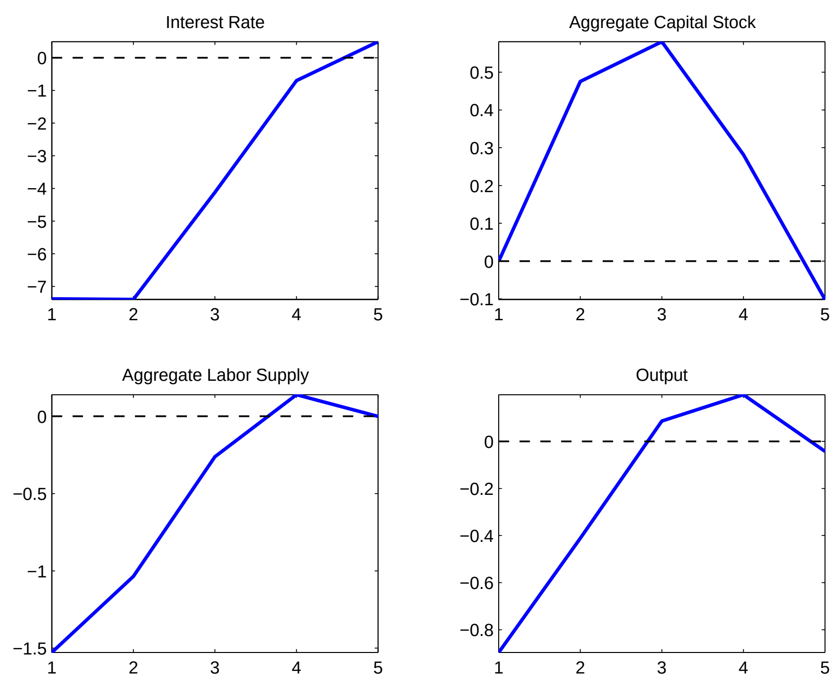

Figure 18: Impact on Economic Aggregates, “Full Surprise,” 2001

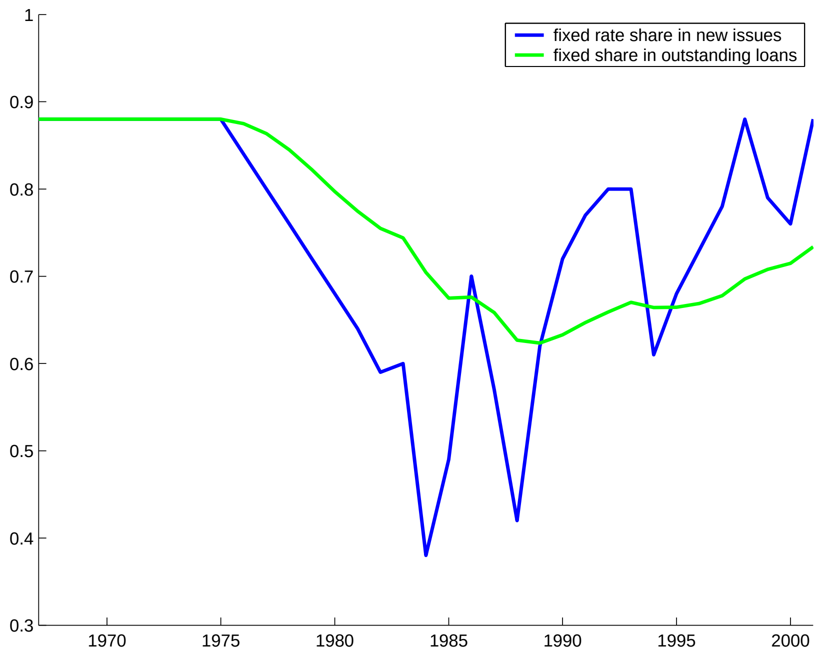

Figure 19: Share of Fixed Rate Mortgages