The Uneven Welfare Costs of the Volcker Disinflation*

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Abstract

We use a Heterogeneous Agent New Keynesian (HANK) model to quantify the distribution of welfare gains and losses of the US Volcker disinflation. In the long run households prefer low inflation, but the Volker disinflation requires a transition period characterized by a sharp increase in the real interest rate and unemployment, as well as a redistribution from net nominal borrowers to net nominal savers. We calibrate the model to match the micro and macro moments of the early 1980s high-inflation environment and examine the actual changes in the nominal interest rate and inflation over the Volcker disinflation. While aggregate welfare gains are positive, the effects are highly skewed across households; just over 50 percent would prefer to avoid the disinflation. This share depends negatively on the liquidity value of money, positively on the average duration of nominal borrowing, and positively on the short-run increase in the real interest rate and unemployment.

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1 Introduction

In most environments, households would prefer an economy with low and stable inflation over one with persistently high inflation. Even putting aside costs from relative price dispersion and inflation uncertainty, high inflation imposes resource costs as consumers alter their savings and consumption behavior in order to economize on nominal liquid assets subject to an inflation tax. In recent years, the welfare costs of high inflation have been especially salient. After averaging 8 percent in 2022, CPI inflation has declined but remains above the Federal Reserve's 2 percent target. The last time US households faced a comparable inflation episode was almost 50 years ago. In the late 1970s, inflation was in excess of 10 percent. Paul Volcker, Chair of the Federal Reserve from 1979 to 1987, publicly committed to reducing inflation and largely succeeded by the mid-1980s. The period of tight monetary policy designed to tame high inflation became known as the Volcker disinflation, and it has been influential for modern practitioners of monetary policy.

In this paper, we revisit the welfare costs and benefits of the Volcker disinflation. The debate over the costs of disinflation typically centers on an aggregate sacrifice ratio, or the short-run loss in output or employment necessary to reduce the rate of price inflation. But the focus on aggregates necessarily abstracts from the underlying heterogeneous effects. By developing a framework to study the distributional effects, we quantity the redistributive costs and benefits of the Volcker disinflation.

The heterogeneous effects are potentially significant for several reasons. First, the Volcker period encompassed a sharp increase in the real interest rate and unemployment; the incidence of which is felt unevenly across the income and wealth distribution. Next, disinflation lowers the burden of the inflation tax whose incidence varies across households with heterogeneous money demand. Furthermore, households typically borrow in nominal contracts with long durations and hold a mix of real and nominal assets. A sudden decrease in inflation and inflation expectations accompanying an increase in the real interest rate increases the real burden of net nominal borrowers and redistributes resources towards net nominal savers (Doepke and Schneider, 2006a).

To isolate the welfare costs imposed by a sudden disinflation, we build a heterogeneous agent New Keynesian (HANK) monetary economy (Kaplan et al., 2018). We extend a Bewley-Imrohoroglu-Huggett-Aiyagari economy to include money, valued for its liquidity services, a durable good, and long-term secured loans. Households face idiosyncratic earnings shocks as in a standard income fluctuation problem but now also face a portfolio choice problem. They must allocate resources between money, a long-term interest-bearing nominal asset, and investment in durable goods. They also have access to secured borrowing against their durable stock in the form of a long-term nominal contract. Nominal borrowing is the first source of nominal rigidities and allows us to capture a common feature of household balance sheets: a fixed-rate mortgage secured by a house or other secured loans, such as those for automobiles. The second source of nominal rigidity arises from sticky wages, which creates a short-run tradeoff between inflation and unemployment embodied in a wage Phillips curve (Erceg et al., 2000; Auclert et al., 2018). The nominal interest rate and inflation rate are jointly determined by the fiscal and monetary authorities.

We calibrate the model to match key features of the US economy just before the Volcker disinflation. Then, we construct a *disinflation equilibrium path* as the economy's dynamic response to a sudden shift in the monetary and fiscal policy stance. We calibrate the monetary and fiscal policies to match the exact sequence of nominal interest rates and inflation observed during the Volcker disinflation. This path includes a short-run increase in the real interest rate before nominal interest rates and inflation fall to their permanently lower level.[1] Because of sticky wages and the resulting wage Phillips curve, there will be a decline in output and an increase in unemployment along the disinflation path, consistent with the recession generated by the Volcker disinflation.

The unanticipated policy shift endogenously redistributes resources away from borrowers and towards savers. Borrowers also experience a sudden increase in their continued borrowing costs due to the rise in the real interest rate. Borrowers deleverage in response to their unexpectedly large real debt burden, while savers further increase their savings to smoothly consume the real value of their windfall over future periods. At the same time, all households are hurt by the rise in unemployment, and all households rebalance their portfolios as a reduced inflation tax lowers the cost of holding real balances.

The full welfare effects of the disinflation will be determined jointly by the benefit of the lower inflation tax, the cost of the redistribution, and the changes in the real interest rate and unemployment. For both borrowers and savers, the immediate impact of the transition is ambiguous. Savers receive a windfall from the redistribution while also benefiting from the lower inflation tax and the higher real interest rate. However, they face costs from the increase in unemployment. For borrowers, the welfare benefit depends on whether the lower inflation tax is enough to compensate them for both the wealth lost in the redistribution and the short-run increase in the real interest rate and unemployment. In our baseline calibration, the aggregate gains from the Volcker disinflation are positive; on average, households need to be compensated between 2 and 3 percent of their consumption in order to be willing to stay in the high-inflation steady state. However, the costs and benefits are unevenly distributed across households; just over 50 percent of households prefer to remain in the high inflation steady state rather than face the costs of the redistribution and the temporary increase in real borrowing costs and unemployment. This suggests that the long-run benefits of the lower inflation tax and lower real interest rate are not enough to compensate most borrowers for their losses during the transition.

The costs and benefits of the Volcker Disinflation are borne unequally across the income distribution. In an up or down vote, 22 percent of low income households, 72 percent of middle income households, and no high-income households would choose to live with high inflation despite the high inflation tax. In the long run, if they could skip the redistribution and disinflation period, most of these households would prefer the low-inflation equilibrium. Only 1.6 percent prefer to remain in the high-inflation equilibrium in the long run. These are all low-income households who dislike the slight long-run decline in employment rates resulting from movements along the wage

[1] Hagedorn (2011) shows that this temporary increase in nominal rates may not have been an optimal strategy depending on the level of credibility of the central bank.

Phillips curve.

We decompose the overall welfare costs into separate efficiency, redistribution, and insurance components, applying the methodology of Bhandari et al. (2023). In the baseline model, the 2 to 3 percent average consumption-equivalent welfare gain follows from positive contributions from the efficiency and insurance benefits of the disinflation, which are partially offset by negative contributions from the redistribution component.

We then explore the sensitivity of the welfare results to four alternative experiments. First, we ask how these welfare results depend quantitatively on the burden of the inflation tax, which is determined by the liquidity value of money. We compare our baseline welfare results to a calibration of an economy with no money. Without any offsetting welfare gains from the reduction of the inflation tax, all borrower households are sufficiently hurt by the redistribution that they would prefer to remain in the high-inflation steady state.

Second, we compare the welfare results from the baseline calibration to a version with a one-period duration for nominal borrowing, as opposed to the 4.5 year duration in the baseline calibration. The shorter duration substantially decreases the size of the redistribution. Because the redistribution is smaller, borrowers are more willing to face the burden of the redistribution in exchange for the benefit of the lower inflation tax. However, the borrowers are still hurt by the short-run increase in the real interest rate. In this economy, although the welfare costs for most households are substantially smaller than the baseline model, most would still prefer to stay in the high inflation steady state because of the changes in the real interest rate during the disinflation.

Third, we compare our results to a version in which there is no change in the real interest rate along the disinflation path. Although borrowers no longer face a temporary increase in their borrowing cost, they are still hurt by the redistribution, and most borrowers still prefer to remain in the high-inflation steady state.

Finally, we consider an experiment in which there is no short-run increase in unemployment. This case could be considered a best-case-scenario for the Federal Reserve if they were able to disinflate without invoking a shift along the wage Phillips curve. Unsurprisingly, removing the increase in unemployment substantially lowers the welfare cost of the disinflation. Nevertheless, borrowers still face substantial losses from the redistribution and over half of households still prefer to remain in the high inflation steady state. The differences between the baseline calibration and the alternative experiments highlight the importance of capturing all four channels—the redistribution, the decrease in the inflation tax, and the changes in the real interest rate and unemployment—when considering the welfare costs of the Volcker disinflation.

After discussing the previous literature, in Section 2 we describe our model and in Section 3 we describe the data and model calibration. In Section 4 we describe the transition period for our baseline experiment: a surprise disinflation calibrated to match the paths of nominal interest rates and inflation during the Volcker disinflation, and discuss the welfare effects of the disinflation. Section 5 compares the results from our baseline calibration to a cashless economy, an economy with only one-period borrowing, and a transition with no change in the real interest rate and

unemployment. Section 6 concludes.

Contribution to the literature

Our analysis of the Volcker disinflation highlights the importance of considering four channels to understand the welfare costs of a disinflationary period: the revaluation of nominal assets, the change in the inflation tax, and the changes in the real interest rate and unemployment. We discuss the literature on each of these channels below. A key contribution of our work is that we are the first to consider this question in HANK model with a rich enough portfolio choice problem on the household side to jointly consider all four channels.

We include money explicitly to allow for long-run benefits of reducing steady-state inflation. With money, inflation serves as a tax, which directly affects households' demand for real balances and consumption. The idea of inflation as a consumption tax is well established, and the effects can be significant for welfare.[2] Allais, Algan, Challe, and Ragot (2020) and Cao, Meh, Ríos-Rull, and Terajima (2018) consider the welfare consequences of an inflation tax in models with incomplete markets, but they do not examine the redistribution consequences of a change in inflation along the transition path. The long-run equilibrium effects of inflation on the real interest rate are developed in Dotsey and Ireland (1996) and Aiyagari et al. (1998). They introduce a channel where inflation draws resources away from production and into credit services to avoid an inflation tax, inducing a general equilibrium effect on the real interest rate.

The redistribution or Fisher channel has been most recently studied in work by Auclert (2019) and Doepke and Schneider (2006a). They show that an unexpected shock to the inflation rate will revalue nominal assets, causing a redistribution between borrowers and savers. Doepke and Schneider (2006a) reinvigorated an early literature on inflation and redistribution (see for example Bach and Stephenson, 1974) by documenting the economically significant net nominal exposure of various cohorts and sectors in the US economy and conducting a reduced form calculation of the redistribution from a surprise inflation episode. Adam and Zhu (2016) perform a similar analysis for Euro Area households, and they further consider redistributional effects across countries within the currency union.

Several papers have also examined the effect of the Fisher channel quantitatively in a heterogeneous agent model with incomplete markets, but they exclude the long-run benefits of lower inflation. Doepke and Schneider (2006b) and Meh, Ríos-Rull, and Terajima (2010) do this by treating a surprise inflation as an exogenous redistribution of wealth and examine the resulting transition path back to the stationary equilibrium. Instead, we model inflation directly and consider the portfolio choice problem by households that captures the long-run welfare effects of the lower inflation tax. Without the inflation tax, changing the steady-state rate of inflation amounts

[2]While Lucas (2000) and Bailey (1956) find small estimates of the welfare costs of inflation from integrating under an estimated money demand curve in a representative agent economy. Chatterjee and Corbae (1992) and Imrohoroglu (1992) find that incomplete market arrangements can significantly amplify welfare costs of an inflation tax over the earlier complete markets estimates. Attanasio et al. (2002) and Erosa and Ventura (2002) also show that transaction costs from inflation vary considerably across households.

to a simple redistribution of wealth with no long-run benefits.

Recent work considers the transmission of monetary policy in an incomplete markets framework.[3] However, the goal of this literature is distinct from our own. These papers are interested in characterizing how heterogeneity will affect the central bank's ability to use monetary policy as a tool to counteract short-term business cycle fluctuations. In contrast, we are interested in characterizing the redistribution effects of a long-run change in monetary and fiscal policy. Kaplan, Moll, and Violante (2018), Gornemann, Kuester, and Nakajima (2016) and Mitman, Manovskii, and Hagedorn (2017) extend these models to include a New Keynesian block on the production side. Their focus is also on the transmission of monetary policy rather than the distributional consequences of a large permanent shock to steady-state inflation. An interesting exception is Sterk and Tenreyro (2018) who use an incomplete markets model with money to consider the effect of a redistribution between households and government on the pass-through of monetary policy. Building on this work, Auclert et al. (2018) embed the sticky-wage framework from Erceg et al. (2000) into a HANK model giving rise to a wage Phillips curve and examine the implications for the fiscal multiplier.

Finally, we build on the work of Hagedorn (2016) and Hagedorn (2018) who prove price-level determinacy under incomplete markets. They show that when the government issues nominal debt, even for an arbitrary interest rate rule, price-level determinacy is assured by equating the real value of government debt with household net asset demand to clear the asset, or equivalently the goods, market—a demand theory of the price level. This is feasible since precautionary motives under incomplete markets break Ricardian equivalence and make net asset demand a well-defined increasing function of the real interest rate. The demand theory is particularly well-suited for our analysis since it allows us to jointly characterize the fiscal and monetary policies that implement the actual path of inflation and nominal interest rates during the Volcker disinflation.

2 Monetary economy with heterogeneity

We start by extending a Bewley-Imrohoroglu-Huggett-Aiyagari economy to include money, durable goods, long-term secured nominal lending contracts, and nominal wage rigidities.[4] As in the standard model, households cannot perfectly insure idiosyncratic shocks to their labor productivity, but may trade in cash, interest-bearing nominal assets, and durable goods, of which the latter may also serve as collateral. We first consider a stationary environment with high inflation. To study the welfare effects of a disinflation, we quantify the response of this high-inflation economy to an unanticipated tightening of the monetary policy stance intended to permanently reduce inflation.

[3] For example, Wong (2015), Cloyne, Ferreira, and Surico (2020), Garriga, Kydland, and Šustek (2017), Bhandari et al. (2021), and Ozkan, Mitman, Karahan, and Hedlund (2017) show that part of the consumption response to a monetary policy or inflation shock will take place through the refinancing of household debt or the effect of interest rate changes on households with adjustable rate mortgages.

[4] Money is included solely to incorporate the welfare costs of economizing on the liquidity it provides under high inflation. Price level determinacy is ensured under incomplete markets through the demand theory of the price level (Hagedorn, 2016) as we describe in Section 2.5.

We then measure both the short-run and long-run benefits and costs of inflation across the evolving distribution of households along the equilibrium path.

2.1 Preliminaries

Time is discrete. The economy consists of a large number of dynastic households indexed by i and represented by the unit interval $i \in [0, 1]$. Each supplies labor to a labor union that negotiates over wages and labor supply with a labor packer; a government implements fiscal and monetary policy.

This is a monetary economy where money, $\tilde{m}$, is together a numeraire, a store of value and a source of liquidity services to the households. As numeraire we define the money price of period t output as P_t and denote the real value of money balances as $m \equiv \tilde{m}/P$. Throughout, we use the $\tilde{\cdot}$ notation to indicate a nominal variable. We capture the liquidity value of money by including real balances m directly in the household's preferences, although the economy would be little changed if demand for real balances were instead determined by shopping time or cash-in-advance constraints.[5]

Preferences and endowments. Households have identical preferences over sequences of non-durable consumption, c_t, real balances, m_t, and the service flow from durables, d_{t-1}, ordered by

$$E_0 \left[\sum_{t=0}^{\infty} \beta^t \left(u\left(c_t, m_t, d_{t-1}\right) - v_t\left(n_t\right) \right) \right], \tag{1}$$

with discount factor β and standard assumptions on u. The expectation is over only the household's idiosyncratic labor efficiency; there is no aggregate uncertainty. Each household supplies n_t units of labor to a production sector, with n_t negotiated by the labor union. Labor efficiency $z_t \in \{z_1, \ldots, z_{N_e}\}$ follows a Markov chain with constant transition matrix $P = [p_{lk}]$ initialized from its stationary distribution $\bar{p} \in \mathbb{R}^{N_z}$. Since draws are independent across households, a law of large numbers implies that the aggregate quantity of efficiency units of labor $\bar{N}$ is constant and equal to $E\left[z_t\right]$. The employment rate, i.e., the share of this labor used in production, $N_t/\bar{N}$, is negotiated by a myopic labor union that trades off higher wages for a lower employment rate. Without loss of generality, we normalize $E\left[z_t\right] = 1$. Thus, the total amount of labor used in production N_t is also the employment rate.

Production The production sector consists of a representative firm that uses capital and labor to produce. They rent capital from the mutual fund, but face costs denominated in the final good, $\zeta(K_{t-1}, K_t)$, to adjusting their installed capital. They choose labor, taking wages as negotiated by the labor union. Given an initial installed capital stock, K_{-1}, firms choose the stream of capital

[5] With some small alterations to the timing assumptions our model would be equivalent to cash-credit or shopping time microfoundations of money demand. We would expect similar results in any model where inflation generates utility or resource costs to economizing on liquid assets.

and labor to maximize profits:

$$\max_{\{K_t,N_t\}} \sum_{t=0}^{\infty} \frac{1}{R_{0,t}^K} \left(P_t A K_{t-1}^{\alpha} N_t^{1-\alpha} - P_t v_t K_{t-1} - P_t w_t N_t - P_t \zeta(K_{t-1}, K_t) K_{t-1} \right). \tag{2}$$

Throughout, we use capital letters to denote aggregate quantities. Aggregate output, $Y_t = A K_{t-1}^{\alpha} N_t^{1-\alpha}$, may be consumed by households, C_t, invested, either in the capital stock, I_t^K, or durables, I_t^D, or purchased by the government, G_t, so that the aggregate resource constraint is:

$$Y_t = C_t + I_t^K + I_t^D + G_t. \tag{3}$$

Given aggregate investment, I_t^K, the capital stock depreciates at rate δ^K and follows the law of motion:

$$I_t^K = K_t - \left(1 - \delta^K\right) K_{t-1} + \zeta(K_{t-1}, K_t) K_{t-1}. \tag{4}$$

Durable investment may vary across households. Given aggregate durable investment, $I_t^D = \int_0^1 i_{it}^D di$, the aggregate durable stock follows the law of motion:

$$D_t = \left(1 - \delta^D\right) D_{t-1} + I_t^D + \int_0^1 \Psi_i di, \tag{5}$$

The last term sums the household-level durable adjustment cost, $\Psi\left(d_{it}, d_{it-1}\right)$, across households so the aggregate adjustment cost will depend on the underlying distribution of durable investment across households.

Nominal wage-setting union Following Erceg et al. (2000) and Auclert et al. (2018), we incorporate sticky wages through the use of a labor union. Workers provide labor services to a continuum of labor unions, indexed by k, who provide differentiated labor services to a labor packer. The packer is a CES aggregator of all the labor varieties in the economy,

$$N_t = \left(\int_k N_{kt}^{\frac{\varepsilon-1}{\varepsilon}} dk \right)^{\frac{\varepsilon}{\varepsilon-1}}.$$

The union k chooses the nominal sequence of wages to maximize the average utility of its members subject to an adjustment cost on nominal wages

$$\max_{\{W_{kt}\}} \sum_{t=0}^{\infty} \beta^t \left(\int_0^1 \left[u\left(c_{it}, m_{it}, d_{i,t-1}\right) - v_t\left(n_{it}\right) \right] di - \frac{\psi}{2} \log\left(\frac{W_{kt}}{W_{kt-1}} / \Pi^* \right)^2 \right)$$

and subject to labor demand $N_{kt} = N_t \left(\frac{W_{kt}}{W_t}\right)^{-\varepsilon}$. This gives rise to a wage Phillips curve:

$$\log\left(1 + \pi_t^W\right) = \log\left(1 + \pi^*\right)\left(1 - \beta\right) + \frac{\varepsilon}{\psi} \left(N_t V_n - \left(1 - \tau\right) \frac{W_t}{P_t} N_t \frac{\varepsilon - 1}{\varepsilon} U_c \right) + \beta \log\left(1 + \pi_{t+1}^W\right) \tag{6}$$

where

$$U_c \equiv \sum_{k=1}^{N_z} \iint \frac{\partial}{\partial c} U\left(c_t\left(q_t, d_{t-1}, z_{kt}^*\right), m_t\left(q_t, d_{t-1}, z_{kt}^*\right), d_{t-1}\right) \frac{z_k}{\psi}_k \left(\partial q_t, \partial d_{t-1}, z_k\right) \bar{p}_k$$

is the efficiency-unit-weighted average marginal utility of consumption for all of the union's members.

2.2 Market arrangements

There are competitive capital rental markets with price $P_t V_t$. Financial intermediation is through a representative mutual fund, which owns the capital stock and makes secured long-term *nominal* lending contracts to households and the government.

Household borrowing and saving. Households may borrow in nominal secured loans from the mutual fund for durable purchases. There is no unsecured borrowing. To match the higher duration borrowing observed for U.S. households, we build on Hatchondo and Martinez (2009) and Auclert (2019) and allow the mutual fund to offer long-term nominal debt contracts with a duration that depends on parameter ρ. A household who borrows $\tilde{l}_t \geq 0$ towards a purchase of durable goods agrees to a perpetual stream of payments $\tilde{l}_t/P_t^{\tilde{L}}$, $\rho\tilde{l}_t/P_t^{\tilde{L}}$, $\rho^2\tilde{l}_t/P_t^{\tilde{L}}, \ldots$ that decay at rate ρ, where $P_t^{\tilde{L}}$ is the price of the loan. With $\rho = 0$ this is a one-period loan, but increasing ρ stretches the duration of the loan, mimicking longer-term borrowing such as mortgages. A secured nominal lending constraint,

$$\frac{\tilde{l}}{P_t^{\tilde{L}}}\left(1 + \rho P_{t+1}^{\tilde{L}}\right) \leq \mu\left(1 - \delta^D\right) d_t P_{t+1}, \tag{7}$$

ensures that the value of the security can be used to repay the loan. The left-hand side is the nominal value of the household's borrowing in period $t+1$, and the right-hand side is some fraction $\mu \leq 1$ times the nominal value of the household's remaining durables in period $t+1$.[6]

Households may save by holding equity, $\tilde{e}_t$, in the mutual fund, but they may not simultaneously borrow or save, i.e., $\tilde{l}_t\tilde{e}_t = 0$. It will be useful to distinguish borrower and saver households by their nominal financial net worth, $\tilde{a} = \tilde{e}_t - \tilde{l}_t$. However, it will not be sufficient to simply track net financial assets. While expected rates of return on household borrowing and saving are equivalent, as we explain below, an unanticipated disinflation would affect the ex post return on borrowing and saving differently.

Government. We treat the government symmetrically to households. The government has a stock of nominal government debt $\tilde{B}_t$. When $\tilde{B}_t > 0$, the government borrows $\tilde{B}_t = \tilde{L}_t^G$ from the

[6]Since the borrowing constraint (7) depends on future prices, an unexpected disinflation may push constrained households beyond their secured borrowing limits ex post. For this reason, we set μ low enough so the value of the loan will never exceed the full value of the remaining durables.

financial intermediary with the same perpetual coupon structure. Unlike household borrowing, government debt is not subject to a collateral constraint since it is backed by future tax revenues. In case the government is a saver, $\tilde{B}_t \leq 0$, (like households) it holds its savings as equity, $\tilde{E}_t^G$, in the mutual fund so that, in general, $-\tilde{B}_t = \tilde{E}_t^G - \tilde{L}_t^G$ with $\tilde{E}_t^G \tilde{L}_t^G = 0$.

Mutual fund. Financial intermediation is through a mutual fund. The fund is financed entirely through its equity, $\tilde{E}_t = \int \tilde{e}_{it} di + \tilde{E}_t^G$, which is invested in capital, $P_t K_t$, and in lending, $\tilde{L}_t = \int \tilde{l}_{it} di + \tilde{L}_t^G$, to households and the government. Capital purchased at price P_t is rented to firms the following period at rate $P_{t+1} V_{t+1}$. Including the value of the undepreciated capital, the gross nominal return on capital investment is:

$$R_{t+1}^{PK} = \frac{V_{t+1} P_{t+1} + (1-\delta) P_{t+1}}{P_t} = \Pi_{t+1} \left(V_{t+1} + 1 - \delta \right), \tag{8}$$

where $\Pi_{t+1} = P_{t+1}/P_t$ is the gross inflation rate, which converts the real return on capital to a nominal return. Given the geometric decay structure of the long-term debt contract, the gross nominal return on the fund's investment in lending is:

$$R_{t+1}^{\tilde{L}} = \frac{1 + \rho P_{t+1}^{\tilde{L}}}{P_t^{\tilde{L}}}. \tag{9}$$

Increases in ρ increase the duration of the loan portfolio and thus the sensitivity of its value to the nominal interest rate.[7]

Since the mutual fund is financed entirely by equity, total equity, $\tilde{E}_t$, equals total assets, $\tilde{L}_t + P_t K_t$. We let $\phi_t \equiv \frac{\tilde{L}_t}{\tilde{L}_t + P_t K_t}$ denote the share of the fund's assets (and equity) held in loans.[8] Then, the gross nominal return on mutual fund equity can be written as the share-weighted average:

$$R_{t+1}^{\tilde{E}} = \phi_t R_{t+1}^{\tilde{L}} + (1 - \phi_t) R_{t+1}^{PK}. \tag{10}$$

We consider an equilibrium where the mutual fund holds both capital and loans in its portfolio, $\phi_t \in (0,1)$, thus a no-arbitrage condition ensures the expected return on bank equity must equal the expected return on its loan and capital investments:

$$E_t \left[R_{t+1}^{\tilde{E}} \right] = E_t \left[R_{t+1}^{\tilde{L}} \right] = E_t \left[R_{t+1}^{PK} \right]. \tag{11}$$

[7] For example, with a constant gross nominal return R, in equilibrium $P_t^{\tilde{L}} = \frac{1}{R-\rho}$ and the duration of the lending portfolio would be $\frac{R}{R-\rho}$. To see this, note that the Macauly duration is defined as the horizon weighted average of discounted future cash flows relative to the price. In this case:

$$D \equiv \sum_{k=1}^{\infty} k \left(\frac{1}{R} \right)^k \rho^{k-1} / P_t^{\tilde{L}} = \frac{R-\rho}{\rho} \sum_{k=1}^{\infty} k \left(\frac{\rho}{R} \right)^k = \frac{R}{R-\rho}.$$

The third equality follows from the convergent power series $\sum_{k=1}^{\infty} k z^k = z/(1-z)^2$.

[8] Because capital is a real asset and lending is a nominal asset, the loan share ϕ_t is also the nominal share of assets.

Under perfect foresight, the expectation operator over returns may appear unnecessary. However, if realized prices were to differ from their expected values, e.g. because of an unanticipated disinflation, the ex post return on equity in (10) would be different than its expected return in (11).

The modeling choice of equity over debt financing for the intermediary is important in this case. A lower-than-expected realization of inflation reduces the nominal return on capital but not the nominal return on lending. And if $\rho > 0$, the nominal return on lending actually increases. In this event, the ex-post return on mutual fund equity simply adjusts according to (10). If the intermediary were instead financed by nominal debt, such as a bank deposits the increases in the nominal return on long-term lending might not offset the reduction in the nominal return on capital, and the intermediary would not be able to pay the interest owed on deposits. If the return paid on deposits matched the return on lending, the intermediary would be insolvent.

2.3 Household behavior

Given these arrangements, the timing is as follows. In each period t, a household begins with its nominal savings $\tilde{m}_{t-1} + \tilde{e}_{t-1} - \tilde{l}_{t-1}$ and its remaining durables $\left(1-\delta^D\right) d_{t-1}$. The current price level P_t is realized. Households earn a nominal wage $P_t W_t$ per efficiency unit of labor. They may purchase consumption, c_t, and invest in durable goods, i_t^D, both at price P_t. They can also adjust their money holdings, $\tilde{m}_t$, and borrow $\tilde{l}_t$ in loans subject to borrowing constraint (7) or save through the purchase of equity $\tilde{e}_t$ (but not both, with $\tilde{l}_t \tilde{e}_t = 0$). Using (5) to substitute for i_t^D and dividing by P_t to express in terms of output, the household is subject to a sequence of real budget constraints:

$$c_t + m_t + e_t - l_t + d_t + \Psi\left(d_t, d_{t-1}\right) = (1-\tau_t) z_t n_t W_t + \frac{e_{t-1} R_t^{\tilde{E}} - l_{t-1} R_t^{\tilde{L}} + m_{t-1}}{\Pi_t} + (1-\delta^D) d_{t-1} \quad (12)$$

where $e_t = \tilde{e}_t / P_t$ and $l_t = \tilde{l}_t / P_t$ are the real values of the nominal saving and borrowing. Given initial real savings $e_{-1} - l_{-1} + m_{-1}$ and durable stock d_{-1}, each household maximizes (1) subject to sequences of borrowing (7) and budget constraints (12) for $t \geq 0$.

To characterize household behavior, it is helpful to rewrite its sequence problem recursively. We first define the household's real net worth in period t after inflation, Π_t is realized:

$$q_t \equiv \frac{m_{t-1} + e_{t-1} R_t^{\tilde{E}} - l_{t-1} R_t^{\tilde{L}}}{\Pi_t} + \left(1-\delta^D\right) d_{t-1}. \quad (13)$$

For all $t \geq 0$, given real net worth q_t, accumulated durables d_{t-1}, and labor efficiency z_t, we let $\mathcal{V}_t\left(q_t, d_{t-1}, z_t\right)$ denote the value of a household in period t. Then for all $t \geq 0$, $\mathcal{V}_t$ satisfies a sequence of Bellman equations:

$$\mathcal{V}_t\left(q_t, d_{t-1}, z_{it}\right) = \max_{c_t, m_t, d_t, e_t, l_t} \left\{ U\left(c_t, m_t, d_{t-1}\right) + \beta E\left[\mathcal{V}_{t+1}\left(q_{t+1}, d_t, z_{t+1}\right) | z_t\right] \right\}, \quad (14)$$

each subject to a real budget constraint,

$$c_t + e_t - l_t + d_t + \Psi\left(d_t, d_{t-1}\right) + m_t = q_t + z_t n_t \left(1 - \tau_t\right) W_t,$$

a real borrowing constraint from (7),

$$l_t R_{t+1}^{\tilde{L}} \leq \Pi_{t+1} \mu \left(1 - \delta^D\right) d_t,$$

which incorporates definition of the gross nominal return on lending, (9), and the requirement that the household is either a saver or borrower, but not both, i.e., $e_t l_t = 0$. Next period q_{t+1} is determined according to (13). The value functions depend on t through interest rates, i_t, wages, W_t and fiscal and monetary policy, which may vary over time. We abuse notation slightly and label the policy functions that satisfy the Bellman equation as $c_t\left(q_t, d_{t-1}, z_t\right)$, $m_t\left(q_t, d_{t-1}, z_t\right)$, $d_t\left(q_t, d_{t-1}, z_t\right)$, $e_t\left(q_t, d_{t-1}, z_t\right)$, and $l_t\left(q_t, d_{t-1}, z_t\right)$.

2.4 Aggregating over heterogeneous households

Before characterizing an equilibrium, we first define a measure to keep track of the distribution of households. Let $\psi_t\left(q, d, z\right)$ be the measure of households that *begin* period t with $q_t \leq q$, $d_{t-1} \leq d$ and efficiency $z_t = z$. For $t \geq 0$, given household policy rules a_t, m_t, and d_t, this measure must satisfy the law of motion:

$$\psi_t\left(q', d', z_j\right) = \sum_{k=1}^{N_z} \left[\iint \mathbf{1} \left\{ \left(\frac{e_{t-1}\left(q, d, z_k\right) R_t^{\tilde{E}} - l_{t-1}\left(q, d, z_k\right) R_t^{\tilde{L}} + m_{t-1}\left(q, d, z_k\right)}{\Pi_t} + (1 - \delta_D) d_{t-1}(q, d, z_k) \right) \right.\right.$$
$$\left.\left. \leq q' \bigcap d_{t-1}\left(q, d, z_k\right) \leq d' \right\} \psi_{t-1}\left(\partial q, \partial d, e_k\right) \right] p_{kj}. \tag{15}$$

This captures the evolution of real net worth and durables given each household's choices and the realization of the Markov state z. The dependence on t is through the household policy rules, which are themselves functions of equilibrium prices.

Using ψ_t, we can define aggregate quantities for consumption

$$C_t \equiv \sum_{k=1}^{N_z} \left[\iint c_t\left(q, d, z_k\right) \psi_t\left(\partial q, \partial d, z_k\right) \right] \bar{p}_k,$$

demand for real balances,

$$M_t^d \equiv \sum_{k=1}^{N_z} \left[\iint m_t\left(q, d, z_k\right) \psi_t\left(\partial q, \partial d, z_k\right) \right] \bar{p}_k,$$

durables,

$$D_t \equiv \sum_{k=1}^{N_z} \left[\iint d_t\left(q, d, z_k\right) \psi_t\left(\partial q, \partial d, z_k\right) \right] \bar{p}_k,$$

and aggregate household savings,

$$S_t \equiv \sum_{k=1}^{N_z} \left[\iint e_t\left(q, d, z_k\right) - l_t\left(q, d, z_k\right) \psi_t\left(\partial q, \partial d, z_k\right) \right] \bar{p}_k.$$

The outer sum in each definition is over the distribution of z, which is stationary.[9]

2.5 Government

The government is a consolidated fiscal and monetary authority. It sets the nominal rate of return, $R_t^{\tilde{L}}$, and nominal borrowing, $\tilde{B}_t$, and provides a perfectly elastic supply of money, $\tilde{M}_t$, to satisfy household demand for real balances at the realized price level. Rather than through money market clearing, the price level is determined by equating the real value of government debt, with the net real asset demand from households.[10] The government achieves its desired path of inflation through its choice of the nominal stock of government debt (Hagedorn, 2016).

Specifically, given initial nominal liabilities $\tilde{M}_{-1}$ and $\tilde{B}_{-1}$, and an inflation target Π^*, a *fiscal and monetary policy* is a sequence for $t \geq 0$ of labor income taxes, $\{\tilde{\tau}_t\}$, nominal interest rates, $\{R_t^{\tilde{L}}\}$, and nominal government debt, $\{\tilde{B}_t\}$. In each period, for a given realization of the price level, P_t, the nominal money stock, $\tilde{M}_t$, is determined endogenously by demand for real balances,

$$\tilde{M}_t = P_t M_t^d, \tag{16}$$

and nominal government expenditures, $P_t G_t$, are determined endogenously by the government's budget constraint,

$$P_t G_t = \tilde{M}_t - \tilde{M}_{t-1} + \tilde{B}_t - R_t^{\tilde{L}} \tilde{B}_{t-1} + \int \tau_t z_{ti} n_t P_t W_t di, \tag{17}$$

given the path of its borrowing along with its seignorage and tax revenue.[11] The price level, P_t, will be determined in equilibrium to clear the asset market:

$$\frac{\tilde{B}}{P_t} = S_t - K_t. \tag{18}$$

[9] Recall that the transition matrix of the Markov chain for labor efficiency z is defined $P = [p_{lj}]$ and the chain is initialized from its unique ergodic distribution $\bar{p} \in \mathbb{R}^{N_e}$.

[10] Under incomplete markets, precautionary motives ensure this net asset demand is well defined and increasing in the real interest rates.

[11] Alternatively, government expenditures could be specified exogenously, and a lump sum transfer would adjust (passively) to maintain budget balance. However, lump sum transfers provide partial insurance to households, and any changes would have direct effects on welfare. We abstract from these effects by allowing government expenditures, which are separable from household preferences, to adjust instead.

In the long run, the government can ensure it implements its inflation target, Π^*, by choosing a path of nominal bonds that grows at the same rate as desired inflation.

2.6 Stationary high-inflation equilibrium

We define the stationary *high-inflation equilibrium* as follows. Given a fiscal and monetary policy with constant nominal interest rate, $R^{\tilde{L}}$, nominal debt, $\tilde{B}_{t+1} = \Pi^H \tilde{B}_t$, growing at the target rate of inflation, and constant labor income tax, τ, a stationary equilibrium consists of prices $\{P_t, P_t^{\tilde{L}}, P_t^{\tilde{e}}, V_t, W_t\}$, aggregates $\{N_t, K_t, C_{t,}, S_t, M_t, G_t, \}$ and nominal wage inflation Π^w such that:

1. Prices $P_t, P_t^{\tilde{L}}$, $P_t^{\tilde{e}}$ that grow at constant inflation rate, $\Pi = \Pi^H$, and constant prices W and V that together satisfy the no arbitrage condition (11) and profit maximization (2).
2. Nominal wage inflation equals Π and together with N_t satisfy the wage-Phillips curve (6).
3. A stationary value function $\mathcal{V}(q, d, z)$ that solves the Bellman equation (14) with decision rules $c(q, d, z)$, $m(q, d, z)$, $d(q, d, z)$, and $a(q, d, z)$.
4. A stationary measure ψ^H that satisfies (15) given household decision rules.
5. Aggregate capital demand from (2) and aggregate savings satisfy asset market clearing (18).

2.7 Disinflation equilibrium path

We use the stationary high inflation equilibrium in $t = 0$ as the starting point What if, in the following period $t = 1$, the monetary and fiscal authorities coordinate to abruptly change their fiscal and monetary policy stance? We consider a scenario where the government abandons its original inflation target Π^H and makes a credible commitment to a lower inflation target $\Pi^L < \Pi^H$ achieved through a sequence of nominal interest rates $\{R_t^{\tilde{L}}\}$ and nominal government debt $\{\tilde{B}_t\}$ for $t \geq 1$. The announcement takes households by surprise as they have already made their portfolio choices in period $t = 0$ in the high-inflation equilibrium.

Redistribution. Any change in the realized level of inflation Π_1 from its previously anticipated value Π^H alters the real value of household net worth across the distribution of households. Moreover, any change in the path of nominal rates changes the realized price $P_1^{\tilde{L}}$ of long-term loans. With the aggregate real value of assets unchanged, the effect is pure redistribution (Fisher effect). The redistribution sets each household's real net worth according to:

$$q_1 = \begin{cases} \frac{m_0 + a_0(1+P_1^{\tilde{L}}\rho)}{\Pi_1} + \left(1-\delta^D\right) d_0 & \text{if} \quad a_0 < 0 \\ \frac{m_0 + \left((1-\phi_0)\frac{\Pi_1}{\Pi^H} + \phi_0(1+P_1^{\tilde{L}}\rho)\right) a_0}{\Pi_1} + \left(1-\delta^D\right) d_0 & \text{if} \quad a_0 \geq 0 \end{cases}. \tag{19}$$

For households with debt, $a_0 < 0$, the redistribution increases the real value of their nominal liabilities. They had anticipated a real borrowing cost of $R_0^{\tilde{L}}/\Pi^H$ and find instead the realized

borrowing cost between period 0 and 1 is $(1+\rho P_1^{\tilde{L}})/(P_0^{\tilde{L}}\Pi_1)$. For households with savings, $a_0 \geq 0$, the redistribution increases the real value of their mutual fund equity, but only for the nominal share of mutual fund assets, ϕ_0. The surprise disinflation has no effect on the real value of the fraction $1-\phi_0$ of the fund's assets invested in the capital stock. The expression $\left((1-\phi_0)\frac{\Pi_1}{\Pi^H}+\phi_0(1+P_1^{\tilde{L}}\rho)\right)$ adjusts the face value of the household's claim on fund equity to reflect the gain in the real value of the fund's nominal assets. Rather than the expected real return $1+V_1-\delta$ on equity, the household instead earns the realized real return of $\phi_0\frac{(1+P_1^{\tilde{L}}\rho)}{P_0^{\tilde{L}}\Pi_1}+(1-\phi_0)(1+V_1-\delta)$.

Given this immediate redistribution, we consider the welfare effects along the exact equilibrium path that converges in finite time to a low inflation stationary equilibrium. The experiment is similar in spirit to Domeij and Heathcote (2004) who popularized this methodology to consider the welfare costs of a one-time change in the capital gains tax rate under imperfect insurance.

Transition path. Given an initial high inflation stationary equilibrium as described in Section 2.6 and its stationary measure ψ^H, we characterize the disinflation transition equilibrium as follows. With $\psi_1=\psi^H$, then for $t\geq 1$, given a monetary and fiscal policy with inflation target Π^L consisting of a sequence of nominal interest rates $\{R_t^{\tilde{L}}\}$, nominal government debt $\{\tilde{B}_t\}$, and constant labor income tax, τ, *a disinflation transition equilibrium* is for $t\geq 1$

1. An initial redistribution described by equation (19).
2. A sequence of measures ψ_{t+1} that satisfy (15).
3. A sequences of prices $P_t^{\tilde{L}}$, $P_t^{\tilde{e}}$, W_t, V_t, and inflation Π_t that satisfy the no-arbitrage condition (11) and profit maximization (2).
4. Decision rules $c_t(q,d,z)$, $m_t(q,d,z)$, $a_t(q,d,z)$, $e_t(q,d,z)$ and $d_t(q,d,z)$ that solve the sequence of Bellman equations (14),
5. Nominal wage inflation is equal to Π and together with N_t satisfy the wage-Phillips curve (6),
6. Aggregate capital demand in (2) and aggregate savings satisfy asset market clearing (18).

2.8 Model solution

For the stationary economy, we use an extended version of the endogenous grid method developed by Hintermaier and Koeniger (2010) to solve for the household decision rules under constant inflation and real prices. For the transition we use an approach similar to Domeij and Heathcote (2004). We work backwards from a stationary low inflation equilibrium. The disinflation equilibrium will converge to the low inflation equilibrium in finite time. We use 200 periods. For a given sequence of nominal interest rates and government debt we can solve backwards from the low inflation equilibrium (using the endogenous grid method to find the sequences of optimal decision rules). Then starting from the distribution of households in the initial high inflation economy, we solve the distribution forwards using the law of motion (15) and the disinflation sequences of policy rules,

and we find the sequence of prices, $\{P_t\}$, and by implication inflation, $\{\Pi_t\}$, which clears the asset market. We guess an initial sequence of labor demand, updating until the wage Phillips curve is satisfied. Because the monetary and fiscal policy effectively determines the market clearing real interest rate, no further iteration is necessary.

3 Initial high-inflation equilibrium

The starting point for our experiment is the high inflation period in the early 1980s during which Paul Volcker became Chairman of the Federal Reserve. We calibrate our model economy to mimic this macro environment and to match moments of the wealth distribution measured in microdata on household finances around that period.

Our calibration proceeds in two steps. First, we set some parameters externally to standard values in the literature. Second, we internally calibrate the parameters of the income process, the discount rate, and durable goods to match moments on the wealth distribution, the share of households with nominal debt, and the marginal propensities to consume durable and non-durable goods. After a brief summary of the household balance sheet data in Section 3.1, we discuss the calibration in Section 3.2, and the model fit in Section 3.3.

3.1 Household finance data

To measure the pre-Volcker high-inflation period, our primary source of data is the 1983 Survey of Consumer Finances (SCF) from the Federal Reserve Board. The survey consists of a representative sample of the U.S. population plus a supplemental sample of high-income households drawn from a sampling frame of 5000 high-income taxpayers estimated to have substantial wealth by the Internal Revenue Service's (IRS) Statistics of Income Division (SOI). The oversampling of high-income households allows for a more accurate representation of the tail of the wealth distribution than comparable surveys.[12] Interviews for the 1983 SCF were conducted in person from February to August of 1983, and respondents in many cases were answering questions about their household finances in 1982. Our view is the 1983 SCF is a reasonable approximation to the wealth and income distributions in the high inflation period.[13] Although in the model the disinflation is completely credible, in practice inflation expectations even during the early Volcker disinflation remained high. So household finances in 1982 to 1983, especially portfolio positions, reflected in part the high inflation period from the late 1970s.

Using the 1983 SCF, we measure components of household wealth. Participants are asked about a variety of asset and debt classes including financial assets, paper assets, liquid assets, the cash

[12] See Avery et al. (1988) for a complete description of the 1983 SCF survey and methodology.

[13] Ideally we would have household finance data measured during the exact high inflation period. Unfortunately, we are not aware of any reliable household finance data covering this time period. The predecessor to the SCF was conducted in 1970 and again in 1977. In 1976 and 1977 inflation had also abated somewhat, so it is not ideal. Also, the 1983 survey design was the first to include the high-income oversample needed to precisely estimate the distribution of wealth.

value of durable goods, consumer debt and real estate debt. We classify these and calculate the nominal, real, and liquid wealth distributions (see Appendix A).

With one exception, this measurement is similar to Doepke and Schneider (2006a) for a different time period. We differ by only identifying direct nominal positions at the household level. Doepke and Schneider (2006a) use the Flow of Funds data from the Federal Reserve Board to correct for the indirect nominal positions of households, where indirect nominal wealth includes the nominal positions of the businesses on which the household has claims. They determine the indirect position using the nominal leverage ratio of the U.S. business sector which they define as the nominal debt position per dollar of equity. This correction is well suited to their goal of characterizing the aggregate nominal position of the household sector and cohorts of the household sector, but it will be substantially less accurate for characterizing the distribution of the nominal wealth among households. We do not make an adjustment, because we believe that any bias from indirect nominal positions at the household level will be small. In the 1983 SCF only 34.9% of households have any claims to public or private equity, and of those, the median equity share of net worth was only 16.6%.

3.2 Calibration of high-inflation equilibrium

Interest rates and inflation. To calibrate nominal interest rates and inflation for the initial high inflation steady state, we use the year 1981.[14] Gross inflation, measured by the CPI-Urban, had reached a high of $\Pi^* = 10.4\%$. We set the nominal interest rate to $i = 15.6\%$ so that the real interest rate is 4.7%, the average real interest rate during the Greenspan period. This is close to the actual value of the 30-year mortgage during this period of 16.4%. In order to remove the welfare costs of a permanent decline in the real interest rate, we choose to instead use the real interest rate from the Greenspan period to enforce that the real interest rate is the same in the initial and final steady state of the model. Both series are downloaded from FRED. We use the 30-year mortgage rate rather than the Federal Funds Rate since the 30-year mortgage rate is a better indicator of the rates at which households would have been able to borrow during this period. As in the demand theory of the price level described in Section 2, we assume that the central bank sets the nominal interest rates and that inflation is determined by outstanding government bonds.

Period length and debt duration. The period length is one year. To capture the longer duration of household debt contracts we use the perpetual coupon structure with a constant decay rate governed by ρ. If ρ is equal to 0 then debt is equivalent to a one-period bond that is typical in this literature. In our baseline calibration we set $\rho = .89$, which implies a duration of 4.5 years to match the average duration of household nominal liabilities in the U.S. for this period as documented by Doepke and Schneider (2006a).

[14] The Volcker disinflation begins in the second half of 1981 with inflation finally achieving a sustained fall starting in September.

Preferences. We specify household preferences with relative risk aversion σ over a CES aggregate of consumption, real balances and durables so that:

$$u\left(c_t, m_t, d_{t-1}, n_t\right) \equiv \frac{1}{1-\sigma}\left(\left(\omega c_t^{\frac{\eta-1}{\eta}}+(1-\omega) m_t^{\frac{\eta-1}{\eta}}\right)^{\frac{\eta}{\eta-1}\theta} d_{t-1}^{1-\theta}\right)^{(1-\sigma)}-\gamma \frac{n_t^{1+\frac{1}{\varepsilon}}}{1+\frac{1}{\varepsilon}} \tag{20}$$

With these preferences the elasticity of substitution between consumption and real balances η will turn out to be the interest elasticity of money demand, since unconstrained households would choose:

$$m=\left(\frac{1+i_t}{i_t}\frac{1-\omega}{\omega}\right)^{\eta} c\ . \tag{21}$$

Lucas (2000) finds $\eta = 0.5$ to be a reasonable approximation for the aggregate interest elasticity of demand for M1, and he uses this value when computing the welfare costs of inflation. Other estimates put the elasticity closer or equal to 1.[15] We choose $\eta = 0.5$ and examine the sensitivity of our results to alternative elasticities. The parameter $\omega \in [0, 1]$ scales the liquidity value of real balances with $\omega = 1$ implying no liquidity value of money and thus zero demand for real balances. With η fixed, we set $\omega = 0.988$ to target the ratio of real balances to output in the high inflation stationary distribution. Following Fernández-Villaverde and Krueger (2011) we set $\theta = .81$ to target a share of the household budget spent on non-durables of 20%. We set the Frisch elasticity, ε to 1, a standard value in the literature, and we calibrate the value of γ to match the employment rate in 1981. Finally, we internally calibrate the discount factor β to match the share of households that are nominal borrowers (see Appendix B.1). In the 1983 SCF, 45% of households have negative net nominal positions.

Durable goods. We follow Hintermaier and Koeniger (2010) and set quadratic adjustment costs for durables:

$$\Psi\left(d_t, d_{t-1}\right)=\frac{\kappa}{2}\left(\frac{d_t-(1-\delta_d) d_{t-1}}{d_{t-1}}\right)^2 d_{t-1} \tag{22}$$

The parameter κ represents the cost of adjusting durable holdings and δ_d the depreciation rate on durable goods. We set δ_d to 0.2, and we calibrate κ internally to match empirical estimates of the marginal propensity to consume durable and non-durable goods. Further details on the calibration procedure are in Appendix B.1. We set the securitization rate on durable goods, μ, to be .8 as in Kaplan et al. (2020).

Production. For production, we use a Cobb-Douglas production function

$$F(K, N)=A K^{\alpha} N^{1-\alpha}$$

with capital share $\alpha = 0.33$, which is roughly in line with long- run average of capital income to output. We set A to normalize expected labor efficiency to 1 (Appendix B.1). We follow

[15] See Hoffman et al. (1995), Holman (1998), Lucas (2000) and citations therein.

Auclert et al. (2018) and assume that capital is subject to quadratic adjustment costs. Specifically, adjustment costs are given by

$$\zeta\left(k_t, k_{t-1}\right) = \frac{k_t}{k_{t-1}} - \left(1 - \delta^K\right) + \frac{1}{2\delta^K \epsilon_I}\left(\frac{k_t}{k_{t-1}} - 1\right)^2.$$

As in Auclert et al. (2018), we set ϵ_I to 4 and the depreciation rate, δ^K, to .08.

Government taxation. We set τ to be 0.2 to target a government spending to GDP ratio of approximately 0.2. Government spending, G, adjusts with the change in seigniorage revenue as discussed in Section 2.5. In practice, the change in seigniorage revenue results in a small change in government spending as a share of output since most government spending is financed by tax revenue.

3.3 Model fit in the high-inflation equilibrium

We calibrate the parameters of the Markov chain governing idiosyncratic labor efficiency to match moments on the distribution of wealth in the data. We follow Castaneda et al. (2003) and choose a 4-state Markov chain with a relatively high productivity state with less persistence. We choose the values of the productivity states and the probability transition matrix to match moments on the wealth distribution. Appendix B.1 provides further details on the calibration of this process.

	Lowest by net worth		Highest by net worth		
Percent of total	10%	50%	10%	5%	1%
Net worth					
data	-0.1	3.8	66.7	54.6	31.2
model	0.05	1.63	69.62	63.42	35.33
Nominal wealth					
data	-4.8	-34.8	121.4	95.4	43.1
model	-0.99	-46.80	100.93	91.29	50.26
Real wealth					
data	0.2	6.3	63.1	51.9	30.5
model	0.11	4.30	67.89	61.88	34.51

Table 1: Distribution of Wealth: Data and Model

Note: We keep the ordering by net worth constant for all asset classes. Data on the wealth distribution and the share of households with net negative nominal wealth is from the 1983 Survey of Consumer Finances. Adjusted net worth is total net worth less the value of any durable assets or secured borrowing against these assets (Appendix A).

In Table 1, we compare the wealth distribution of households in the 1983 SCF with our calibrated high-inflation economy. Instead of expressing the distribution in dollars, we instead describe points along the Lorenz curve. For example, in the 1983 SCF, the top 10 percent of households ordered by their net worth, owned 66.7 percent of total net worth, and the bottom 50 percent of households

owned only 3.8 percent of total net worth. We hold the ordering by net worth fixed across all variables.

In 1983, as in other years, the distribution of net worth is skewed, with the top one percent of households owning 31.2 percent of total net worth. The precautionary savings motive in our model and the use of a superstar state (as in Castaneda et al., 2003) is able to generate this extreme wealth inequality. We miss some of the debt accumulation for the poorest 10% of the households whose share of net worth in the data is negative.[16]

In the data, net nominal positions are negative for 45 percent of the population versus 49 percent in the high-inflation steady state in our model. This reflects secured borrowing in the form of mortgages, which is captured in our model by secured borrowing against durables. This is important when thinking about welfare since households with nominal debt contracts stand to lose in a sudden disinflation. In a model that incorporates secured nominal borrowing against durable real assets, this means welfare losses occur across the income distribution, not just among the poor. The calibration successfully matches the share of households with nominal debt and the debt accumulation of households in the bottom 50th percentile of nominal wealth.

4 The welfare costs of the Volcker disinflation

To quantify its welfare costs, we treat the Volcker disinflation as a perfect foresight shock. The model starts in a high-inflation equilibrium which we calibrate to match the average inflation rate in 1981 described in Section 3.[17] While slightly different from the actual nominal interest rate in 1981, we set the initial value of the nominal rate to be 15.6% so that the real rate is equal to the average real rate in the Greenspan period. Then, at the beginning of 1982, the government announces a new path of nominal interest rates and government bonds in order to achieve a new, lower inflation target of 3.1 percent. Figure 1 plots the path implied by the Volcker disinflation shock (broken line) for the nominal interest rate and inflation against the data (solid line). We calibrate the announced monetary and fiscal policy sequence of nominal interest rates $\{R_t^{\tilde{L}}\}$ and nominal debt $\{\tilde{B}_t\}$ to match the exact path of nominal interest rates and inflation rates during Volcker's remaining 7 years of his term as Chairman. Thereafter, we assume monetary and fiscal policy maintains a constant nominal rate and inflation rate, which we set to match the average over Chairman Alan Greenspan's terms (Aug 1987 to January 2006). While we match the series in Figure 1 by construction, Appendix Figure D.1 shows the dynamics of other (non-targeted) aggregate variables over the disinflation are broadly consistent with the data.[18]

[16] With no unsecured borrowing, the model is unable to generate negative net worth positions.

[17] The exact timing of when the Volcker disinflation begins is up for debate. In the summer of 1981 the central bank re-raised the federal funds rate to a high of 19.1 percent after several unsuccessful attempts to tame inflation throughout the 70s and in 1980. As a result of these previous failed attempts inflation increases in 1981 before finally starting a sustained fall that September. Thus we choose to calibrate the initial steady to 1981 and start the perfect foresight shock in 1982. Goodfriend and King (2005) recount the course of events and policy commitments leading up to and through the "incredible Volcker disinflation." See also Lindsey et al. (2005).

[18] See discussion in Appendix D.

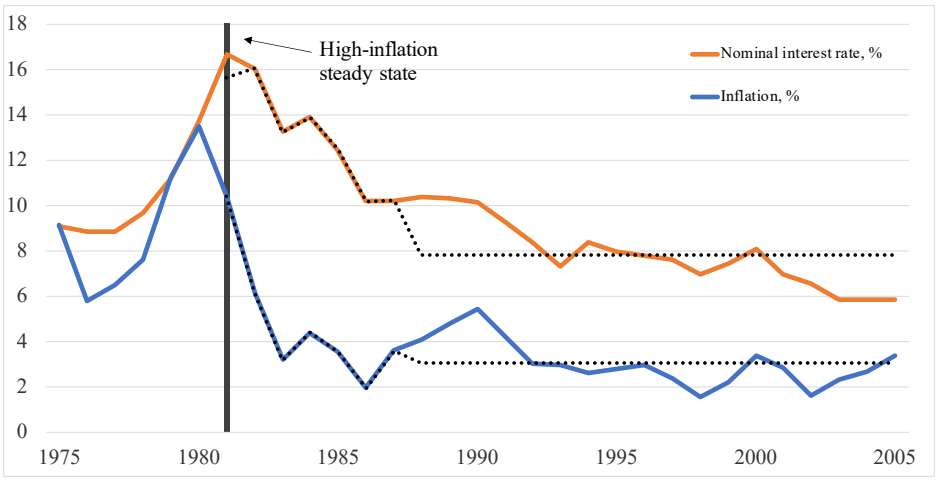


Figure 1: Interest rates and inflation during the Volcker disinflation

Note: Figure shows the path of interest rates and inflation in the data (the solid lines) and the path that is fed into the perfect foresight shock in the model (the broken lines). For interest rates we use the 30-year mortgage rate and for inflation we use CPI-U. The initial steady state is calibrated to the rate of inflation and interest rate in 1981 right before the Volcker disinflation and the final steady state averages inflation and interest rates during Alan Greenspan's tenure as Chairman.

The short- and long-run effects of this policy across the distribution of households are mixed. All things equal, everyone benefits from a lower inflation tax, but the policy has a number of short-run costs. All households are hurt by the recession induced by the rise in the real interest rate and the corresponding drop in output and rise in unemployment. In addition, the unexpected change in the price level and future path of nominal rates imposes a one-time wealth redistribution. Those with net nominal liabilities find the real burden of their liabilities unexpectedly higher. Those with net nominal savings receive an unexpected windfall. More concretely, both saver and borrower households had expected to receive a real return or pay real interest of 4.7 percent on their savings or debt. According to equation (19), the realized real return on equity in the first period of the transition is 16.8 percent for savers, while borrower households unexpectedly pay 23.4 percent on their debt. The effects are asymmetric because the mutual fund also invests in capital whose real value is unaffected by the disinflation. Borrowers and savers are also affected differently by the changes in the real interest rate, which increases significantly during the disinflation before settling at a new lower level in the long run.

We start by examining directly the distribution of consumption-equivalent welfare costs faced by each household. For each household, the welfare costs of the disinflation will depend on whether the benefit of the lower inflation tax is enough to compensate them for rise in unemployment, the effects of the redistribution, and the changes in the path of real interest rates. Then in the next section, we decomposed the aggregate welfare impact into contributions from efficiency, redistribution, and insurance effects (Bhandari et al. (2023).

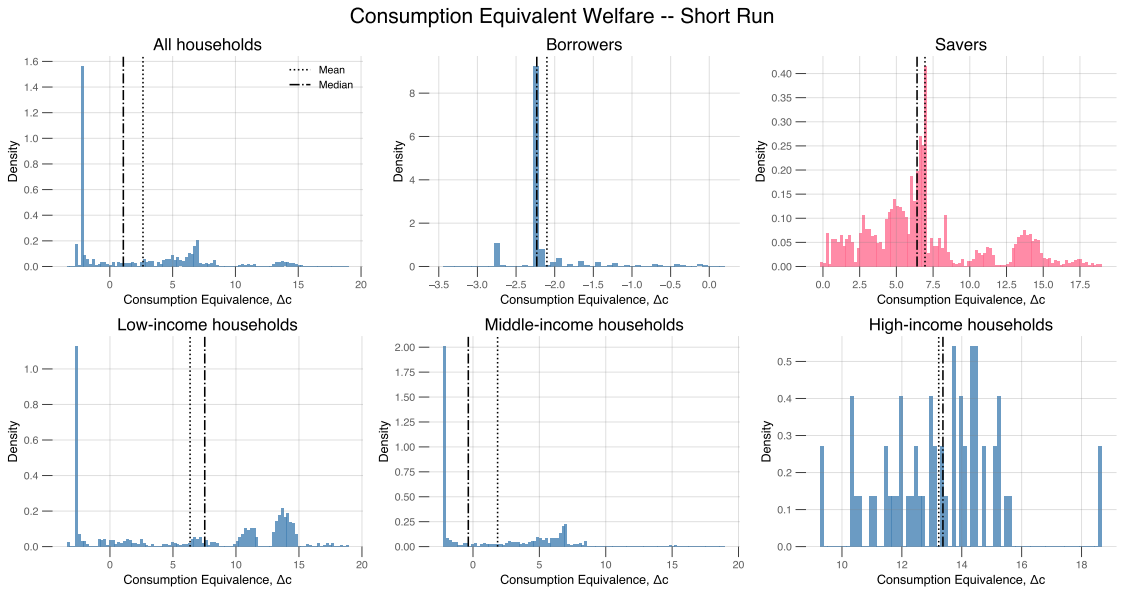


Figure 2: Consumption equivalent measure of welfare of Volcker disinflation as percent

Note: Figure shows the consumption equivalent needed to make households indifferent between the disinflation and the high inflation steady state plotted against their initial nominal wealth position (see equation 23). A negative value means households would sacrifice a permanent fraction Δ_c of their consumption in the high-inflation steady state to avoid the disinflation.

4.1 Short-run conditional welfare

We compute a conditional welfare measure that asks on the eve of the inflation reform what consumption equivalent each household would require to be indifferent between the economy with the disinflation and a counterfactual economy which remains in the high inflation equilibrium permanently.

Since the unanticipated disinflation begins in period $t = 1$, we define $\{c_t, m_t, d_{t-1}\}_{t=1}^{\infty}$ to be the realized sequences of consumption, money, and durables for a given household along the disinflation path. We then define $\{c_t^H, m_t^H, d_{t-1}^H\}_{t=1}^{\infty}$ to be the counterfactual sequences of consumption, money, and durables if inflation had remained high. We define the consumption equivalent welfare change Δ_c as the permanent adjustment to their stream of consumption, money, and durables needed to make the counterfactual environment equivalent to a transition to a new low inflation steady state. Specifically, Δ_c sets the expected streams of utility equal,

$$E_i\left[\sum_{t=0}^{\infty}\beta^t\left(u\left(\Delta_c c_t^H, \Delta_c m_t^H, \Delta_c d_{t-1}^H\right) - v\left(n_t^H\right)\right)\right] = E_i\left[\sum_{t=0}^{\infty}\beta^t\left(u\left(c_t, m_t, d_{t-1}\right) - v(n_t)\right)\right] \tag{23}$$

When $\Delta_c < 0$, this implies that they would be willing to sacrifice fraction Δ_c of their consumption every period in order to avoid going through the transition while $\Delta_c > 0$ means they need to be compensated with an additional fraction Δ_c of their consumption each period to stay in the high inflation steady state. We plot in Figure 2 the distribution of consumption equivalents from a simulation of the model with 10,000 households.

The gains from the Volcker disinflation are not spread equally across the distribution. It is apparent from Figure 2 that nominal borrowers bear the cost from the disinflation with low and middle income nominal borrowers bearing the worst costs—up to 5 percent of their consumption for the poorest households. In the next section, we apply the decomposition of Bhandari et al. (2023) to decompose the overall welfare costs into efficiency, redistribution, and insurance components for the baseline disinflation as well as several alternatives.

Overall, in this baseline disinflation 52.6 percent of households prefer to remain in the high-inflation steady state rather than undergo the disinflation. In Table 2 we tally who would vote for the Volcker disinflation. Since 51.6 percent of households are borrowers, most stand to lose from the redistribution and from the short-run increase in the real interest rate. Compensating borrowers for the redistribution and short-run increase in borrowing costs is the decline in the inflation tax. However, only a few of these borrowers, concentrated among the low and middle earners who have little nominal debt, are willing to go through the disinflation.

At first glance, the prevalence of households who prefer to avoid the disinflation may appear at odds with contemporaneous news coverage that indicated inflation was a major concern (Goodfriend and King, 2005). However, the perceived harms from high inflation do not imply that households would unanimously prefer to accept the costs of a disinflation. In Appendix C, we use the Michigan Survey of Consumers to assess consumer sentiments during this historical period. While we cannot directly observe welfare costs, we do find evidence supportive of the model's predictions, namely that the benefits of the Volcker disinflation are concentrated among higher-income households. As we discuss in Appendix C, over the disinflation period, the share of high-income households who report being *better* off from prices rises significantly, whereas the share of low-income and middle-income households who report the same is little changed. Reciprocally, the decline in the share who report being *worse* off from prices during the disinflation is significantly larger for high-income than for low- and middle-income households. Similarly, Michelacci and Paciello (2022) use the Bank of England Inflation Attitudes Survey to show that wealthy households are 20 percentage points more likely to dislike inflation than debtor households.

	Percent that prefer high inflation		Percent borrowers	Percent of Population
	Short run	Long run		
Total economy	47.6	0.0	47.6	100.0
Borrowers	99.8	0.0	100.0	47.6
Savers	0.2	0.0	0.0	52.4
Low income	32.7	0.0	32.1	16.0
Middle income	71.6	0.0	71.7	59.2
High income	0.0	0.0	0.0	24.2
Very high income	0.0	0.0	0.0	0.6

Table 2: Preference for Disinflation Policy

4.2 Long-run measures

We then ask whether households would choose differently if they could immediately reach the low-inflation equilibrium. To do this we examine the same individuals in the counterfactual and disinflation economies long after the disinflation has concluded and the economy has reached its low-inflation stationary equilibrium. In Table 2 we report the same vote far into the future, and see that about 1.6 percent of households now prefer the low inflation and low real interest rate equilibrium. We note that our experiment *does* include the initial redistribution and the short-term increase in the real interest rate, but many years have passed and households have sufficient time to readjust their savings.

Most prefer the low-inflation economy given the lower cost of liquidity from the reduction in the inflation tax and the lower real interest rate. What may be surprising is the 1.6 percent of households that would still prefer to remain in the high-inflation economy. These are low-income households who dislike the small long-run decline in the employment rate. The small drop in employment results from a shift in the wage Phillips curve. As the inflation tax declines and consumption rises, the union negotiates slightly lower employment and wages.

5 Sensitivity of welfare to alternative calibrations

The baseline welfare results depend on the trade-off between the benefit from lowering the inflation tax, the cost of the redistribution, and the time paths of the real interest rate and unemployment. In this section, we explore the sensitivity of our results to shutting down or mitigating each of these channels.

5.1 Description of alternative calibrations

No inflation tax. The more money held by households, the greater the burden of the inflation tax. To generate demand for money, we include it directly in the household's utility function. When unconstrained, a household's money demand is proportional to their consumption (as shown in equation (21)). We interpret the demand for money as demand for liquidity: households need money in order to consume and pay bills. The amount of money held will be determined by ω. When $\omega = 1$, households hold no money and are unaffected by the inflation tax.[19] We compare our baseline welfare results from Section 4 to the same calibration with no liquidity value of money, $\omega = 1$. In this calibration, the results are solely driven by the effect of the redistribution and changes in the real interest rate and unemployment. Households get no benefit from the lower inflation tax.

One-period loans. The duration of the debt contracts will determine the size of the redistribution. In the model, the duration is governed by ρ. When $\rho = 0$ households borrow in one-period

[19] Since the price level is determined independently of money market clearing, this need not be the cashless limit, $\omega \to 1$.

contracts. The effect of increasing ρ can be seen in the law of motion for wealth, equation (13). When $\rho = 0$ and there is an unexpected disinflation, households are only affected by the change in Π_t. When $\rho > 0$ they are also affected by the unexpected change in the price of nominal lending $P_t^{\tilde{L}}$. As nominal interest rates fall during the disinflation, the price $P_t^{\tilde{L}}$ will increase. For borrowers, the increase in $P_t^{\tilde{L}}$ implies an increase in their real debt burden. Below we present the welfare results from a calibration that uses one-period nominal loans instead of the longer duration loan with the geometric coupon structure. We compare the welfare results to our baseline calibration in which the duration was set to 4.5 years to match the average duration of nominal liabilities in the U.S. as documented by Doepke and Schneider (2006a). With one-period nominal debt, the size of the redistribution will be smaller and households are more likely to be compensated by the benefit of the lower inflation tax.

Constant real interest rate. We compare the baseline results to a calibration in which there is no change in the real interest rate. During the Volcker disinflation, the real interest rate rises sharply as the monetary and fiscal authority increase nominal interest rates and decrease the supply of government bonds in order to decrease inflation. We ask what the effects of the disinflation would have been if the central bank set nominal interest rates to keep real rates constant at 4.7 percent while the fiscal authority adjusts the path of bonds to lower inflation. This allows us to isolate the welfare effect of the Volcker disinflation that was generated by the change in real rates rather than the redistribution or the decrease in the inflation tax.[20]

No rise in unemployment Finally, we compare the baseline welfare results to a calibration in which there is no short-run rise in unemployment. As the real interest rate spikes during the Volcker disinflation, there is a sharp decline in investment and output. As a result, unemployment spikes. We ask what would happen if the same disinflation policy had been implemented, but without the sharp increase in unemployment.

5.2 Welfare results

For each economy, Table 3 presents the results from a straight up or down vote of whether households prefer to go through the disinflation or remain in the high inflation steady state.

[20] We note that a constant (expected) real interest rate does not eliminate redistribution. The realized real rate in the initial period of the disinflation still adjusts because of the change in inflation relative to what had been expected and through the price of the long-term asset, which adjusts as the path of nominal interest rates change, see discussion of equation (19).

	Percent that prefer high inflation				
	baseline	no inflation tax	1-period loans	constant r	no change U
Total economy	47.6	48.15	47.0	46.5	48.0
Borrowers	99.8	99.8	97.9	96.9	99.8
Savers	0.2	0.5	0.2	0.04	0.06
Low income	32.7	33.2	32.0	31.1	31.7
Middle income	71.6	71.8	70.1	69.9	72.9
High income	0.00	0.00	0.00	0.00	0.00
Very high income	0.00	0.00	0.00	0.00	0.00

Table 3: Alternative Experiments: Preference for Disinflation Policy

No inflation tax. Without money, there is no decrease in the inflation tax. The only effect of the disinflation is to redistribute wealth away from borrowers towards saver households and increase the real interest rate and unemployment in the short-run. Without the lower inflation tax only the long-run decline in real rates can compensate borrowers for their loss in the redistribution and the short-run increase in borrowing costs, as a result, 54.4 percent of households would prefer to remain in the high inflation steady state versus 52.6 percent in our baseline calibration. The biggest increase in the share voting for high inflation is concentrated amongst low-income households. These households do not like the long-run decline in the employment rate from the movements along the wage Phillips curve and are no longer compensated by the decline in the inflation tax. Without the lower inflation tax to compensate them, they prefer to remain in the high inflation steady state, despite their windfall from the redistribution.

One-period loans. In the economy with one-period loans, instead of the 4.5 year duration in the baseline economy, the size of the redistribution induced by the disinflation is smaller. As a result, the welfare cost for borrowers is smaller. On the other hand, the share of high-income households who vote for high inflation increases as they receive a smaller windfall from the redistribution. Consistent with this, the share of households that vote to remain in the high-inflation steady state remains about the same. In an up or down vote, all borrower households still prefer to remain in the high inflation steady state, though we will show in Table 4, that the cost of the disinflation is smaller.

Constant real interest rate. Next, we consider the welfare results if there were no change in the real interest rate along the transition path. In this case, the share of households that vote for the high inflation steady state falls. The biggest change is for low and middle-income borrower households, who were hurt by the short-run increase in real rates.

No rise in unemployment Finally, we consider the welfare results if there had been no increase in unemployment along the transition path. This is akin to asking what the welfare results

would have been if the monetary authority could avoid the rise in unemployment from movements along the wage-Phillip's curve; a best-case-scenario for a perfectly credible monetary authority who wishes to implement a disinflation. The rise in unemployment makes the disinflation costlier for all households. The 90th percentile of welfare costs decline from -1.7 to -1.3 percent. However, it has little effect on the extensive margin—the share of households who would vote for the disinflation.

5.2.1 Comparing the distributions of welfare costs

Next, we turn our attention to the distribution of the welfare costs. For each experiment, we rank households by the cost of the disinflation using the amount of consumption each household would need to be compensated in order to make them indifferent between the high inflation steady state and the redistribution as described in Section 4.1. This ranking places households who are harmed the most by the disinflation at the top of the distribution and households who benefit at the bottom. We then compute moments of the distribution of these welfare costs in Table 4.

	p10	p50	p90	Mean
baseline	-2.23	1.07	10.79	2.64
no inflation tax	-2.53	0.54	10.37	2.37
1-period loans	-0.95	0.94	9.59	3.05
constant r	-2.09	1.12	3.18	0.35
no change U	-2.19	0.99	10.61	2.59

Table 4: Alternative Experiments: Distribution of welfare benefits

Note: Table shows the distributions of consumption equivalents needed to make households indifferent between the disinflation and the high inflation steady state (see equation 23).

In the baseline model, at the 90th percentile of welfare costs, households would sacrifice -1.7 percent of their consumption in the high-inflation steady state in order to stay in the high inflation economy. Whereas at the 10th percentile households benefit from the disinflation and would need to be compensated 5.8 percent of their consumption to stay in the high inflation steady state. On average, households benefit from the disinflation; the average welfare gain is 2.0 percent of consumption. Eliminating the benefits from the reduction in the inflation tax increases the welfare costs (or reduces the benefits) across the distribution, lowering the average welfare gain to 0.9 percent of consumption.

By moving to only one-period debt, the welfare cost of the disinflation for borrowers declines, but this is off-set by a decline in the welfare gain for savers. On net, the average welfare gain declines to 1.9 percent of consumption, while for the median household, the cost declines substantially, from -1.6 to -1.1. The decrease in welfare costs stems primarily from borrowers who are in the right of the distribution. This is because, in the baseline, the long duration of nominal liabilities amplifies the effects of the disinflation. Relative to an expected real borrowing cost of 4.7 percent under high inflation, the unanticipated shift in Π_1 *and* $P_1^{\tilde{L}}$ results in a realized borrowing cost in the first period of the disinflation of 23.4 percent (see discussion of equation (19)). Under one-period debt,

by eliminating the effects of the future path of nominal interest rates through $P_1^{\tilde{L}}$, the realized borrowing cost is reduced to 8.86 percent. This is reflected in the reduction of costs for the median households. The effects on savers, who are in the left of the distribution, of moving to one-period debt are smaller than for borrowers. They realize a real return on equity of 16.8 percent in the baseline, which is cut to 7.4 percent under one-period loans. Recall that their windfall from the redistribution is always diluted by the (real) share of the mutual fund's assets in capital.

A constant real interest rate has heterogeneous effects on welfare for borrowers and savers. The costs are substantially smaller for borrower households who no longer face a short-term increase in their borrowing cost. Conversely, the benefit for savers is smaller as they no longer receive a short-run increase in the return on their savings. On net, the average welfare gains and costs fall substantially; the median welfare cost falls from -1.6 to -0.8. It is important to emphasize that even when the government maintains a constant 4.7 percent real interest rate throughout the disinflation, there is still a redistribution. The real interest rate is the cost of borrowing between the current and future periods. The realized real borrowing cost and return on equity still diverge from the expected 4.7 percent because of the unanticipated change in inflation to Π_1 and unexpected change in the price of loans to $P_1^{\tilde{L}}$.

Finally, removing the increase in unemployment increases the benefits of the disinflation for all but a few households. The decline in the welfare benefits stems from a few households who dislike the decline in the employment rate. The median welfare cost declines from -1.6 to -1.3 percent of consumption. Because the incidence of the increase in unemployment is felt across the income distribution, the increase in consumption equivalents can also be seen throughout the distribution of households. Collectively, the differences between the baseline calibration and the alternative experiments highlight the importance of capturing all four channels (the redistribution, the decrease in the inflation tax, and the increase in the real interest rate and unemployment) when considering the welfare costs of the Volcker disinflation.

5.2.2 Contributions to welfare costs

We decompose the overall welfare costs of disinflation in the baseline as well as each alternative economy into separate efficiency, redistribution, and insurance components, applying the methodology of Bhandari et al. (2023). Appendix E provides the implementation of this decomposition in our settting. Table 5 reports the percent contribution of each component to the overall change in welfare costs. These will sum to 100 by construction. the baseline model, the 2 to 3 percent average welfare gain in consumption equivalence follows from positive contributions from the efficiency and insurance benefits of the disinflation, which are partially offset by negative contributions from the redistribution component. Consistent with our results above, the redistribution component contributes most negatively in the economy without an inflation tax, and least negatively in the economy where the real interest rate is held fixed.

	Efficiency	Redistribution	Insurance	ΔV
baseline	211.9	-164.9	53.0	0.405
no inflation tax	277.9	-260.2	82.7	0.238
1-period loans	212.2	-165.2	53.0	0.405
constant r	129.9	-46.3	16.3	0.205
no change U	205.6	-157.6	52.0	0.402

Table 5: Welfare Decomposition (in % of welfare change)

6 Conclusion

We examine the welfare effects of a permanent and unexpected change in the monetary and fiscal policies of the government to reduce inflation. The unexpected change in the inflation rate redistributes wealth from nominal borrowers towards savers, but it also lowers the burden of the inflation tax for all households. In the case of the Volcker disinflation, the combined effect of the monetary and fiscal policies also entailed a short-run increase in the real interest rate and unemployment. We quantify the welfare effects stemming from each of these channels.

Our analysis relies on a HANK model extended to include a consumer portfolio choice between nominal savings or debt, real durable goods, and money. Nominal borrowing is secured against real durable goods meaning that even wealthy households can have negative nominal wealth positions, as is often the case for US households with a nominal fixed rate mortgage. The change in the inflation rate redistributes wealth from households with net nominal liabilities towards those with positive net nominal assets.

We calibrate the model to consider the Volcker disinflation of the early 80s. We compare the welfare results from several calibrations. In the baseline, we calibrate the duration of nominal debt and the liquidity value of money to match characteristics of the US wealth distribution in the early 1980s. The disinflation redistributes wealth from borrowers to savers and also increases the unemployment rate and the short-run borrowing costs for debtors. As a result, even though they are compensated by the lower inflation tax, almost all debtor households, 51.6 percent of the population, prefer to remain in the high inflation steady state rather than go through the disinflation. Middle income households, who have large nominal debt positions secured against their durables, are most likely to prefer the high inflation steady state (72.4 percent of middle income households) rather than face the disinflation.

We then consider four alternative versions of our baseline model: a version with no money in which there is no benefit from a lower inflation tax, a version with only short term nominal borrowing in which the size of the redistribution is smaller, a version in which the real interest rate remains constant throughout the redistribution, and a version with no increase in the unemployment rate. In all of the experiments, the percent of households who prefer to stay in the high inflation steady state remains high ($\sim 50\%$). This is because borrowers, who make up 51.6 percent of the population, are hurt both by the redistribution and by the short-run increases in the real interest rate and unemployment. Undoing only one of these channels will decrease the welfare costs of the

disinflation, but not undo them. In the cashless version of the economy, more households prefer to remain in the high-inflation steady state. Without the lower inflation tax, there is nothing to compensate borrowers for their losses during the disinflation and 54.4 percent of households prefer to remain in the high inflation steady state. These results suggest that it is crucial to capture the duration of assets, the change in the real interest rate, the change in the inflation tax, and the change in unemployment when considering the welfare consequences of changing the inflation rate.

References

Adam, K. and J. Zhu (2016): "Price-Level Changes And The Redistribution Of Nominal Wealth Across The Euro Area," *Journal of the European Economic Association*, 14, 871–906.

Aiyagari, S. R., R. A. Braun, and Z. Eckstein (1998): "Transaction services, inflation, and welfare," *Journal of Political Economy*, 106, 1274–1301.

Allais, O., Y. Algan, E. Challe, and X. Ragot (2020): "The Welfare Cost of Inflation Risk under Imperfect Insurance," *Annals of Economics and Statistics*, 1–20.

Attanasio, O. P., L. Guiso, and T. Jappelli (2002): "The Demand for Money, Financial Innovation, and the Welfare Cost of Inflation: An Analysis with Household Data," *Journal of Political Economy*, 110, 317–351.

Auclert, A. (2019): "Monetary Policy and the Redistribution Channel," *American Economic Review*, 109, 2333–2367.

Auclert, A., M. Rognlie, and L. Straub (2018): "The Intertemporal Keynesian Cross," Working Paper 25020, National Bureau of Economic Research.

Avery, R. B., G. E. Elliehausen, and A. B. Kennickell (1988): "Measuring wealth with survey data: An evaluation of the 1983 survey of consumer finances," *Review of income and Wealth*, 34, 339–369.

Bach, G. L. and J. B. Stephenson (1974): "Inflation and the Redistribution of Wealth," *The Review of Economics and Statistics*, 1–13.

Bailey, M. J. (1956): "The welfare cost of inflationary finance," *The Journal of Political Economy*, 93–110.

Bhandari, A., D. Evans, M. Golosov, and T. Sargent (2023): "Efficiency, Insurance, and Redistribution Effects of Government Policies," Working paper, University of Minnesota.

Bhandari, A., D. Evans, M. Golosov, and T. J. Sargent (2021): "Inequality, Business Cycles, and Monetary-Fiscal Policy," *Econometrica*, 89, 2559–2599.

Cao, S., C. Meh, J.-V. Ríos-Rull, and Y. Terajima (2018): "The Welfare Cost of Inflation Revisited: The Role of Financial Innovation and Household Heterogeneity," Staff Working Papers 18-40, Bank of Canada.

Castaneda, A., J. Dia-Gimenez, and J.-V. Rios-Rull (2003): "Accounting for the U.S. Earnings and Wealth Inequality," *Journal of Political Economy*, 111, 818–857.

Chatterjee, S. and D. Corbae (1992): "Endogenous Market Participation and the General Equilibrium Value of Money," *Journal of Political Economy*, 100, 615–46.

Christiano, L. J. and T. J. Fitzgerald (2003): "The Band Pass Filter," *International Economic Review*, 44, 435–465.

Cloyne, J., C. Ferreira, and P. Surico (2020): "Monetary Policy when Households have Debt: New Evidence on the Transmission Mechanism," *Review of Economic Studies*, 87, 102–129.

Doepke, M. and M. Schneider (2006a): "Inflation and the Redistribution of Nominal Wealth," *Journal of Political Economy*, 114, 1069–1097.

——— (2006b): "Inflation as a Redistribution Shock: Effects on Aggregates and Welfare," NBER Working Papers 12319, National Bureau of Economic Research, Inc.

Domeij, D. and J. Heathcote (2004): "On The Distributional Effects Of Reducing Capital Taxes," *International Economic Review*, 45, 523–554.

Dotsey, M. and P. Ireland (1996): "The welfare cost of inflation in general equilibrium," *Journal of Monetary Economics*, 37, 29–47.

Erceg, C. J., D. W. Henderson, and A. T. Levin (2000): "Optimal monetary policy with staggered wage and price contracts," *Journal of Monetary Economics*, 46, 281–313.

Erosa, A. and G. Ventura (2002): "On inflation as a regressive consumption tax," *Journal of Monetary Economics*, 49, 761–795.

Fernández-Villaverde, J. and D. Krueger (2011): "Consumption and Saving Over the Life Cycle: How Important are Consumer Durables," *Macroeconomic Dynamics*, 15, 725–770.

Garriga, C., F. E. Kydland, and R. Šustek (2017): "Mortgages and Monetary Policy," *The Review of Financial Studies*, 30, 3337–3375.

Goodfriend, M. and R. G. King (2005): "The incredible Volcker disinflation," *Journal of Monetary Economics*, 52, 981–1015.

Gornemann, N., K. Kuester, and M. Nakajima (2016): "Doves for the Rich, Hawks for the Poor? Distributional Consequences of Monetary Policy," CEPR Discussion Papers 11233, C.E.P.R. Discussion Papers.

Hagedorn, M. (2011): "Optimal disinflation in new Keynesian models," *Journal of Monetary Economics*, 58, 248 – 261.

——— (2016): "A demand theory of the price level," CEPR discussion paper no. DP11364.

——— (2018): "Prices and Inflation when Government Bonds are Net Wealth," CEPR Discussion Papers 12769, C.E.P.R. Discussion Papers.

Hatchondo, J. C. and L. Martinez (2009): "Long-duration bonds and sovereign defaults," *Journal of international Economics*, 79, 117–125.

Hintermaier, T. and W. Koeniger (2010): "The method of endogenous gridpoints with occasionally binding constraints among endogenous variables," *Journal of Economic Dynamics and Control*, 34, 2074–2088.

Hoffman, D. L., R. H. Rasche, and M. A. Tieslau (1995): "The stability of long-run money demand in five industrial countries," *Journal of Monetary Economics*, 35, 317–339.

Holman, J. A. (1998): "GMM estimation of a money-in-the-utility-function model: The implications of functional forms," *Journal of Money, Credit and Banking*, 679–698.

Imrohoroglu, A. (1992): "The welfare cost of inflation under imperfect insurance," *Journal of Economic Dynamics and Control*, 16, 79–91.

Kaplan, G., K. Mitman, and G. L. Violante (2020): "The Housing Boom and Bust: Model Meets Evidence," *Journal of Political Economy*, 128, 3285–3345.

Kaplan, G., B. Moll, and G. L. Violante (2018): "Monetary Policy According to HANK," *American Economic Review*, 108, 697–743.

Lewis, D. J., D. Melcangi, and L. Pilossoph (2019): "Latent Heterogeneity in the Marginal Propensity to Consume," Staff Reports 902, Federal Reserve Bank of New York.

Lindsey, D. E., A. Orphanides, and R. H. Rasche (2005): "The reform of October 1979: how it happened and why," *Federal Reserve Bank of St. Louis Review*, 87, 187–235.

Lucas, R. E. (2000): "Inflation and welfare," *Econometrica*, 68, 247–274.

Meh, C. A., J.-V. Ríos-Rull, and Y. Terajima (2010): "Aggregate and welfare effects of redistribution of wealth under inflation and price-level targeting," *Journal of Monetary Economics*, 57, 637–652.

Michelacci, C. and L. Paciello (2022): "Ambiguity Aversion and Heterogeneity in Households' Beliefs," Working paper, EIEF.

Mitman, K., I. Manovskii, and M. Hagedorn (2017): "Monetary Policy in Incomplete Market Models: Theory and Evidence," 2017 Meeting Papers 1605, Society for Economic Dynamics.

Ozkan, S., K. Mitman, F. Karahan, and A. Hedlund (2017): "Monetary Policy, Heterogeneity, and the Housing Channel," 2017 Meeting Papers 1610, Society for Economic Dynamics.

Sterk, V. and S. Tenreyro (2018): "The Transmission of Monetary Policy through Redistributions and Durable Purchases," *Journal of Monetary Economics*, 99, 124–137.

Wong, A. (2015): "Population Aging and the Transmission of Monetary Policy to Consumption," Ph.D. thesis, Northwestern University.

A Data appendix

Table A.1 reports the real and nominal categorization of assets and liabilities measured in the SCF.

Assets	Liabilities
A. Nominal assets and liabilities	
Liquid:	**Secured borrowing:**
Cash in checking accounts	Home mortgages
Cash in savings or share accounts	Amount owed against land contract notes
Money market and call accounts	Amount outstanding on other property mortgages
IRA or Keogh accounts	
Certificates of Desposit	
U.S. Savings Bonds	
Non liquid:	**Unsecured borrowing:**
Face value of bonds	Amount outstanding on loans other than mortgages[1]
Loans owed to household and gas leases	Credit card debt
Aggregate gross value of land contracts and notes	Amount owed on lines of credit
Thrift type pension account assets	
B. Real assets	
Durables:	
Home	
Other properties	
Vehicles	
Financial:	
Stocks and mutual funds	
Trust accounts	
Business:	
Net value of business with management interests	

Table A.1: Categorization of SCF household assets and liabilities

Note: classification of assets and liabilities variables in 1983 Federal Reserve Board Survey of Consumer Finances.
[1]Also subtracts loans against life insurance policies.

B Model Appendix

B.1 Internal Calibration

We calibrate the Markov process and several key parameters that govern the wealth distribution and the marginal propensities to consume durable and non-durable goods. The calibration of the Markov process follows Castaneda et al. (2003). We choose the parameters of the probability transition matrix, the income states (normalized such that they average to 1), aggregate productivity, the discount factor, the adjustment cost for durable goods, and the depreciation rate for durables to match moments on the wealth distribution and the MPCs. Specifically, we choose the parameters

to minimize the sum of the squared difference between a set of moments in the model and the data:

$$\min_{\mathbb{P}} \left(X_{model} - X_{data}\right)\left(X_{model} - X_{data}\right) \tag{B.1}$$

where $\mathbb{P}$ is the set of parameters and X is a vector of moments. The moments targeted along with the model fit are summarized in Table 1.

Equation (B.2) gives the income states for our productivity process. There are four income groups normalized so the average income using the stationary probability distribution is 1.

$$z \in [0.0381;\ 0.6739;\ 2.4197;\ 49.69] \tag{B.2}$$

Equation (B.3) gives the transition matrix describing how households transition between states. An element of the matrix π_{ij} describes the probability that the household transitions from state i to state j.

$$\begin{array}{c|cccc} & z_1 & z_2 & z_3 & z_4 \\ z_1 & 0.9727 & 0.0194 & 0.0080 & 0.0000 \\ z_2 & 0.0022 & 0.9854 & 0.0125 & 0.0000 \\ z_3 & 0.0126 & 0.0211 & 0.9643 & 0.0020 \\ z_4 & 0.0020 & 0.0926 & 0.0017 & 0.9037 \end{array} \tag{B.3}$$

Given the transition matrix, in steady state, 16.0 percent of the population will be low income, 59.2 percent will be middle income, 24.2 percent high income, and 0.6 will be very high income. As described in Table 1, the process does a good job of replicating the distribution of income and wealth across households.[21]

The values of aggregate productivity, A, the discount factor, β, the depreciation rate for durables δ_d, and the adjustment cost for durables κ are given in Table B.1. We target moments on the share of households that are nominal borrowers from the SCF and empirical estimates of the marginal propensities to consume durable and non-durables from Lewis et al. (2019).

Parameter	Value	Moment	Data	Model
β	0.9156	share nominal borrowers	0.45	0.49
σ	1.4898	MPC durables	0.19	0.12
θ	0.6027	MPC non-durables	0.26	0.23

Table B.1: Internal Calibration

C Consumer Sentiments during the Volcker Disinflation

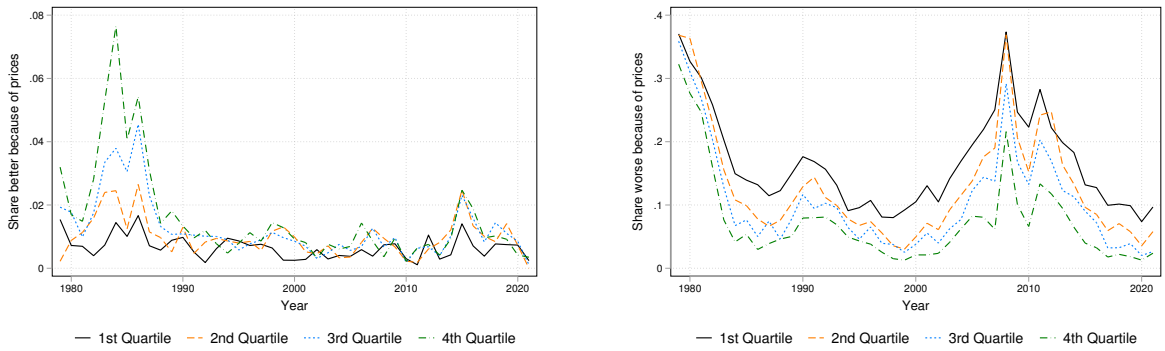
In this section, we compare data from the Michigan Survey of Consumers with the welfare costs measured within the model. While the data cannot measure the actual welfare costs of a disinflation, we find evidence supportive of the model's predictions.

For this analysis, we focus on the responses to two specific questions. The survey asks respondents about whether they are better or worse off than a year ago and the reason they are better or worse off. Amongst the answers, respondents can say they are worse off due to "higher prices",

[21] In practice, we solve the model with $A = 1$ and allow the average labor productivity across households (and thus $\bar{N}$) to differ from 1, and we find $z \in [0..0381; 0.5801; 2.227; 49.917]$. We then choose $A = 1.1530^{0.67} = 1.1001$ to normalize $E[z] = 1$.

or inflation. We tabulate for each calendar quarter the fraction of households who report being better or worse off by income quartile. Figure C.1 plots these shares of respondents who say they are better or worse off because of prices by income over time.

First, in accordance with the presence of a substantial inflation tax in the model, very few if any households in the Michigan Survey say they are better off because of prices before the Volcker Disinflation, and roughly one-third say they are worse off due to prices. Moreover, as in the model, a consistently larger share of low- and middle-income households report being worse off from prices than of high-income households. In the model, these households pay the inflation tax on a larger share of their assets.



(a) Better

(b) Worse

Figure C.1: Share of households better or worse because of prices by income quartile

However, disliking inflation in steady state is *not* the same as being willing to go through the disinflation. While we do not have data on how households viewed the disinflation directly, we examine the share who say they are better or worse off due to price changes over time. After the Volcker Disinflation begins in 1982, there is a significant increase in the share of high-income households who say they are better off due to inflation, while the share of low- and middle-income households who say they are better off remains negligible.

Turning to the shares who report being worse off, the declines during the Volcker disinflation were uneven across the income distribution. By 1987, the share of high-income households who say they are hurt by inflation falls almost to zero, while for low-income households it only falls by two-thirds. Together, these patterns align with the model's predictions that the benefits of the disinflation policy are concentrated among the higher income households who are net nominal savers, while low- and middle-income households bear the costs.

D Dynamics of Aggregate Variables over Disinflation Period

As an additional check on our model, we compare the model's implied dynamics for key aggregate variables against their data counterparts over the Volcker disinflation. While we match the series in Figure 1 by construction, Figure D.1 shows the dynamics of other (non-targeted) aggregate variables over the disinflation are broadly consistent with the data. In the absence of high-quality household-level time series to compare with the model's household-level predictions, we compare the observed aggregate data from this period with the model's aggregates. This exercise is especially useful

since these aggregates are not used as calibration targets.[22] Because the model is not designed to capture high-frequency aggregate fluctuations, nor long-run trends, in our comparison, we apply a Christiano and Fitzgerald (2003) two-sided band-pass filter to the data to isolate medium-run fluctuations. We keep fluctuations with periodicities between 4 and 16 years, but the results are very similar if we also include shorter-run fluctuations by including periodicities between 2 and 16 years.

In the first row of Figure D.1, we compare the dynamics of nondurable consumption, real balances, and durable consumption when aggregated in the model (solid black line) versus the data (gray broken line) over the Volcker disinflation period. The model predicts a long-run aggregate increase in nondurable consumption and real money balances as the inflation tax declines. In the data, we remove this variation since we cannot say what portion of the aggregate increase in consumption and money balances are due to the Volcker disinflation as opposed to other aggregate trends. However, the model does a good job of matching the initial decline and subsequent rise in durable consumption.

The second row of Figure D.1 shows the aggregate path of output, wages, and government bonds in the data and the model. All three model series match their data counterparts well. In particular, the model generates a 6% decline in output versus 4% in the data. For wages, the model matches the 4% decline seen during the Volcker disinflation.

[22] Inflation and the nominal interest rate, for example, are matched by construction when we define the disinflation shock.

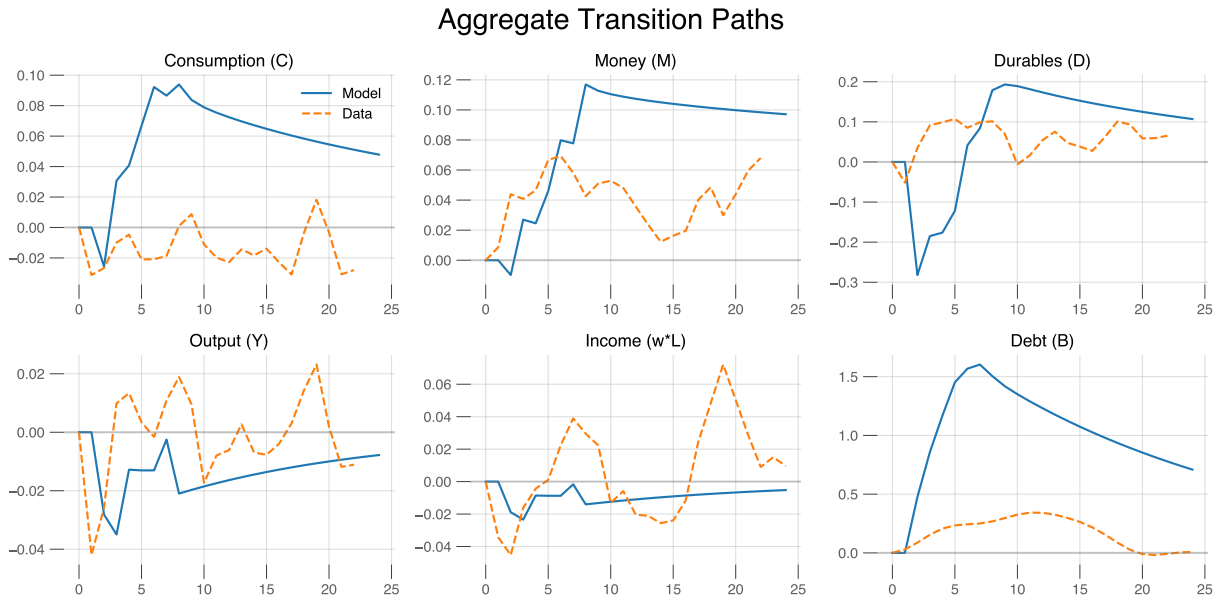


Figure D.1: Path of aggregate variables

Note: Figure shows time series path of consumption, money, durables, output, wages and government debt in the data and the model. For consumption we use Personal Consumption Expenditures (PCE), money is the M2 Money Stock (M2SL), durables is "Accumulation of produced assets: Consumption of fixed capital: Private: Residential" (K160231A027NBEA), output is GDP (GDPC1), compensation is "National Income: compensation of employees" (A033RC1A027NBEA), and government bonds is outstanding government debt. The FRED series IDs are given in parentheses with the exception of outstanding debt which is downloaded from the Treasury (https://fiscaldata.treasury.gov/datasets/historical-debt-outstanding/historical-debt-outstanding). PCE and M2 are deflated by the PCE Price Index (PCEPI) and Consumption of Fixed Capital is deflated by the PCE Durables Price Index (DDURRG3M086SBEA). Series are passed through a Christiano and Fitzgerald two-sided band-pass filter to remove periodicities under 4 years and greater than 16 years.

E Welfare Decomposition

In this appendix section, we describe how we implement the method from **?** in our model. The goal is to decompose the change in aggregate welfare caused by the Volcker disinflation into a component arising from aggregate efficiency, redistribution, and insurance.

For ease of notation, let ι collect the state variables of the household in the high-inflation economy into a vector: $\iota = \{q^H, d^H, z^H\}$. In our economy, the aggregate welfare is $\mathbb{E}\left[\alpha_\iota V^H(\iota)\right]$, the average value of a household in the high-inflation economy weighted by their Pareto weights α_ι. Similarly, the aggregate welfare for households going through the transition is $\mathbb{E}\left[\alpha_\iota V^T(\iota)\right]$, where $V^T(\iota)$ gives the value of a household during the transition, with ι referencing their state variables in the high-inflation steady state before the redistribution.

? show that the change in welfare can be written as

$$\begin{aligned}\Delta W &= \mathbb{E}\left[\alpha_\iota V^T(\iota)\right] - \mathbb{E}\left[\alpha_\iota V^H(\iota)\right] \\ &\approx \underbrace{\mathbb{E}\left[\sum_t \sum_k \phi_{k,t}(\iota)\Gamma_{k,t}\right]}_{\text{Aggregate efficiency}} + \underbrace{\mathbb{E}\left[\sum_t \sum_k \phi_{k,t}(\iota)\Delta_{k,t}(\iota)\right]}_{\text{Redistribution}} + \underbrace{\mathbb{E}\left[\sum_t \sum_k \sum_g \phi_{k,t}(\iota)\gamma_{kg,t}(\iota)\Lambda_{kg,t}(\iota)\right]}_{\text{Insurance}}.\end{aligned}$$

Here k and g index over different good types, consumption, money, durables, and labor, $k, g \in$

$\{c, m, d, n\}$. Let $j \in \{T, H\}$ index the aggregate policies of transition or high-inflation steady state, respectively. Then define:

$$\begin{aligned}
\Gamma_{k,t} &= \ln X_{kt}^T - \ln X_{kt}^H, \\
\Delta_{k,t}(\iota) &= \ln\big(w_{k,t}^T(\iota)\big) - \ln\big(w_{k,t}^H(\iota)\big), \\
\Lambda_{kg,t}(\iota) &= -\tfrac{1}{2}\left[\operatorname{cov}\big(\ln(x_{kt}^T), \ln(x_{gt}^T) \mid \iota\big) - \operatorname{cov}\big(\ln(x_{kt}^H), \ln(x_{gt}^H) \mid \iota\big)\right], \\
w_{k,t}^j(\iota) &= \frac{\mathbb{E}_\iota[\, x_{kt}^j \mid \iota\,]}{\mathbb{E}[\,\mathbb{E}_\iota[\, x_{kt}^j \mid \iota\,]\,]}.
\end{aligned}$$

The weights and marginal utility terms are:

$$\begin{aligned}
\phi_{k,t}(\iota) &= \alpha_\iota U_{k,t}(\iota)\, x_{k,t}^Z(\iota), \\
\gamma_{kg,t}(\iota) &= \frac{-U_{kg,t}(\iota)\, x_{k,t}^Z(\iota)}{U_{k,t}(\iota)}, \\
x_{kt}^Z(\iota) &= \sqrt{x_{kt}^T\, x_{kt}^H},
\end{aligned}$$

where U_k, t refers to the marginal utility with respect to good k at time t and $U_{kg,t}$ refers to the second derivative