Inequality in the Welfare Costs of Disinflation∗

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PRELIMINARY AND INCOMPLETE

Abstract

We consider an economy where in the long run almost all households prefer low and stable inflation to high inflation, but a disinflation requires a potentially costly transition period. With perfect insurance markets the short run costs are small relative to the long run benefit of permanently lower inflation. However, when insurance markets are incomplete the welfare costs are borne unequally across households. For poorer households, especially those with nominal debt contracts, the disinflation is so costly they would prefer to remain in the high inflation equilibrium. We abstract from aggregate output effects introduced by a monetary tightening through nominal and real rigidities, focusing instead on the roles of redistribution and portfolio rebalancing across households. We use the model to quantify the welfare costs from these channels of the Volcker disinflation that brought inflation from over 10 percent to less than 4 percent over a little more than 2 years. When the model is calibrated to match the high inflation environment prior to the disinflation, more than 70 percent of households would have preferred to remain in the high inflation equilibrium.

1 Introduction

There is little controversy that if given the choice the overwhelming majority, if not all, consumers would prefer to inhabit an economy with low and stable inflation over one with persistently high inflation.1 Even putting aside costs from relative price dispersion or inflation uncertainty, high and stable inflation imposes resource costs as consumers alter their savings and consumption behavior in order to economize on non interest bearing assets subject to an inflation tax. In the late 1970s in the United States consumers faced a substantial inflation tax. Figure 1 plots several measures of annual price inflation. By almost all measures, consumers faced inflation in excess of 10 percent. It seems likely that most households in the late 1970s would have preferred the low and stable price inflation now common in the US. But one cannot switch from one environment to another without
In this paper we characterize one aspect of a disinflation transition period, namely its unequal costs and benefits across households of varying types. The debate over the costs of disinflation typically center on the sacrifice ratio, or the short-run loss in aggregate output necessary to reduce the rate of price inflation. But the focus on aggregates necessarily abstracts from the diversity of responses underlying the aggregate effects. We fix our sights on quantifying in a precise way the potential redistributive costs of a large disinflation. Households typically borrow in nominal contracts and hold a mix of real and nominal assets. A sudden change in inflation and inflation expectations increases the real burden of nominal borrowers. At the same time, it redistributes these resources towards those with assets paying a fixed nominal return.

To isolate the welfare costs from the endogenous redistribution imposed by a sudden disinflation, we abstract from the monetary non-neutralities embodied in a short-run sacrifice ratio. We consider an environment with perfectly flexible prices, that should right away adjust to the new inflation rate without any short-run output costs. While still highly stylized our purpose is to study the welfare consequences of the endogenous redistribution. To the extent that the required monetary tightening induces real effects on output through an upward sloping Phillips curve, we think of our results as conditioning out these aggregate effects.\footnote{It is of course true, that the aggregate real effects may themselves be distributed unequally. This is a challenging question that we leave to future work.} An alternative interpretation is that we answer the question, what would the welfare costs be in a central banker’s ideal world where the

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central bank could commit to a disinflation with perfect credibility, inflation expectations can adjust
instantaneously, and firms and workers can reset their prices immediately? In practice, credibility
is far from perfect, especially with such a potentially costly policy.

To do this we build a model of inflation with incomplete markets. To think about unequal effects
of inflation and disinflation we need to shut down perfect insurance markets that would make all
households effectively alike. We start with an Aiyagari (1994) framework, which we modify to
include money and nominal assets and liabilities. Households may hold cash, nominal bonds, and
have access to a limited amount of unsecured borrowing. They face idiosyncratic earnings shocks as
in the standard Bewley (1977) income fluctuation problem that now also includes a portfolio choice
between money and bonds. We use this to construct a stationary environment with 10 percent
inflation, which we see as an analogue to the late 1970s in the US. We calibrate the high inflation
economy to match key features of the US economy prior to the Volcker disinflation.

From that starting point, we construct a disinflation equilibrium path as the economy’s response
to a sudden shift in the monetary policy stance. The central bank (consolidated in our case
with the treasury as single government), announces a permanent shift to a lower inflation target
of 3 percent. We imagine this is perfectly credible so that inflation expectations immediately
reflect the lower target. This of course deviates wildly from the experience during the Volcker
disinflation that was initially plagued with credibility problems. In that sense, as we describe, this
is a best case scenario. The unanticipated shift in policy endogenously redistributes resources away
from borrowers and towards savers. In addition, households expecting permanently lower inflation
rebalance their portfolios as a reduced inflation tax substantially lowers the cost of liquidity in the
form of real balances. Both the redistribution and the rebalancing shift the aggregate supply of
non-cash savings, a version of the Tobin (1965) effect. For this reason we consider a production
economy where an elastic demand for capital relieves some of the pressure to adjust aggregate
savings. The real interest rate (and the capital stock) must adjust as does the fiscal authority to
maintain its budget constraint in light of a permanent drop in seigniorage revenues. The disinflation
equilibrium path incorporates all of these endogenous movements.

In our case we consider a “helicopter drop” monetary policy where seigniorage revenues are
rebated back to the households. This is not an innocuous assumption since the incomplete markets
shut down any Ricardian equivalence. The transfers provide some insurance to households against
low earnings. For this reason, even in the long run, a small share of households with low earnings
and little or negative savings would prefer a high inflation economy. For them the cost of the
inflation tax is secondary to the insurance benefits of the seigniorage revenues. As an alternative to
the helicopter drop, we consider open-market operations where seigniorage revenues cover interest
expenses on government issued bonds. With this policy and without any further lump sum transfers,
the insurance benefit from high inflation is eliminated.

In our economy, households shift into more liquidity, but this is offset by an increase in precau-
tionary savings from the redistribution, the implied long-term reduction in transfers, and a slight
tightening of an unsecured borrowing limit. The net result is a small initial decline in the real
interest rate and a slow decline to its long run value. The portfolio rebalancing also creates a one time jump in the level of real balances as the central bank responds to households new additional demand for liquid assets. Although this outcome may be surprising, we see a similar movement in 1983 when empirically household expectations of lower inflation seemed to first stick.

With the disinflation equilibrium path in hand, we compute short- and long-run measures of welfare. Because of the heterogeneity, these welfare costs differ substantially across the population. As expected low earning borrowers pay significant costs from the disinflation. However, they represent less than 10 percent of our economy. But the welfare losses are more broad-based. Overall, more than 70 percent of households would prefer to remain in the high inflation economy over the disinflation economy. This is despite the fact that almost 90 percent of the households ultimately prefer the low inflation economy in the long run.

When we average over the entire economy, the disinflation is equivalent to a roughly 1.7 percent decline in consumption. We decompose the overall welfare effect into an aggregate component and a redistribution component. In fact, the aggregate effects of the disinflation are positive almost immediately. Aggregate output and consumption climb towards higher long run levels. The aggregate component is equivalent to a 1 percent gain in consumption. This is easily undone by the redistributive costs of the disinflation of roughly 2.8 percent of consumption.

Overall, the results tell us that disinflation has substantial redistributive consequences. Even in the central banker’s ideal world where inflation expectations and prices adjust immediately, the short-run costs for more than half of the economy exceed the long-run benefits. The model also gives us an opportunity to consider alternative paths to disinflation, such as open market operations or coordinated fiscal policy. With our framework we can evaluate the extent to which they can minimize the short-run redistributive costs.

**Contribution to the Literature**

There is a large literature that measures and provides microfoundations for the long run welfare costs of inflation. Lucas (2000) revisits early empirical work from Bailey (1956) who found small welfare costs from integrating under an estimated money demand curve and finds these small estimates are consistent with welfare costs arising from a microfounded monetary model. Dotsey and Ireland (1996) and Aiyagari, Braun, and Eckstein (1998) introduce a channel where inflation draws resources away from production and into credit services to avoid an inflation tax. In the case of Dotsey and Ireland (1996) the reallocation can affect long run growth rates and amplify the welfare costs.

These papers consider an economy with complete markets. Chatterjee and Corbae (1992) and Imrohoroglu (1992) find that incomplete market arrangements can further amplify welfare costs. Our paper adds to this literature. It builds on work by Erosa and Ventura (2002) and Algan and Ragot (2010) who look at the long run consequences of inflation with incomplete markets and borrowing constraints. Erosa and Ventura (2002) focus on the non convexities in the transaction costs to credit purchases so that inflation mimics a non linear consumption tax that is largest for
the poor who make most purchases with cash. We are closer to Algan and Ragot (2010) to embed the Sidrauski (1967) framework into an Aiyagari (1994) framework with production to quantify inflation’s impact on the real interest rate and thus long run capital accumulation. We extend this framework to compute a non stationary equilibrium path between stationary high and low inflation economies using the methodology from Domeij and Heathcote (2004). Similar to Chatterjee and Corbae (1992) the real interest rate in our model has an allocative role as aggregate supply of savings shifts in response to the redistribution and new low inflation environment.

The welfare cost literature concentrates on long run effects, whereas disinflation is inherently a short run phenomenon. Gordon, King, and Modigliani (1982) and Cecchetti and Rich (2001) estimate sacrifice ratios for the US that imply disinflation imposes large output costs. More recently Ascari and Ropele (2012) show in medium scale DSGE model that despite an output loss, disinflation is actually welfare improving in the long run and the short run. They abstract from any redistribution and study an economy with complete markets. Our work complements their by demonstrating that even without a temporary output loss from a disinflation vis-a-vis a Phillips curve, that just the disinflation induced redistribution has a first order effect on aggregate welfare.

Goodfriend and King (2005) consider the “incredible Volcker disinflation” explicitly. They recount the environment just prior to Volcker’s confirmation as Chairman of the Federal Reserve Board, and the credibility problems that plagued the policy shifts during the disinflation period. They provide a model where sacrifice ratios emerge from an imperfect commitment to disinflation. Their work is a natural counterpart to our analysis. We analyze an economy where the central bank has perfect credibility and the Phillips curve is vertical, yet the equilibrium consequences of the endogenous redistribution are still welfare reducing for the majority of the economy.

There two other papers close in spirit to our analysis. Doepke and Schneider (2006a) document the net nominal position of various cohorts and sectors in the U.S. economy, and they conduct a reduced form experiment, computing the redistribution from a surprise inflation episode. They find that inflation is beneficial to young domestic households and the government who hold large nominal debt positions. The losers from an inflation episode are foreigners who hold U.S. bonds and old domestic households.

In a subsequent paper, Doepke and Schneider (2006b) treat an inflation shock as a surprise wealth distribution in a quantitative analysis of an overlapping generations growth model. They find that while inflation reduces output, the implied increased fiscal transfers and intergenerational transfers from older savers to younger borrowers is actually aggregate welfare improving. Meh, Ríos-Rull, and Terajima (2010) find similar results in a quantitative overlapping generation model calibrated to match Canadian data. Although we study a disinflation rather than an inflation our results are complementary with these papers.

Our contribution is to measure the welfare effect of disinflation-induced redistribution and the endogenous behavioral responses to the new low inflation environment. Households savings and portfolio choice decisions respond both factors, and this feeds back on overall welfare. As in Doepke and Schneider (2006b) and Meh, Ríos-Rull, and Terajima (2010) our quantitative model allows us
2 A Monetary Model with Heterogeneity

We start by developing a monetary equilibrium model where households cannot perfectly insure
idiosyncratic shocks to their labor productivity and may only trade in cash and a one-period risk-free
nominal bond. We first consider a stationary environment where there is no aggregate uncertainty.
This will be a standard Aiyagari (1994) model modified to support the introduction of money and
inflation and with some limits on unsecured borrowing. In this economy the overall endogenous
wealth distribution remains constant, although individual households will transit the distribution
in response to their idiosyncratic shocks. The way in which we introduce money and inflation
is to embed the Sidrauski (1967) model in an imperfect insurance framework with production.
Algan and Ragot (2010) do exactly this in a stationary environment, and the model we use extends
their work to consider a disinflation. To study the welfare effects of a disinflation we quantify the
response of this economy to an unanticipated and credible change in the monetary policy stance of
the government. Inflation adjusts to a new constant and lower level, and the economy converges to
a new stationary distribution with low inflation. In this environment we measure both the short
run and long run benefits and costs of inflation across the distribution of households.

We first define the environment and the initial high-inflation equilibrium. Next we characterize
the disinflation period as an unanticipated change in the inflation rate and a sequence of distribu-
tions of the endogenous variables that converge to a new low-inflation stationary distribution.

2.1 Environment

Time is discrete and the period length is one year. The economy consists of a large number of
dynastic households indexed by $i$ and represented by a unit measure $i \in [0,1]$, a production sector
represented by a single competitive firm, and a government that implements an exogenous and
deterministic fiscal and monetary policy. This is a monetary economy with two commodities: a
non durable consumption good and money.

Money $\tilde{m}$ is a numeraire, a store of value, and a source of liquidity services to the households. As a numeraire we define the money price of period $t$ consumption as $P_t$, and denote as the real value of money balances as $m \equiv \tilde{m}/P_t$. We capture the liquidity value of money by including real balances $m$ directly in the household’s preferences as in the original Sidrauski (1967) model. Households have identical preferences over sequences of consumption $c$ and real balances $m$ ordered

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Footnotes:

3 Households may also trade in claims to physical capital, but with no aggregate uncertainty they will be indifferent between nominal bonds and claims to capital.
4 Here we use $\tilde{\cdot}$ notation to denote nominal variables, and we use capital letters to denote aggregate quantities.
5 This stands in for alternative microfoundations of money demand. 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 similar results in any model where inflation generates utility or resources costs to economizing on liquid assets.
by
\[ E_0 \left[ \sum_{t=0}^{\infty} \beta^t U (c_t, m_t) \right] \]
where \( U \) is homogeneous in \( c \) and \( m \), and further
\[ \lim_{c \to 0} U_c(c, m) = \infty \quad \lim_{m \to 0} U_m(c, m) = \infty \quad \text{and} \quad U_{cm}(c, m) > 0. \]

Each household has one unit of raw labor that is supplied inelastically to a production sector. That labor’s efficiency \( e_t \in \{e_1, \ldots, e_{N_e}\} \) is a Markov chain with constant transition matrix \( P = [p_{lk}] \) initialized from its unique stationary distribution \( \bar{p} \in \mathbb{R}^{N_e} \). \(^6\) Labor efficiency is independent across households, and there are enough households so that a law of large numbers implies that aggregate labor efficiency is constant \( \bar{n} \equiv E[n_t] = \bar{p}'(e_1, \ldots, e_{N_e}) \).

A representative firm uses the capital stock \( K_{t-1} \) and aggregate efficiency units of labor \( N_t \) to produce output with a stationary constant returns to scale technology \(^7\)
\[ Y_t = F(K_{t-1}, N_t). \]
Output may consumed by households as \( C_t \), by the government \( G_t \) or invested \( I_t \) in the capital stock. There are no adjustment costs so that an aggregate resource constraint on total output \( Y_t \) is
\[ Y_t = C_t + I_t + G_t. \]
The capital stock depreciates at rate \( \delta \) and follows the law of motion
\[ K_t = (1 - \delta) K_{t-1} + I_t. \]

We consider an equilibrium with competitive markets for output and its factor inputs. The firm sells its output at price \( P_t \) and rents capital and efficiency units of labor at nominal prices \( P_t v_t \) and \( P_t w_t \) respectively. Financial markets are incomplete, and the household may trade only in a single risk-free nominal bond \( \tilde{a}_t \) sold at discount \( \frac{1}{1 + i_t} \), money \( \tilde{m}_t \) and claims on the capital stock \( k_t \). Unsecured borrowing is permitted up to an ad-hoc constant limit
\[ a_t \equiv \frac{\tilde{a}_t}{P_t} \geq -b, \quad (1) \]
where \( b \geq 0 \) is tighter than the natural borrowing limit. \(^8\) With no aggregate uncertainty over productivity or future policy, in an equilibrium the ex-post nominal return on the bond and capital must be equivalent
\[ 1 + i_t = (1 + v_{t+1} - \delta) \Pi_{t+1}. \quad (2) \]

\(^6\) We only consider transition matrices \( P \) that admit a unique stationary distribution.
\(^7\) For all variables we adopt the notation that any variable dated \( t \) is first measurable with respect to the information in period \( t \). So the available capital stock in period \( t \) was determined in period \( t - 1 \).
\(^8\) The borrowing limit \( b \) is in real terms, which implies that it in fact tightens in a disinflation.
With identical returns to bonds and capital the ownership of the capital stock is indeterminate. To resolve this we have all households trade only in the nominal bond and assign ownership to capital according to a rule. The assignment of ownership will not be an innocuous assumption, and we return to this issue when we define the disinflation equilibrium. Although prices are deterministic, it is important to note that the nominal return on bonds $1 + i_t$ is determined before inflation $\Pi_{t+1}$ is realized. If ex-post $\Pi_{t+1}$ differs from its expected (actually deterministic) value because of an unanticipated policy change, the ex-post return on capital will be different than the ex-ante contracted return on the nominal bonds. In the case we study with an unanticipated disinflation the real value of a payoff from the capital stock will be less than the payoff from the nominal bond.

Given these arrangements, the timing is as follows. A household begins period $t$ with its nominal savings $\tilde{m}_{t-1} + \tilde{a}_{t-1}$ accumulated from period $t-1$. The period $t$ price level $P_t$ is realized. Households earn an after-tax nominal wage $P_t (1 - \tau_t) w_t$ per efficiency unit of labor and receive any transfers $P_t T_t$ from the government. They may purchase consumption at nominal price $P_t$, trade in nominal claims $\tilde{a}_t$ sold at discount $\frac{1}{1 + i_t}$ and money $\tilde{m}_t$, subject to a sequence of nominal budget constraints

$$P_t c_t + \tilde{m}_t + \frac{1}{1 + i_t} \tilde{a}_t = c_t (1 - \tau_t) P_t w_t + \tilde{a}_{t-1} + \tilde{m}_{t-1} + P_t T_t .$$

We next describe the household’s behavior in more detail.

### 2.2 Households

To characterize household behavior, it is helpful to define the problem recursively. First, since we will be interested in a stationary equilibrium, we normalize the budget constraint (3) by the price of output $P_t$ to reformulate it in terms of real values. Then we introduce a net worth variable $x$, and we let $x_t$ be the real value at the end of period $t$ of the households total nominal savings. Finally, we let $V_t (x_{t-1}, e_t)$ denote the maximum value of a household in period $t$ with end of period $t-1$ real resources $x_{t-1}$ and period $t$ labor efficiency $e_t$. Then $V_t$ satisfies a sequence of Bellman equations

$$V_t (x_{t-1}, e_t) = \max_{c_t \geq 0, m_t \geq 0, a_t \geq -b} \{ U (c_t, m_t) + \beta E [V_{t+1} (x_t, e_{t+1}) | e_t] \} \quad t = 0, 1, \ldots$$

subject to the real budget constraint

$$c_t + \frac{a_t}{1 + i_t} + m_t = \frac{x_{t-1}}{\Pi_t} + w_t (1 - \tau_t) e_t + t_t$$

the unsecured borrowing constraint (1) and a law of motion for resources

$$x_t = a_t + m_t .$$
The value function depends on $t$ through the sequence of interest rates $i_t$, wages $w_t$ and fiscal and monetary policy. We abuse notations slightly and label the sequence of policy functions that satisfy the sequence of Bellman equations as $c_t(x_{t-1},e_t)$, $m_t(x_{t-1},e_t)$ and $a_t(x_{t-1},e_t)$.

2.3 Production

The production sector is straightforward and its primary purpose is to generate demand for savings. An endowment economy puts substantial pressure on the real rate to accommodate shifts in the aggregate supply of savings. The representative firm rents capital and efficiency units of labor in a competitive market at real prices $v_t$ and $w_t$ respectively. Imposing market clearing in the rental market for capital and labor, profit maximization requires

$$F_k(K_{t-1},\bar{\bar{\kappa}}) = v_t \quad F_n(K_{t-1},\bar{\bar{\kappa}}) = w_t .$$

(5)

Here we have already imposed market clearing in the factor markets for capital and efficiency units of labor.

2.4 Government

The government is a consolidated fiscal and monetary authority. It purchases an exogenous quantity of output $G_t$, supplies households with nominal transfers $P_tT_t$, and adjusts the nominal stock of money $\tilde{M}_t$ to achieve an inflation target $\Pi^*$.\(^9\) In addition to any seigniorage revenues from issuing new cash liabilities, it raises revenue from a proportional income tax $\tau_t$ on households’ earned income, and issuing interest bearing one-period nominal liabilities $\tilde{D}_t$ at discount $1/(1+i_t)$. Given an exogenous sequence of expenditures $G_t$ the government faces a sequence of budget constraints

$$P_tG_t + \tilde{D}_{t-1} + \tilde{M}_{t-1} + P_tT_t = \frac{\tilde{D}_t}{1+i_t} + \tilde{M}_t + P_t\tau_tw_t\bar{\bar{\kappa}} , \quad t = 0, 1, \ldots$$

or expressed in units of the final good

$$G_t + \frac{D_{t-1} + M_{t-1}}{\Pi_t} + T_t = \frac{D_t}{1+i_t} + M_t + \tau_tw_t\bar{\bar{\kappa}} ,$$

(6)

where $D_t \equiv \tilde{D}_t/P_t$ and $M_t \equiv \tilde{M}_t/P_t$ are the real value of the nominal liabilities.

Given an exogenous sequence of expenditures $G_t$, an inflation target $\Pi^*$, and initial liabilities $D_{-1}$ and $M_{-1}$, a fiscal and monetary policy is a sequence of taxes $\tau_t$, transfers $T_t$, real money stocks $M_t$, and debt $D_t$ so that $P_t/P_{t-1} = \Pi^*$ and the government budget constraint (6) is satisfied in each period $t \geq 0$. With the behavior of households, firms, and the government defined, we next describe the initial equilibrium.

\(^9\)We can think of government expenditures as completely separable from household preferences over consumption and real balances.
2.5 Aggregating over Heterogeneous Households

Before defining an equilibrium we first define a measure $\psi_t$ to keep track of distribution of households. We characterize the heterogeneity in households by their characteristics at the beginning of each period. Let $\psi_t([-b,x],e)$ be the measure of households that begin period $t$ with $x_{t-1} \leq x$ and efficiency $e_t = e$. Given the sequence of household policy rules $a_t$ and $m_t$, this measure must satisfy the law of motion

$$\psi_t([-b,x],e) = \sum_{l=1}^{N_e} \int \mathbf{1}\{a_{t-1}(s,e_t) + m_{t-1}(s,e_t) \leq x\} \psi_{t-1}(ds,e_t)p_{lj}, \quad (7)$$

so that $\psi_t([-b,x],e)$ represents the share of households with efficiency $e_t = e$ that would have accumulated no more than $x_{t-1}$ at the end of the previous period.

Using this measure we can define aggregate quantities for consumption

$$C_t = \sum_{l=1}^{N_e} \int c_t(x,e_t) \psi_t(dx,e_t) \bar{p}_t$$

real balances

$$M_t = \sum_{l=1}^{N_e} \int m_t(x,e_t) \psi_t(dx,e_t) \bar{p}_t. \quad (8)$$

and aggregate savings

$$A_t = \frac{1}{1+i_t} \sum_{l=1}^{N_e} \int a_t(x,e_t) \psi_t(dx,e_t) \bar{p}_t. \quad (9)$$

Recall that the transition matrix of the Markov chain for labor efficiency is defined $P = [p_{lj}]$ and the chain is initialized from its unique ergodic distribution $\bar{p} \in \mathbb{R}^{N_e}$. These aggregates depend on $t$ through the sequence of prices.

2.6 Stationary Equilibrium with High Inflation

We define the *stationary high inflation equilibrium* as follows. Given a fiscal and monetary policy with inflation target $\Pi^H$, constant expenditures $G$, transfers $T$, tax rate $\tau$ and government debt $D$. A stationary high inflation equilibrium is a stationary measure $\psi^H$ that satisfies (7), a set of prices $i$ and $v$, inflation $\Pi = \Pi^H$ that satisfy the no arbitrage condition (2), decision rules $c(x,e)$, $m(x,e)$, and $a(x,e)$ that solve the Bellman equation (4), firms maximize profits (5) with

$$K + D = \frac{A}{1+i}, \quad (10)$$

from aggregate savings (9), and the government budget constraint (6) holds given aggregate demand for real balances given by (8).

For a fixed inflation objective $\Pi^*$ and constant government expenditures $G$, this equilibrium
definition admits a continuum of equilibria differentiated by fiscal policy $B$, $\tau$, and $T$, that satisfy the government budget constraint (6). Restricting the number of equilibria requires fixing two of the three variables and letting the third be determined endogenously. When we look for a stationary equilibrium we fix the tax rate $\tau = 0$, government debt, $D = 0$, and let transfers $T$ be determined endogenously.

### 2.7 A Disinflation Equilibrium Path

We use the stationary high inflation equilibrium as the starting point for the following experiment. What if, at the beginning of period $t = 1$, the government changes its monetary policy stance? It abandons its original inflation target $\Pi^H$ and makes a credible commitment to a lower inflation target $\Pi^L < \Pi^H$. The announcement takes households by surprise as they have already made their portfolio choices in period $t-1$ in the high inflation equilibrium. The government does whatever it takes to reach the lower inflation rate by accommodating the initial shock to aggregate real money demand as households rebalance their portfolios under the new lower inflation environment.

We define a $J$ period disinflation as the following. At the beginning of period $t = 1$, the government commits to a path of inflation

$$\Pi_t^L = \begin{cases} \Pi^H - \left(\frac{\Pi^H - \Pi^L}{J}\right) (t + 1) & \text{if } t \leq J - 1 \\ \Pi^L & \text{if } t \geq J \end{cases}$$

and pledges to accommodate aggregate demand for real balances by adjusting as needed the growth rate in the nominal stock of money $\tilde{M}_t$ and the supply of transfers $T_t$ to satisfy its budget constraint.

We will consider the welfare effects of this disinflation in a transition equilibrium 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. More recently Guerrieri and Lorenzoni (2011) use the same idea to study the adjustment in the natural rate of interest in response to a tightening of the borrowing constraint. In our case, the production economy introduces a slight complication to the disinflation equilibrium. Households save in nominal assets, either money or interest-bearing bonds. If there were no capital, an unanticipated decline in inflation would be a pure redistribution of real resources from borrowers to savers, with no effect on aggregate savings. In the production economy, aggregate nominal savings finances the nominal value of the capital stock. An unanticipated decline in inflation increases the real value of nominal aggregate household savings but leaves the real value of the capital stock unaffected. This introduces a shortfall—in this case from the owners of the capital stock—that finances a windfall for all saver households, and these resources must come from somewhere. The real value of this one-time gap $l_1$ is

$$l_1 = \left(\frac{1}{\Pi^H} - \frac{1}{\Pi^L}\right) \frac{A_0}{1 + i_0},$$

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where the 0 subscript denotes the objects from the high inflation stationary equilibrium in period 0. To close the gap, we impose a resource cost on a subset $E$ of households who own the capital stock when the low inflation commitment is announced. Because of the linear returns to nominal bonds and capital, ownership is indeterminate and must be specified exogenously. In practice, we will define $E$ as the wealthiest households. These households each pay a one-time proportional capital tax

$$
\tau_k = \frac{l_1}{\sum_{i=1}^{N_e} \int \mathbf{1} \{ (x, e) \in E \} x \psi_1 (dx, e) \bar{p}_i} .
$$

Finally we can describe the disinflation equilibrium path. Given an initial high inflation stationary equilibrium as described in Section 2.6 and its stationary measure $\psi^H$ we characterize the disinflation transition equilibrium as follows. Let $\psi_1 = \psi^H$, then for $t \geq 1$ given a constant sequence of government expenditures $G_t = G$, an inflation path $\Pi^L_t$ defined by (11), constant taxes $\tau$, and a sequence of transfers $T_t$ and real balances $M_t$ that satisfy the government budget constraint (6) and aggregate demand for real balances given by (8), a disinflation transition equilibrium is for $t \geq 1$ a sequence of measures $\psi_t$ that satisfy at satisfies (7), a sequences of prices $i_t$, $v_t$, realized inflation $\Pi_t = \Pi^L_t$ that satisfy the no-arbitrage condition (2), decision rules $c_t(x, e)$, $m_t(x, e)$, and $a_t(x, e)$ that solve the sequence of Bellman equations (4) where firms maximize profits (5) with

$$
K_t + B_t = \frac{A_t}{1 + i_t},
$$

from aggregate savings (9), and the government budget constraint (6) holds given aggregate demand for real balances given by (8).

### 2.8 Model Calibration and Solution

Our starting point is the high inflation equilibrium. We calibrate the model to mimic the economic environment in the US just prior to the Volcker disinflation. Then we implement the disinflation policy as an unanticipated but credible change in the inflation rate with all other parameters held fixed. The economy under the low inflation policy eventually converges to a new low inflation stationary equilibrium. We compute the exact transition path of the aggregates, but also the distributions along the path to the new stationary equilibrium. These are the basis for our welfare calculations.

#### 2.8.1 High Inflation Equilibrium

We choose the period length to be one year rather than a more common choice of one quarter. The longer time period is a compromise between studying short-run effects of the disinflation and providing a long enough duration for nominal borrowing and saving contracts. Unsecured credit is typically at variable rates that would adjust within a year given a shift in expected inflation. Although fixed rate mortgages in the US are 15 or 30 year contracts, they include a prepayment option. So in practice, a surprise disinflation that increased the real burden of the nominal debt
would create strong incentives to refinance. In fact in the early 1980s there was a boom in mortgage refinancing for exactly that reason. In the model the surprise disinflation increases the carrying cost of the debt for one period, but then it is “refinanced” at the lower rates that prevail under the disinflation regime. For the initial high inflation equilibrium we consider a gross inflation rate target of $\Pi^* = 1.10$. This is roughly in line with price inflation at the beginning of Volcker’s term as Chairman of the Federal Reserve Board.

We specify household preferences with relative risk aversion $\sigma$ over a CES aggregate of consumption and real balances so that

$$U(c,m) = \frac{1}{1-\sigma}\left(\omega c^{\frac{n-1}{\eta}} + (1 - \omega) m^{\frac{n-1}{\eta}}\right)^{\eta/(\eta-1)}.$$  

With these preferences the elasticity of substitution between consumption and real balances $\eta$ will turn out to be the interest elasticity of money demand. When unconstrained, households will choose

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

The parameter $\omega \in [0, 1]$ scales the liquidity value of real balances. The interest elasticity of money demand is not precisely estimated in the data. 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.\textsuperscript{10} We choose $\eta = 0.5$ and examine the sensitivity of our results to alternative elasticities. With $\eta$ fixed, we set $\omega = 0.988$ to target the ratio of real balances to output in the high inflation stationary distribution. We choose the discount factor $\beta = 0.934$ to generate a steady state capital to output ratio of 3.3 in equilibrium. In the high inflation environment, this implies a nominal interest rate of $i = 14.3$ percent and a real return of $r = 4.0$ percent.

For production we use a Cobb-Douglas production function

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

with capital share $\alpha = 0.33$, which is roughly in line with long run average of capital income to output. We choose an annual depreciation rate of $\delta = 0.06$ to generate a investment to output ratio of roughly 0.2 given the capital to output ratio.

In this version of the paper we do not consider any government spending so we fix $G = 0$ and $\tau = 0$. We rebate seigniorage revenues to households as a lump sum transfer as in Friedman’s “helicopter drop”. The only parameters remaining are the real borrowing limit and the parameters of the Markov chain governing idiosyncratic labor efficiency. For now we follow Heathcote and Domeij (2004) and choose a 3 state Markov chain with a relatively high productivity state with less persistence.

2.8.2 Disinflation Policy

The Volcker disinflation period lasted roughly two years. From the end of 1981 to mid 1983 inflation had declined from over 10 percent to a little less than 4 percent. We model this policy as an immediate shift (i.e., \( J = 1 \)) in the inflation target to \( \Pi^* = 1.03 \). In the future we will assess longer disinflation periods where the disinflation surprise is reduced. In this version of the paper, we do not include government expenditures or proportional income taxes. So to implement this policy the government accommodates the change in demand for real balances induced by the new inflation target and continues to choose transfers \( T_t \) to refund all seigniorage revenues to the households as a lump sum.

2.8.3 Model Solution

We discuss the model solution in detail in Appendix B. We use a version of the endogenous grid method to solve for the household decision rules under constant prices and compute the prices in which aggregate savings over the implied stationary distribution of households is equal to demand from government borrowing and the capital stock. In our formulation this requires solving both for the nominal rate \( i \) and the lump sum transfer \( T \) from the seigniorage revenues implied by the level of real balances demanded by households.

Computing the non stationary solution for the disinflation equilibrium path is by now relatively standard. We use an approach similar to Domeij and Heathcote (2004). We look for a stationary low inflation equilibrium using the method just described. The disinflation equilibrium will converge to the low inflation equilibrium in finite time. For our calibration this is well under 150 periods. We consider 150 period sequences of prices and transfers that would characterize the transition path. For a given sequence we can solve backwards from the low inflation equilibrium along the conjectured sequence of prices and transfers using the endogenous grid method to find the sequence 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 (7) with the disinflation sequence of policy rules. We look for a sequence of prices and transfers where the capital market (12) and the government budget constraint (6) clears in each period. The disinflation equilibrium solution delivers the sequence of policy rules and distributions characterizing household heterogeneity during the disinflation period.

3 Household Heterogeneity in the Data and Model

The starting point for our experiment is the high inflation period from the mid 1970s to 1981 that preceded the Volcker disinflation. In the previous section we calibrated our model economy to mimic this environment. In this section we use microdata on household finances during that period to compare the heterogeneity in the data against the heterogeneity we have induced in our artificial economy.
3.1 Household Finance Data

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 tax payers 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.\(^{11}\) Ideally we would have household finance data measured during the exact high inflation period. Unfortunately, we are not aware of any data for this time period.\(^{12}\) Interview 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. Although in the model the disinflation is completely credible, in practice inflation expectations even during the Volcker disinflation remained stubbornly 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 value of durable goods, consumer debt and real estate debt. We classify the debt and assets into nominal and real positions and calculate the net nominal, the net real and the liquid wealth distribution.\(^{13}\)

We only identify 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. 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 nominal position of the household sector and cohorts of the household sector, but will be substantially less accurate for characterizing the distribution of the nominal wealth among households. However, we believe that the bias created by not correcting for indirect nominal positions 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%. As a result we only include direct nominal holdings in our statistics.

\(^{11}\)See Avery, Elliehausen, and Kennickell (1988) for a complete description of the 1983 SCF survey and methodology.
\(^{12}\)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. We thank Kyle Herkenhoff for making us aware of the 1970 and 1977 years of the Survey of Consumer Finances at the University of Michigan’s ICPSR data archive.
\(^{13}\)Appendix A.1 describes in detail our grouping of the household assets and liabilities in the 1983 SCF.
3.2 High Inflation Period

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. We also report the Gini statistic for each of our variables. The Gini measures the area between a 45 degree line and the Lorenz curve for each variable. When all shares are non negative, it will be between zero and one, with zero indicating perfect equality and one indicating perfect inequality. In our case some households will be net borrowers so the Gini coefficient could in principle be above one.

In 1983, as in other years, the distribution of net worth is skewed, with the top one percent of households owning 31 percent of total net worth. The precautionary savings motive in our model is able to replicate the inequality in the wealth distribution, but fails to generate the substantial wealth accumulation in the very far tail. This is typical in this class of model where precautionary motives cannot along account for the extreme wealth accumulation of the very rich. Models with that include a rare and transient superstar state, entrepreneurship with financial constraints, or bequest motives are better able to replicate this behavior.

<table>
<thead>
<tr>
<th>Percent of Total</th>
<th>10%</th>
<th>25%</th>
<th>50%</th>
<th>10%</th>
<th>5%</th>
<th>1%</th>
<th>Gini</th>
</tr>
</thead>
<tbody>
<tr>
<td>1983 SCF</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Net Worth</td>
<td>-0.14</td>
<td>0.12</td>
<td>3.82</td>
<td>66.65</td>
<td>54.56</td>
<td>31.23</td>
<td>0.78</td>
</tr>
<tr>
<td>Liquid Assets</td>
<td>0.31</td>
<td>1.07</td>
<td>6.58</td>
<td>50.18</td>
<td>34.80</td>
<td>13.97</td>
<td>0.81</td>
</tr>
<tr>
<td>Nominal Wealth</td>
<td>-4.83</td>
<td>-9.22</td>
<td>-34.81</td>
<td>121.4</td>
<td>95.44</td>
<td>43.03</td>
<td>—</td>
</tr>
<tr>
<td>Real Wealth</td>
<td>0.17</td>
<td>0.73</td>
<td>6.33</td>
<td>63.09</td>
<td>51.90</td>
<td>30.46</td>
<td>0.76</td>
</tr>
<tr>
<td>Adjusted Net Worth</td>
<td>0.01</td>
<td>0.28</td>
<td>2.26</td>
<td>79.06</td>
<td>67.71</td>
<td>42.81</td>
<td>0.89</td>
</tr>
<tr>
<td>Equity</td>
<td>0.01</td>
<td>0.09</td>
<td>0.55</td>
<td>90.56</td>
<td>81.13</td>
<td>52.26</td>
<td>0.96</td>
</tr>
<tr>
<td>Model</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Net Worth</td>
<td>-0.59</td>
<td>0.46</td>
<td>0.90</td>
<td>62.06</td>
<td>37.20</td>
<td>8.80</td>
<td>0.81</td>
</tr>
<tr>
<td>Liquid Assets</td>
<td>0.50</td>
<td>10.59</td>
<td>26.7</td>
<td>33.87</td>
<td>19.30</td>
<td>4.27</td>
<td>0.39</td>
</tr>
</tbody>
</table>

Notes: 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. See appendix for detailed descriptions. We omit the Gini coefficient for nominal net worth because it is negative for almost 75 percent of households.

We calibrated our model to approximately match the distribution of net worth. We include the decomposition of the wealth distribution in advance of the next iteration of this paper that will include durable goods. In our model, in the high inflation equilibrium fewer than 20 percent of households are net (nominal) borrowers. However in the data, it is clear that net nominal positions are negative for significantly more than half of the population. This of course reflects secured borrowing in the form mortgages, which is absent from this initial formulation. This is important
Table 2: Distribution of Income in Data and Model

<table>
<thead>
<tr>
<th>Percent of Total</th>
<th>Lowest 10%</th>
<th>25%</th>
<th>50%</th>
<th>Highest 10%</th>
<th>5%</th>
<th>1%</th>
<th>Gini</th>
</tr>
</thead>
<tbody>
<tr>
<td>1983 SCF</td>
<td>11.82</td>
<td>15.44</td>
<td>20.93</td>
<td>62.15</td>
<td>55.65</td>
<td>35.97</td>
<td>0.46</td>
</tr>
<tr>
<td>Model</td>
<td>1.21</td>
<td>10.43</td>
<td>26.51</td>
<td>37.46</td>
<td>20.23</td>
<td>4.31</td>
<td>0.41</td>
</tr>
</tbody>
</table>

Notes: 1983 Survey of Consumer Finances.

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 would mean welfare losses across the distribution, not just among the wealth poor.

We also compute in the SCF the distribution of total household income and the model analogue in Table 2. This is the sum of all earnings, capital and interest income, and transfers. We use the same concept in the model measuring the distribution of an income measure that includes earnings, net interest payments, and transfers. In the high inflation equilibrium transfers from seigniorage revenues reduce inequality, although quantitatively the effect is very small, reducing the Gini coefficient to 0.41 from 0.42.

The goal of the high inflation equilibrium we describe here is to construct an environment similar to the one that prevailed in the US in the first year of Volcker’s term as Fed chair. Then we use this as a starting point to consider the disinflation with perfectly flexible prices.

3.3 Volcker Disinflation Period

In November of 1980 to very early 1981 the Volcker disinflation began in earnest. Goodfriend and King (2005) recount the course of events and policy commitments leading up to and through the “incredible Volcker disinflation.” We consider this disinflation policy in the model as an unexpected and immediate shift in the monetary policy stance. The government announces a 3 percent inflation target and commits to whatever it takes to achieve this new lower inflation rate.

Before we study disinflation in the model, we see where it will eventually lead the economy. In Table 3 we compare the high inflation and low inflation long run economies that represent the beginning and ultimate ending of the disinflation. The first thing we notice is that monetary policy is not super-neutral. Even in the long run, higher inflation slightly raises the real rate and thus lowers the capital stock. This is not a general feature of high inflation. In fact the higher inflation rate tilts portfolios towards less cash that puts downwards pressure on the real rate, a version of the Tobin (1965) effect. In this case transfers from the seigniorage revenues offer sufficient insurance to the lower productivity households to weaken the precautionary savings motive. An equilibrium with

\[14\] Lindsey, Orphanides, and Rasche (2005)

\[15\] Moreover, our specification of the borrowing constraint relaxes with higher inflation also weakening the precau-
monetary policy conducted through open market operations rather than a helicopter drop would reverse this property. In either case, inflation policy is not super-neutral in this environment.\footnote{See Algan and Ragot (2010) who discuss this property in more detail.}

<table>
<thead>
<tr>
<th>Table 3: High Inflation and Low Inflation Steady State Comparison</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Inflation Target</strong></td>
</tr>
<tr>
<td>$\Pi^*$</td>
</tr>
<tr>
<td>1.10</td>
</tr>
<tr>
<td>1.03</td>
</tr>
<tr>
<td><strong>Interest rates</strong></td>
</tr>
<tr>
<td>$i$</td>
</tr>
<tr>
<td>14.3</td>
</tr>
<tr>
<td>7.0</td>
</tr>
<tr>
<td>$r$</td>
</tr>
<tr>
<td>4.0</td>
</tr>
<tr>
<td>3.9</td>
</tr>
<tr>
<td><strong>Aggregates</strong></td>
</tr>
<tr>
<td>$C$</td>
</tr>
<tr>
<td>1.45</td>
</tr>
<tr>
<td>1.45</td>
</tr>
<tr>
<td>$Y$</td>
</tr>
<tr>
<td>1.81</td>
</tr>
<tr>
<td>1.81</td>
</tr>
<tr>
<td>$K$</td>
</tr>
<tr>
<td>5.98</td>
</tr>
<tr>
<td>6.02</td>
</tr>
<tr>
<td>$M$</td>
</tr>
<tr>
<td>0.45</td>
</tr>
<tr>
<td>0.62</td>
</tr>
<tr>
<td>$T$</td>
</tr>
<tr>
<td>0.041</td>
</tr>
<tr>
<td>0.018</td>
</tr>
</tbody>
</table>

Now we mimic the Volcker disinflation by computing the transition equilibrium path to the new low-inflation long run equilibrium. As we describe in Section 2.7, the first period of the transition 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 find the opposite and receive an unexpected windfall. This is attenuated somewhat in this group because of the one time capital tax imposed on the top 25 percent to cover the mismatch between the new real value of net nominal savings and the value of capital stock.

In Figure 2 we compute the response of the aggregate variables along this transition path, which is plotted as the solid line. The star represents the levels in period 0’s high inflation equilibrium and the broken line indicates the new low inflation long run values. The reduction in inflation induces an economy wide portfolio rebalancing. Real balances, previously unattractive because of the high inflation tax, become more desirable. The government accommodates the increased demand with a big jump in real bala

\[\text{ADD DESCRIPTION/INTERPRETATION OF AGGREGATES}\]
\[\text{ADD DESCRIPTION OF REAL RATE RESPONSE}\]
Figure 2: Aggregate effects of Volcker disinflation

Figure 3: Real interest rate during Volcker disinflation
4 Measuring Inequality in the Welfare Costs of Disinflation

To quantify the welfare impact of the disinflation period, we offer several different measures. First we define a simple 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 where the economy remains in the high inflation equilibrium permanently. Next we consider a utilitarian measure that averages the consumption equivalence over the entire economy. We decompose this measure as in Domeij and Heathcote (2004) to decompose this average welfare change into an aggregate component and a redistribution component. Finally we consider the same measures over the long run.

4.1 Measures of Welfare

4.1.1 Short Run Conditional Welfare

We consider an unanticipated disinflation in period $t = 1$. We define $V^L_t(x_0, e_1)$ as the value of a household in period $t = 1$ with its resources $x_0$ determined in the high inflation period

$$V^L_t(x_0, e_1) = E \left[ \sum_{k=0}^{\infty} \beta^k U \left( c^L_{t+k}, m^L_{t+k} \right) | t = 1, e_1 \right],$$

where $c^L_t$ and $m^L_t$ for $t \geq 1$ are the sequences of consumption and money balances determined along the disinflation equilibrium path. Note that since resources $x_0$ were determined under the high inflation regime, in period $t = 1$ there is a one-time windfall gain to those with positive net worth and a loss to borrowers. Next, we define for the same household with $x_0$ and $e_1$ the counterfactual value $V^H_t(x_0, e_1)$ of remaining in the high inflation environment forever.

$$V^H_t(x_0, e_1) = E \left[ \sum_{k=0}^{\infty} \beta^k U \left( c^H_{t+k}, m^H_{t+k} \right) | t = 1, e_1 \right].$$

Since the initial high inflation environment is stationary of course $V^H_0 = V^H$.

We define the conditional welfare change $\Delta_{SR}(x_0, z)$ as the adjustment to counterfactual liquidity-adjusted consumption needed to make the counterfactual environment equivalent to a transition to a new low inflation steady state

$$E \left[ \sum_{k=0}^{\infty} \beta^k U \left( \Delta_{SR}c^H_{t+k}, \Delta_{SR}m^H_{t+k} \right) | t = 1, e_1 \right] = V^L_t(x_0, e_1).$$

Since $U$ is homogenous of degree $1 - \sigma$ then

$$\Delta_{SR} = \left( \frac{V^L_t(x_0, e_1)}{V^H_t(x_0, e_1)} \right)^{\frac{1}{1-\sigma}}.$$
We plot in figure 4 the consumption equivalent for each household and in figure 5 the distribution of the consumption equivalent across the initial high inflation distribution of households.

Despite the disinflation raising output and consumption in the medium and long run, the gains are not spread equally across the distribution. It is apparent from Figure 4 that nominal borrowers bear a significant cost from the one time redistribution from the surprise disinflation. We can also see a jump in the welfare costs across all productivities near resource value 11.1, which marks the 75th percentile of the overall distribution of net worth. For middle and high earners, despite paying the capital tax, the long-run gains from the redistribution more than offset the short-run costs. Low earning but wealthy households would be worse off, but in practice they are relatively rare.

The conditional welfare gains are plotted across the state space without regard to the actual distribution of wealth. In Figure 5 we compute the simulated distribution of these welfare gains across the two economies. Although there is a sizable fraction of households that stand to benefit from the disinflation, the vast majority are worse off and some significantly worse off. In Table 4 we tally a simple vote. Who would vote for the Volcker disinflation? We see that more than 70 percent of the households, at least according to these preferences, would prefer to remain in the high inflation equilibrium than start a disinflation period. These voters are concentrated among the low and middle earners, specifically among the segment of those groups that are borrowers or have little net worth. We return to why these households prefer the high inflation equilibrium in Section 4.1.4. Next we step behind the Rawlsian veil of ignorance to evaluate which economy a household would prefer ex-ante.
Figure 5: Distribution of welfare gains in consumption equivalence units

Table 4: Preference for Disinflation Policy

<table>
<thead>
<tr>
<th></th>
<th>Percent that Prefer High Inflation</th>
<th>Percent Borrowers</th>
<th>Percent of Population</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Short Run</td>
<td>Long Run</td>
<td></td>
</tr>
<tr>
<td>Total Economy</td>
<td>71.2</td>
<td>11.1</td>
<td>15.98</td>
</tr>
<tr>
<td>Low Income</td>
<td>93.87</td>
<td>65.77</td>
<td>78.40</td>
</tr>
<tr>
<td>Middle Income</td>
<td>77.72</td>
<td>4.76</td>
<td>9.10</td>
</tr>
<tr>
<td>High Income</td>
<td>1.88</td>
<td>0.00</td>
<td>0.00</td>
</tr>
</tbody>
</table>
4.1.2 Short-Run Economy-wide Welfare Losses

To get an ex-ante economy-wide measure we find \( \Delta_{SR} \)

\[
\Delta_{SR}^{1-\sigma} \sum_{i=1}^{N_e} \int V_1^H (x_0, e_i) \psi^H (dx_0, e_i) \bar{p}_i = \sum_{i=1}^{N_e} \int V_1^L (x_0, e_i) \psi^H (dx_0, e_i) \bar{p}_i .
\]

The average welfare gains include both the overall increase in output and consumption, which are positive, but also the redistribution that is most costly for the poorest segment of the population. To separate the two effects we follow the decomposition of Domeij and Heathcote (2004). The idea is to isolate the aggregate effects by holding households shares of aggregate consumption fixed through the transition.

We define

\[
C_t^L = \sum_{i=1}^{N_e} \int c_t^L (x, e) \psi_t^L (dx, e) \bar{p}_i \quad \text{and} \quad M_t^L = \sum_{i=1}^{N_e} \int m_t^L (x, e) \psi_t^L (dx, e) \bar{p}_i
\]

as the aggregate (average) consumption and real balances in each period \( t \) in the transition. Then we define shares \( \theta (x, e) \) as the household \( i \)'s share of aggregate consumption in the high inflation environment. Finally, we define that aggregate component as the value of \( \Delta_{SR}^a \) that satisfies

\[
(\Delta_{SR}^a)^{1-\sigma} \sum_{i=1}^{N_e} \int V_1^H (x_0, e_i) \psi^H (dx_0, e_i) \bar{p}_i = \sum_{i=1}^{N_e} \int \left[ \sum_{k=0}^{\infty} \beta^k U \left( \theta \omega C_{t+k}^L, \theta M_{t+k}^L \right) \mid t = 1, e_i \right] \psi^H (dx_0, e_i) \bar{p}_i .
\]

This component reflects the change in overall welfare from changes in aggregate consumption. Other changes in overall welfare reflect an updating of each household’s share of aggregate consumption and we define

\[
\Delta_{SR}^R \equiv \frac{1 + \Delta_{SR}}{1 + \Delta_{SR}^a} - 1 .
\]

### Table 5: Aggregate Welfare Losses

<table>
<thead>
<tr>
<th>Percent Welfare Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Economy</td>
</tr>
<tr>
<td>Aggregate component</td>
</tr>
<tr>
<td>Redistribution component</td>
</tr>
</tbody>
</table>

In Table 5 we see that the overall welfare change is negative. This reflects the majority that prefer the high inflation as well as few that suffer large losses from the redistribution. We see that the aggregate component is positive reflecting the higher aggregate consumption and liquidity with lower inflation.
4.1.3 Long Run Measures

Although the majority would prefer to remain with high inflation, we ask whether they would choose differently if they could immediately reach the low inflation equilibrium. To do this we examine the same individuals in the simulated counterfactual and disinflation economies long after the disinflation equilibrium has reached its permanent state. We compute the same conditional and overall welfare measures across the same individuals in both economies. In Table 4 we report the same vote far into the future, and see that almost 90 percent of households now prefer the low inflation equilibrium. We note that our experiment does include the one-time initial redistribution, but many years have passed and households have sufficient time to readjust their savings. That most prefer the low inflation economy should not be surprising, given the lower liquidity in the high inflation economy. What may be surprising is the 11 percent of households that would still prefer to remain in the high inflation economy. We address this question next.

4.1.4 Interpreting the Welfare Losses

From the results in the previous sections it’s clear that redistribution from the surprise disinflation imposes substantial short run costs on the economy. The bulk of this effect is explained by the costs borne by the nominal borrowers. However, some of costs do not vanish even over the very long run. The reason is a reduction in transfers. Low seigniorage in the low inflation economy requires a reduction in transfers to maintain fiscal budget balance. These transfers provide additional insurance against being a low earner with little or negative net worth.

With an alternative means to keep budget balance some of these effects can be reversed. For example, if the government adjusts the money supply through open market operations, all seigniorage revenues are rebated to the treasury, which uses them to pay interest on the government debt. This policy is closer to the operation of the Federal Reserve in practice. In a steady state comparison, long run low inflation dominates long run high inflation for all of the distribution, as we would expect. We have not yet been able to successfully solve for the transition path between these steady states.

We should also remark that the model provides equal unsecured access to credit for all households. In practice some low income households are unbanked, conducting their expenditures almost exclusively in cash. These households would stand to benefit from the disinflation since it would permanently reduce the inflation tax on their consumption.

4.2 Sensitivity to our High Inflation Environment

[DESCRIBE RESPONSE IN CALIBRATED VERSION WITH $\eta = 1$ WHERE $\beta$ AND $\omega$ ARE ADJUSTED TO MATCH $K/Y$ AND $M/Y$]
5 Conclusion

[TO BE COMPLETED]

References


A Data Appendix

A.1 Categorization of Assets and Liabilities

Nominal Assets

- Liquid Assets
  - Cash in checking accounts
  - Cash in savings or share accounts
  - Money market and call accounts
  - IRA or Keogh accounts
  - Certificates of Deposit
  - US Savings Bonds

- Financial Assets
  - Total face amount of bonds
  - Loans owed to household and gas leases
  - Aggregate gross value of land contracts and notes
  - Total thrift type pension account assets

Real Assets

- Durables
  - Home
  - Other properties
  - Vehicles

- Financial Assets
  - Total dollar amount in stocks and mutual funds
  - Total dollar amount in trust accounts

- Business
  - Net value of business with management interests
  - Total value of business with management interests plus dollar amount owed to business minus dollar amount owed to business by household

Nominal Liabilities

- Real Estate Debt
  - Home mortgage
  - Aggregate amount owed against land contract notes
  - Aggregate amount outstanding on other property mortgages

- Consumer Debt
  - Amount outstanding on loans other than mortgages. Also subtracts loans against life insurance policies
  - Total credit card debt
  - Amount owed on lines of credit

B Numerical Solution

[TO BE SUMMARIZED FROM MODEL SOLUTION NOTES]