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The welfare effects of inflation: a cost-benefit perspective

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Abstract:

This paper reviews theory and evidence of the welfare effects of inflation from a cost-benefit perspective. Basic models and selected empirical results are discussed. Historically, in assessing the welfare effects of inflation, the distortion of money demand played a prominent role. More recently, interactions of inflation and taxation came into focus. Growth effects of inflation as well as welfare effects of unanticipated inflation and of inflation uncertainty are also addressed. To assess the policy question whether inflation should be reduced or eliminated, the costs of disinflation play a role. Finally, the trade-off between the benefits of reducing inflation and the costs of disinflation is discussed and an overall assessment of the net welfare effects of achieving price stability is provided.

Keywords: Inflation, price stability, welfare costs and benefits, distortions, money demand, consumption allocation, tax-inflation interaction, disinflation, sacrifice ratio.

JEL-Classification: D61, E31, E41, E21, H21

Non technical summary

Inflation creates and amplifies distortions in many areas of economic activity and influences virtually all decisions of economic agents. This paper provides a theoretical and empirical overview of the welfare effects of inflation from a cost-benefit perspective. Cost-benefit analysis is a technique of applied welfare analysis which is widely used to judge the social desirability of an economic project or a policy change.

Understanding the welfare effects of achieving and keeping low inflation requires a combination of the traditional subjects of macroeconomics and public finance. Economic research has uncovered a number of channels through which inflation affects output and welfare. Historically, in assessing the welfare effects of inflation, the distortion of money demand played a prominent role. More recently, interactions of inflation and taxation came into focus.

In this paper basic models and selected empirical results of the welfare effects of inflation are discussed. Inflation induced distortions of money demand and tax-inflation distortions of intertemporal saving and consumption allocation are reviewed, followed by brief discussions of the effects of inflation on growth, the welfare effects of unanticipated inflation and of inflation uncertainty. To assess the policy question whether inflation should be reduced or eliminated, the costs of disinflation play a role. Finally, the trade-off between the benefits of reducing inflation and the costs of disinflation is discussed. In the concluding overall assessment of the net welfare effects of achieving price stability the benefits of price stability appear to be large and permanent while the costs of disinflation are small in comparison and temporary. In combination with certain behavioral patterns (saving rates) and institutional facts (tax rules), even low inflation can generate high welfare losses.

Nicht technische Zusammenfassung

Inflation verursacht und verstärkt Verzerrungen in vielen Bereichen ökonomischer Aktivitäten und beeinflusst nahezu sämtliche Entscheidungen der Wirtschaftssubjekte. Dieses Papier gibt einen Überblick über Theorie und Empirie der Wohlfahrtskosten von Inflation aus der Perspektive der Nutzen–Kosten–Analyse. Dabei handelt es sich um eine Technik der angewandten Wohlfahrtsanalyse, die weithin eingesetzt wird, um die sozialen Folgen von Projekten oder wirtschaftspolitischen Maßnahmen zu beurteilen.

Um die Wohlfahrtseffekte der Erzielung und Bewahrung niedriger Inflation zu verstehen, ist eine Kombination der beiden traditionellen Gebiete Makroökonomie und öffentliche Finanzen notwendig. Die Wirtschaftsforschung hat eine Reihe von Kanälen aufgedeckt, durch welche Inflation die gesamtwirtschaftliche Produktion und den Wohlstand beeinflusst. Bei der Analyse der Wohlfahrtseffekte der Inflation spielte historisch die Geldnachfrage eine herausragende Rolle. In jüngerer Zeit sind die Interaktionen von Inflation und Besteuerung stärker in den Vordergrund gerückt.

In diesem Papier werden grundlegende Modelle und ausgewählte empirische Ergebnisse der Wohlfahrtseffekte von Inflation diskutiert. Die inflationsinduzierten Verzerrungen der Geldnachfrage und die Verzerrungen bei der intertemporalen Allokation von Konsum und Ersparnissen aufgrund von Interaktionen zwischen Inflation und Steuersystem werden untersucht, gefolgt von einer kurzen Diskussion der Einflüsse von Inflation auf das reale Wachstum, der Wohlfahrtseffekte nicht antizipierter Inflation und von Inflationsunsicherheit. Bei der Beurteilung der wirtschaftspolitischen Frage, ob Inflation reduziert oder eliminiert werden sollte, spielen die Disinflationskosten eine Rolle. Schließlich wird der trade-off zwischen dem Nutzen einer Reduktion der Inflationsrate und den Kosten der Disinflation diskutiert. In der abschließenden Beurteilung der Netto - Wohlfahrtseffekte von Preisstabilität wird der Nutzen von Preisstabilität als groß und dauerhaft bewertet, während die Kosten der Disinflation vergleichsweise klein und vorübergehend sind. Im Zusammenwirken mit bestimmten Verhaltensmustern (Sparquote) und institutionellen Regeln (Steuerrecht) kann sogar niedrige Inflation hohe Wohlfahrtseinbußen zur Folge haben.

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The Welfare Effects of Inflation: A Cost-Benefit Perspective[*)]

„If there is anything in the world which ought to be stable it is money, the measure of everything which enters the channels of trade. What confusion would there not be in a state where weights and measures frequently changed? On what basis and with what assurance would one person deal with another, and which nations would come to deal with people who lived in such disorder?"
(Francois LeBlanc 1690)

1. Introduction

This paper provides a theoretical and empirical overview of the welfare effects of inflation from a cost-benefit perspective. Cost-benefit analysis is a technique of applied welfare analysis which is widely used to judge the social desirability of an economic project or a policy change.[1]

In a modern society, inflation creates or amplifies distortions in many areas of economic activity and influences virtually all decisions of economic agents. Inflation has a similar effect on the value of money and savings as the sun on a cube of ice, it simply melts it away. Moving the ice cube into the shadow, like moderate and even low inflation, just slows the melting process. In contrast, price stability – potentially – freezes the value of money indefinitely.[2]

People decidedly dislike inflation (Shiller 1997, 14), but *"… opinions differ across countries, between generations in both the US and Germany, and, even more strikingly, between the general public and economists."* For long time there have been conflicting views among economists concerning the costs and benefits of inflation (Dowd 1994, 305). While many economists agreed that inflation is undesirable – without having a clear idea how bad it is - others argued that eliminating inflation would impair output and employment. Still others said that

[*)] The views expressed in this paper do not necessarily reflect those of the Deutsche Bundesbank. For helpful comments we thank Ch. Gerberding, H. Herrmann and K. Wendorff. Of course, all remaining errors are ours.

[1] See Chakravarty (1986, 687) on cost-benefit and Feldman (1986, 889) on welfare analysis.

inflation could be dealt with by other means, e.g. indexing the tax code (Aiyagari 1991). Today, price stability is widely accepted as the overriding objective of monetary policy, with a view to keep inflation low and stable and to avoid deflation (Wood 2005, 1; Weber 2007). However, despite this broad consensus and concerted action, Romer and Romer (1997, 1) remark, that *"… the economic rationale and policy implications of low inflation are only partly understood."*

Understanding the welfare gains of reducing inflation requires a combination of the traditional subjects of macroeconomics and public finance. Economic research has uncovered a number of channels through which inflation affects output and welfare. In assessing the welfare implications of inflation, starting with Bailey (1956), the distortions to money demand played a prominent role. Later, Darby (1975) and Feldstein (1976) focused attention to distortions created by interactions of inflation and taxation.

In this paper, we embark on a journey through theory and evidence of the welfare effects of reducing inflation. We stop at some important places, but we will also miss a lot of interesting vistas. We concentrate on simple, stripped down, models and selected empirical results.[3] Partial as well as general equilibrium approaches are discussed. As regards empirical evidence, Feldstein (1999a) is stressed for two reasons: The Feldstein report covers a wider range of inflation cost channels than most other studies and it provides comparable evidence for four large OECD countries, based on a common analytical framework.

The benefits of reducing inflation are discussed in Section 2. Inflation induced distortions of money demand and tax-inflation distortions of intertemporal saving and consumption allocation are reviewed, followed by brief discussions of the effects of inflation on growth, the welfare effects of unanticipated inflation and of inflation uncertainty. Section 3 addresses the costs of disinflation. The sacrifice ratio is analyzed within a New Keynesian model and some empirical evidence is presented.

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[2] Notwithstanding the difficulties to measure inflation or the "true" cost of living; see Boskin et al. (1996), Gordon (2006).
[3] Surveys are provided by Driffill et al. (1990), Dowd (1994), Briault (1995), Lucas (2000), Palenzuela et al. (2003). Advanced textbook treatments can be found in Blanchard and Fischer (1989), McCallum (1989), Walsh (2003), Heijdra and van der Ploeg (2002), among others.

Finally, the trade-off between the benefits of reducing inflation and the costs of disinflation is discussed. Section 4 concludes.

2. Benefits of reducing inflation

The benefits of reducing inflation or – expressed differently – the costs of inflation depend on two major factors: the institutional structure of an economy and the extent to which inflation is fully anticipated or not. Fischer and Modigliani (1978, 812) present a *"long and surprisingly pervasive"* list of the real effects of inflation. They divide the costs of inflation into six categories, those that would

- (1) persist in a fully indexed economy, those due to
- (2) nominal government institutions,
- (3) nominal private institutions and habits,
- (4) unanticipated inflation through existing nominal contracts,
- (5) uncertainty of future inflation, and
- (6) government attempts to suppress symptoms of inflation.

(1) Even in an economy that has fully adapted to inflation,[4] there are inflation costs because money holdings pay no interest and menu costs rise because firms have to change price lists more frequently. (2) Nominal government institutions create inflation costs because the tax system was largely designed for non-inflationary times. Asset holders are taxed on nominal interest income which can have dramatic negative effects on the after-tax real return. Inflation also tends to increase the cost of capital. Moreover, progressive tax brackets and nominal accounting methods accentuate these effects. (3) The private sector continues to rely on nominal institutions and practices such as nominal mortgage repayment contracts in the face of ongoing inflation (frontloading effect). Nominal accounting methods reflect a type of money illusion that results from the convenience to use money as a unit of account. (4) If contracts for goods or services are fixed in money terms or otherwise sticky, unanticipated inflation leads to arbitrary redistributions between buyers and sellers and nominal debt contracts lead to redistributions between debtors and creditors. (5) Inflation uncertainty creates or increases the reluctance to make future

[4] Fischer and Modigliani (1978, 810) describe the indexed economy as follows: Public and private institutions are fully inflation proof, current and future inflation is fully reflected in contracts inherited from the past, and future inflation is fully reflected in contracts for the future.

commitments and leads to a shortening of nominal contracts, thereby increasing transaction costs. The final point (6) becomes relevant in times of high inflation, as public annoyance over inflation may lead to costly wage and price controls and concern over fiscal losses through bankruptcies and instability of the financial system may trigger control of interest rates and intervention in bond and equity markets.

2.1. Distortion of money demand

Economic theory has had difficulties to establish the welfare costs of inflation firmly. For a long time the Classical dictum of monetary neutrality (*'money is a veil'*) hampered a profound analysis.[5] Economic theory suggests (McCallum 1989, 124) that the *„… pace of a steady, anticipated inflation has little effect on the values of most real variables including per capita income, consumption, and the real rate of interest."* We may then ask, whether the rate of inflation is of any consequence at all in terms of the welfare of the individuals of a society. If economic agents care only about real magnitudes, why should inflation be a problem, provided it is steady and anticipated?

Even in a fully indexed economy there is one real variable that is not invariant to inflation: real money balances. Since money earns no interest, the nominal interest rate is the opportunity cost of holding it. Thus, inflation raises interest rates and renders holding money more costly. More time and energy is required for trips to the bank and shopping activities, giving rise to the proverbial *"shoe leather costs"* of inflation. Since individuals are induced to hold less real money balances than in times of price stability, their attainable utility level is lowered. Moreover, inflation either induces firms to change their prices more often, increasing their "*menu costs,*" or causes variability in relative prices, leading to misallocation and microeconomic inefficiency. In addition, in order to accommodate the increased number of currency transactions by households, more economic resources are allocated to the financial sector and diverted away from potentially more productive uses (*over-development of the financial system*).[6]

[5] Money is said to be neutral if changes in the level of money supply have no effect on real variables in equilibrium. Money is superneutral if changes in the growth rate of money supply have no real effects in equilibrium (Blanchard and Fischer 1989, 207).
[6] English (1999) provides an empirical estimate of this effect for the U.S.

Quantitative analysis of the welfare cost of inflation was started by Bailey (1956). In his classic article he treats the welfare cost of inflation analogous to an excise tax on a commodity or productive service and measures its quantitative importance by an appropriate area underneath a money demand function. Assuming fully anticipated and stable inflation, the following discussion focuses on two central questions (Walsh 2003, 59): How large is the welfare cost of inflation and what is the optimal inflation rate?

2.1.1. A partial equilibrium framework

Money demand: To review Bailey's approach, it is convenient to start with a simple money demand function:[7]

(1) $$\frac{M}{P} = k(i)Y\ , \qquad \frac{\partial k}{\partial i} \equiv k_i < 0$$

Real money demand (M/P) is proportional to real income (Y). The cash ratio (k = M/PY), that is the ratio of money demand to GDP, is decreasing in the nominal interest rate. The nominal (i) and the real (r) interest rate are related through the Fisher equation[8]

(2) $$i = (1+r)(1+\pi) - 1 = r + \pi(1+r)$$

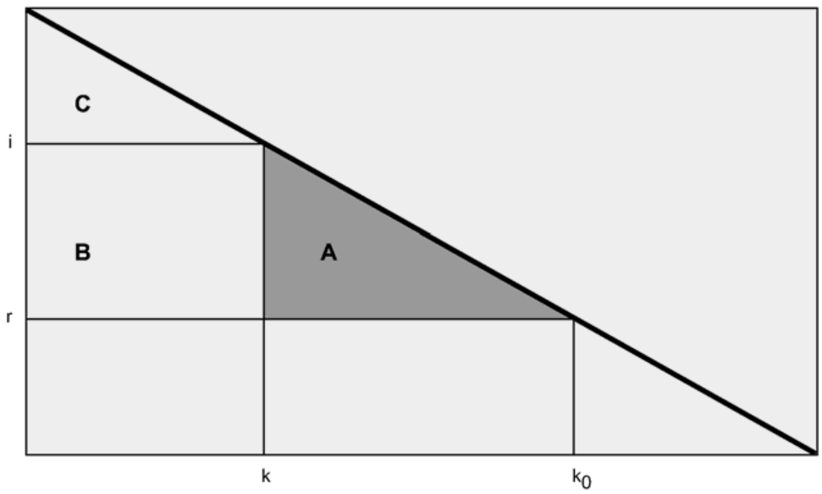
where π denotes the rate of inflation. Under price stability (π = 0) money demand becomes $k(r) \equiv k_0$. The absolute interest rate elasticity (η) and semi-elasticity (ξ) are:

(3) $$\eta(i) = -\frac{\partial M}{\partial i}\frac{i}{M} = -\frac{\partial k}{\partial i}\frac{i}{k}\ , \qquad \xi(i) = \frac{\eta(i)}{i}$$

[7] Theoretical and empirical approaches to money demand are discussed by, e.g., Serletis (2007).
[8] The Fisher equation (2) will be used throughout, rather than the approximation $i \approx r + \pi$.

The welfare triangle: Whenever market prices are distorted by taxes, monopolistic practices, or other forms of inefficiency, Harberger triangles appear (Harberger 1954).[9] Figure 1 depicts money demand (expressed as cash ratio) as a function of the interest rate. Consumer surplus (CS), as a ratio to income (PY), corresponds to the area A+B+C. Inflation reduces CS to the area C and inflation tax revenue (TR) is raised (area B). A deadweight loss (DWL) or excess burden of inflation (area A) is created, which is the loss of CS not compensated by TR.

Figure 1: Money demand



The Harberger welfare triangle is a linear approximation of the DWL:

(4) $$A = \frac{(i-r)}{2}\left[k_0 - k(i)\right].$$

A Taylor expansion of k(i) at $\pi = 0$,

(4') $$A = \frac{(i-r)^2}{2}\frac{\eta k(i)}{i}$$

shows that the elasticity of money demand (η or ξ) is key to DWL measurement. If money demand is nonlinear, the integral

[9] Hines (2002) traces the concept of welfare triangles back to Jules Dupuit in 1844.

(5) $$A = \int_r^i k(x)dx \quad - B$$

can be used to calculate the DWL more accurately.[10] The TR of the inflation tax is

(6) $$B = \pi(1+r)k(i)$$

Since lump-sum taxes leave no room for evasion, they are welfare neutral and create no DWL. Thus, the ratio of DWL to TR is a measure of the (average) inefficiency of the inflation tax:

(7) $$\lambda_{inf} = \frac{A}{B}$$

Table 1 summarizes the welfare accounting.

Table 1: Welfare accounting I

Scenario	CS	TR	DWL
No inflation	A+B+C	0	0
Inflation	C	B	A

Indirect welfare effects: Phelps (1973) pointed out that the Harberger triangle overstates inflation cost if there is no lump-sum tax available. Collecting the inflation tax (6) enables the government to reduce other taxes, which creates indirect welfare gains.[11] Accepting that logic, the overall welfare loss of inflation can be defined as

(8) $$W = A - \lambda B, \qquad \lambda \geq 0$$

[10] Here, the DWL of inflation is calculated as the area between r and i. Several authors, in particular those applying general equilibrium models, calculate the DWL between zero and i; see Tower (1971) and Gillman (1995).

[11] Generally, taxes create distortions due to substitution effects. For example, the substitution effect of wage taxes reduces labor supply and in a similar way capital income taxes have negative effects on investment.

where λ denotes the inefficiency of the tax system. Since (8) can be written as $W = (\lambda_{inf} - \lambda)B$, inflation is costly if $\lambda_{inf} > \lambda$.

Illustration: Consider the linear money demand function,

(9) $$k(i) = \gamma - \delta i, \quad \gamma > \delta i, \quad \eta = \delta i / k$$

where γ is the satiation level which applies at zero interest. From (9) both, the Harberger triangle (4) and integration (5), yield:

(10) $$A = \pi^2 \frac{\delta(1+r)^2}{2}$$

Inflation cost is small at low inflation rates but increases rapidly. Setting (r = 0.04, γ = 0.3, δ = 2) implies a cash ratio of 14% of GDP at 4% inflation, which is close to the average ratio of M1 to GDP in the U.S. between 1991 and 2006. Table 2 suggests that the direct welfare cost of 1 or 2 percent inflation is less than 0.1% of GDP. At 10% inflation it reaches 1% of GDP, even net of indirect revenue effects.

Table 2: Inflation cost for linear money demand (% of GDP)

Inflation (%)	1	2	3	4	5	10
Direct welfare effect (A)	**0.01**	**0.04**	**0.10**	**0.17**	**0.27**	**1.08**
Indirect revenue effect ($-\lambda B$)	-0.06	-0.11	-0.15	-0.17	-0.18	-0.04
Overall welfare effect (W)	**-0.05**	**-0.07**	**-0.05**	**0.00**	**0.09**	**1.04**
Inflation tax inefficiency (λ_{inf})	*0.05*	*0.12*	*0.20*	*0.30*	*0.45*	*8.67*

r = 0.04, γ = 0.3, δ = 2, λ = 0.3

2.1.2. A general equilibrium framework

More recently, neoclassical general equilibrium models have been applied to quantify inflation cost. In these models of a non-monetary economy there is no money as a medium of transactions and money as a store of wealth is dominated by interest bearing assets.[12] To use this framework, a role must be assigned to money. Three main approaches have been followed in the literature (Walsh 2003, 43): (1) impose transactions or illiquidity costs of some form that create a demand for money,[13] (2) put money directly into the utility function (MIU or Sidrauski approach)[14] or (3) assume that money is used to transfer wealth intertemporally in an overlapping generations (OLG) model.[15]

<u>A Sidrauski model</u>: Following Lucas (2000), consider a simple version of a MIU type model. The representative household faces the budget constraint: $P_t Y_t + M_t = P_t C_t + H_t + M_{t+1}$. Nominal income ($P_tY_t$) and the stock of money (M_t) are used to finance consumption (P_tC_t), to pay or receive lump sum taxes (H_t), and to transfer money to the next period (M_{t+1}). The household solves the dynamic optimization problem

$$\text{(11)} \qquad \begin{aligned} &\text{Max } \textstyle\sum_{t=0}^{\infty} \beta^t U(C_t, M_t / P_t) \\ &\text{s.t.} \quad Y_t + M_t / P_t = C_t + H_t / P_t + (M_{t+1} / P_{t+1})(1 + \pi_{t+1}) \end{aligned}$$

where U denotes utility, ß $(0 < \beta < 1)$ is the discount factor and $\pi_t = P_t / P_{t-1} - 1$ inflation. The budget constraint in (11) is re-written in real terms. The first order conditions (f.o.c.) imply that the marginal rate of substitution between money and consumption equals the opportunity cost of holding money (i), neglecting time subscripts[16]

$$\text{(12)} \qquad \frac{U_m(C, M/P)}{U_c(C, M/P)} = i$$

where i is given in (2) and r is the real return on capital. With logarithmic utility

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[12] For more on this so called *"Hahn problem"; s*ee Hahn (1965), Bewley (1983), Walsh (2003, ch. 2), Heijdra and van der Ploeg (2002, ch. 12).

[13] See Clower (1967), McCallum (1983, 1989), Kyotaki and Wright (1989), Dotsey and Ireland (1996).

[14] See Patinkin (1965), Sidrauski (1967). Feenstra (1986) demonstrates that there is a functional equivalence between models with money in the utility function and models with liquidity costs which show up in the budget constraint. Fischer (1974) puts money into the production function.

[15] See Samuelson (1958), Wallace (1980).

[16] Walsh (2003, 91) shows that depending on „timing" assumptions in the utility function and in the budget constraint, condition (12) may also appear as $U_m/U_c = i/(1+i)$.

(13) $$U(C, M/P) = \ln(C) + \alpha \ln(M/P)$$

(12) becomes $\alpha PC/M = i$. In equilibrium (C = Y) the following relationship between real money and real income holds

(12') $$\frac{M}{P} = \frac{\alpha Y}{i}$$

or, equivalently, k(i) = α/i. To measure the welfare cost of inflation, Lucas (2000) employs the "*compensating variation*" approach. He calculates the percentage income compensation (ω) needed to leave the household indifferent by solving the condition:

(14) $$U\left[Y_0, \frac{\alpha Y_0}{r}\right] = U\left[(1+\omega)Y_0, \frac{\alpha(1+\omega)Y_0}{i}\right]$$

Conceptual, ω corresponds to the area A+B in Figure 1. Correcting the private welfare loss for changes in tax revenues (B) yields (15.1). Integration (5) and the Harberger triangle (4) yield (15.2) and (15.3):

(15.1) $$A_{Comp} = \left(\frac{i}{r}\right)^{\frac{\alpha}{1+\alpha}} - 1 - \alpha(1+r)\frac{\pi}{i}$$

(15.2) $$A_{Int} = \alpha \ln(\frac{i}{r}) - \alpha(1+r)\frac{\pi}{i}$$

(15.3) $$A_{Harb} = \pi^2 \frac{(1+r)^2 \alpha}{2ri}$$

Table 3: Deadweight loss of inflation in partial and general equilibrium (% of GDP)

Inflation (%)	1	2	3	4	5	10
Compensation	0.03	0.08	0.15	0.22	0.29	0.62
Integration	0.03	0.09	0.16	0.23	0.30	0.63
Harberger triangle	0.03	0.10	0.19	0.30	0.41	1.05

r = 0.04; To be broadly consistent with the linear money demand function (9) used in Table 2, the parameter α is calibrated such that $\gamma - \delta i = \alpha / i$ holds at i = r + 0.03, giving α = 0.0112.

Table 3 shows that for inflation rates up to 10 percent, (15.1) and (15.2) yield almost identical results, while the Harberger triangle increasingly overstates inflation costs.

2.1.3. What is the optimal rate of inflation?

Zero inflation: Money is the yardstick with which economic transactions are measured. Inflation changes that yardstick and undermines all three roles of money, as a unit of account, as a means of transactions, and as a store of value. The rationale of zero inflation was nicely expressed by LeBlanc (1690) more than 300 years ago, cited at the beginning. In particular, money is most useful as a *unit of account* if people think and calculate in nominal rather than in real terms (Akerlof 2007, 30). Moreover, price stability improves the transparency of the price mechanism. People can recognize changes in relative prices without being confused by changes in the overall price level. Such considerations (Konieczny 1994) suggest that the optimal inflation rate is zero:

(16.1) $\pi^* = 0$.

Friedman rule: Money demand reflects the marginal utility of economic agents from cash holding (Tower 1971, 850). Money can be printed (almost) costless but individuals incur positive costs of holding money balances.[17] Thus, inflation induces them to hold less cash than would be socially optimal. Friedman (1969, 34) stated the famous rule: *„Our final rule for the optimum quantity of money is that it will be attained by a rate of price deflation that makes the nominal rate of interest equal to zero."* This implies[18]

(16.2) $\pi^* = -r$

Seigniorage maximization: Seigniorage (s) is the government revenue from its monopoly to print money. A frequently used definition, expressed as a fraction of

[17] Lacker (1996) reports manufacturing and operating costs of coins and currency of approximately 0.2 percent of face value.
[18] See Chari et al. (1996) and Correia and Teles (1999) on the optimality of the Friedman rule when there are distortionary taxes.

GDP, is: $s = i\, M/PY = i\, k(i)$.[19] Lower private money stocks (M) induce the government to issue more interest bearing bonds. Seigniorage is maximized if condition $\partial s/\partial i = k + i\partial k/\partial i = 0$ holds, which can be expressed as $\eta(i) = 1$. Linear money demand (9) gives:

(16.3) $$\pi^* = \left(\frac{\gamma}{2\delta} - r\right)\frac{1}{1+r}$$

<u>Welfare loss minimization</u>: Viewing the overall welfare loss in (8) as function of the inflation rate, and assuming that λ is a constant, loss minimization yields the f.o.c.

(17) $$A_\pi(\pi) - \lambda B_\pi(\pi) = 0$$

Hence, at the optimum the (marginal) inefficiency of the inflation tax (A_π / B_π) equals that of the alternative tax (λ) (Marty 1976). Money demand (9) implies optimal inflation:

(16.4) $$\pi^* = \frac{\lambda}{1+2\lambda}\left[\frac{\gamma}{\delta} - r\right]\frac{1}{1+r}$$

Unless λ = 0, positive inflation is optimal. As Table 4 illustrates, there is no unique optimal rate of inflation. Moreover, it should be noted that only the money demand channel of inflation cost is taken into account so far.

Table 4: Optimal inflation (%)

	Friedman rule	Zero inflation	Loss minimization	Seigniorage maximization
Optimal inflation	- 4	0	2.0	3.4

Money demand (9) with γ= 0.30, δ = 2, r = 0.04, λ = 0.3.

[19] The concept used here differs from the seigniorage of money creation, defined as $\sigma = \Delta M/PY = \mu\, k$, where μ is the growth rate of money supply. For $\mu = g + \pi$, where g is the growth of real output, , $s = \sigma + (r - g)k$. Thus, both concepts coincide at r = g. Empirically, seigniorage in industrial countries is about 0.5 percent of GDP.

2.1.4. Empirical evidence

Recently, Lucas (2000) reviewed the state of knowledge in the line of research started by Bailey (1956). He considered two alternative money demand specifications: a double-log version originated by Meltzer (1963) with constant elasticity η and a semi-log version originated by Cagan (1956) with constant semi-elasticity ξ:

(18.1) $$k(i) = A i^{-\eta}.$$

(18.2) $$k(i) = Be^{-\xi i}.$$

If the interest rate approaches zero, money demand in (18.1) rises without bound, whereas it converges to a fixed satiation level (B) in (18.2). Thus, at low interest rates, both functions behave very differently. Integration (5) yields inflation cost:

(19.1) $$A_{LogLog} = \frac{\eta}{1-\eta} A i^{1-\eta}\left[1 + \frac{1-\eta}{\eta}\frac{r}{i} - \frac{1}{\eta}\left(\frac{r}{i}\right)^{1-\eta}\right]$$

(19.2) $$A_{SemiLog} = \frac{B}{\xi}\left[e^{-\xi r} - (1+\xi(i-r))e^{-\xi i}\right]$$

Based on US data for 1900 – 1994, Lucas (2000) estimated: η = 0.5, ξ = 7. Serletis and Yavari (2004) as well as Ireland (2007) updated Lucas' data up to 2001 and 2006 respectively. Cointegration tests led Ireland to prefer the semi-log form (ξ = 1.79) while Serletis and Yavari chose a log-log function (η = 0.21).

Table 5: Inflation cost with log-log and semi-log money demand (as % of GDP)

Inflation (%)	1	2	3	4	5	10
Lucas, Log-Log (1)	0.01	0.04	0.08	0.13	0.18	0.42
Lucas, Semi-Log (2)	0.01	0.04	0.08	0.13	0.20	0.63
Serletis & Yavari, Log-Log (3)	0.01	0.02	0.04	0.06	0.08	0.22
Ireland, Semi-Log (4)	0.00	0.01	0.01	0.02	0.04	0.14

Source: Lucas (2000), Ireland (2007), Serletis and Yavari (2004), and own calculations.
r = 0.04, (1) A = 0.05, η = 0.5; (2) B = 0.35, ξ = 7, (3) A = [0.12], η = 0.21; (4), B = 0.17, ξ = 1.79

As Table 5 confirms, the interest rate elasticity is very important in determining inflation cost. Thus, Gillman (1995, 60) rightly noted: "*…trustworthy welfare cost estimates require trustworthy money demand functions.*" Unfortunately, empirical estimates of money demand elasticities are uncertain. Knell and Stix (2005) report a wide range of estimates. The median estimate for U.S. narrow money (η = 0.26) suggests that inflation–caused distortions of money demand are small.

Checking robustness, Lucas generalized the Sidrauski MIU model (11) by including the labor–leisure choice and a proportional income tax, similar to Chari et al. (1996). Apart from very low interest rates, similar inflation costs are obtained. Moreover, Lucas applied a version of the transaction cost model developed by McCallum and Goodfriend (1987, 263). In this model, the use of cash is motivated by an explicit transactions technology, rather than by the MIU approach. Again, only small differences in the estimated inflation costs result.

Search-theoretic models: Monetary macromodels typically assign some role for money that is not made explicit, such as putting money in the utility function or imposing cash-in-advance constraints. Search-theoretic models of monetary exchange explicitly model the frictions that render money essential. Lagos and Wright (2005) developed a model, refined by Craig and Rocheteau (2007), that allows agents to interact periodically in centralized and decentralized markets. Under competitive pricing (sellers receive no economic profit), this model comes up with welfare costs of 10% inflation of about 1% of GDP, which is only slightly higher than in most previous studies. However, if sellers have market power such that the gains from trade are divided between buyers and sellers, the welfare cost of 10% inflation can be as high as 5% of GDP, depending on the trading frictions assumed, which lead Craig and Rocheteau (2005) to conclude: "*Overall, the search approach of monetary exchange seems to suggest that inflation may be significantly more costly than previously thought.*" Chiu and Molico (2007) also present a search-theoretic model along the lines of Lagos and Wright (2005) in which the welfare cost of increasing inflation from zero to 10% is only 0.62 (0.20)% of income for the U.S. (Canada).

Hyperinflation: In extreme cases of hyperinflations the welfare losses of inflation can be dramatic (Bernholz 2003). Under such conditions people stop using money and return to inefficient barter transactions. Evaluating evidence from seven historical hyperinflations in Europe between 1920 and 1946, Bailey (1956, 110) found that the welfare cost was about a third of income, the largest reaching half of income.

Moderate Inflation: Gillman (1995) reports partial equilibrium evidence of the welfare gains of reducing inflation from 10% to zero in the range from 0.22% (Eckstein and Leiderman 1992) to 0.45% of GDP (Lucas 1981) with Fischer's (1981) estimate of 0.3% in between. Wolman (1997), using a transactions-time approach to money demand, estimated the welfare gain from reducing inflation from 5% to zero at 0.6% of output, the additional benefit achieved by optimal deflation being small. More recently, Attanasio et al. (2002) arrive at estimates less than 0.1% of GDP.

General equilibrium models, summarized by Gillman (1995), have been employed more recently to estimate inflation costs through the money demand channel. Making use of a cash-in-advance constraint, Cooley and Hansen (1989) were among the first to try to evaluate the costs of inflation in such a framework. They found that an inflation rate of 10% (relative to an optimal inflation rate of -4% in their model) resulted in a welfare cost of 0.4% of income. This result is, however, rather sensitive to the assumption on the relevant period over which individuals are constrained (which is closely related to the definition of money).

The general equilibrium model of Dotsey and Ireland (1996) features an explicit transactions technology that produces a money demand function similar to those estimated for the U.S. economy. In this model inflation induces agents to inefficiently substitute market activity for leisure and to devote productive time to economize their cash holdings. Solving the model with exogenous growth yields welfare losses of 10% inflation of 0.20 (0.92)% of output if money is measured as currency (M1).

Zee (2000) estimates the welfare effects of lowering inflation from 4% to 2% in an OLG model with money as a factor of production. Modifying the Fisher equation so that the after-tax real interest rate is held constant, the welfare gain he calculates is rather modest, amounting to less than 0.2% of GDP annually.

Low inflation: Table 6 reports results for the welfare effect of permanently reducing inflation from 2% to zero through the money demand channel in four countries, recently published by Feldstein (1999a). As Table 6 shows, the benefits of reducing money demand distortions are small. If indirect tax effects are taken into account, the overall welfare effect of eliminating 2% inflation becomes negative.

Table 6: Money demand

Welfare effect of reducing inflation from 2 percent to zero as % of GDP

	U.S.	Germany	U.K.	Spain
Direct welfare effect	0.02	0.03	0.02	0.04
Indirect revenue effect	-0.05	-0.06	-0.05	-0.10
Overall welfare effect	-0.03	-0.04	-0.02	-0.07

Source: Feldstein (1999a)

Summing up, empirical evidence from partial and general equilibrium approaches suggests that the welfare effects of low inflation through the money demand channel are relatively small, net of revenue changes even negative. Thus, in view of the high degree of inflation aversion among the population (Shiller 1997; Di Tella et al. 2001), there must be other and possibly more powerful channels through which low inflation causes welfare losses, as will be explored in the next subsection.

2.2. Distortion of savings and consumption allocation

Tax laws in most countries are written for an economy without inflation. The interaction of inflation with existing tax rules (and social security systems) is complex and exerts powerful effects on the economy. Inflation affects decisions of households about savings and of firms about investment.[20] Tax-inflation distortions arise in many areas of economic activity, e.g. in the taxation of wages, profits, interest incomes, and capital gains. One of the most important channels through which inflation affects real economic activity is a nominal-based capital-income tax structure. In particular, taxation of nominal capital income directs savings away from fixed non-residential investment and causes increases in the effective tax rates. On the other hand, in many countries nominal interest expenses for residential investment can be deducted. This encourages the expansion of consumer debt and stimulates the

[20] See Darby (1975), Feldstein (1976), Feldstein et al. (1978), Auerbach (1981), Gordon (1984).

demand for owner-occupied housing. The likely result is a reduction of productive capital formation (Feldstein 1983, 1).

2.2.1. A general equilibrium framework

Money as the only store of value: In a basic OLG model,[21] individuals live for two periods (generations). They derive utility (U) from consumption in their youth ($C_{young} \equiv C_y$) and from consumption in retirement, when old ($C_{old} \equiv C$). Young individuals receive labor income (Y), consume (C_y) and save for retirement ($S = Y - C_y$). Since for now it is assumed that money is the sole store of value, financing retirement consumption creates money demand (M = S). The representative agent solves:

(20.1) $\text{Max } U = U(C_y, C)$

(20.2) $\text{s.t. } C_y + M = Y$

(20.3) $C = M / P$

Both constraints combine to the intertemporal restriction $C_y + PC = Y$, where P is the price of retirement consumption, which is normalized to 1 in the first period. The following intertemporal relationship holds between savings of the young generation (S) and their retirement consumption (C):

(21) $C = S / P$

With annual inflation π and generation length of T years, the price level in the second period is $P = (1 + \pi)^T$. From the f.o.c. one sees that in the optimum the ratio of marginal utilities is equal to the (relative) price of retirement consumption ($U_C / U_{C_y} = P$). With a logarithmic utility function

(22) $U = \ln(C_y) + \alpha \ln(C)$

where α measures the preference for retirement consumption, the following solution is obtained:

(23.1) $$C_y = \frac{1}{1+\alpha} Y$$

(23.2) $$C = \frac{M}{P} = \frac{\alpha}{1+\alpha} \frac{Y}{P}$$

The Harberger triangle (4) underneath the demand curve for retirement consumption (area A) measures the DWL of inflation (as a ratio to income Y):

(24) $$A = \frac{1}{2}(P - P_0)\left[C(P_0) - C(P)\right] = \frac{\alpha}{1+\alpha} \frac{(P - P_0)^2}{2P_0P}$$

where $P_0 = 1$ is the price for retirement consumption under price stability. The DWL of inflation implied by (24) is large because inflation erodes total savings. Assuming (π = 2% p.a., T = 30 years) yields P = 1.81. Thus, each Dollar saved at youth has a purchasing power of only 55 Cents when old. With $\alpha = 0.25$, the DWL of 2% inflation is 3.63 % of income.[22]

Interest bearing money: If the government pays interest π on money holdings, ignoring technical problems, constraint (20.3) changes to $C = (1+\pi)^T M/(1+\pi)^T = M$. Thus, the price of retirement consumption remains constant ($P = P_0 = 1$), agents are immune to inflation and the DWL vanishes (A = 0).

Interest bearing bonds, untaxed: Now assume that an interest bearing bond (B), paying nominal interest (i), is available to transfer savings across time in the OLG economy. The budget constraints change to:

(20.2') $$C_y + B = Y$$

(20.3') $$C = \frac{(1+i)^T}{(1+\pi)^T} B$$

[21] Blanchard and Fischer (1989) and Romer (2006) include textbook treatments of the OLG model.

[22] The parameter α is related to the discount factor β (≤ 1) in the following way: $\alpha = \beta^T$. For example, $\alpha = 0.25$ corresponds to a discount factor ß = 0.955 or a discount rate of 4.5% p.a.

The price of retirement consumption becomes $P=(1+\pi)^{T}(1+i)^{-T}$. Using (2) gives $P = (1+r)^{-T}$, which is independent of inflation. Again, the DWL of inflation vanishes (A = 0).

Interest bearing bonds, taxed: Things change dramatically, if nominal capital income (iB) is taxed. With a tax rate τ $(0 \leq \tau \leq 1)$, nominal after tax return of bonds (net return) becomes

(2') $$i_n = [(1+r)(1+\pi)-1](1-\tau)$$

and constraint (20.3) changes to:

(20.3'') $$C = \frac{(1+i_n)^{T}}{(1+\pi)^{T}} B$$

Thus, taxation changes the price of retirement consumption to $P=(1+\pi)^{T}(1+i_n)^{-T}$. Because there is an interaction between inflation and (capital income) taxation, the welfare loss can no longer be approximated by the Harberger triangle. As will be shown in the next subsection, the welfare cost of 2% inflation amounts to 1.54% of income.

Indexing the tax system: Trivially, the welfare loss of inflation can be eliminated if either capital income taxation is abolished $(\tau=0)$ or price stability rules $(\pi=0)$. A third way is indexation of the capital income tax. To do this, the price of retirement consumption under inflation $P(\tau_{ind})$ must be the same as under price stability, which is $P_0 = (1+r(1-\tau))^{-T}$. Solving yields the indexation formula:

(25) $$\tau_{ind} = \tau \frac{r(1+\pi)}{r(1+\pi)+\pi}$$

Thus, indexation requires a downward adjustment of the tax rate in line with inflation. In principle, indexation can eliminate the welfare cost of inflation (A = 0). However, indexation of tax codes has not been used by major industrial countries.[23] Table 7 summarizes the preceding discussion.

Table 7: Welfare cost in the OLG model (Cost of 2% inflation as % of GDP)

Money only		Bonds		
no interest	interest	untaxed	taxed	
			indexed	non-indexed
3.63	0	0	0	1.54*)

*α = 0.25, T = 30, τ = 0.3, r = 0.04, π = 0.02; *) see Table 9.*

2.2.2. A partial equilibrium framework

Partial equilibrium approaches do not formulate a fully developed general equilibrium model. However, usually there is a theoretical framework in the background, as for example an OLG model in the Feldstein report, where the intertemporal relationship (21), linking savings of the young generation and their retirement consumption, is exploited. In the simple benchmark OLG model (20) this does not imply any loss of information.

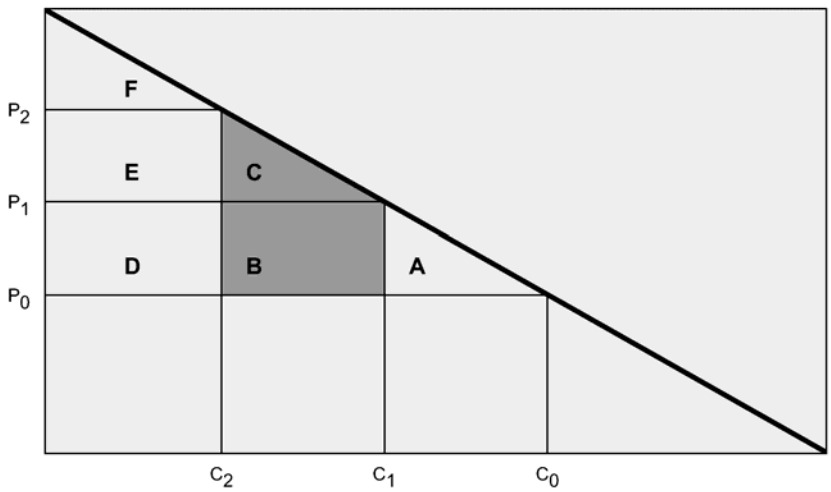
Welfare trapezoid: To determine the welfare loss of inflation when there are interactions of two distortions, inflation and taxation, three scenarios with different interest rates, prices and consumption levels (R, P, C) need to be distinguished:

No tax, no inflation:	R_0	$P_0 = (1+R_0)^{-T}$	$C_0(P_0)$
Tax, no inflation:	$R_1 = R_0(1-\tau)$	$P_1 = (1+R_1)^{-T}$	$C_1(P_1)$
Tax and inflation:	$R_2 = [(1+R_0)(1+\pi) - 1](1-\tau)$	$P_2 = (1+\pi)^T(1+R_2)^{-T}$	$C_2(P_2)$

If there is neither taxation nor inflation, with annual return R_0, saving increases by the factor $(1+R_0)^T$ and the price of retirement consumption becomes P_0. With taxes and no inflation, the net return reduces to R_1 and the price rises to $P_1 \geq P_0$. With taxes and inflation the net return is R_2 and the price increases to $P_2 \geq P_1$. The corresponding demands for retirement consumption are $C_2(P_2) \leq C_1(P_1) \leq C_0(P_0)$. To assess the welfare consequences, consider Figure 2:

[23] Feldstein (1997, 150-153) discusses technical, legal, and administrative problems of indexation.

Figure 2: Demand for retirement consumption



Without taxes and inflation consumer surplus (CS) is the sum of areas A to F. Introducing capital income taxes in an environment of price stability, equilibrium changes from (P_0, C_0) to (P_1, C_1) with less retirement consumption at a higher price. CS is reduced to the area C+E+F and capital income taxes (TR) corresponding to B+D are raised. The difference, the triangle A, is a DWL of taxation; it is the reduction of CS not compensated by TR. Introducing both, taxes and inflation, moves the equilibrium to (P_2, C_2) with a higher price and consumption reduced further. The remaining CS is the area F, whereas TR corresponds to the rectangle D+E. The deadweight loss (DWL) of taxation plus inflation increases to the triangle A+B+C. Hence, the additional DWL of inflation is the area

(26) $$B + C = (C_1 - C_2)\left[(P_1 - P_0) + \frac{P_2 - P_1}{2}\right]$$

This is no longer the traditional ‘small’ second order Harberger triangle. Interaction of taxation and inflation creates a first order welfare loss, measured by the trapezoid B+C (Feldstein 1999b). Table 8 summarizes the welfare accounting.

Table 8: Welfare accounting II			
Scenario	CS	TR	DWL
No tax, no inflation	A+B+C+D+E+F	-	-
Tax, no inflation	C+E+F	B+D	A
Tax and inflation	F	D+E	A+B+C

If the government faces a strict budget constraint at the margin, the inflation-induced change in tax revenues $[(D+E)-(B+D)=E-B]$ (if negative) needs to be compensated by increasing other taxes. Denoting the DWL per Dollar of a compensating tax by λ, the overall welfare loss is

$$(27) \qquad W = (B + C) - \lambda(E - B)$$

The inefficiency of the capital income tax (DWL per Dollar taxes raised) (λ_{cit}) and the inflation-induced change in capital income taxes (referred to as inflation tax for simplicity) (λ_{inf}) are measured as:

$$(28) \qquad \lambda_{cit} = \frac{A}{B+D}\,; \quad \lambda_{inf} = \frac{B+C}{E-B}$$

With a logarithmic utility function, retirement consumption in the OLG model was given in (23.2) as $C = (\alpha/(1+\alpha))Y/P$. Illustrative calculations are provided in Table 9.

The welfare loss of inflation is high when inflation and capital income taxation interact. A low rate of 2% inflation induces a welfare loss equivalent to 1.54% of income. Calculating the welfare loss of inflation by integration (5) or as compensated variation (14) yields similar results. Indirect tax effects reduce the welfare loss. However, even at only 2% inflation it is still about 1% of income. The final two rows report measures of tax inefficiency. Every Dollar raised by the capital income tax creates a welfare loss of 34 Cent, in contrast to 83 Cent for the inflation tax at 2% inflation.

Table 9: Welfare cost of inflation in the OLG model (% of income)

Inflation (%)	1	2	3	4	5	10
Area B	0.66	1.26	1.79	2.28	2.72	4.41
Area C	0.07	0.29	0.64	1.13	1.74	6.67
Direct welfare loss	**0.73**	**1.54**	**2.44**	**3.41**	**4.46**	**11.08**
ditto by integration (1)	*0.73*	*1.53*	*2.38*	*3.28*	*4.23*	*9.35*
ditto by compensation (2)	*0.75*	*1.59*	*2.51*	*3.51*	*4.58*	*10.68*
Indirect revenue effect	-0.29	-0.56	-0.80	-1.02	-1.22	-1.97
Overall welfare loss	**0.44**	**0.98**	**1.63**	**2.39**	**3.25**	**9.11**
CIT*) inefficiency (λ_{cit})	0.34	0.34	0.34	0.34	0.34	0.34
Inflation tax inefficiency (λ_{inf})	0.75	0.83	0.91	1.00	1.10	1.69

**) Capital income tax; α = 0.25, T = 30, τ = 0.3 , λ = 0.3, R_0 = 0.06 (With τ = 0.3, R_0 = 0.06 is roughly consistent with r = 0.04 used before.)*

(1) $B+C = (\alpha/(1+\alpha))Y \ln(P_2/P_1) - (C_1 - C_2) P_0$; (2) $B+C = (P_2/P_1)^{\alpha/(1+\alpha)} - 1 - (C_1 - C_2) P_0$

It may be noted that Bullard and Russell (2004) present a general equilibrium OLG life-cycle model with financial intermediation, calibrated to U.S. post-war data, which produces a welfare cost of 10% inflation at 11.2% of output, close to the value shown in Table 9 for the simple OLG model.

A decomposition: It is instructive to express the direct welfare loss of inflation as:

$$(26') \qquad B + C \equiv B(1+\frac{C}{B}) = \frac{\alpha}{1+\alpha}(1-\frac{P_0}{P_1})(1-\frac{P_1}{P_2})(1+\delta)$$

where the residual factor (1+δ) measures the contribution of the triangle C. The first term, the savings rate, reflects the amount saved and invested. The second term measures the combined effect of the return on capital (R_0), compounding (T) and the erosion of capital income by taxation (τ). The third term is the effect of inflation. This decomposition shows that the DWL of inflation essentially is a tax on a tax. Consider an individual who saves and invests 20% of his income (Y) for retirement.[24] Capital income taxation generates a loss of 8.04%. 2% inflation induces a loss on that loss of 1.28%. Second order effects increase it to 1.54% (See Table 10).

[24] In the OLG model, savings of the young do not conform to the concept of savings in national accounts, which is the balance of savings of the young and dissaving of the old.

Table 10: Decomposition of direct welfare loss of inflation (% of income)

Inflation (% p.a.) π	Income Y..	Saving rate x $\alpha/(1+\alpha)$..	Tax factor x $(1-P_0/P_1)$..	Inflation factor x $(1-P_1/P_2)$..	DWL x $(1+\delta)$
1	100	20	8.04	0.66	0.73
2	100	20	8.04	1.26	1.54
10	100	20	8.04	4.41	11.08

Calibration as in Table 9.

Summing up, the welfare costs of inflation in the OLG economy are the higher, the higher

- the saving preferences (α)
- the return on capital (R_0)
- the capital income tax (τ)
- the rate of inflation (π)

<u>A digression on optimal inflation</u>: In the simple OLG model with logarithmic utility the optimal rate of inflation can be solved analytically. Solving first for the optimal price level of retirement consumption yields:

(29) $$P_2^* = \sqrt{P_1[2P_0(1+\lambda)-P_1]}$$

The optimal price level depends on (R_0, τ, T) but is independent of saving behavior (α). Moreover, as expected, λ tends to increase the optimal price level. From (29) optimal inflation can be calculated as:

(29') $$\pi^* = \frac{(P_2^*)^{1/T}(1+R_0(1-\tau))-1}{1-(P_2^*)^{1/T}(1+R_0)(1-\tau)}$$

Substituting the parameters used in Table 9 implies that π^* = -3.3% minimizes the net welfare loss implied by distortions of the savings and consumption allocation. The negative inflation tax implied by deflation reduces the impact of distortions created by capital income taxation.[25]

[25] At 3.3% deflation the nominal interest would be 2.5%, well above the zero bound.

Extensions: The simple OLG model considered above has been extended in several directions. Implicitly, it was assumed that a fully funded system is in place for providing old age pensions. Tödter and Ziebarth (1999) introduce a "*pay as you go*" system into the model but obtain essentially the same results. Further extensions include a more general utility function (such that the intertemporal elasticity of substitution differs from unity), endogenous labor-leisure choice, a production technology (to model the real interest rate and the capital stock), and others.

2.2.3. Empirical evidence

The Feldstein (1999a) report is a comprehensive empirical study of the welfare effects of inflation and the cost of disinflation. It applies a common OLG-based analytical framework, developed by Feldstein (1997), to provide empirical evidence for the U.S. (Feldstein 1999b), Germany (Tödter and Ziebarth 1999), the U.K. (Bakhshi et al. 1999) and Spain (Dolado et al. 1999). The study reports welfare effects for the hypothetical policy measure of going from 2 percent inflation to price stability. Four channels are evaluated:

- (1) Money demand and seigniorage
- (2) Intertemporal allocation of saving and consumption
- (3) Demand for owner-occupied housing
- (4) Public debt service

The money demand channel was already discussed in 2.1 (Table 6). The first three channels include the indirect tax revenue effects arising through the government budget constraint, which are usually ignored in welfare analyses by the assumption of lump sum taxes or transfers. The final channel accounts for the indirect welfare effects of inflation on the public debt service.

Intertemporal allocation of saving and consumption: In the Feldstein report, the DWL of inflation is approximated by the trapezoid (26) underneath the (compensated) demand for retirement consumption (21). The report calculates the costs of a steady, anticipated rate of 2% inflation. To put it differently, it estimates the benefits of going from 2% inflation to zero. Space limitations do not allow to review all the country specific details of the tax system included in the report.

For Germany, Tödter and Ziebarth (1999, 61) estimate the average gross yield on fixed capital at R_0 = 10.8% p.a. The average tax burden (based on 1991-95 data) amounts to 60.7% (compared to 41% for the U.S.),[26] reducing the net yield to R_2 = 4.24%. Zero inflation increases it by 63 basis points to R_1 = 4.87%. The associated prices of retirement consumption (T = 27) imply that 2% inflation raises the price of a Dollar spent in retirement by 4.84 Cent. Turning to quantities, the inflation-induced change in retirement consumption is approximated by $C_1 - C_2 \approx \eta_{CP} C_2 (P_2 - P_1)/P_2$, where η_{CP} is the (absolute) compensated price elasticity of consumption. The Slutsky decomposition allows to express the unobservable elasticity as a function of the uncompensated interest elasticity of savings of the young, estimated at (η_{SR} = 0.25) as $\eta_{CP} = 1 - \sigma_y + \eta_{SR}(1 + R_2)/R_2 T$, where σ_y is the income effect. The authors obtain η_{CP} = 0.854 and calculate welfare costs of 1.95% of GDP. Taking into account indirect tax effects (λ = 0.34) reduces the overall loss to 1.48% of GDP.

Table 11 provides the results for the countries included in the Feldstein report. The higher welfare loss of inflation in Germany compared to the U.S. basically rests on higher tax rates and the fact that the saving ratio (as a percentage of GDP) is almost twice as high in Germany as it was in the U.S. in the sample period of the study.

Table 11: Intertemporal allocation of savings and consumption
Welfare effect of reducing inflation from 2 percent to zero as % of GDP

	U.S.	Germany	U.K.	Spain
Direct welfare effect	1.02	1.95	0.40	0.91
Indirect revenue effect	-0.07	-0.47	-0.12	-0.19
Overall welfare effect	0.95	1.48	0.29	0.72

Source: Feldstein (1999a)

Similar to the money demand elasticity, the interest elasticity of savings (η_{SR}) is a key parameter in the calculation of the welfare effects, but estimates in the literature vary widely. Changing it within a plausible range has a marked effect on the results. Another important parameter is the inefficiency of the tax system (λ). Except for

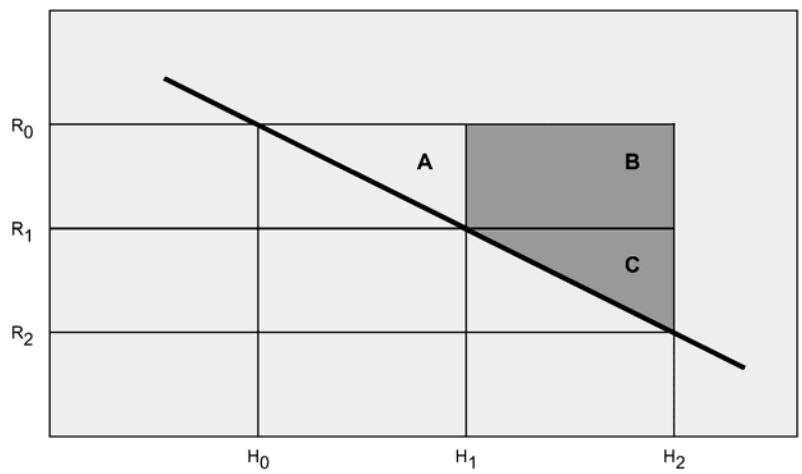
[26] Profits of German corporations distributed to domestic individuals were subject to a variety of taxes: a trade tax (on return and capital), a corporation tax, an investment income tax, a property tax, the income tax, and the solidarity surcharge to finance German unification. Tax rules including tax rates have changed since the study was conducted.

Germany, the authors use λ = 0.4 (and alternatively λ = 1.5). For Germany, the parameter (λ_{cit} = 0.34) is estimated from the model as inefficiency of the capital income tax (28). In contrast, the estimated inefficiency of the inflation-induced revenue change is much higher (λ_{inf} = 1.43).

Housing demand: In many industrial countries owner-occupied housing receives preferential treatment under the personal income tax law. Mortgage interest payments and possibly maintenance and depreciation costs and local property taxes are deductible. On the other hand, the notional rental value, which represents implied investment income, is not subject to taxation. Such a treatment induces excessive consumption of housing services even in the absence of inflation (Feldstein 1999b, 26; Rosen 1985). Inflation increases that loss through the deduction of nominal mortgage interest payments and raises the loss from excessive housing demand.

Let H(R) (H_R < 0) denote the demand for owner-occupied housing and R the user cost per Dollar of invested housing capital. For Germany, Tödter and Ziebarth (1999), following Feldstein (1999b), estimate the user costs in the absence of tax and inflation at R_0 = 14.8% p.a. Preferential tax treatment reduces housing cost to R_1 = 9.09 percent and 2% inflation decreases it further to R_2 = 8.84%.[27]

Figure 3: Housing demand



[27] Meanwhile legislation in Germany has changed considerably.

As shown in Figure 3, the inflation-induced DWL of owner-occupied housing can be measured by the trapezoid

(30) $$B + C = (H_2 - H_1)[(R_0 - R_1) + (R_1 - R_2)/2]$$

The inflation-induced change in housing demand is approximated by $H_2 - H_1 \approx \varepsilon_{HR} H_2 (R_1 - R_2)/R_2$, where ε_{HR} is the compensated interest elasticity of housing demand. For Germany, ε_{HR} is estimated at 0.25. As the value of the owner-occupied housing stock is 170% of GDP, H_1-H_2 = 1.20% of GDP follows. Hence, the direct (total) DWL amounts to just 0.07 (0.09) % of GDP.

Table 12 reports the results. Except for Spain, the welfare losses through the housing demand channel are small compared to the savings and consumption allocation channel.[28]

Table 12: Demand for owner-occupied housing

Welfare effect of reducing inflation from 2 percent to zero as % of GDP

	U.S.	Germany	U.K.	Spain
Direct welfare effect	0.10	0.07	0.04	0.69
Indirect revenue effect	0.12	0.02	0.07	0.64
Overall welfare effect	0.22	0.09	0.11	1.33

Source: Feldstein (1999a)

Public debt service: Higher real interest rates increase the real cost of the public debt service. Inflation, if fully anticipated, leaves the real gross interest rate on public debt unchanged, whereas the inflation premium is subject to income taxation. Reducing the rate of inflation from 2% to zero does not reduce the pre-tax cost of debt service, that means, it does not generate a direct welfare gain. But it does reduce the tax revenue accruing from the (eligible) interest payment on the public debt, which requires a compensatory increase of other taxes (Feldstein 1999b, 72). Table 13 reports.

[28] Dolado et al. (1999, 115) explain the exceptionally high loss for Spain by the high ratio of housing value to GDP and the enormous implicit subsidy that tax rules and inflation provide to the purchase of owner-occupied houses.

Table 13: Public debt service

Welfare effect of reducing inflation from 2 percent to zero as % of GDP

	U.S.	Germany	U.K.	Spain
Overall welfare effect	-0.10	-0.12	-0.09	-0.10

Source: Feldstein (1999a)

Total benefits: Table 14 summarizes the overall welfare benefits of eliminating 2% inflation, accruing from distortions of money demand, consumption timing, housing demand and the public debt service. The lowest welfare gain of price stability is estimated for the U.K. (0.29% of GDP), whereas the highest gain is reported for Spain (1.88%), which is largely due to the housing channel. The benefit obtained for the U.S. is 1.04% of GDP. At 1.41% of GDP, the benefit is somewhat higher for Germany.[29]

Table 14: Total welfare effects (Reducing inflation from 2 percent to zero as % of GDP)

	U.S.	Germany	U.K.	Spain
Direct effect	1.14	2.04	0.47	1.64
Revenue change	-0.10	-0.63	-0.18	0.25
Overall welfare effect	**1.04**	**1.41** *(0.473)*[*)]	**0.29**	**1.88**

*Source: Feldstein (1999a); *) Standard deviation.*

Cross-checking: The welfare gains of price stability of the Feldstein report reviewed above were obtained in a partial equilibrium, OLG-based setting. Abel (1997) used a calibrated and suitably modified version of the Sidrauski (1967) general equilibrium model to perform a robustness check for the results reported in Feldstein (1997) for the U.S. He introduced three modifications into the Sidrauski model: Two types of capital (non-housing and housing capital), a government budget constraint to capture the effects of various distortionary taxes, and endogenous labor supply so that taxes on labor income are distortionary. In Abel (1999), this model was also applied to calculate welfare effects of inflation for Germany, the U.K. and Spain, using

[29] Tödter and Ziebarth (1999) performed a stochastic simulation exercise by simultaneously shocking all 23 parameters in their model subject to uncertainty. Repeating this exercise 10.000 times, they obtain a distribution of the overall welfare gain. The median (1.34%) is below the mean (1.39%), indicating positive skewness of the distribution. The standard deviation is 0.473% and with probability of 79% the welfare gain exceeds 1% of GDP.

parameters that were calibrated to match those in the country studies. Table 15 reports Abel's results in comparison to those of the case studies.[30]

Despite the differences in analytic approaches, for the U.S. and Germany the results are strikingly close to each other. Both sets of results have four features in common (Abel 1997, 164; 1999, 189): (1) Benefits of price stability arising through the money demand channel are negative but tiny. (2) Benefits through the housing-demand channel are positive but relatively small. (3) By far the largest benefits come through the reduced distortion in the effective taxation of non-housing capital. (4) The overall welfare gain of eliminating 2% inflation obtained in a general equilibrium (Sidrauski) framework and those from a partial equilibrium (OLG-based) approach in the case studies for the US and Germany exceed 1% of GDP.[31]

Table 15: Comparison of overall welfare effects
(Reducing inflation from 2 percent to zero as % of GDP)

	U.S.		Germany		U.K.		Spain	
	A	B	A	B	A	B	A	B
Money demand	-0.06	-0.03	-0.12	-0.04	0.00	-0.02	-0.04	-0.07
Consumption timing	1.15	0.95	1.49	1.48	0.72	0.29	0.76	0.72
Housing demand	0.11	0.22	0.08	0.09	-0.02	0.11	-0.01	1.33
Debt service	-	-0.10	-	-0.12	-	-0.09	-	-0.10
Total	**1.20**	**1.04**	**1.45**	**1.41**	**0.70**	**0.29**	**0.71**	**1.88**

Source: Columns A: Abel (1997) for the U.S and Abel (1999) for the other countries;
Columns B: Feldstein (1999);

User cost of capital: The case studies did not address the effects of inflation on the user cost of capital. Cohen et al. (1999) investigated inflation effects on the net-of-tax profitability of several kinds of business assets: equipment versus structures and short-lived versus long-lived assets. They find that inflation raises the user cost of capital and amplifies the distortion of the tax system, but the magnitude of the effect and its welfare consequences are rather small.

[30] Since Abel calculated the welfare effects as a percentage of steady state consumption, his results are scaled by country specific ratios of consumption to GDP for comparability.

[31] For the United Kingdom the welfare gain through the consumption channel from the Sidrauski model is about twice the size of the country study. Concerning Spain, a large discrepancy shows up for the housing channel. The effect reported in the case study is much larger than in the Sidrauski model (and also higher than in the other country studies). Both discrepancies are difficult to explain (Abel 1999, 190; Bakhshi et al. 1999, 154; Dolado et al. 1999, 115).

Labor markets: With regard to the effects of inflation on labor markets there may be benefits if inflation "*greases the wheels*" of the labor market and there may be costs, if inflation "*throws sand*" to wage and price adjustments. Both effects can arise from nominal rigidities of wages and prices in the face of shocks. The grease effect arises from resistance to nominal wage cuts due to, e.g., money illusion or fairness considerations. The sand effect derives from the impairment of the value of the price signal, it leads to misallocations, more frequent wage and price changes and higher search costs. Groshen and Schweitzer (1999) provide evidence that the grease and the sand effects roughly cancel out.

Open economies: In open economies there are opportunities for borrowing and lending that are unavailable to closed economies. On the other hand, openness has the potential to amplify or to moderate domestic distortions such as those resulting form interactions of inflation and taxation. Desai and Hines (1999) analyzed the role of international capital flows for the burden of inflation in open economies. They found that the gain from price stability can be substantially larger than in an otherwise similar closed economy.

2.3. Inflation and growth

The preceding analysis has reported measures of several effects of inflation on the level of output and welfare. Researchers have also questioned whether inflation causes a reduction in the rate of output growth.

Growth effects of inflation, if they are permanent, have the potential to outweigh level effects, even if they are small. Assume that price stability permanently raises welfare by w percent of baseline output Y_0. With trend growth rate g and a social discount rate $\rho > g$, the present value (PV) of the benefits is $wY_0(1+\rho)/(\rho-g)$. Alternatively, assume that price stability increases the growth rate from g to $g + \omega$. The PV of that effect is $\omega Y_0(1+\rho)/(\rho-g)(\rho-g-\omega)$. Hence, the PV's are equal if the growth effect is

(31) $$\omega = (\rho - g)\frac{w}{1+w}$$

Let the level effect be w = 1% of GDP, g = 2.5% and ρ = 5%.[32] To obtain the same PV requires an increase of the growth rate by just ω = 0.025 percentage points, e.g. from 2.5% to 2.525%. Thus, it is not surprising that it is difficult to identify statistically significant growth effects of moderate inflation.

Haslag (1997), reviewing the literature on inflation and growth, points out that theory provides little reason for expecting that a sustained rate of inflation permanently alters the real growth rate in either direction. Empirically, Lucas (1973) found no significant relation between average growth and average inflation across a sample of 18 countries. More recently, considerable empirical evidence was revealed that high inflation, exceeding 10 percent per year, has negative effects on economic growth (Barro 1995; Bruno and Easterly 1995; Fischer 1993; Sarel 1996). But those studies could not detect growth effects of inflation below 10 percent.

Using data of 21 industrial countries, Grimes (1991, 641) found in the long-run even low inflation has a negative impact on the rate of growth. In a cross section study of 82 countries, Gomme (1993) found that inflation and output growth are negatively correlated. However, eliminating an inflation rate of 10 percent would result in a very small (less than 0.01 percentage point) increase in output growth. In contrast, Haslag (1995) reports that 10 percent inflation slows down growth by sizeable 0.2 percentage points. Running regressions for each of the G7-countries, Ericsson et al. (2000) report no significant long-run effect on output growth. Andrés and Hernando (1999) found substantial level effects but no growth effect of inflation. In a study for the G7, Fountas and Karanasos (2007) report that inflation increases uncertainty about inflation, yet there is mixed evidence regarding the effect of inflation uncertainty on output growth. In the aforementioned model of Dotsey and Ireland (1996), drawing on Romer (1986), inflation can potentially influence not only the level but also the growth rate of aggregate output. They estimate the welfare cost of 10% inflation at 0.92 (1.73)% of output if money is measured as currency (M1). A large part of the welfare cost of inflation is caused by the endogenous growth feature of the model, as the annual growth rate falls from 2.12 % under zero inflation to 2.07 % under 10% inflation. Summing up, there appears to be little evidence that stable single-digit inflation has a sizable impact on growth.

2.4. Cost of unanticipated inflation

So far various channels of the costs of a steady, anticipated rate of inflation have been discussed. Quantifying the welfare costs of unanticipated changes of inflation and of inflation uncertainty is more difficult. In the former case, welfare costs essentially arise through artificial redistributions of income and wealth, which may also undermine confidence in property rights. In the latter case welfare costs arise because most individuals are risk averse, preferring steady income and consumption flows. In this and the next subsection, the nature of inflation costs arising through these two channels is briefly discussed.

Inflation surprises emerge as a key stylized fact in Fischer et al. (2002), studying more than 200 post-war high-inflation episodes in 92 countries. Unanticipated changes in inflation are a potentially important source of inflation cost that occur through the existence of nominal contracts for goods and services, and for debts (Fischer and Modigliani 1978, 822). This results in redistributions of income and wealth, the details of which depend on the contract structure. Redistributions take place between the private and the government sector as well as within the private sector. For example, evidence suggests that wages lag behind inflation, implying a shift from wage incomes towards profit incomes.

Probably even more important are redistributions caused by unanticipated inflation from nominal creditors to nominal debtors. Since the domestic private sector is the main creditor of the government sector, an unanticipated increase in the price level lowers its outstanding real claims on the government. Within the private sector an unanticipated increase in the price level reduces the real value of outstanding corporate debt. Initially, this seems to benefit the corporate sector at the expense of the private sector. Ultimately, the lower level of corporate debt will be reflected in an

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[32] Azar (2007) reports estimates of the U.S. social discount rate of about 5 percent.

increase in the value of corporate equity, leaving the net wealth of the private sector largely unaffected (Fischer and Modigliani 1978, 824).

Redistribution effects are not taken into account in most studies on the welfare cost of inflation employing a representative-agent framework (Doepke and Schneider 2006). Fischer and Modigliani (1978) regard welfare redistributions arising from unanticipated inflation as large, about 1% of GNP per 1 percentage point of unanticipated increase in the price level. However, it is difficult to attach a social welfare cost to such redistributions. Doing this requires a Bergson-Samuelson social welfare function that weighs the welfare of every individual appropriately (Fischer and Modigliani 1978, 827; Johansen, 1991, 27). Even if a social welfare function is assumed to exist, the aggregate welfare effect of income or wealth redistributions is likely to be indetermined. Let social welfare simply be the sum of the utility of two individuals (indexed by a, b):

(32) $$U = U_a(W_a) + U_b(W_b)$$

Let θ ($0 < \theta < 1$) be a's share of total wealth (W) and assume that due to nominally fixed contracts unanticipated inflation leads to a redistribution of the amount $\omega\theta W$ from a to b, where ω ($0 < \omega < 1$) is the fraction of a's wealth that is redistributed. A second order Taylor expansion yields the following expression for the change in social welfare

(32') $$\Delta U = \omega\theta W\left[U_b^{'} - U_a^{'}\right] + \frac{(\omega\theta W)^2}{2}\left[U_a^{''} + U_b^{''}\right]$$

with $U_i^{'} > 0$ and $U_i^{''} < 0$ for i = (a, b). The first order effect, the difference in marginal utilities, is proportional to the amount redistributed and can be positive or negative. The second order effect is unambiguously negative. To be concrete, let the individuals have constant relative risk aversion (CRRA) preferences with identical risk aversion $\rho > 0$ $(\neq 1)$., e.g. $U_a = (W_a)^{1-\rho}/(1-\rho)$. Thus, the change in social utility becomes

(32'') $$\Delta U = (\theta W)^{1-\rho}\left[\omega(\psi^{\rho}-1)-\frac{\omega^2\rho}{2}(\psi^{1+\rho}+1)\right]$$

where $\psi = \theta/(1-\theta)$ denotes the wealth ratio. Approximately, the change of utility is negative, if θ < ½. Thus, if unanticipated inflation redistributes wealth from a poorer to a richer person (or group) social wealth declines (and vice versa).

Romer and Romer (1999) and Easterly and Fischer (2001) have evidence showing that inflation affects the welfare of the poorest groups in society. Focusing on the transaction patterns of heterogeneous households, Erosa and Ventura (2002) find that inflation is effectively a regressive consumption tax. It has redistributive effects as the detrimental impact on the welfare of low income households is larger than the impact on high income households who find it less costly to substitute credit for money in transactions.

Doepke and Schneider (2006) formulate an OLG model of the U.S. economy and calculate the effects of an unanticipated shock to the wealth distribution. The shock is zero sum, yet households react asymmetrically, mainly because redistribution occurs from old lenders to young borrowers. As a result, inflation decreases labor supply and increases savings. The inflation-induced redistribution has a persistent negative effect on output, however, the weighted welfare of domestic households improves. An unanticipated inflation shock of 10% increases aggregate welfare between 2.5% and 5.7% of GDP, depending on the reaction of fiscal policy. In an indexing scenario the inflation benefits still range between 1% and 2.6% of GDP.

2.5. Cost of inflation uncertainty

What are the implications of inflation uncertainty? Inflation is uncertain, if there are (unpredictable) random fluctuations of the inflation rates about its mean.[33] Uncertainty of inflation leads agents to confuse aggregate and relative price changes and impedes disentanglement of permanent from transitory changes (Driffill et al. 1990). These arguments are stronger in case the central bank adopts an inflation targeting regime than under price level targeting as in the latter case uncertainty about the long-run price level is reduced. Except for indexed assets, inflation uncertainty reduces the safety of nominal assets and increases the relative attractiveness of real, non-reproducible assets as inflation hedges such as land, houses, gold etc. Given the relative inelasticity of supply, the prices of such assets will tend to increase faster than the general price level. It may be that the resulting "capital gains" increase in real wealth will result in a decline in saving and, eventually, in physical investment. Another effect of inflation uncertainty is the shortening of the length of contracts. Both effects will tend to reduce the rate of investment by firms and lead to investment in shorter lived assets (Fischer and Modigliani 1978, 828).

Inflation uncertainty also creates uncertainty in real income and consumption. Consider an individual who consumes the certain amount C and enjoys utility U(C). Alternatively, he is offered an uncertain consumption Z, where Z is a random variable with mean C and variance σ_C^2. Which risk premium would this individual demand to compensate him for uncertainty? The following condition needs to hold

(33) $$U(C) = E[U(Z + \psi C)]$$

where E(.) is the expectations operator and ψ is the relative risk premium. Applying a second order Taylor expansion around C, (33) can be approximated by $U(C) = U(C) + U'\psi C + U''\sigma_C^2 / 2$. Solving for the risk premium yields

(34) $$\psi C = A \frac{\sigma_C^2}{2}$$

where A = –U''/U' is the Arrow-Pratt measure of absolute risk aversion. A can be interpreted as the price of risk, whereas σ_C^2 measures its quantity.[34] The sign of A depends on the individuals' preferences towards risk. Risk averse people (A > 0) require a positive risk premium as compensation for uncertainty. Hence, inflation

[33] Variability or volatility of inflation is not the same as uncertainty. Inflation might be highly volatile but if the generating process is understood and predictable, uncertainty can be low.

uncertainty, if uncompensated, creates a welfare loss. For example, if the utility function is of the CRRA type, i.e. $U = C^{1-\rho}/(1-\rho)$ for $\rho > 0$ and $\rho \neq 1$ [$U = \ln(C)$ for ρ = 1], the inflation risk premium falls with the level of consumption:

(34’) $$\psi C = \frac{\rho}{C}\frac{\sigma_C^2}{2}.$$

Empirically inflation uncertainty increases with the level of inflation, such that both types of inflation costs, the level costs and the uncertainty costs reinforce each other (Barro 1995).

Quantitatively, relatively little is known about the welfare cost of inflation volatility. To estimate the cost of inflation variability, stochastic shocks of a realistic magnitude to productivity and money supply could be added in a general equilibrium framework. Lucas (2000, 258) conjectured: *“I am very confident that the effects of such a modification on the welfare costs … would be negligible.”*

To check Lucas’ conjecture, consider the simple OLG model discussed in (2.2.1). With the CRRA utility function $U = (C_y^{1-\rho} + \alpha C^{1-\rho})/(1-\rho)$, retirement consumption becomes

(35) $$C = \frac{a}{1+a}\frac{Y}{P}, \qquad a = \alpha^{1/\rho}P^{1-1/\rho}$$

For ρ = 1, (23.2) is obtained as a special case. The price of retirement consumption is P = $(1+z)^T$, with $1+z \equiv (1+\pi)/(1+R_2)$ and $R_2 = [(1+R_0)(1+\pi)-1](1-\tau)$.

Tödter (2007) estimates the coefficient of relative risk aversion from U.S. stock return data over the period 1926 to 2002 and obtains ρ = 3.5. However, ranging from 1.4 to 7.1, the 95% confidence interval is fairly wide. Using the calibration (α = 0.25, ρ = 3.5, R_0 = 0.06, τ = 0.4) the trapezoid measure (26) yields a direct welfare loss (B+C)

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[34] Kimball (1990) discusses a third order approximation of the utility function, which shows that the risk premium also depends on the skewness (asymmetry) of the income distribution.

of 1.52% of income for 2% inflation, which is close to the loss shown in Table 9. Hence, for an individual with income Y = 50,000 $, which is roughly the median household income in the U.S., the annual welfare loss of a steady inflation rate of 2% amounts to 758 $ annually (63 $ monthly).

Now, let inflation be stochastic and assume that the central bank targets inflation such that $\pi_t = \hat{\pi} + \varepsilon_t$, where $\hat{\pi}$ is the inflation target and ε_t is a normal random variable with zero mean and variance σ^2.[35] The random price level of retirement consumption is $P = (1+z_1)(1+z_2)...(1+z_T)$. Assume that $\hat{\pi} = 2\%$ and $\sigma = 2\%$. Simulating this process 10,000 times, a mean direct welfare loss of 1.49% of income (747 $) is obtained which is close to the deterministic loss. The simulated standard deviation of the deadweight loss is 0.33% of income (163 $).

Table 16: Welfare loss of inflation uncertainty in the OLG model

		%	$
Direct welfare loss of 2% inflation		1.49	747
Std. deviation of direct welfare loss		*0.33*	*163*
Std. deviation of retirement consumption		*1.96*	*613*
	ρ = 1.4	*0.072*	*18.73*
Risk premium (inflation targeting)	ρ = 3.5	0.068	21.08
	ρ = 7.1	*0.089*	*29.53*
Risk premium (price level targeting)		0.002	0.71

Source: Own calculation, results of 10,000 Monte Carlo simulations;
$\alpha = 0.25$, $R_0 = 0.06$, $\tau = 0.4$, $T = 30$; $Y = 50.000$ \$; $\hat{\pi} = 2\%$, $\sigma = 2\%$.

What is the risk premium needed to compensate for this uncertainty? The simulated standard deviation of retirement consumption is σ_C = 1.96%. (Mean retirement consumption is C = 31,200 $ with standard deviation of 613 $). The risk premium (34) turns out as just ψC = 21.08 $.[36] Thus, Lucas was right, this is merely ψ = 0.068% of the consumption level, and indeed negligible compared to the loss created by the

[35] Alternatively, a strategy of price level targeting is assumed, where the price level is allowed to increase over time. If δ_{t-1} denotes the deviation from the price level target in the previous period, actual inflation is corrected accordingly in the current period: $\pi_t = \hat{\pi} + \varepsilon_t - \delta_{t-1}$. Thus, uncertainty about the price level in the long run is largely eliminated.
[36] Price level targeting slashes this amount by the factor T = 30 to 0.71 $.

level of inflation.[37] Table 16 also shows that the risk premium is not sensitive to variation of the risk aversion parameter.

3. Costs of reducing inflation

The theoretical and empirical evidence reviewed in Section 2 suggests that there are large costs even of low inflation and, for that matter, benefits of price stability. Does it mean that there is a *"free lunch"* to be had by reducing the rate of inflation down to zero? If price stability has not yet been reached, there are likely to be disinflation costs in terms of output and employment losses, at least over the short term. Thus, an analysis of the welfare effects of inflation would be incomplete if the costs of disinflation were neglected. The hypothetical policy question raised by Feldstein (1997, 123) was: *"If the true and fully anticipated rate of inflation (i.e. the measured rate of inflation minus 2 percentage points) has stabilized at 2%, is the gain from reducing inflation to zero worth the sacrifice in output and employment that would be required to achieve it?"*

Breakeven benefit: Given the benefits of achieving price stability, how large can the costs of disinflation be before reducing inflation becomes counterproductive? The costs of reducing inflation in terms of employment and output losses are transitional, depending on[38]

- real rigidities in the goods and labor markets
- nominal rigidities in the formation of inflation expectations
- the stance of monetary and fiscal policy
- the initial level of inflation.

Let $C(\pi)$ be the present value (as a percentage of GDP) of the cost of reducing inflation from π to zero. Applying the discount rate for a growing economy (ρ-g) to obtain the annualized cost of disinflation, the breakeven value is $(\rho-g)C(\pi)$. This value

[37] This may still be an overestimation because even simple forecasting techniques would allow to cut inflation uncertainty in half. Lucas (2003) obtained comparably low estimates for the welfare cost of business cycle fluctuations (DeJong and Dave 2007, 127).

[38] Akerlof et al. (1996) argue that the long-run Phillips curve is not vertical but downward-sloping at very low rates of inflation because of nominal wage rigidity. Feldstein (1999a, 5) points out that in sustained periods of price stability such resistance would gradually disappear.

is comparable to the permanent annual benefit ($W(\pi)$) of reducing inflation from 2 percent to zero. Thus, from a cost-benefit perspective, the benefit of price stability should be greater than the breakeven value:

(36) $$W(\pi) > (\rho - g)C(\pi)$$

Zero bound problem: One potential cost of lowering inflation rates to values close to zero which is not elaborated in more detail here but could nevertheless be potentially important is the rising probability of hitting the zero bound for nominal interest rates. In that case costs would arise because monetary policy would partly forego its power to counteract large deflationary shocks since nominal (and therefore real) interest rates could not be cut further once the zero bound is reached. In extreme cases it is even conceivable that the economy enters a deflationary spiral. In a quantitative study for the euro area Coenen (2003) finds that distortions due to the zero bound are likely to be economically insignificant for inflation targets at or above one (two) percent in case of low (high) inflation persistence. In a survey of the literature Yates (2004, 464) concludes that the risks of hitting the zero bound seems to be *"small, down to inflation rates close to those currently pursued by central banks, but gets much larger below that*" while he judges the risk of a deflationary spiral to be very small indeed.

3.1. Output sacrifice ratio

For policy purposes the sacrifice ratio is used to quantify the transitional costs of disinflation. The output sacrifice ratio (OSR) measures the cumulative loss of output caused by a reduction of the inflation rate by 1 percentage point.

Ball (1994) estimated the OSR by cumulating the output loss that occurred during identified historical periods of disinflation. Another approach estimates the OSR on the basis of a Phillips curve for inflation dynamics. If η is the response of inflation to changes in the output gap, the real rigidity, the OSR (σ) is often measured as $\sigma = 1/\eta$. If real rigidity is high (small η), disinflation tends to be costly. Below it will be seen that this measure is only valid in a special case. Performing dynamic simulations with a structural macroeconometric model offers a third way to estimate disinflation costs. If the model features forward looking expectations, anticipated and unanticipated permanent disinflations can be simulated. Stochastic simulations yield estimates of the associated uncertainty.

Consider the following simple New Keynesian model (Tödter 2002):

(37.1) $$gap_t = -\alpha(i_t - \pi_t - r) + \upsilon_t\ , \quad \alpha \geq 0$$

(37.2) $$\pi_t = \pi_t^e + \eta\, gap_t + u_t\ , \quad \eta \geq 0$$

(37.3) $$\pi_t^e = \lambda\pi_{t-1} + (1-\lambda)\hat{\pi}\ , \quad 0 \leq \lambda \leq 1$$

(37.4) $$i_t = r + \hat{\pi} + \gamma(\pi_{t-1} - \hat{\pi}), \quad \gamma > 1$$

The output gap (gap_t) depends negatively on the deviation between the current real interest rate (i_t - π_t) and its equilibrium value (r), and on a demand shock (υ_t). The Phillips equation postulates that inflation (π_t) exceeds inflation expectations (π_t^e) if there is a positive output gap or a price shock (u_t); the parameter η measures real rigidity.[39] Inflation expectations are modeled as a weighted average of lagged inflation and the inflation target ($\hat{\pi}$), where λ measures nominal rigidity. If expectations are forward looking and the central bank is credible, λ tends to be low.[40] The final equation is the policy reaction function of the central bank. The interest rate is raised above its equilibrium $(r + \hat{\pi})$ if lagged inflation exceeds the inflation target.

The following solutions (shock terms neglected) for the inflation process and the output gap are obtained:

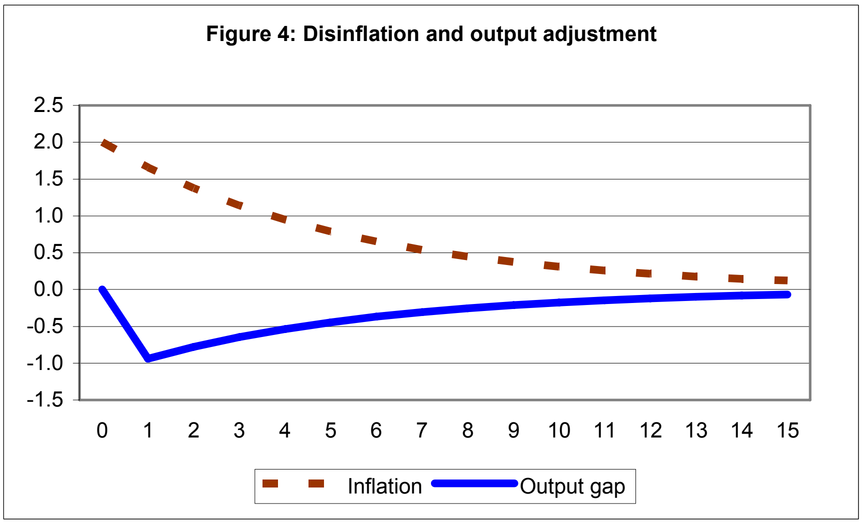
(38.1) $$\pi_t - \hat{\pi} = \psi(\pi_{t-1} - \hat{\pi})\ , \quad \psi = \frac{\lambda - \alpha\eta\gamma}{1 - \alpha\eta} < 1$$

[39] See Blanchard and Gali (2007) on real wage rigidities in the New Keynesian model. Rudd and Whelan (2007) give a critical account of modelling inflation dynamics in a New Keynesian - Phillips approach.

[40] Palenzuela et al. (2003) summarize the evidence on downward nominal rigidities. Recently, based on the analysis of 13 million price records underlying the computation of the French consumer price index, Baudry et al. (2007) found that consumer prices are rather sticky (with average duration around 8 months), but they have no evidence of specific downward nominal rigidity.

(38.2) $\quad gap_t = -\omega(\pi_{t-1} - \hat{\pi})\,, \qquad \omega = \dfrac{\alpha(\gamma - \lambda)}{1 - \alpha\eta} > 0$

Excess inflation follows a first order autoregressive process. Stability of the inflation process requires the mild restriction $\psi < 1$. Figure 4 shows the adjustment process of inflation and output following a reduction of the inflation target from 2% to zero, using the calibration $(\alpha = 0.7,\ \eta = 0.15,\ \lambda = 0.9,\ \gamma = 1.5)$.



Calculating the output loss in the New Keynesian model that results from a reduction of target inflation in t = 1 from $\hat{\pi}_0$ to $\hat{\pi}$ $(< \hat{\pi}_0)$ yields the OSR

(39) $\quad \sigma = \dfrac{\sum_{t=1}^{\infty} \beta^t gap_t}{\hat{\pi} - \hat{\pi}_0} = \dfrac{\beta\omega}{1 - \beta\psi}$

where $ß = 1/(1 + \rho - g)$ is the discount factor. The OSR depends on all structural parameters of the model. Non-discounting and extreme nominal rigidity (λ = 1) gives $\sigma = 1/\eta$ as a special case. High real rigidity (small η) increases the OSR. Higher sensitivity of aggregate demand to the real interest rate (large α) increases the OSR as well. Finally, more aggressive monetary policy (large γ) increases the OSR in this model. Table 17 provides some illustrative calculations.

Table 17: Output sacrifice ratio in the New Keynesian model (% of GDP)

	λ	η	α	γ	σ	
					ρ-g = 0	ρ-g = 0.025
Benchmark	0.9	0.15	0.7	1.5	2.75	2.40
Nominal rigidity	0				1.00	0.98
	1				6.67	4.67
Real rigidity		0.50			1.53	1.44
		0			4.20	3.36
Demand elasticity			0.3		1.47	1.23
			1.5		4.24	3.88
Policy reaction				1.0	0.70	0.57
				2.0	3.76	3.39

3.2. Empirical evidence

Estimates of the OSR in the literature vary widely, depending on the method used and the sample period. Based on Euro area data from 1985:1 to 2004:4, Coffinet et al. (2007) estimate the sacrifice ratio between 1.2 and 1.4. The Feldstein (1999a) report provides empirical evidence for the four countries included. Based on Ball (1994), Feldstein (1999b) chooses σ = 3 for the U.S. The preferred estimate of Bakshi et al. (1999) for the U.K. is σ = 2.8. For Spain Dolado et al. (1999) estimate σ = 2.6, both very close to the U.S. figure. For Germany, Tödter and Ziebarth (1999, 55) report estimates between 0.8 and 4.0. To avoid underestimation of disinflation costs, they use σ = 4, an estimate that was obtained by a simulation exercise with the structural macroeconometric model of the Bundesbank for Germany. Moreover, they assume that the Phillips curve is non-linear (Schelde-Andersen 1992; Huh and Jang 2007), such that disinflation costs rise more than proportional: $C(\pi) = 4\,\pi^{1.5}$. Table 18 collects the evidence. Thus, the benefit of price stability needs to exceed between 0.13 (Spain) and 0.28 percent of GDP (Germany) to render disinflation worthwhile.

Table 18: Disinflation costs of going from 2 percent to zero inflation (% of GDP)

	U.S.	Germany	U.K.	Spain
Sacrifice ratio	3	4	2.8	2.6
Disinflation costs	6	11.3	5.6	5.2
Ann. disinflation cost*)	0.15	0.28	0.14	0.13

*Source: Feldstein 1999a. *) Discount rate ρ - g = 2.5%*

3.3. A menu of choice

Table 19 summarizes the permanent annual welfare gain from reducing inflation from 2 percent to zero, i.e. the overall welfare gain of price stability (reported in Table 14) minus annualized disinflation costs (from Table 18).

Table 19: Benefits and costs of going from 2 percent to zero inflation (% of GDP)

	U.S.	Germany	U.K.	Spain
Benefits of price stability	1.04	1.41	0.29	1.88
Costs of disinflation (annualized)	0.15	0.28	0.14	0.13
Net welfare benefits	0.89	1.13	0.15	1.75

Source: Feldstein 1999a

In all four countries the estimated benefit of price stability exceeds the estimated disinflation costs. The lowest gain is reported for the U.K., while the highest gain is estimated for Spain. The net welfare gains reported for the U.S. and Germany are both around 1 percent of GDP per annum.

Sensitivity: Finally, some sensitivity considerations may be warranted. In the Feldstein report estimates of the benefits and (disinflation) costs of price stability were performed under the assumption of going from 2% inflation to zero. However, during the period underlying the estimates (1991-95 in the case of Germany), actual inflation was higher, 3.3% on average. To check the sensitivity of their results, Tödter and Ziebarth (1999, 80) calculated benefits and costs for different rates of disinflation, collected in the following menu of choice (Table 20).

Table 20: Menu of choice (Germany) (Benefits and costs as % of GDP)

Initial rate of inflation (%)	3.3	3.3	3.3	3.3	3.3	3.3
Rate of disinflation (%)	0.0	1.0	2.0	3.3	4.0	5.0
Final rate of inflation (%)	3.3	2.3	1.3	0	-0.7	-1.7
Benefits per annum	0.00	0.85	1.41	1.86	2.01	2.24
Costs of disinflation per annum	0.00	0.10	0.28	0.60	0.80	1.12
Net benefit	0.00	0.75	1.13	1.26	1.21	1.12
Loss of non-optimal disinflation	*-1.26*	*-0.51*	*-0.13*	*0.00*	*-0.05*	*-0.14*

Source: Tödter and Ziebarth (1999, 80)

Howitt (1990) postulated that a central bank should disinflate until the marginal gain from reducing inflation balances the marginal cost of doing so (Howitt's rule). Thus, according to this rule, reducing inflation from the (then) current level of 3.3% to zero would have been optimal, creating a permanent welfare gain of 1.26% of GDP. The benefit foregone by disinflating by only 2 percentage points would have been small (-0.13% of GDP).[41]

4. Conclusions

Milton Friedman's famous dictum that "*inflation is always and everywhere a monetary phenomenon*" is widely accepted nowadays. There is also a broad consensus that high, volatile and unanticipated inflation induces large costs. However, it is a remarkable result of research activities in the past decade that even low, steady and anticipated inflation creates substantial welfare losses.

Theory and evidence reviewed in this paper suggest that the benefits of price stability are large and permanent while the costs of disinflation are small in comparison and temporary. The money demand channel, though important at two-digit inflation, is of relatively minor importance at low rates of inflation. In contrast, the interaction of nominal-based tax codes and inflation creates powerful distortionary effects on the

[41] Taking into account that substitution effects and quality changes bias the measured consumer price index upwards (Boskin et al. 1996), exceeding the true rate of inflation by probably half a percentage point in the case of Germany (Hoffmann 1998, Deutsche Bundesbank 2002)), disinflating from 3.3% to 1.3% in the measured rate of inflation is almost consistent with price stability in the true rate of inflation and reduces the risk of hitting the zero nominal interest rate bound.

intertemporal allocation of savings and consumption. In combination with certain behavioral patterns (saving rates) and institutional facts (tax rules), even low inflation generates high welfare losses. Empirical country studies based on partial as well general equilibrium models for the U.S. and Germany suggest that a permanent welfare gain of about one percent of GDP, net of indirect tax effects and disinflation costs, can be obtained by eliminating two percent inflation. Expressed in present value terms, the net benefit of price stability reaches about 40% of GDP.[42]

Not all channels of inflation costs have yet been identified, thoroughly studied, modeled and quantified empirically. Especially costs of low inflation arising from higher probabilities of hitting the zero bound for nominal interest rates could potentially provide a justification for targeting low instead of zero or negative inflation. More work is certainly needed to complete our understanding of the benefits and costs of price stability. The welfare effects of inflation remain an important issue for future research that is likely to generate benefits for the economy that will outweigh its costs.

[42] At a discount rate of ρ-g = 2.5%.

References

Abel, A. B. (1997): Comment, in: C.D. Romer and D.H. Romer (eds.), *Reducing Inflation, Motivation and Strategy*, 156-166, Chicago and London: The University of Chicago Press.

Abel, A. B. (1999): Comment on Chapters 2, 3, and 4, Feldstein, M. (ed): *The Costs and Benefits of Price Stability,* Chicago and London: The University of Chicago Press, 180-191.

Aiyagari, S.R. (1991): Response to a Defense of Zero Inflation, Federal Reserve Bank of Minneapolis *Quarterly Review* (Spring), 21-24.

Akerlof, G.A. (2007): The Missing Motivation in Macroeconomics, *The American Economic Review* 97 (March), 5-36.

Akerlof, G., W. Dickens, and G. Perry (1996): The Macroeconomics of Low Inflation, *Brookings Papers on Economic Activity*, No. 1, 1-59.

Andrés, J. and I. Hernando (1999): Does Inflation Harm Economic Growth? Evidence from the OECD. in: M. Feldstein (ed.): *The Costs and Benefits of Price Stability*, 315-341, Chicago and London: The University of Chicago Press.

Attanasio, O.P., Guiso, L, Jappelli, T. (2002): The Demand for Money, Financial Innovation, and the Welfare Cost of Inflation: An Analysis with Household Data, *Journal of Political Economy*, 110 (2), 317-351.

Auerbach, A.J. (1981): Inflation and the Tax Treatment of Firm Behavior, *American Economic Review* 71 (May): 419-423.

Azar, S.A. (2007): Measuring the US Social Discount Rate Aversion, *Applied Financial Economics Letters* (3), 63-66.

Bailey, M.J. (1956): The Welfare Costs of Inflationary Finance, *Journal of Political Economy* 64 (2), 93-110

Bakhshi, H., A. Haldane, and N. Hatch (1999): Some Costs and Benefits of Price Stability in the United Kingdom, in: M. Feldstein (ed.): *The Costs and Benefits of Price Stability*, 95-132, Chicago and London: University of Chicago Press.

Ball, L. (1994): What Determines the Sacrifice Ratio?, in: N.G. Mankiw (ed.): *Monetary Policy*, 155-93, Chicago: The University of Chicago Press.

Barro, R.J. (1995): Inflation and Economic Growth, NBER Working Paper No. 5326, Cambridge, Mass.: National Bureau of Economic Research, October.

Baudry, L., H. Le Bihan, P. Sevestre, and S. Tarrieu (2007): What do Thirteen Million Price Records have to Say about Consumer Price Rigidity? *Oxford Bulletin of Economics and Statistics* 69 (2), 139-183.

Bernholz, P. (2003): *Monetary Regimes and Inflation*, Cheltenham, UK, Northampton, MA, USA: Edward Elgar.

Bewley, T. (1983): A Difficulty with the Optimum Quantity of Money, *Econometrica*, 51(5), 1485-1504.

Blanchard, O. and S. Fischer (1989): *Lectures on Macroeconomics*, Cambridge Mass.: The MIT Press.

Blanchard, O., and J. Gali (2007): Real Wage Rigidities and the New Keynesian Model, *Journal of Money, Credit and Banking*, Suppl. to Vol. 39 (1), 35-65.

Boskin, M.J., E. Dulberger, R. Gordon, Z. Griliches, and D. Jorgenson (1996): Toward a More Accurate Measure of the Cost of Living, Final Report to the Senate Finance Committee, December 4.

Briault, C. (1995): The Costs of Inflation, *Bank of England Quarterly Bulletin*, February, 33-45.

Bruno, M. and W. Easterly (1995): Inflation Crises and Long-run Growth. *NBER Working Paper* No. 5209, Cambridge, Mass.: National Bureau of Economic Research, October.
Bullard, J.B. and S. Russell (2004): How Costly is Sustained Low Inflation for the U.S. Economy? Federal Reserve Bank of St. Louis *Review* 86 (3), 35-67.
Cagan, P. (1956): The Monetary Dynamics of Hyperinflation, in: Milton Friedman (ed.) S*tudies in the Quantity Theory of Money*, Chicago: The University of Chicago Press.
Chakravarty, S. (1986): Cost-Benefit Analysis, *The New Palgrave*, 687-690.
Chari, V.V., L.K. Christiano and P. Kehoe (1996): Optimality of the Friedman Rule in Economies with Distorting Taxes, *Journal of Monetary Economics* 37, 203-223.
Chiu, J. and M. Molico (2007): Liquidity, Redistribution, and the Welfare Cost of Inflation, *Working Paper* 2007-39, Bank of Canada
Clower, R.W. (1967): A Reconsideration of the Micro foundations of Monetary Theory, *Western Economic Journal,* 6(1), 1-9.
Coenen, G. (2003): Zero Lower Bound: Is it a Problem in the Euro Area?, *ECB Working Paper No. 269*.
Coffinet, J., J. Matheron, and C. Poilly (2007): Estimating the Sacrifice Ratio for the Euro Area, Quarterly Selection of Articles, Banque de France, 8, 35-48
Cohen, D., K.A. Hasset, and R.G. Hubbard (1999): Inflation and the user Cost of Capital: Does Inflation Still Matter? in: M. Feldstein (ed.): *The Costs and Benefits of Price Stability,* 199-230, Chicago and London: The University of Chicago Press.
Cooley, T.F. and G. D. Hansen (1989): The Inflation Tax in a Real Business Cycle Model, *American Economic Review*, 79/4, 733-48.
Correia, I. and P. Teles (1999): The Optimal Inflation Tax, *Review of Economic Dynamics*, 2 (2), 325-46.
Craig, B. and G. Rocheteau (2005): Rethinking the Welfare Cost of Inflation, *Federal Reserve Bank of Cleveland*, March 1. 2005.
Craig, B. and G. Rocheteau (2007): Inflation and Welfare: A Search Approach, *Federal Reserve Bank of Cleveland*, 2/16/2007.
Darby, M. (1975): The Financial and Tax Effects of Monetary Policy on Interest Rates, *Economic Inquiry* 13 (June): 266-276.
DeJong, D.N. and C. Dave (2007): *Structural Macroeconometrics*, Princeton and Oxford: Princeton University Press.
Desai, M.A. and J.R. Hines jr. (1999): Excess Capital Flows and the Burden of Inflation in Open Economies, in: M. Feldstein (ed.): *The Costs and Benefits of Price Stability,* 235-268, Chicago and London: University of Chicago Press.
Deutsche Bundesbank (2002), Changes in the Official Consumer Price Statistics and their Implications for the “Measurement Bias“ in the inflation rate, *Monthly Report*, August 2002, 38-39.
Di Tella, R., R. MacCulloch, and A. Oswald. (2001): Preferences over Inflation and Unemployment: Evidence from Surveys of Happiness, *American Economic Review* 91 (1), 335-341.
Doepke, M., M. Schneider (2006): Inflation as a Redistribution Shock: Effects on Aggregates and Welfare, NBER Working Paper 12319, June.

Dolado, J.J., J.M. Gonález-Páramo, and José Viñals (1999): A Cost-Benefit Analysis of Going from Low Inflation to Price Stability in Spain, in: M. Feldstein (ed.): *The Costs and Benefits of Price Stability,* 95-132, Chicago and London: University of Chicago Press.

Dotsey, M. and P. Ireland (1996), The Welfare Cost of Inflation in General Equilibrium, *Journal of Monetary Economics* 37, 29-47.

Dowd, K. (1994): The Costs of Inflation and Disinflation, *Cato Journal*, 14 (2), 305-331

Driffill, J., G.E. Mizon, and A. Ulph (1990): Costs of Inflation, *Handbook of Monetary Economics*, Vol. II, ed. by. B.M. Friedman and F.H. Hahn, Amsterdam: North-Holland, 1014-1066.

Easterly, W. and S. Fischer (2001) Inflation and the Poor, *Journal of Money, Credit, and Banking* 33 (2), 160-178.

Eckstein, Z. and L. Leiderman (1992): Seigniorage and the Welfare Cost of Inflation: Evidence from an Intertemporal Model of Money and Consumption, *Journal of Monetary Economics*, June, 389-410.

English, W.B. (1999): Inflation and financial sector size, *Journal of Monetary Economics* 44, 379-400.

Ericsson, N. R., J.S. Irons, and R.W. Tryon (2000): Output and Inflation in the Long Run, *FRB International Finance Discussion Paper* No. 687, November.

Erosa, A. and G. Ventura (2002): On Inflation as a Regressive Consumption Tax, *Journal of Monetary Economics* 49 (4), 761-795.

Feenstra, R.C. (1986): Functional Equivalence Between Liquidity Costs and the Utility of Money, *Journal of Monetary Economics*, 17, 271-291.

Feldman, A.M. (1986): Welfare Economics, *The New Palgrave*, 889-895.

Feldstein, M. (1976): Inflation, Tax Rules and the Rate of Interest: A Theoretical Analysis, *American Economic Review* 66 (June): 809-820.

Feldstein, M. (1983): Inflation, Tax Rules, and Capital Formation, Chicago: University of Chicago Press.

Feldstein, M. (1997): The Costs and Benefits of Going from Low Inflation to Price Stability, in: C.D. Romer and D.H. Romer (eds.), *Reducing Inflation, Motivation and Strategy*, 123-156, Chicago and London: The University of Chicago Press.

Feldstein, M. (1999a): *The Costs and Benefits of Price Stability,* Chicago and London: The University of Chicago Press.

Feldstein, M. (1999b): Capital Income Taxes and the Benefit of Price Stability, in: M. Feldstein (ed.): *The Costs and Benefits of Price Stability,* 1-46, Chicago and London: The University of Chicago Press.

Feldstein, M., J. Green, and E. Sheshinski (1978): Inflation and Taxes in a growing Economy with Debt and Equity Finance, *Journal of Political Economy* 86, No. 2, pt. 2 (April): S53-S70.

Fischer, S. (1974): Money and the Production Function, *Economic Inquiry* 12: 517-533.

Fischer, S. (1993): The Role of Macroeconomic Factors in Growth. *Journal of Monetary Economics*, 32: 485-512.

Fischer, S., (1981): Towards an Understanding of the Costs of Inflation: II, *Carnegie-Rochester Conference Series on Public Policy* 15, 5-41.

Fischer, S. and F. Modigliani (1978): Towards an Understanding of the Real Effects and Costs of Inflation, *Weltwirtschaftliches Archiv* 114 (4): 810-33.

Fischer, S., R. Sahay, and C.A. Vegh (2002): Modern Hyper- and High Inflations, *Journal of Economic Literature* 40 (3), 837-80.

Fountas, S., and M. Karanasos (2007): Inflation, Output Growth, and Nominal and Real Uncertainty: Empirical Evidence for the G7, *Journal of International Money and Finance* 26, 229-250.
Friedman, M. (1969): The Optimum Quantity of Money, in: *The Optimum Quantity of Money and Other Essays*, Chicago: Aldine, 1-50
Gillman, M. (1995), Comparing Partial and General Equilibrium Estimates of the Welfare Cost of Inflation, *Contemporary Economic Policy*, XIII, 60-71.
Gomme, P. (1993): Money and Growth Revisited: Measuring the Costs of Inflation in an Endogenous Growth Model, *Journal of Monetary Economics* 32, 51-77.
Gordon, R.H. (1984): Inflation, Taxation, and Corporate Behavior, *Quarterly Journal of Economics* 94 (May): 313-317.
Gordon, R.J. (2006): The Boskin Commission Report: A Retrospective one Decade Later, *NBER Working Paper* 12311.
Grimes, A. (1991): The Effects of Inflation on Growth: Some International Evidence, *Weltwirtschaftliches Archiv* 127, 4, 631-644.
Groshen, E. L. and M.E. Schweitzer (1999): Identifying Inflation's Grease and Sand Effects in the Labor Market, in: M. Feldstein (ed.): *The Costs and Benefits of Price Stability,* 273-308, Chicago and London: The University of Chicago Press.
Hahn, F.H. (1965): On Some Problems of Proving the Existence of an Equilibrium in a Monetary Economy, in: F.H. Hahn and F.P.R. Brechling (eds.), *The Theory of Interest Rates*, London: Macmillan, pp. 126-135.
Harberger, A. C. (1954): Monopoly and Resource Allocation, *American Economic Review*, May, Vol. 44(2) , 77-87.
Haslag, J.H. (1997): Output, Growth, Welfare, and Inflation: A Survey, *Economic Review*, Federal Reserve Bank of Dallas, 11-21.
Haslag, J.H. (1995): Monetary Policy, Banking, and Growth, *Economic Inquiry*, 36(3), 489-500.
Heijdra, B.J. and F. van der Ploeg (2002): *The Foundations of Modern Macroeconomics*, Oxford: Oxford University Press.
Hines, J.R. Jr. (2002): Applied Public Finance Meets General Equilibrium: The Research Contributions of Arnold Harberger, University of Michigan and NBER, January.
Hoffmann, J. (1998): Problems of Inflation Measurement in Germany, Economic Research Group of the Deutsche Bundesbank Discussion Paper 1/98.
Howitt, P. (1990): Zero Inflation as a Long-Term Target for Monetary Policy, in: R.G. Lipsey (ed.) *Zero Inflation: The Goal of Price Stability*, Toronto: C.D. Howe Institute.
Huh, H. and I. Jang (2007): Nonlinear Philips Curve, Sacrifice Ration, and the Natural Rate of Unemployment, *Economic Modelling* (24), 797-813.
Ireland, P. (2007): On the Welfare Cost of Inflation and the Recent Behavior of Money Demand, *Boston College Working Papers in Economics* No 662.
Johansen, P.-O. (1991): *An Introduction to Modern Welfare Economics*, Cambridge: Cambridge University Press.
Kimball, M.S. (1990): Precautionary Saving in the Small and in the Large, *Econometrica* 58 (1), 53-73.
Knell, M. and Stix. H. (2005): The Income Elasticity of Money Demand: A Meta-Analysis of Empirical Results, *Journal of Economic Surveys*, 19 (3), 513-533.

Konieczny J.D. (1994): The Optimal Rate of Inflation: Competing Theories and their Relevance to Canada", in: Bank of Canada (ed.), *Economic Behaviour and Policy choice Under Price Stability*, Proceeding of a Conference held at the Bank of Canada, October 1993, Ottawa, 1-46.

Kyotaki, N., and R. Wright (1989): On Money as a Medium of Exchange, *Journal of Political Economy*, 97(4), 927-954.

Lacker, J.M. (1996): Stored Value Card: Costly Private Substitutes for Government Currency, Federal Reserve Bank of Richmond *Economic Quarterly*, 82, 1-25.

Lagos, R. and R. Wright (2005): A Unified Framework for Monetary Theory and Policy Analysis, *Journal of Political Economy*, 113, 463-84.

Le Blanc, F. (1690): Traité historique des monnayes de France, Paris; quoted by: L. Einaudi, 1953, The theory of imaginary money from Charlemagne to the French Revolution. In : *Enterprise and secular change*, ed. by F.C. Lane and J.S. Riemersma, 229-61, Homewood, Ill.: Irwin.

Lucas, R.E. Jr. (1973): Some International Evidence on Output-Inflation Tradeoffs, *The American Economic Review*, 63, 326-334.

Lucas, R.E. Jr. (1981): Discussion of Stanley Fischer, 'Towards an Understanding of the Costs of Inflation: II' in: K. Brunner and A. Meltzer (eds.), *The Cost and Consequences of Inflation*, Amsterdam: North Holland, 5-42.

Lucas, R.E. Jr. (2000): Inflation and Welfare, *Econometrica*, Vol. 68(2), 247-74.

Lucas, R.E. Jr. (2003): Macroeconomic Priorities, *American Economic Review* 93, 1-14.

Marty, A.L. (1976): A Note on the Welfare Cost of Money Creation, *Journal of Monetary Economics* 2, 1976, 121-24.

McCallum, B.T. (1983): The Role of Overlapping-Generations Models in Monetary Economics, *Carnegie-Rochester Conference Series on Public Policy*, New York: Macmillan Publishing Company

McCallum, B.T. (1989): Monetary Economics, Theory and Policy, New York; Macmillan Publishing Company.

McCallum, B.T., and M. S. Goodfried (1987): Demand for Money: Theoretical Studies, *The New Palgrave*, 775-781.

Meltzer, A.H. (1963): The Demand for Money: The Evidence from the Time Series, *Journal of Political Economy*, 71 (June), 219-246

Palenzuela, D.R., G. Camba-Mendez and J.A. Garcia (2003) : Relevant Economic Issues Concerning the Optimal Rate of Inflation, *ECB Working Paper* No. 278.

Patinkin, D. (1965): *Money, Interest and Prices*, 2nd ed., New York: Harper and Row.

Phelps, E. (1973): Inflation in the Theory of Public Finance, *Swedish Journal of Economics* 75, 67-82.

Romer, P.M. (1986): "Increasing Returns and Long-Run Growth", *Journal of Political Economy,* 94 (October), 1002-1037.

Romer, D. (2006): *Advanced Macroeconomics*, 3rd ed., Boston: McGraw-Hill.

Romer, C.D. and D.H. Romer (1997): *Reducing Inflation: Motivation and Strategy*, Chicago and London: The University of Chicago Press.

Romer, C.D. and D.H. Romer (1999): Monetary Policy and the Well-Being of the Poor, Federal Reserve Bank of Kansas City *Economic Review*, 21-49.

Rosen, H. (1985): Housing Subsidies: Effects on Housing Decisions, Efficiency and Equity, in M. Feldstein and A. Auerbach (eds.), *Handbook of Public Economics*, Vol. 1, Amsterdam: North Holland.

Rudd, J., and K. Whelan (2007): Modeling Inflation Dynamics: A Critical Review of Recent Research, *Journal of Money, Credit and Banking*, Suppl. to Vol. 39 (1), 155-170.

Samuelson, P.A. (1958): An Exact Consumption-Loan Model of Interest with or without the Social Contrivance of Money, *Journal of Political Economy*, 66(6), 467-482.

Sarel, M. (1996): Nonlinear Effects of Inflation on Economic Growth. *IMF Staff Papers* 42: 199-215.

Schelde-Andersen, P. (1992): OECD Country Experiences with Disinflation, in: A. Blundell-Wignall (ed.), Inflation, Disinflation and Monetary Policy, Sydney: Ambassador Press, 104-181.

Serletis, A. (2007): *The Demand for Money, Theoretical and Empirical Approaches*, 2nd. ed., Boston: Kluwer Academic Publishers.

Serletis, A. and Yavari, K. (2004), The Welfare Cost of Inflation in Canada and the United States, *Economics Letters*, 84, 2, 199-204.

Shiller, R.J. (1997): Why do People Dislike Inflation?, in C.D. Romer and D.H. Romer, *Reducing Inflation: Motivation and Strategy*, 13-65, Chicago and London: The University of Chicago Press.

Sidrauski, M. (1967): Rational Choice and Patterns of Growth in a Monetary Economy, *American Economic Review* 57: 534-44

Tödter, K.-H. (2002): Monetary Policy Indicators and Policy Rules in the P-star Model, *Discussion Paper* 18/092, Economic Research Centre of the Deutsche Bundesbank.

Tödter, K.-H. (2007): Estimating the Uncertainty of Relative Risk Aversion, *Applied Financial Economics Letters*, forthcoming.

Tödter, K.-H., and G. Ziebarth (1999): Price Stability versus Low Inflation in Germany: An Analysis of Costs and Benefits, in: M. Feldstein (ed.): *The Costs and Benefits of Price Stability*, 47-94, Chicago and London: The University of Chicago Press.

Tower, E. (1971): More on the Welfare Cost of Inflationary Finance, *Journal of Money, Credit, and Banking*, 3, 1971, 850-60.

Wallace, N (1980): The Overlapping Generations Model of Fiat Money, in: J. Kareken and N. Wallace, eds., *Models of Monetary Economies*, Federal Reserve Bank of Minneapolis.

Wolman A.L. (1997): Zero Inflation and the Friedman Rule: A Welfare Comparison, Federal Reserve Bank of Richmond *Economic Quarterly* 83/4, 1- 21.

Walsh, C.E. (2003): *Monetary Theory and Policy*, Cambridge, Mass.: The MIT Press, 2nd ed.

Weber, A. (2007): A Central Banker's Interest in Phillips Curves, Symposium on "The Phillips Curve and the Natural Rate of Unemployment" at the Kiel Institute for the World Economy, Kiel, 3 June 2007

Wood, J. (2005): *A History of Central Banking in Great Britain and the United States*, Cambridge: Cambridge University Press.

Yates, T. (2004): Monetary Policy and the Zero Bound to Interest Rates: A Review, *Journal of Economic Survey*, 18 (3), 427- 481.

Zee, H. H. (2000): Welfare Cost of (Low) Inflation: A General Equilibrium Perspective, *Finanzarchiv*, 57, 376-93.

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