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SOME COSTS AND BENEFITS OF PRICE STABILITY IN THE UNITED KINGDOM

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ABSTRACT

In a previous attempt to articulate the costs of inflation (Leigh-Pemberton (1992)), the Bank of England outlined the following costs of a *fully-anticipated* inflation:

- the cost of economising on real money balances -- so-called 'shoe-leather' effects;
- the costs of operating a less-than-perfectly indexed tax system;
- the costs of 'front-end loading' of nominal debt contracts;
- the cost of constantly revising price lists -- so called 'menu costs'

Feldstein (1996) quantified the first two of these costs when moving from 2% inflation to price stability in the U.S. Feldstein concluded that the permanent welfare gains through these two channels -- suitably discounted -- alone exceeded the transient costs of doing so. This paper aims to replicate Feldstein's analysis for the U.K.

Welfare effects are quantified using deadweight loss analysis familiar from public finance economics. Because inflation exacerbates tax distortions that exist even without inflation, the welfare costs are *trapezoids* rather than the usual triangles, or, alternatively, first-order rather than second-order losses.

We find that the welfare gains from moving to price stability through the two channels identified above are *lower* in the United Kingdom compared with the United States. Differences in the two countries' tax systems are mainly responsible for this result.

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Summary

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Welfare effects are quantified using deadweight loss analysis familiar from public finance economics. Because inflation exacerbates tax distortions that exist even without inflation, the welfare losses are *trapezoids* rather than the usual triangles, or, alternatively, first-order rather than second-order losses.

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The paper is organised as follows. Following the introduction in section I, section II quantifies the output costs of disinflationary transition; and it quantifies the discounted flow of future benefits needed to offset this cost. Section III calculates distortions to rates of return resulting from inflation. Sections IV and V look at similar distortions affecting owner-occupied housing and money demand; while section VI considers the impact on government debt servicing. Finally, the concluding section draws these estimates together and suggests some policy conclusions and extensions. These estimates are summarised in Table 1 for the

United Kingdom; while Table 2 provides the equivalent estimates for the United States as a counterpoint.

SOME COSTS AND BENEFITS OF PRICE STABILITY IN THE UK

I. Introduction

There is now widespread acceptance of price stability as a macroeconomic objective among policymakers. This price stability consensus appears to extend to the public at large and, to lesser extent, to professional economists too. That is the good news from Shiller's (1996) survey of these two sets of agents. The bad news from the survey is the reason the public gave for disliking inflation: it was thought to have eroded real wages over time, something which is patently at odds with the facts. There are two ways to interpret Shiller's results. The pessimistic interpretation would be to take Shiller's findings at face value and conclude that the costs of inflation are, literally, illusory - they derive from money illusion. The optimistic interpretation would be that policymakers and academics have, to date, done a poor job of identifying, quantifying and ultimately advertising the costs of inflation to the public.

With the optimistic interpretation in mind, this paper aims to identify and quantify some such costs for the United Kingdom. Much has been written on the *theoretical* justification for stable prices (Fischer and Modigliani (1975) is a classic treatment; see also Driffill, Mizon and Ulph (1990), Fischer (1981) and Briault (1995) for surveys). But there is less *empirical* work quantifying the costs and benefits of price stability and, particularly, placing them in a welfare context.

One of the few previous attempts by the Bank of England to articulate concretely some of the costs of inflation (Leigh-Pemberton (1992)) listed the following costs of a *fully anticipated* inflation:

- the cost of economising on real money balances - so-called "shoe-leather" effects;
- the costs of operating a less-than-perfectly indexed tax system;
- the costs of "front-end loading" of nominal debt contracts;
- the cost of constantly revising price lists - so-called "menu costs".

Feldstein (1996) seeks to quantify the first two of these costs when moving from 2% inflation to price stability in the US. That is the primary aim of this paper too. It focuses on distortions to saving, (housing and business) investment and money demand decision-making brought about by a fully anticipated 2% inflation tax, operating either unilaterally or, more often, in tandem with the tax system in the UK.[1] The paper also explores the indirect effects on the government's period-by-period budget constraint of a shift to price stability. We end up with estimates of the costs of inflation in the UK that work through the channels identified by Feldstein in the US. Exercises such as this inevitably require simplifying assumptions. So we also conduct some sensitivity analysis on our results. The analysis is clearly restrictive, as it ignores many of the other welfare costs of inflation - for example, those associated with *un*anticipated inflation. Because of this, the paper is best seen as quantifying a subset of the feasible range of welfare benefits which lower inflation might engender; it is strictly a lower bound. In other words, we calculate *some* of the benefits of lower inflation and then compare those with an estimate of the *total* cost of disinflating. This is rather a tough test.

Focusing on the effects of fully-anticipated inflation means that the welfare costs we consider are the deadweight loss triangles familiar from public finance economics.[2] Until recently, many economists have believed that the costs of fully-anticipated inflation are relatively unimportant; or at least that they are less important than the costs of *un*anticipated inflation. In a celebrated quote, Tobin summarised this view in "...it takes a heap of Harberger triangles to fill an Okun gap". And on the face of it, there is little in the aggregate time-series or cross-section data to question this view at the levels of inflation currently prevailing within developed economies.

For example, in a cross-section study of over 100 countries, Barro (1995) finds little relationship between inflation and growth at rates of inflation below 10% - though at rates of inflation above this there is evidence of inflation being a significant drag on growth. Likewise, Sarel (1996) finds no evidence of inflation inhibiting growth at rates of inflation below 8% - but, again, that there are significantly adverse effects on growth at rates of inflation above this.[3] Looking at one level of disaggregation, Rudebusch and Wilcox (1994) find a significant inverse relationship between productivity growth and inflation in the US over the period 1955-93. But even that relationship appears to disintegrate in the UK at levels of inflation below 5% (Bianchi and Smith (1995)).[4] Taken together, there is little from this aggregate evidence strongly to support a move from single-digit inflation figures to price stability.

There are at least three reasons why these empirical studies are, by themselves, insufficient to close the case for price stability. First, even if lower inflation has little or no effect on an economy's *growth* rate, it can still generate a permanent boost to the *level* of GDP, with potentially infinitely-lived effects on welfare (Feldstein (1979)). The resulting welfare gain may well then have a large present value even if, at first blush, its first-round effect appears trivial. By contrast, in a world of policy neutrality, the welfare costs of disinflating are likely to be one-off and transient. So welfare analysis of the costs and benefits of inflation is inevitably a comparison between *static* costs and *dynamic* benefits - with the odds correspondingly weighted in favour of the latter (see King (1994)). Importantly, such effects may well go undetected by empirical studies looking at secular *growth* rates over long runs of data.

Second, aggregate time-series may simply be too crude a tool to pick up some of the distorting effects of inflation - especially as such distortions are likely to be smaller and more subtle at lower rates of inflation. One response to this mixed bag of macro-empirical results would therefore be to look directly at the *micro*-level decisions which inflation is thought likely to be distorting. That has been the response most recently among general equilibrium real business cycle theorists (*inter alia*, Cooley and Hansen (1989), Dotsey and Ireland (1996)). By viewing inflation as a tax on micro-level decisions, these authors have been able to identify explicitly, and quantify empirically, some sizeable welfare costs of inflation at the macroeconomic level. This is broadly our approach too, though within a *partial* rather than *general* equilibrium setting.

Third, in a world of existing distortionary taxes, the consumer surplus forgone by the interaction of taxes and inflation is not just the conventional Harberger deadweight loss *triangle*, but a *trapezoid*.[5] Or, put differently, adding a distortion - inflation - to an existing distortion - taxes - is likely to lead to welfare losses which are first rather than second-order in a world of unindexed tax systems. Because these first-order distortions derive inherently from the *interaction* between inflation and taxes, we cannot then uniquely ascribe these welfare costs to a failure of monetary policy. Fiscal policy could equally well step into the breach. But what we can identify is the welfare benefits monetary policy, acting via lower inflation, might bring. And in the absence of a response from fiscal policy, these effects will be first- rather than second-order or trapezoids rather than triangles.

So what is the precise experiment we simulate? Much of the existing literature focuses on comparative static comparisons of low and moderate inflation - for example, the costs of moving from 10% to zero inflation. That type of experiment seems less apposite in today's low-inflation environment. For example, in the UK RPIX inflation - retail prices excluding mortgage interest payments, the government's targeted measure of consumer prices - averaged 12.7% in the 1970s, 7.0% in the 1980s, but has fallen to average 4.4% in the 1990s so far. Feldstein's (1996) study draws data from the period 1960-1994 in the US, during which time inflation averaged 4-5%. Making an allowance for the measurement bias in the US CPI of 2%,[6] a shift to price stability would then be equivalent to a 2% point fall in inflation from its historical levels in the US. That is the policy experiment Feldstein simulates.

In the United Kingdom, RPIX inflation is currently around 3%. It is widely thought that available price indices overstate inflation but estimates of the extent of the overstatement are highly uncertain. Cunningham (1996) quotes a possible range of central estimates of 0.35-1.3% per year. It is possible that starting from its *current* position, a 2 percentage point reduction in inflation would deliver approximate price stability in the UK. So this is the experiment we consider for the UK: a 2% point fall in inflation, as in Feldstein's US study. Historically, of course, UK inflation has been rather higher than 3%, averaging 6%-7% between 1970-95.[7]

The paper is organised as follows. Section II quantifies the output costs of disinflationary transition; and it quantifies the discounted flow of future benefits needed to offset this cost. Section III calculates distortions to rates of return - and hence to the price of retirement consumption - resulting from inflation. Sections IV and V look at similar distortions affecting owner-occupied housing and money demand; while section VI considers the impact on government debt servicing. Finally, the concluding section draws these estimates together and suggests some policy conclusions and extensions.[8] These estimates are summarised in Table 1 for the United Kingdom; while Table 2 provides the equivalent estimates for the United States as a counterpoint.

II. The Costs of Disinflation

(a) Ball's Sacrifice Ratio for the UK

We begin by calculating some estimates of the output cost of a 2% point reduction in inflation in the UK. Feldstein uses Ball's (1994) well-known work on the sacrifice ratio. Ball's approach is to estimate the cumulated loss in output required for each percentage point reduction in inflation. The resulting event study sacrifice ratio estimates for the UK, based upon two events in the 1960s, one in the 1970s and a further two in the 1980s, are summarised in Table 3. They suggest numbers which are typically smaller than those found by Ball for the US, averaging less than 1% compared with 2-3% in the US.

But just how robust are these estimates? One reason to be sceptical is that structural reforms in the UK in the 1980s - in particular in the labour market - may have led to a change in the short-run trade-off between inflation (wages) and output (unemployment).[9] Ball's last estimate for the UK relates to the period 1984-1986 and is thus unlikely to capture these changes. Moreover, his latest estimates may be distorted by two supply shocks at either end of the sample: the 1984 miners' strike and the 1986 oil price shock. Further, the estimated trade-off might be different - less favourable - at the lower rates of inflation prevailing in the 1990s, compared to the 1970s and 1980s.[10] Recognising this, we used Ball's approach to calculate an updated estimate of the sacrifice ratio for the most recent disinflationary episode in the UK between 1990Q3-1994Q4. As shown in Table 3, the ratio is considerably higher than earlier estimates, suggesting around a 3% output loss for each percentage point reduction in inflation. This is consistent with the notion of a flatter Phillips curve at lower rates of inflation and is more in line with the US evidence.

(b) Breakeven Benefits from Price Stability

If we take these estimates at face value, then the cost of reducing inflation by 2% points in the UK would be around 6% of annual output - close to Ball's US estimates. With this cost estimate, we can then calculate the welfare gain (as a percentage of initial GDP) necessary to counterbalance this cost on the assumptions: (a) that the welfare gain accrues indefinitely into the future; (b) that any future gains are discounted to give us a present value; and (c) that, following Feldstein (1979), we make an allowance for growth effects - the fact that the level of the GDP base on which the welfare cost is being calculated grows over time. The net benefit (B, as a % of initial GDP) which ensures that disinflationary costs (C, also as a % of initial GDP) are exactly counterbalanced - the breakeven benefit - is given by:

$$B = C * (r - g) \qquad (1)$$

where r is the discount rate and g is the steady-state growth rate of the economy. Real growth in the UK economy over the last 25 years has averaged around 2% (g=0.02).[11] For the discount rate, following Feldstein (1996), we take the average net of tax real rate of return that an individual investor earned on a risky equity portfolio (the FT-SE All-Industrials Index) between 1970-95.[12] Over this period, the FT-SE All-Industrials Index rose by 10.6% in nominal terms, with an average dividend yield of 4.9%. We need to adjust both dividend and capital gains income for taxes. For dividends, we assume an average marginal tax rate of 28.7% over the period.[13] For capital gains, we assume that realised gains are subject to the higher capital gains tax rate of 40% - that most capital gain investment income accrues to higher rate income tax payers. But we need to make two further adjustments to the marginal tax rate on capital gains to arrive at an *effective* marginal tax rate. First, capital gains tax is indexed in the UK, so it is only *real* capital gains that are subject to tax. Second, we need to make an adjustment for the £6,000 annual exemption limit on capital gains and for the fact that gains accrued but unrealised at death are exempt from capital gains tax.[14] The Inland Revenue publish estimates of the tax revenue lost through the two exemptions and the indexation allowance. Adding these to actual capital gains tax revenue and using the 40% marginal tax rate allows us to derive an estimate of the underlying total capital gain. When combined with the actual figure for capital gains tax revenue, this provides an estimate of the effective capital gains tax rate. Using data for financial year 1994/95 gives an effective tax rate on capital gains of 14.1% - which is similar to Feldstein's estimate of 10%. Finally, note that RPIX inflation averaged 8.6% over the period 1970-95. Netting-off the measurement bias thus gives a "true" inflation rate of 7.3%. Our estimate of the discount rate is then r=5.3% ((1-0.141)10.6+(1-0.287)4.9-7.3) - again not too different than Feldstein's US estimate.

From (1), this higher estimate of the discount rate, taken together with the UK's lower average real growth rate than the US, raises the breakeven benefit, B, necessary to offset disinflationary costs. For the United Kingdom the breakeven benefit is 0.18% of GDP, compared with 0.16% in Feldstein's study.

(c) Some Sensitivity Analysis

There are obviously risks to this present value calculus; it is sensitive to the underlying assumptions regarding r, g and C. Particular risks attach to estimates of r and C. On discount rates, at one extreme Ramsey (1928) argued that any discounting of the utility of future generations was "ethically indefensible" - in which case the net benefits of moving to price stability would be infinite. At the other extreme, it is well-known that firms in the UK often discount future income streams at much higher rates than would be implied by returns on the stock market (Wardlow (1994)). Our discount rate estimate steers a - conservative - middle course between these extremes by taking a risky real return as a benchmark.

Just how conservative this discount rate estimate is can be gauged by looking at two alternatives. For example, it could be argued that the appropriate real return is one on a debt and equity, rather than a pure equity, portfolio. Over the period 1970-95, the real after-tax return to government bonds in the UK was only 0.2%.[15] That would drag down markedly the implied discount rate for any plausible personal sector asset gearing ratio. Alternatively, following Feldstein (1995), we might derive a discount rate directly from the utility function. For example, assuming CES preferences and equating the discount rate with the marginal rate of substitution of consumption over time, it follows that:

$$(3) \qquad 1 + r = (1 + w - n)^{\gamma}$$

where γ is the elasticity of marginal utility, and w and n are steady-state aggregate wage and population growth. Taking γ=2 from Feldstein (1995) and plugging in values for w and n gives r=3.2% - similar to Feldstein's US estimate of 3.0%. This again would imply a much larger - and potentially infinite - present value of welfare gains. In sum, the risks to our welfare estimates from the discount rate appear clearly to lie on the upside.

Another area of particular uncertainty - most likely working in the opposite direction - concerns the cost estimate, C. There are theoretical arguments, and some empirical evidence, to suggest Ball's estimates may understate the costs of transitioning to price stability. There are at least two such transition costs. First, as illustrated in Table 3, temporary disinflationary costs may be higher at lower rates of inflation. That would imply that even the 1990s' sacrifice ratio for the UK may be an understatement of the true output costs of achieving price stability. There are several strands of empirical evidence which point in this direction. For example, Laxton, Meredith and Rose (1995) find strong evidence of Phillips curve convexities among the G7. And a similar result emerges from the work of Ball, Mankiw and Romer (BMR, 1988), looking at a cross-section of 43 industrialised countries.[16] Indeed, Ball's (1994) own work finds some (albeit weak) evidence of the initial level of inflation affecting the size of the sacrifice ratio.

It is unclear, theoretically, why such asymmetries may exist - and hence whether they are likely to survive a shift in inflation regime. For example, rigidities in prices and wages - due, say, to psychological or legal impediments to nominal wage cuts - could be an explanation of Phillips curve convexities.[17] But these may well disappear if a shift to price stability is deemed credible. Other - real - rigidities may be more entrenched. One way of gauging possible Phillips curve convexities in a regime approximating price stability is to look at pre-War historical evidence. Chart 1, for example, is a simple scatter plot of inflation/growth outcomes over the period 1832-1942 in the UK, together with a second-order polynomial line of best fit.[18] While there is some evidence of convexity, the degree of curvature is not great enough to suggest that our transitional cost estimates are a significant understatement.

A second potential cost of transitioning to price stability, which goes unquantified by Ball's (1994) analysis, is hysteresis - *permanent* - effects on output.[19] The empirical evidence on hysteresis effects has been equivocal. But a recent paper by Ball (1996) himself presents cross-section evidence to suggest that hysteretic effects on the NAIRU may have been both commonplace and large during recent disinflations among the OECD countries. On the assumption that any disinflation has a permanent effect on the *level* of output, the breakeven benefit becomes:

(4) $$B = C * (r - g) + D$$

where D is the effect of a disinflation on the natural level of output. If we take Ball's (1996) cross-section estimates at face value, then each percentage point of disinflation is associated with a 0.42% point rise in the NAIRU (Ball (1996), Table II). Taking a (conservative) estimate of Okun's Law coefficient of 2, this would imply a 1.7% fall in the level of output for a 2% point disinflation.[20] This then raises the break-even benefit to around 1.9% - possibly exceeding the benefits which Feldstein finds for the US. This hysteresis estimate is no doubt an upper bound. Over the 1980s, Ball's estimate of the UK NAIRU rose by 1.1% points, while inflation fell by 8.5% points over the same period. This would imply a much lower hysteresis coefficient of maybe 0.1 in the UK - though even this would raise the break-even benefit to just under 0.6%. Further, it could be that Ball is picking up highly persistent, rather than permanent effects from disinflation on the NAIRU.[21] The present value of these losses would then be overstated. But notwithstanding these caveats, it is clear that hysteresis effects, even if modest, have the potential to alter radically any cost-benefit evaluation of price stability.[22]

The above are indicative of the risks to the cost-benefit calculus. Chart 2 conducts some sensitivity analysis of the breakeven benefit to different assumptions about the disinflationary costs, *C* and the discount rate, *r*. Intuitively, the more GDP that is lost for each percentage point reduction in inflation, the higher the welfare benefit required to make disinflation worthwhile. Similarly, the higher the discount rate, the higher the welfare benefit that is required. To take a specific example, assume welfare gains of 0.2% of GDP (as we calculate later in the paper). A welfare gain of 0.2% of GDP corresponds to the thick line between the two shaded areas closest to the bottom left corner and the four shaded areas in the top right on the chart. For any pair of parameter values lying in the two areas (below the line), welfare benefits of 0.2% would be sufficient to offset disinflationary costs. So even with high estimates of the output costs of disinflation - say, 6% of a year's output lost for a 2 percentage point reduction in inflation - the welfare benefits of reducing inflation exceed the output costs of doing so.

III. Inflation and the Intertemporal Allocation of Consumption

(a) Distortions to Saving Behaviour

For households, there are two main expenditure decisions to be made: how much to consume and how much to invest in each period. This section focuses on how household *consumption* decisions are affected by inflation; while the next section considers the impact of inflation on housing *investment* decisions.

Feldstein (1996) derives the welfare gain from reducing inflation in a two-period consumption model. Individuals are given an initial endowment and then decide how much to save in the first period in order to consume when they retire in the second period. Agents' first-period savings earn a real rate of return. So the period one price of retirement consumption (p) can be thought to be inversely related to this rate of return - the higher the return on savings, the cheaper the effective price of retirement consumption. It is here that inflation and the tax system come into play. Taxes drive a wedge between the pre-tax rate of return - which is assumed to be invariant to inflation - and the post-tax return which households earn. Higher inflation raises the tax wedge and reduces the effective (real) post-tax return to saving. This lowers retirement consumption from its (zero tax, zero inflation) optimum, with corresponding welfare implications. Rather than reproduce the basic arguments and calculations here, the gain to households from increased retirement consumption resulting from a reduction in inflation is simply stated here as equation (5) (see Feldstein (1996), equation (4) and Figure 1):

$$G_1 = C + D = [(p_1 - p_0)/p_2 + 0.5(p_2 - p_1)/p_2]\,[(p_2 - p_1)/p_2] S_2 (1 - \eta_{Sp} - \sigma) \qquad (5)$$

where p_0 is the price of retirement consumption at zero inflation with no distortionary taxes; p_1 is the retirement price evaluated under the current tax regime with zero inflation; p_2 is the price evaluated under the current tax regime with 2% inflation; S_2 represents the initial gross saving of individuals at the early stage of their life-cycle; η_{Sp} is the uncompensated elasticity of saving with respect to the price of retirement consumption; and σ is the propensity to save out of exogenous income. The welfare gain associated with a reduction of inflation (and hence with a reduction in the retirement price p_2-p_1) is the area under the compensated demand curve, the trapezoid C+D in Figure 1. To evaluate (5), we first need a measure of the price of retirement consumption. Feldstein (1996) calculates this as $(1+r)^{-T}$ where r is the real post-tax rate of return and T is the number of years which agents engage in saving for retirement. Following Feldstein, we take T=30 years.[23]

To calculate p_0 we require a *pre-tax* rate of return to capital for UK industrial and commercial corporations. Such data are published by the UK Office for National Statistics. Between 1970-95, this real rate of return averaged 8.2%. It is slightly below returns in the United States.[24] Using OECD data as a cross-check confirms that returns to capital in the United Kingdom have on average been below those in the United States over the last thirty years. Translating the estimated pre-tax return into a price of retirement consumption in the absence of taxes, $p_0=(1.082)^{-30}=0.094$.

To estimate a real return to saving in a world of taxes and inflation, we need to adjust the above figures for both corporate and personal sector taxes. The United States operates a "classical" tax system under which dividends are taxed twice, once as profits at the corporate level and again as income at the personal level. By contrast, the United Kingdom operates an imputation tax system which provides protection against the double taxation of dividends through a system of Advance Corporation Tax (ACT). When dividends are paid to individuals the companies pay ACT, currently 20% of gross dividends (25% of net dividends), but can use this payment to offset their later liability to Mainstream Corporation Tax (MCT).[25] Individuals can then use this payment against their total tax liability at the end of the financial year. Individuals who have marginal tax rates above or below the ACT rate will incur a credit or debit accordingly. An example illustrates the imputation system (see Table 4).

In our calculations we take payments of MCT having netted-off ACT payments (to prevent double-counting). We then deal with the taxation of dividends at the personal level. These MCT payments amounted to some 22% of firms' pre-tax profits in 1995. This tax ratio is not zero because not all profits are distributed and because corporate tax rates are on average generally higher than personal tax rates. *Ceteris paribus*, this leads to higher tax payments the lower the dividend payout ratio. But the effective tax rate is still much lower than the corresponding US figure, reflecting the difference between the US (classical) and UK (imputation) systems of dividend taxation. Netting-off this ratio leaves a post-tax rate of return of 6.38%.

To arrive at a real post-tax return for savers, we also need to take account of personal taxes. What we need for our policy simulations are measures of the currently effective marginal tax rates on capital income. But these effective marginal tax rates depend on how this income is received (dividends, capital gains, interest income) and the tax status of the individual. Feldstein proxies these effects by assuming an individual marginal tax rate of 25% across all sources of income. We look at one level of disaggregation, identifying separately average marginal tax rates on interest income, dividends and capital gains and then weighting these to give an individual marginal tax rate. At this stage we make no allowance for tax-exempt savings, which are important in the United Kingdom. We assume, in effect, that marginal savings flow into taxable assets. But we return to this issue below, when we conduct some sensitivity analysis assuming a different - tax-exempt - margin.

For dividends we begin by calculating an average marginal tax rate on dividends using Inland Revenue individual data for financial year 1994/95 and the methodology in Robson (1988). This gives a headline tax rate of 28.7%. For interest income on corporate bonds we use a headline marginal tax rate of 31.1%, again based on Inland Revenue figures for 1994/5. The headline marginal tax rate on capital gains (on equity and bonds) is that used earlier when calculating the discount rate - 14.1%.

For the weights on dividends, capital gains and bond interest income, Feldstein assumes the same debt-equity split for persons as for companies. That amounts to assuming that the corporate sector is owned directly by households. This assumption is, in turn, only valid under three conditions. First, when open economy considerations are unimportant. Second, when there are no debt-equity transformations through financial intermediation. And third, when personal sector net banking assets are counterbalanced by their net banking liabilities, so that bank loans to companies are not backed by household saving. For the US - a relatively closed economy where many debt and equity holdings are direct - these are reasonable approximations.

But the UK situation is rather different. Overseas holdings of UK company securities amounted to over 18% of these companies' balance sheets in 1995; while around 5% of the personal sector's equity holdings were with overseas companies. Further, the majority of households' equity and debt holdings are indirect - through pension funds, unit trusts and such like - that may transform corporate debt to equity or vice versa. To overcome these problems, we take the debt-equity split directly from the personal sector's balance sheet, by explicitly identifying their (direct and indirect) holdings of UK companies' capital using sectoral flow of funds data. That negates the problems of overseas holdings of company capital and possible debt-equity transformations of assets as they pass from the corporate to personal sectors. Doing this gives a 95%/5% split of personal sector *non-bank* assets between equity and debt.[26] We then use this asset split when accounting for the incidence of personal taxation on corporate bonds and equity. For the dividends (interest)/capital gains split of equity (bond) income, we assume that individuals receive income from dividends (interest) and capital gains in broadly the same ratio used in our discount rate calculation - roughly 60/40.

But to the extent that the personal sector's net *banking* assets are also indirectly financing UK companies' bank loans, we need to take account of these too.[27] Feldstein sidesteps this problem by assuming household bank deposits and bank loans are offsetting. UK companies held net banking liabilities of around £60bn in 1995. Because of the nature of banking, it is impossible to say which of these were financed from personal sector deposits and which from other sources. But if we assume that net bank loans to companies were effectively financed from personal deposits, we can calculate a marginal effective personal tax rate inclusive of the banking sector.[28] The weights in the personal sector's balance sheet are then 5%/89%/6% for corporate bonds, equity and deposits respectively.[29] For the average marginal tax rate on deposits we apply a rate of 23.6%, comprising a 26.2% tax rate on interest-bearing deposits and, trivially, a zero rate on non-interest-bearing deposits.

Using these weights and our adjusted average marginal tax rates gives us a total effective marginal individual tax rate of 23.0%. This implies a real net rate of return to savers in the UK of around 4.9%, which corresponds to a price of retirement consumption of 0.237 evaluated at 2% inflation. The wedge between pre- and post-tax returns in the UK (3.3%) is around two-thirds that in the US case (5.13%). This largely reflects the effects of ACT.

We now calculate the effect on the post-tax real return to saving - and hence on the price of retirement consumption - of a reduction in inflation of 2% points. Work in the UK, along similar lines to that in the US, has shown that inflation tends to increase effective tax rates for both the personal and corporate sector. For companies, this inflation non-neutrality in the UK tax system has three sources. First, since 1984 UK companies have received no stock relief: that is, any nominal capital gains made on inventories as a result of general price level rises are treated as taxable profit. Second, depreciation allowances are based on historic cost asset valuations and are thus reduced in real terms by inflation. And third, acting against the first two effects, is the fact that nominal debt interest payments are tax-deductible.[30]

Bond, Devereux and Freeman (1990) calibrate these inflation non-neutralities using micro-level data drawn from company accounts. They estimate that moving from 10% inflation to price stability is associated with a decrease in companies' effective tax rate of over one third. Making an assumption about the initial pre-tax rate of return, and assuming a fixed capital stock, we can translate this ready-reckoner into an effect of inflation on companies' profit rates. The rule-of-thumb we use, based on Bond *et al* (1990), is that a 1% point fall in inflation is associated with a 0.37% point rise in the taxable profit rate.[31] We take the average marginal corporation tax rate to be 32%, based on Inland Revenue data.[32] The effect of a 2% point reduction in inflation is hence to raise the post-tax return to savers by 0.32*0.37*0.02=0.0024 (0.24% points) as a result of corporation tax non-neutralities. That is, the rate of return after corporate taxes is raised from 6.38% to 6.62%.

The effect of inflation on households' effective tax rates depends on the debt-equity-deposit composition of their asset portfolio. We assume the same weights as earlier. For equity holdings, one key difference with the US is that since 1985 capital gains in the UK have been indexed. This effectively neutralises any effect from a change in inflation on equity income.[33] Taken alongside the higher proportion of equity in UK households' portfolios, this reduces substantially the fall in effective tax rates - and hence the rise in post-tax savings rates - induced by a fall in inflation.

But a change in inflation *does* affect marginal tax rates on deposits and corporate debt, because it is nominal interest income which is taxed. For deposits and for debt, we use our earlier average marginal effective tax rates of 23.6% and 31.1% respectively. Taking these debt and deposit non-neutralities together, this gives a 0.06% point reduction in the effective tax rate for a 2 percentage point fall in inflation. This then raises the post-tax rate of return to individuals to 5.16% and implies that the price of retirement consumption falls to p_1=0.22 when inflation is zero. In the United Kingdom the move to price stability has less effect on the post-tax savings rate (around 0.24 percentage points) than in the US (around 0.49% points). This is due largely to the indexation of capital gains and the greater importance of equity as a source of personal sector income in the UK.

The price of retirement consumption under the various tax and inflation assumptions (p_1, p_2 and p_0) can now be substituted into (5), to give:

(6) $$G_1 = 0.038\, S_2\, (1 - \eta_{Sp} - \sigma)$$

To evaluate (6), we need an estimate of the saving of the young at an inflation rate of 2% (S_2). Feldstein derives an estimate from the steady state relationship between savers and dis-savers implied by the two-period model. He shows that the saving of the young is $(1+n+g)^T$ times the saving of the older generation, where n is the rate of population growth and g is the growth in per capita wages. If we follow that approach, real aggregate wage growth in the UK between 1970 and 1995 was 2%, somewhat lower than in the US. Taking n+g=0.02 and T=30 implies that the saving of the young is around 2.23 times the *net* personal saving rate.

Given an average UK personal saving rate of 9.2% of GDP between 1970-95, this implies that S_2 is around 21% of GDP, more than double the US figure.

This figure for gross saving seems high.[34] So we also considered some complementary micro evidence from the US Consumer Expenditure Survey and the UK Family Expenditure Survey. Table 5 shows the saving ratio in 1990 of a set of population cohorts spanning the age range 30-60 in the US (from Attanasio (1994)) and the UK (Banks and Blundell (1994)). This is the age range likely to match most closely with the theoretical notion of first-period savers, as the very young are likely to be net borrowers and the very old gross dis-savers.

Table 5 suggests two things.[35] First, that there is little difference between saving ratios in the UK and US over the 30-60 year age range; they both average around 11%. And second, that the UK saving ratio of the young is nearer to 10% than to the 21% implied by the macro-estimates above. In what follows we use a lower implied estimate of gross saving - $S_2=0.11$ - which seems more consistent with micro and with international evidence. Feldstein further assumes that the propensity to save out of exogenous income is the same as that out of earned income and that average and marginal savings propensities can be conflated. On these assumptions, given that earnings from employment are some 63% of GDP in the UK and $\sigma = S_2/0.63$, it follows that $\sigma=0.17$.

The final piece in the jigsaw is the elasticity of saving with respect to real interest rates.[36] There is a good deal of academic controversy over this issue. Feldstein uses Boskin's (1978) work in the US, which finds the elasticity to be around 0.4. Boskin's approach is to take the interest semi-elasticity from a standard consumption function and then infer from this the full interest-elasticity of savings. On the assumption of fixed income, the full and semi-elasticities are linked by:

(7) $$\eta_{SR} = - (\overline{R} * \overline{C}) / \overline{S}\ \xi_{CR}$$

where C, S and R denote consumption, saving and the real interest rate respectively, a bar denotes a mean value and ξ_{CR} is the real interest rate semi-elasticity of consumption. To arrive at an estimate of η_{SR} for the UK, we take ξ_{CR} from a range of recently estimated consumption functions in the UK (Muellbauer and Murphy (1993), Bayoumi (1993), Fisher and Whitley (1998)),[37] and then convert them using (7) into saving elasticities. Most of the above studies imply saving elasticities fairly close to zero. So we take $\eta_{SR}=0$ as our central guess, but also consider $\eta_{SR}=0.2$ and $\eta_{SR}=0.4$ for comparability with Feldstein.

While our central assumption may seem extreme, there is a good deal of theoretical as well as empirical support for it. With CES preferences, a positive savings elasticity only obtains in a two-period model when the intertemporal elasticity of substitution exceeds unity.[38] And most empirical studies of the elasticity of substitution put it closer to zero than to unity (for example, Hall (1988)); certainly, there is little to suggest it is greater than unity. This implies that a zero saving elasticity - where income and substitution effects are broadly offsetting - is a reasonable central guess. Moreover, while a zero saving elasticity lowers the direct welfare costs calculated below, it certainly does not eliminate them. A larger part of the welfare gain is the result of a direct price effect of cheaper retirement consumption on the quantity of consumption purchased.

Using the above estimates of the saving elasticity, adjusted so that it is expressed as an elasticity of the price of retirement consumption,[39] together with our previous calculations, we can compute the overall gain from moving to price stability. Using (6), we estimate the gain to be G_1=0.35% of GDP with $\eta_{SR}=0$ when $S_2=0.11$. At $\eta_{SR}=0.2$, G_1=0.40% of GDP; while at

η_{SR}=0.4, G_1=0.46% of GDP. All of these direct welfare costs are considerably smaller than in Feldstein. For example, if one makes the comparable assumption of η_{SR}=0 for the United States, the gain would be some 0.75% of GDP. In large part this is due to the lesser susceptibility of the United Kingdom tax system to inflation-induced distortions.

(b) Indirect Revenue Effects

Next we consider the effect on government revenue of the above experiment. The working assumption here, as in Feldstein (1996), is that any effect of a move to price stability on government revenues *cannot* be made good by a rise in lump-sum taxes. Instead, distortionary taxes are required to fill any financing gap, with corresponding welfare implications.

Assume we start from a price of retirement income p_2 and consumption level c_2 (see Figure 1) with inflation at 2% and the current tax system in place. Now consider lowering the inflation rate to zero. There are two offsetting effects on revenue. First, lower inflation raises the real return to saving and hence lowers the price of retirement consumption to p_1. This results in a loss of revenue equal to $(p_2-p_1)c_2$. Against this, the lower price of retirement consumption stimulates higher consumption $(c_1- c_2)$ which is in turn revenue-generating by an amount $(p_1-p_0)(c_1-c_2)$. The aggregate change in revenue is:

(8) $$dREV = S_2\{[(p_1-p_0)/p_2]\ [(p_2-p_1)/p_2]\ (1-\eta_{Sp}) - (p_2-p_1)/p_2\}$$

This expression can in principle be either positive or negative. But with η_{SR}=0, and substituting in earlier parameter values, we get a net revenue *loss*, dREV=0.34% of GDP. The corresponding net revenue losses at η_{SR}=0.2 and η_{SR}=0.4 are 0.29% and 0.23% of GDP respectively. These are typically much larger than Feldstein's US numbers, in part owing to the United Kingdom's higher gross saving ratio and in part the result of our lower assumed interest elasticity of saving.

We can map this change in revenue into a change in *welfare* by scaling it using a deadweight loss coefficient, λ. This measures the marginal deadweight loss of an across-the-board tax increase which raises one extra pound of revenue. Feldstein bases his λ estimate on Ballard, Shoven and Whalley's (BSW, 1985) computable general equilibrium model of the United States. BSW concluded: "The welfare loss from a 1 per cent increase in all distortionary taxes is in the range of 17 to 56 cents per dollar of extra revenue". There are many reasons why such a λ-range might be inaccurate for our exercise. For example, the BSW estimates refer to the United States and are based on a model which is calibrated on data drawn from 1973. More generally, λ can only really be pinned down by simulating the effects of a specific tax experiment in a general equilibrium model in which the existing configuration of distortionary taxes is fully set down (see Ballard and Fullerton (1992)): λ is not a fixed, policy-invariant parameter. But in the absence of such estimates for the UK, we take as our benchmark two values of λ (λ=0.4 and λ=1.5) as in Feldstein. This broadly covers the range of estimates found in other recent studies of specific tax simulations (*inter alia*, Stuart (1984), Hansson and Stuart (1985), Fullerton and Henderson (1989)).

We can go a little further towards justifying these values. Abel (1996) uses Sidrauski's (1967) general equilibrium model to compute the welfare effects of eliminating inflation in the US. He extends the model to include both housing and non-housing capital, includes a government budget constraint and endogenises labour supply. We take Abel's model and recalibrate it for UK data. It is then possible to arrive at an estimate of the deadweight loss parameter by simulating the effects of a tax change on utility, subject to the government budget constraint being satisfied. We conduct two experiments. In the first experiment, all three tax rates (on labour income, housing capital, and non-housing capital) are raised by

10%. There is a rise in overall tax revenue and a fall in consumption. Using the utility function, we then calculate the change in consumption necessary to maintain the new level of utility, with money and labour income (the other two arguments in the utility function) held at their base values. This yields an estimate of around £0.40 of welfare loss for every £1 in revenue gained - a λ of around 0.4. As a second experiment, we raise all three taxes by 1 percentage point. The resulting estimate of the deadweight loss parameter is 0.37. Although the general equilibrium model we use is small, and the calibrated results depend on a number of key parameters, there appears to be some support for a λ estimate of around 0.4. This is taken as our central estimate below.

The total welfare gain from the reduced distortion to consumption timing resulting from a 2 percentage point reduction in inflation is then:

(9) $$G_2 = G_1 + \lambda \, dREV$$

As Table 1 illustrates, assuming $\lambda = 0.4$ the net welfare gain from price stability operating through savings distortions is bounded between 0.21%-0.37% of GDP. This is around a quarter the size of Feldstein's US estimates. Much of the difference is due to offsetting revenue effects. This is shown up clearly when we raise the deadweight loss coefficient to $\lambda = 1.5$. All net welfare gains are then sacrificed.

(c) Some Sensitivity Analysis

Chart 3 illustrates more generally the sensitivity of the welfare calculations to different assumptions about the saving elasticity and deadweight loss parameter. For any given pair of parameter values, there is a point on the contour map that shows the size of the net welfare gain from a 2 percentage point reduction in inflation. It is evident that relatively small adjustments to the central assumptions - in particular regarding the deadweight loss parameter - can markedly alter the estimated net welfare gain. But the net welfare benefit in the central case is still non-trivial, at around 0.2% of GDP, even when the saving elasticity is assumed to be low.

There are further extensions and risks we might consider. First, Feldstein (1996) points out that his calculations exclude current non-savers. This is a potentially important omission if, first, non-savers are a significant proportion of the population; and, second, they are responsive to changes in real interest rates. Were both conditions to be satisfied, the estimated welfare costs above could be a significant understatement, as they would miss the effect of higher real interest rates in inducing previous non-savers to save.

Using data from the 1991/92 Financial Research Survey of 6600 households in the United Kingdom, Banks, Dilnot and Low (1994) found that over half of the households in the survey held gross financial assets of less than £455 (net assets of less than £180); while around 10% had no gross savings whatsoever. These results suggest that, as in the United Savers, non-savers are non-trivial in number. How responsive these agents might be to changes in real interest rates is less clear. That depends on whether non-saving is a *voluntary* decision - for example, among young "life-cycle" savers - or an *involuntary* one - for example, among credit-constrained "Keynesian" consumers. The former set are likely to be interest-sensitive; the latter set much less so. In fact, the saving elasticity we derived from the aggregate consumption functions already implicitly embodies the average effect of real interest rates on both savers and non-savers. And, since our central case has η_{SR}=0, this non-savers effect is in any case likely to be quantitatively small.

Second, the above calculations take no account of the depressing effect of increased saving on the marginal product of capital. This would tend to reduce estimated welfare gains. But the effect is small. For example, assuming Cobb-Douglas technology, the implied fall in the marginal product of capital is only 0.06% points when η_{SR}=0.2; and 0.1% points when η_{SR}=0.4. Of course, when η_{SR}=0 - our central case - the marginal product of capital is unchanged. These effects in turn translate into small welfare changes: for example, a fall of 0.0027 GDP when η_{SR}=0.2. Moreover, these losses are almost exactly counterbalanced by the rise in the marginal product of *labour* resulting from the rise in the capital stock. For example, this leads to an offsetting welfare gain of 0.0025 GDP when η_{SR}=0.2. So the net welfare effect of these production mix adjustments seems likely to be negligible.

Third, more substantively, the stylised life-cycle model makes no allowance for social security income received during retirement. Recognising this exogenous source of second-period income lowers the implied interest elasticity of saving by an amount (C-B)/C (see Feldstein (1997)), where C is retirement consumption and B social security benefits. Taking B/C=0.25, as in Feldstein, lowers the direct welfare gain by around 30%: for example, with η_{SR}=0 direct welfare gains fall from 0.35% to 0.25% of GDP.

Fourth, our central case assumes that all net company bank loans are effectively financed from personal sector deposits. Assuming instead company bank loans are financed from elsewhere - that is, stripping-out the banking system from our calculations - lowers the welfare gain from around 0.21% to 0.19% with η_{SR}=0.

Finally, the analysis so far has assumed that all marginal saving flows into taxable assets. In practice, a relatively high proportion of UK personal sector saving is held in a tax-exempt form. We estimate that around 38% of personal sector equities are tax-exempt (including pensions funds, pension business of life-assures and Personal Equity Plans (PEPs)).[40] Direct holdings of equity that are taxed account for 37%. The remainder are equities held indirectly via not tax-exempt unit trusts and the non-pension business of life-assurers (25%). Direct shareholdings are assumed to be taxed at the headline rate of 28.7% and the remaining 25% of taxable holdings are taxed at 20%. Tax-exempt equity holdings are obviously taxed at a zero rate. So assuming that the marginal tax rate on equity holds is the same as its average, this would give an adjusted average marginal tax rate of dividend income of 15.7% (0.38*0-0.37*28.7+0.25*0.20).

Doing the same thing for deposits, we need to make an adjustment for Tax Exempt Special Savings Accounts (TESSAs). These comprised 6% of total personal sector bank deposits in 1995. So the marginal tax rate on deposits, inclusive of tax-exempt funds, would fall to 22%. Finally, for interest income on corporate bonds, we estimate that around 26% of personal sector holdings of corporate bonds are held in tax-exempt vehicles (pension funds, corporate bond PEPs etc). A further 68% are held by taxed institutions, and 6% are held directly. Direct bond holdings are taxed at the 31.1% headline rate, and non tax-exempt unit trusts and the non-pension business of life-assurers are assumed to be taxed at the basic rate of income tax.[41] This gives an adjusted average marginal tax rate on bond interest of 19.0% (0.26*0+0.06*0.311+0.68*0.25).

The headline marginal tax rate on capital gains (on equity and bonds) is that used earlier when calculating the discount rate - 14.1%. But again, these capital gains will be earned on securities held in a range of saving outlets, and we assume the same distribution of holdings across these outlets as for dividends and bonds. Direct holdings are taxed at 14%, indirect holdings via non tax-exempt unit trusts, and the non-pension business of life-assurers at the basic rate (25% in 1994/95), and tax-exempt holdings are tax-free. This gives an adjusted marginal effective capital gains tax rate of 11.6% on equities and 17.9% on bonds.

The effects of the tax-exempt saving adjustments are significant. For example, the effective marginal individual tax rate after weighting dividends, bond interest, deposit income and capital gains was 23.0% before adjustment for tax-exempt saving. This falls to 14.8% after adjusting for tax-exempt saving. At $\eta_{SR} = 0\ 2$ and $\lambda = 0.4$, the effect of tax-exempt saving is to reduce the net welfare gains by 0.07% of GDP to 0.14%; at $\eta_{SR}= 0.2$ and $\eta_{SR}= 0.4$, the reductions are 0.08% (to 0.21%) and 0.13% (to 0.27%) of GDP respectively. So the choice of destination for marginal saving is clearly crucial to the welfare calculus. Indeed, if all saving flowed into tax-exempt vehicles, then the welfare gain arising from the effects of lower inflation on saving behaviour would be zero.

But this would almost certainly overestimate the effects of tax-exempt saving vehicles. For example, there are restrictions on the quantity of marginal saving that is allowed to flow into tax-exempt assets. And there are ceilings on the amount that can be invested in a TESSA, and restrictions on the Additional Voluntary Contributions (AVCs) that can flow into personal pensions. Further, ACT credits to pension funds were abolished with immediate effect in the July 1997 Budget. These institutional features help to justify the main case, under which saving flows into taxable assets.

IV. Inflation and Residential Investment

(a) Distortions to Housing Investment

House prices in the United Kingdom have been around 25% more volatile than the general level of prices since 1970. And UK house price inflation has outstripped general price inflation by 2% per year on average over this period. Without question, the tax environment has played a role in this. The availability of mortgage interest relief - which in the United Kingdom is normally implemented through Mortgage Interest Relief At Source (MIRAS) - has meant that the tax system has consistently favoured housing over alternative real and financial assets. More recently, there has been a progressive scaling-back of the tax benefits available for owner-occupiers. The nominal ceiling on which relief is available has been raised only once since it was first introduced in 1974; while the effective rate of tax relief has also come down progressively over this period to its current rate of 15% (Table 6). Indeed, one irony is that much of the reduction in the effective impact of mortgage tax relief in the 1980s was achieved through the rise in house prices itself. This took the average value of a mortgage well above the £30,000 ceiling for mortgage relief.

While it is widely perceived that distortionary tax benefits have led to a switch of resources towards housing, investment in dwellings is actually lower as a percentage of GDP, and the capital stock lower, in the UK than in many other countries (Table 7). That perhaps suggests that tax-induced distortions to housing investment are not obviously more serious in the UK than elsewhere - a conclusion borne out by the welfare analysis which follows.

The tax incentives offered by the MIRAS system in the UK lower the effective user-cost of housing to owner-occupiers. Moreover, because relief is given on nominal interest payments, the effective extent of this tax relief rises with inflation, further lowering the user-cost. This is identical to the situation in the US. Its effect is to induce an over-investment in housing compared to a situation of zero inflation - where tax distortions would be minimised - or one where tax distortions were eliminated entirely. Figure 2 illustrates these three situations. A "0" suffix denotes the no-tax outcome; a "1" suffix the zero-inflation outcome; and a "2" the current (2% inflation) outcome. As in the previous section, the deadweight distortion is equal to the area C+D. And the resulting gain from a reduction in inflation is (see Feldstein (1996), equation (19)):

$$(10) \qquad G_2 = \varepsilon_{HR} \{[(R_0-R_1)/R_2][(R_1-R_2)/R_2] + 0.5\,(R_1-R_2)^2 R_2^{-2}\} R_2 H_2$$

where the elasticity of housing with respect to the user-cost, $\varepsilon_{HR} = -(R_2/H_2)\,(dH/dR)$.

To evaluate this expression we need to determine the three user-costs, R_0, R_1 and R_2. In a zero-tax world, the implied rental cost of housing per pound of housing capital is reduced to $R_0 = \rho + m + \delta + t$, where ρ is the pre-tax rate of return (8.2%); m is the maintenance cost per pound of housing capital; t are transactions costs; and δ is the rate of housing depreciation.

For depreciation and maintenance costs, we assume 0.8% per annum.[42] We assume transactions costs are around 0.6% per annum (Robinson and Skinner (1989), University of Greenwich/Woolwich Building Society "Cost of Moving Survey"). This takes account of stamp duty, legal and estate agent fees and removal costs, written-off over the lifetime of a mortgage. So in sum we arrive at a figure of 1.4%, covering miscellaneous housing costs. This estimate is in line with those used by Henry and Pain (1994), Miles (1994) and Pain and Westaway (1996) for the UK. Using these values gives R_0=0.096 for the UK - a user-cost of

9.6 pence per pound of housing investment. This is somewhat lower than calculated by Feldstein for the US.

Turning to a world with taxes, Feldstein uses an itemiser/non-itemiser classification of owner-occupiers in the US. The situation in the UK is somewhat different. But it is useful (as we demonstrate below) to make a similar distinction - between that part of the mortgage stock which is subject to MIRAS below the £30,000 ceiling and that proportion which is not.[43] The non-MIRAS mortgage stock will largely reflect the value of the outstanding mortgage stock which falls above the £30,000 MIRAS ceiling. But it will also include mortgages on second properties, which are not eligible for tax relief. The MIRAS/non-MIRAS distinction we make is clearly artificial, but is nonetheless useful analytically.[44]

The average price of a house in the UK is £55,000 according to Halifax Building Society figures. Even assuming a low mortgage-to-value ratio, this means that the majority of *new* mortgages in the UK will exceed the ceiling. But it takes some time for the mortgage stock to turn over. So mortgages which do not exhaust the tax relief fully are still non-trivial in number and an important factor in the calculations below. For loans subject to MIRAS, the user-cost of housing is:

(11) $$R_{MIRAS} = \mu(1 - \theta)i_m + (1 - \mu)(r_n + \pi) + (1 - \varphi)\,\tau_p + m + \delta + t - \pi$$

where μ is the mortgage loan-to-value ratio, θ is the effective rate of tax relief, r_n is the real post-tax rate of return on saving (calculated in the previous section), i_m is the interest rate paid on the mortgage, τ_p is the rate of property tax and π is house price inflation.

The rate of tax relief (θ) used in the calculations was 16%, which was the marginal rate of MIRAS prevailing in 1995 for the value of mortgages under the £30,000 ceiling.[45] The interest rate paid on building society mortgages (i_m) averaged 7.5% in 1995, when the (bias-adjusted) inflation rate was 1.6%. Thus, the mortgage rates that would apply under zero and 2% inflation would be 5.9% and 7.9% respectively, on the assumption that the Fisher effect holds exactly. On property taxes (τ_p), the ratio of Council Tax payments to the value of the housing stock was around 0.8% per annum in 1995. There is no tax relief on these payments, so φ=0.

Finally on the expected house price inflation term (π), Feldstein assumes that house prices grow in line with the general price level. We do the same for consistency. It could be that a premium should be added to the inflation term, to reflect the fact that UK house prices have tended historically to grow faster than retail prices. But adding a constant to the user-cost would have little impact on our calculations at the margin.

In order to calculate the implicit rental rate, we need an estimate of the loan-to-value ratio. For new business, this is around 70%. But the average loan-to-value ratio for the *outstanding* mortgage stock will clearly be lower as, for example, loans are repaid through time. Aggregate mortgage and housing stock data suggest that the ratio is 35%. For loans qualifying for MIRAS, the ratio is likely to be higher than this average. We make a somewhat arbitrary assumption that the ratio is 60%. And using (11), this then suggests that a combination of 2% inflation and the current tax regime would reduce the rental cost of housing from around 9.6 pence to around 6.9 pence (R_2=0.069) per pound of housing capital.

Next, we consider the effect of inflation on the user-cost. From (11) we can see that the change in rental cost for a given change in inflation is:

$$(12) \qquad dR_{MIRAS}/d\pi = \mu(1\text{-}\theta)\,(di_m/d\pi) + (1\text{-}\mu)\,(d[r_n+\pi]/d\pi) - 1$$

Assuming $di_m/d\pi=1$,[46] we calculate that $dR_{MIRAS}/d\pi= -0.15$. A 1% point rise in inflation reduces the implicit rental rate on housing by 0.15 pence per pound of housing capital. This occurs through two channels: a direct channel, whereby higher inflation increases the real value of MIRAS; and an indirect channel, as the fall in the real savings rate reduces the opportunity cost of the owner-occupier's equity stake in the house. Hence, the rental rate of 6.9 pence per pound of housing capital at 2% inflation rises to 7.2 pence (R_1=0.072) at zero inflation.

The implicit rental rate on the non-MIRAS part of the owner-occupied mortgage stock is given by:

$$(13) \qquad R_{NON\text{-}MIRAS} = \mu_{NON\text{-}MIRAS}\, i_m + (1 - \mu_{NON\text{-}MIRAS})(r_n + \pi) + \tau_p + m + \delta - \pi$$

The only differences are that we drop the tax relief terms and assume a different loan-to-value ratio. Despite the disappearance of the direct tax wedge, inflation still affects the user-cost because of its impact on the opportunity cost of housing equity. We would expect the loan-to-valuation ratio to be lower for non-MIRAS mortgages and set it to be 35%. Using this estimate in (9), we calculate the rental price to be 7.5 pence (RN_2=0.075) at 2% inflation and 7.6 pence (RN_1=0.076) at zero inflation. Not surprisingly, both are higher than the MIRAS user-costs.

Finally, we consider the private rented sector.[47] A significant proportion of the value of the private rented sector housing stock is likely to be owned outright and rented out. But there are also some landlords who let their properties but who have mortgages outstanding. Further, there is tax relief available on these loans at the rate of income tax; and there is no ceiling on this relief. Hence, inflation and the tax system again introduce wedges into the rental user-cost. The user-cost for the rental sector, (14), is similar to the MIRAS user cost, (11):

$$(14) \qquad R_{RENTAL} = \mu_{RENTAL}(1-\theta_{RENTAL})i_m + (1-\mu_{RENTAL})(r_n+\pi) + (1-\varphi)\,\tau_p + m + \delta + t - \pi$$

There is likely to be a different loan-to-value ratio (μ_{RENTAL}) for the rental sector than for MIRAS owner-occupiers. We can deduce this by residual. This gives us a 25% loan-to-value ratio for the rental sector - which, as we would expect, is low. The second difference from the MIRAS calculation is that the rate of tax relief (θ_{RENTAL}) is levied at the individuals' rate of income tax. We calculate this to be 32%. This reflects the average effective rate of relief claimed by tax payers in the three income tax bands (20%, 25% and 40%).[48] Not surprisingly, this is higher than the basic rate because of the preponderance of landlords in the higher rate tax bracket. So despite the smallness of the rental sector in stock terms, and its low loan-to-value ratio, the sector is still important because of the size of the tax wedge. From (14), the implied user-cost is 7.1 pence with inflation at zero and 6.7 pence with inflation at 2%. Not surprisingly, these figures differ little from those obtained for MIRAS mortgages.

We next identify the outstanding stock of loans for each sector and the corresponding value of their housing stocks. Inland Revenue figures show that the value of MIRAS tax deductions in 1995 was £2.9 bn. Given a 16% average rate of tax relief, this implies total mortgage interest payments of around £18 bn. Using the average building society mortgage rate of 7.5% in 1995 implies that the value of the mortgage stock on which these MIRAS deductions were made was around £239 billion. If the loan-to-value ratio is around 60%, as we assumed earlier, this makes the value of the housing stock on which MIRAS deductions are claimed worth around £398 bn. For the rental sector, the current market value of their housing stock was around £113 bn in 1995. With a 25% loan-to-value ratio, this implies an outstanding stock of mortgages of around £28 bn held by the rental sector. We also know that the total stock of lending secured on dwellings in 1995 was some £390 billion. So we can determine the non-MIRAS mortgage stock by residual. This was around £124 bn (£390 bn-£239 bn-£28 bn) in 1995. The value of the non-MIRAS housing stock also drops out by residual at £356bn (£753 bn-£398 bn).[49]

We can now evaluate (10). See Figure 2. With no taxes, the rental price is R_0 and the housing stock is H_0. With existing tax rules and zero inflation the rental price drops to R_1 and the housing stock increases to H_1. Finally, with inflation at 2% the rental cost drops further to R_2 and the housing stock increases to H_2. The additional deadweight loss of 2% inflation is the area C+D. By substituting values for the user-cost into (10), and adding subscripts to distinguish MIRAS, non-MIRAS and rental variables, we have:

(15) $$G_{MIRAS} = 0.0154\varepsilon_{HR}\ R_{MIRAS2}\ H_{MIRAS2}$$

(16) $$G_{NON-MIRAS} = 0.0059\ \varepsilon_{HR}\ R_{NON-MIRAS2}\ H_{NON-MIRAS2}$$

(17) $$G_{RENTAL} = 0.0205\varepsilon_{HR}\ R_{RENTAL2}\ H_{RENTAL2}$$

Adding these terms together gives us our estimate of the aggregate welfare gain G_3.

To evaluate (15)-(17) we now only need an estimate of the compensated elasticity of housing demand with respect to the user-cost. Feldstein (1996) assumes ε_{HR}=0.8. We take an estimate of the uncompensated elasticity of 0.53 from King (1980), a unit income elasticity, and a budget share of housing of 13.5%.[50] This gives an estimated compensated elasticity of around 0.4.

But the assumption that this elasticity holds for all three categories of housing seems implausible. In practice, changes in the user-cost are more likely to affect the fraction of housing investment that lies above the £30,000 MIRAS ceiling. To account for this, we assume that the elasticity of MIRAS housing investment is closer to zero - say, around 0.1; while the elasticity of non-MIRAS investment is correspondingly higher at around 1.0.[51] This leaves the average aggregate elasticity unchanged at 0.4. Substituting these values into (15)-(17) and summing gives an estimated total welfare gain of around 0.038% of GDP. This is around a quarter the size of Feldstein's US estimate. This difference reflects the somewhat smaller mortgage interest relief distortions under the current UK tax system.

(b) Indirect Revenue Effects

The fall in the housing capital stock associated with a move to price stability totals around £12 bn. There are four main channels through which this change in housing demand affects government revenues. First, there is a flow effect as the reduction in inflation lowers the value of the tax relief subsidy to MIRAS holders and to those claiming relief outside of MIRAS (the rental sector). This translates into increased revenues of £0.96 bn. Second, there are direct stock effects on tax revenue. The reduction in the stock of mortgages reduces mortgage payments, thus reducing the value of tax relief and increasing net tax revenues. This is worth £0.03 bn. It is small because we have assumed a low elasticity for the MIRAS mortgage stock. Third, there will also be a loss of revenue from property taxes, estimated at £0.09 bn. Finally, the transfer of capital to the business sector affects tax revenue. The extra business investment yields a return - which is subject to tax - and this is worth around £0.36 bn.[52] The overall change in revenue is:

(18) $$dREV_2 = £0.96\text{ bn} + £0.03\text{ bn} + £0.36\text{ bn} - £0.09\text{ bn} = £1.25\text{ bn}$$

The overall gain from lower inflation on housing investment is the sum of these effects:

(19) $$G_4 = G_3 + \lambda\, dREV_2$$

With these adjustments and λ=0.4, the overall gain is around 0.11% of GDP. This estimate is less than half Feldstein's US estimate (Table 2). That is not too surprising given the gradual erosion in the real value of MIRAS over the last 20 years in the UK. For example, the cost of mortgage relief was reduced from a peak of over £6 bn per annum at the end of the 1980s to under £3 bn in 1995.

(c) Sensitivity Analysis

Chart 4 offers some sensitivity analysis on the results, plotting net welfare gains against ε_{HR} and λ. Here the risks to net benefits are more clearly on the upside, searching across the two parameters. The plane is everywhere positive and is increasing in both parameters. The gains themselves are never that large over reasonable parameter ranges: they are very unlikely to exceed 0.3-0.4% of GDP. But they are nonetheless tangible. Indeed, given the risks that attach to achieving such gains via monetary policy, it might plausibly be argued that a strong case can be made for fiscal reform. Unlike monetary policy, the abolition of MIRAS could be targeted explicitly at extracting the welfare gains in Chart 4; it would have few downside (potentially negative welfare) risks - unlike monetary policy; and it could be achieved without incurring transient output costs - again, unlike monetary policy.

Counterbalancing these upside risks, however, is the fact that our comparative static analysis implicitly assumes that the MIRAS/non-MIRAS split of mortgages would remain constant if 2% inflation were to persist indefinitely. That is clearly implausible if the MIRAS ceiling were to remain unchanged in nominal terms - as historically it largely has. Inflation then increases over time the stock of mortgages ineligible for MIRAS; it denudes the real value of MIRAS relief. This dynamic effect is not taken into account in the above calculus and would act to reduce net welfare benefits over time.[53]

V. Inflation and the Demand for Money

(a) "Shoe-Leather" Costs

Following Bailey (1956), the most widely-studied deadweight losses of a fully-anticipated inflation derive from distortions to money demand - so-called "shoe-leather" costs. In essence, these costs capture the transactions time agents expend in replenishing money balances, the stock of which is held at a sub-optimally low level at any positive nominal interest rate.[54]

The gain in consumer surplus which results from a fall in inflation from π_2 to π_1 is given by the trapezoid underneath a conventional money demand schedule. This is associated with a fall in the opportunity cost of money balances (proxied here by the nominal net return on a debt-equity portfolio) equal to $(r_n+\pi_2)-(r_n+\pi_1)$. Friedman's welfare optimum, where the marginal cost and marginal benefit of money balances are equalised at zero, is given by the point $(r_n+\pi_0)=0$. On the assumption of linearity of the money demand curve, the trapezoid of lost consumer surplus (G_5) can be approximated by:

$$(20) \qquad G_5 = 0.5\,[(r_n+\pi_2) - (r_n+\pi_1)]\,[M_2 - M_1] + [r_n+\pi_1]\,[M_2 - M_1]$$

From earlier we have r_n=4.9% at 2% inflation and r_n=5.1% at zero inflation, given $dr_n/d\pi = -0.12$. Observing that, again under the linearity assumption, $M_2-M_1 = -\varepsilon_M\,[(r_n+\pi_2)-(r_n+\pi_1)]\,[M/(r_n+\pi)]$, then:

$$G_5 = 0.00109\,\varepsilon_M \;\; [\overline{M}/\overline{(r_n+\pi)}]$$

where a bar denotes a mean value and ε_M is the interest elasticity of money demand. We take $\overline{(r_n + \pi)}$=6.9. For M we take the stock of non-interest-bearing M1 in the UK. This was equivalent to 4.9% of GDP in 1995.[55]

As in the United States, there are a range of estimates for ε_M in the United Kingdom. But the Bank's work (Breedon and Fisher (1993)) suggests a steady state interest elasticity of around 0.3. This is very much a conservative estimate. Others have arrived at higher elasticities looking at longer and more recent runs of data.[56] But on these conservative assumptions, G_5=0.023% of GDP. This is similar to Feldstein's estimate of 0.016% of GDP. Moving to the Friedman optimum - of deflation equal to the real rate of interest - yields a welfare gain of G_5=0.051% of GDP. The gains are larger here than in Feldstein (0.02% of GDP), but remain small quantitatively. And although small, these estimates are of the same order of magnitude as those found in previous partial equilibrium studies, when measured over the same interest rate interval. For example, Fischer (1981) and McCallum (1989) both arrive at a figure of around 0.3% of GDP when transitioning from 10% to zero inflation. Linearly interpolating, this would deliver a gain of around 0.06% of GDP when moving from 2% to zero inflation - which is in the same ballpark as the estimates here.[57]

(b) Indirect Revenue Effects

Feldstein (1996) considers three government revenue implications of the higher real money balances held by agents at lower rates of inflation: (a) the reduction in direct seigniorage revenues as the (inflation) tax rate falls (the Phelps (1972) effect); (b) the revenue loss as assets are switched from (taxed) capital assets to (non-taxed) money balances (a kind of Mundell-Tobin effect); and (c) the reduction in debt-service costs as money balances substitute for interest-bearing debt.

On (a), Feldstein shows that the marginal response of seigniorage to a change in inflation is:

$$(21) \qquad dSEIG/d\pi = M_2 \{1 - \varepsilon_M [d(r_n+\pi_2)/d\pi_2] \pi_2/(r_n+\pi_2)\}$$

The first term in braces captures the direct price effect of the fall in the tax rate (inflation); and the second term, the offsetting effect upon revenues of the rise in the tax base as money balances increase. Using the assumptions from earlier gives a net revenue loss equal to 0.09% of GDP.

On (b), the fall in business capital is equal to the rise in money balances (M_2-M_1). The gross real rate of return to capital in the United Kingdom between 1970-1995 averaged 8.2% with a net return of 4.9%, giving a tax wedge of 3.3% points. The revenue loss is 0.012% of GDP.

Finally on (c), we calculate the reduction in government debt servicing costs as r_{ng}*(M_2-M_1), where r_{ng} is the real return on government debt, net of the tax the government receives on those interest payments. Proxying gross *nominal* interest payments by the ratio of debt interest payments to national debt in 1995 (6.8%), a 1995 inflation rate of 1.6% (netting-off the measurement bias) and assuming a marginal tax rate of 31.1%, gives r_{ng}=(1-0.31)*(0.068)-0.016=0.031. The reduction in debt-servicing is 0.012% of GDP.

Bringing these estimates together, we have a shoe-leather gain of 0.023% of GDP and revenue losses totalling 0.11λ% of GDP. So at λ=0.4 we have a net welfare loss of around

0.022% of GDP. These net welfare losses are smaller than in Feldstein, but are still negative. In all of our cases, the Phelps effect dominates the Bailey effect.

(c) Risks to the Calculus

Chart 5 conducts some sensitivity analysis, plotting net shoe-leather gains against ε_M and λ. From this it is clear that it is quite difficult to make a case for a positive net welfare contribution from money demand distortions. The net welfare gains are also everywhere small. This reflects the smallness of the aggregate currency stock compared with the housing stock.

But there may also be some upside risks - in particular to the assumed interest elasticity - which are not captured by Chart 5. We have assumed throughout linearity of the money demand function. But Lucas (1994) has recently argued, on theoretical and empirical grounds, that money demand functions are best viewed as a *log*-linear representation. Such an assumption can have a dramatic impact on welfare cost calculus. As we approach nominal interest rates of zero, money demand asymptotes on the zero axis, raising the size of the welfare triangle. Lucas (1994) suggests that deadweight losses could then amount to as much as 1% of GDP when moving to zero nominal interest rates; and Chadha, Haldane and Janssen (1996) arrive at similar numbers for the UK also using a logarithmic specification.

Against this, the Lucas specification does imply that the largest welfare gains accrue - the interest elasticity is largest - near to the Friedman optimum. That is not our experiment here. Moreover, neither the UK nor the US has very much time-series evidence on money demand at near-zero interest rates to shed light on the plausibility of Lucas's thesis. Indeed, Mulligan and Sala-i-Martin (1996) argue, contrarily, that money demand is likely to be largely interest-*in*elastic at low nominal interest rates. This follows from the fact that, at low interest rates, the *incentive* to shift into interest-bearing assets is reduced for a large fraction of the population. They present some cross-sectional evidence to support their thesis. And Chadha, Haldane and Janssen (1996) ultimately reject a log specification over a conventional semi-log form as a description of steady state (if not dynamic) money demand behaviour in the UK.

Another uncertainty concerns the use of a partial rather than general equilibrium framework. The latter approach often appears to have yielded larger welfare benefits (Cooley and Hansen (1989), Dotsey and Ireland (1996)). The source of these higher costs is the explicit recognition of labour/leisure choices. So, for example, if - as in Cooley and Hansen (1989) - lower inflation lowers the tax on consumption goods and leads agents to supply extra labour, then income will rise. The money demand schedule will then shift outwards. And welfare gains will be correspondingly greater than when income is held fixed, as under the partial equilibrium approach. Likewise, the conventional Mundell-Tobin effect of moving to price stability - a fall in capital accumulation as agents switch into money balances - need not arise in a general equilibrium setting. Because investment is simply deferred consumption, and since inflation acts as a consumption tax, lower inflation may actually *increase* investment and the capital stock. That would, in turn, reduce some of the revenue losses described above.[58]

But even after allowing for these effects, Cooley and Hansen (1989) and Dotsey and Ireland (1996) still arrive at welfare costs which are similar to those here over the same inflation rate range. For example, a fall in inflation from 4% to 2% in Dotsey and Ireland (1996) still yields a welfare benefit of only around 0.045% of GDP.[59] Moreover, and perhaps most importantly, neither of the above papers recognise distortionary taxes. Cooley and Hansen (1991) do explicitly introduce labour and capital taxes into their earlier equilibrium framework. They conclude that, while adding in taxes doubles the gross welfare costs of inflation, these gains are more than counterbalanced by the need to raise distortionary taxes elsewhere to satisfy the government's budget constraint. So the upshot is a net welfare loss - as here and in Feldstein (1996) - and for the same reasons. So the risks to the above analysis seem to be broadly counterbalancing; and they do not clearly imply that the net distortions to money demand are anything other than negligible and quite possibly negative.

VI. Debt Service and the Government Budget Constraint

Lower inflation lowers tax receipts on the *nominal* interest payments made by government when servicing their debt. Using the government's cashflow identity and a steady state condition of a stable debt/GDP ratio, Feldstein (1996) shows that the increase in taxes necessary to maintain a stable debt/ratio in the light of this higher debt-servicing cost is:[60]

$$(22) \qquad dT = d\pi \, \theta_i \, H$$

where T denotes taxes (as a % of GDP), θ_i is the effective tax rate on interest payments and H notes government debt (again as a % of GDP).

The calculus is complicated slightly in the UK because: first, some large-scale holders of UK government debt are tax-exempt - in particular pension funds and charities; and second, some domestic debt is also held by overseas residents, on most of which the UK government levies no tax.[61] At end-1995, pension funds held 21% of the stock of government debt and the overseas sector around 14.5%. Deducting these tax-exempt holdings from the stock of debt gives H=0.355 (as a % of GDP in 1995, using Maastricht definitions). We take θ_i =0.31, the marginal personal tax rate on debt interest income used earlier, and $d\pi = 0.02$. So the welfare costs associated with higher net debt servicing costs - and hence higher taxes - when moving to price stability are 0.221λ. Hence, at $\lambda = 0.4$ the welfare cost is 0.088% of GDP, and at $\lambda = 1.5$ it is 0.33% of GDP. Both of these welfare losses are slightly lower than in Feldstein (*ibid.*), though not by much.

VII. Conclusions

Adding together the net welfare gains arising from consumption, housing investment, money demand and debt-servicing distortions gives an aggregate welfare benefit of 0.21% of GDP, using central estimates of the key parameters (see Table 1). This annual net welfare gain is translated into a present value using the formula (1). Given an estimated discount rate of 5.3% and growth rate of 2%, the net present value of an annual welfare gain of 0.21% of GDP is equivalent to around 6.5% of GDP.

There are of course uncertainties on both sides of this central estimate, not least about the magnitude of the key parameters, and in particular the parameters measuring the welfare loss resulting from an extra pound of taxation and the saving elasticity. Chart 6 considers the sensitivity of the aggregate net welfare benefit to both of these parameters.

Any combination of the two parameters is associated with a point on the contour map indicating the size of the net welfare gain. High values of the deadweight loss parameters, such as 1.5 eliminate the aggregate benefits entirely. But a higher saving elasticity increases the estimated welfare benefits.

The welfare benefits of lowering inflation must be set against any potential disinflationary costs. In Section II, it was shown that the breakeven benefit is 0.18% of GDP. So on our central estimates of the key parameters, the benefits of reducing inflation exceed the costs.

A major uncertainty concerns the marginal tax rates used in the study. For example, when discussing saving, the crucial question is whether marginal funds are invested in proportion to their existing share of households' saving (average and marginal tax rates are equal); or whether instead they flow exclusively into either taxable or tax-exempt vehicles.

Notwithstanding this caveat, we would make the following observations on the basis of our welfare comparisons:

First, it is clear that aggregate welfare gains in the UK are much smaller than those of Feldstein for the US - perhaps around one quarter of the size. Idiosyncrasies in the two countries' tax systems largely account for these differences. Tax wedges tend to be smaller in the UK than the US. And the sensitivity of tax rates to inflation is likewise lesser in the UK than the US - for example, because of indexation of capital gains. The gradual erosion of MIRAS and the indexation of capital gains - to take two examples - mean that some of the welfare benefits identified by Feldstein for the US have already been realised in the UK.

This leads onto the second point: can we say whether the welfare benefits we have identified are best secured through monetary or fiscal policy? The identified distortions are the result of the *interaction* between taxes and inflation, rather than being the result of one or other acting in isolation. So it is unclear *a priori* whether monetary or fiscal policy is best suited to reaping these benefits. A full discussion of that issue would take us beyond this paper, and into the realms of optimal fiscal policy. But the Institute for Fiscal Studies in the UK have already put forward proposals which would all but eliminate inflation-induced distortions to corporate taxes, at little administrative cost (Institute for Fiscal Studies (1995)). Likewise, the complete abolition of mortgage interest relief would not be a difficult administrative step, though there are clearly political-economy implications. Upping the limit, or extending the range, of tax-exempt savings vehicles would be a third option.

Third, our analysis takes as given the fact that we are currently operating at a second-best. It is conceivable - if not perhaps likely - that the existing configuration of taxes and subsidies is already close to being optimal. Adjustments to taxes around this point - in either direction - would not then be Pareto-improving. This is equivalent to saying that the direct welfare benefits we identify may in fact be triangles rather than trapezoids; and that λ

would, in general equilibrium, be high enough to counterbalance these direct welfare gains. More generally, the only foolproof way of simulating the welfare effects of a specific change in taxes (and their interaction with inflation) is in a fully general equilibrium model in which λ is endogenous to the tax experiment. That is the task of another - and very different - paper.

Finally, the welfare costs we identify are only a subset of the total costs of inflation and there are a variety of possible extensions to the existing analysis. A complete treatment of business investment is one. An initial attempt has been made in the Appendix. A formal treatment of front-end loading - as it relates to household and corporate debt - is another. And capital flows effects may be considered, as in Desai and Hines (1996). A fourth is an analysis of inflation's effect on the financing and investment mix of firms. A fifth is an analysis of distortions to that part of household savings which is not financing UK companies - for example, holdings of government bonds. Hence, the calculations in the paper clearly understate the benefits of reducing inflation. A subset of the benefits of reducing inflation is being compared with all of the costs of achieving price stability. Other benefits of price stability, such as those associated with the - possibly much larger - welfare costs of unanticipated inflation, are not quantified. Because these costs are positive, they would increase the permissible breakeven range of discount rates and output costs. All in all, the costs of inflation quantified here go some distance towards justifying and explaining the aversion to inflation that is shared by the public, economists and policy-makers alike.

Appendix: Inflation and Business Investment

(a) Distortions to Business Investment

In the main text we considered the effect of a reduction in inflation on household consumption and saving; on residential investment; on money demand; and on government financing. One area that remains is business investment. But because households do not consume - at least directly - the capital stock, it is more difficult to conduct welfare analysis on business investment. Capital services are not strictly-speaking demanded by individual households. So the estimates below have a less direct mapping into welfare than those from previous sections. That said, it is plausible to think that the physical capital stock could enter into agents' utility functions *in*directly - for much the same reasons as might the money stock or the human capital stock. Physical capital - like human capital and money - is time-saving and is thereby leisure and utility-enhancing. That is one way to interpret the thought experiment below.

There are a variety of channels through which inflation, operating in tandem with the tax system, might affect investment and the capital stock. The most widely-studied effect of inflation on investment is through the cost of capital (in a UK context see, *inter alia*, King (1974, 1977), King and Fullerton (1984), Devereux (1989)). With no taxes, the return on a hypothetical investment project and the return on the savings used to finance this project will be equalised. There is no "tax wedge" between the returns to saving and investment. But once distortionary taxes are admitted, the returns to saving and investment will differ. There is a tax wedge. The effect of the wedge, for given savings rate, is to increase the effective pre-tax rate of return which a project must earn to make it worthwhile to undertake: it raises the effective cost of capital. This tax wedge depends on both the corporate and personal tax systems and their interaction with inflation, as well as on the nature of the investment project and its method of finance. Higher (personal and corporate) taxes increase the tax wedge and hence the cost of capital. So too does higher inflation as it raises effective personal and corporate tax rates. Both taxes and inflation will hence lower the capital stock below its no-tax equilibrium.

The distorting effects of taxes and inflation, acting through business investment, can be analysed using the residential investment framework described earlier. Let r_0 be the cost of capital in the absence of taxes (a zero tax wedge), with corresponding capital stock K_0. With taxes and zero inflation, the cost of capital rises to r_1 (a wedge of $r_1 - r_0$) and the capital stock falls to K_1. While with taxes and 2% inflation the corresponding cost of finance and capital stock are suffixed with a "2": the cost of capital is sub-optimally high and the capital stock sub-optimally low. The resulting distortion from inflation is the conventional trapezoid, approximated by:

$$G_6 = \varepsilon_K \{[(r_1 - r_0)/r_2][(r_2 - r_1)/r_2] + 0.5\,(r_2 - r_1)^2 r_2^{-2}\} r_2 K_2 \qquad (23)$$

where ε_K is the elasticity of the capital stock with respect to the cost of capital.

Calculating the cost of capital at different tax/inflation rates requires a detailed breakdown of the components of the existing capital stock and its sources of financing, as well as knowledge of the tax system itself (see, eg, Cohen, Hubbard, Hassett (1996)). But our earlier calculations, based on the savings-investment nexus, contain provide most of the basic ingredients. For example, the Hall-Jorgenson (1967) tax-adjusted formula for the real cost of capital is:

$$(24) \qquad r = (\rho + \delta - dq/q)\,(1 - \tau_c z)\,/\,(1 - \tau_c)$$

where ρ is the cost of (debt and equity) financing, δ is the depreciation rate, q is the relative price of capital goods, τ_c is the rate of corporation tax and z the present value of depreciation allowances. We devise a proxy for this cost of capital at 2% inflation (r_2) by adding $\delta\left(\frac{1-\tau_c Z}{1-\tau_c}\right)$ to the pre-tax real rate of return to capital among UK companies between 1970-95. This proxy can be reconciled with (24) as follows.

As is conventional (King and Fullerton (1984)), we assume that providers of capital - savers - demand a fixed *post*-tax return. We set this post-tax return equal to its historic value at 2% inflation - 4.9%.[62] But the cost of this capital to firms is affected by taxation at both the personal and corporate level. This is embodied in the tax wedge calculated earlier, which explicitly takes account of the historical debt-equity split of investment financing and the personal and corporate tax rates attaching to returns as they are passed down from firms to households. This tax wedge is equal to 3.3%. Adding this to the post-tax return demanded by providers of capital gives us the cost of funds for firms (ρ); it tells us the pre-tax returns available for distribution to holders of debt and equity. Our measure of pre-tax returns already embodies the direct effect of depreciation allowances (z) on the cost of funds; these are captured directly in the corporation tax wedge. We assume throughout that dq/q=0 and is invariant to inflation.

But the pre-tax real return to capital is insufficient by itself to capture fully the cost of capital for firms. This is because both the numerator - profits plus interest payments - and the denominator - the capital stock - are defined net of depreciation. So this measure of the pre-tax return makes no adjustment for the cost of depreciation. We take the average depreciation rate, δ=5.5%, from Bond *et al* (1993). We then need to make a further adjustment for the interaction between depreciation and z.[63] This gives r_2=14.3%. This constructed measure captures quite accurately the cost of capital in (24). We arrive at a rate of return which takes full account of tax distortions at the corporate and personal level; of depreciation and depreciation allowances; and of the debt/equity financing split of firms.[64]

We can now simulate the effects of moving to zero inflation. This has the effect of narrowing the tax wedge between the returns to saving and investment because of the non-neutralities associated with both personal taxation (of bond interest) and corporate taxation (bond interest deductibility and the nominal value of depreciation allowances). Our earlier estimates provided ready-reckoners for these non-neutralities. To these we add a further adjustment to reflect the depreciation allowance non-neutrality embodied in the extra depreciation term. Their combined effect is to narrow the tax wedge - and hence lower the effective user-cost of capital - by 0.18% points for every 1% point fall in inflation. This gives r_1=13.9%. Note also that with no taxes, the cost of capital equals the return on saving plus depreciation, r_0=10.4% - the minimum after-tax return that savers are willing to accept to finance a project. Thus, we have values for the three costs of capital necessary to evaluate (23).

For the elasticity of the capital stock with respect to the cost of capital, we take ε_K=0.5. This is in line with the estimates set out in Mayes and Young (1993) for the UK; and is consistent with the international evidence in Cummins, Hassett and Hubbard (1996). The net stock of capital held by firms at the end of 1995 (K_2) was around £664 bn. Plugging-in these estimates, the fall in the cost of capital from r_2 to r_1 as we move to price stability raises the capital stock by around £17.5 bn. Evaluating (23), this then gives a direct "welfare" gain of G_6=0.05% of GDP.

(b) Indirect Revenue Effects

Again, there are revenue effects associated with this rise in the capital stock. In particular, extra tax receipts accrue on the additional investment income generated by the higher equilibrium capital stock. These have further positive effects on welfare as distortionary taxes elsewhere are lowered; though these effects are relatively small, equal to 0.03% of GDP with λ=0.4. This give a total net "welfare" gain from the removal of distortions to business investment of around 0.08% of GDP with ε_K=0.5 and λ=0.4.

(c) Sensitivity Analysis

Chart 7 plots net benefits arising from reduced distortions to business investment against ε_K and λ. As with residential investment, the net gains are almost everywhere positive, though they are generally smaller than with residential investment. But as well as the cost of capital there are other channels through which inflation might affect investment. Information asymmetries may mean that corporate cashflow has a direct impact on investment, over and above cost of capital effects (Fazzari, Hubbard and Petersen (1988)). Since corporate cashflow is affected by inflation through higher effective tax rates, then inflation may have further direct effects on investment spending. Blundell *et al* (1992) report evidence of just this in a study of UK manufacturing companies; as do Cummins, Hassett and

Hubbard (1996) in an international context. Because of this, the above calculations probably underestimate the benefits of price stability arising from business investment distortions.

References

Abel, A (1996), "Comment on "The Costs and Benefits of Going from Low Inflation to Price Stability"", *mimeo*.

Akerlof, G and Yellen J (1985), "A Near-Rational Model of the Business Cycle with Wage and Price Inertia", *Quarterly Journal of Economics*, Supplement 100, 708-21.

Akerlof, G A, Dickens, W T and Perry G L (1996), "The Macroeconomics of Low Inflation", *Brookings Papers on Economic Activity*, 1-76.

Attanasio, O P (1994), "Personal Saving in the United States", in *International Comparisons of Household Saving*, J M Poterba (ed.), NBER.

Bailey, M (1956), "The Welfare Cost of Inflationary Finance", *Journal of Political Economy*, 64, 93-110.

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

Ball, L (1996), "Disinflation and the NAIRU", *NBER Working Paper No. 5520.*

Ball, L, Mankiw, N G and Romer D (1988), "New Keynesian Economics and the Output-Inflation Trade-Off", *Brookings Papers on Economic Activity*, No. 1, 1-65.

Ballard, C Shoven, J and Whalley J (1985), "General Equilibrium Computations of the Marginal Welfare Cost of Taxes in the United States", *American Economic Review*, 75, 128-38.

Ballard, C L and Fullerton D (1992), "Distortionary Taxes and the Provision of Public Goods", *Journal of Economic Perspectives*, Vol. 6, 117-131.

Banks, J and Blundell R (1994), "Household Saving Behaviour in the United States", in *International Comparisons of Household Saving*, J M Poterba (ed.), NBER.

Banks, J W, Dilnot, A and Low H (1994), The Distribution of Wealth in the UK, *Commentary No. 45, London: Institute for Fiscal Studies.*

Barro, R (1995) "Inflation and Economic Growth", *Bank of England Quarterly Bulletin*, May, 166-76.

Bayoumi, T (1993), "Financial Deregulation and Household Saving", *Economic Journal*, Vol. 103, 1432-43.

Bianchi, M and Smith J (1995), "Inflation and Productivity Growth: An Empirical Investigation", *mimeo*, Bank of England.

Blinder, A S (1992), "Why Are Prices Sticky? Preliminary Results from an Interview Survey", *American Economic Review*, Vol. 81, 89-96.

Blundell, R, Bond S, Devereux M and Schianterelli F (1992), "Investment and Tobin's Q", *Journal of Econometrics*, Vol. 51, 233-257.

Bond, S, Devereux M and Freeman H (1990), "Inflation Non-Neutralities in the UK Corporation Tax", *Fiscal Studies*, Vol. 11, No. 4, November 1990.

Bond, S, Denny K and Devereux M (1993), "Capital Allowances and the impact of Corporate Tax on Investment in the UK", *Fiscal Studies*, Vol. 14 no. 2, 1-14.

Boskin, M (1978), "Taxation, Saving and the Rate of Interest", *Journal of Political Economy*, Vol. 83, No. 3, 447-75.

Boskin, M (1996), "Toward a More Accurate Measure of the Cost of Living", *Final Report to the Senate Finance Committee.*

Breedon, F J and P G Fisher (1993), "M0: Causes and Consequences", *Bank of England Working Paper No. 20.*

Briault, C B (1995), "The Costs of Inflation", *Bank of England Quarterly Bulletin*, Vol. 35, No. 1, 33-45.

Cecchetti, S G (1994), "Comments on Ball's "What Determines the Sacrifice Ratio?"", in N G Mankiw (ed.) *Monetary Policy*, University of Chicago Press.

Chadha, J, Haldane, A G and Janssen N (1996), "Shoe-Leather Costs Reconsidered", *mimeo*, Bank of England.

Cohen, D, Hassett, K A and Hubbard R G (1996), "Inflation and the User Cost of Capital: Does Inflation Still Matter?", mimeo, Columbia University.

Cooley, T F and Hansen G D (1989), "The Inflation Tax in A Real Business Cycle Model", *American Economic Review*, 79, 733-48.

Cooley, T F and Hansen G D (1991), "The Welfare Costs of Moderate Inflations", *Journal of Money, Credit and Banking*, August, 483-503.

Crawford, A (1994), "Measurement Biases in the Canadian CPI: A Technical Note", *Bank of Canada Technical Report No. 64.*

Cummins, J G, K A Hassett and Hubbard R G (1996), "Tax Reforms and Investment: A Cross-Country Comparison", *Journal of Public Economics*, Vol. 62, 237-73.

Cunningham, A W F. (1996) "Measurement Bias in Price Indices: an Application to the UK's RPI", *Bank of England Working Paper No. 47.*

Desai, M and Hines J (1996), "The Tax-Inflation Interaction in Open Economies", *mimeo*, Harvard University.

Devereux, M (1987), "Taxation and the Cost of Capital: The UK Experience", *Oxford Review of Economic Policy*, Vol. 3, No. 4, 17-32.

Devereux, M (1989), "Tax Asymmetries, the Cost of Capital and Investment: Some United Kingdom Evidence", *Economic Journal*, Supplement.

Dolado, J J, Gonzalez-Paramo J M and Vinals J (1997), "A Cost Benefit Analysis of Going from Low Inflation to Price Stability in Spain", paper presented at the NBER Conference held at the Federal Reserve Bank of New York, 20-21 February 1997.

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

Driffill, J J, Mizon G E and Ulph A (1990), "Costs of Inflation", in Friedman, B M and F H Hahn (eds.), *Handbook of Monetary Economics*, Amsterdam: North Holland.

Fazzarri, S M, Hubbard R G and Petersen B C (1988), "Financing Constraints and Corporate Investment", *Brookings Papers on Economic Activity*, No. 1, 141-195.

Feldstein, M (1978), "The Welfare Cost of Capital Income Taxation", *Journal of Political Economy*, Volume 86, No. 2, part 2, 29-51.

Feldstein, M (1979), "The Welfare Cost of Permanent Inflation and Optimal Short-Run Economic Policy", *Journal of Political Economy*, Vol. 87, No. 4, 749-768.

Feldstein, M (1995), "Would Privatising Social Security Raise Economic Welfare?", *NBER Working Paper No. 5281.*

Feldstein, M (1996), "The Costs and Benefits of Going from Low Inflation to Price Stability", *NBER Working Paper No. 5469.*

Feldstein, M (1997), "Adjustments to the Calculations in Working Paper 5469", *mimeo*, Harvard University.

Fischer, S (1981). "Toward an Understanding of the Costs of Inflation: II", in The Costs and Consequences of Inflation, Brunner, K and A H Meltzer (eds.), *Carnegie-Rochester Conferences Series on Public Policy*, Vol. 15, Amsterdam, North-Holland.

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

Fischer, S. (1994) "Modern Central Banking", in *The Future of Central Banking*, Capie, F, Goodhart, C A E, Fischer, S and Schnadt, N, Cambridge: Cambridge University Press.

Fischer, S and Modigliani F (1975), "Towards an Understanding of the Real Effects and Costs of Inflation", *Weltwirtschaftliches Archive*, 114, 810-33.

Fisher, P G and Whitley J D (1998), "The Bank of England Suite of Models", *Bank of England Working Paper*, forthcoming.

Fuhrer, J and Madigan B (1994), "Monetary Policy when Interest Rates are Bounded at Zero", *Federal Reserve Bank of Boston Working Paper No. 94-1.*

Fullerton, D and Henderson Y K (1989), "The Marginal Excess Burden of Different Capital Tax Instruments", *The Review of Economics and Statistics*, Vol. 71, 435-42.

Hall, R E (1988), "Intertemporal Substitution in Consumption", *Journal of Political Economy*, Vol. 96, 339-357.

Hall, R E and Jorgenson D W (1967), "Tax Policy and Investment Behaviour", *American Economic Review*, 57, 391-414.

Hall, S, Walsh, M and Yates A (1996), "How Do UK Companies Set Prices*?", Bank of England Quarterly Bulletin*, Vol. 36, No. 2, 180-192.

Hansson, I and Stuart C E (1985), "Tax Revenue and the Marginal Cost of Public Funds in Sweden", *Journal of Public Economics*, Vol. 27, 331-53.

Henry, S G B and Pain D L (1994), "The User Cost Approach to Housing costs in the RPI", *Bank of England submission to the RPI Advisory Committee,* June/July 1992.

Hills, J (1991), *Unravelling Housing Finance: Subsidies, Benefits and Taxation*, Oxford University Press.

Hurd, M D (1989), "Mortality Risk and Bequests", *Econometrica*, 779-813.

Institute for Fiscal Studies (1995),"Options for 1996: the Green Budget".

Janssen, N J (1996), "Can We Explain the Shift in M0 Velocity? Some Time-Series and Cross-Section Evidence", *Bank of England Quarterly Bulletin*, Vol. 36, No. 1, 39-48.

Kay, J A and King, M A (1990), *The British Tax System*, Oxford University Press, 5th edition.

Kearly, J R (1979), "Inflation, Mortgages, and Housing", *Journal of Political Economy*, Vol. 87, No. 5, 1115-1138.

King, M A (1974), "Taxation and the Cost of Capital", *Review of Economic Studies*, 41, 21-35.

King, M A (1977), *Public Policy and the Corporation*, London: Chapman and Hall.

King, M A (1980), "An econometric Model of Tenure Choice and Demand for Housing as a Joint Decision", *Journal of Public Economics*, Vol. 14, 137-159.

King, M A, (1994), "Monetary Policy in the UK", *Fiscal Studies*, 15, 109-28.

King, M A and Fullerton D (1984), *The Taxation of Income from Capital: A Comparative Study of the United States, the United Kingdom, Sweden and West Germany*, NBER.

King, M A and Robson M (1988), *Turbo PTAX: A Program to Calculate Effective Tax Rates on Capital Income.*

Laxton, D, Meredith, G and Rose D (1995), "Asymmetric Effects of Economic Activity on Inflation", *IMF Staff Papers*, Vol. 42, No. 2.

Layard, R, Nickell S and Jackman, R (1991), *Unemployment: Macroeconomic Performance and the Labour Market*, Oxford University Press, Oxford.

Leigh-Pemberton, R (1992), "The Case for Price Stability", *Bank of England Quarterly Bulletin*, November.

Lucas, R E Jr (1994), "On the Welfare Costs of Inflation", *mimeo*, University of Chicago.

Mankiw, N G (1985), "Small Menu Costs and Large Business Cycles: A Macroeconomic Model", *Quarterly Journal of Economics*, Vol. 100, 529-39.

Mayes, D and Chapple, B (1994), "The Costs and Benefits of Disinflation: A Critique of the Sacrifice Ratio", *New Zealand Reserve Bank Bulletin*, Vol. 57, No. 4.

Mayes, D and Young G (1993), "Industrial Investment and Economic Policy", *National Institute Discussion Paper No. 56.*

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

Miles, D (1994), *Housing, Financial Markets and the Wider Economy*, John Wiley and Sons.

Muellbauer, J and Murphy A (1993), "Income Expectations, Wealth and Demography in the Aggregate UK Consumption Function", *paper presented at HM Treasury's Academic Panel.*

Mulligan, C B and Sala-i-Martin X X (1996), "Adoption of Financial Technologies: Implications for Money Demand and Monetary Policy", *NBER Working Paper No. 5504.*

Nordhaus, W (1994), "Do Real Output and Real Wage Measures Capture Reality? The History of Lighting Suggests Not", *Cowles Foundation Discussion Paper No. 1078.*

Pain, N and Westaway P (1996) "Modelling structural change in the UK housing market: a comparison of alternative house price equations", paper presented *at Society of Housing and Property Economists 1996 Conference* at the London Business School.

Phelps, E S (1972), "Inflation in a Theory of Public Finance", *Swedish Journal of Economics*, Vol. 75, 67-82.

Ramsey, F P (1928), "A Mathematical Theory of Saving", *Economic Journal*, 543-59.

Report of the **Retail Prices Index Advisory Committee** (1995), "Treatment of Owner Occupiers' Housing Costs in the Retail Prices Index", *Central Statistical Office*, January 1995.

Robinson, W and Skinner T (1989), "Reforming the RPI: A Better Treatment of Housing Costs?", *Commentary No.15, London: Institute for Fiscal Studies*.

Robson, M (1988), "Estimating Tax Rates on Income from Capital in the UK from Official Statistics", *LSE Financial Markets Group Discussion Paper No. 28*.

Rudebusch, G D and Wilcox D W (1994), "Productivity and Inflation: Evidence and Interpretations", Federal Reserve Board, Washington, *mimeo*, May.

Sarel, M (1996), "Nonlinear Effects of Inflation on Economic Growth", *IMF Staff Papers*, Vol. 43, No. 1, 199-215.

Schwab, R M (1982), "Inflation Expectations and the Demand for Housing", *American Economic Review*, 72(1), 143-153.

Shapiro, M D and Wilcox D W (1996), "Mismeasurement in the Consumer Price Index: An Evaluation", *NBER Working Paper No. 5590*.

Sidrauski, M (1967), "Rational Choice and Patterns of Growth in a Monetary Economy", *American Economic Review*, 57(2), 534-544.

Shiller, R (1996), "Why Do People Dislike Inflation?", *NBER Working Paper 5539*, NBER.

Smyth, D J (1994), "Inflation and Growth", *Journal of Macroeconomics*, Vol. 16, 261-70.

Stuart, C E (1984), "Welfare Costs Per Dollar of Additional Tax Revenue in the United States", *American Economic Review*, Vol. 74, 352-62.

Summers, L H (1989), "How Should Long-Term Monetary Policy be Determined?", *Journal of Money, Credit and Banking*, 625-31.

Thornton, D L (1996), "The Costs and Benefits of Price Stability: An Assessment of Howitt's Rule", *Federal Reserve Bank of St Louis Review*, Vol. 78, No. 2, 23-35.

Tower, E (1971), "More On the Welfare Costs of Inflationary Finance", *Journal of Money, Credit and Banking*, Vol. 3, 850-60.

Wadhwani, S B ((1986), "Inflation, Bankruptcy, Default Premia and the Stock Market", *Economic Journal*, 96, 120-38.

Wardlow, A (1994), "Investment Appraisal Criteria and the Impact of Low Inflation", *Bank of England Quarterly Bulletin*, Vol. 34, No. 3, 250-254.

Yates, A (1995), "On the Design of Inflation Targets", in *Targeting Inflation*, A G Haldane (ed.), Bank of England.

Yates, A and Chapple, B (1996), "What Determines the Short-Run Output-Inflation Trade-off?", *Bank of England Discussion Paper No. 53.*

Figures & Charts

Table 1: UK estimates

The Welfare Effects of a 2 percentage point reduction in inflation (measured as a percentage of GDP)

Source of Change		Direct effect of reduced distortion	Indirect Welfare effect of revenue change		Net Welfare effect	
			$\lambda=$ 0.4	$\lambda=$ 1.5	$\lambda=$ 0.4	$\lambda=$ 1.5
Consumption timing	$\eta_{SR}=$ 0.2	0.40	-0.12	-0.43	0.29	-0.03
	$\eta_{SR}=$ 0.0	0.35	-0.14	-0.51	0.21	-0.17
	$\eta_{SR}=$ 0.4	0.46	-0.09	-0.35	0.37	0.11
Housing Demand		0.04	0.07	0.27	0.11	0.30
Money Demand		0.02	-0.05	-0.17	-0.02	-0.15
Debt Service		n/a	-0.09	-0.33	-0.09	-0.33
Total	$\eta_{SR}=$ 0.2	0.47	-0.18	-0.67	0.29	-0.20
	$\eta_{SR}=$ 0.0	0.41	-0.20	-0.75	0.21	-0.34
	$\eta_{SR}=$ 0.4	0.52	-0.16	-0.59	0.37	-0.06

Table 2: US estimates

The Welfare Effects of a 2 percentage point reduction in inflation (measured as a percentage of GDP)

Source of Change		Direct effect of reduced distortion	Indirect Welfare effect of revenue change		Net Welfare effect	
			$\lambda=$ 0.4	$\lambda=$ 1.5	$\lambda=$ 0.4	$\lambda=$ 1.5
Consumption timing	$\eta_{SR}=$ 0.4	1.04	-0.07	-0.27	0.97	0.77
	$\eta_{SR}=$ 0.0	0.75	-0.18	-0.67	0.57	0.07
	$\eta_{SR}=$ 1.0	1.49	0.09	0.33	1.58	1.82
Housing Demand		0.11	0.14	0.51	0.25	0.62
Money Demand		0.016	-0.05	-0.19	-0.03	-0.17
Debt Service		n/a	-0.10	-0.38	-0.10	-0.38
Total	$\eta_{SR}=$ 0.4	1.17	-0.09	-0.33	1.09	0.84
	$\eta_{SR}=$ 0.0	0.87	-0.19	-0.73	0.68	0.14
	$\eta_{SR}=$ 1.0	1.61	0.07	0.27	1.69	1.89

λ is the marginal deadweight loss of an across-the-board tax increase which raises one extra pound of revenue.

η_{SR} is the elasticity of private savings to the post-tax real rate of return.

n/a = note applicable

Table 3: UK sacrifice ratios

Period of downturn	Ratio	
1961Q1-1963Q3	1.9 (a)	
1965Q2-1966Q3	0.0 (a)	
1975Q1-1978Q2	0.9 (a)	
1980Q2-1983Q3	0.3 (a)	0.8 (b)
1984Q2-1986Q3	0.9 (a)	
Average	**0.8** (a)	
1990Q3-1994Q4	2.8 (b)	

Notes: Quarterly data. Sources: (a) Ball (1994); (b) Own estimates. One reason for the difference between the two estimates for the 1980 downturn is because we use RPIX inflation rather than the RPI series used by Ball.

Table 4: Advance Corporation Tax (ACT) and Mainstream Corporation Tax (MCT)

Taxable profits		£100
Corporation tax rate		33%
Liability to CT	£33	
ACT rate		25%

Dividend paid	£40	
Payments of ACT	£10	(0.25*40)
Payments of MCT	£23	(33-£10)

Table 5: Saving Ratios in the United States and United Kingdom in 1990

Age Cohort	US	UK
31-35	7.1	8.0
36-40	9.4	12.0
41-45	9.8	12.0
46-50	11.2	11.0
51-55	13.9	10.0
56-60	16.6	13.0

Source: Attanasio (1994) and Banks and Blundell (1994)

Table 6: Changes in Mortgage Interest Relief

pre 1974/75	Mortgage interest relief given on the full amount of any loan
1974/75	Limit introduced of £25,000
1983/84	Limit raised to £30,000, and relief given at source (MIRAS)
1988/89	Tax relief on new loans for home improvement withdrawn, limit of one claim on each property (home sharers were previously able to claim double tax relief)
1991/92	Higher rate relief abolished; relief restricted to basic rate (25%)
1994/95	Rate of tax relief reduced to 20%
1995/96	Rate of tax relief reduced to 15%

Table 7: Value of housing stock in 1992

	Gross ($ bn) *	Net ($ bn) *	Net stock per capita ($)
UK	1,425	919	15,845
Australia	361	252	14,376
USA	8,086	5,190	20,314
Germany **	3,280	2,252	36,286

Source: OECD, "Flows and stocks of fixed capital" and "Main Economic Indicators"

* Calculations based on market exchange rates, $/£1.512 , DM/$1.6139, A$/$1.4513.

** Estimate for Western Germany

Notes

1. Physical menu costs and front-end loading have generally been found to have small effects. For example, survey evidence in Blinder (1992) for the US and Hall, Walsh and Yates (1996) for the UK finds little evidence of menu costs being an important influence on firms' price-setting behaviour. Schwab (1992) finds that the welfare costs of front-end loading are not large for reasonably-sized changes in inflation.

2. Bailey (1956) was one of the first exponents of such micro-to-macro welfare analysis in the context of money demand distortions.

3. See also Fischer (1993), Smyth (1994) and Fry, Goodhart and Almeida (1996) for cross-section evidence on inflation-growth correlations.

4. On the relationship between investment and growth in the cross-section, see Barro (*op.cit.*) and Fischer (*op.cit.*).

5. This is the adjustment suggested by Tower (1971) to the original money demand welfare analysis presented by Bailey (1956).

6. Recent estimates by Shapiro and Wilcox (1996) suggest that this adjustment may be on the high side. They estimate that there is a one in ten chance that the bias in the US CPI is greater than 1.5%. The Shapiro/Wilcox estimates accord closely with Canadian evidence (Crawford (1994)). But measurement biases remain an area of great uncertainty, in particular with regard to new good and quality biases (see, eg, Nordhaus (1994) and, indeed, Shapiro and Wilcox's (1996) Medicare example). See also Boskin (1996).

7. We select 1995 as the base year for our calculations since it is the most recent year for which a (near) full set of data is available Because we are simulating the effect of a change in inflation from current levels, we use the effective marginal tax rates in operation during 1995, rather than historical averages.

8. An Appendix provides some analysis of inflation effects on business investment.

9. Other methodological questions are raised in Cecchetti (1994) and Mayes and Chapple (1994).

10. We discuss in greater detail below the evidence on such Phillips curve convexities.

11. Real growth should perhaps be defined on a per capita basis. But that would make little difference to our estimate here as the UK population has been steady over the period.

12. The choice of period over which to average is in some sense arbitrary.

[13] To simplify calculations we use the 1995 tax system as a base. The marginal tax rate is calculated using Inland Revenue data for this year and the methodology in Robson (1988). It would have been costly to calculate an average of marginal tax rates operating in every year between 1970-95. Our approach is likely to lead to a conservative estimate of the discount rate if, on average, tax rates in 1995 were lower than those over the period as a whole. However, this approach may provide a better estimate of the discount rate to apply when discounting *future* welfare gains.

[14] Though not from inheritance tax - but this has a much higher exemption limit.

[15] Calculated using redemption yields rather than holding-period returns.

[16] For example, Table 8 of BMR suggests that the output-inflation trade-off (and hence the implied sacrifice ratio) doubles between inflation rates of 5% - close to the historical mean for the UK over the sample - and 0%. Yates and Chapple (1996) confirm this result using a more general formulation of the empirical output/inflation relationship.

[17] Though North American and UK evidence on the distribution of prices and earnings finds mixed support for such a proposition: see Yates (1995) for a summary. Akerlof, Dickens and Perry (1996) present evidence to suggest that the distribution of wage settlements in the US is truncated below zero.

[18] Higher-order polynomial terms added nothing to the fit. Because we are attempting to fit an aggregate supply curve, we have crudely attempted to purge the data of supply shocks by removing observations where the change in the price level and in output are oppositely-signed.

[19] See, for example, Layard, Nickell and Jackman (1991) and more recently Akerlof, Dickens and Perry (1996).

[20] Ball (1996) also allows for multiplicative effects with the duration of unemployment benefits (Table IV). Making an allowance for this effect raises the effect of disinflation on the level of output to 2% points in the UK because of the greater duration of UK unemployment benefits.

[21] For example, because even discouraged and deskilled workers will exit the labour force at some stage, through death or retirement.

[22] There may be costs to operating at, as well as transitioning to, price stability - such as the non-negativity constraint imposed on real interest rates (Summers (1989)). What little evidence there is suggests that the Summers constraint only rarely binds in a costly way (Fuhrer and Madigan (1994)).

[23] All subsequent calculations are based on estimates up to and including 1995, the last year for which we have a full set of data. A number of changes to the tax system have been announced since 1995 but have not been taken into account.

[24] As in Feldstein, the capital stock is defined net of depreciation; pre-tax profits are gross of interest payments but, unlike Feldstein, no attempt has yet been made to gross up for property taxes.

[25] This means that a number of firms each year have ACT credits outweighing their taxable income: they are "tax exhausted" (see, eg, Devereux (1987)). This tax credit typically gets carried forward. This gives rise to an asymmetry in the corporate tax system - but one which we ignore here.

[26] If we use instead the UK corporate sector's balance sheet to infer a equity/debt ratio for companies' non-bank liabilities, we get a ratio of around 8% in 1995.

[27] We are only interested here in the savings channel running from households to companies. So personal sector assets which are backing *non*-UK-corporate liabilities are not included in the calculations - for example, household holdings of government debt, or foreign debt and equity.

[28] We discuss variants on this assumption in the sensitivities section below.

[29] There is an argument for basing the weights on gross rather than net banking liabilities. Using gross liabilities changes the weights to 4%/81%/15% but this does not appear to have a very significant effect on the estimates of the welfare gain.

[30] In the US, only the second and third of these effects is relevant.

[31] If a 1 percentage point rise in inflation lowers tax liabilities by 3.7% then, for fixed capital stock, this is equivalent to a 3.7% rise in the profit rate. The pre-tax return to capital in 1989 - the year when Bond *et al* (1990) do their analysis - was around 10%. Hence a 1% point rise in inflation implies an increase in the profit rate of 0.37 percentage points. This ready-reckoner takes account of all three tax non-neutralities simultaneously, whereas Feldstein looks at them separately. We can identify separately the debt-interest deductibility effect to ensure our estimates aren't too wayward. With debt 21% of ICCs' capital and a marginal corporate tax rate of 32%, a 2 percentage point fall in inflation raises the effective corporate tax rate by 0.32*0.21*0.02=0.0013 (or 0.13 percentage points). That would imply an effect upon the effective tax rate from the lack of indexation of depreciation allowances and stock relief of 0.5% points - not too dissimilar to the 0.57 percentage point depreciation non-neutrality used by Feldstein.

[32] This is a weighted average of the 33% headline MCT rate and the 25% reduced rate for small firms.

[33] Dividend income taxation is immune to inflation effects.

[34] Two possible reasons for this are: first, that our aggregate real wage growth assumption is too low - certainly, real wage growth is higher (around 2.5%) if we extend our data back to the 1960s; and second, that our net savings ratio is too high. One cause of the latter is that our saving ratio is not inflation-adjusted and

average inflation over the sample has been higher than our 2% benchmark. An inflation-adjusted saving ratio would, over the 1980s, have been nearer to 4%.

35. One potential problem with the FES data is that it is known to undersample high-income households. That, in turn, would depress the average saving ratio. But in 1990 the aggregate saving ratio in the UK was in line with the average reported by the FES.

36. It can be shown that $\eta_{SR} = \frac{-RT\eta}{1+R} Sp$

37. Though only the first of these studies uses *post*-tax real interest rates.

38. For example, with Cobb-Douglas preferences in a two-period model, η_{Sr}=0.4 and r=4%, the implied elasticity of substitution is 1.7.

39. This involves scaling by -(1+R)/RT where R is some benchmark saving rate. We take R to be the post-tax saving rate at 2% inflation, 4.9%.

40. The tax treatment of PEPs and pensions is not the same: in the former case final receipts are tax-deductible, whereas in the latter, initial contributions are tax-deductible. We ignore that complication here.

41. Policyholder and shareholder funds actually have a different tax treatment in the United Kingdom - bond interest and capital gains on the former being taxed at the basic rate of income tax (and at a lower rate of 20% from April 1996), whereas the latter are taxed at the higher corporation tax rate of 33%. In the absence of disaggregated data, our calculation assumes that all bond holdings are taxed as policyholder funds.

42. This is based on the figure of 1.4% contained in the 1995 RPI Advisory Committee Report, representing the average annual expenditure on renovation - expressed as a percentage of the value of the dwelling *excluding* land - needed to make good deterioration and obsolescence. But the value of land may be as much as half of the total price of a dwelling. This would tend to lower the percentage cost of maintenance and depreciation by around half, to around 0.7%. There is also some expenditure necessary to maintain the value of the land for each dwelling of, say, 0.1% per annum.

43. The US and UK distinctions are different. In the US, non-itemisers get a lump-sum of interest relief, whereas in the UK the non-MIRAS component gets no relief of any kind. Feldstein is able to ignore the lump-sum benefit to non-itemisers because it has no effect at the margin.

44. There are various alternative ways of capturing the MIRAS limit. For example, presentationally it might appear preferable to make a distinction between those households who *claim* MIRAS and those that do not. For example, Hills (1991) calculates that 90% of the mortgage stock, and some 22% of all mortgages, were above the

£30,000 ceiling at the end of 1988. These figures will of course have increased since 1988, since when the MIRAS ceiling has been fixed in nominal terms. It is possible to use these as weights to calculate an effective rate of tax relief for all those who claim MIRAS. But the effective rate of tax relief would then vary systematically with the mortgage stock in response to any change in the rental price.

45. That is, 1/4 of the tax rate in Financial Year 1994/95 (20%) and 3/4 of the rate in 1995/96 (15%).

46. It is unclear whether we would expect the *pre-tax* Fisher effect to hold exactly.

47. We exclude any effects from the public or housing association sectors and concentrate on the private rented sector. Together, public sector housing (19%) and housing associations (4%) account for 23% of the housing stock by tenure. Given an owner-occupied rate of 67%, the residual of 10% reflects the proportion of households in the private rented sector. We assume that the value of the housing stock is divided in the same proportion as tenure rates. This is likely to underestimate the value of the owner-occupied sector.

48. Inland Revenue figures suggest that 8% of individuals' rental income is taxed at 20%, 44% at 25% and 48% at 40%

49. Hence, the aggregate loan-to-value ratio is 35%=123/356*100, as above.

50. Which is the average share of housing costs in the RPI in the 1990s.

51. The elasticity of the private rental sector is still set equal to 0.4.

52. However, this calculation only includes the revenue gained from the existence of the wedge between the rate of return earned by companies and the post-tax real rate of interest earned by households. Following Dolado *et al* (1997) there is also a Value Added Tax (VAT) effect. With a capital share of value-added assumed fixed at 37% in 1995, and a pre-tax return of 8.2%, value-added will be around 22% of the capital stock per year. Given our estimated £10.4bn rise in the business capital stock, this generates an additional £2.3bn of value-added, which in turn generates £0.4 bn (0.06% of GDP) of VAT receipts with VAT at 17.5%. To maintain consistency with other countries' calculations this additional revenue effect has not been added to the results in the main table.

53. We can gauge its size - and put a lower bound on welfare gains - by assuming *all* of the mortgage stock is effectively ineligible for MIRAS. The welfare gain would then fall to 0.04% of GDP.

54. On the assumption that the marginal cost of money creation is close to zero.

55. Most authors use an M1 measure of the money stock. This will lead to an *over*statement of money demand distortions because much of the M1 stock is interest-bearing. Feldstein (1995) takes the stock of currency and reserves, which will be an *under*statement because it omits non-interest bearing bank deposits.

[56] Chadha, Haldane and Janssen (1996) look at narrow money demand relationships between 1870-1994 and find an interest elasticity of around 0.8; while Janssen (1995) looks at the behaviour of M0 during the 1990s and finds that its interest elasticity has risen markedly compared with the 1980s

[57] Neither of these studies takes account of tax effects which mean that the interest rate opportunity cost falls less than proportionately with inflation. They also use a broader (M1) measure of the money stock. This largely accounts for the differences. See also Feldstein (1979) and, more recently, Dotsey and Ireland (1996).

[58] There are other effects which might be introduced into a general equilibrium set-up and which would aggravate inflation's distortions. For example, Dotsey and Ireland (1996) have a model where higher inflation leads to an employment redistribution from production towards financial intermediation, where the returns to the latter are smaller.

[59] Using a currency specification - as in Feldstein - and switching-off the endogenous growth channel. The benefits are, however, much greater as we approach the Friedman optimum.

[60] Assuming no change in the inflation risk premium on government debt.

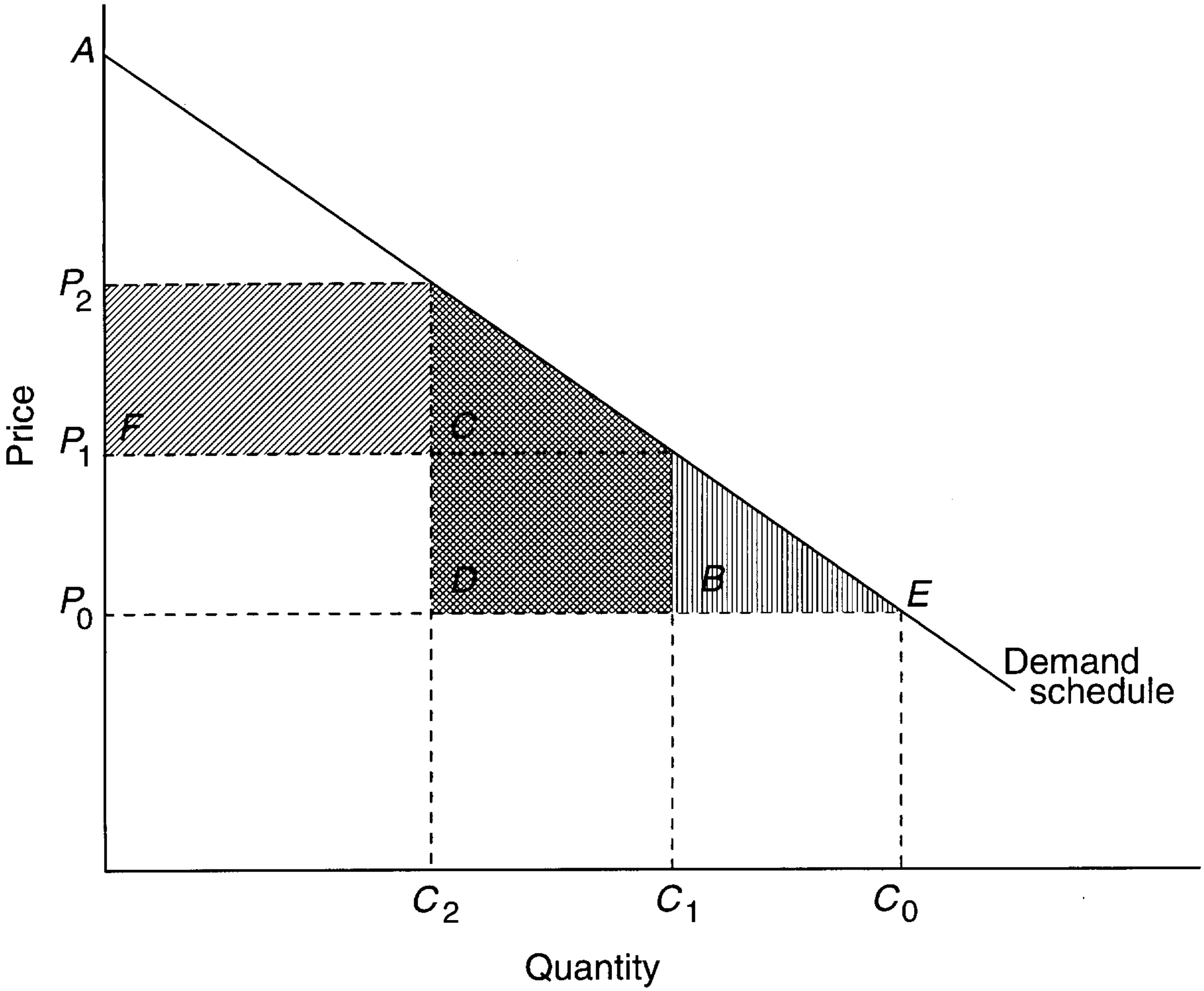
[61] A third complication comes in the tax treatment of index-linked debt. Coupons are taxed in nominal terms and so changes in inflation do have revenue implications, but this is not true generally of the capital gains component. We ignore this effect here.

[62] The assumption here is that the supply of international capital is perfectly elastic at this rate, which is not unreasonable in an open-economy setting. To prevent double-counting of the capital stock effects from Section III, we are also effectively assuming $\eta_{SR}=0$ ie private savings are interest-inelastic at the domestic level.

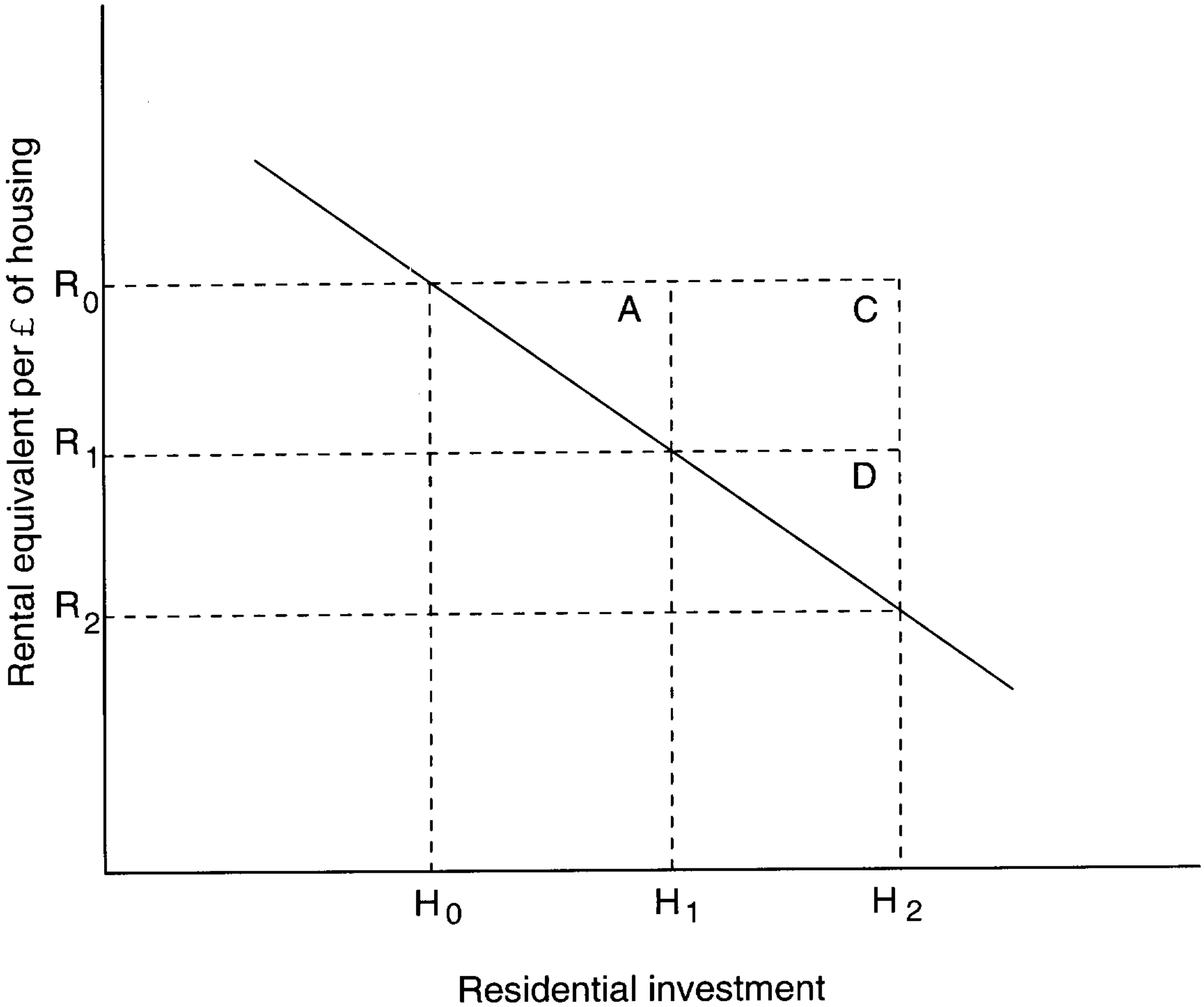
[63] Investment in vehicles and plant and machinery made up around 75% of gross domestic fixed capital formation in 1995, with buildings making up the further 25%. Applying these weights to capital allowance rates of 25% for vehicles and plant and machinery and 4% for buildings gives a weighted average capital allowance rate of 19.7%. Assuming a declining balance method of depreciation and discounting at the rate of return demanded by investors plus the inflation rate provides a measure of z.

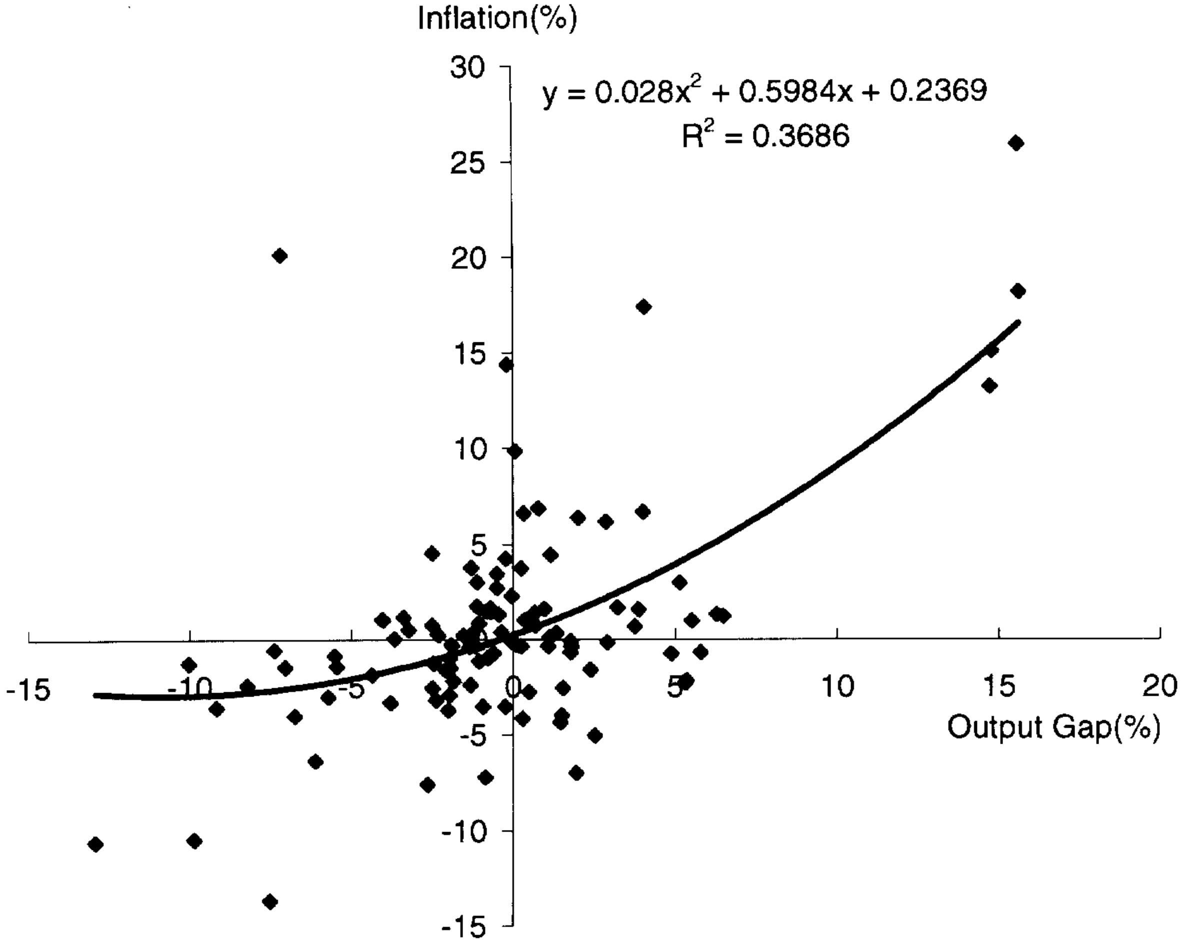
[64] One restriction which the analysis imposes is that the market value of companies' capital and its capital stock are equal; that Tobin's q is unity.

Figure Legends

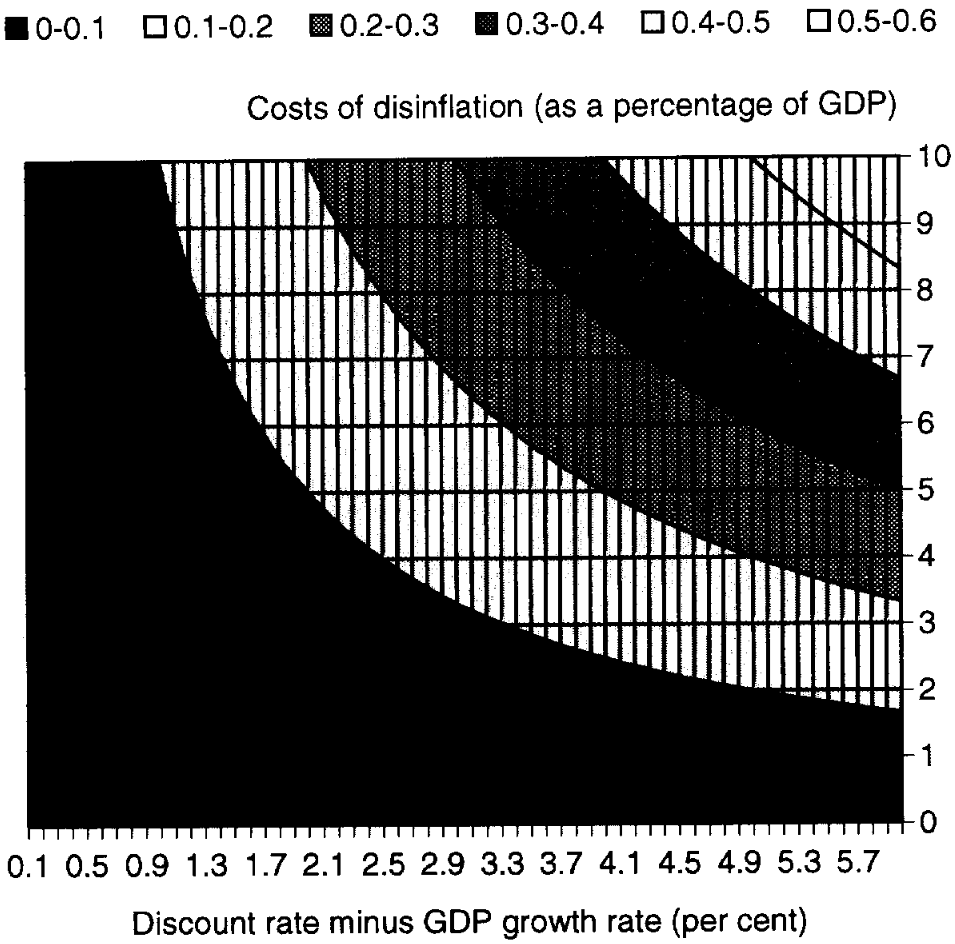


A
P2
P1
F
C
P0
D
B
E
Demand schedule
Price
C2
C1
C0
Quantity

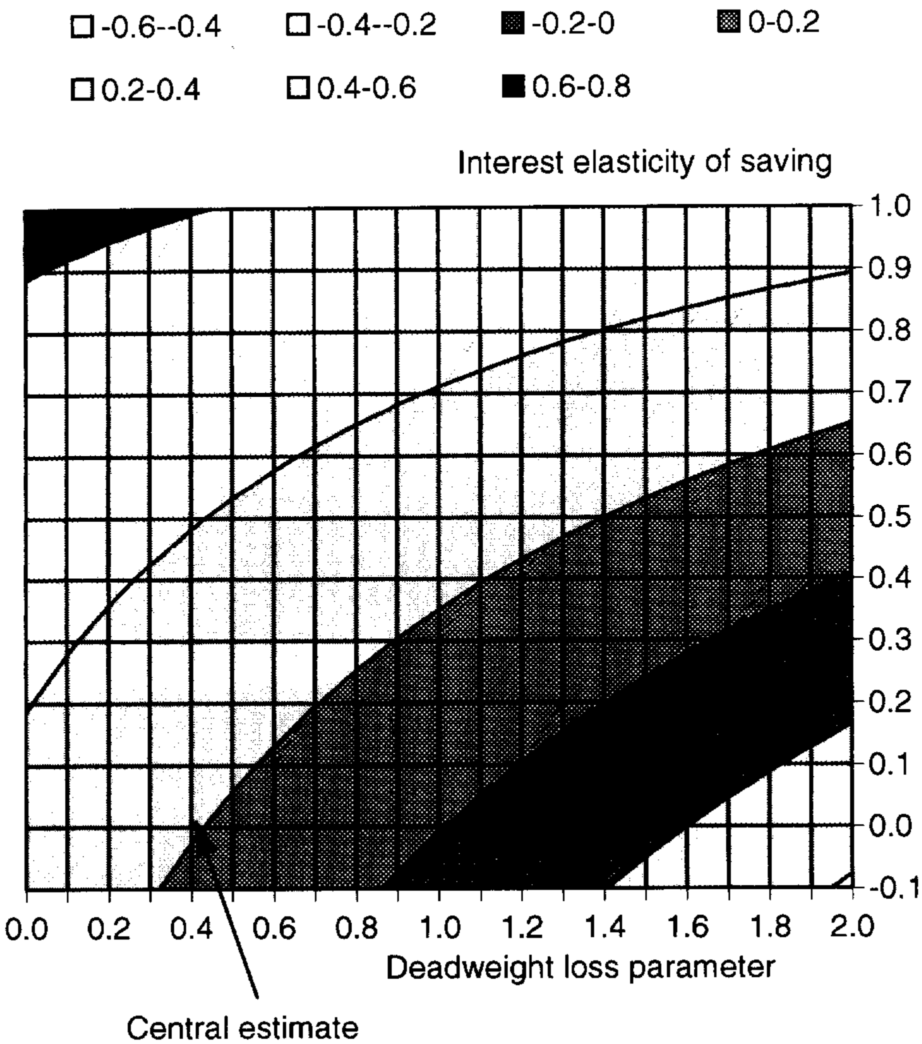

Rental equivalent per £ of housing
R0
R1
R2
A
C
D
H0
H1
H2
Residential investment



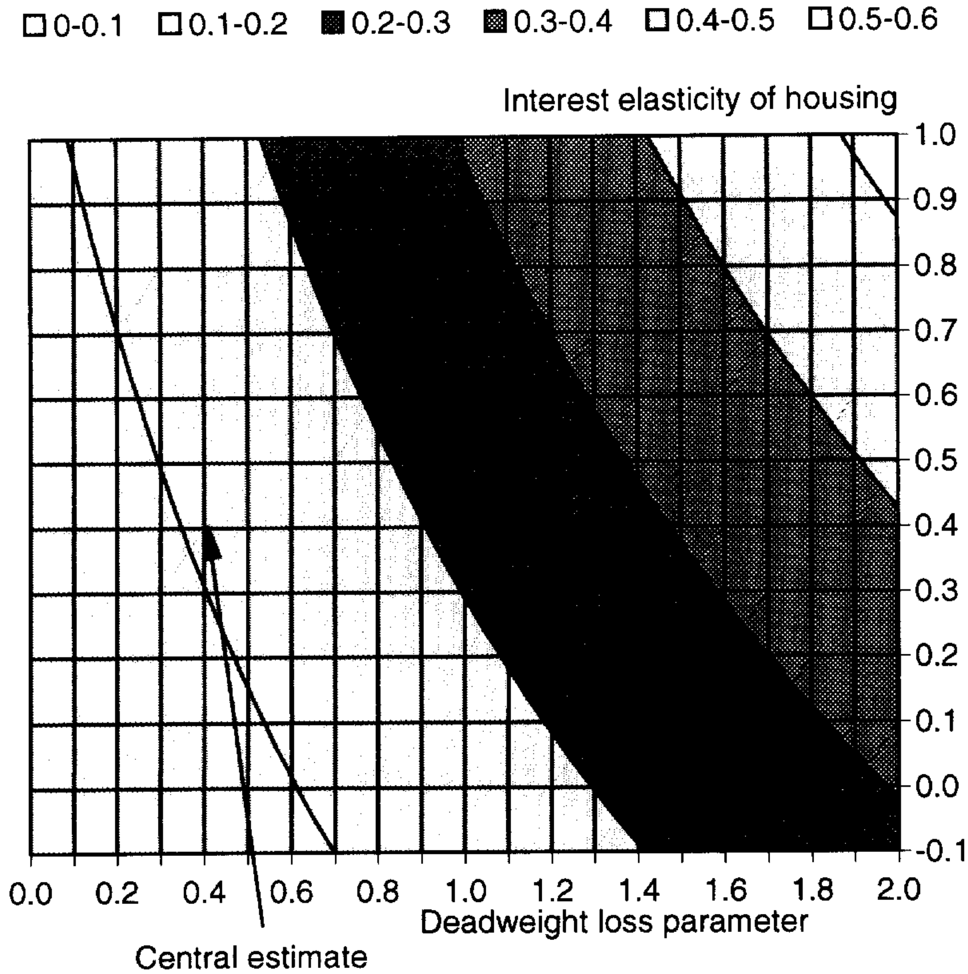
Inflation(%)
y = 0.028x² + 0.5984x + 0.2369
R² = 0.3686
30
25
20
15
10
5
0
-5
-10
-15
-15
-10
-5
0
5
10
15
20
Output Gap(%)



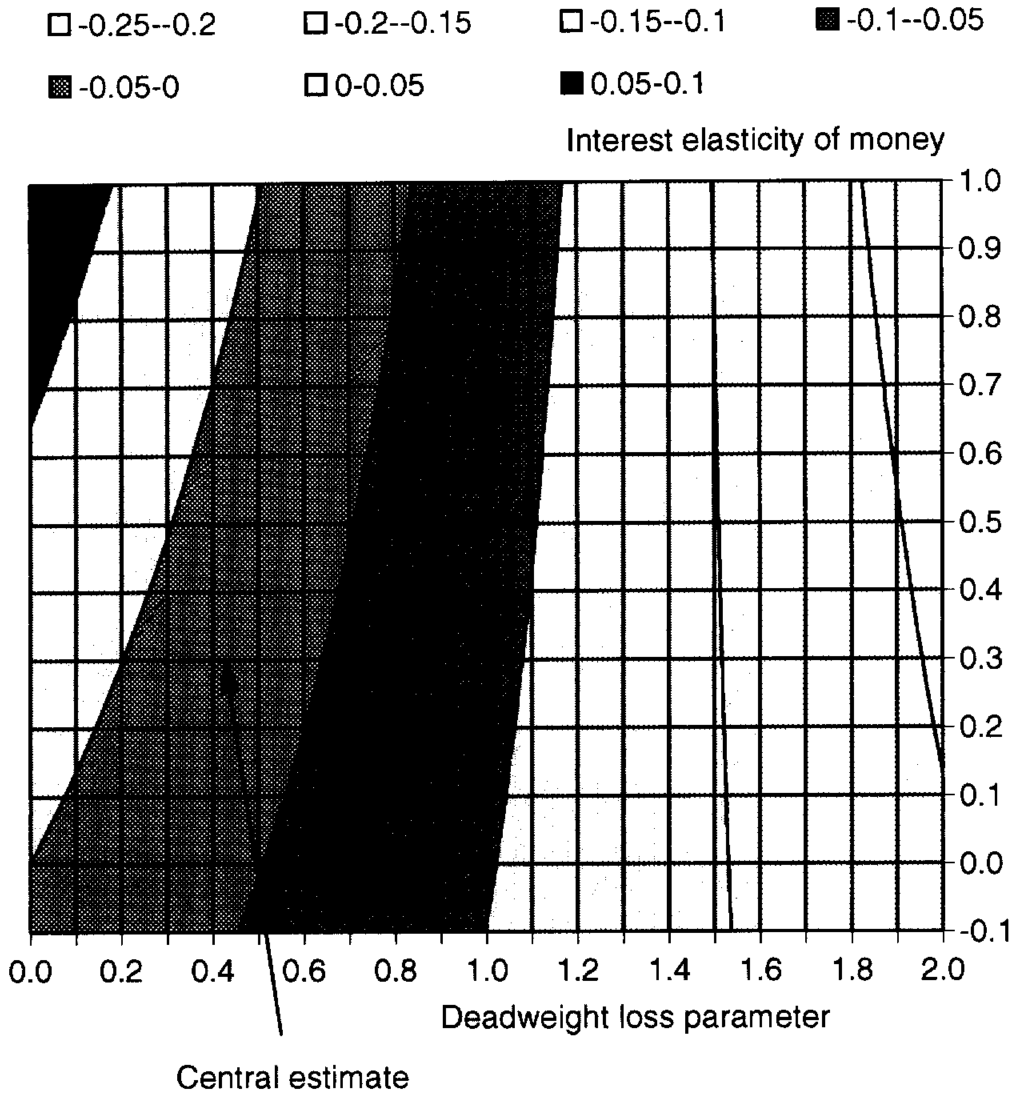
0-0.1
0.1-0.2
0.2-0.3
0.3-0.4
0.4-0.5
0.5-0.6
Costs of disinflation (as a percentage of GDP)
10
9
8
7
6
5
4
3
2
1
0
0.1 0.5 0.9 1.3 1.7 2.1 2.5 2.9 3.3 3.7 4.1 4.5 4.9 5.3 5.7
Discount rate minus GDP growth rate (per cent)

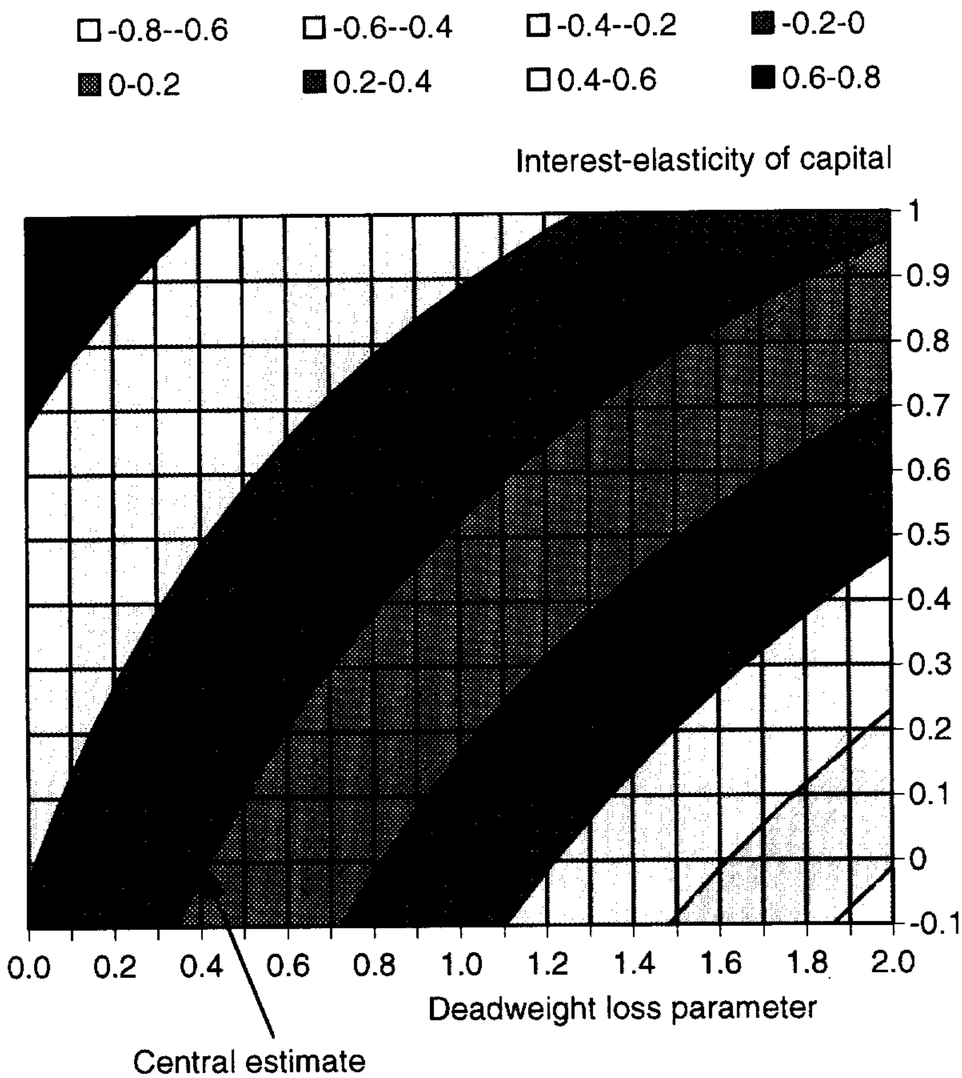


-0.6--0.4
-0.4--0.2
-0.2-0
0-0.2
0.2-0.4
0.4-0.6
0.6-0.8
Interest elasticity of saving
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
-0.1
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
2.0
Deadweight loss parameter
Central estimate

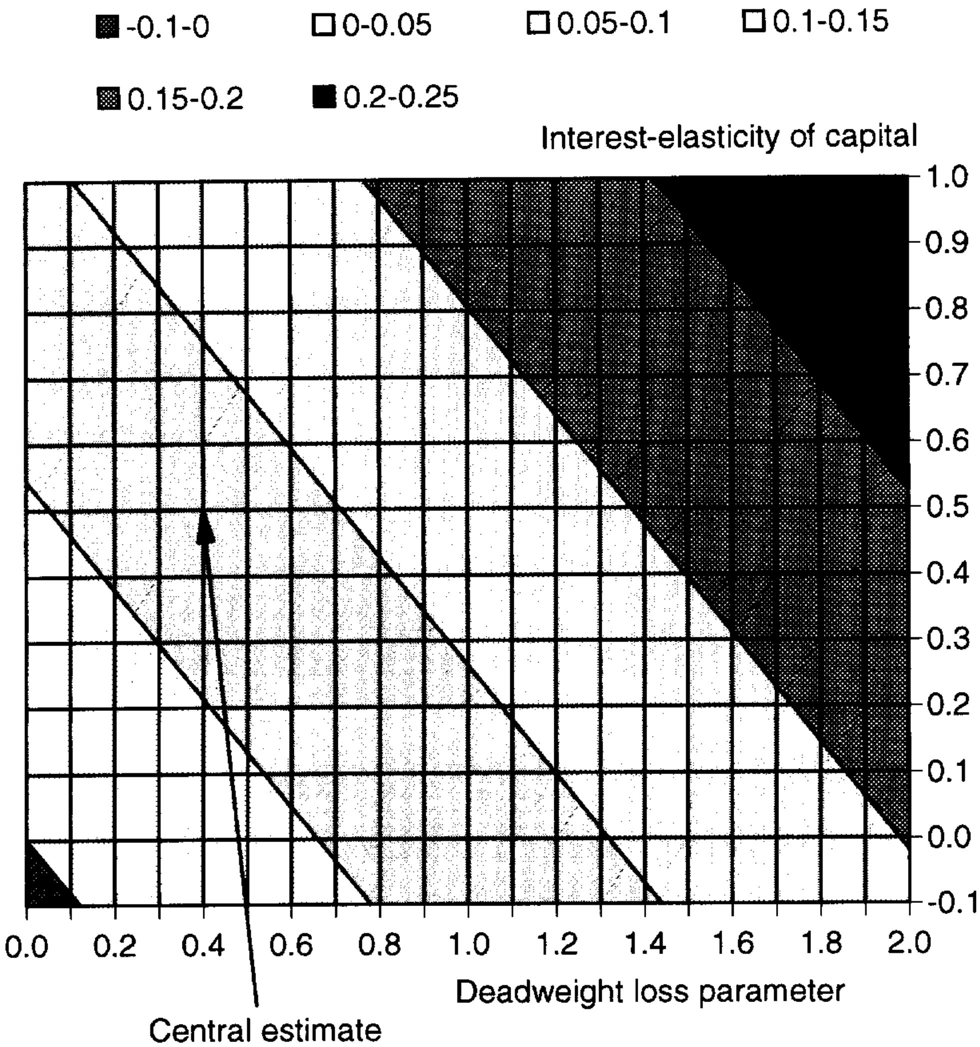


0-0.1
0.1-0.2
0.2-0.3
0.3-0.4
0.4-0.5
0.5-0.6
Interest elasticity of housing
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
-0.1
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
2.0
Deadweight loss parameter
Central estimate


-0.25--0.2
-0.2--0.15
-0.15--0.1
-0.1--0.05
-0.05-0
0-0.05
0.05-0.1
Interest elasticity of money
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
-0.1
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
2.0
Deadweight loss parameter
Central estimate



-0.8--0.6
-0.6--0.4
-0.4--0.2
-0.2-0
0-0.2
0.2-0.4
0.4-0.6
0.6-0.8
Interest-elasticity of capital
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
-0.1
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
2.0
Deadweight loss parameter
Central estimate



-0.1-0
0-0.05
0.05-0.1
0.1-0.15
0.15-0.2
0.2-0.25
Interest-elasticity of capital
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
-0.1
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
2.0
Deadweight loss parameter
Central estimate

Figure Legends

Figure 1: Calculating welfare losses

Figure 2: Residential investment

Chart 1: UK Phillips Curve: 1831 - 1938

Chart 2: Breakeven welfare benefits (as a percentage of GDP)

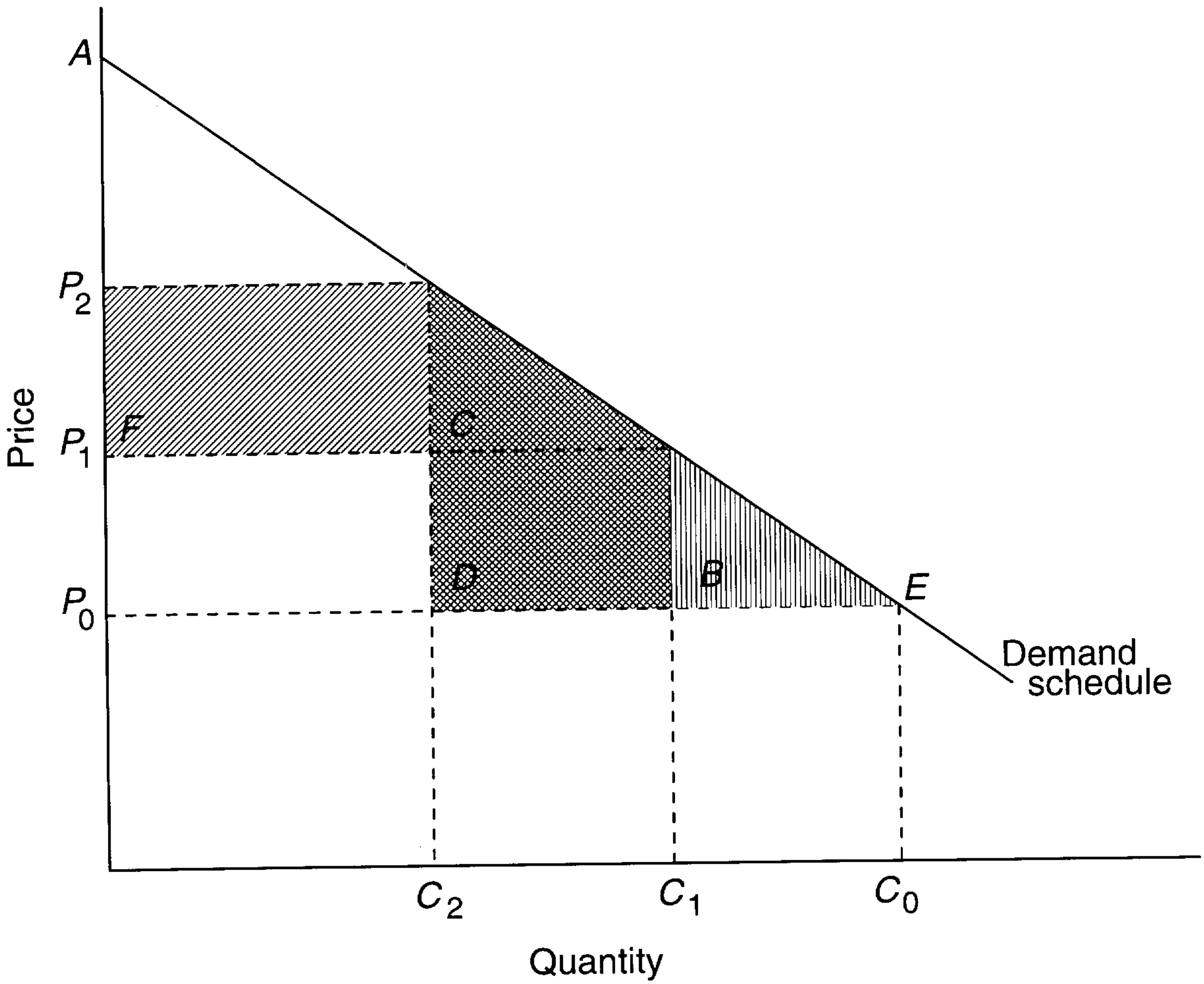
Chart 3: Net welfare benefits from consumption (as a percentage of GDP)

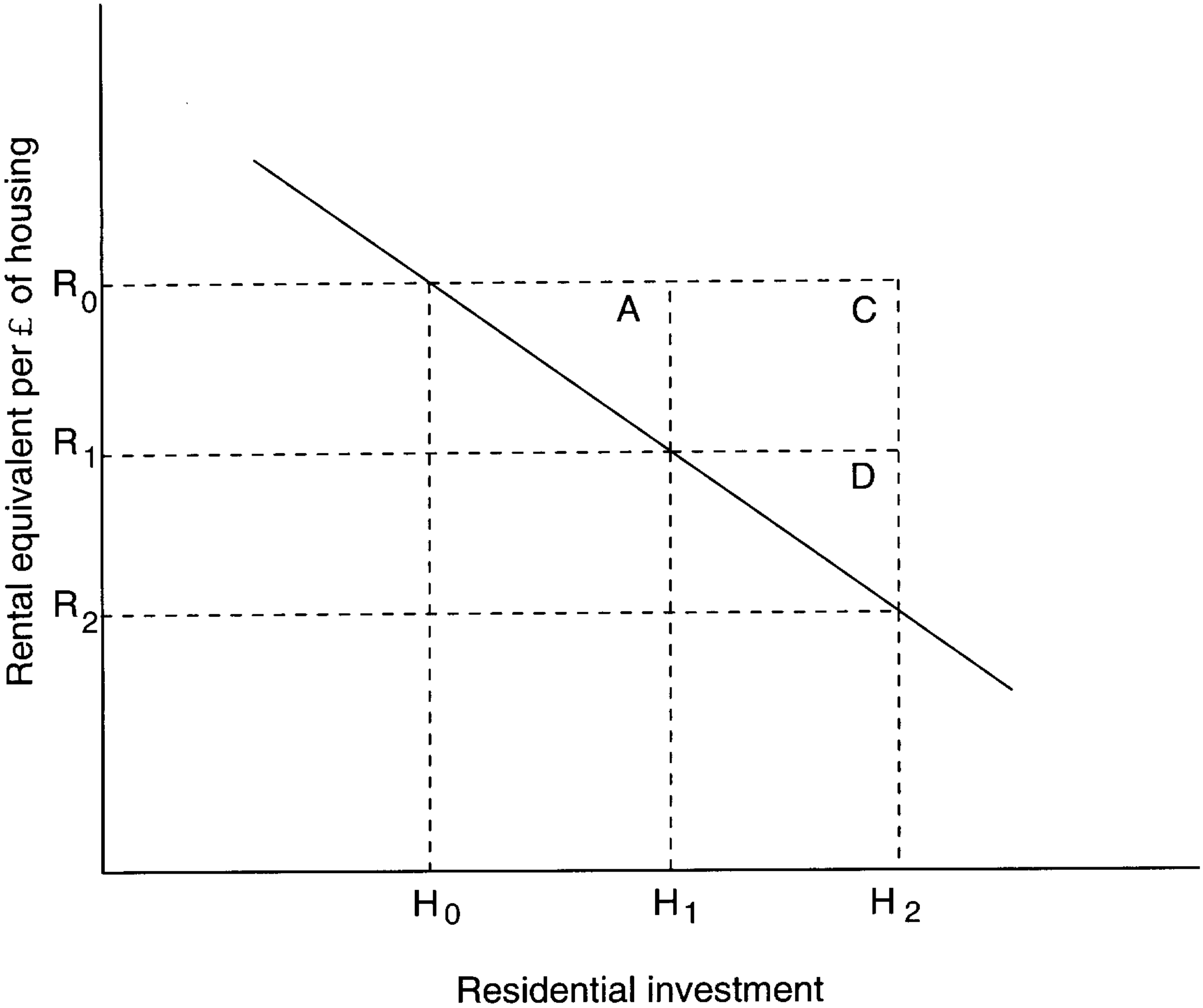
Chart 4: Net welfare benefits from housing investment (as a percentage of GDP)

Chart 5: Net welfare benefits from money demand (as a percentage of GDP)

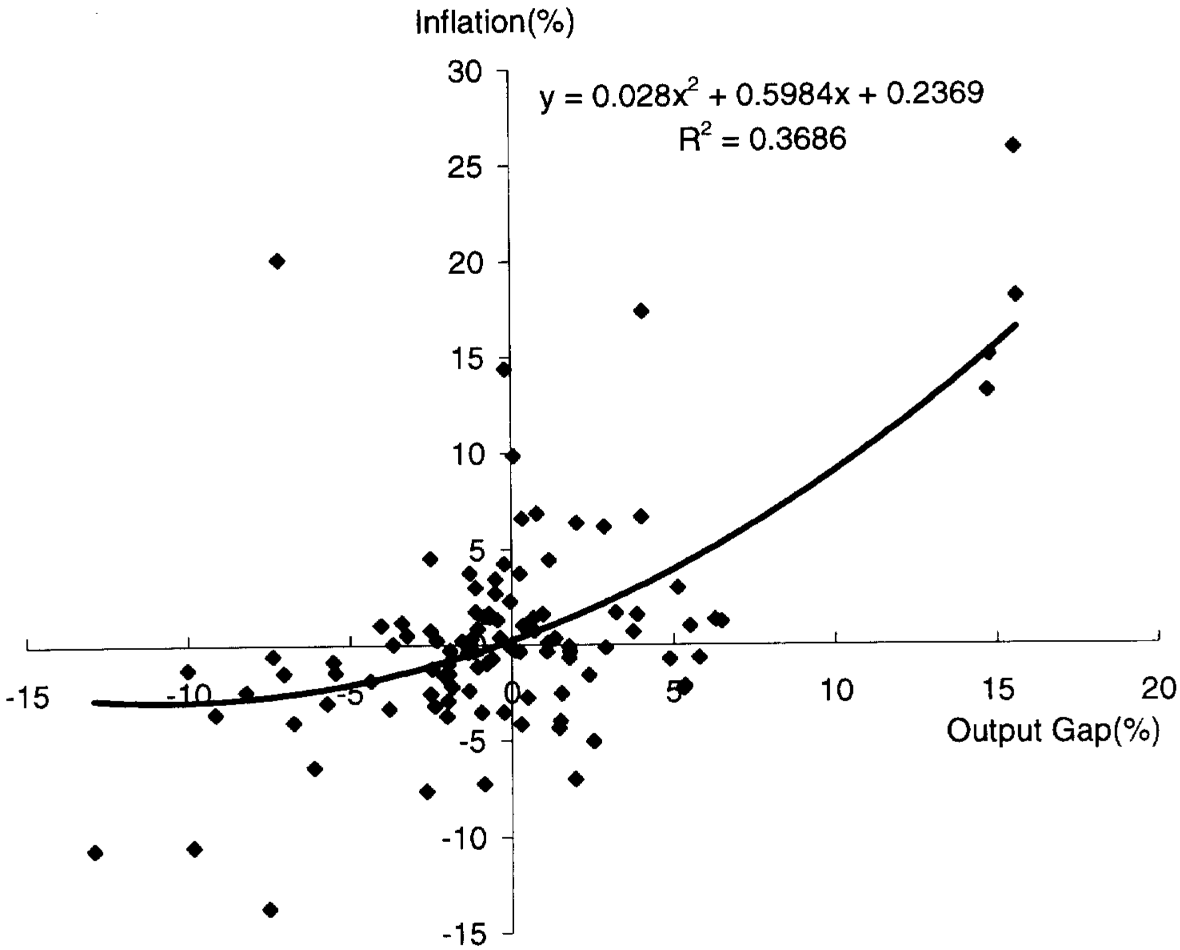
Chart 6: Aggregate welfare benefits (as a percentage of GDP)

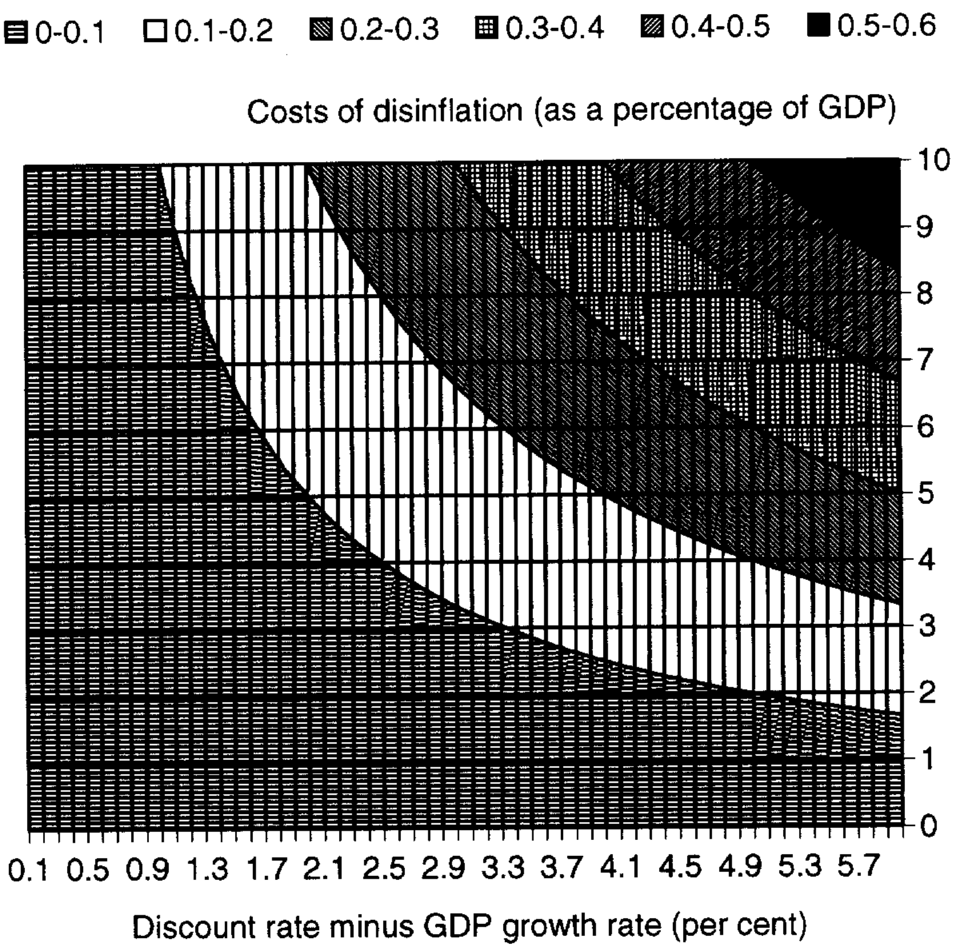
Chart 7: Net welfare benefits from business investment (as a percentage of GDP)

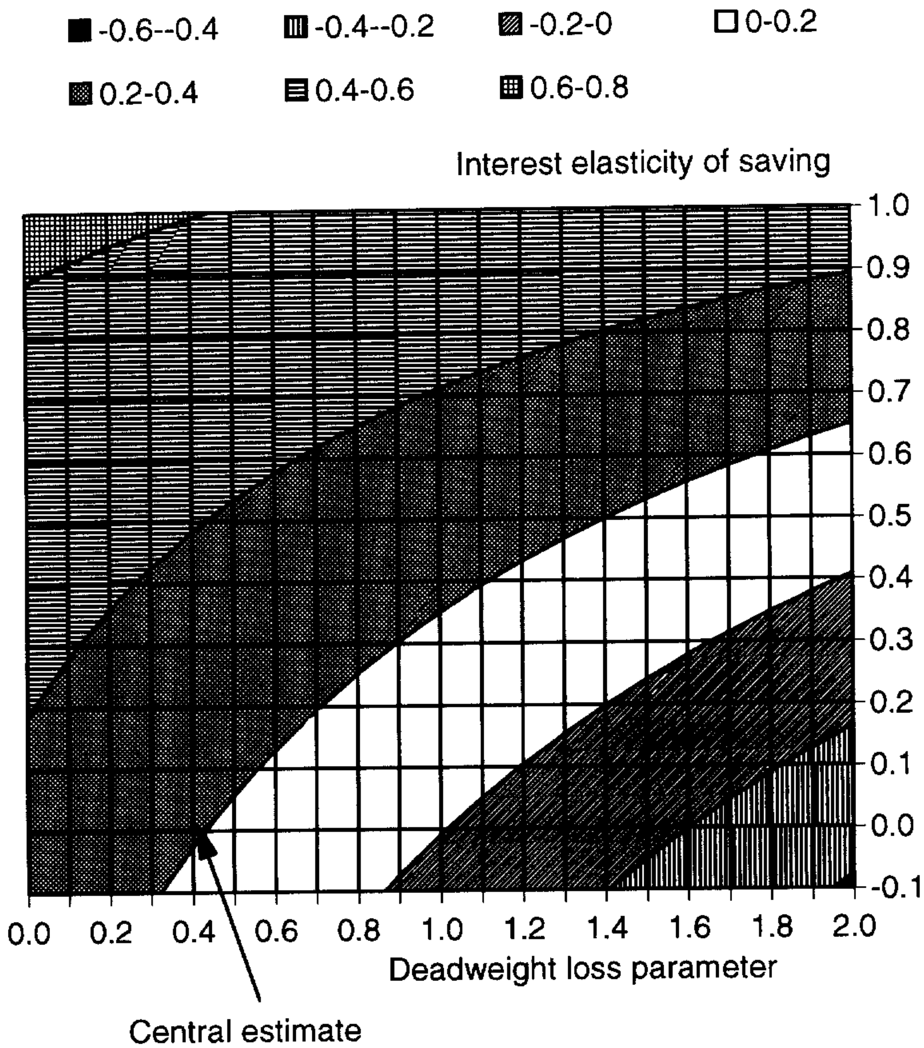

A
P2
P1
P0
F
C
D
B
E
Price
Demand schedule
C2
C1
C0
Quantity

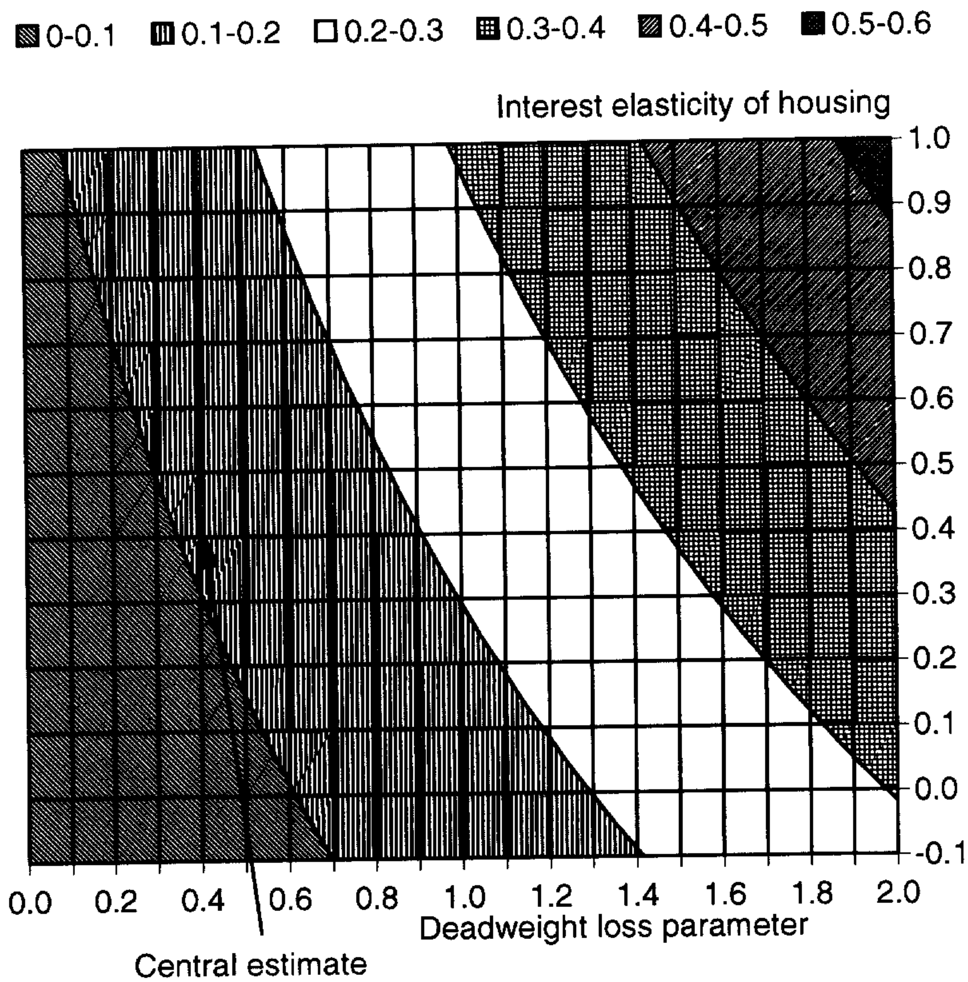


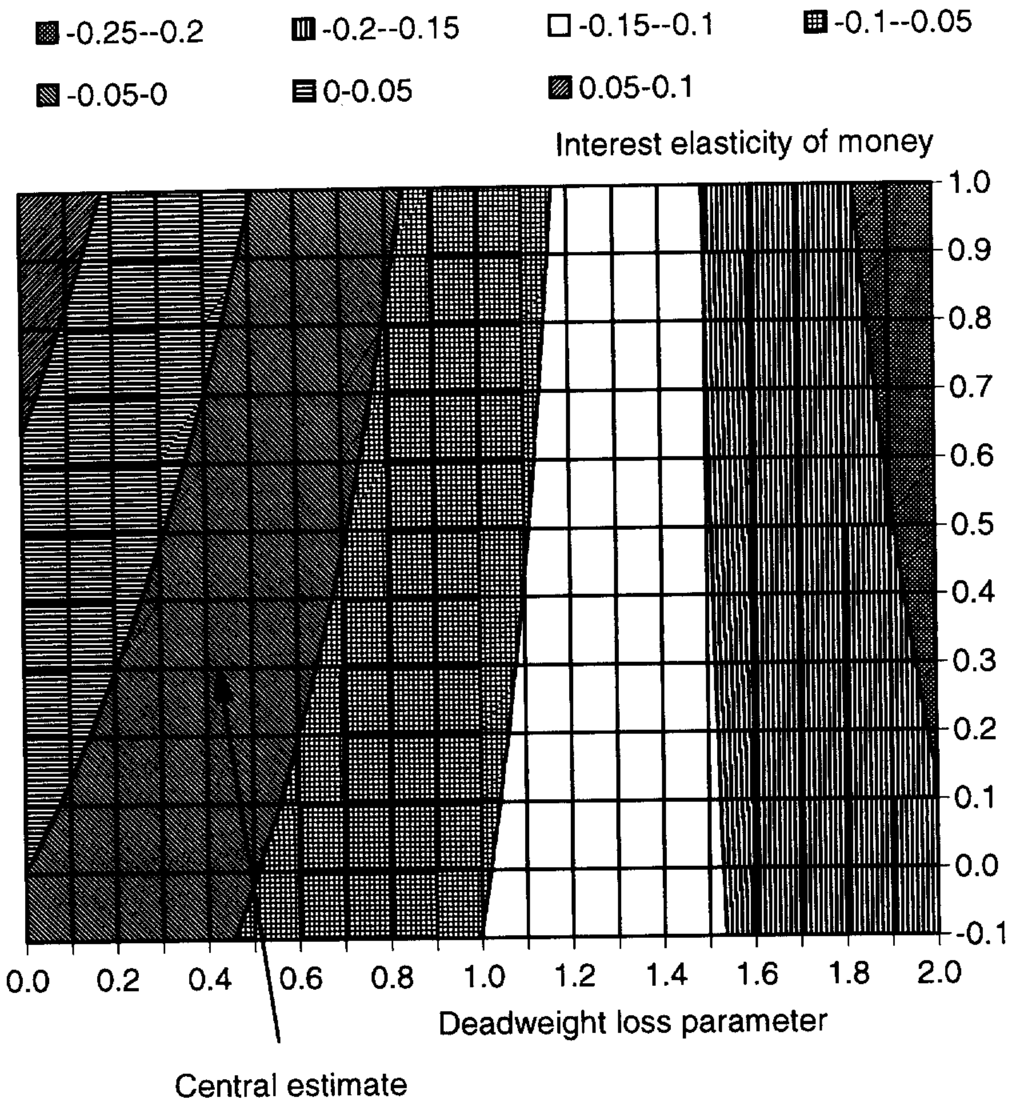
Rental equivalent per £ of housing
R0
R1
R2
A
C
D
H0
H1
H2
Residential investment

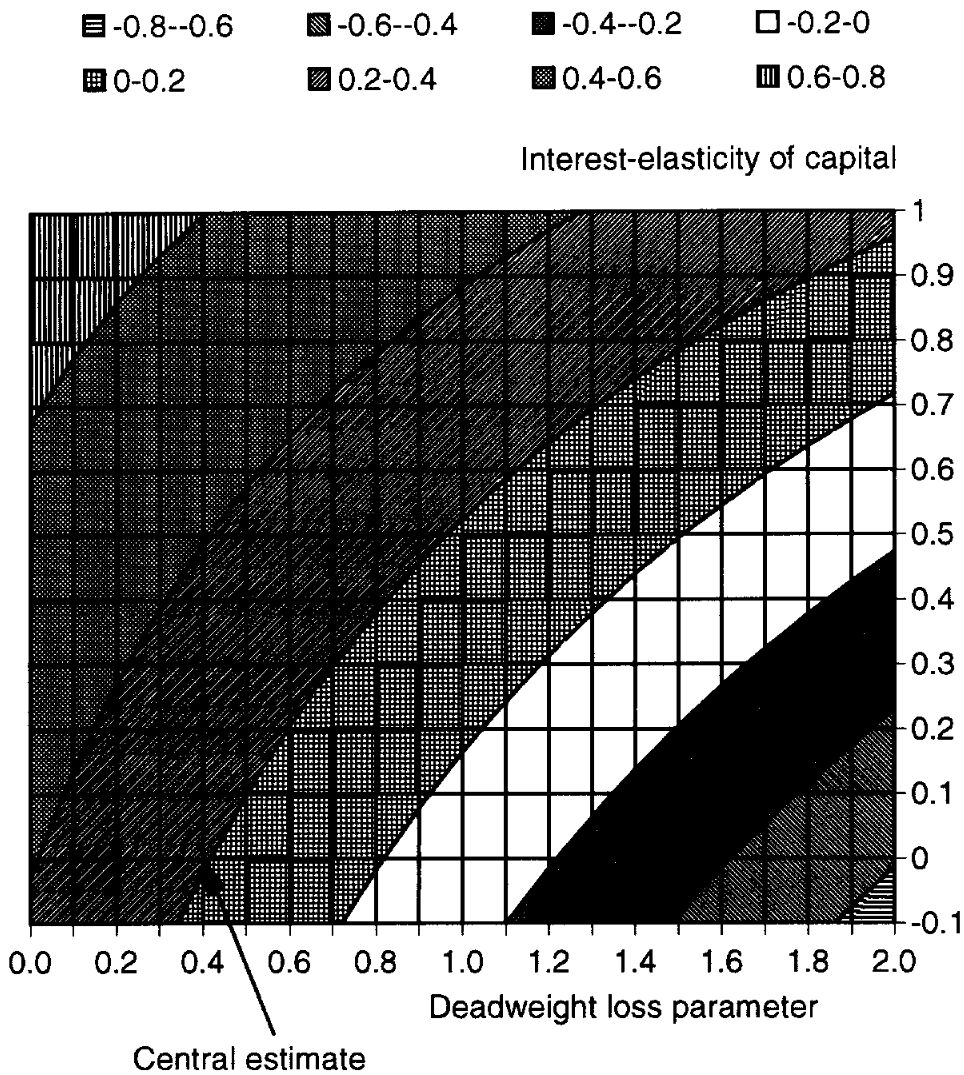

Inflation(%)
30
25
20
15
10
5
-5
-10
-15
y = 0.028x² + 0.5984x + 0.2369
R² = 0.3686
-15
-10
-5
0
5
10
15
20
Output Gap(%)


0-0.1
0.1-0.2
0.2-0.3
0.3-0.4
0.4-0.5
0.5-0.6
Costs of disinflation (as a percentage of GDP)
10
9
8
7
6
5
4
3
2
1
0
0.1 0.5 0.9 1.3 1.7 2.1 2.5 2.9 3.3 3.7 4.1 4.5 4.9 5.3 5.7
Discount rate minus GDP growth rate (per cent)

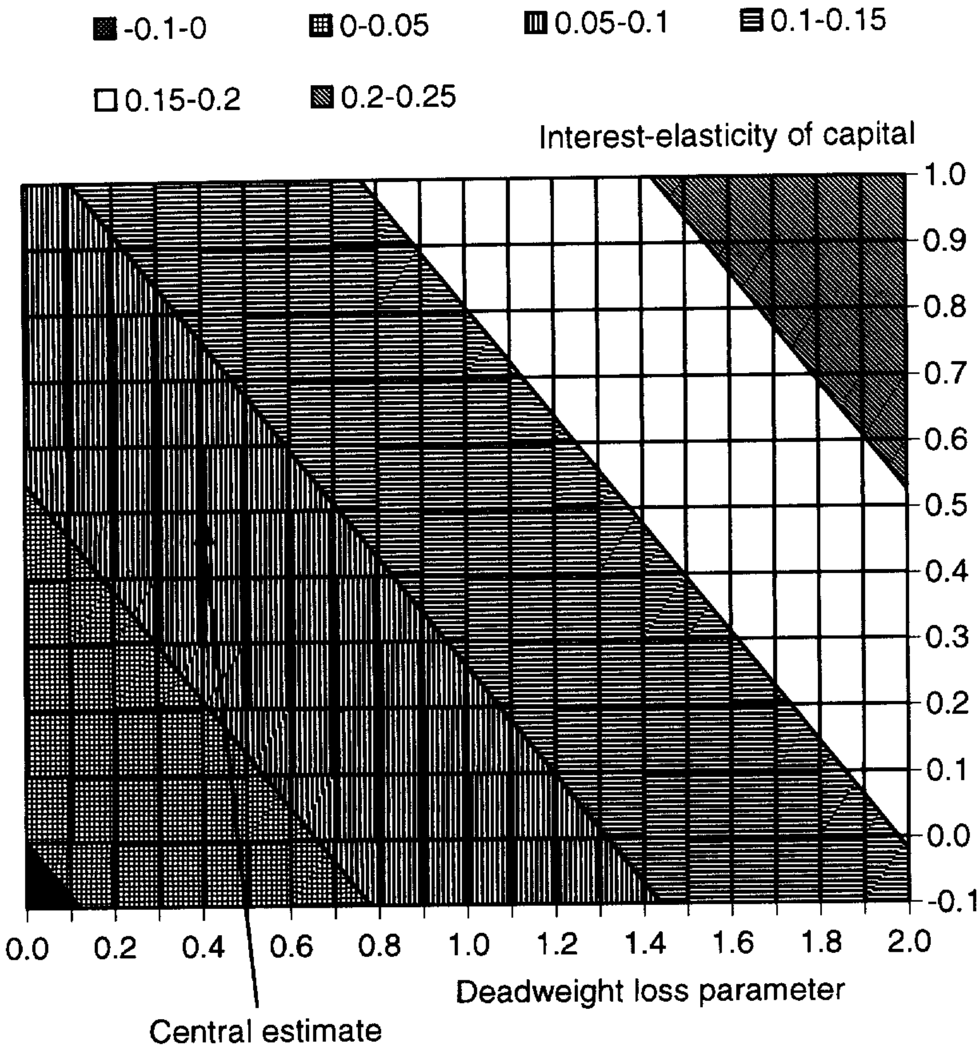

■ -0.6--0.4
-0.4--0.2
-0.2-0
0-0.2
0.2-0.4
0.4-0.6
0.6-0.8
Interest elasticity of saving
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
-0.1
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
2.0
Deadweight loss parameter
Central estimate


0-0.1
0.1-0.2
0.2-0.3
0.3-0.4
0.4-0.5
0.5-0.6
Interest elasticity of housing
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
-0.1
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
2.0
Deadweight loss parameter
Central estimate


-0.25--0.2
-0.2--0.15
-0.15--0.1
-0.1--0.05
-0.05-0
0-0.05
0.05-0.1
Interest elasticity of money
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
-0.1
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
2.0
Deadweight loss parameter
Central estimate



-0.8--0.6
-0.6--0.4
-0.4--0.2
-0.2-0
0-0.2
0.2-0.4
0.4-0.6
0.6-0.8
Interest-elasticity of capital
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
-0.1
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
2.0
Deadweight loss parameter
Central estimate


-0.1-0
0-0.05
0.05-0.1
0.1-0.15
0.15-0.2
0.2-0.25
Interest-elasticity of capital
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
-0.1
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
2.0
Deadweight loss parameter
Central estimate