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Sectoral money demand behaviour and the welfare cost of inflation in the UK

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Abstract

In this paper, we estimate separate UK money demand functions for the household and corporate sectors. Our approach allows for known differences across sectors; estimates equations with different functional forms; and estimates, rather than assumes, a scale elasticity. We use the estimation results to calculate estimates of the welfare cost of inflation, both by sector and in aggregate; and we consider the relative burden borne by the two sectors. We find that the welfare cost is much higher for the household sector than that for the corporate sector – which is in sharp contrast to previous (US) evidence that this welfare cost is borne equally across these two sectors. Also, we find that the aggregate welfare cost estimates are much smaller than previous (largely US) estimates – sufficiently smaller as to challenge the oft-quoted Lucas finding that shoe leather costs are by no means trivial. For the UK, we find welfare costs that are no greater than one tenth of a per cent of real income.

Keywords

Welfare cost of inflation; ‘Shoe-leather’ costs; Demand for money; Sectoral money demand;

JEL Classification

E31; E41

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Introduction

There has been a marked revival of interest in measuring the welfare cost of inflation, largely stemming from Lucas (2000). Lucas provides a substantive summary of work on the welfare cost of inflation and provides measures using Bailey's (1956) consumer surplus approach as well as the compensating variation approach. Importantly, his estimates served to counter any received wisdom that 'shoe-leather costs' of inflation are relatively trivial in macroeconomic terms. Few would argue that (nearly) 1% of US GNP in perpetuity is inconsequential – and this is the Lucas estimate of the welfare gain from reducing the annual inflation rate from 10 per cent to zero (Lucas, 2000, p.247). Indeed, Chadha et al (1998) report Lucas referring to the net present value as - 'this is real money' (p.364).

Lucas (2000) ensured that the welfare cost of inflation has again assumed importance among the classic questions in monetary economics; and a recent flurry of papers adopting the Bailey-Lucas approach attests to the on-going research interest (see, for example, Attanasio et al, 2002, Calza and Zaghini, 2010, 2011; Ireland, 2009; and Serletis and Yavari, 2004, 2007). One reason for this on-going interest derives from the fact that estimates of the welfare cost of inflation provide a basis for estimating potential welfare gains from implementing monetary policies to reduce inflation. The prevalence of inflation in relatively recent economic history both in the US and in Europe has ensured that measures to maintain low and stable inflation have become central in contemporary monetary economics; just as measuring the impact of policies to reduce inflation have become central in contemporary macroeconomics. For example, with policies of low but positive inflation now well established in many economies, questions arise about the cost of these policies when compared with Friedman's optimal policy rule; and welfare cost estimates can usefully shed light on this (as done in Ireland, 2009 and Calza and Zaghini, 2011). Furthermore, the

generalised shift from double digit inflation towards lower inflation both in the US and in Europe has given added impetus to the relevance of calculating welfare cost estimates. For example, Calza and Zaghini (2010) calculate welfare costs of inflation in order to provide estimates of the welfare gains obtained from the recent ‘Great Disinflation’ in the US. More generally, the more recent literature has provided estimates of welfare gains from reducing inflation which inform contemporary thinking on the issue.

Fundamental to all of this work on estimating welfare cost is the underlying demand for money behaviour; and the validity of obtaining estimates of the welfare cost of inflation by integrating under the money demand function.¹ Amongst issues raised in the recent literature are: i) the chosen functional form for the demand for money – whether the double logarithmic functional form better captures the money demand behaviour than the semi-logarithmic functional form; and ii) the potential importance of fully estimating the interest elasticity of the demand for money. These issues do matter. For example, Ireland (2009) shows how the welfare costs implied by the two functional forms may differ substantially;² and Serletis and Yavari (2004) find significantly smaller estimates of the welfare cost when they estimate the interest elasticity of the demand for money.³

These findings underscore the importance of determining the appropriate form of the money demand function for estimating this welfare cost of inflation. In this paper we estimate

¹ The most quoted (and thus influential) paper is Lucas (2000); and Gillman (1995) provides clear evidence for the validity of integrating under the money demand function.

² For example, an on-going two per cent inflation is calculated to cost the economy 1.09 percent of income with the double-log functional form and just 0.25 percent with the semi-log (Ireland, 2009, p.1041); with such divergence particularly marked at low values of the interest rate. For these calculations, Ireland takes Lucas (2000) and the assumptions therein as given.

³ For example, using the double-log money demand specification but relaxing the imposed 0.5 interest elasticity, Serletis and Yavari (2004) report estimates of the welfare cost five times smaller than those of Lucas (p.202).

money demand behaviour in the UK taking account of two further issues. Firstly, we estimate the scale elasticity of money demand. Imposing a unit scale elasticity is typical in this literature – and fairly uncontroversial for the US, the context for many of these studies – yet a relatively recent survey of cross country demand for money studies (Sriram, 2001) reports values for the scale elasticity in the range of 0.4 to over 3 for narrowly defined monetary aggregates (Table 2, pp.351-8); and a unit scale elasticity has little support in the UK context. Secondly, rather than estimating an aggregate demand for money, we separately estimate demand for money functions for each of the household and (private non-financial) corporate sectors. In this way, we allow for the well-known fact that money demand behaviour differs across these sectors (see for example: Goldfeld, 1973; Drake and Chrystal, 1994, 1997; Jain and Moon, 1994; Butkiewicz and McConnell, 1995; and von Landesberger, 2007).⁴ The evidence that parameter/coefficient estimates differ across sectors, of itself, gives support to our strategy of sectoral disaggregation; but also, estimating sectoral demand for money equations will allow us to calculate welfare cost estimates for each sector. Whilst the welfare cost of inflation, in aggregate, is unavoidable, it may be that one sector may be more adept at shifting the burden elsewhere. This could be important, not least because differential burdens suggest that the two sectors would assign rather different weight to policies designed to reduce inflation; and, more generally, would assign rather different weight to a stated

⁴ Differences in sectoral money demand behaviour could reflect different constraints on money holding decisions (different regulatory factors and/or access to wholesale markets) which may account for empirical findings that the corporate sector is more responsive to both the opportunity cost and the scale variables (see for example Jain and Moon, 1994 (US); Drake and Chrystal, 1994, 1997 (UK)). Jain and Moon (1994) report significant interest elasticities (-1.1) for US Business M1 holdings yet negligible elasticities for Households; and higher scale elasticities for the Business M1 holdings. Drake and Chrystal (1994) report strong interest elasticities for UK company sector holdings of narrow and broad monetary aggregates (-4.3, -2.6 and -2.6); whilst Drake and Chrystal (1997) find much smaller interest elasticities for UK personal sector holdings of two broad monetary aggregates (-0.1, -0.2). With regard to scale elasticities, Drake and Chrystal (1997) explicitly make a sectoral comparison, noting much higher estimated coefficients in the company sector (all in the range of 2.5 to 3) and arguing that this provides further evidence for estimating separate sectoral money demand equations.

commitment to inflation targets (now so prevalent across so many countries). Our approach allows us to address this question.

We therefore use the results from our estimation work not only to provide estimates of the welfare cost of inflation (by sector) but also to consider the relative burden borne by each of the sectors. In this regard, this paper parallels analysis undertaken by Calza and Zaghini (2010) - the only previous paper to address the sectoral burden - but with data from the UK rather than the US. Whilst Calza and Zaghini found evidence of equal sharing of the burden, we find that the household sector bears a disproportionately high burden of the welfare cost of inflation. Perhaps more importantly, we find estimates of the welfare costs that are nowhere near as large as those found by Lucas. In this study, the cost of a 10% inflation is never found to be higher than 0.1% of GDP – some ten times smaller than the oft-quoted estimate of 1% GDP. The scale of difference is such that we are forced to some modification of the view that these costs are non-trivial, at least for the UK.

The paper is structured as follows. Section 1 briefly sets out the Lucas-Bailey approach to the measurement of the welfare cost of inflation and makes explicit its relationship to underlying money demand behaviour. Section 2 deals with some relevant data and estimation issues before proceeding to present results from estimating different money demand functions for both households and corporations. Section 3 calculates welfare costs of inflation under a number of scenarios. Section 4 draws some conclusions.

1. Welfare cost and money demand

The specification of the underlying money demand function is fundamental to the estimation of the welfare cost of inflation. Whilst early contributors (such as Bailey, 1956 and Friedman,

1969) had used a semi-log demand schedule, Lucas (2000) argues that the double log (constant elasticity) is more appropriate for his US data set consisting of annual data extending from 1900 to 1994. Ireland (2009) notes that this almost century-long data period spans two unusual episodes in US monetary history (in the late 1940s and the late 1970s) and suggests that these may be unduly influential in driving a preference for the log-log money demand specification. We follow Ireland (2009) and estimate both functional forms to see which is the best fit for our data.

The two money demand equations can be written:

$$\log (M/P) = \log A + \beta \log(Sc) - \eta \log(r) \quad (1)$$

$$\log (M/P) = \log B + \beta \log(Sc) - \gamma (r) \quad (2)$$

where: (M/P) is real balances; (Sc) is the relevant scale variable, differing for personal and corporate sectors (measured in real terms); and r is the opportunity cost variable (the nominal interest rate).

To estimate the welfare cost associated with a nominal interest rate, we adopt the traditional approach developed by Bailey (1956). This approach involves calculating the inverse of the money demand function and integrating on the interval of defined nominal interest rates.⁵

The expressions obtained define the welfare costs associated with a specific positive level of the nominal interest rate, r and, crudely, measure the ‘welfare triangles’:

$$\text{Welfare cost} = WC(r) = A(Sc)^{(\beta)} \left(\frac{\eta}{1-\eta} \right) r^{(1-\eta)} \quad (3)$$

$$\text{Welfare cost} = WC(r) = \frac{B}{\gamma} (Sc)^{(\beta)} [1 - (1 + \gamma r)e^{-\gamma r}] \quad (4)$$

From these expressions, it is clear that estimates of the welfare cost of inflation require three parameter values from each of equations (1) and (2): the value of the intercept; the scale

⁵ Since the nominal interest rate, r is the sum of the real rate of interest, r_{real} and inflation, the welfare cost of inflation is given by integrating on the interval (r_{real}, r) . See Chadha et al (1998).

elasticity; and the interest elasticity (for the log-log specification) or semi-elasticity (for the semi-log).

Since these parameter values derive from money demand behaviour which is likely to differ between households and firms (Goldfeld, 1973, Jain and Moon, 1994, Drake and Chrystal, 1994, 1997), we separately estimate equations (1) and (2) for each of the household and (non-financial) corporate sectors. By allowing for differences in terms of motives for holding money balances, access to payments technologies and money management practices across sectors, we expect to obtain more precise estimates of the key parameter values relevant for calculating the welfare cost of inflation. This is over and above the greater precision gained from fully estimating (rather than assuming) values for these key behavioural response parameters.

2. Estimating money demand

The sample period for our estimation work, from the second quarter of 1978 (the earliest date for which relevant data is available, after allowing for lags) to the second quarter of 2008, covers a sufficiently long period of both high and low inflation to permit us to draw conclusions about money demand behaviour across inflation regimes. The period spans some three decades; and captures two periods of disinflation from double digit inflation. Inflation was 21% in 1980(Q2) dropping to 2.6% by 1986(Q3); was up to 10% in 1990(Q3) falling to 1.3% in 1993(Q2).

We use data on sectoral holdings of (M1) monetary assets held by households and (non-financial) corporations, made available by the Bank of England.⁶ These relate to holdings of sterling notes and coins and sterling sight deposits with UK monetary financial institutions. Aggregation of these monetary assets closely corresponds to the definition of the monetary aggregates used by Calza and Zaghini (2010) (and Lucas, 2000 and Ireland, 2009). To reflect the different motives for holding monetary assets across the sectors, the scale variable used for households' demand is total consumer spending; and, for the (non-financial) corporate sector, we use GDP, following Drake and Chrystal (1994).⁷ Data for money and the scale variables are all seasonally adjusted; and are deflated by the consumer price index (for the household sector) and the producer price index (for the corporate sector). We use the three month Treasury bill rate, as a proxy for the risk free return, to measure the opportunity cost.⁸

An important issue relevant both to the selection of the monetary assets for the dependent variable and to the measure of the opportunity cost variable is that, over the sample period, an increasing share of bank sight deposit accounts started to pay interest. If we were to exclude

⁶ The authors are grateful to the Bank of England for the provision of data on sectoral holdings of monetary assets: Quarterly amounts outstanding of households' sterling holdings of notes and coin, monetary financial institutions' sterling non-interest-bearing sight deposits, and UK resident banks' sterling interest bearing sight deposits (in sterling millions); and Quarterly amounts outstanding of private non-financial corporations' sterling holdings of notes and coin, monetary financial institutions' sterling non-interest-bearing sight deposits, UK resident banks' sterling interest-bearing sight deposits (in sterling millions) – all seasonally adjusted. Building Society deposits are excluded from our monetary aggregate. The class of building society deposits most similar to bank sight deposits is instant access deposits, but this may include deposits which require notice of up to seven days to withdraw funds without penalty. In contrast, sight deposits may be withdrawn immediately, without penalty.

⁷ We would have preferred to use a sector-specific scale variable such as 'real business GDP' used by, for example, Jain and Moon (1994) and Calza and Zaghini (2010) – both US studies. However, presumably like Drake and Chrystal, we found data availability is limited when working with UK data.

⁸ There is an element of arbitrariness about the selection of the monetary aggregate (acknowledged by Lucas, 2000). Following Ireland (2009) and Lucas (2000), we use M1 as the relevant reference definition of money – the sum of currency holdings (that do not pay interest) and demand deposits (that may or may not pay interest). We treat M1 as the best available proxy for the monetary aggregate providing monetary services that deliver consumer surplus to its holders. Interest rate data was obtained from the Bank of England database; all other data series from the Office of National Statistics (ONS).

this interest-bearing money, we would bias the welfare cost of inflation (essentially because technological innovations have ensured that these assets provide equivalent monetary services – see Cysne and Turchick, 2010). However, their inclusion makes the specification of the opportunity cost somewhat tricky. There is an argument that a more appropriate opportunity cost variable would be the difference between the Treasury bill rate and that paid on interest-bearing sight deposits – although this is not relevant for the non-interest-bearing components of the aggregate. Since data on the rates paid on commercial bank deposits is not available until the mid-1990s, we use the Treasury Bill rate as a ‘best proxy’.

As a preliminary to estimating the demand functions, we examine the statistical properties of the variables. Unit root tests (see Appendix Table A1) confirm that sector holdings of real M1 balances, real consumption and real GDP are stationary in first differences. The nominal interest rate may be either trend stationary or first difference stationary and thus it is reasonable to test for cointegration and, in the event of finding cointegration, proceed to estimation.

Table 1 here

Table 1 summarises the estimation results. At the foot of the table are the results from testing for cointegration of the variables in each equation: Johansen’s maximum likelihood estimator rejects no cointegration, but cannot reject a maximum of one cointegrating vector. We therefore infer that the three variables - real money balances, the relevant scale variable and the opportunity cost variable - meet the minimum requirement of constituting a cointegrating vector in each sector. Table 1 also presents estimates using the Auto-Regressive Distributed Lag (ARDL) estimator of Pesaran and Shin (1999) and Pesaran et al (2001); the full

estimating equation for the ARDL method being equation (5) below.

$$\Delta m_t = \alpha_0 + \alpha_1 m_{t-1} + \alpha_2 s_{t-1} + \alpha_3 R_{t-1} + \sum_{j=1}^n \phi_{1,j} \Delta m_{t-j} + \sum_{j=1}^n \phi_{2,j} \Delta s_{t-j} + \sum_{j=1}^n \phi_{3,j} \Delta R_{t-j} + \varepsilon_t \quad (5)$$

Where: m is $\log(M/P)$; Δ is the first difference operator, s is $\log(SC)$; R is the nominal interest rate (or its log); and ε is the error term. The results of the parsimonious estimation of the ARDL obtained using the general to specific method, are given in the upper part of the table, together with inferred (long-run) estimates of the key parameters in equations (1) and (2) calculated from the parsimonious equation. The estimation of these functions for the UK is notoriously difficult but it can be seen that each of the four estimated equations satisfy the usual battery of tests. Cointegration also indicates stable long run parameters. Furthermore, not only does the 12 quarters ahead Chow forecast test indicate parameter stability but also, the CUSUM statistic remains within the error bounds (see Appendix 2). We conclude that we have evidence of stable and robust long-run money demand relationships which can be used for inference about the underlying welfare costs implied for each sector.

Turning to the estimated coefficients, it is evident that the underlying money demand behaviour is markedly different across the two sectors, underscoring the importance of having specified separate equations for estimation (we also note that the underlying lag is shorter for the corporate sector, possibly implying better information and greater ability to react). For each sector, the estimated coefficients on the opportunity cost variable are similar to those found by Calza and Zaghini (2010). However, the estimated elasticities of the scale variable are worthy of further comment. It was noted in the introduction that a unit scale elasticity has little support in the UK context⁹ and this is a reason for our estimating the

⁹ There is very little recent work on the demand for money in the UK. Bissoondeal et al (2010) find long-run money demand relationships for the UK household sector for both a Divisia and a simple sum (broad) measure of money. They report four estimates of the coefficient on the scale variable that are each significantly different from unity – the highest of which is 1.36. Drake and Chrystal (1994) report a (normalised) estimate of the

elasticity here (and testing the validity of imposing a unit scale elasticity). The estimated coefficients are in the range of 2.2 to 3.4; and each of the four estimates is found to be significantly different from unity. This demonstrates that the assumption of unit elasticity – often made in previous work for the US - would not be appropriate here.

The relatively high scale elasticities reported here warrant some additional comment. For the corporate sector, such high values are not surprising. For example, Drake and Chrystal (1997) report coefficient estimates on the scale variable in the range of 2.5 to 3, pointing to “ ... [t]heoretical work by, for example, Miller and Orr (1966) [suggesting] ... that these values are plausible for the corporate sector ...” (p.204). However, for the household sector, scale elasticities above unity are less readily explained. Whilst it is not difficult to find estimated scale elasticities of (aggregate) money demand which exceed unity (see, for example, Sriram, 2001), presenting an intuitive explanation for such findings is more challenging. Having said that, this has long been recognised in the literature – both Cuthbertson (1985) and Laidler (1993) discuss factors driving the relationship between money holdings and income (desired transactions volume) in opposite directions. Both point to the possibility that households economise on time when the opportunity cost of time in terms of forgone income rises. As a result, “the volume of money holding associated with any planned volume of transactions [would] rise ... [and] might well swamp the economies of scale associated with a growing transactions volume” (Laidler, 1993, p.181). For the sample period used in this paper, velocity falls for both household and corporate sector M1 holdings – entirely consistent with estimated scale elasticities above unity.

coefficient on the scale elasticity of 3.22 for NIBM1. Cuthbertson and Taylor (1987) report an estimate for the scale elasticity for M1 of 2.08.

Having established that we have found stable and robust long run money demand relationships, we turn to the main thrust of this work which is to use the (robust) estimated coefficients to calculate the welfare cost. This is the focus of the work undertaken in the next section. Since the estimation results presented in Table 1 provided no clear preference for one functional form, we follow Calza and Zaghini (2010) and use estimates from both functional forms, not least as a test of robustness and consistency.

3. Calculating the welfare cost

Having estimated the demand for money functions, it is relatively straightforward to obtain measures of the welfare cost associated with a specific level of the interest rate. We take the Table 1 estimates of the long-run coefficients β , η and γ in equations (1) and (2) and insert these into the expressions for the welfare cost set out as equations (3) and (4). Following Lucas (2000), we calibrate values for the constants A and B so that they equal the average value over the sample of $(M/P)(Sc)^{-\beta r \eta}$ and $(M/P)(Sc)^{-\beta} e^{\gamma r}$.

The resultant values measure the consumer surplus lost when agents reduce their money holdings in the light of inflation. This is obviously a monetary measure. More commonly reported in the literature is this measure calculated as a fraction of the scale variable. For ease of comparison, in the Tables below, we report both measures.

Table 2 here

Table 2 takes a typical inflation example from the literature – a 10 per cent inflation (with an assumed real rate of interest of 3%). What is not typical is the breakdown by sector. This is important. Previous research indicates that there are significant differences in the demand for

money between these sectors in the UK (Belongia and Chrystal, 1991 and Drake and Chrystal, 1994, 1997). In our work, we too have found marked differences across the sectors. Taking account of these differences should result not only in more accurate measures of the welfare cost, but also, allows us to address the question of whether inflation imposes greater costs on one sector relative to the other and thus, whether disinflation favours one sector over another.

Welfare cost by sector (relative to price stability)

Table 2 presents the welfare cost of a ten per cent inflation ($WC(0.13)$) together with the welfare cost of a ten per cent inflation relative to price stability (ΔW). The Table shows that, for the household sector, the estimated welfare cost of a 10% inflation is either £1,053million or £651million, depending on the underlying functional form for estimating money demand; and is, *at most, around 0.1%* of GDP. The welfare cost for the corporate sector is smaller, either £59million or £37million (and *less than 0.01%* of GDP). In general, there is evidence of the functional form influencing the size of the welfare cost; yet rather more importantly, these estimates indicate that the household sector bears by far the bigger burden of the aggregate welfare cost of the inflation – the (arguably more sophisticated) corporate sector bears little more than 5% of the burden (whichever functional form is employed). This result stands in contrast to that found by Calza and Zaghini (2010) – the only other paper to present such a sectoral breakdown: they found that the burden was equally shared across the sectors (in the US). The result suggests that, in the UK, households and firms may have different assessments of the welfare losses associated with inflation and may therefore value inflation targets rather differently; and may place different values on policies to reduce inflation (so popular in recent economic history).

We turn now to the actual scale of the welfare cost to households. This can be viewed from different perspectives. The traditional approach defines this welfare loss as the fraction of consumption households would require as compensation in order to make them indifferent between living in a steady state with 10% inflation and an otherwise identical state with price stability. On this basis, the welfare cost to households is either 0.12% or 0.10% of consumption (see Table 2). Whether one regards this as big or small will of course depend on the parameters one feeds into a Net Present Value formula, not least the time horizon. Yet whilst one would never deny the power of compounding, most might regard this as lying at the ‘small to trivial’ end of the spectrum. This is perhaps most readily inferred from the calculations of the burden on a per household basis. In the bottom portion of Table 2, we see that the burden borne is no more than about £28 (approx. \$46) per household – albeit on a permanent per annum basis.¹⁰

Aggregate welfare cost

Given the relatively modest size of the welfare cost borne by households and the even smaller cost borne by corporations, it is no surprise to be reporting aggregate welfare costs which are small. In Table 2, the estimated welfare cost of 10% inflation (relative to price stability) is either £782million (0.08% GDP) or £645million (0.06% GDP), depending on the underlying functional form. Again there is evidence of functional form influencing the size of the welfare cost; yet, much more importantly, under each functional form, the calculated welfare cost is much lower than the oft-quoted benchmark of ‘slightly less than one percent [of real income]’. At this stage, two things should be noted: i) the ‘Lucas 1%’ relates to the *welfare gain* of reducing inflation from 10 percent to zero (comparable with figures presented in Table 3 of this paper); and ii) it is unexceptional to obtain estimates lower than that of Lucas:

¹⁰ Attanasio et al (2002) also report very small values for the ‘welfare triangle’ - 16 euros per household found in a study of microeconomic data relating to currency holdings of Italian households.

a ranking of the estimates to be found in the literature places the ‘Lucas 1%’ firmly at the top. Having said that, the estimates reported here are pretty much at the bottom of the range. We return to this point later, after testing for the robustness of our findings for 10% inflation reductions across different initial inflation rates.

Known nonlinearities in the underlying money demand behaviour imply that the welfare cost implications of 10% inflation reductions will differ with different initial inflation rates, or equivalently, with different general inflation environments. In Table 3 we present the estimated welfare gain, ΔW , from reducing inflation by 10 percentage points from nominal interest rates of 13, 15 and 20%. The most striking observation is that, whilst the calculated welfare gain from a disinflation of 10% is smaller in the higher general inflation environment when the demand for money has been estimated with a log-log specification, it is larger when the semi-log functional form has been specified. This simply reflects the shape of these schedules but, more importantly, it reinforces the importance of taking care both with the selection of the functional form for estimating the demand for money and then with the selection of interest rates used to calculate welfare costs.

Table 3 here

With regard to the robustness of our earlier findings, there is nothing in Table 3 which would lead us to conclude anything other than that which we had already concluded: functional form matters (but not sufficient to change any inference about the sectoral breakdown); the estimated welfare gain is small; and the welfare cost falls disproportionately on the household sector (the corporate sector bearing between 5 and 6% of the overall welfare cost).

Comparing welfare measures

The small size of the estimated welfare costs (and gains) found here warrants further comment. Given that different countries have been researched using a variety of data frequencies and estimating techniques, it is not surprising, that previous studies have produced a relatively broad range of estimates although the reported estimates in the literature are not strictly comparable with each other. Lucas (2000), Serletis and Yavari (2004) and Ireland (2009) are, very broadly, comparable in that they use M1 data for the US for overlapping data periods (1900-94; 1948-2001 and 1980-2006 respectively); although Ireland uses quarterly, not annual, data - and the much longer time horizon used in Lucas (2000) makes that study somewhat distinctive.¹¹ Ireland (2009) estimates the welfare cost of a 10% inflation at around 0.2%GDP; Serletis and Yavari (2004) estimate the welfare gain of reducing inflation from 14% to 3% at around 0.45%GDP attributing the difference between their result and that of Lucas to the lower interest elasticity (-0.22 as compared with -0.5 used in Lucas). When US M1 data is adjusted to exclude US dollars held abroad, Calza and Zaghini (2011) report an estimated welfare cost of a 10% inflation four times smaller than that of Ireland (2009) at around 0.05%GDP (having used data, adjusted for US dollar holdings overseas, for the same data period as that used by Ireland, 1980-2006).

Estimates based on data from other countries are also lower than that found in the influential Lucas (2000) study. For example, Serletis and Yavari (2007) study seven Eurozone countries over the period 1960 to 2000 and report estimated gains from reducing inflation by 5% points in the range of 0.1%GDP in France to 0.5%GDP in Ireland. Yet lower estimates have been found by, for example, Attanasio et al (2002) - using microeconomic data on currency

¹¹ The only other study to use such a long span of (annual) data is Chadha et al (1998), reporting welfare cost estimates broadly in line with the Lucas 1% of GDP - but for the UK: 1870-1994. It does seem that estimation over long time spans yields the high estimates of welfare cost.

holdings by Italian households, they find that the welfare cost of inflation is never more than 0.1% of consumption (and thus an even lower percentage of GDP).

As is standard in this literature, all welfare calculations have been calculated at the sample average. In order to test the sensitivity of these results to this assumption and, therefore, to see the effect of the estimated coefficient values, we examined the sensitivity of our results to changes in the values of the scale, opportunity cost and monetary aggregate variables.

Examining one standard deviation perturbations gave a maximum range for ΔW of 0.02% to 0.17% of GDP (for the log-log) and 0.02% to 0.13% of GDP (for the semi-log). Even at these extremes, these welfare measures remain small.

The welfare cost measure is smaller when the semi-logarithmic functional form is used; and it is smaller for lower estimated coefficients on the opportunity cost variable. Both of these features are already noted in the literature. For example, Ireland (2009) documents the former; and Serletis and Yavari (2004) and Ireland (2009) both attribute their welfare cost estimates lying below the benchmark ‘1% of GDP’ to lower estimated coefficients on the opportunity cost variable. The measures are also dependent on the estimated scale elasticity and this does create some difference when comparing our results with those found in work which has assumed a unit scale elasticity (known to be inappropriate for our UK context).

Relative to Calza and Zaghini (2010), our estimated coefficients on the opportunity cost variable are either at the low end (or are lower than) the range of estimates they report; and our estimated coefficients on the scale variable are much higher. As already noted in the more general context, our lower opportunity cost coefficients go some way towards explaining lower estimates of the welfare costs; but also relevant are differences captured in

the intercept term of the demand for money. It seems that the UK context for this study is particularly important – money demand behaviour in the UK (at least in the three decades since 1978) shows both households and firms as particularly effective in shielding themselves from the inflation tax. This result is not entirely surprising. Boel and Camera (2011) is one of few papers to undertake a cross-country study of the welfare cost of inflation and they find that their estimates vary quite substantially across 23 OECD countries. Whilst their (model calibration) approach is not directly comparable with that employed here, the paper has relevance since the UK is included in their study. They report welfare cost measures for the UK which are consistently at the low end of the reported estimates. For example, in their benchmark calibration Table 2, the estimated welfare cost of a 10% inflation versus price stability for the UK is 0.02% of consumption (therefore an even lower percentage of GDP) compared with an average welfare cost across countries of 0.32% of consumption in the common sample. Furthermore, estimates for the UK are always smaller than those for the US with comparisons across 20 estimates which show the UK estimate to be smaller by a considerable factor – at least a factor of 1.75.

Different behaviour in the UK relative to the US may lie in the different inflationary environments: in the US, there is strong awareness of the Great Disinflation – inflation at its highest (15%) in 1980 and brought under control by the end of the 1990s; in the UK, there have been two periods of disinflation from double digit inflation; inflation being significantly reduced from a height of over 20% (in 1980); and then rising again to double digits (10% in 1990) before being controlled again. This ‘double-peak’ may have encouraged agents to manage their money holdings differently; and it is inefficiency in this money management that is measured in the Bailey estimates of welfare cost.

4. Conclusion

Since 2000, research on the welfare cost of inflation has undergone a significant revival, largely prompted by the publication of Lucas (2000). This paper is something of a *tour de force* providing a summary of research on the welfare cost of inflation – including theoretical justifications of the Bailey consumer surplus formulae; and presenting estimates of the welfare cost of inflation which suggest that ‘shoe leather costs’ of inflation may have important macroeconomic implications. Perhaps unsurprisingly, this stimulated a considerable amount of further research on the welfare cost of inflation (for example, Attanasio et al, 2002; Serletis and Yavari, 2004, 2007; Ireland, 2009; Calza and Zaghini, 2010, 2011; Cysne and Turchick, 2010). This further research has generated a number of welfare cost estimates, though none are as high as that reported in Lucas (2000). This is potentially important, not least because these results constitute something of a challenge to the oft-quoted finding that - ‘*shoe leather costs*’ are by no means trivial (*a 10% inflation imposing a welfare cost of nearly 1% of real income in perpetuity*).

This paper contributes to this literature by providing further estimates of the welfare cost of inflation having taken careful account of issues raised in that subsequent literature. Using UK quarterly data for a 30 year period to 2008(2), we find stable and robust long-run money demand relationships for both household sector and corporate sector holdings of M1. The robust estimated coefficients are markedly different across the two sectors thereby justifying having specified separate equations for estimation; and, since these are used to calculate the welfare cost of inflation, contribute to different estimates of the welfare cost across the two sectors (and more accurate welfare measures). We find that the welfare cost for the household sector is much higher than that for the corporate sector. Indeed, the (arguably more sophisticated) corporate sector is found to bear little more than 5% of the overall welfare cost

in the UK – very different from the equal sharing of the burden found by the only other paper to provide a sectoral breakdown (Calza and Zaghini, 2010 - for the US). The finding of differential burdens could have important policy implications since the sectors may value policies to reduce inflation rather differently.

At the aggregate level, this paper finds estimates of the welfare cost of inflation that are smaller than those reported in the recent literature. It seems that, at least in the UK, the specific inflation-related welfare costs are relatively trivial in macroeconomic terms (perhaps no greater than one tenth of a per cent of real income for a 10% inflation). Furthermore, the welfare gain from reducing inflation by 10 percentage points differs for different initial inflation rates, but again is found to be never higher than 0.1%GDP. Further research is needed to ascertain whether this result carries over to other country contexts.

It is of course inappropriate to suggest that the findings presented here imply that inflation is harmless. There are many good reasons for adopting a macroeconomic anti-inflation policy stance. The generalised move toward lower inflation in both Europe and the US delivers welfare benefits, but those which accrue from the reduction of ‘shoe-leather costs’ constitute a very small part in these. The debates will continue about appropriate inflation targets, price stability and the Friedman (1969) rule; but the implication is that the modelling frameworks used for analysis are likely to focus even more on the inefficient allocation of resources due to increased uncertainty, distortions to relative prices and arbitrary redistribution effects of wealth.

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TABLE 1. DYNAMIC ESTIMATION RESULTS AND TESTS OF COINTEGRATION

	HOUSEHOLD SECTOR		CORPORATE SECTOR	
<i>Functional Form</i>	Log-Log	Semi-Log	Log-Log	Semi-Log
<i>Dependent Variable</i>	Δm	Δm	Δm	Δm
m_{t-1}	-0.09*** (0.03)	-0.09*** (0.03)	-0.12*** (0.04)	-0.12*** (0.04)
Scale s_{t-1}				
c_{t-1} (consumer spending)	0.20*** (0.06)	0.20*** (0.06)		
y_{t-1} (GDP)			0.41*** (0.13)	0.41*** (0.13)
Long-Run	2.22***	2.20***	3.42***	3.42***
unit elasticity	9.89***	9.87***	9.58***	9.87***
Opportunity Cost				
$\log r_{t-1}$	-0.015** (0.006)		-0.024* (0.013)	
r_{t-1}		-0.19*** (0.07)		-0.33** (0.15)
Long-Run	0.17***	2.11***	0.20*	2.75***
Intercept	-1.32*** (0.41)	-1.25*** (0.41)	-3.27*** (1.26)	-3.67*** (1.25)
$\Delta_4 m_{t-1}$	0.09*** (0.02)	0.08*** (0.02)		
Δm_{t-3}			0.27*** (0.06)	0.27*** (0.06)
Δy_{t-3}			-1.09** (0.44)	-1.16*** (0.43)
Adjusted R ²	0.71	0.71	0.59	0.60
SER	0.018	0.017	0.035	0.035
LM5	0.99	0.97	0.83	0.75
ARCH	0.01	0.01	3.16*	3.00*
RESET	0.55	0.66	1.50	0.22
CHOW	0.47	0.49	0.69	0.71
Johansen Cointegration Tests				
0				
Max Eigen	31.98**	33.91**	33.91**	34.10**
Trace	19.56*	20.91*	22.56**	23.34**
1				
Max Eigen	11.36	15.49	11.35	10.76
Trace	12.41	13.00	11.35	10.59

Notes: ***, **, * indicate significance at 1%, 5% and 10% respectively. Numbers in parentheses are standard errors. For the scale variables, c is log of total consumer spending measured in constant prices; and y is the log of GDP at 2005 prices. The long run scale and opportunity cost (semi) elasticity are calculated as α_2/α_1 and α_3/α_1 , respectively. Δ_4 is the fourth difference. Results presented are the parsimonious equations from the ARDL with the lags on the differenced terms being those indicated in the Table and determined as the lag required for residuals that satisfy the diagnostic tests. Full results of the unrestricted equation are available on request. In each equation, seasonal dummy variables are estimated and dummy variables are introduced to accommodate for significant outliers. LM5 is the F test Breusch-Godfrey Lagrange multiplier test for residual serial correlation of up to the 5th order; RESET is the F test Ramsey test for misspecification and ARCH is the F test of the test for autoregressive conditional heteroscedasticity. Unit elasticity is an F test of the validity of imposing a unit scale elasticity. CHOW is the F version of the forecast test: results reported refer to break at 2006Q1 (inference is robust across other break points).

TABLE 2. WELFARE COST OF A 10% INFLATION, RELATIVE TO PRICE STABILITY

	HOUSEHOLD SECTOR		CORPORATE SECTOR		AGGREGATE	
	Log-log	Semi-log	Log-log	Semi-log	Log-log	Semi-log
$WC(0.13)$	1052.8498	651.3628	59.2472	36.7226	1112.0970	688.0854
$WC(0.13)$ as %GDP	0.1020	0.0631	0.0057	0.0036	0.1077	0.0667
$\Delta W = WC(0.13) - WC(0.03)$	741.1016	611.5155	40.9152	34.3815	782.0168	645.8970
ΔW as %C	0.1204	0.0994				
ΔW as %GDP	0.0718	0.0592	0.0040	0.0034	0.0758	0.0626
ΔW per household	£28.21	£23.28				
Burden of welfare cost borne by corporate sector					5.23%	5.69%

Notes: Results are presented in terms of interest rates rather than inflation rates since a real rate of interest of 3% is assumed. The calculations use the Lucas calculated intercept – the standard approach in this literature; results using the estimated intercept give the same inferences for the relative size and burden of the welfare costs. WC measures are in £million (2011 prices). %GDP calculations are based on the period average for GDP. Per Household calculations are based on 2011 data for Number of UK Households (26.3million: Office of National Statistics).

TABLE 3. WELFARE GAIN FROM A 10% DISINFLATION

(inferred from nominal interest rate ranges: 13% to 3%; 15% to 5%; and 20% to 10%)

		HOUSEHOLD SECTOR		CORPORATE SECTOR		AGGREGATE	
		Log-log	Semi-log	Log-log	Semi-log	Log-log	Semi-log
<i>WC</i> (0.13)- <i>WC</i> (0.03)	ΔW	741.1016	611.5155	40.9152	36.7226	782.0168	645.8970
	ΔW as%C	0.1204	0.0994				
	ΔW as%GDP	0.0718	0.0592	0.0040	0.0036	0.0758	0.0628
<i>WC</i> (0.15)- <i>WC</i> (0.05)	ΔW	709.2665	736.0993	38.8473	40.9166	748.1138	777.0159
	ΔW as%C	0.1152	0.1196				
	ΔW as%GDP	0.0687	0.0713	0.0038	0.0040	0.0725	0.0753
<i>WC</i> (0.20)- <i>WC</i> (0.10)	ΔW	658.5632	999.5187	35.5951	53.9080	694.1583	1053.4267
	ΔW as%C	0.1070	0.1624				
	ΔW as%GDP	0.0638	0.0968	0.0034	0.0052	0.0672	0.1020

Notes: See Notes to Table 2.

APPENDIX 1

TABLE A1 UNIT ROOT TESTS

	ADF no trend	ADF with trend	PP no trend	PP with trend
Household				
<i>m</i>	0.41 (0)	-2.63 (0)	0.29 [4]	-2.76 [4]
Δm	-9.47*** (0)	-9.47*** (0)	-9.51*** [4]	-9.51*** [4]
<i>c</i>	0.01 (3)	-2.88 (3)	0.05 [5]	-2.19 [5]
Δc	-4.28*** (2)	-4.27*** (2)	-12.96*** [6]	-12.92*** [6]
Corporate				
<i>m</i>	0.41 (0)	-2.92 (0)	0.29 [6]	-3.04 [6]
Δm	-11.24*** (0)	-11.29*** (0)	-11.34*** [6]	-11.37*** [6]
<i>y</i>	0.13 (1)	-3.56* (3)	0.49 [7]	-2.51 [7]
Δy	-3.47*** (2)	-3.51** (2)	-11.41*** [7]	-11.42*** [7]
Interest Rates				
<i>r</i>	-1.29 (0)	-4.11*** (1)	-1.69 [4]	-4.02*** [5]
Δr	-8.32*** (0)	-8.33*** (0)	-8.29*** [1]	-8.31*** [1]
$\log r$	-1.57 (1)	-4.14*** (1)	-1.49 [4]	-4.06*** [5]
$\Delta \log r$	-7.89*** (0)	-7.91*** (0)	-7.83*** [1]	-7.88*** [2]

Notes: ADF is the augmented Dickey Fuller test; PP the Philips Peron test. Numbers in brackets indicate the maximum lag on the differenced terms selected by the Schwarz criteria for the ADF and the bandwidth for the PP. ***, **, * indicate significance at 1%, 5% and 10% levels respectively. *m* is log of real balances, *c* is log of total consumer spending measured in constant prices, *y* is log of GDP at 2005 prices and *r* is the nominal interest rate. Δ is the first difference operator.

APPENDIX 2

CUSUM RESULTS

HOUSEHOLD SECTOR

Log-log functional form:

Semi-log functional form:

CORPORATE SECTOR

Log-log functional form

Semi-log functional form: