ASECU South-Eastern Europe Journal of Economics 1 (2012) 41-52 SEEJE

THE WELFARE COST OF INFLATION IN GREECE

KENT KIMBROUGH[a,*]
IOANNIS SPYRIDOPOULOS[b]
[a,b]Duke University, Department of Economics

Abstract
This paper measures the welfare cost of inflation for the case of Greece, using quarterly data for the period 1980Q1-1999Q4. Log-log and semi-log money demand functions are estimated using both OLS and Stock and Watson's (1993) dynamic OLS method. These estimates show the welfare cost of a 10 percent inflation rate in the range of 0.59 percent to 0.91 percent of GDP.

JEL Classification: E52
Keywords: Welfare cost of inflation, Inflation tax, inflation

* *Corresponding Author:* Kent Kimbrough, Dept. of Economics, Duke University, Box 90097, Durham, NC 27708. e-mail: kent@econ.duke.edu. fax:919-684-8974.

We are thankful to Dr. George Tavlas and Mr Pavlos Petroulas for their contribution to this paper, as well as two anonymous referees for their helpful comments.

1. Introduction

The deflationary path Greece followed in the period preceding its entry to the Eurozone in 1999 was impressive. From 1980-1999 inflation in Greece averaged 15 percent per year, falling from 24.7 percent in 1980, and converging quickly during the second half of the 1990's to the Eurozone average, stabilizing below 3 percent in 1999[1]. The purpose of this paper therefore, is to empirically estimate the welfare gain from reducing inflation in Greece using evidence from 1980Q1-1999Q4.

The effects of inflation on welfare have been the subject of extensive theoretical and empirical analysis. Bailey (1956) and Friedman (1969) compare the welfare cost of inflation to that of an excise tax. In particular, Bailey (1956) defines the area under the money demand curve, as the welfare cost of the reduction of real cash balances due to inflation. These ideas underlie the work of Lucas (2000) who estimates the welfare cost of inflation for the US using annual data for the period 1900-1994. He considers two different money demand specifications and for each specification he identifies the welfare cost function as theoretically analyzed by Bailey (1956). Lucas concludes that the welfare cost of inflation for the US is significant, on the order of 1.8 percent of GDP for a 10 percent inflation, but it also depends on the money demand specification chosen. In this light, Serletis and Yavari (2004) use recent advances in econometrics to perform the same sort of empirical exercise for both the US and Canada. They estimate a lower interest elasticity of the demand for money than Lucas uses in his welfare cost calculations and find significantly lower welfare gains from reducing inflation. Serletis and Yavari (2005) apply similar methods to look at the welfare cost of inflation in Italy and once again find them to be quite low. Ireland (2009) combines recent advances in econometrics and higher frequency data for the US to perform a similar empirical exercise. He concludes that the welfare gain from reducing inflation in the US is trivial. Yavari and Serletis (2007, 2011) use a similar approach to explore the welfare cost of inflation for European and Latin American countries. For the European countries they find that the welfare gain of reducing interest rates from 10 percent to 5 percent ranges from 0.1 to 0.5 percent of GDP, with smaller countries benefiting the most, whereas for the Latin American countries reducing inflation varies from 0.1 percent of GDP, in countries with moderate inflation rates, to 90 percent of GDP in countries with hyperinflation.

The rest of the paper proceeds as follows. Section 2 provides estimates from OLS regressions on two money demand specifications, as well as unit root and cointegration test results and then the implied welfare cost estimates are presented. Section 3 improves the OLS regression estimates by using the Stock and Watson's (1993) dynamic OLS estimation. The new welfare cost estimates are presented and compared with the previous ones. In section 4 concluding remarks are presented.

1. Annual inflation based on CPI. OECD Database.

2. Money Demand and Welfare Cost Estimates

In this paper two alternative specifications of money demand are considered, the log-log, or constant elasticity specification, (1) and the semi-log, or Cagan's specification, (2).

$$m = Ar^{-\eta} \Rightarrow lnm = lnA - \eta lnr \quad (1)$$

$$m = Be^{-\xi r} \Rightarrow lnm = lnB - \xi r \quad (2)$$

where m represents the ratio of money to nominal GDP and r the short-term nominal interest rate. Money is measured by the narrow aggregate M1 and the nominal interest rate by the three-month treasury bill rate which is taken to be the best indicator for the opportunity cost of holding money. The data is quarterly for the period 1980Q1-1999Q4[2]. We chose 1980 as our starting period for reasons of data availability. Another reason why we do not use more recent data is that savings deposits in euros started being included in M1 after 2000, which induced a break in the M1 series. As a result, the estimated money demands fitted the data poorly, suggesting that using M1 as a measure for money after this reclassification is probably not the most appropriate measure.

Table 1 shows the results of OLS regressions on (1) and (2) and then the two money demand specifications are drawn in Figure 1 using these estimates. The main difference in the two specifications is that the money to GDP ratio according to the semi-log specification has a finite satiation point, whereas the log-log version implies an arbitrarily large ratio when interest rates approach zero. Consequently, as stressed by Lucas (2000) and Ireland (2009), special care has to be taken in choosing the specification as they predict very different welfare cost estimates.

Table 1. Regressions of the log-log and semi-log specifications

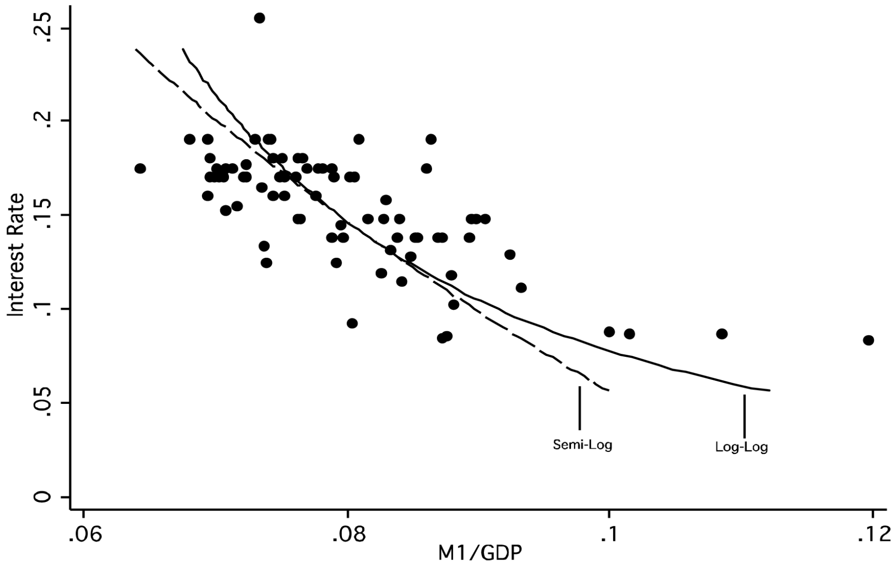
	Log-Log Model	**Semi-log model**
	ln(m)	ln(m)
lnr	-0.351***	-
	(0.0371)	-
r	-	-2.453***
	-	(0.278)
Constant	-3.199***	-2.157
	(0.0709)	(0.0435)
N	80	80
Adj.R-sq	0.528	0.494

Standard errors in parentheses, *p <0.05, **p <0.01, ***p <0.001

2. Data for M1 was collected from the Bank of Greece, GDP is from the OECD database and the 3-month treasury bill is from the series of Global Financial Data.

The elasticity of money demand with respect to the nominal interest rate implied by the semi-log estimates is -0.367 [(mean r of 0.149×(-2.453)], which is quite close to the direct estimate of -0.351 obtained from the log-log specification. These estimates are close to Sarantides and Varelas (1985), who find the long-run elasticity of money demand with respect to the nominal interest rate to be -0.334, using Greek data for the period 1954-1982. These results are slightly different from Boel and Camara (2011), who, using currency as their measure for money, find the estimated elasticity of money demand for the period 1973-1998 to be -0.279 (and the implied welfare cost of 10 percent inflation to be 0.26 percent of GDP). Brissimis et al. (2003), for the period 1976Q1-2000Q4, use Vector Error Correction (VEC) and Random Coefficient (RC) modeling and find the estimated elasticity to lie between -0.038 and -0.035. This difference in the slope coefficients is mainly attributed to the fact that the latter used M3 as their measure for money, which, as one would expect, yields a lower estimate of the elasticity of money demand with respect to the nominal interest rate than do our estimates using M1. Finally, Ericsson and Sharma (1998) also use M3 and find the interest rate semi-elasticity of interest rates to be between -3.07 and -3.87 (estimates closer to the dynamic OLS estimates of the next section).

Figure 1. Money demand functions, Log-log vs Semi-log



In Figure 1, the estimated values from Table 1 are used to graph the two money demand functions. Comparing the adjusted R squared of each specification it is evident that the log-log specification performs better than the semi-log model. From Figure 1 it is clear that this is mainly due to its ability to better fit the behavior of money demand at lower interest rates.

To check the validity of the estimations of Table 1 it is necessary to see if the money to GDP ratio and the interest rate are stationary variables. In this respect, Table 2 shows the Phillips-Perron (1988) unit root tests. The Phillips-Perron (1988) test statistics are robust to serial correlation by using the Newey-West (1987) heteroskedasticity and autocorrelation-consistent covariance matrix estimator.

Table 2. Unit Root Tests

Variables	Phillips-Perron Z_t Test Statistic	DF-GLS Test Statistic	k_maic
lnm	-2.043	-0.347	8
lnr	-0.802	-1.139	1
r	-1.443	-1.387	1

Note: Critical Values for Phillips Perron unit root test are -2.588 at 10% significance level, -2.907 at 5% significance level, -3.539 at 1% significance level. Critical Values for the DF-GLS test are for lnm, lnr and r respectively: -2.577, -2.794, -2.711 at 10% significance level, -2.855, -3.089, -3.002 at 5% significance level and -3.656, -3.656, -3.554 at 1% significance level.

Table 2 shows the results of the Phillips-Perron unit root tests for three Newey-West lags. The null hypothesis of stationarity can be rejected, implying that the variables lnm, lnr and r have unit roots at every common level of significance[3]. Ng and Perron (2001) suggest an improved procedure to first enhance the power of tests, like the ADF unit root test, that may suffer from small size distortions. Essentially, they suggest a GLS detrending of the data series before performing an ADF test, following the work of Elliot et al. (1996). This procedure, in conjunction with choosing an appropriate truncation lug, the modified AIC or the MAIC (indicated as k_maic on table 2), will, the authors claim, lead to substantial power gains and size improvements in all unit root tests performed. The results in table 2, confirm the existence of a unit root in all three variables also under this more robust test. The estimations in table 1 are therefore consistent only if the variables are cointegrated. Table 3 shows the results of the Phillips-Ouliaris (1990) two-step residual based cointegration test. In short, once

3. Using also 0-8 Newey-West lags the null hypothesis of a unit root still cannot be rejected.

it is verified that the variables have unit roots, the Phillips-Ouliaris cointegration test uses OLS regressions to estimate equations (1) and (2). Hamilton (1994) explains that if the OLS sample residuals are non-stationary, then the estimated coefficients are not consistent and the regression is subject to the spurious regression problem. For this case, the Phillips-Ouliaris cointegration test includes another Phillips-Perron test on the residuals and if the residuals do not have a unit root (i.e they are stationary), then the variables are cointegrated and consequently the OLS estimators are consistent. For robustness checks, we also used Johansen's cointegrating vectors approach.

Table 3 shows Phillips-Ouliaris' Z_t statistic for three Newey-West lags. Comparing with the critical values it is evident that we can reject the null of no cointegration at every significance level for both specifications[4]. Therefore, the variables for both models are cointegrated and the OLS estimates of Table 1 are consistent[5]. It has to be noted that the statistical analysis so far, as pointed by Ireland (2009) is assuming a linear autoregressive process with a unit root for both *lnr* and *r*. Following Ireland (2009), as well as Anderson and Rache (2001), this paper also deals with this issue by putting the two specifications "in equal footing ex ante" treating both of them as linear relationships.

Table 3. Phillips-Ouliaris Cointegration Test

	Test Statistic	1% Critical Value	5% Critical Value	10% Critical Value
$lnm = \hat{\alpha} - \hat{\beta} lnr$	$Z_t = -6.551$	-3.96	-3.37	-3.07
$lnm = \hat{\alpha} - \hat{\xi} r$	$Z_t = -6.450$	-3.96	-3.37	-3.07

Notes: Critical values are reported by Hamilton (1994). The intercept and the slope coefficient for each specification are estimated using ordinary least squares estimation.

Following Bailey (1956) and Lucas (2000), we can now compute the welfare cost of inflation as the loss of consumers' surplus from a rise in the interest rate. Letting *m(r)* denote the money demand function we have estimated and denoting by *ψ(m)* the inverse money demand function, then the welfare cost function can be found by *w(r)*, where *w(r)* is found as follows:

$$w(r) = \int_{m(r)}^{m(0)} \psi(x)dx = \int_0^r m(x)\,dx - rm(r) \qquad (3)$$

4. We can still reject the null of no cointegration for 0-8 Newey-West lags.
5. For robustness checks we also used Johansen's cointegrating vectors approach. The results further support the evidence of cointegration between lnm and lnr as well as between lnm and r.

Lucas (2000) interprets the function w(r) as the compensation agents require to accept living at a steady state with nominal interest rate r, rather than one with a nominal interest rate of zero. The welfare cost function can be found as shown below for each specification[6]:

for $m(r) = Ar^{-\eta}$

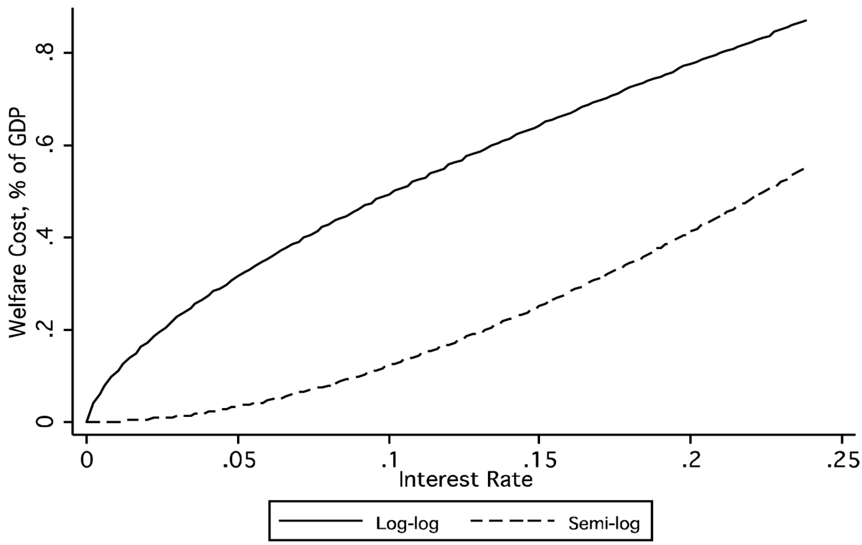
$$(3) \quad \Rightarrow w(r) = A\frac{\eta}{1-\eta}r^{1-\eta} \tag{4}$$

whereas for $m(r) = Be^{-\xi r}$

$$(3) \quad \Rightarrow w(r) = B\left[1-(1+\xi r)e^{-\xi r}\right]/\xi \tag{5}$$

Using the constants and slope coefficients from the money demand functions estimated in Table 1, (4) and (5) can be used to generate Figure 2, which graphs the resulting estimated welfare cost functions. From the figure it is evident that for moderate inflation rates the two money demand specifications imply very different welfare cost estimates.

Figure 2. Estimated Welfare Cost Functions



6. For a more detailed derivation of the welfare functions see Bailey (1956) and Lucas (2000).

Table 4 shows the welfare cost estimates for the two specifications for different levels of interest rate/inflation (considering that the real interest rate is constant at 3%). These numbers suggest a significant welfare cost at the 10 percent level of inflation or more for the log-log model, but a relatively insignificant welfare cost for the semi-log model. In particular, at the 10 percent inflation rate (or 13 percent interest rate), the log-log specification implies that the welfare cost of inflation is 0.58 percent of GDP whereas the semi-log specification implies a cost of 0.19 percent of GDP, a significantly lower welfare cost estimate. Choosing the appropriate money demand specification is critical for drawing valid conclusions regarding the welfare cost of inflation.

Table 4. Welfare cost (percent of income)

Interest Rate	Log-Log	Semi-log	Inflation
0.03	0.2263	0.0121	0%
0.06	0.3549	0.0463	3%
0.13	0.5863	0.1944	10%
0.18	0.7242	0.3443	15%
0.23	0.8492	0.5199	20%

3. Dynamic OLS estimates and the Welfare Cost of Inflation

This section improves on the OLS estimates of the previous section by using Stock and Watson's (1993) dynamic OLS estimation method. Under the assumption of cointegration, adding leads and lags of Δlnr and Δr for the log-log and semi-log model respectively, helps account for correlation between the regressors and the residuals from the cointegrating relationship between *lnm*, *lnr* and *r*. Table 5 provides the new dynamic OLS estimates using 4 leads and lags, and 4 Newey-West lags[7].

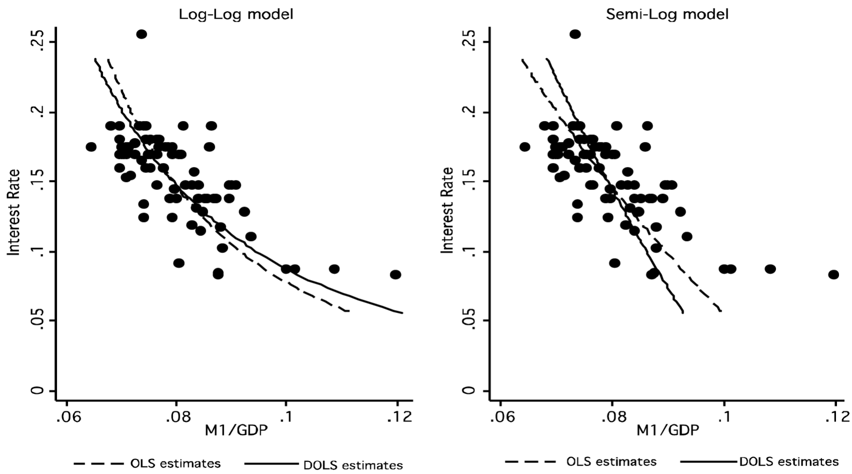
Table 5. Dynamic OLS Estimates

	Log-Log Model	**Semi-log model**
	ln(m)	ln(m)
lnr	-0.4284***	-
	(0.0661)	-
r	-	-3.2052***
	-	(0.5410)
Constant	-3.3471***	-2.157
	(0.1200)	(0.0899)
N	75	75
Adj.R-sq	0.610	0.593

7. The coefficient of the constants, lnr and r are significant at all levels for 1-4 leads and lags, as well as for Newey-West's standard errors lag truncation parameter 0-8.

Using the new estimates, Figure 3 and Figure 4 show how estimated money demand and welfare cost functions are altered.

Figure 3. Money Demand Functions with DOLS Estimates



Compared to the OLS estimates, the adjusted R-squared is higher using dynamic OLS, as can be seen readily by looking at Tables 1 and 5. This is confirmed graphically by Figure 3, which shows the estimated money demand functions using both OLS and dynamic OLS. The log-log specification continues to have a higher adjusted R-squared than the semi-log model, and as shown from the left-hand panel of Figure 3, there is also an improvement in how the demand function fits the data. The slope coefficients for both specifications of the money demand functions are higher than their counterparts using OLS (see Table 1). Also, once again the implied interest elasticity of money demand using the semi-log specification is fairly close to that directly estimated using the log-log specification (-0.48 versus -0.43).

Table 6 shows the new welfare cost estimates for different levels of inflation. The welfare cost estimates do not change much for the semi-log model. However, for the log-log model the change is considerable, with the new estimates giving welfare cost estimates that are, at low rates of inflation, roughly twice as large as the welfare cost estimates emerging from the OLS estimates. The big change in the estimated welfare cost under the log-log specification is driven mainly by the increase in the constant term but also from the slope coefficient, whereas under the semi-log specification the reduction in absolute terms of the constant term and the slight increase (in absolute terms again) of the interest rate semi-elasticity more or less cancel each other out leaving the welfare cost estimates virtually unchanged.

Figure 4. Welfare Cost Functions. OLS vs DOLS estimates

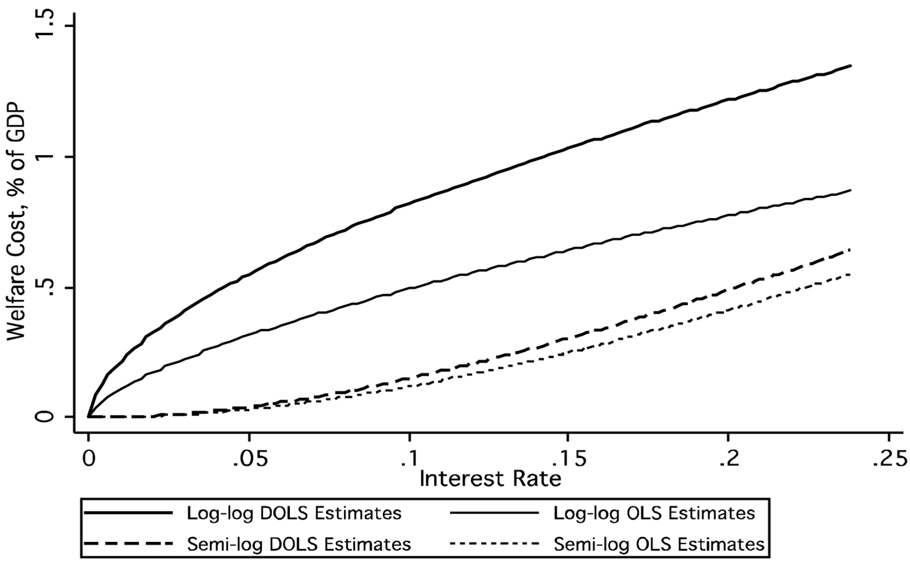


Table 6. Welfare cost (percent of income) with DOLS

Interest Rate	Log-Log	Semi-log	Inflation
0.03	0.4120	0.0156	0%
0.06	0.6123	0.0587	3%
0.13	0.9099	0.2074	10%
0.18	1.1473	0.4127	15%
0.23	1.3198	0.6093	20%

It is evident that the welfare cost estimates depend on the interest elasticity of money demand. Lucas (2000) assumed this elasticity to be -0.5 and consequently concluded that the welfare cost of inflation in the US is not trivial. Lucas' assumption for the interest elasticity of money demand was tested by Serletis and Yavari (2004), who estimated the elasticity to be -0.21 for the US and -0.22 for Canada. Using annual data from 1948 to 2001 and Lucas' (2000) welfare cost functions to measure the welfare cost of inflation, they reported welfare cost estimates of less than a half of 1 percent. Ireland (2009) also estimated the interest elasticity of money demand for the US, but argues that the semi-log money demand specification best describes the behavior of money demand after 1980. He also reports lower welfare cost estimates, however at the level of 0.22 percent of income for a 10 percent annual inflation rate.

Serletis and Yavari (2005)[8] also found the interest rate elasticity in Italy to be -0.26 and claim that reducing interest rates from 14 percent to 3 percent results in a welfare gain of 0.4 percent of income, a relatively small welfare gain. Finally, measuring the welfare cost of inflation for several European countries, Serletis and Yavari (2007) find smaller welfare cost estimates at the level of 0.1 or 0.2 percent of income for countries such as Germany and France respectively, whereas for smaller countries it reaches higher levels such as 0.45 percent for Austria and 0.5 percent for Ireland. The estimates for the smaller economies are evidently closer to our findings when we use the OLS estimates of interest elasticity of money demand to measure the welfare cost of inflation. Country heterogeneity is therefore a critical factor on the welfare cost of inflation. Variance across countries in financial market development and financial regulations can affect the demand for money and hence the welfare cost of inflation, making this an interesting area to explore in future research.

4. Conclusions

This paper examined two different money demand specifications to find which one fits the empirical observations better for the case of Greece. In particular, using both OLS and dynamic OLS regressions to estimate the elasticity of money demand to interest rates, it is found that the log-log model performs better than the semi-log model, due to its ability to better track the behavior of the money demand as nominal interest rates in Greece fell. Using the welfare function formulas from Lucas (2000), the cost of a 10 percent inflation rate lies between 0.58 and 0.91 percent of income. In particular, the estimated interest elasticity of money demand with the improved DOLS estimates is -0.428, implying a welfare cost of 0.91 percent of income for a 10 percent inflation rate. As already stressed, these estimates are significantly higher than the welfare cost found by using the semi-log money demand function. The results suggest a significant welfare gain for Greece during the two-decade period that is examined in this paper, since inflation has fallen from an average of 15.3 percent from 1980-1999 to an average of 3 percent in late 1990's. Our estimates using the log-log specification of money demand and dynamic OLS, our preferred estimates, imply that declining inflation has resulted in an average (annual) welfare gain for Greece of 0.53 percent of GDP.

All the empirical findings presented here, therefore, confirm the need for individual analysis of the welfare effects of inflation in different countries. This paper provided evidence from another small economy like Greece, adding new estimates of the interest elasticity of money demand. With the new money demand estimates, we measured the welfare cost of inflation in Greece and showed that these estimates can be further refined and become more accurate, using Stock and Watson's (1993) DOLS

8. See also Serletis (2007).

estimators. In conclusion, our findings also shed light on one of the potential effects a departure from the Eurozone might have on the Greek economy. For instance, if a departure from the Eurozone were to be accompanied by a rise in inflation in Greece from 3 percent to 20 percent, our estimates imply an increase in the welfare cost of inflation from 0.61 to 1.32 percent of income. That is, a welfare loss of 0.71 percent of income per annum. This is a significant loss and would, of course, be even greater if inflation were to rise more sharply.

References

Anderson, Richard G. and Robert H. Rasche (2001), "The remarkable stability of monetary base velocity in the United States, 1919-1999." Federal Reserve Bank of St. Louis Working Paper, 008A.

Bailey, Martin J. (1956), "The welfare cost of inflationary finance." *Journal of Political Economy*, 64, 93–110.

Boel, Paola and Gabriele Camera (2011), "The welfare cost of inflation in OECD countries." *Macroeconomic Dynamics*, 1–35.

Brissimis, Sophocles N., George Hondroyiannis, P.A.V.B. Swamy, and George S. Tavlas (2003), "Empirical modeling of money demand in periods of structural change: The case of Greece." Working Papers 01, Bank of Greece.

Elliot, G., Rothenberg, T. Stock, J., 1996. Efficient tests for an autoregressive unit root, *Econometrica,* 64, 813-836.

Ericsson, Neil. R. and Sunil Sharma (1998), "Broad money demand and financial liberalization in Greece." *Empirical Economics*, 23, 417–436.

Friedman, Milton (1969), The Optimum Quantity of Money. In The Optimum Quantity of Money and Other Essays, Aldine Publishing Company.

Hamilton, James D. (1994), Time Series Analysis. Princeton University Press.

Ireland, Peter (2009), "On the welfare cost of inflation and the recent behavior of money demand." *American Economic Review*, 99, 1040–1052.

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

Newey, Whitney K. and Kenneth D. West (1987), "A simple, positive semi- definite, heteroskedasticity and autocorrelation consistent covariance matrix." *Econometrica*, 3, 703–08.

Ng, S., Perron, P., 2001, Lag length selection and the construction of unit root tests with good size and power, *Econometrica*, 69, 1519-1554.

Phillips, Peter C. B. and Pierre Perron (1988), "Testing for a unit root in time series regression." *Biometrika*, 75, 335–346.

Phillips, Peter C.B. and S. Ouliaris (1990), "Asymptotic properties of residual based tests for cointegration." *Econometrica*, 58, 165–93.

Sarantides, Stylianos and Erotokritos Varelas (1985), "Money anticipations and the demand for money: The case of Greece." *European Journal of Political Economy*, 1, 385 – 397.

Serletis, Apostolos and Kazem Yavari (2004), "The Welfare Costs of Inflation in Canada and the United States." *Economics Letters*, 84, 199-204.

Serletis, Apostolos and Kazem Yavari (2005), "The Welfare Cost of Inflation in Italy." *Applied Economics Letters*, 12, 165-168.

Serletis, Apostolos (2007), *The Demand for Money: Theoretical and Empirical Approaches*, Springer.

Serletis, Apostolos and Kazem Yavari (2007), "On the welfare cost of inflation in Europe." *Applied Economic Letters*, 14, 111–113.

Stock, James H. and Mark W. Watson (1993), "A simple estimator of cointegrating vectors in higher order integrated systems." *Econometrica*, 61, 783– 820.

Yavari, Kazem and Apostolos Serletis (2011), "Inflation and welfare in Latin America." *Open Economies Review*, 22, 39–52. 10.1007/s11079-009-9163-3.