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Abstract

I quantify the redistributive effects of expected inflation in a sample of OECD countries using a microfounded model of money where agents differ in their consumption risk. The model is calibrated using harmonized wealth microdata from the *Luxembourg Wealth Study.* I find that inflation acts as a regressive tax in all countries considered. The magnitude of inflation's redistributive impact, however, depends not only on wealth distribution but also, and importantly, on the shape of the money demand curve. A higher and less elastic money demand leads to more regressive effects of inflation, thus implying such effects are not necessarily stronger in a country with a more unequal wealth distribution.

Keywords: Money, Heterogeneity, Calibration, Welfare Cost of Inflation

JEL codes: E4, E5

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1 Introduction

What are the welfare costs induced by inflation? This has been a classic question in monetary economics ever since Bailey (1956). The consensus is that expected inflation and aggregate welfare are negatively correlated, but few studies so far have investigated inflation's redistributive effects. Among them, Boel and Camera (2009) develop a microfounded model of money with heterogeneous trade shocks in which agents can choose between money and an inflation-protected nominal asset providing consumption insurance. For moderate levels of inflation, an equilibrium exists such that poorer agents choose to hold money, while the wealthier ones hold the alternative asset. In this environment, inflation acts as a regressive tax that increases wealth inequality.[1] These findings share similarities with the cash/credit models in Erosa and Ventura (2002) and Albanesi (2007), and the one with incomplete markets in Camera and Chien (2014). All suggest that expected inflation's effects on different segments of society depend on composition and distribution of wealth, both of which vary substantially across countries.[2] These cross-country differences, however, have been so far overlooked by the literature on the welfare cost of inflation.

I take a step towards filling this gap by quantifying the redistributive effects of expected inflation in a sample of OECD countries using the framework developed in Boel and Camera (2009). Quantitatively, the issue is nontrivial for several reasons. First, any rigorous analysis of this topic must be based on comparable estimates of wealth distribution across countries. Such comparisons, however, have been unreliable in the past since estimates of personal wealth are sensitive to data source choices, definition of wealth and accounting conventions, all of which vary across countries. I overcome this limitation by using data from the *Luxembourg Wealth Study* (LWS), an international project that has collected household microdatabases from a sample of OECD countries, and has standardized the wealth concept and sampling frame. This allows me to pin down the distribution of different types of fi-

[1] In other microfounded models of money, Chiu and Molico (2010) and Chiu and Molico (2011) investigate the redistributive effects of inflation in economies where money is the only asset.

[2] See for example Wolff (1996) and Jantti et al. (2008).

nancial assets for Austria, Canada, Finland, Italy, Japan, Norway, the United Kingdom and the United States.[3] For all countries considered, I find that the share of household financial wealth held in liquid assets decreases with income. There are, however, significant cross-country differences in terms of the magnitude of that share. For example, in the United States the top income decile holds approximately 10% of its financial wealth in liquid assets, but that fraction is as high as 83% in Japan. One would expect such differences to have important implications for the redistributive effects of inflation.

Second, money demand must be estimated carefully. This is particularly important because, in the tradition of Bailey (1956), the welfare cost of inflation is defined as the area under the money demand curve that is lost as steady-state inflation increases. Given the extensive research concerned with the stability of money demand,[4] a careful estimation of money demand should test for structural breaks. Indeed, Boel and Camera (2011) suggest that the poor fit in some of the countries in their study might be a consequence of an unstable money demand. I test for such breaks and find them to be significant for Canada, Italy, Japan, Norway and the United Kingdom. I also identify the policy issue or economic shock that led to such structural changes.

When the model in Boel and Camera (2009) is calibrated for all countries in the sample, I find that two results hold. First, inflation always acts as a regressive tax. Second, the magnitude of such regressive effects differs across countries and it depends not only on the distribution of financial wealth, but also on the shape of the money demand curve. For example, one would expect inflation's regressive effects to be stronger in the United States, where financial wealth is more unequally distributed, compared to Japan, where the composition of financial portfolios remains relatively constant along the income distribution. Instead, I find the opposite is true. Why? Because money demand has steepened and shifted upward over time in Japan due to QE polices. As the welfare cost of inflation is defined

[3] Financial assets include deposit accounts, bonds, stocks and mutual funds. Cyprus, Germany, Luxembourg and Sweden also participate in the LWS, but I exclude them from the analysis because of data limitations.
[4] For a recent literature survey, see Sriram (2001).

as the area under the money demand curve that is lost due to inflation, a higher and less elastic money demand will imply a more severe loss due to inflation. This burden falls more heavily upon poorer agents who hold more liquid and less inflation-protected portfolios, thus directly linking the shape of money demand to the regressive effects of inflation.

The remainder of the paper is organized as follows. Section 2 summarizes the model, Section 3 discusses its quantitative performance in a sample of OECD countries and Section 4 concludes.

2 The model

Consider the heterogeneous-agent model in Boel and Camera (2009), which builds on Lagos and Wright (2005). Time is discrete, the horizon is infinite and there is a large population of infinitely-lived agents who consume perishable goods and discount across periods. In each period agents may visit two sequential rounds of trade—we refer to the first as DM and the second as CM. Rounds of trade differ in terms of economic activities and preferences. In the DM, agents face an idiosyncratic trading risk so that they either consume, produce, or are idle. We refer to consumers as buyers and producers as sellers. Agents are ex-ante heterogeneous in DM trading shocks, with production and consumption being equally likely. The population is divided into two types $j = H, L$ in proportions ρ and $1 - \rho$.

Key notation is as follows. In the CM of each period, an agent of type j consumes $q_j \geq 0$ goods and supplies $x_j \geq 0$ labor (equivalently, produces x_j goods), thus deriving utility $U(q_j) - x_j$. In the DM, consumers of type j derive utility $u(c_j)$ from $c_j \geq 0$ consumption and all producers suffer the same linear disutility $\phi(y_j) = y_j$ from producing y_j goods. Let $\sigma_j \in (0, 1]$ denote the probability of trading in the DM for any type j agent, with $0 < \sigma_L < \sigma_H \leq 1$. The functions u, ϕ and U satisfy the standard Inada conditions and $u(0) = U(0) = 0$. A star denotes the quantities that uniquely solve $u'(c) = 1$ and $U'(q) = 1$.

The selected preference structure generates a single-coincidence problem in the DM since buyers do not have a good desired by sellers. Moreover, two additional frictions characterize the DM. First, agents are anonymous as in Kocherlakota (1998), since trading histories of agents in the goods markets are private information. This in turn rules out trade credit between individual buyers and sellers. Second, there is no public communication of individual trading outcomes, which in turn eliminates the use of social punishments to support gift-giving equilibria. The combination of these two frictions together with the single coincidence problem implies that sellers require immediate compensation from buyers. So, buyers must use money to acquire goods in the DM.

Agents are price takers. The government is the only supplier of fiat money, of which there is an initial stock $\bar{M} > 0$ and which grows deterministically at a constant gross rate π via lump-sum transfers τ. In stationary equilibrium, the gross growth rate of inflation equals the gross growth rate of the money supply.

Agents can buy consumption insurance in addition to money. Specifically, in the CM an intermediary exists that sells one-period nominal assets to the public at price $\psi > 0$, operates at zero resource costs and earns zero profits. Assets can only be redeemed in the following DM for claims to money, which are enforceable in the CM and are financed with the revenue from asset sales. Buyers can redeem the asset spending its claims to money to buy consumption, while sellers can redeem it to cash its claims in the next CM. Idle agents cannot participate in DM trades, so they cannot redeem the asset. Thus, the asset becomes less attractive to type L who can trade less often. For a type j holding $m_j \geq 0$ money balances and $b_j \geq 0$ assets, at the start of the DM:

$$V_j(m_j, b_j) = m_j + \sigma_j b_j + \frac{\sigma_j}{2}[u(c_j) - c_j] + U(q^*) - q^* + \tau - \pi(m'_j + \psi b'_j) + \beta V_j(m'_j, b'_j) \quad (1)$$

where a $'$ denotes next-period variables and the term σ_j appears in front of b_j because bonds can only be redeemed in the DM with probability σ_j.

A stationary equilibrium exists in this environment such that agents H hold only financial assets, while agents L hold only money. This equilibrium exists provided that $\pi \in (\bar{\pi}, \tilde{\pi})$ where $\bar{\pi} = \beta + \sigma_H(1-\beta)$ and $\tilde{\pi} = \beta + \sigma_H - \beta\sigma_L$. Hence, in this equilibrium $c_H = b_H/p$ and $m_H = 0$, while $c_L = m_L/p$ and $b_L = 0$ and the repayment constraint faced by the intermediary is:

$$\pi\psi b_H = \sigma_H b_H \tag{2}$$

The expressions for c_L and c_H are obtained from the following expressions:

$$i = \frac{\sigma_j}{2}\left[\frac{u'(c_j)}{p} - 1\right] \text{ for } j = H, L \tag{3}$$

$$\sigma_H\left(\frac{1}{\beta} - 1\right) = \frac{\sigma_H}{2}\left[\frac{u'(c_H)}{p} - 1\right] \tag{4}$$

where $i = \frac{\pi}{\beta} - 1$ denotes the net nominal interest rate and $p = \phi'(y) = 1$ denotes the equilibrium relative price between CM and DM. Note that asset holdings of type H are not subject to the inflation tax. That is because the asset's expected return is $\sigma_H \frac{1}{\psi} = \pi$ and therefore it adjusts with inflation.

3 Quantitative analysis

In this section, I calibrate the model for a subsample of OECD countries that participate in the *Luxembourg Wealth Survey* (LWS), namely Austria, Canada, Finland, Italy, Japan, Norway, the United Kingdom and the United States.[5] The LWS constitutes the first cross-country wealth database in existence and it provides harmonized microdata for deposit accounts holdings, financial assets holdings and disposable income among others, all of which are necessary to calibrate the model's parameters.

[5]Cyprus, Germany, Luxembourg and Sweden also participate in the LWS, but they are excluded from our analysis due to lack of data availability. Specifically, data on deposit accounts are not available for Germany and Luxembourg. M1 data for Sweden are only available starting from 1998Q1 and M0 data from 1995Q2. Money-market interest rate data for Cyprus are only available starting from 1996Q1.

I use the model's calibrated parameters to quantify the redistributive effects of inflation. I start by focusing on a representative-agent version of the model—this is done in order to determine the value of the preference parameters common across agents. I subsequently reintroduce heterogeneity to study the welfare impact of inflation for different segments of society. Throughout, I report the welfare cost of ten percent annual inflation as a comparison to an economy with no inflation. Data is quarterly and data sources are in the Appendix.

In the representative agent model $\sigma_j = \sigma$ and $\beta_j = \beta$ for $j = H, L$. I consider standard functional forms: $u(c) = \frac{(c+b)^{1-\eta} - b^{1-\eta}}{1-\eta}$ with $\eta > 0$ and $U(q) = A\ln(q)$ which implies $q^* = A$. I assume preferences are homogeneous across countries and set a quarterly discount factor $\beta = 0.9898$ consistent with an annual $\beta = 0.96$, $b = 0.00001$ and $\eta = 1$ so that $u'(q) = q^{-1}$ and $u''(q) = -q^{-2}$, i.e. preferences are unit elastic in both DM and CM. In a monetary equilibrium the relative price p satisfies $p = 1$ and $c = m$ satisfies the agent's Euler equation in (3) in the case of a representative agent. Thus, I can find c as a function of the model's parameters and the nominal interest rate i: $c = \frac{\sigma}{2i+\sigma}$, where i is the average nominal quarterly yield on a money-market instrument. The parameters to identify are therefore σ and A. First, I set σ so that the theoretical interest elasticity of money demand $\varepsilon_m = -\frac{2i}{2i+\sigma}$[6] matches its empirical counterpart, which I estimate following Goldfeld and Sichel (1990).

The stability of money demand should be of concern here, as pointed out for example in Sriram (2001). That is because the welfare cost of inflation is measured as the area under the money demand curve that is lost as steady-state inflation rate increases, following Bailey (1956). Thus, a poor fit of money demand leads to meaningless estimates of the welfare cost of inflation. I therefore test for money demand stability by running Chow (1960) tests on the money demand equation specified in Goldfeld and Sichel (1990). I find evidence of structural breaks for most countries, except Austria, Finland and the United States. Dates and changes responsible for such breaks, as well as calibrated parameters, are in Table 1.

[6]The Euler equation for a representative agent is $\frac{\sigma}{2}\left[u'(m/p) - 1\right] - i = 0$. Using the implicit function theorem, market clearing $c = y$ and $p = 1$ from the seller's problem, the elasticity of money demand is $\varepsilon_m = 2i/\sigma c u''(c)$. Given the functional form for $u(c)$, (3) and $c = \frac{\sigma}{2i+\sigma}$, the expression for elasticity becomes $\varepsilon_m = -\frac{2i}{2i+\sigma}$.

A brief explanation is in order. In Canada, a break occurs in the third quarter of 1982, which coincides with the end of the M1-targeting policy conducted by the Bank of Canada between 1975 and 1982. In Italy, it happens in the third quarter of 1994, that is at the start of a new regime for the Bank of Italy. Indeed, Italy's central bank was given full independent power to set official interest rates in 1992, but it only stopped participating in government securities auctions in the summer of 1994. For Japan, I find evidence of two structural breaks, one in the first quarter of 2001 and the other in the third quarter of 2006. The first coincides with the start of the Quantitative Easing policy implemented by the Bank of Japan which reduced the overnight call rate to zero, and the second with the end of the same policy in March 2006. In Norway, the break occurs in the last quarter of 1992. In December 1992, the Norwegian krone was allowed to float after being pegged since 1986. Interest rates, which had previously increased sharply to defend the peg, decreased rapidly after the devaluation. Last, in the United Kingdom, the break is due to the end of the European Exchange Rate Mechanism (ERM) in the third quarter of 1992, and to the start of inflation targeting.

For each subperiod identified, I then determine A to fit the real balances-income ratio $L = \frac{M}{PY}$, where P is the nominal price level, M is money supply, and Y is real output.[7] As explained in Lagos and Wright (2005), this relationship can be interpreted as money demand in the sense that the desired real balances M/P are proportional to Y, with a factor of proportionality L that depends on the opportunity cost of holding cash, i. The theoretical expression for L in the model is $L = \frac{m}{\frac{\sigma}{2}pc+A}$.[8] Since $c = m$ in a representative agent model, given the functional forms selected the theoretical money demand becomes $L = \frac{c}{\sigma c/2+A}$. I calibrate A by minimizing the distance between L in the data and in the model, given the calibrated σ. Parameter values are in Table 1. The related Figure 1 shows the quality of the fit of the model to the data. Figure and Table A1 in the Appendix provide analogous information for the case when no possibility of structural breaks is considered.

[7]M1 is used as the measure of money supply in all countries except the United Kingdom, where M0 is used since M1 due to lack of data availability.

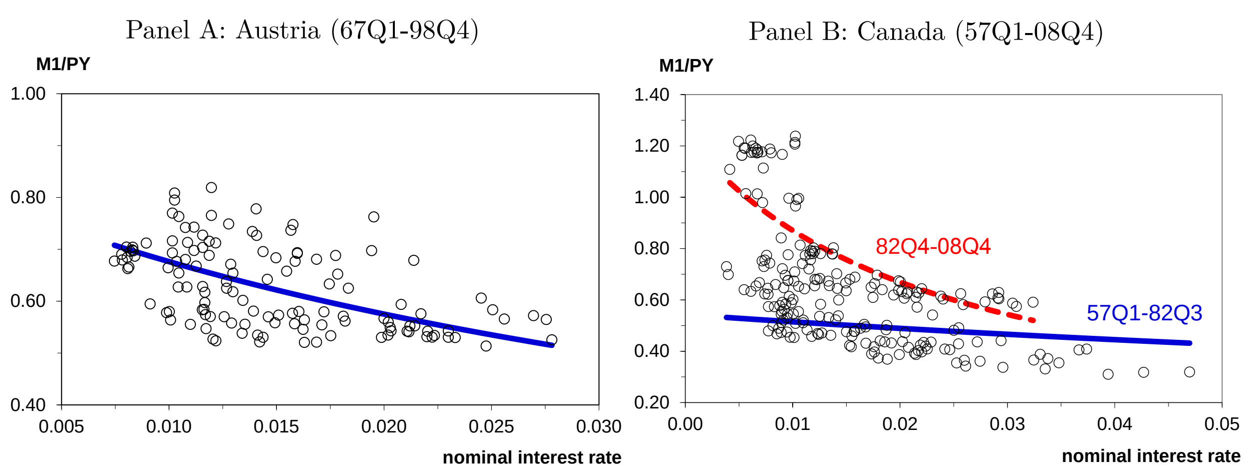
[8]Note that $\frac{\sigma}{2}pc + A$ is the sum of output in the first and second market.

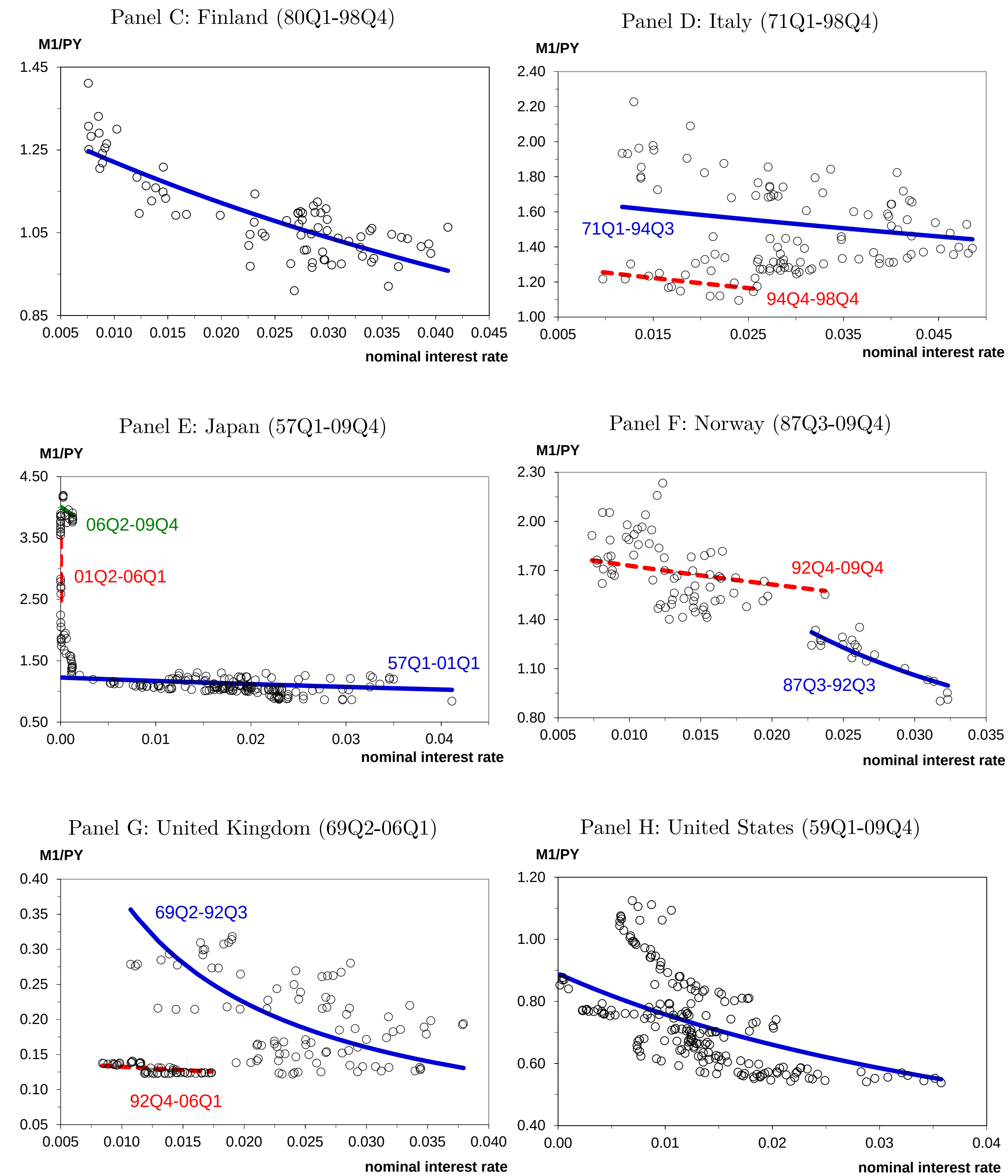
Table 1: Money demand structural breaks dates and calibrated parameters.

Country	Quarters	Break Explanation	ε_m	σ	A	R^2
Austria	67Q1-98Q4	No break	-0.248	0.09	1.17	0.26
Canada	57Q1-82Q3	M1 target end	-0.087	0.33	1.68	0.27
	82Q4-08Q4		-0.402	0.05	0.78	0.66
Finland	80Q1-98Q4	No break	-0.212	0.18	0.66	0.70
Italy	71Q1-94Q3	CB Independence	-0.141	0.38	0.40	0.14
	94Q4-98Q4		-0.113	0.30	0.61	0.13
Japan	57Q1-01Q1	QE start	-0.089	0.33	0.65	0.24
	01Q2-06Q1	QE end	-0.103	0.00	0.28	0.54
	06Q2-09Q4		-0.024	0.06	0.22	0.33
Norway	87Q3-92Q3	Krone devaluation	-0.812	0.01	0.16	0.79
	92Q4-09Q4		-0.110	0.21	0.43	0.17
UK	69Q2-92Q3	ERM crisis	-1.219	0.01	0.89	0.21
	92Q4-06Q1		-0.096	0.24	6.86	0.42
US	59Q1-09Q4	No break	-0.191	0.11	1.07	0.37

Notes: ε_m is the estimated interest elasticity of money demand. For the UK, M0 is used as the money supply measure, instead of M1. Structural breaks are identified conducting Chow (1960) tests on the regression for money demand specified in Goldfeld and Sichel (1990). No evidence of structural breaks is found for Austria, Finland and the US. For Canada, Italy, Japan and Norway the Chow test is significant at the 1% level and for the UK at the 5% level. The exact value of σ for Japan in the period 01Q2-06Q1 is 0.0002.

Figure 1: Money Demand with Fitted Model and Structural Breaks





Notes for Figure 1: circles identify empirical money demand M/PY against the nominal interest rate for each quarter in the sample period. The solid lines identify the calibrated money demand. Different subperiods are identified when structural breaks in money demand occur.

For each country considered, I then recalibrate the parameters σ and A for the entire period as the weighted average of σ and A for the subperiods listed in Table 1. This allows me to pin down parameter values for the full period while still accounting for how σ and A changed over time. The parameter values, which are listed in Table 3, are then used to quantify the welfare cost of inflation for the representative agent. The definition is standard and it follows the one in Lucas (2000). Thus, it should be interpreted as the percentage adjustment in consumption (in both DM and CM) the representative agent would require in order to be indifferent between a steady state with gross inflation rate π and a lower inflation rate $z \in [\beta, \pi)$. Fixing π, equilibrium ex-ante welfare is:

$$(1-\beta)V_\pi = \frac{\sigma}{2}[u(c_\pi) - \phi(c_\pi)] + U(q^*) - q^* \tag{5}$$

If we reduce π to z and adjust consumption in both markets by the proportion $\bar{\Delta}_z$, then:

$$(1-\beta)V_z = \frac{\sigma}{2}[u(\bar{\Delta}_z c_z) - \phi(c_z)] + U(\bar{\Delta}_z q^*) - q^* \tag{6}$$

The welfare cost of having π instead of z inflation is the value $\Delta_z = 1 - \bar{\Delta}_z$ such that $V_\pi = V_z$, where V_π and V_z are defined in (5) and (6) respectively. If $\Delta_z > 0$, agents are indifferent between π inflation, or alternatively z inflation and consumption reduced by Δ_z percent. Values for the different countries are shown in Table 3.

3.1 Heterogeneity

In order to measure the redistributive effects of inflation I proceed as follows. First, I fix the common preference parameters (η, β, b, A) to the values calibrated for the representative-agent model. Second, I fix the average trading friction to the value σ from the representative-agent model and then consider mean preserving spreads such that $\rho\sigma_H + (1-\rho)\sigma_L = \sigma$ for some given value ρ. Third, I use LWS microdata[9] and pin down the empirical ratio of

[9]For the countries where LWS microdata are available for more than one year, data should be interpreted as averages across all years available. Data availability is as follows: Austria (2002), Canada (1999), Finland (1994 and 1998), Italy (2002 and 2004), Japan (2003), Norway (2002), United Kingdom (2000), United States (1994, 1997, 2000, 2003 and 2006).

liquidity holdings over total financial assets for different households' income quintiles in the countries considered. I find that such ratio decreases with income, as shown in Table 2. Fourth, I measure the empirical ratio of liquidity holdings over total financial assets in the economy held by the bottom 50% of the income distribution and match it to its theoretical counterpart $\mu_L = \frac{(1-\rho)m_L}{\rho b_H + (1-\rho)m_L}$. Associating $j = H$ to the top 5 income deciles one gets $\rho = 0.5$. Fifth, I find the values for σ_L and σ_H by matching the theoretical liquidity share μ_L to its empirical counterpart and using the mean preserving spread $\rho\sigma_H + (1-\rho)\sigma_L = \sigma$ and the expressions for $m_L = c_L$ and $c_H = b_H$ in (3) and (4).

It is worth emphasizing that cross-country comparisons of wealth have been unreliable in the past since estimates of personal wealth are sensitive to the choice of the data source, the definition of wealth and accounting conventions, all of which vary across countries. I overcome this limitation by using microdata from the *Luxembourg Wealth Study*, an international project that has collected household microdatabases from a sample of OECD countries, and has standardized the wealth concept and sampling frame. Specifically, the LWS reports harmonized data for household deposit accounts (DA),[10] which I use as a measure of liquidity holdings, total financial assets (TFA1)[11] and disposable income (LIS_DPI).[12] Table 2 reports the calculations for the empirical ratio of deposit accounts over total financial assets for different households' income quintiles.

As reported in Table 2, the share of liquidity (deposit accounts) over total financial assets decreases with income for all countries considered, even though its magnitude varies across countries. This implies that the model in Boel and Camera (2009), in which rich agents prefer to hold inflation-protected assets over liquid ones (cash), describes a feature of wealth distribution common across all countries I am analyzing. Japan stands out as an outlier, since the ratio of deposit accounts over total financial assets stays pretty much constant

[10] Deposit accounts (DA) include transaction accounts, savings accounts and term deposits or CDs (i.e. bank deposits, current account deposits, bank savings, postal bank deposits, etc.).

[11] Total financial assets (TFA1) are the sum of deposit accounts, bonds, stocks and mutual funds.

[12] I use data on disposable income instead of gross income due to data availability, since the LWS does not provide data on gross income for Austria and Italy.

(although it is still lower for the top two income quintiles than for the lower six) across income quintiles for Japanese households. This should come as no surprise, since it is well documented that the average Japanese household has a financial balance sheet that is far more conservative than that of the representative household in other industrialized countries, as reported in Nakagawa and Yasui (2009).

Table 2: Deposit accounts' share of total financial assets by disposable income quintiles.

Country	Lowest 20%	Second 20%	Third 20%	Fourth 20%	Highest 20%
Austria	0.86	0.82	0.78	0.72	0.66
Canada	0.54	0.52	0.47	0.39	0.21
Finland	0.82	0.73	0.73	0.66	0.38
Italy	0.82	0.75	0.66	0.58	0.43
Japan	0.89	0.87	0.89	0.82	0.84
Norway	0.85	0.81	0.75	0.66	0.42
UK	0.62	0.569	0.558	0.486	0.467
US	0.40	0.29	0.27	0.17	0.11

Notes: Deposit accounts (DA) include transaction accounts, savings accounts and term deposits or CDs. Total financial assets (TFA1) are the sum of deposit accounts, bonds, stocks and mutual funds. Data availability is as follows: Austria (2002), Canada (1999), Finland (1994 and 1998), Italy (2002 and 2004), Japan (2003), Norway (2002), United Kingdom (2000), United States (1994, 1997, 2000, 2003 and 2006).

Once I have the calibrated the parameters σ_L and σ_H for all countries, using equations (3) and (4) I can calculate the welfare costs of inflation for type H and type L agents. I proceed as follows. Let $c_{j\pi}$ and $m_{j\pi}$ denote equilibrium consumption and money holdings for an agent of type j given the gross inflation rate π. Ex-ante equilibrium welfare for type L agents is:

$$(1-\beta)V_{L\pi} = \frac{\sigma_L}{2}[u(c_{L\pi}) - c_{L\pi}] + U(q^*) - q^* - \rho(\pi - 1)m_{L\pi} \tag{7}$$

where q^* solves $U'(q^*) = 1$. Ex-ante welfare for type H agents instead is:

$$(1-\beta)V_{H\pi} = \frac{\sigma_H}{2}[u(c_{H\pi}) - c_{H\pi}] + U(q^*) - q^* + (\pi - 1)(1-\rho)m_{L\pi} \tag{8}$$

If we reduce π to z and adjust consumption in both markets by the proportion $\bar{\Delta}_{jz}$, then:

$$(1-\beta)V_{Lz} = \frac{\sigma_L}{2}[u(\bar{\Delta}_{Lz}c_{Lz}) - c_{Lz}] + U(\bar{\Delta}_{Lz}q^*) - q^* - \rho(z-1)m_{Lz} \tag{9}$$

Ex-ante welfare for type H agents instead is:

$$(1-\beta)V_{Hz} = \frac{\sigma_H}{2}[u(\bar{\Delta}_{Hz}c_{Hz}) - c_{Hz}] + U(\bar{\Delta}_{Hz}q^*) - q^* + (z-1)(1-\rho)m_{Lz} \tag{10}$$

The welfare cost of having π instead of z inflation for a type j agent is the value $\Delta_{jz} = 1-\bar{\Delta}_{jz}$ such that $V_{j\pi} = V_{jz}$, where $V_{j\pi}$ and V_{jz} for $j = H, L$ are defined in (7), (8), (9) and (10). If $\Delta_{jz} > 0$, agents are indifferent between π inflation, or alternatively z inflation and consumption reduced by Δ_{jz} percent. That is, inflation is welfare reducing if $\Delta_{jz} > 0$, while it is welfare increasing if $\Delta_{jz} < 0$ instead. Table 3 reports the results for different countries.

I find that inflation acts as a regressive tax in all countries considered, so that consumption-rich agents benefit from inflation whereas poor ones suffer from it. The magnitude of such redistributive effects, however, varies across countries and depends not only on the distribution of financial wealth, but also, and importantly, on the shape of money demand. Specifically, a higher and less elastic money demand curve leads to a more regressive impact of inflation. For example, one would expect inflation's regressive effects to be stronger in the United States, where financial wealth is more unequally distributed, compared to Japan, where the composition of financial portfolios remains relatively constant along the income distribution. Instead, I find that such impact is less severe in the United States than in Japan. That is because money demand has steepened and shifted upward over time in Japan due to QE polices.

Table 3: Calibrated parameters and welfare costs of inflation.

Country	i	ε_m	σ	A	μ_L	σ_L	σ_H	Welfare Cost Rep. Agent	Welfare Cost Type L	Welfare Cost Type H
Austria	1.48	-0.25	0.09	1.17	21.07	0.016	0.169	0.43	-0.18	0.60
Canada	1.54	-0.14	0.19	1.22	10.62	0.004	0.376	0.28	-0.05	0.22
Finland	2.45	-0.21	0.18	0.66	21.80	0.019	0.341	0.50	-0.31	1.13
Italy	2.90	-0.14	0.36	0.43	15.18	0.012	0.708	0.39	-0.23	1.38
Japan	1.24	-0.08	0.28	0.58	30.79	0.019	0.541	0.39	-0.31	1.30
Norway	1.62	-0.17	0.16	0.37	17.82	0.009	0.311	0.89	-0.26	1.29
UK	2.03	-0.29	0.10	3.07	15.38	0.009	0.912	0.16	-0.04	0.16
US	1.30	-0.19	0.11	1.07	0.55	0.000	0.220	0.43	-0.00	0.02

Notes: the net nominal interest rate (i) is in percentage points on a quarterly basis; σ and A are calculated as the weighted average of their counterparts for the subperiods listed in Table 1 and ε_m is the corresponding interest elasticity of money demand; μ_L is the the share of liquid assets (DA) over total financial assets in the economy held by the bottom 50% of the income distribution in percentage points. For the calibration exercise, type H and L are interpreted as households belonging to the highest 50% and the lowest 50% of the income distribution respectively, so that $\rho = 0.5$. Welfare costs are for 10% annual inflation relative to 0% inflation in percentage points. The exact values of σ_L and the welfare cost of inflation for type L agents in the US are 0.0002 and 0.0004 respectively.

This result depends on the interaction between the parameters A and σ. A higher money demand implies a lower value for A, and thus a higher weight placed upon the monetary DM trade relative to the CM one. In turn, a higher money demand induces a higher welfare cost of inflation, since the latter is defined as the area under the money demand curve that is lost as inflation increases. Similarly, a lower interest elasticity of money demand implies a higher value for the average trading friction σ and thus a higher relative weight on the monetary DM trade than the CM one. In turn, a less elastic money demand curve implies a higher welfare cost of inflation. Since this burden falls more heavily upon consumption-poor agents who hold more liquid and fewer inflation-protected portfolios, there is a direct link between the shape of money demand and the regressive effects of inflation.

4 Final remarks

I quantify the redistributive effects of inflation in a sample of OECD countries by calibrating the microfounded model in Boel and Camera (2009). In order to do so, I address two quantitative issues. First, I pin down money demand rigorously by accounting for the possibility of policy breaks. I show that this approach improves the quality of the fit when compared to the representative-agent study in Boel and Camera (2011), where the model actually failed to fit the data for some countries. Second, I account for differences in wealth distribution across countries by using harmonized microdata from the *Luxembourg Wealth Study*. For all countries considered, I find that the share of household financial wealth held in liquidity decreases with income. There are, however, significant cross-country differences in terms of the magnitude of that share.

Two main results emerge from this study. First, in all countries considered inflation acts as a regressive tax. Second, the magnitude of inflation's redistributive effects differs across countries and it depends not only on wealth distribution but also on the shape of the money demand curve. Specifically, a higher and less elastic money demand leads to more pronounced regressive effects. Therefore, such effects are not necessarily stronger in a country with a more unequal wealth distribution.

The analysis also raises questions. In particular, one must wonder if the direction of inflation's redistributive effects may depend also on the nature of the alternative asset considered and thus if results may change in an economy with real assets or private credit. The ongoing work in Boel, Díaz and Finocchiaro (2016) investigates this issue in a microfounded model of money.

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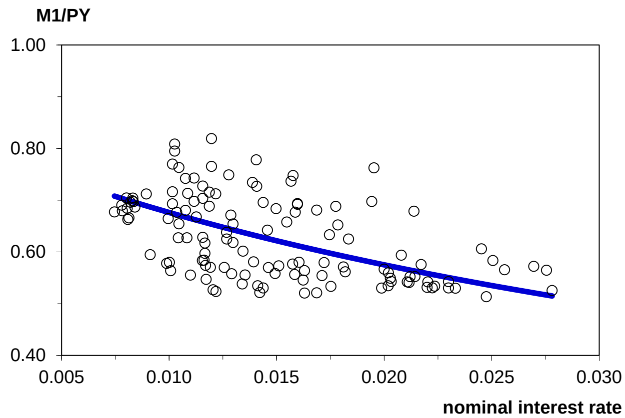
Appendix

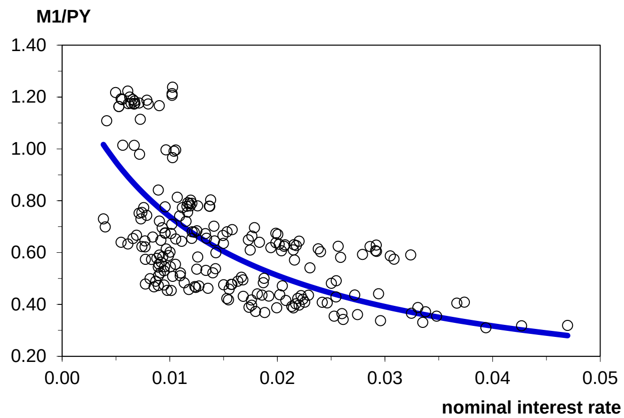
A1. Money demand fit without structural breaks

Figure A1: Money Demand with Fitted Model without Structural Breaks

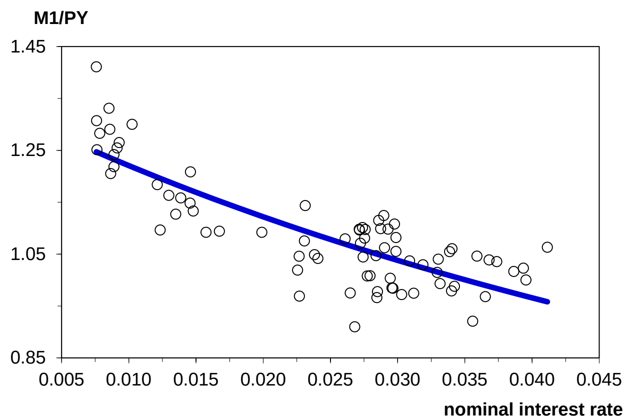
Panel A: Austria (67Q1-98Q4)



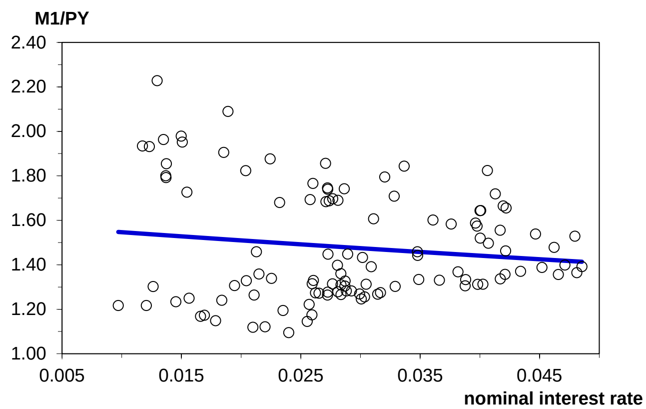
Panel B: Canada (57Q1-08Q4)



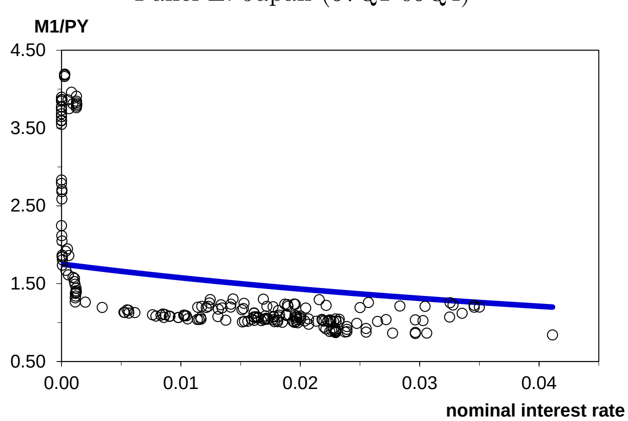
Panel C: Finland (80Q1-98Q4)



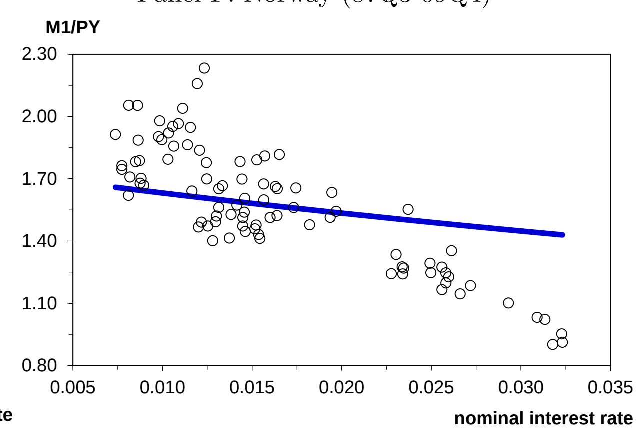
Panel D: Italy (71Q1-98Q4)



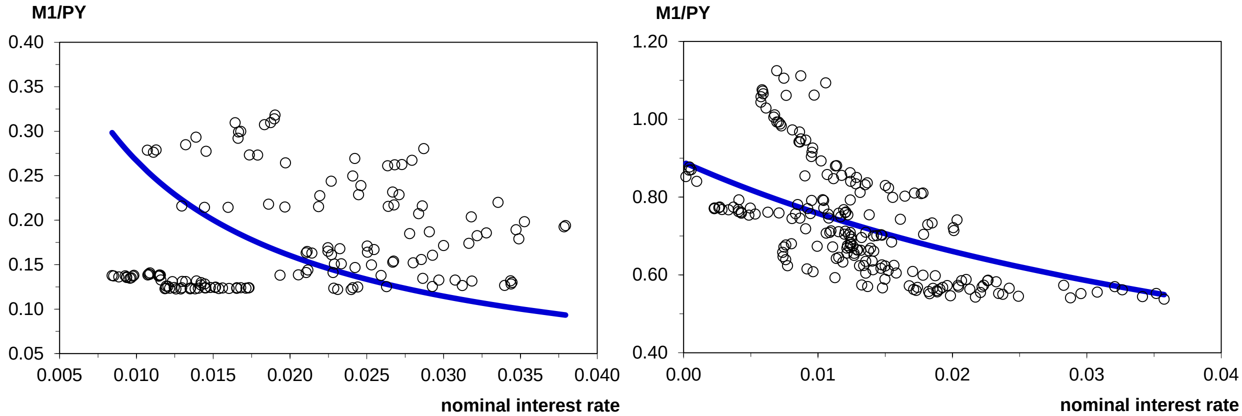
Panel E: Japan (57Q1-09Q4)



Panel F: Norway (87Q3-09Q4)



Panel G: United Kingdom (69Q2-06Q1) Panel H: United States (59Q1-09Q4)



Notes for Figure A1: for each country, circles identify empirical money demand M/PY against the nominal interest rate for each quarter in the sample period. The solid lines identify the calibrated money demand.

Table A1: Calibrated parameters and money demand fit (no structural breaks).

Country	Quarters	ε_m	σ	A	R^2	Welfare Cost
Austria	67Q1-98Q4	-0.248	0.09	1.17	0.26	0.43
Canada	57Q1-08Q4	-0.547	0.02	0.74	0.42	0.69
Finland	80Q1-98Q4	-0.212	0.18	0.66	0.70	0.50
Italy	71Q1-98Q4	-0.106	0.49	0.39	0.02	0.32
Japan	57Q1-09Q4	-0.151	0.15	0.49	0.20	0.74
Norway	87Q3-09Q4	-0.121	0.24	0.46	0.32	0.54
UK	69Q2-06Q1	-0.998	0.01	1.24	-1.23	0.30
US	59Q1-09Q4	-0.191	0.11	1.07	0.37	0.43

Notes: ε_m is the estimated interest elasticity of money demand. For the UK, M0 was used as the money supply measure, instead of M1. Note that a negative R^2 (UK) is possible since the model is non linear. Welfare costs are for 10% annual inflation relative to 0% inflation in percentage terms.

A2. Data sources

Data for deposit accounts (DA), total financial assets (TFA1) and disposable income (DPIW) are from the *Luxembourg Wealth Study.* Data for money supply, interest rate, price deflator and nominal GDP are from the *International Financial Statistics* unless otherwise noted. GDP and money supply are in local currencies.

Austria (1967Q1-1998Q4). Money supply: M1 (12234); interest rate: money market rate (12260B); price deflator: GDP deflator (12299BIP); output: nominal GDP, sa (12299B).

Canada (1957Q1-2008Q4). Money supply: M1 (15634); interest rate: treasury bill rate (15660C); price deflator: GDP deflator (15699BIR); output: nominal GDP, sa (15699B).

Finland (1980Q1-1998Q4). Money supply: M1 (OECD); interest rate: money market rate (17260B); price deflator: GDP deflator (17299BIP); output: nominal GDP (17299BIP).

Italy (1971Q1-1998Q4). Money supply: Money supply: M1 (13634); interest rate: money market rate (13660B), price deflator: CPI (13664), output: nominal GDP (13699B.C).

Japan (1957Q1-2009Q4). Money supply: M1, sa (IFS, National Definition) (15859MAC); interest rate: money market rate (15860B); price deflator: GDP deflator (15899BIR); output: nominal GDP, sa (15899B.C).

Norway (1987Q3-2009Q4). Money supply: M1 (14234); interest rate: government bond yield (14261), price deflator: CPI (14264); output: nominal GDP (14299B).

United Kingdom (1969Q2-2006Q1). Money Supply: break-adjusted M0, Bank of England (LPMVUBNI); interest rate: treasury bill rate (11260C); price deflator: GDP deflator (11299BIR); output: nominal GDP, sa (11299B.C).

United States (1959Q1-2009Q4). Money supply: sweep-adjusted M1 (M1S from sweepmeasures.com, Cynamon et al., 2006); interest rate: treasury bill rate (11160C); price deflator: GDP deflator (11199BIR); output: nominal GDP, sa (11199B).