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THE WELFARE COST OF INFLATION IN OECD COUNTRIES

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The welfare cost of anticipated inflation is quantified in a matching model of money calibrated to 23 different OECD countries for several sample periods. In most economies, in the common period 1978–1998, a representative agent would give up only a fraction of 1% of consumption to avoid 10% inflation. The welfare cost of inflation varies across countries, from a fraction of 0.1% in Japan, to more than 2% in Australia, reaching 6% with bargaining. The model fits money demand data of several countries poorly, however. The fit generally improves with longer sample periods. The results are fairly robust to variations in choice of calibrated parameters and calibration targets.

Keywords: Money, Friedman Rule, Trade Frictions

1. INTRODUCTION

There is a sizable literature on the social welfare cost of fully anticipated inflation for monetary models calibrated to the U.S. economy. The typical finding is that anticipated inflation does not have a quantitatively large impact on social welfare. A representative agent would typically be willing to give up less than 1% of consumption in order to move from an economy with 10% permanent inflation to one with no inflation. This quantitative assessment emerges from calibrations executed for various sample periods and with diverse types of models.[1] The literature has almost exclusively focused on the United States, with few exceptions [e.g., the studies of Canada in Chiu and Molico (2007b) and Serletis and Yavarib (2004)].

The present study takes a first step toward filling this gap by using an existing methodology and an existing monetary model to quantify the welfare cost of anticipated inflation in twenty-three of the thirty countries belonging to the Organization for Economic Co-operation and Development (OECD). The framework adopted is the representative-agent model of Lagos and Wright (2005), with sequential

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trade in two markets, the first of which displays random trade. We consider both price-taking and bargaining. In the first market that opens up in each period, trade and consumption opportunities are random, whereas in the second market, trade and consumption opportunities are deterministic. In the model, each country is a closed economy and fiat money is the only asset available to self-insure against idiosyncratic consumption risk. In stationary equilibrium, inflation is pinned down by the rate of growth of the money supply, which is controlled by a central bank by means of lump-sum transfers.

The model is calibrated to every OECD economy for which sufficient quarterly data exist for a common sample period spanning two decades, from 1978 to 1998.[2] For some countries the data available include periods spanning roughly the past four decades. The benchmark calibration technique adopted is similar to that employed in Lagos and Wright (2005), to facilitate comparisons with the findings in the original study. Alternative calibrations are also considered, partly drawing from Aruoba et al. (2007).

The benchmark analysis is executed for a quarterly specification of the model where preferences are unit elastic in both markets. Two parameters, the trade friction characterizing market one and marginal utility in market two, are calibrated to match one target represented by inverse velocity data. Countries are assumed homogeneous in the way agents discount future utility and rank consumption bought on markets where trade is random. In a subsequent calibration, the market-one trade parameter is fixed to a value common to all countries, whereas two preferences parameters (one for each market) are calibrated to inverse velocity for each country. Additional calibrations have been conducted to account for country-specific discount factors and different sample periods, and to match estimates of the interest elasticity of money demand and not only of inverse velocity.

Five main results emerge from this analysis. First, during the years 1978–1998, in the average OECD economy studied, 10% inflation is worth less than 0.5% of consumption, given price-taking behavior; only two countries exceed 1%. For the entire sample, the average welfare cost rises to about 0.5%, but only three countries are above 1%. Australia and Switzerland consistently display the highest welfare cost, even when the model is calibrated to different targets or different sample periods. Overall, such an impact of inflation is in line with that typically reported in studies of the U.S. economy. When buyers and sellers bargain—assuming equal bargaining power—the average welfare cost of inflation is much higher because an additional distortion is introduced; this is in line with the findings of Lagos and Wright (2005), Aruoba et al. (2007), and Craig and Rocheteau (2008).

Second, the welfare cost of inflation is heterogeneously distributed across the twenty three countries studied. With price taking, it ranges from less than 0.01% in Japan to 2.32% in Australia. With bargaining, it rises above 6%.

Third, the model does not fit equally well the money demand data of each country and sometimes it fits very poorly. In the benchmark calibration, the trade friction parameter—the probability of trade in market one, where money must be exchanged to trade—cannot be satisfactorily calibrated for some countries. In the economies for which this is the case, the fit of the theoretical money demand to the empirical money demand is poor.

Fourth, the model specification adopted allows a quantification of the lower bound on shares of internal trade relying on monetary exchange. The shares are different across countries, but below 12% for countries where the model fits the money-demand data reasonably well. This is in line with numbers reported in the literature: see Lagos and Wright (2005), Aruoba et al. (2007), and Boel and Camera (2009). In countries where the model fits the money demand data poorly, trade shares are much larger, between 40 and 90%.

Fifth, the fit of the model does not generally improve when the trading parameter is fixed to a value common to all countries (which minimizes trade frictions), using money demand data to identify two preferences' parameters, one for each market. Using the full sample available (i.e., considering uncommon samples) does increase the welfare cost of inflation on average by 0.2% points and improve the fit on average. Considering subsamples of the common sample period or subsamples of the full sample period does not lead to consistent improvements.

Given these findings, one could hypothesize that the heterogeneity in the welfare cost of inflation stems from countries' differences in the shares of trade carried out with money, greater shares being associated with greater costs. In fact, even excluding economies where the model fits the data poorly, the welfare cost of inflation is positively associated with the calibrated values of the trade friction parameter. The welfare cost tends to be higher in economies where trade opportunities are less frequent. An interpretation is that with greater trade opportunities in the first market there is less of a chance that money sits idle, so the inflation tax has less of a bite. Agents hold higher real balances and consume more, so their marginal valuation for consumption is less than in an economy with fewer frequent random trade opportunities (more frictions). A poorly fitting model also tends to generate quantitatively smaller social costs of inflation.

These findings are fairly robust to analyses conducted by considering subsamples of the full sample periods, calibration targets, or preference specifications. For example, with price taking, the average welfare cost remains below 1% when the model is calibrated to money demand data each spanning half of the common sample period, or subsets of years before and after 1973. The ranking of countries, in terms of their welfare cost of inflation, does not vary much either. Of course, the calibrated parameters and the fit of the model to money demand data do vary from country to country with sample periods. Using all available data generally supports a better fit. The quantitative results on welfare costs do not vary much either when cross-country differences in rates of time preference are accounted for, or when the model's parameters are calibrated to match two money demand targets, instead of one.

The paper proceeds as follows. Section 2 presents the model. Section 3 studies stationary monetary equilibrium. Section 4 discusses data and calibration procedure, and reports the quantitative findings. Section 5 concludes.

2. THE MODEL

Consider the representative agent model in Lagos and Wright (2005) with two markets, denoted one and two. The key notation is as follows. The variables $c \geq 0$ and $q \geq 0$ denote individual consumption in markets one and two. Preferences in market two are $U(q) - x$, where x denotes production. Preferences in market one are $u(c)$ for a consumer, and $\phi(y)$ is disutility from producing y goods. The functions u, ϕ, and U are twice continuously differentiable and strictly increasing, with $u'' < 0$, $\phi' \geq 0$, $U'' < 0$, and $\phi(0) = 0$. Let $\alpha \in (0, 1]$ denote the probability of trading in market one, where buying or selling is equally probable, and $\beta \in (0, 1)$ denotes the discount factor.

In stationary equilibrium the gross rate of inflation equals the gross growth rate of the money supply, denoted π. Suppose buyers and sellers are matched in pairs in market one. Suppose also that every buyer and seller bargain on the price and quantity of goods to be delivered using a Nash bargaining protocol with threat points given by their continuation payoffs if no trade takes place. Let $\theta \in (0, 1]$ denote the buyer's bargaining power, and $1 - \theta$ the seller's. In order to have well-defined continuation payoffs as threat points, assume $u(0) = 0$. It is well known that in this case consumption in market one satisfies the Euler equation

$$i = \frac{\alpha}{2}\left[\frac{u'(c)}{\Phi'(c)} - 1\right], \tag{1}$$

where $i = \frac{\pi}{\beta} - 1$ denotes the net nominal interest rate. Also, we have defined (omitting the argument c from the functions ϕ and u and their derivatives)

$$\Phi'(c) = \frac{u'\phi'[\theta u' + (1-\theta)\phi'] + \theta(1-\theta)(u-\phi)(u'\phi'' - \phi' u'')}{[\theta u' + (1-\theta)\phi']^2}, \tag{2}$$

and we have imposed market clearing $y = c$. For details see Lagos and Wright [(2005), p. 469, equation (8), p. 470, equation (11), and p. 474, equation (22)].

Expression (1) defines one equation in the unknown c, which can be determined (not always uniquely, if $\theta < 1$) as a function of the model's parameters and the policy parameter i. Policy affects the return of money, the choice of real balances, and therefore market one consumption.

When $\theta = 1$ the model is equivalent to one in which buyers and sellers are price-takers. Here $\Phi'(c) = \phi'(c)$, equilibrium consumption in market one satisfies the simple expression

$$i = \frac{\alpha}{2}\left[\frac{u'(c)}{\phi'(c)} - 1\right], \tag{3}$$

and c is uniquely determined as a function of the model's parameters and the policy parameter i. It is clear that consumption is not the same under price taking and bargaining. With bargaining ($\theta < 1$), buyers who have less-than-full bargaining power will carry less money than in the price-taking case ($\theta = 1$), in order to

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avoid being "held up" by a seller. This is of course a distortion in addition to that generated by nonzero nominal interest rates. See Lagos and Wright (2005).

Let c_π denote equilibrium consumption given π. As usual, equilibrium ex ante welfare is defined by $(1-\beta)V_\pi$, with

$$(1-\beta)V_\pi = \frac{\alpha}{2}[u(c_\pi) - \phi(c_\pi)] + U(q^*) - q^*, \qquad \textbf{(4)}$$

where q^* is the unique solution to $U'(q) = 1$.

The welfare cost of inflation for an agent is the percentage adjustment in consumption of *both* markets that leaves the agent indifferent between some inflation $\pi > \beta$ and a lower rate $z \geq \beta$. Given that consumption is adjusted by the proportion $\bar{\Delta}_z$ (income, expenditure, and hours worked are unaltered), use (4) to define adjusted ex ante welfare $\bar{V}_z$ by

$$(1-\beta)\bar{V}_z = \frac{\alpha}{2}[u(\bar{\Delta}_z c_z) - \phi(y_z)] + U(\bar{\Delta}_z q^*) - q^*.$$

For a representative agent, the welfare cost of π instead of z inflation is the compensating variation value $\Delta_z = 1 - \bar{\Delta}_z$ that satisfies $V_\pi = \bar{V}_z$. If $\Delta_z > 0$, then the agent is indifferent between π inflation or z inflation with consumption reduced by Δ_z percent. The analysis that follows focuses on the welfare cost of 10% inflation as opposed to no inflation, unless otherwise specified.

Quarterly data coming either from the International Monetary Fund's *International Financial Statistics* or from the OECD data bank are used to study twenty-three OECD countries. The data include nominal Gross Domestic Product (nsa), GDP deflator (2000 = 100), Consumer Price Index (2000 = 100), and money supply (M1 nsa). The nominal interest rate i is the money market interest rate corresponding to the Treasury Bill rate (percent per annum), reported in the *International Financial Statistics*, unless otherwise noted.[3] Table 1 displays summary statistics for the full sample period as well as the common sample period 1978:1–1998:4. It also displays the interest elasticity of M1, which we have estimated using a standard approach, for the entire sample period (used in some calibration procedure).[4]

3. CALIBRATION OF THE MODEL

In this section we discuss how the model is calibrated for the price-taking case, i.e., $\theta = 1$, as well as for the bargaining case, i.e., $\theta \in (0, 1)$. A quarterly model specification is used and standard functional forms are selected; e.g., see Lagos and Wright (2005) or Aruoba et al. (2007).[5] In particular, let

$$u(c; a) = \frac{(c + b_0)^{1-a} - b_1^{1-a}}{1-a},$$

let $\phi(y) = y^\delta/\delta$, and let $U(q) = A\ln(q)$, so that $q^* = A$. For each country, the vector of parameters to identify is $(\alpha, \beta, \delta, a, b_0, b_1, A)$.

TABLE 1. Relevant statistics for the calibration

	Full sample			1978–1998			
Country: years	i	$\pi - 1$	ε_i	β	i	$\pi - 1$	ε_i
AT: 1967–1998	1.52	1.01	−0.295	0.992	1.60	0.80	−0.204
AU: 1970–2004	2.11	1.55	−0.462	0.988	2.52	1.41	−0.487
BE: 1980–1998	1.85	1.85	−0.041	0.988	1.85	0.87	−0.041
CA: 1960–2003	1.73	1.08	−0.774	0.989	2.27	1.16	−1.436
CH: 1970–2004	1.14	0.78	−0.863	0.995	1.15	0.70	−0.815
DE: 1960–1998	1.37	0.91	−0.412	0.993	1.51	0.75	−0.253
DK*: 1977–2004	2.26	1.11	−0.073	0.986	2.59	1.18	−0.092
ES: 1974–1998	3.06	2.36	−0.147	0.988	3.18	1.94	−0.640
FI: 1980–1998	2.56	2.56	−0.268	0.986	2.56	1.16	−0.268
FR: 1978–1998	2.22	2.22	−0.236	0.990	2.22	1.25	−0.236
GR*: 1974–1998	3.84	3.66	−0.279	0.996	4.13	3.72	−0.010
IE: 1960–1998	2.56	1.75	−2.250	0.988	2.74	1.53	−2.702
IT: 1971–1998	3.05	2.31	−0.180	0.989	3.20	2.01	−0.256
JP: 1973–2004	1.05	0.74	−0.020	0.993	1.18	0.53	−0.104
MX: 1981–2003	9.12	10.80	−0.596	0.988	10.80	9.61	−0.596
NL: 1977–1998	1.59	0.71	−0.112	0.991	1.63	0.68	−0.120
NO*: 1961–2003	1.95	1.34	−0.285	0.989	2.48	1.35	−0.311
NZ: 1966–2004	2.23	1.75	−0.464	0.990	2.82	1.82	−0.122
PT: 1977–1998	3.54	3.21	−0.480	0.995	3.59	3.07	−0.438
SE: 1980–2004	2.14	2.54	−0.175	0.988	2.54	1.38	−0.148
SK: 1977–2004	3.01	1.70	−0.450	0.985	3.47	1.94	−2.138
UK*: 1970–2004	2.14	1.72	−0.508	0.991	2.43	1.50	−0.043
US: 1947–2006	1.18	0.94	−0.129	0.994	1.78	1.17	−0.413

Notes: The values for net nominal interest rates (i) and net inflation rates ($\pi - 1$) are in percentage points on a quarterly basis; ε_i is the estimated interest elasticity of money demand; β is the quarterly discount factor. In all tables, the asterisk identifies a country for which currency or M0 was used as the money supply measure, instead of M1; 1978–1998 is the common sample period (for BE, FI, MX, SE the starting date is slightly different as indicated in the first column). Inflation is measured using CPI data with the exception of Germany, for which GDP deflator data were used. Data for GR, IE, and NZ are annual.

There are several possible ways to proceed in calibrating the model. For clarity, we start with a benchmark calibration that closely follows earlier calibrations in this same class of models. Then we perform additional calibrations. In the additional analyses we vary the parameters to be calibrated, the number of targets, and the sample periods.

The benchmark calibration is as follows. We presume that agents in every country share the same preferences over current consumption and labor effort in market one, and have the same attitudes toward risk. Buyers in each country have the same bargaining power θ, also. Countries may only differ in trade frictions, pinned down by the parameter $\alpha \in (0, 1]$, and market two consumption, determined by the parameter $A > 0$.

In this benchmark calibration we follow Lagos and Wright (2005, p. 475), setting $b_0 = b_1 = 0.00001$ and $\delta = 1$. This implies $u(0) = 0$ and identically linear disutility of labor in both markets. Note that with $\delta = 1$ we have $\phi'(c) = 1$ and $\phi''(c) = 0$ for all c; hence (2) becomes

$$\Phi'(c) := \frac{\theta(c+b_0)^{-a} + (1-\theta) + \theta(1-\theta)\left[\dfrac{(c+b_0)^{1-a} - b_1}{1-a} - c\right] a(c+b_0)^{-1}}{(c+b_0)^a\left[\theta(c+b_0)^{-a} + (1-\theta)\right]^2}. \quad (5)$$

In addition, set $1 - a = 0.00001$, so that $u'(c) \approx c^{-1}$, $u''(c) \approx -c^{-2}$; i.e., preferences are approximately unit elastic in both markets.

This calibration is chosen as a benchmark for several reasons. First, the parameterization of market one preferences facilitates comparisons with quantitative studies for the United States based on the same model, as the published studies often assume unit elastic preferences and linear disutility. Second, although δ could be calibrated to match labor elasticity measures, we could find data on labor elasticities for only a few countries. Third, calibrating δ and a to values different than one has the implication that markets one and two are intrinsically different, but these differences are unobservable in the data. Hence, remaining agnostic about possible differences in the two markets seems a good starting point. This being said, we have also carried out an analysis for an alternative calibration strategy that pins down country-specific pairs (a, A), while fixing the trade friction $\alpha = 1$ in all countries.

The analysis is conducted under the conjecture that the rate of time preference is homogeneous across countries, setting $\beta = 0.994$ (quarterly) as in the United States. We also calibrate the model to country-specific discount factors, obtained by subtracting the average CPI inflation rate $\pi - 1$ from the average short-term nominal interest rate i, where i is the average nominal annualized yield on a standardized money market instrument. Table 1 reports the discount factor values that result from applying this procedure. We next discuss what we match to pin down the desired parameters.

Under bargaining, the variable c can be expressed as a function of i using the Euler equation (1), with $\Phi'(c)$ given by (5). The Euler equation generalizes the model to include the entire spectrum of bargaining powers, including price taking. With $\theta < 1$, prices are nonlinear in the quantity purchased and a closed-form solution for c is no longer possible in general. In addition, multiple solutions may be possible. We follow Lagos and Wright (2005) and set $\theta = 0.5$ in each country in the benchmark calibration. That is, buyers and sellers have equal bargaining powers.[6]

The trade friction parameter α and the preference parameter A are then calibrated separately for each country by fitting the theoretical money demand to the empirical money demand data $L = M/PY$. This means that in the benchmark calibration two parameters are matched to one target.[7] Here P is the nominal price

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level, M is the nominal money supply, and Y is real output. For the empirical counterpart of L, nominal output PY is measured by nominal GDP. The value L can be interpreted as money demand because real balances M/P are proportional to real spending Y with a factor of proportionality $L(i)$ that depends on the nominal interest rate i; see Lucas (2000).

As reported in Lagos and Wright [(2005), p. 476, equation (24)], the model implies that the money demand function can be expressed as

$$L = L(i) := \frac{\Phi(c)}{\frac{\alpha}{2}\Phi(c) + A},$$

where

$$\Phi(c) := \frac{\theta u'(c)\phi(c) + (1-\theta)u(c)\phi'(c)}{\theta u'(c) + (1-\theta)\phi'(c)}. \tag{6}$$

Under price-taking, $\theta = 1$, the Euler equation (3) becomes $(c + b_0)^a c^{\delta-1} = \alpha/(\alpha + 2i)$. Hence, for b_0 close to zero, we can approximate the equilibrium c using a simple function of i and the model's parameters,

$$c = \left(\frac{\alpha}{\alpha + 2i}\right)^{\frac{1}{\delta+a-1}}. \tag{7}$$

This implies a simple money demand expression,

$$L = L(i) := \frac{1}{\alpha/2 + Ac^{-\delta}}, \tag{8}$$

where c is defined in (7). Tables 2–7 report the fitted parameter values α and A. Tables 2–7 also report results for the following additional calibrations performed. First, instead of fixing $a = 0.9999$ in each country and calibrating (α, A) to match inverse velocity $L(i)$, we fixed the trade friction $\alpha = 1$ in every country and pinned down a and A to match $L(i)$; i.e., we allowed preferences to be country-specific while minimizing trade frictions in each country. Second, we matched two parameters, either (α, A) or (a, A), to two different targets, interest elasticity of money demand and inverse velocity $L(i)$ (more on this later).

4. RESULTS

The main findings are reported in the next three sections, starting with a discussion of the fit of the model to the data. Subsequently, we discuss the share of monetary trade implied by the model and the welfare cost of inflation. Unless otherwise noted, welfare cost of inflation measures refer to 10% inflation versus 0%. The tables report results for the Friedman rule, also.

TABLE 2. Common and full sample results (price-taking, unit elastic preferences)

	Common sample						Full sample					
	Calibrated parameters				Welfare cost		Calibrated parameters				Welfare cost	
Country	α	A	R^2	μ	0%	FR	α	A	R^2	μ	0%	FR
AT	0.20	1.29	0.27	6.2	0.26	0.29	0.14	1.17	0.21	4.7	0.35	0.39
AU	0.04	0.23	0.68	3.9	2.32	2.86	0.03	0.20	0.61	3.3	2.61	3.31
BE	1.00	0.72	−0.13	40.2	0.08	0.09	1.00	0.72	−0.13	40.2	0.08	0.09
CA	0.22	2.75	0.19	3.2	0.12	0.13	0.05	1.65	0.58	0.9	0.35	0.43
CH	0.02	0.31	0.39	1.4	1.58	2.17	0.01	0.15	0.65	0.5	1.87	3.25
DE	0.14	1.06	0.24	5.1	0.38	0.43	0.14	1.12	0.17	4.9	0.37	0.42
DK*	1.00	8.12	−0.22	5.5	0.01	0.01	1.00	8.11	−0.22	5.6	0.01	0.01
ES	1.00	0.56	0.00	45.7	0.09	0.10	0.58	0.69	0.05	27.4	0.16	0.18
FI	0.19	0.65	0.69	10.2	0.49	0.55	0.19	0.65	0.69	10.2	0.49	0.55
FR	1.00	0.56	−0.12	46.3	0.09	0.10	1.00	0.56	−0.12	46.3	0.09	0.10
GR*	1.00	9.67	−0.03	3.7	0.13	0.15	0.56	7.96	0.23	2.2	0.23	0.26
IE	1.00	6.78	−0.40	5.7	0.19	0.21	0.10	1.90	0.22	0.8	1.19	1.57
IT	1.00	0.22	−0.05	67.8	0.14	0.15	0.79	0.28	0.01	56.9	0.18	0.20
JP	0.06	122.77	0.71	0.0	0.00	0.01	0.06	116.01	0.73	0.02	0.00	0.01
MX	0.17	1.72	0.71	2.1	0.22	0.25	0.22	1.96	0.75	3.0	0.16	0.18
NL	0.07	0.75	0.43	3.2	0.70	0.82	0.09	0.80	0.34	4.0	0.61	0.71
NO*	1.00	5.04	−0.03	8.6	0.02	0.02	0.04	2.19	0.17	0.4	0.27	0.33
NZ	0.66	7.30	0.50	3.3	0.23	0.26	0.18	4.35	0.68	1.0	0.57	0.70
PT	1.00	0.46	−0.02	50.4	0.10	0.11	1.00	0.44	0.00	51.8	0.11	0.12
SE	1.00	0.06	−0.01	89.0	0.18	0.19	1.00	0.06	−0.01	88.4	0.17	0.19
SK	1.00	0.54	−0.03	46.3	0.09	0.10	0.10	0.58	0.36	4.9	0.80	0.93
UK*	1.00	5.94	−0.07	7.4	0.02	0.02	1.00	5.07	−0.01	8.6	0.02	0.02
US	0.41	1.39	0.15	12.0	0.13	0.14	0.02	0.61	0.46	0.7	0.83	1.14

Notes: Welfare cost and μ are in percentage points; μ is output share traded on market 1; welfare costs are for 10% inflation relative to 0% inflation and the Friedman rule (FR).

4.1. The Fit of the Model to Money Demand Data

The model does not fit money demand data of every country studied equally well. Sometimes the model fails to fit or the fit is extremely poor. In the benchmark calibration, the model fails to fit when the trade friction parameter α cannot be satisfactorily calibrated. To see this, consider the fitted values α and A in Table 2 (shaded columns) referring to the common-sample, price-taking case (for bargaining see Table 3, shaded columns). By definition $\alpha \leq 1$ and such a constraint binds for twelve countries in the common sample period (thirteen with bargaining). In these cases, the model fails to fit. The fit of the calibrated model can be visually evaluated by considering Figures 1–23. The figures plot the empirical and theoretical money demand against the nominal interest rate i for each country. The continuous line represents the calibrated function $L(i)$.

As an additional way to judge the quality of fit of the model to the data, we report the R^2 statistic. Note that because the model is nonlinear, R^2 can be

TABLE 3. Common and full sample results (bargaining, unit-elastic preferences)

	Common sample						Full sample					
	Calibrated parameters				Welfare cost		Calibrated parameters				Welfare cost	
Country	α	A	R^2	μ	0%	FR	α	A	R^2	μ	0%	FR
AT	0.50	1.14	0.27	16.8	1.57	2.25	0.36	1.06	0.21	13.6	1.70	2.46
AU	0.14	0.22	0.66	18.7	6.08	9.03	0.12	0.20	0.59	17.2	6.43	9.65
BE	1.00	0.67	−0.40	41.6	1.94	2.75	1.00	0.67	−0.40	41.6	1.94	2.75
CA	0.59	2.58	0.19	9.5	0.77	1.11	0.16	1.67	0.57	3.7	1.06	1.58
CH	0.04	0.21	0.62	4.9	4.58	7.75	0.04	0.23	0.62	5.3	4.45	7.41
DE	0.36	0.96	0.24	14.6	1.85	2.68	0.35	1.01	0.17	13.9	1.77	2.56
DK*	1.00	7.50	−0.97	5.9	0.29	0.41	1.00	7.57	−1.21	5.9	0.28	0.40
ES	1.00	0.51	−0.07	48.0	2.26	3.20	1.00	0.48	0.05	49.6	2.33	3.30
FI	0.44	0.53	0.69	27.0	2.85	4.09	0.44	0.53	0.69	27.0	2.85	4.09
FR	1.00	0.52	−0.35	47.9	2.23	3.17	1.00	0.52	−0.35	47.9	2.23	3.17
GR*	1.00	6.62	−0.40	5.2	1.20	1.72	1.00	6.43	0.17	5.5	1.23	1.77
IE	1.00	5.20	−1.23	7.2	1.50	2.15	0.45	2.33	0.21	6.1	2.78	4.15
IT	1.00	0.20	−0.13	69.9	3.22	4.56	1.00	0.17	0.01	73.7	3.38	4.79
JP	0.19	123.94	0.70	0.1	0.02	0.02	0.20	119.01	0.68	0.1	0.02	0.02
MX	0.67	1.82	0.74	12.0	1.04	1.48	0.67	1.82	0.74	12.4	1.04	1.48
NL	0.21	0.70	0.42	11.1	2.40	3.53	0.25	0.73	0.33	12.7	2.33	3.40
NO*	1.00	4.66	−0.11	9.2	0.44	0.63	0.14	2.39	0.17	2.1	0.73	1.10
NZ	1.00	5.88	0.31	6.4	1.34	1.92	0.64	4.63	0.67	5.0	1.58	2.32
PT	1.00	0.41	−0.07	53.0	2.49	3.53	1.00	0.39	−0.02	54.3	2.55	3.62
SE	1.00	0.05	−0.03	89.8	4.07	5.75	1.00	0.06	−0.04	89.1	4.03	5.70
SK	1.00	0.49	−0.10	48.8	2.30	3.26	0.28	0.52	0.33	18.0	3.06	4.44
UK*	1.00	5.51	−0.20	7.9	0.38	0.54	1.00	4.74	−0.05	9.1	0.44	0.62
US	0.94	1.13	0.15	28.5	1.42	2.02	0.10	0.72	0.42	5.2	2.11	3.23

Notes: The values for welfare cost and μ are in percentage points; μ is market 1 output share; welfare costs are for 10% inflation relative to 0% inflation and the Friedman rule (FR). The analysis assumes equal bargaining power, $\theta = 0.5$, and unit-elastic preferences. The parameters (α, A) are calibrated to match $L(i)$.

negative, and it is not an uncontroversial measure of fit. This being said, consider Table 2. The correlation between α and R^2 is strongly negative in the common sample (−.84). In particular, when the constraint $\alpha \leq 1$ binds, the R^2 statistic is never positive. Twelve countries fit this pattern. These "poor fit" countries include all those for which currency is used instead of M1 (Denmark, Greece, Norway, and the United Kingdom). In the eleven remaining countries, instead, the implied R^2 ranges from 0.15 for the United States to 0.71 for Japan and Mexico. The analysis suggests that countries where the trade friction parameter α is calibrated to a small value display less good of a fit. A small value α is in line with results for similar models calibrated to U.S. data, e.g., Lagos and Wright (2005), Aruoba et al. (2007), and Boel and Camera (2009). A possible reason that α and the fit are negatively correlated is that, all else equal, larger α values increase market one consumption, and hence lift and flatten the curve $L(i)$.[8] This means that large

TABLE 4. Common sample results (additional calibrations with price-taking)

	Common trade friction $\alpha = 1$						Unit-elastic preferences, country-specific β	
	Calibrated parameters				Welfare cost		Welfare cost	
Country	a	A	R^2	μ	0%	FR	0%	FR
AT	0.02	0.91	0.26	8.0	0.47	0.55	0.24	0.26
AU	0.02	0.00	0.22	95.3	3.11	3.57	2.33	3.02
BE	>100	0.74	0.00	40.2	0.00	0.00	0.09	0.10
CA	0.24	2.43	0.18	14.6	0.12	0.13	0.12	0.14
CH	0.01	0.04	0.31	72.6	2.38	2.73	1.68	1.87
DE	0.12	0.66	0.23	36.8	0.54	0.58	0.35	0.37
DK*	>100	8.53	0.00	5.5	0.00	0.00	0.01	0.02
ES	1.79	0.57	0.01	45.7	0.05	0.06	0.10	0.12
FI	0.12	0.27	0.66	54.4	0.84	0.86	0.54	0.65
FR	>100	0.58	0.00	46.2	0.00	0.00	0.09	0.10
GR*	2.75	11.54	0.02	3.7	0.04	0.05	0.09	0.09
IE	>100	8.19	0.00	5.7	0.00	0.00	0.19	0.22
IT	>100	0.24	0.00	67.8	0.00	0.00	0.14	0.16
JP	0.09	126.41	0.67	0.3	0.01	0.01	0.00	0.00
MX	0.28	1.69	0.67	12.9	0.14	0.16	0.23	0.27
NL	0.06	0.37	0.39	44.9	1.05	1.44	0.69	0.80
NO*	>100	5.29	0.00	8.6	0.00	0.00	0.02	0.02
NZ	0.70	7.17	0.50	4.9	0.23	0.26	0.21	0.23
PT	>100	0.49	0.00	50.4	0.00	0.00	0.08	0.08
SE	>100	0.06	0.00	89.0	0.00	0.00	0.19	0.21
SK	>100	0.58	0.00	46.3	0.00	0.00	0.12	0.14
UK*	>100	6.21	0.00	7.4	0.00	0.00	0.01	0.02
US	0.36	1.11	0.15	29.1	0.16	0.17	0.11	0.12

Notes: Welfare cost and μ are in percentage points; μ is output share traded on market 1; welfare costs are for 10% inflation relative to 0% inflation and the Friedman rule (FR). We report >100 for calibrated a values that lie above that threshold. The last two columns (shaded) report welfare costs for the benchmark calibration in Table 2 with country-specific discount factors reported in Table 1.

values of α are calibrated for countries in which, fixing a sample period, high interest rates are (too) often associated with high money demand observations, i.e., countries in which the money demand function is not well-behaved, perhaps because of instability. It is not a surprise, then, that the model fits poorly countries where α is large.[9]

The fit of the model to the data is poorest for several European countries and South Korea, and especially good for Japan and Mexico (Table 2 and Figures 1–23). This result carries through to the bargaining case (Table 3).[10]

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TABLE 5. Full sample results (additional calibrations with price-taking)

	Common trade friction $\alpha = 1$						Unit elastic preferences, matching (α, A) to two targets					
	Calibrated parameters				Welfare cost		Calibrated parameters				Welfare cost	
Country	a	A	R^2	μ	0%	FR	α	A	R^2	μ	0%	FR
AT	0.12	0.76	0.21	33.7	0.49	0.52	0.07	1.03	0.11	2.4	0.52	0.61
AU	0.02	0.00	−0.02	97.4	3.11	3.52	0.05	0.24	0.59	5.2	2.18	2.65
BE	>100	0.74	0.00	40.2	0.00	0.00	0.87	0.77	−0.16	35.1	0.09	0.10
CA	0.07	1.40	0.55	18.1	0.42	0.46	0.01	0.74	0.09	0.2	0.51	0.79
CH	0.01	0.01	0.43	77.4	2.36	2.98	0.00	0.09	—	0.00	—	—
DE	0.11	0.72	0.16	35.6	0.52	0.55	0.04	0.85	−0.17	1.3	0.68	0.84
DK*	>100	8.46	0.00	5.6	0.00	0.00	0.58	8.07	−0.57	3.2	0.02	0.02
ES	0.49	0.49	0.05	47.3	0.19	0.21	0.35	0.75	0.02	16.7	0.25	0.28
FI	0.12	0.27	0.66	54.4	0.84	0.86	0.14	0.63	0.62	7.5	0.61	0.70
FR	>100	0.58	0.00	46.3	0.00	0.00	0.14	0.79	−2.01	6.5	0.49	0.56
GR*	0.67	8.09	0.23	4.0	0.21	0.24	0.80	8.75	0.22	3.2	0.17	0.19
IE	0.23	2.37	0.21	8.6	1.16	1.30	0.00	0.00	—	0.00	—	—
IT	0.56	0.18	0.01	71.9	0.25	0.28	0.28	0.46	0.28	19.9	0.47	0.53
JP	0.09	118.25	0.68	0.3	0.01	0.01	1.00	147.47	0.11	0.3	0.00	0.00
MX	0.28	1.75	0.73	14.0	0.13	0.15	0.12	1.62	0.66	1.5	0.27	0.31
NL	0.07	0.40	0.32	44.7	0.95	0.95	0.25	0.88	0.21	11.4	0.30	0.33
NO*	0.07	2.26	0.17	11.3	0.29	0.32	0.10	3.10	0.14	1.1	0.16	0.18
NZ	0.31	4.78	0.66	5.8	0.56	0.63	0.21	4.64	0.67	1.2	0.53	0.63
PT	>100	0.47	0.00	51.8	0.00	0.00	0.08	0.51	−0.62	3.8	1.00	1.17
SE	>100	0.07	0.00	88.3	0.00	0.00	0.20	0.39	−0.90	17.6	0.71	0.80
SK	0.10	0.26	0.26	51.7	0.59	0.62	0.07	0.54	0.34	3.6	0.96	1.13
UK*	>100	5.28	0.00	8.7	0.00	0.00	0.04	3.09	−0.51	0.3	0.19	0.24
US	0.03	0.31	0.38	39.6	1.32	1.79	0.16	0.98	0.17	6.6	0.38	0.43

Notes: The values for welfare cost and μ are in percentage points; μ is market 1 output share; welfare costs are for 10% inflation relative to 0% inflation and the Friedman rule (FR). The shaded columns report results for the case where α is calibrated to match the elasticity of money demand and A is calibrated to match inverse velocity $L(i)$. The welfare costs of inflation and R^2 for CH and IR are not reported because market 1 is inactive because the calibration gives $\alpha = 0$. The remaining columns report results for the case where a and A are calibrated to match $L(i)$.

There are several possible reasons for the reported difference in how the model fits money demand data from different countries. First, the common sample period might not have enough data to obtain a good fit. For this reason, the model has been calibrated for the full sample periods reported in Table 1. Consider the benchmark calibration, the price-taking case (Table 2). The model's fit improves for many countries, especially because the constraint $\alpha \leq 1$ binds in half as many cases, relative to the common sample. The countries for which the fit improves include, for instance, Greece and Ireland (for which only annual data are available), where $\alpha \leq 1$ does not bind in the full sample, but it also improves for Canada and the United States, where $\alpha \leq 1$ never binds but α falls in the full sample period. Calibrating the bargaining economy to the full sample also generates a better fit,

TABLE 6. Subsamples of common sample results (price-taking, unit elastic preferences)

	1978–1988						1989–1998					
	Calibrated parameters				Welfare cost		Calibrated parameters				Welfare cost	
Country	α	A	R^2	μ	0%	FR	α	A	R^2	μ	0%	FR
AT	1.00	1.06	−0.01	31.24	0.06	0.07	0.10	1.18	0.86	3.10	0.41	0.47
AU	0.21	0.39	0.37	17.79	0.67	0.76	0.06	0.25	0.68	6.54	2.06	2.46
BE	1.00	0.66	−0.17	42.13	0.08	0.09	1.00	0.77	0.00	38.53	0.08	0.08
CA	1.00	2.82	−0.03	14.38	0.03	0.03	0.08	2.33	0.60	1.14	0.23	0.27
CH	0.01	0.24	0.36	0.72	1.59	2.44	0.02	0.31	0.87	1.65	1.68	2.26
DE	0.27	1.23	0.51	8.87	0.21	0.24	0.09	0.90	0.76	3.75	0.54	0.63
DK*	1.00	7.98	−0.31	5.56	0.01	0.01	0.52	8.22	0.50	2.87	0.02	0.02
ES	1.00	0.60	−0.10	43.70	0.09	0.10	1.00	0.52	−0.05	47.88	0.10	0.11
FI	0.86	0.49	0.02	44.93	0.12	0.14	0.15	0.65	0.82	8.55	0.56	0.64
FR	1.00	0.48	0.00	49.55	0.10	0.11	1.00	0.65	−0.18	42.62	0.09	0.09
GR*	0.30	5.74	0.89	1.26	0.40	0.47	1.00	11.30	−1.47	3.18	0.11	0.13
IE	1.00	6.09	−0.26	6.05	0.20	0.23	0.21	5.21	0.84	1.10	0.47	0.57
IT	0.43	0.41	0.07	30.76	0.33	0.36	1.00	0.28	−0.06	63.12	0.13	0.14
JP	0.23	167.87	0.62	0.06	0.00	0.00	0.09	122.87	0.65	0.03	0.00	0.00
MX	0.25	2.07	0.61	2.64	0.14	0.15	0.11	1.48	0.61	1.67	0.31	0.36
NL	0.14	0.96	0.52	5.47	0.42	0.48	0.10	0.72	0.74	5.26	0.63	0.73
NO*	0.01	0.67	0.82	0.08	0.52	0.84	1.00	6.03	−0.22	7.39	0.02	0.02
NZ	0.22	4.81	0.66	1.01	0.51	0.61	1.00	7.56	−1.59	5.33	0.17	0.19
PT	0.26	0.59	0.03	14.33	0.41	0.46	0.19	0.77	0.68	8.46	0.42	0.48
SE	1.00	0.02	0.00	95.84	0.19	0.21	0.49	0.33	0.18	40.26	0.32	0.35
SK	1.00	0.52	−0.04	47.45	0.10	0.11	0.42	0.78	0.06	18.84	0.21	0.23
UK*	1.00	5.07	−0.05	8.55	0.02	0.02	1.00	7.23	−1.12	6.23	0.01	0.01
US	0.27	1.36	0.60	7.98	0.19	0.21	0.17	1.42	0.17	4.90	0.26	0.29

Notes: The values for welfare cost and μ are in percentage points; μ is market 1 output share; welfare costs are for 10% inflation relative to 0% inflation and the Friedman rule (FR). The parameters α and A are calibrated to match $L(i)$.

but the improvement is less marked than in the price-taking case (the model fails in eight countries; see Table 3).

Second, it is possible that the fit in some countries is poor because money demand is unstable. For instance, see Figure 16 for Norway. For this reason, the price-taking model has been calibrated for subsets of the common sample (years 1978–1988 and 1989–1998), as well as for subsets of the entire sample, pre-1973, when available, and from 1973 on (Tables 6 and 7). The year 1973 is selected because it can be interpreted as a year where a common break point occurs due to the demise of the Bretton Woods agreements on exchange rates. Consider the 1989–1998 subsample. The number of countries where the model fails to fit decreases, Norway being a clear example; still, in eight countries $\alpha \leq 1$ binds (and $R^2 < 0$). The fit of the model does not seem to increase much, on average, in the post-1973 and in the 1978–1988 subsamples (the model fails in about ten

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TABLE 7. Subsamples of full sample results (price-taking, unit elastic preferences)

	Pre-1973						1973 and after					
	Calibrated parameters				Welfare cost		Calibrated parameters				Welfare cost	
Country	α	A	R^2	μ	0%	FR	α	A	R^2	μ	0%	FR
AT	0.19	1.06	0.06	7.0	0.32	0.36	0.21	1.25	0.14	7.0	0.25	0.28
AU	0.13	0.34	0.23	13.1	1.07	1.22	0.02	0.17	0.70	2.6	2.95	3.89
BE	—	—	—	—	—	—	1.00	0.72	−0.13	40.2	0.08	0.09
CA	0.08	1.67	0.41	1.7	0.31	0.36	0.08	2.04	0.45	1.3	0.26	0.31
CH	0.04	0.41	0.70	2.6	1.37	1.73	0.01	0.14	0.65	0.4	1.87	3.31
DE	0.06	1.04	0.23	2.1	0.53	0.63	0.15	1.11	0.19	5.4	0.35	0.40
DK*	—	—	—	—	—	—	1.00	8.11	−0.22	5.6	0.01	0.01
ES	—	—	—	—	—	—	0.58	0.69	0.05	27.4	0.16	0.18
FI	—	—	—	—	—	—	0.19	0.65	0.69	10.2	0.49	0.55
FR	—	—	—	—	—	—	1.00	0.56	−0.12	46.2	0.09	0.10
GR*	—	—	—	—	—	—	0.56	7.96	0.23	2.2	0.23	0.26
IE	0.08	1.26	0.65	1.0	1.70	2.28	1.00	6.20	−0.40	6.3	0.20	0.22
IT	0.04	0.33	0.39	2.1	1.69	2.11	1.00	0.19	−0.01	70.9	0.14	0.16
JP	—	—	—	—	—	—	0.06	116.01	0.73	0.0	0.00	0.01
MX	—	—	—	—	—	—	0.22	1.96	0.75	3.0	0.16	0.18
NL	—	—	—	—	—	—	0.09	0.80	0.34	4.0	0.61	0.71
NO*	0.05	1.86	0.41	0.8	0.31	0.38	1.00	4.78	−0.01	9.2	0.02	0.02
NZ	0.00	0.06	0.14	0.0	1.02	3.73	0.25	5.11	0.69	1.4	0.47	0.55
PT	—	—	—	—	—	—	1.00	0.44	0.00	51.8	0.11	0.12
SE	—	—	—	—	—	—	1.00	0.06	−0.01	88.4	0.17	0.19
SK	—	—	—	—	—	—	0.10	0.58	0.36	4.9	0.80	0.93
UK*	1.00	2.79	−0.16	14.7	0.21	0.25	1.00	5.47	−0.04	8.1	0.02	0.02
US	0.02	0.50	0.85	0.7	0.98	1.37	1.00	1.23	−0.04	28.5	0.06	0.06

Notes: The values for welfare cost and μ are in percentage points; μ is market 1 output share; welfare costs are for 10% inflation relative to 0% inflation and the Friedman rule (FR). The parameters α and A are calibrated to match $L(i)$.

countries).[11] All in all, this suggests that unstable money demand, perhaps due to policy breaks, may be part of the reason for the poor fit. One way to solve this problem could be to modify the model in a manner similar to that of the study in Chiu and Molico (2007b), which achieves a remarkable fit for U.S. and Canada money demand data by including endogenous nonconvex participation costs in market two (but this reduces analytical tractability).

Finally, a poor fit may stem from the calibration method used. It may tend to assign too much weight to the trade parameter α, which in turn leads too often to a binding constraint $\alpha \leq 1$, and hence a poor fit. To explore this issue further, two additional calibrations have been performed.

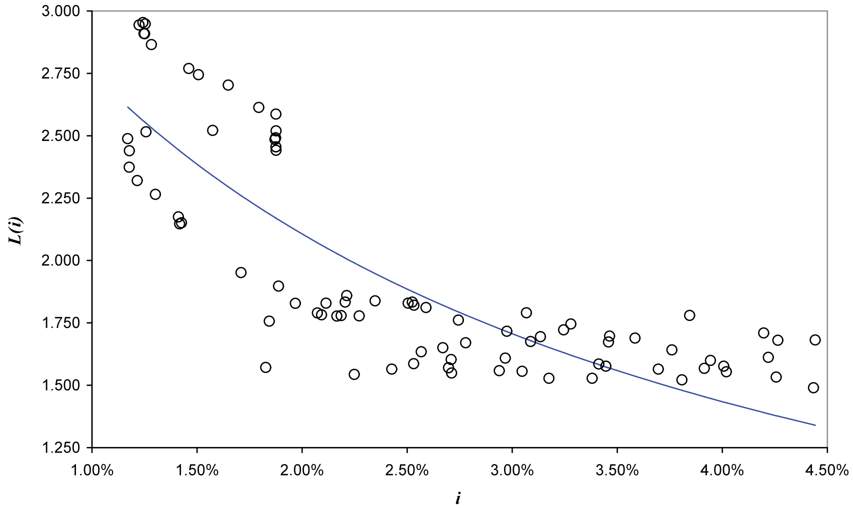

FIGURE 1. Australia quarterly money demand with fitted model (1978–1998).

Additional calibration 1. Instead of imposing unit-elastic preferences in both markets, we fixed $\alpha = 1$ in every country and calibrated (a, A) for each country to match $L(i)$. A comparable procedure is adopted in Lagos and Wright (2005, p. 476). Here, agents can have different preferences over consumption goods across markets and countries, but countries have identical trade frictions (everyone participates in trade in market one, either buying or selling). The parameters (a, A)

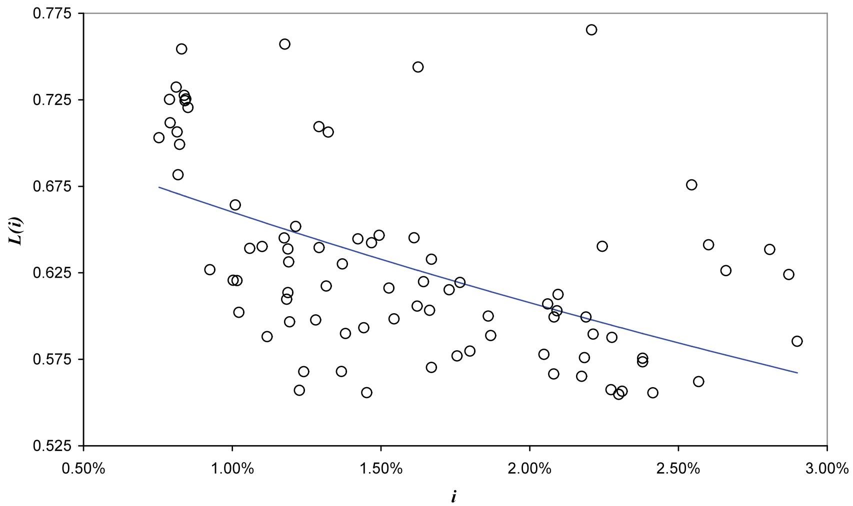

FIGURE 2. Austria quarterly money demand with fitted model (1978–1998).

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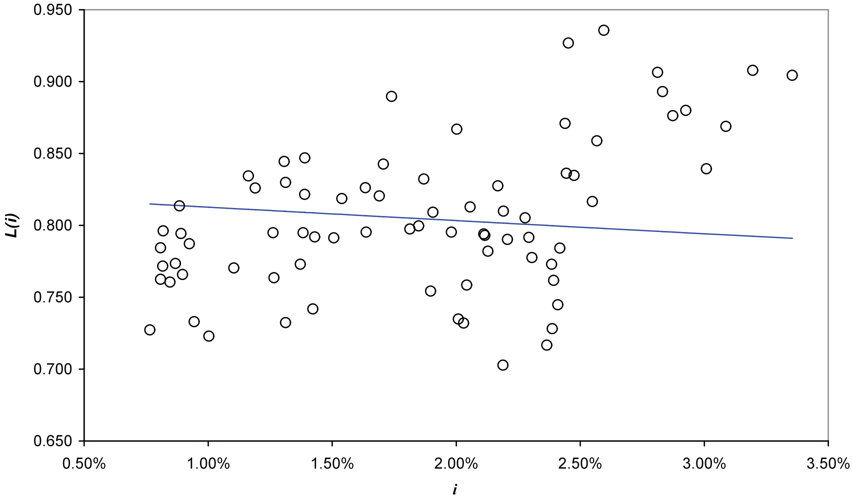

FIGURE 3. Belgium quarterly money demand with fitted model (1980–1998).

are calibrated to fit inverse velocity $L(i)$ given the constraints a, $A > 0$. The results for the common sample period are reported in Table 4 (full sample: see Table 5).

The fit does not improve much. The reason is that the model implies a very large, unreasonable, risk aversion parameter a in those same countries where the model fails to fit with unit-elastic preferences. For the common sample, we obtain $a > 100$ in ten instances (South Korea and nine European countries); in that case R^2 is essentially zero. Also, the average R^2 does not increase relative to the

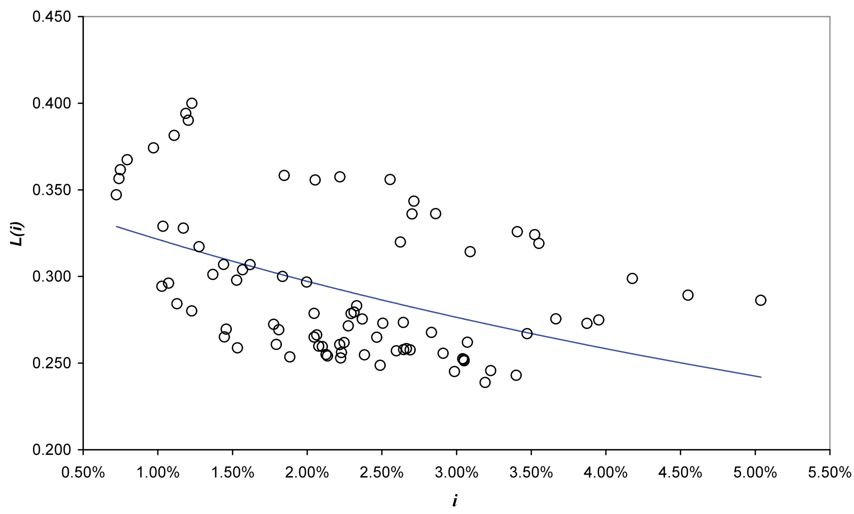

FIGURE 4. Canada quarterly money demand with fitted model (1978–1998).

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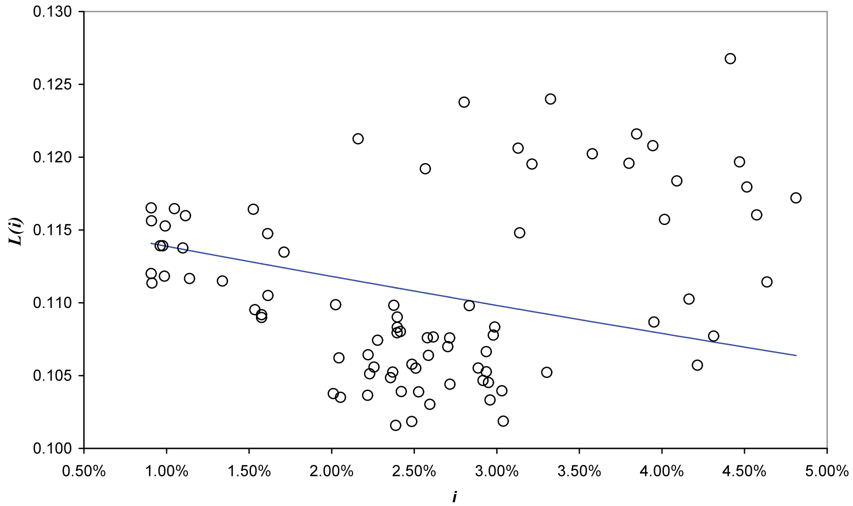

FIGURE 5. Denmark quarterly money demand with fitted model (1978–1998).

benchmark calibration, on average. For the full sample, the model fails in the same six European countries for which it failed in the benchmark calibration. Similar effects can be seen when $\theta = 0.5$ (Table 3). This suggests that the model does not fail to fit due simply to the assumption of unit-elastic preferences.

Additional calibration 2. Instead of matching (α, A) to one target, we matched each parameter to a separate money demand target. We first estimated the interest

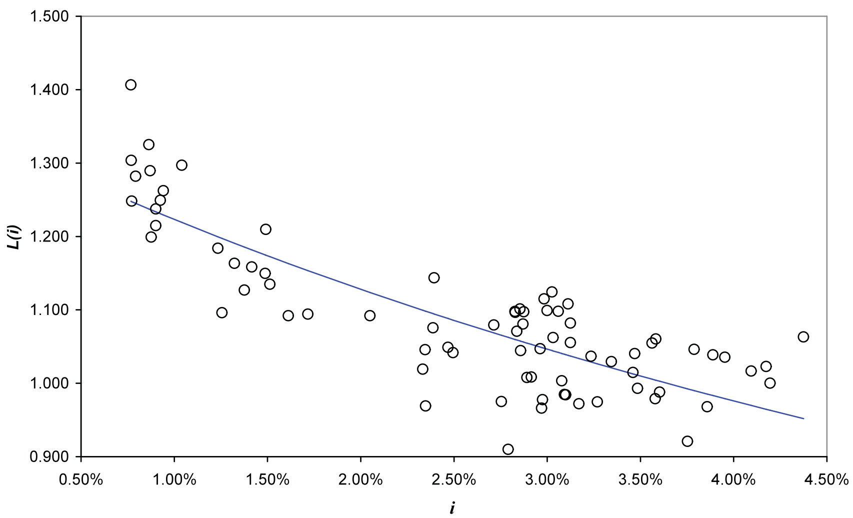

FIGURE 6. Finland quarterly money demand with fitted model (1980–1998).

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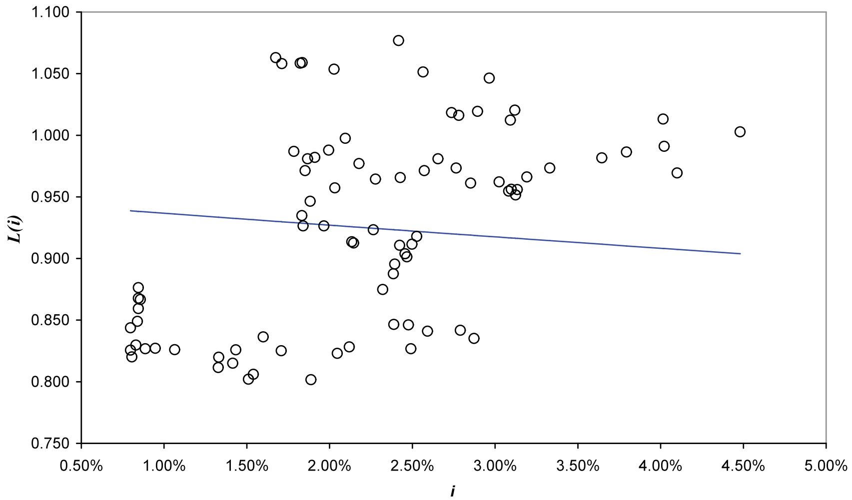

FIGURE 7. France quarterly money demand with fitted model (1978–1998).

elasticity of money demand for each country for the full sample period (see Table 1). We used this target to first identify the parameter α. Once this had been done, we pinned down A to match inverse velocity $L(i)$. This was done for the full sample, given $\theta = 1$. In this case, the theoretical interest elasticity of money demand is

$$\varepsilon_m = \frac{2\phi'(c)}{\alpha u''(c)} \times \frac{i}{c} = \frac{2i\phi'(c)}{\alpha c u''(c)}.$$

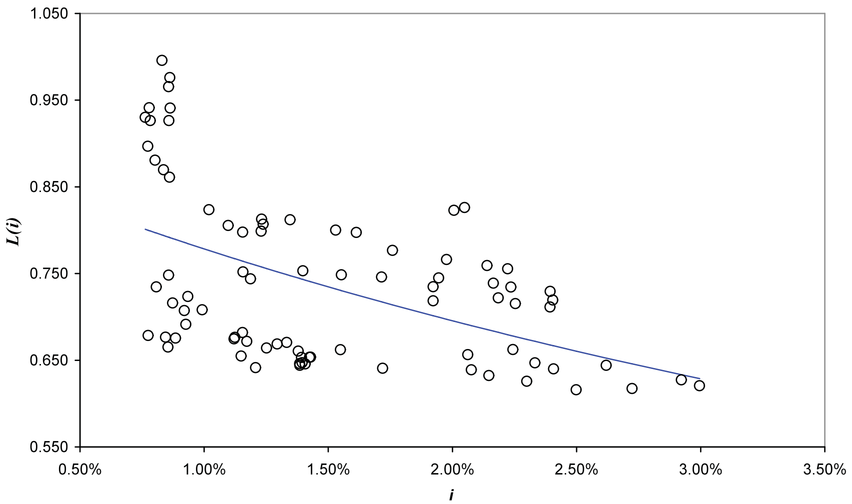

FIGURE 8. Germany quarterly money demand with fitted model (1978–1998).

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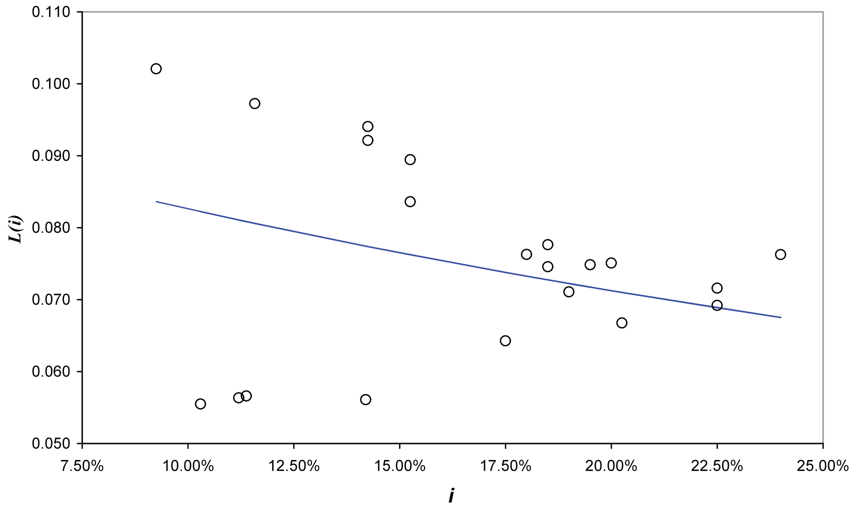

FIGURE 9. Greece annual money demand with fitted model (1978–1998).

Now note that $-c\frac{u''(c)}{u'(c)} = a$ for the preference specification selected. Hence, $u'(c)/\phi'(c) = -2i/\alpha a\varepsilon_m$. Using this last result in the Euler equation (3) gives us

$$\varepsilon_m = -\frac{2i}{a(2i+\alpha)}, \qquad (9)$$

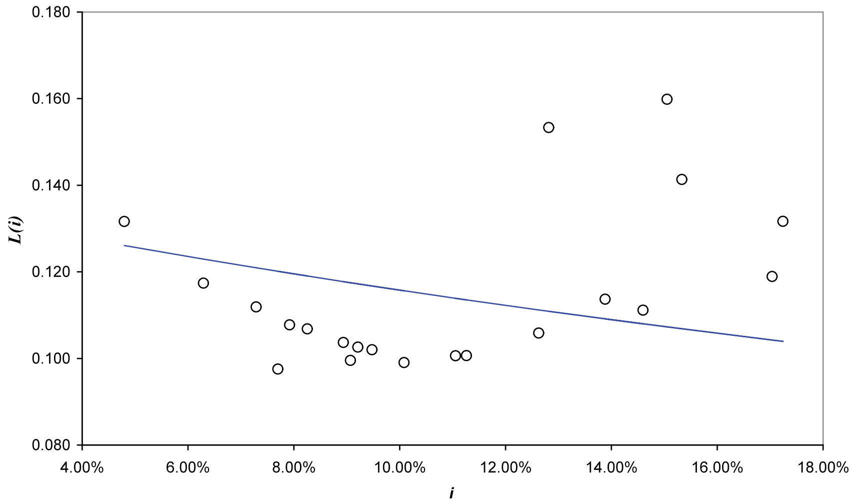

FIGURE 10. Ireland annual money demand with fitted model (1978–1998).

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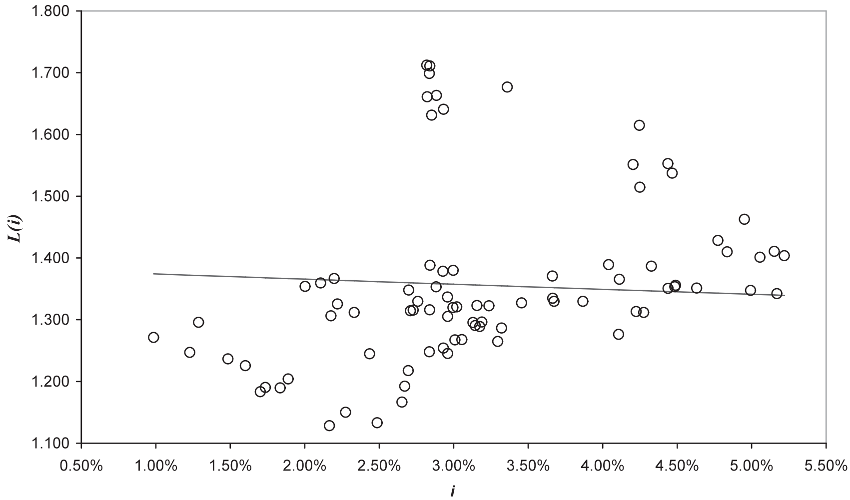

FIGURE 11. Italy quarterly money demand with fitted model (1978–1998).

an expression that depends only on i, a, and α. Given $a = 0.9999$, the parameter α is obtained by matching the empirical elasticity of money demand (reported in Table 1) to the theoretical elasticity of money demand given the average nominal interest rate in the data. The parameter A is then chosen to minimize the distance between $L(i)$ in the model and the data.

We report results for the full sample period in Table 5 (unshaded area). Two findings stand out. First, the calibrated parameters change sometimes significantly.

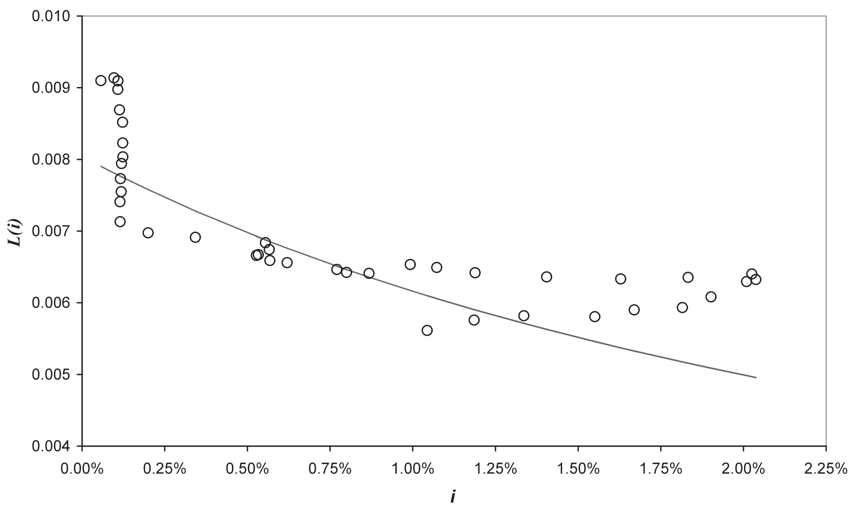

FIGURE 12. Japan quarterly money demand with fitted model (1989–1998).

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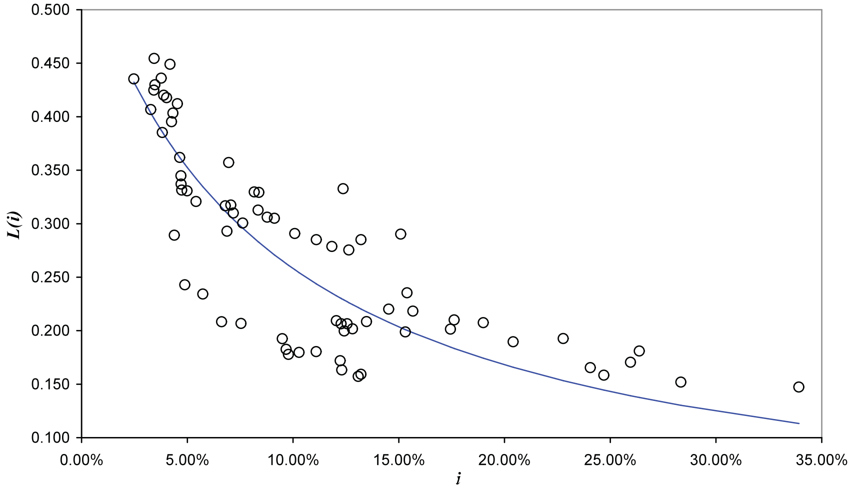

FIGURE 13. Mexico quarterly money demand with fitted model (1981–1998).

For example, the value of α is smaller, on average, relative to the benchmark calibration. The reason for this is that this technique identifies the two parameters separately. So we have that the constraint $\alpha \leq 1$ binds only for Japan (unlike the case with the earlier calibration technique), and the constraint $\alpha \geq 0$ now also binds sometimes (Ireland and Switzerland). Second, the fit worsens; the average R^2 coefficient is now close to zero. The same qualitative results obtain in the common sample period (results not reported), and also if we fix $\alpha = 1$ to use the

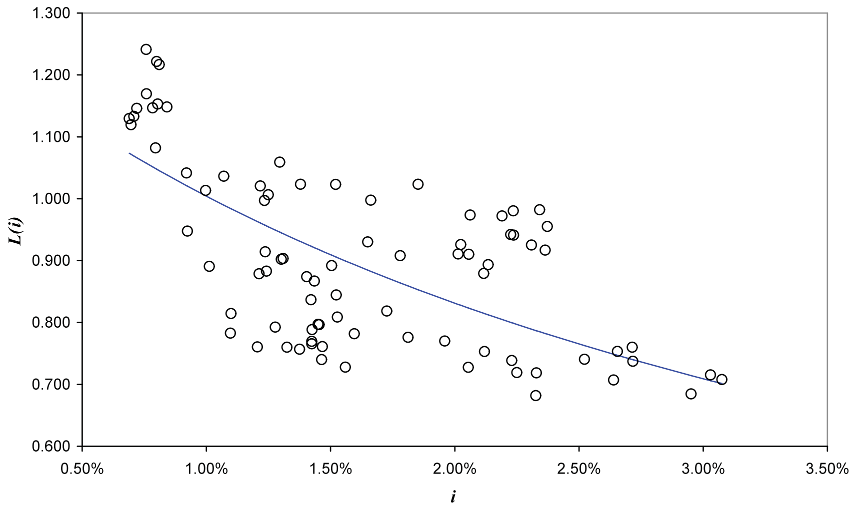

FIGURE 14. Netherlands quarterly money demand with fitted model (1978–1998).

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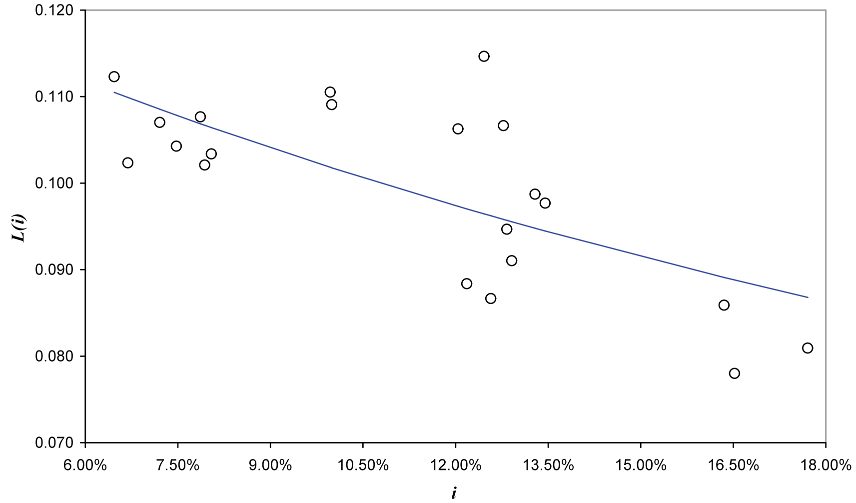

FIGURE 15. New Zealand annual money demand with fitted model (1978–1998).

elasticity of money demand to identify a and use $L(i)$ to identify A (results not reported); again, the fit does not improve.

4.2. The Share of Trade Carried Out with Money

In the benchmark calibration, countries differ in the trade parameter α and the preference parameter A. This implies that countries differ in the implied share of

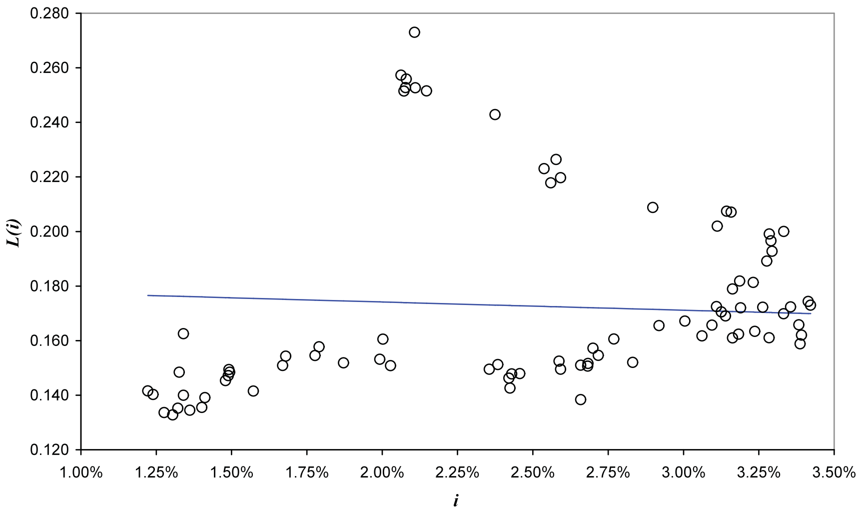

FIGURE 16. Norway quarterly money demand with fitted model (1978–1998).

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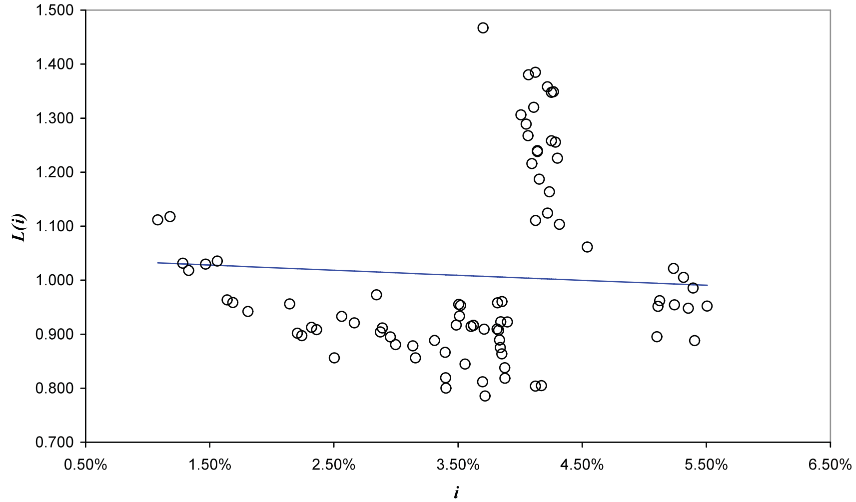

FIGURE 17. Portugal quarterly money demand with fitted model (1978–1998).

output traded by exchanging money. To see this, note that α and A affect the share of output produced and traded in markets one and two. All else equal, a larger α implies a greater frequency of trade and greater consumption in market one, where trade is conducted with money. The value A, instead, pins down the equilibrium

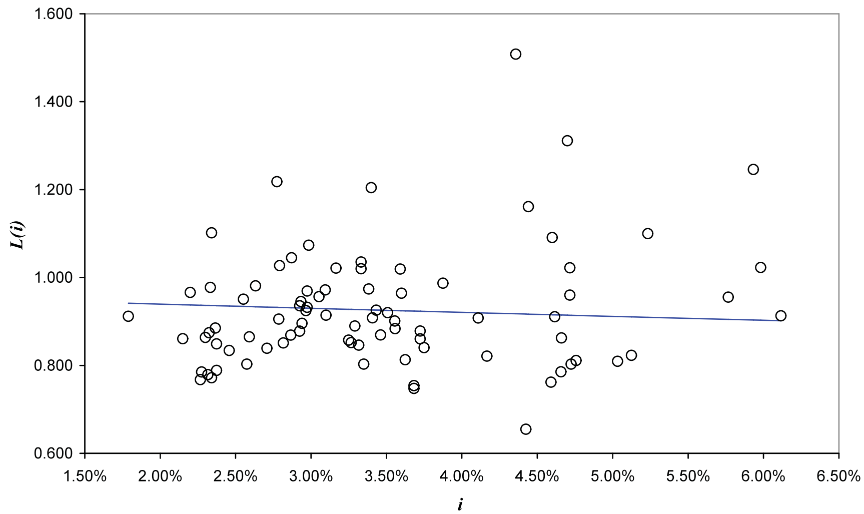

FIGURE 18. South Korea quarterly money demand with fitted model (1978–1998).

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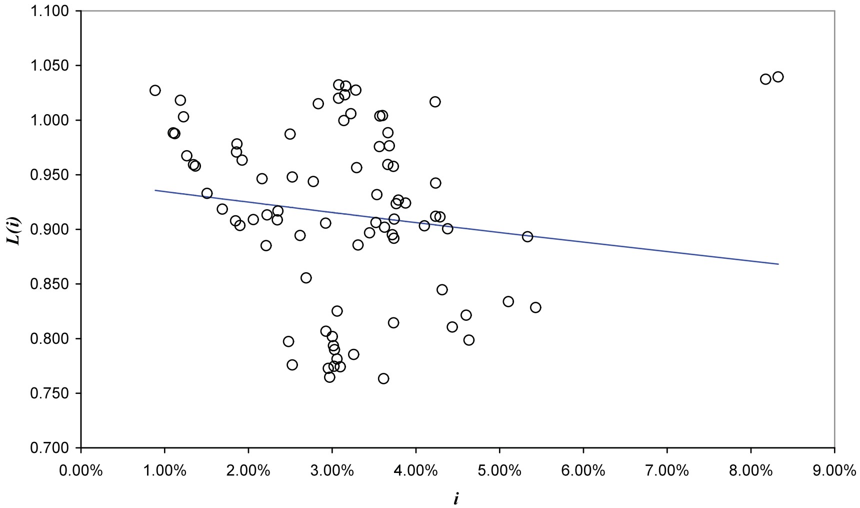

FIGURE 19. Spain quarterly money demand with fitted model (1978–1998).

quantity of output produced and consumed in market two, where trade can be conducted without money. Consequently, a lower bound can be defined for the share of output sold in exchange for money.

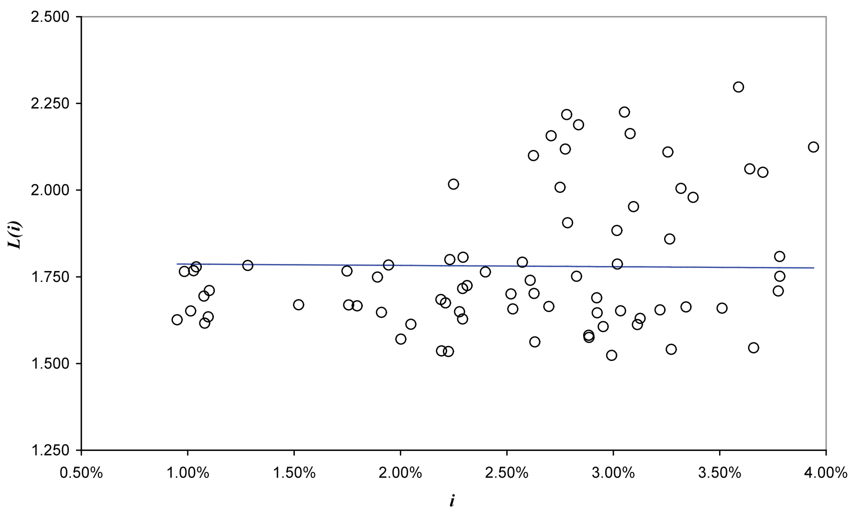

FIGURE 20. Sweden quarterly money demand with fitted model (1980–1998).

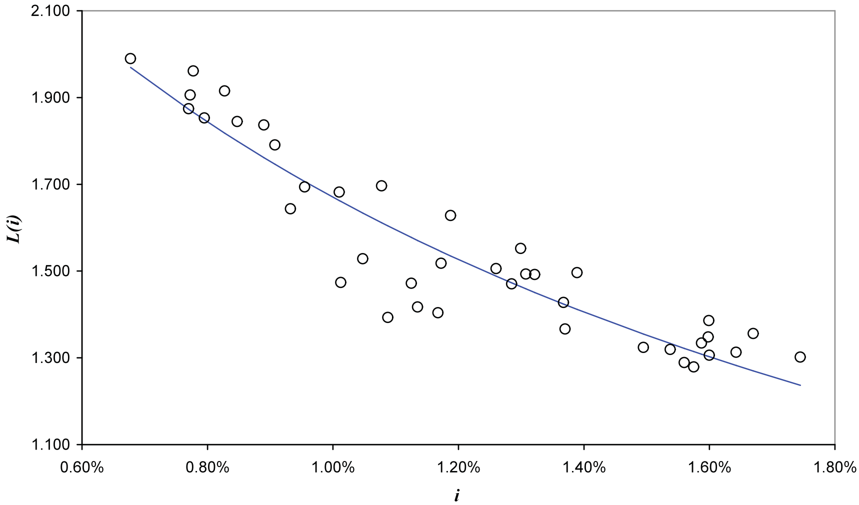

FIGURE 21. Switzerland quarterly money demand with fitted model (1989–1998).

With linear labor disutility, $\delta = 1$, total output traded in the economy is $\frac{\alpha}{2}c + A$, where $\frac{\alpha}{2}c$ is from market one. Using the definition of $L(i)$ from (8), the variable

$$\mu := \frac{\frac{\alpha}{2}c}{\frac{\alpha}{2}c + A} = \frac{\alpha}{2}L(i),$$

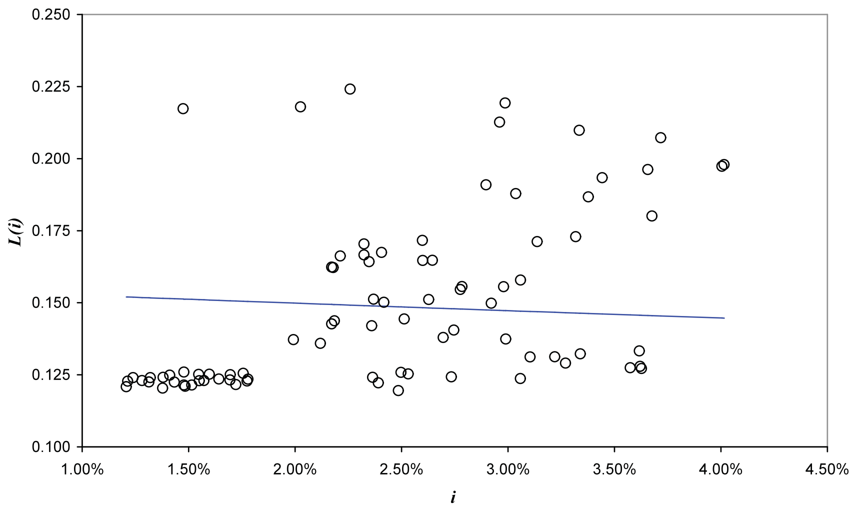

FIGURE 22. U.K. quarterly money demand with fitted model (1978–1998).

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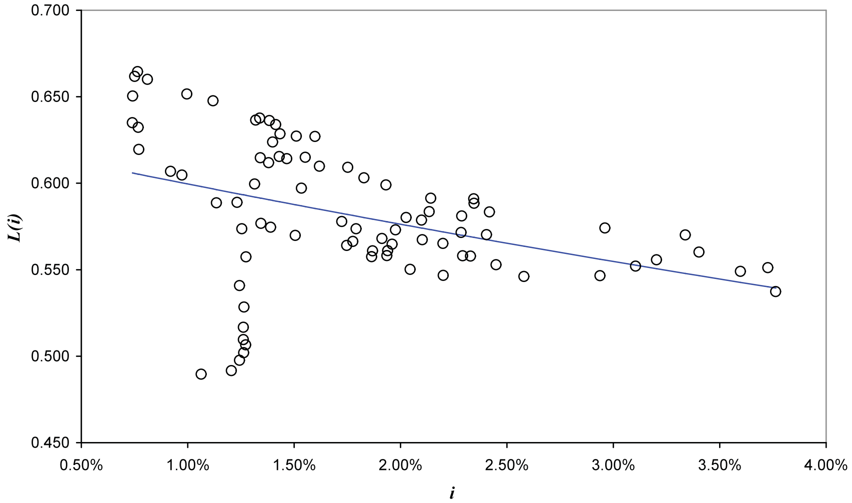

FIGURE 23. U.S. quarterly money demand with fitted model (1978–1998).

corresponds to the share of output traded for money in market one. Equivalently, μ is the share of trade that relies on monetary exchange, as is implied by the model.[12] Fixing all other parameters and the interest rate i, the variable μ increases with α and decreases with A. As an illustration, Figure 24 reports μ for $(\alpha, A) \in [0, 1] \times [0, 6]$, when the interest rate is $i = 1.78\%$, i.e., the average nominal short-term interest rate in the United States during the common sample period. The values taken in each country by μ, for the various calibrations executed, are reported in the relevant tables. There are two main observations.

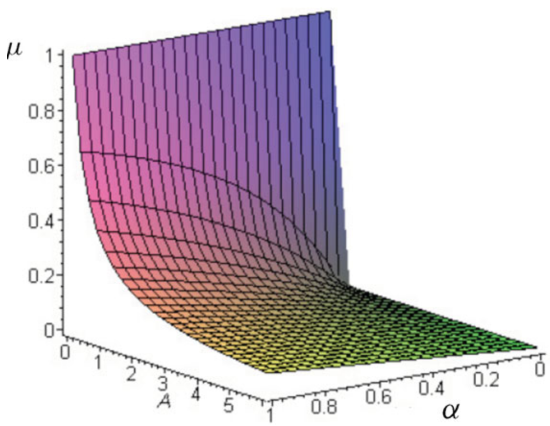

FIGURE 24. Share of trade that relies on monetary exchange, given $i = 1.78\%$.

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First, when α is one of the calibrated parameters, then the share μ is generally small, unless the model fails to fit the data. To see this, consider μ for the common sample period in Table 2. The average value for all twenty-three countries studied is 20%, which falls to 4.6% when countries for which $\alpha \leq 1$ binds (poor fit countries) are excluded. The share μ lies below 12% in those calibrated economies where the model fits the data reasonably well (where $\alpha < 1$ and R^2 is positive); it is between 40 and 90% in the remaining economies. In addition, if we consider only countries where the model fits the data reasonably well, then there is a negative association between μ and how the model fits the money demand data. The qualitative results are similar under bargaining, when we calibrate the economies to the full sample period, or when the two parameters (α, A) are matched to two different targets from money demand data. We note that μ is higher under bargaining on average, and lower when full sample periods are used.

Second, the share of output traded in market one is generally large when we fix $\alpha = 1$ and calibrate (a, A). The average value of μ, even excluding countries for which the model fails to fit the data, is above 30%. The reason is that A is often calibrated close to zero in this case; i.e., very little trade occurs in the second market (see, for example, Australia or Switzerland in Tables 4 and 5). Hence, the assumption of unit-elastic preferences and country-specific trade frictions has a definite effect on the model's implications regarding how much trade goes through which market. The model with unit-elastic preferences puts little weight on trade in market one.[13]

4.3. The Welfare Cost of Inflation

This section focuses on quantitative findings for the benchmark analysis carried out for the common sample period 1978–1998 (Tables 2 and 3). It also reports results of analyses carried out for different sample periods (full sample, and subsets of common sample and full sample), for country-specific discount factors, and for the different calibration techniques earlier discussed. Two findings stand out. In the average OECD economy studied, the welfare cost of fully anticipated inflation is a fraction of a percentage point of private consumption, if prices are not bargained. With bargaining, instead, the average welfare cost of inflation jumps up to more than 2%. Second, the welfare cost of inflation is heterogeneously distributed across the OECD economies studied. These results are robust to the alternative specifications and calibrations discussed above. Support for these results comes from the following observations.

Consider the benchmark calibration results reported in Table 2 for the case $\theta = 1$. In the average OECD economy studied, 10% inflation is worth less than one-half percent of consumption of a representative agent in both the common and full sample periods. The average welfare cost across countries is 0.32% of private consumption in the common sample and 0.5% in the full sample (Table 2). In only two countries does the welfare cost exceed 1%. Switzerland and Australia, two countries for which the model exhibits a good fit to the data, in general, have welfare costs of 1.58% and 2.31%, respectively, in the common sample period. Japan is at the opposite end of the spectrum, with less than 0.01%. Overall, these findings are in line with the impact of inflation typically reported in studies of the U.S. economy; e.g., see Cooley and Hansen (1989), Lucas (2000), and Lagos and Wright (2005, price-taking case).

When the buyer's bargaining power is halved to $\theta = 0.5$, the welfare cost of inflation increases more than fourfold, on average (Table 3). Considering the common sample, for instance, the welfare cost for Switzerland moves from 1.58% to 4.58%, whereas that for the United States goes from 0.13% to 1.42%. The ranking of countries, in terms of welfare costs, does not change much when θ drops from 1 to 0.5. The correlation between the welfare costs associated with the two calibrations, $\theta = 1$ and $\theta = 0.5$, is 0.78 (0.76 in the full sample). This correlation increases if we exclude countries where the fit is poor, with $\theta = 1$ and $\theta = 0.5$. That is, a decrease in the buyer's bargaining power has similar magnifying effects on the welfare cost of inflation across the countries studied. This confirms earlier findings that distortions coming through the pricing mechanism can substantially augment the distortionary impact of inflation in the United States [e.g., Lagos and Wright (2005), Aruoba et al. (2007)].[14]

The average welfare cost of inflation does not change much when different periods are selected, country-specific rates of time preference are used, or parameters are calibrated to match interest elasticity of money demand and inverse velocity. In particular, the average welfare cost of inflation remains around 0.3% when country-specific discount factors are considered for the common sample (Table 4) and when smaller common sample periods are considered (Table 6). However, the welfare costs are generally higher in the model calibrated to the full sample period instead of the common sample (Tables 2 and 3). The average increase is 0.2%; South Korea stands apart because the fit of the model increases substantially and there is a positive correlation between the model's fit and the welfare cost of inflation. The welfare cost of inflation falls on average in the years following 1973 (compared to pre-1973 years), but not for all countries (Table 7). Considering only those countries for which the model's fit improves in the post-1973 sample, for example, the greatest drop is from 1.02% to 0.47% (New Zealand), whereas the largest increase is from 1.07% to 2.95% (Australia).

There is substantial heterogeneity in welfare costs of inflation across countries for all sample periods considered. Consider Table 2, common sample period. The welfare cost ranges from less than 0.01% for Japan to 2.32% for Australia, two countries for which the model fits the money demand data particularly well. In eight of the remaining countries, the welfare cost of inflation is at or below 0.1%, and only in one country is it above 1% (Switzerland). When the buyer's bargaining power falls to 0.5, the ranking of countries in terms of the welfare cost of inflation does not vary much, especially for those countries at the tails of the distribution (Table 3). The same holds when alternative calibration strategies are used (Tables 4–6). In particular, Japan is at the low end, whereas Australia and Switzerland are almost always at the high end. Differences in welfare costs can be seen as hinging on three factors. First, the average welfare cost is higher in countries where the theoretical money demand displays a better fit to the data (there is a positive correlation between R^2 and the welfare cost of inflation). Second, the analysis reveals the existence of a negative association between the trade friction parameter α and the welfare cost of inflation (-0.55 in Table 2, common sample, which increases to -0.46 when countries where the constraint $\alpha \leq 1$ binds are excluded). Third, the risk aversion parameter a and the welfare cost of inflation are also negatively associated.[15]

Finally, the welfare cost of inflation increases nonlinearly as inflation increases. Table 8 reports results for the benchmark calibration of the common sample period, $\theta = 1$ and $\theta = 0.5$. The results demonstrate that the average welfare cost increases nonlinearly, from 0.33% at 10% inflation to 2.99% at 100% inflation in the price-taking case, and from 2% to 11% in the bargaining case. This is in line with the finding in Chiu and Molico (2007b), where the welfare cost is found to be a concave function of the inflation rate. For example, considering the price-taking model in Table 8, the welfare cost grows the least in high-welfare-cost countries such as Switzerland and Australia (from 1.58% to 5.57% and from 2.32% to 10.85%, respectively), and the most in low-welfare-cost countries such as Denmark and Norway (from 0.01% to 0.3% and 0.02% to 0.46%, respectively).

5. FINAL REMARKS

A monetary economy has been constructed as in Lagos and Wright (2005), where ex ante homogeneous agents hold money to insure against consumption risk. Using an existing methodology, the model has been calibrated to data for twenty-three OECD economies for the common sample period 1978–1998, as well as for longer, non–common sample periods. The calibrated model has been used to quantify the welfare cost of anticipated inflation in each of those twenty-three economies.

The analysis shows that when buyers and sellers are price takers, the average welfare cost of 10% permanent inflation across all countries studied is less than 0.5% of private consumption, a result in line with previous studies on the United States. Yet the impact of inflation varies noticeably across the economies, going from less than 0.01% for Japan to 2.31% for Australia. With bargaining, the welfare cost of inflation is substantially higher. Assuming buyers and sellers have equal bargaining powers, the average welfare cost across countries is 2%, given the common sample period.

The analysis shows that a negative correlation exists between trade frictions, measured by α, and the social burden of inflation. High-friction economies, characterized by lower calibrated α values, tend to exhibit higher welfare costs of inflation, which suggests that the consumption distortion generated by inflation is magnified by frictions in trade. The analysis also shows that countries with high calibrated α values are also those in which the fit to money demand data is poorer.

The analysis also raises questions. In particular, the analysis suggests that the model cannot generally fit money-demand data reasonably well for a number of

TABLE 8. Welfare costs for high inflation (common sample, unit elastic preferences)

	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
					Price-taking					
AT	0.26	0.61	0.98	1.34	1.68	1.99	2.29	2.56	2.82	3.06
AU	2.32	4.19	5.64	6.80	7.75	8.56	9.24	9.85	10.38	10.85
BE	0.08	0.22	0.41	0.62	0.85	1.09	1.33	1.58	1.83	2.08
CA	0.12	0.28	0.46	0.63	0.80	0.95	1.10	1.24	1.37	1.49
CH	1.58	2.58	3.28	3.81	4.23	4.58	4.88	5.14	5.37	5.57
DE	0.38	0.86	1.32	1.75	2.15	2.51	2.83	3.13	3.41	3.66
DK*	0.01	0.03	0.06	0.09	0.12	0.15	0.19	0.22	0.26	0.30
ES	0.09	0.26	0.47	0.71	0.97	1.25	1.53	1.81	2.10	2.38
FI	0.49	1.14	1.83	2.48	3.10	3.67	4.21	4.70	5.16	5.59
FR	0.09	0.26	0.47	0.71	0.97	1.25	1.53	1.81	2.10	2.39
GR*	0.13	0.34	0.57	0.82	1.08	1.33	1.57	1.81	2.04	2.26
IE	0.19	0.47	0.80	1.15	1.50	1.85	2.19	2.52	2.83	3.14
IT	0.14	0.38	0.68	1.04	1.42	1.82	2.23	2.64	3.05	3.46
JP	0.00	0.01	0.01	0.02	0.02	0.02	0.02	0.03	0.03	0.03
MX	0.22	0.50	0.80	1.07	1.33	1.57	1.79	1.99	2.18	2.35
NL	0.70	1.40	2.00	2.52	2.96	3.35	3.69	3.99	4.27	4.51
NO*	0.02	0.05	0.09	0.14	0.19	0.24	0.29	0.35	0.40	0.46
NZ	0.23	0.54	0.87	1.21	1.53	1.84	2.12	2.40	2.66	2.90
PT	0.10	0.28	0.52	0.78	1.07	1.37	1.68	2.00	2.31	2.62
SE	0.18	0.49	0.89	1.34	1.83	2.35	2.87	3.40	3.94	4.46
SK	0.09	0.26	0.48	0.72	0.99	1.26	1.55	1.84	2.13	2.42
UK*	0.02	0.04	0.08	0.12	0.16	0.21	0.25	0.30	0.35	0.40
US	0.13	0.34	0.59	0.85	1.11	1.38	1.64	1.89	2.13	2.36
					Bargaining					
AT	1.57	2.89	4.02	5.01	5.89	6.67	7.37	8.01	8.59	9.13
AU	6.08	10.29	13.45	15.94	17.98	19.69	21.15	22.42	23.53	24.53
BE	1.94	3.63	5.13	6.47	7.68	8.79	9.79	10.72	11.58	12.38
CA	0.77	1.43	2.01	2.52	2.98	3.39	3.77	4.11	4.43	4.72
CH	4.58	7.10	8.79	10.05	11.04	11.85	12.54	13.12	13.63	14.08
DE	1.85	3.36	4.63	5.71	6.65	7.48	8.22	8.89	9.49	10.05
DK*	0.29	0.54	0.77	0.98	1.17	1.34	1.50	1.65	1.79	1.92
ES	2.26	4.23	5.96	7.51	8.91	10.18	11.34	12.40	13.39	14.30
FI	2.85	5.20	7.17	8.88	10.36	11.67	12.84	13.90	14.86	15.73
FR	2.23	4.18	5.90	7.43	8.81	10.07	11.21	12.27	13.24	14.14
GR*	1.20	2.20	3.05	3.79	4.45	5.04	5.58	6.07	6.51	6.93
IE	1.50	2.74	3.80	4.72	5.53	6.26	6.92	7.52	8.07	8.59
IT	3.22	6.01	8.44	10.60	12.53	14.27	15.85	17.30	18.63	19.85
JP	0.02	0.03	0.04	0.04	0.05	0.06	0.06	0.07	0.07	0.07
MX	1.04	1.93	2.71	3.41	4.04	4.60	5.12	5.59	6.03	6.43
NL	2.40	4.22	5.67	6.87	7.88	8.76	9.52	10.20	10.80	11.35
NO*	0.44	0.84	1.19	1.51	1.80	2.07	2.32	2.55	2.76	2.96
NZ	1.34	2.45	3.40	4.22	4.96	5.61	6.20	6.75	7.24	7.70

TABLE 8. Continued

	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
PT	2.49	4.66	6.57	8.27	9.80	11.19	12.45	13.61	14.68	15.68
SE	4.07	7.55	10.58	13.24	15.60	17.73	19.65	21.39	22.99	24.46
SK	2.30	4.31	6.08	7.65	9.08	10.37	11.54	12.63	13.63	14.55
UK*	0.38	0.72	1.02	1.30	1.55	1.78	1.99	2.19	2.38	2.55
US	1.42	2.66	3.77	4.76	5.65	6.47	7.22	7.91	8.55	9.14

Notes: The analysis assumes unit elastic preferences with α and A are calibrated to match $L(i)$. The calibrated parameters and model's fit are reported in Table 2 for $\theta = 1$ and Table 3 for $\theta = 0.5$.

OECD countries, especially more than half a dozen European economies. There are several possibilities for why this is so. It seems reasonable to exclude the main reason for the poor fit hinging on countries' differences, because many of the economies studied are similar to that of the United States, where the fit is not bad. However, it is possible that the model is not rich enough; for example, firms and capital are missing. An interesting avenue would thus be to extend the model as in Aruoba et al. (2007), which does include capital. One could also consider more general preferences in market two or financial intermediation as in, say, Berentsen et al. (2007). A third possibility is to introduce frictions in accessing or operating market two, where money is bought to self-insure against market one consumption shocks as, for instance, is done in Chiu and Molico (2007b). This could give a much more substantial role to precautionary money holdings. As noted by a referee, yet other avenues are to consider policy breaks, or to move away altogether from a representative-agent formulation in order to focus on the distributional effects of inflation. Existing work [e.g., Erosa and Ventura (2002), Molico (2006), Chiu and Molico (2007a), Boel and Camera (2009)] suggests this latter avenue is an interesting one to pursue.

NOTES

1. Investigations based on matching models of money, e.g., as in Lagos and Wright (2005), Molico (2006), Reed and Waller (2006), Rocheteau and Wright (2006), Aruoba et al. (2007), Chiu and Molico (2007a), and Boel and Camera (2009), find quantitative results that are not very much different from those that emerge in alternative specifications of monetary economies; e.g., see Fischer (1981), Cooley and Hansen (1989), Dotsey and Ireland (1996), Akyol (2004), and Barelli and Pessoa (2009). An exception is the recent study in Wen (2009), based on a store-of-value heterogeneous-agents monetary model, which finds significant costs from inflation. Welfare costs are also higher in matching models of money where prices are bargained, as in Lagos and Wright (2005) and Aruoba et al. (2007).

2. There are three exceptions. For Belgium, Finland, and Sweden the starting period is 1980, and for Mexico it is 1981.

3. The data set is an updated version of the data used in the recent inflation study in Wang and Wen (2007). See details in the Appendix. For Denmark, Greece, Norway, and the United Kingdom, sufficient M1 data are not available, so currency or M0 is used. For Greece, Ireland, and New Zealand, sufficient quarterly data are unavailable, so annual data are used. The countries considered are Australia (AU), Austria (AT), Belgium (BE), Canada (CA), Denmark (DK), Finland (FI), France (FR), Germany

(DE), Greece (GR), Ireland (IE), Italy (IT), Japan (JP), Mexico (MX), the Netherlands (NL), New Zealand (NZ), Norway (NO), Portugal (PT), Spain (ES), South Korea (SK), Sweden (SE), Switzerland (CH), the United Kingdom (UK), and the United States (US). The data for GR, IE, and NZ are annual. The following countries have been excluded for lack of sufficient data: the Czech Republic, Hungary, Iceland, Luxembourg, Poland, the Slovak Republic, and Turkey.

4. Following Goldfeld and Sichel (1990), we regressed the log of real money balances on each date t (M_t/P_t) on the date t log of real GDP, nominal interest rates, and one-period lagged balances: $\ln m_t = \gamma_0 + \gamma_1 \ln y_t + \gamma_2 \ln i_t + \gamma_3 \ln m_{t-1} + v_t$. To account for first-order autocorrelation in the residuals v_t we used the Cochrane–Orcutt procedure.

5. We calibrated the model to yearly data for those countries in which only yearly data were available (GR, IE, NZ). Previous studies of the United States with this model find small differences from calibrating the model to quarterly versus yearly data [Aruoba et al. (2007), Boel and Camera (2009)].

6. An alternate procedure is to pin down θ in each country by means of some price markup measure, as done in similar works [Lagos and Wright (2005), Aruoba et al. (2007)]. Unfortunately such data are readily available only for the United States.

7. This procedure is similar to the one used in Lagos and Wright (2005). We also use an alternative procedure, calibrating α to match an alternate money demand target [the estimated interest elasticity of money demand, as done in Aruoba et al. (2007)] and then calibrating A to match the empirical inverse velocity $L(i)$. The results (reported later) do not display significant differences from the benchmark calibration procedure.

8. To see this consider that, with $\theta = 1$ and $a = 1$, inverse velocity in the model is given by the function $L(i) = 1/(\frac{\alpha}{2} + A\frac{2i+\alpha}{\alpha})$.

9. For example, consider Belgium, Denmark, Greece, or the United Kingdom, where empirical money demand behaves erratically during the common sample period and interest elasticities are among the lowest, and really close to zero.

10. The correlation between R^2 in the two specifications ($\theta = 1$ and $\theta = 0.5$) is close to one.

11. We have also done the following. For three countries we could readily identify policy breaks. In 1990 and 1991 New Zealand and Canada switched to an inflation targeting regime and the United Kingdom did so in 1992. Hence, we calibrated (benchmark calibration) the models for these countries with data post-1991 (for New Zealand and Canada) and post-1993 (for the United Kingdom). The results for Canada and New Zealand do not vary greatly, relative to the full sample, but they do change a lot for the United Kingdom because now the model does not fail. This suggests that policy breaks may matter, at least for some countries. The results are as follows. For Canada, $(\alpha, A) = (0.03, 1.53)$, $R^2 = .62$, and the welfare cost of 10% inflation is 0.37%. For New Zealand $(\alpha, A) = (0.03, 1.30)$, $R^2 = .57$, and the welfare cost of 10% inflation is 0.9%. For the United Kingdom $(\alpha, A) = (0.12, 6.37)$, $R^2 = .56$, and the welfare cost of 10% inflation is 0.07%.

12. An alternative interpretation, suggested by a referee, is that μ can be interpreted as quantifying the extent of precautionary money demand in the economy.

13. Note that, without further specializing the model, it is difficult to use aggregate payments data to match parameters or to assess whether this model predicts correctly usage patterns for payments systems. Supposing that, say, 10% is the share of output traded in market one in the calibrated model does not imply that only 10% of transactions are executed by exchanging money, whereas the rest are not. The model does suggest that 10% of transactions *require* money, and the others do not, but it does not rule out payment with money in market two. That is, as suggested by a referee, the model tells us what is precautionary money demand in the model. A way to resolve the issue is to specialize the model further to study payments systems as, for example, in the interesting model in Telyukova and Wright (2007).

14. As a comparison, the average welfare cost across countries is 1.17% (data not reported in the tables). This suggests that the welfare cost of inflation is concave in the seller's bargaining power $1-\theta$.

15. The welfare cost results do not change when the model is modified to account for small differences in the elasticity of labor supply between market one and market two. In the price-taking

model, market one elasticity of labor supply with respect to the relative wage (which is p) is $\frac{1}{\delta-1}$ [see the Appendix in Boel and Camera (2009)]. The model calibrated to $\delta = 1.1$ display results similar to the benchmark model. For greater values of δ the fit of the model to money demand generally worsened.

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APPENDIX

A.1. ELASTICITY OF MONEY DEMAND

Consider a representative-agent economy and focus on odd dates. The Euler equation for the representative agent is

$$F(m/p, i) = \frac{\alpha}{2}\left[\frac{u'(m/p)}{\phi'(y)} - 1\right] - i = 0.$$

Using the implicit function theorem, we have

$$\frac{\partial m/p}{\partial i} = -\frac{\partial F/\partial i}{\partial F/\partial(m/p)} = -\frac{-1}{\dfrac{\alpha}{2\phi'(y)}u''(m/p)} = \frac{2\phi'(y)}{\alpha u''(m/p)}.$$

Given $c = m/p$ and market clearing $c = y$, the elasticity of money demand is

$$\varepsilon_m = \frac{\partial m/p}{\partial i} \times \frac{i}{m/p} = \frac{2\phi'(y)}{\alpha u''(c)} \times \frac{i}{c} = \frac{2i\phi'(y)}{\alpha c u''(c)}. \quad \textbf{(A.1)}$$

We have $\phi'(y) = y^{\delta-1}$ and $y = c$. So (A.1) is $2ic^{\delta-1}/\alpha c u''(c)$. Substituting c from (7), one gets

$$\varepsilon_m = -\frac{2i}{a(2i+\alpha)}$$

For the case of bargaining, one has simply to substitute Φ' instead of ϕ' in (A.1), where Φ' is given in (2).

A.2. DATA

The analysis has been conducted using the following data.

- Australia: Quarterly Data. Money Supply: M1 (SA) from OECD; interest rate: average rate on money market (IMF); nominal GDP (SA) is from IMF. Unit: Australian dollar.
- Austria: Quarterly data. Money Supply: M1 (NSA) is from OECD in Euros, interest rate is money market rate (IMF); nominal GDP (NSA) is in Euros (IMF). Unit: Euro.
- Belgium: Quarterly data. Money Supply: M1 (NSA) from OECD; interest rate is Treasury paper rate (IMF); nominal GDP (NSA) is in Euros (IMF). Unit: Euro.
- Canada: Quarterly data. Money Supply: M1 (SA) from OECD; interest rate: Treasury Bill rate (IMF); nominal GDP (SA) is from IMF. Unit: Canadian dollar.
- Denmark: Quarterly data. Money Supply: Currency (NSA) from IMF; interest rate: call money rate (IMF); nominal GDP (NSA) is from IMF. Unit: Kroner.
- Finland: Quarterly data. Money Supply: M1 (NSA) from OECD; interest rate: money market rate (IMF); nominal GDP (NSA) is from IMF. Unit: Euro.
- France: Quarterly data. Money Supply: M1 (SA) from OECD; interest rate: call money rate (IMF); nominal GDP (SA) is from IMF. Unit: Euro.

- Germany: Quarterly data. Money Supply: M1 (SA) from OECD; interest rate: call money rate (IMF); nominal GDP (SA) is from IMF. Unit: Euro.
- Greece: Annual data. Money Supply: Currency (NSA) from IMF; interest rate: Treasury bill rate (IMF); nominal GDP (NSA) is from IMF. Unit: Euro.
- Ireland: Annual data. Money Supply: M1 (NSA) from OECD; interest rate: Government bond yield (IMF); nominal GDP (NSA) is from IMF. Unit: Euro.
- Italy: Quarterly data. Money Supply: M1 from Bank of Italy; interest rate: money market rate (IMF); nominal GDP (SA) is from IMF. Unit: Euro.
- Japan: Quarterly data. Money Supply: M1 (SA) from OECD; interest rate: call money rate (IMF); nominal GDP (SA) is from IMF. Unit: Yen.
- Mexico: Quarterly data. Money Supply: M1 (SA) from OECD; interest rate: Treasury bill rate (IMF); nominal GDP (SA) is from IMF. Unit: Peso.
- Netherlands: Quarterly data. Money Supply: M1 (NSA) from OECD; interest rate: call money rate (IMF); nominal GDP (SA) is from IMF. Unit: Euro.
- New Zealand: Yearly Data. Money Supply: M1 (NSA) from OECD; interest rate: Government bond yield (IMF); nominal GDP (SA) is from IMF. Unit: New Zealand dollar.
- Norway: Quarterly data. Money Supply: Currency (NSA) from IMF; interest rate: government bond yield (IMF); nominal GDP (SA) is from IMF. Unit: Kroner.
- Portugal: Quarterly data. Money Supply: M1 (NSA) from OECD; interest rate: government bond yield (IMF); nominal GDP (NSA) is from IMF. Unit: Euro.
- South Korea: Quarterly data. Money Supply: M1 (NSA) from OECD; interest rate: money market rate (IMF); nominal GDP (NSA) is from IMF. Unit: Won.
- Spain: Quarterly data. Money Supply: M1 (NSA) from IMF; interest rate: call money rate (IMF); nominal GDP (SA) is from IMF. Unit: Euro.
- Sweden: Quarterly data. Money Supply: M1 (NSA) from IMF; interest rate: 3 months discount notes rate (IMF); nominal GDP (NSA) is from IMF. Unit: Kronor.
- Switzerland: Quarterly data. Money Supply: M1 (NSA) from OECD; interest rate: government bond yield (IMF); nominal GDP (SA) is from IMF. Unit: Franc.
- United Kingdom: Quarterly data. Money Supply: M0 (NSA) from IMF; interest rate: Treasury bill rate (IMF); nominal GDP (SA) is from IMF. Unit: Franc.
- United States: Quarterly data. Money Supply: M1 (NSA) from St. Louis Fed FRED database; interest rate: yield on commercial paper. For 1976–1996 it is from Economic Report of the President (1996, Table B-69). For 1997–2006 it is the Financial Commercial Paper with 3-month maturity in H.15 Selected Interest Rates, Federal Reserve Statistical Release. Nominal GDP (NSA) is from National Income and Product Accounts. Unit: U.S. dollar.