Revisiting Speculative Hyperinflations in Monetary Models*

Maurice Obstfeld
International Monetary Fund

Kenneth Rogoff
Harvard University

May 4, 2017

*The views expressed here are those of the authors alone and do not represent those of the International Monetary Fund, its executive board, or its management. The authors would like to thank Jón Steinsson and Nihar Shah for helpful comments on an earlier draft, and Eugenio Cerutti and Haonan Zhou for research assistance.

In an interesting and provocative paper in the *Journal of Political Economy,* John Cochrane (2011) examines a host of New Keynesian and micro-founded models of money demand, and finds them all guilty of arbitrarily assuming uniqueness when, in fact, the whole class of models is generically riddled with multiple-equilibrium problems. He concludes that only the "fiscal theory of the price level"—which posits that the price level simply follows from the government budget constraint—offers a coherent and rigorous theory of the value of money.[1]

Cochrane focuses mainly on so-called Taylor-rule models where the monetary authority specifies an interest-rate feedback rule; and without necessarily agreeing with every detail, we have some sympathy for the concerns he raises. After all, it has long been known that models in which the central bank employs a pure interest-rate rule can be subject to indeterminacy.[2] Moreover, even in microfounded models of money demand, it is necessary to impose some restrictions on either individual utility functions and/or the derived utility from real money balances in order to rule out multiple *dynamically stable* equilibria.[3] We are deeply skeptical of Cochrane's claim that the fiscal theory of the price level really resolves multiplicity problems without additional restrictions, and we will return to this point in our conclusions.

Our main objective here, however, is to dispute Cochrane's further claims that the literature has not correctly identified alternative ways to rule out speculative hyperinflationary paths in which the price level grows exponentially even if the money supply itself is exogenous and stationary (or even fixed). In particular, Cochrane claims to find error in the analysis in Obstfeld and Rogoff (1983). There, we showed that while speculative hyperinflationary monetary bubbles can always arise in *pure* fiat money models (where

[1] Cochrane (pp. 607–608) concludes: "The price level can be determined for economies like ours in models that adopt—or, perhaps, recognize—that governments follow a fiscal regime that is at least partially non-Ricardian. Such models solve all the determinacy and uniqueness problems in one fell swoop."

[2] Canzoneri, Henderson and Rogoff (1983) show that with one-period nominal wage contracts, indeterminacy of equilibrium can arise under a pure interest-rate rule unless the central bank specifies at least one point along its money supply path. More recent authors (for example, Woodford 2003) argue that in an overlapping-contracts setting, pre-existing nominal contracts are sufficient to tie down equilibrium even with a pure interest-rate rule. See also Calvo (2016), who argues that nominal contracting is what gives money value (an approach that begs the question why money is used as a unit of account).

[3] See, for example, Obstfeld (1984).

the backing for paper currency is literally zero), they can be decisively ruled out if the government credibly guarantees an extremely small trade-in value for currency—which, we argued, effectively puts an upper bound on the price level. Our model demonstrating this result used a "money-in-the-utility-function" framework for modeling money demand, but analogous results hold in other models, as Wallace (1981) showed independently in a "hybrid fiat-commodity money" model with overlapping generations.[4] Wallace's term "hybrid" refers to the small fractional backing intended to ensure that the currency will not be rejected entirely in any equilibrium.

Cochrane suggests, however, that the supposed barrier provided by a hybrid support scheme (to use Wallace's term) is in fact a Maginot line. He claims that there still is an equilibrium in which the economy drifts off into a speculative hyperinflation that ends abruptly with a demonetized economy, as all individuals trade in their cash to the government for real output at the minimal guarantee price. He argues that, provided the demonetized situation is an equilibrium, the usual money Euler condition, which would otherwise be violated going forward (since the price level is capped) is not relevant in the period before demonetization. Instead, he constructs an alternative Euler condition that accounts for the consumption value of selling money to the government in the final monetized period of the equilibrium. Superficially, his analysis seems to parallel the argument of Obstfeld and Rogoff (1983) that, absent any backing, there are speculative equilibria where money simply becomes worthless on a finitely distant future date.

As we discuss here, however, there is an obvious, but nonetheless critical, difference between the cases of pure fiat money and hybrid fiat-commodity money: If people can always trade in money for some amount of output, no matter how minuscule, the price of money can never literally be zero, and hence, the price level cannot be infinite, as Cochrane's conjectured steady-state nonmonetary equilibrium supposes. And if that is the case, it is hard to contend that people will nonetheless be happy to do without money. In short, Cochrane's suggested outcome is not a Nash equilibrium, in that individuals will

[4]Indeed, Obstfeld and Rogoff (1983, 1986) show that even a small probability of a trivially small real backing for currency is enough to rule out hyperinflationary bubbles. (Obstfeld and Rogoff 1983 build on Brock 1974, 1975 and Calvo 1979.)

have incentives to behave differently from what he assumes. Therefore, our result stands. It is important to note that in the simplistic money-in-the-utility-function approach of our model (which Cochrane also employs), an individual's derived benefit from holding real balances depends on the behavior of others only through the aggregate price level and does not depend, say, on what percent of the population holds a positive level of money. We argue, however, that in any realistic model of money the same kind of hybrid scheme that we assume will still rule out speculative hyperinflationary equilibria in which the price level explodes even though the money supply is stationary.

This note proceeds by first reprising our argument that credible fractional backing of currency can foreclose the possibility of hyperinflationary equilibria. We then briefly review Cochrane's critique, stressing the point at which we believe he goes wrong. A final example, based on a simplified version of the setup that Wallace (1981) uses, amplifies our point in a setting where the demand for money is motivated quite differently than in our heuristic money-in-the-utility-function model. We conclude with some reflections on the continuing inadequacy of theories of "money," and how this long-standing gap in economic theory bedevils all attempts to pin down rigorously equilibria with pure fiat money, including through the fiscal theory of the price level.

1 Speculative Hyperinflations and Partial Backing: Reprise

We will use the slightly simpler version of the model in Obstfeld and Rogoff (1983, 1986), also employed in Cochrane (2011), which excludes physical capital. Importantly, in this setup the government can always make good any commitment to redeem money partially by levying lump-sum taxes.

Individuals receive y units of the perishable consumption good each period. Let c_t denote an individual's consumption rate at time t, M_t her nominal money holdings, and $\beta \in (0, 1)$ her subjective discount factor. The infinitely lived representative agent maximizes

$$U_0 = \sum_{t=0}^{\infty} \beta^t \left[u\left(c_t\right) + v\left(M_t/P_t\right) \right], \tag{1}$$

where P_t is the price level at time t,subject to

$$M_t - M_{t-1} = P_t(y - c_t) + H_t, \quad M_{-1} \text{ given,}$$

with H_t denoting transfers from the government that the individual takes to be exogenous. We assume that $u(.)$ and $v(.)$ are increasing and strictly concave, with the usual smoothness and Inada properties. The above assumption of separability between the utility from consumption and the derived utility from holding cash balances is quite important, as Obstfeld and Rogoff (1983, 1986) emphasize: Otherwise, even though there may not exist divergent speculative paths, there can still be multiple stable equilibrium paths converging to the same monetary equilibrium (as shown in Obstfeld 1984), a fundamental point to which we return later. The Euler equation characterizing individual optimization is given by

$$\frac{u'\left(c_t\right)}{P_t} = \frac{v'\left(M_t/P_t\right)}{P_t} + \beta \frac{u'\left(c_{t+1}\right)}{P_{t+1}}. \tag{2}$$

Defining real balances as $m_t = M_t/P_t$, and assuming purely for simplicity that the money supply is constant at M, the last equation above can be rewritten as the simple difference equation

$$\beta u'(y) m_{t+1} = m_t[u'(y) - v'(m_t)], \tag{3}$$

where we have imposed the equilibrium condition $c_t = y$. Following the diagrammatic technique of Brock (1974, 1975), we define $A(m) = m[u'(y) - v'(m)]$ and $B(m) = \beta u'(y)m$, in which case the equilibrium can be illustrated graphically as in Figure 1, replicated below from Obstfeld and Rogoff (1983, Figure 2).[5]

[5]Figure 1 assumes that

$$\lim_{m \to 0} m v'(m) = 0,$$

so that the utility level from money balances is bounded from below even as real balances become very small (Obstfeld and Rogoff 1983, Theorem 1). We argued that the case where $v(m)$ becomes unboundedly negative as $m \to 0$ is implausible.

Figure 1 illustrates how, unless the price level starts out exactly at the unique stationary equilibrium level $\bar{P}$, then the price will either implode (if it starts out below the equilibrium level), or grow exponentially (if it starts out above the stationary equilibrium level). As we showed, in a pure fiat money system, it is not possible to rule out explosive bubbles where $m_{T+1} = 0$ (that is, where the price level reaches infinity at time $T + 1$) if the prior path of real balances $\{m_t\}_{t=0}^{T}$ ends at the point $m_T = \widetilde{m}$ where

$$u'(y) = v'(\widetilde{m}). \tag{4}$$

Even though money becomes worthless at $T+1$, it still gives just enough marginal benefit at time T to compensate for the (small) loss of consumption the individual must forgo to hold on to it, which is why P_T can remain finite even when everyone knows $P_{T+1} = \infty$ is imminent.

We went on to show, however, that speculative price bubbles can be ruled out if the government gives even a very small backing ϵ to the currency, sufficient to cap the price level at $\overline{\overline{P}} = 1/\epsilon < \bar{P}$ through the simple arbitrage argument that money can never trade at a price below the value at which the government is willing to redeem it. (In fact, both the probability the government will back the currency and the value of the backing can be uncertain.) It is immediately obvious from Figure 1 that such a price ceiling (a floor on the value of money) implies that all the aforementioned equilibrium hyperinflationary paths must unravel backward, because the price level cannot go to infinity as the equilibrium paths would require.

2 Cochrane's Critique

Cochrane (2011) argues that even if there is a ceiling $\overline{\overline{P}}$ on the price level (a floor $1/\overline{\overline{P}}$ on the price of money), there will still be an equilibrium path leading to a steady state with $P = \infty$ *and* with $M = 0$. He contemplates the possibility of a date-T Nash equilibrium in which all individuals trade their entire money balances to the government at the support price $1/\epsilon$, leaving the economy demonetized thereafter. He writes: "Here is how the hyperinflationary equilibrium actually ends, with the buyback guarantee in place: $P_{T+1} = \infty$" (Cochrane 2011, p. 613).

To support this ultimate equilibrium, Cochrane argues that an individual deciding money demand at the start of penultimate period T will balance the marginal utility of consuming another \$1 against the marginal flow utility from, instead, adding \$1 to money balances over period T *plus* consuming the \$1 at the end of T by trading it to the government at the redemption price $1/\overline{\overline{P}}$. This possibility gives a terminal Euler equation for period T that differs from the one set out above:

$$\frac{u'(c_T)}{P_T} = \frac{v'(M/P_T)}{P_T} + \frac{u'(c_T)}{\overline{\overline{P}}}. \tag{5}$$

Cochrane (p. 613) concludes that in the equilibrium with $c_T = y$, the price level just prior to the government's absorption of the money supply will be slightly below $\overline{\overline{P}}$, and defined implicitly by

$$P_T = \left[1 - \frac{v'(M/P_T)}{u'(y)}\right]\overline{\overline{P}} < \overline{\overline{P}}.$$

Alas, this line of argument, albeit clever, falls afoul of one fundamental difficulty: The last Euler equation requires money to have no value on date $T+1$, that is, $P_{T+1} = \infty$. But the government's promise to redeem money remains good on date $T+1$. Any individual who deviates from the proposed equilibrium and instead carries \$1 into period $T+1$, will be able to sell it on the market to other agents at any real price less than or equal to $1/\overline{\overline{P}} = \epsilon$, because they, in turn, can then sell the \$1 to the government for ϵ in output. That simple arbitrage argument implies that the market price of money on date $T+1$ will not be zero, it will be ϵ, and so the price level will be $\overline{\overline{P}}$, not ∞.

In this case, we need to ask why people would in fact all turn in their money at the end of T, and collectively revert thereafter to barter, when they know the price level will continue to be finite. One could perhaps argue that starting at time $T+1$, everyone suddenly expects that no one will accept currency any longer, even though the government fully backs the currency and even though everyone was accepting currency a period before. Can't we then jump to a new equilibrium in which money is useless for transaction purposes simply because everyone shares the belief that it is? This strikes us as implausible, to say the least, and for two reasons:

1. All the infrastructure for using cash is not going to disappear overnight, nor will the custom of using cash, even if the cash becomes commodity currency rather than fiat currency. If one explores the history of currency (for example, the literature discussed in Rogoff 2016, chapter 2), one finds that the use of currency is surprisingly robust given its seeming fragility in our theoretical models.

2. In a more complex model of exchange—say, one based on specialized endowments—one would be able to convince others to take at least a little money for goods, because they might be able to trade it to someone else, and failing that, could cash it in to the government and be no worse off or barely worse off (depending on the search technology). Thus, accepting a little money should be a dominant strategy. But if everyone is playing that strategy, we return to a monetary equilibrium. That's why history shows that the use of transactions media can spread from relatively small beginnings as economies exploit the resulting network externalities.

Why does Cochrane's argument go aground so fundamentally? He may be tacitly assuming that, once the government redeems money for output in period T, it has then exhausted its ability to redeem money in future periods—in the manner of a central bank that exhausts its reserves defending a fixed exchange rate (Krugman 1979). But that is not the case here—the government's taxing capacity always allows it to redeem money at a sufficiently low price, so why would it withdraw its guarantee after a single period of testing? Our analysis in Obstfeld and Rogoff (1983, 1986) actually is supported by Cochrane's statement on p. 607 of his paper that "Commodity standards...can work in theory...."[6] In our model, money is fiat at price levels below $\overline{\overline{P}}$ but becomes a commodity

[6]If Cochrane's critique is correct, it is hard to see how a commodity standard helps avoid a Nash equilibrium in which everyone simply rejects the fiat money component of the money supply. Incidentally, Cochrane claims in this same sentence that the monetarist model $MV = PT$, with velocity V interest-inelastic, also gives a determinate price level. Not so. The price level can always jump unexpectedly to infinity, demonetizing the economy.

money at $\overline{\overline{P}}$, so we have a hybrid fiat-commodity standard in Wallace's (1981) sense.[7,8]

It is instructive to revisit the rhetorical argument Cochrane (2011, pp. 610–11) advances to support his analysis: "How could offering one kernel of corn for a billion dollars destroy an equilibrium? Given that people were holding money at T that they knew would be worthless at $T+1$, why would a tiny residual value make any difference? It doesn't." The argument is seductive, but what the formal analysis is really saying is that equilibrium speculative hyperinflations are spectacularly fragile, and require very little effort to resist.

3 An Alternative Model

The preceding money-in-the-utility-function framework is a crude shorthand for a much richer multi-good model in which the transactions value of money is derived from its ability to solve the problem of "double coincidence of wants" on the part of inherently heterogenous market actors who might be unable fully to realize the available multilateral gains from trade without using a commonly accepted medium of exchange. Reasonably interpreting the model as capturing a richer underlying multi-good model with heterogenous agents underscores the implausibility of a sudden rejection of a widely used—and backed—currency for no reason whatsoever.

This point is quite clear in Wallace's (1981) overlapping-generations model of money. While arguably unrealistic as a complete model of money demand, it does illustrate

[7] In Obstfeld and Rogoff (1983) we consider only a limiting official buying price for money. Wallace (1981) looks at official buying and selling prices for money. The presence of a ceiling as well as a floor on money's value precludes hyperdeflationary equilibria where $P \to 0$ as well as hyperinflationary equilibria where $P \to \infty$. In Obstfeld and Rogoff (1986) we concluded that reasonable preference restrictions suffice to rule out speculative hyperdeflationary equilibria (that is, those not driven by a falling money supply)—in sharp contrast to the case of hyperinflationary equilibria. Buiter and Sibert (2007) reaffirm this result.

[8] Cochrane (2011, p. 613) conjectures that his results may differ from ours because of a confusion (on our part) between discrete- and continuous-time modeling. He states: "The central problem is Obstfeld and Rogoff's "arbitrage" condition (685) that $\overline{\overline{P}} = P_T$ in any period that people are tendering money. That argument is not valid in this discrete-time model because people can get $v(m)$ plus the redemption value. This arbitrage argument would be valid in a continuous-time version of the model, and perhaps the error comes from mixing correct continuous-time intuition with a discrete-time model." As one can see from the analysis of this section and the next, the question of discrete versus continuous time, as usual, is irrelevant for the substantive economic conclusions.

rigorously how potential gains from monetary trade between heterogeneous agents can underpin the demand for money and lead some individuals to deviate from supposedly nonmonetary equilibria provided the government gives some backing to the currency.[9] Here, we develop a simple example based on Gale (1973) and Brock and Scheinkman (1980).[10]

In this example a generation lives for two periods, receiving an endowment w^y when young and $w^o < w^y$ when old and maximizing

$$U_t = u(c_t^y) + u(c_{t+1}^o) \tag{6}$$

subject to the constraints

$$M_t = P_t\left(w^y - c_t^y\right) = P_{t+1}\left(c_{t+1}^o - w^o\right), \;\; M_t \geq 0, \tag{7}$$

where M_t is the money that a member of the generation born on date t (generation t) carries into its old age in period $t+1$. The utility function $u(c)$ is, as usual, increasing and strictly concave. The assumption that $w^y > w^o$ creates an incentive for the young to acquire money balances so as to smooth their consumption over time—an incentive that can be offset by a sufficiently high expected rate of price-level inflation.

On the tentative assumption that the nonnegativity constraint on money balances will in fact never bind, the intertemporal Euler equation for an individual who is born on date t will be

$$\frac{1}{P_t} u'(c_t^y) = \frac{1}{P_{t+1}} u'(c_{t+1}^o). \tag{8}$$

On the assumption of a fixed aggregate money supply M and again defining aggregate real money balances on date t as $m_t \equiv M/P_t$, equilibrium paths satisfy the difference equation

$$A(m_t) \equiv m_t u'(w^y - m_t) = u'(w^o + m_{t+1})\, m_{t+1} \equiv B(m_{t+1}). \tag{9}$$

[9] As is well known, under perfect certainty, monetary equilibrium in this model might not survive the introduction of dominating assets such as capital.

[10] Sims (2013), also in an overlapping-generations framework, develops the related idea that monetary equilibrium becomes unique if the government each period levies taxes to repurchase some money (in contrast to the offer of a free put option that we model here).

There is a steady-state positive level of real balances $\overline{m}$ that satisfies $A(\overline{m}) = B(\overline{m})$, and therefore a finite steady-state price level given by $\overline{P} = M/\overline{m}$. Figure 2 illustrates the determination of this Pareto-optimal steady state, but also shows there are other, inefficient equilibria (for example, the speculative hyperinflationary path starting at $m = m_0$) such that money asymptotically becomes worthless. The intuition is the same as in the Brock model.[11] However, in parallel to the Brock model, a government promise to redeem money for a small amount ϵ of goods effectively caps the price level at $\overline{\overline{P}} = 1/\epsilon$, and this fact therefore rules out all paths but the steady-state path, because those paths are supported only by the self-fulfilling expectation of an ever-increasing path of prices.

An important nuance here is that absent any backing, there is a second steady-state equilibrium other than the monetary equilibrium $\overline{m}$, in which money is rejected instantly and entirely. In the nonmonetary equilibrium, people do not use money simply because no one else uses money—everyone thinks money is useless and will be forever, and so it is. Here, $P = \infty$ (permanently) and $m = 0$, so money is irrelevant: each generation is restricted to consuming its own current endowment. Instant rejection of money is a legitimate equilibrium, albeit an inefficient one. A date-t young person might *wish* for a way to transfer some savings into old age, but would never pay a positive price for money on date t if the money will be worthless on date $t+1$. In other words, no individual young person would deviate from a date-t equilibrium with $P_t = \infty$ so long as she knows that $P_{t+1} = \infty$. And the date-$(t+1)$ young will act the same, knowing that $P_{t+2} = \infty$, and so on, *ad infinitum*.

Things are different if the government guarantees for all dates a small redemption

[11]For simplicity, the figure shows the simple special case in which $u(c) = \ln(c)$, but our main points carry over more generally. In the logarithmic case, $\overline{m} = \frac{1}{2}(w^y - w^o)$. The equilibrium of this economy when there is no money is inefficient. The government can raise every generation's welfare, however, by endowing the initial old with the stock of money M, which they immediately sell to the initial young for output, allowing the initial young to do the same next period when they are old and have lower income. The result will be efficient if the price level settles immediately at $\overline{P}$ and stays there forever. But as our diagram shows, this need not happen if the market is left to find the equilibrium on its own—and this is where the government's partial backing of money is helpful. For a lucid discussion of the welfare economics of the overlapping-generations model, see Weil (2008). Figure 2 (the main features of which are valid more generally) makes clear that the nonnegativity constraint on money holdings will never bind in any equilibrium. The figure also shows that speculative hyperdeflations cannot arise in equilibrium (because the real money balances proferred by the old can never exceed the endowment of the young).

value for money, ϵ. To see why, let's ask if there is a Cochrane-like equilibrium where on some date t, the old suddenly tender their money to the government for backing at the price $1/\overline{\overline{P}} = \epsilon$ and the price level then jumps permanently to $P = \infty$.

The easy answer is no. Any individual young person can dissuade an old person from exchanging their money with the government by offering to pay them instead the price $\epsilon + \eta$, where $\eta > 0$ is arbitrarily small. Because the autarky (nonmonetary) consumption levels over the young person's lifetime would satisfy $u'(w^o) > u'(w^y)$, she can raise her utility by purchasing money at $\epsilon + \eta$ from an old person and selling it at ϵ to the government later when she, herself, is old—provided η is small enough. The alleged equilibrium therefore collapses, just as the analogous one collapses in the Brock model.

4 Concluding Remarks

The main point of Cochrane's (2011) paper is that multiple equilibria are endemic to monetary models, which calls into question the assumptions they impose to determine the price level. Rather than make a dubious argument about explosive speculative price paths with stationary money supplies (a phenomenon that as far as we know has never been observed), it would have been far simpler to follow Obstfeld and Rogoff's (1983) emphasis on the point (familiar from an earlier literature, including Obstfeld 1984) that if the utility function in consumption and real balances is not separable, there can exist multiple non-explosive equilibria, leading to the type of concern Cochrane raises in his article.

As Hahn (1965) argued over a half century ago, the absence of a rigorous and realistic theory of money opens up the possibility of multiplicities such as the nonmonetary equilibrium, and this is a continuing discomfort for macroeconomics. Kydland and Prescott (1982) attempted to side-step the problem by arguing that macroeconomics could do completely without money. That view seems wildly inconsistent with the facts. More recently, models such as the Taylor-rule models Cochrane criticizes avoid the need to model money demand by effectively postulating an infinitely elastic supply curve for money at the level of the policy interest rate—Woodford (2003) makes this point very explicitly. But as Cochrane's discussion indicates, uniqueness of the price level in those models cannot be assessed without a deeper understanding of the nature of money and of money demand.

The "fiscal theory of the price level" is yet another in the series of attempts to get around the fundamental theoretical indeterminacy in monetary models by sweeping the problem under the rug. But we doubt Cochrane's contention that this approach succeeds where all others fail. For one thing, the fiscal theory of the price level assumes away default (as well as its cousin, financial repression) for convenience. But anyone familiar with the literature on sovereign debt will know that it is replete with multiple-equilibrium issues (see Obstfeld and Rogoff 1996), which in turn would affect the uniqueness of equilibrium in a fiscal theory of the equilibrium price level. Financial repression (Reinhart, Kirkegaard, and Sbrancia 2011) gives additional avenues for governments to balance budgets without outright inflation. Multiple equilibria could also arise from the government's fiscal policy rule—which, in turn, would arise in an equilibrium reflecting private-sector and government objectives and constraints (Bassetto 2002). Finally and perhaps most fundamentally, provided some money yields a nominal return below the market rate of interest, the consolidated government budget constraint depends on seigniorage revenue, which in turn is driven by the demand for money and hence (in general) by expectations. This dependence, too, opens the door to multiple equilibria. Once again, we do not have a satisfactory theoretical account of why governments can issue (monetary) liabilities at below-market rates of interest (Wallace 1988), but given the reality of seigniorage from money creation, the fiscal theory remains incomplete as a model of price-level determination. In sum, it seems to us extremely unlikely that there is any simple mechanical way to rule out multiple equilibria in macroeconomic models with pure fiat money, and we agree that the problem is understated in the literature.

The truly striking thing about monetary equilibria with government-issued fiat money is that, contrary to the tenuousness predicted by our theoretical models, they seem to be remarkably stable and robust. To set off a monetary hyperinflation, it takes a large-scale government resort to monetary finance of deficits—a fiscal theory, not of the price level in general, but of its instability. And in such circumstances, there are always broader questions about more pervasive institutional breakdown—as Lerner (1947) put it, money is a "creature of the state."[12] While it goes too far to argue that the literature on money has made no progress at all, there clearly remains a difficult puzzle to be solved.

Credible partial backing of the currency does rule out at least one possible type of indeterminacy: speculative hyperinflations unrelated to fundamentals. Cochrane's (2011) resistance to that simple idea is puzzling, because in our model (as in any commodity standard), it is essentially fiscal policy that makes the price level determinate, quite in line with the insight of the fiscal theory that the equilibrium price-level path must be consistent with the public sector's intertemporal budget constraint. In the hyperinflationary equilibria in Figures 1 or 2, the government confronts a declining path of real money demand by the public. It avoids a loss of seigniorage revenue by letting the inflation tax erode the public's real balances over time—eventually to zero. On the other hand, the government could promise to levy lump-sum taxes to repurchase money at a given price-level trigger. In that case, if the price level ever reached the trigger level, seigniorage revenue would indeed fall as the government purchased money, with the higher taxes matching the seigniorage loss and thereby balancing the public budget. This promise turns out to be a (credible) off-the-equilibrium-path threat, in that it eliminates Nash equilibria other than the monetary steady state.

There may well be other approaches to tying down the price level. The problem of multiple equilibria in monetary economies certainly remains a profound one. But it is an overstatement to say that standard models do not offer any solutions at all, nor do we see a strong case for the argument that the fiscal theory of the price level offers more general and profoundly better ones.

[12] Lerner (1947) suggested that a monetary equilibrium is assured if the government requires money in payment of taxes. Brock and Scheinkman (1980) explored this avenue further.

References

Bassetto, Marco. "A Game-Theoretic View of the Fiscal Theory of the Price Level." *Econometrica* 70 (November 2002): 2167–2195.

Brock, William A. "Money and Growth: The Case of Long-Run Perfect Foresight." *International Economic Review* 15 (October 1974): 750–777.

Brock, William A. "A Simple Perfect-Foresight Monetary Model." *Journal of Monetary Economics* 1 (April 1975): 133–150.

Brock, William A. and José Alexandre Scheinkman. "Some Remarks on Monetary Policy in an Overlapping Generations Model." In John H. Kareken and Neil Wallace, eds., *Models of Monetary Economies.* Minneapolis, MN: Federal Reserve Bank of Minneapolis, 1980.

Buiter, Willem H. and Anne C. Sibert. "Deflationary Bubbles." *Macroeconomic Dynamics* 11 (4, 2007): 431–454.

Calvo, Guillermo A. "On Models of Money and Perfect Foresight." *International Economic Review* 20 (February 1979): 83–103.

Calvo, Guillermo A. *Macroeconomics in Times of Liquidity Crises: Searching for Economic Essentials.* Cambridge, MA: MIT Press, 2016.

Canzoneri, Matthew B., Dale W. Henderson and Kenneth S. Rogoff. "The Information Content of the Interest Rate and Optimal Monetary Policy." *Quarterly Journal of Economics* 98 (November 1983): 545–566.

Cochrane, John. H. "Determinacy and Identification with Taylor Rules." *Journal of Political Economy* 119 (June 2011): 565–615.

Gale, David. "Pure Exchange Equilibrium of Dynamic Economic Models." *Journal of Economic Theory* 6 (1973): 12–36.

Hahn, Frank H. "On Some Problems of Proving the Existence of an Equilibrium in a Monetary Economy." In F. H. Hahn and F. P. R. Brechling, eds., *The Theory of Interest Rates.* London: Macmillan, 1965.

Krugman, Paul. "A Model of Balance-of-Payments Crises." *Journal of Money, Credit and Banking* 11 (August 1979): 311–325.

Lerner, Abba P. "Money as a Creature of the State." *American Economic Review, Papers and Proceedings* 37 (May 1947): 312–317.

Kydland, Finn and Edward Prescott. "Time to Build and Aggregate Fluctuations." *Econometrica* 50 (November 1982): 1345–1370.

Obstfeld, Maurice. "Multiple Stable Equilibria in an Optimizing Perfect-Foresight Model." *Econometrica* 52 (January 1984): 223–228.

Obstfeld, Maurice, and Kenneth Rogoff. "Speculative Hyperinflations in Maximizing Models: Can We Rule Them Out?" *Journal of Political Economy* 91 (August 1983), 675–687.

Obstfeld, Maurice, and Kenneth Rogoff. "Ruling Out Divergent Speculative Bubbles." *Journal of Monetary Economics* 17 (1986) 349–362.

Obstfeld, Maurice, and Kenneth Rogoff. *Foundations of International Macroeconomics.* Cambridge, MIT Press, 1996.

Reinhart, Carmen M., Jacob F. Kirkegaard, and M. Belen Sbrancia. "Financial Repression Redux." *Finance and Development* 48 (June 2011): 22–26.

Sims, Christopher A. "Paper Money." *American Economic Review* 103 (April 2013): 563–584.

Rogoff, Kenneth. *The Curse of Cash.* Princeton University Press, 2016.

Wallace, Neil. "A Hybrid Fiat-Commodity Monetary System." *Journal of Economic Theory* 25 (December 1981): 421–430.

Wallace, Neil. "A Suggestion for Oversimplifying the Theory of Money." *Economic Journal* 98, no. 390 (1988): 25–36.

Weil, Philippe. "Overlapping Generations: The First Jubilee." *Journal of Economic Perspectives* 22 (Fall 2008): 115–134.

Woodford, Michael. *Interest and Prices: Foundations of a Theory of Monetary Policy.* New York: Princeton University Press, 2003.

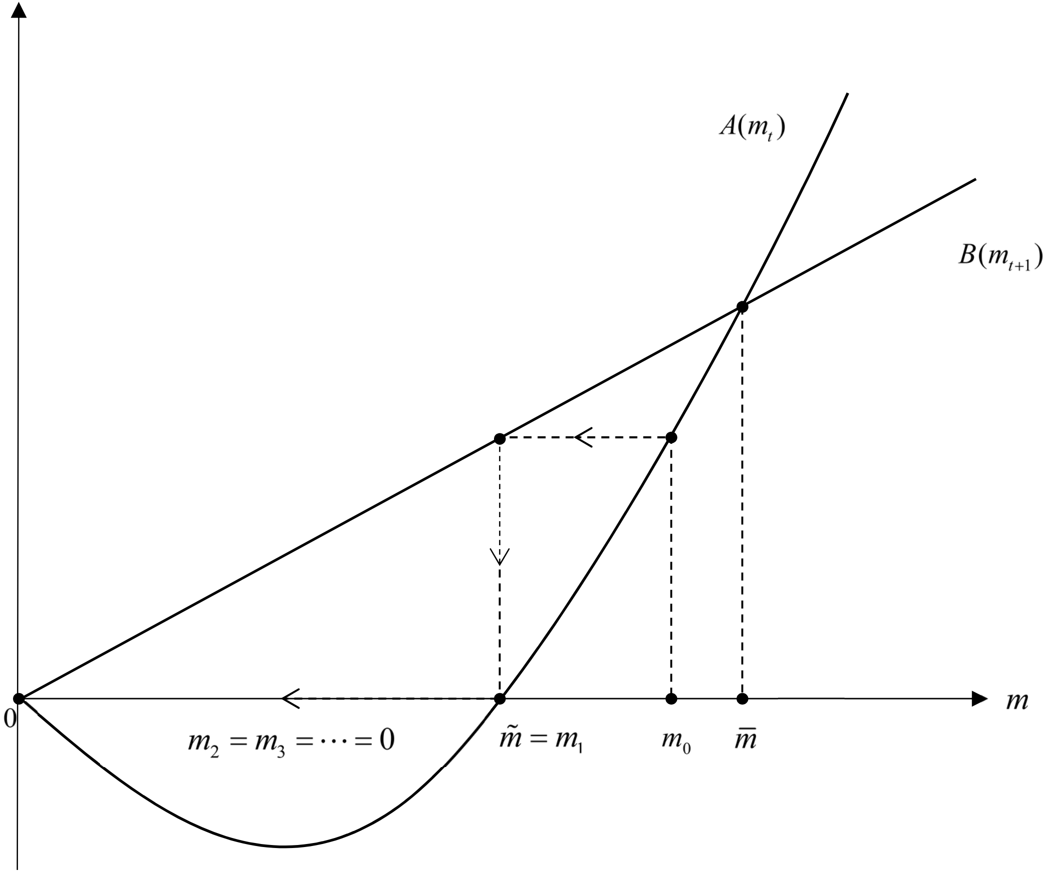

Figure 1: Speculative hyperinflation in the Brock representative-agent model

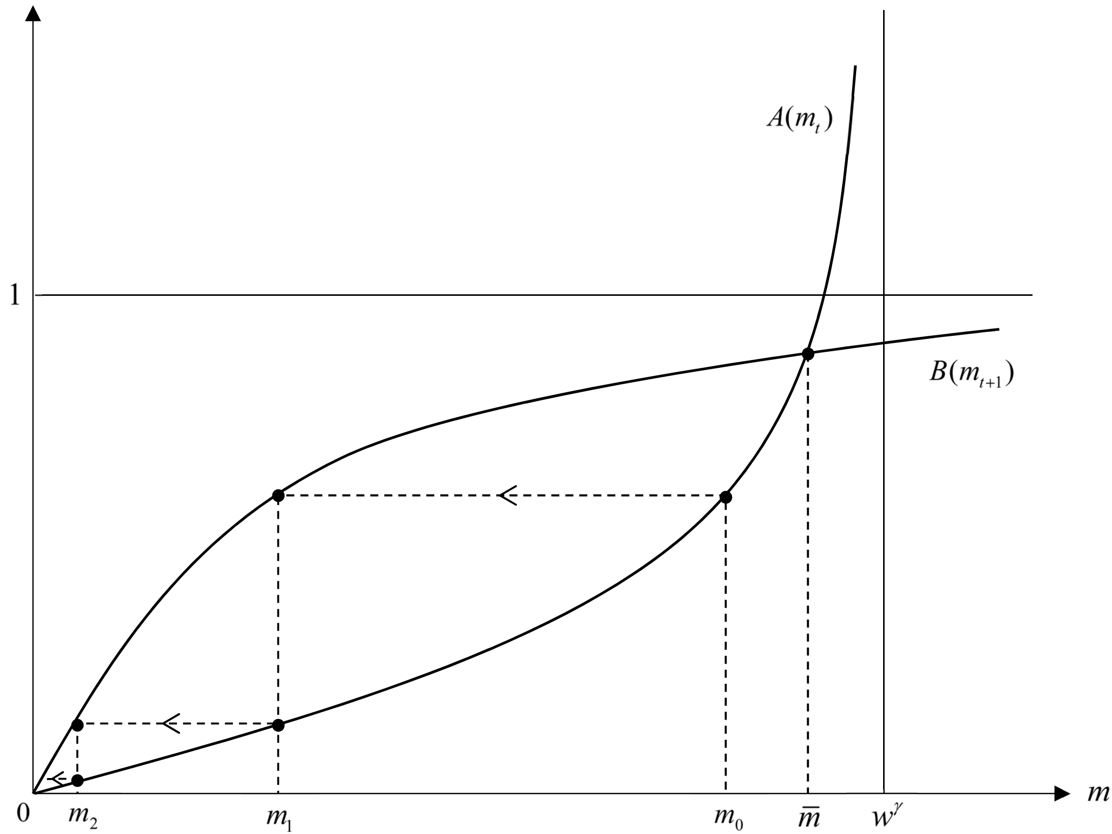

Figure 2: Speculative hyperinflation in an overlapping-generations model