On the Benefits of Currency Reform*

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Abstract

Money allows agents to achieve allocations that are not possible without it. However, currency in most economies is a uniform object, and there may be incentive compatible allocations that cannot be implemented with a uniform currency. We show that *currency reform*, ie, changing the monetary base by replacing one currency with another, is a powerful tool that can enable a central authority to achieve its desired allocation. If this central authority is also benevolent, then this allocation is constrained efficient. Our monetary mechanism with currency reform is *anonymous* and features *non-linear* pricing of consumption goods and future assets, as observed in practice. Our result suggests that currency reform is rarely seen in practice precisely because it is such a powerful tool and none but the most benevolent planner can be trusted to use it wisely.

1. Introduction

Money has been a fact of economic life for thousands of years because it helps the agents in economy achieve desirable outcomes. Money is said to be *essential* to an economy if it allows the agents to achieve allocations that are unachievable without it. For instance, money is essential in settings with an absence of double-coincidence of wants. Indeed, a good part of modern monetary theory focuses on finding environments where money is essential and a useful way to find such settings is by focusing on frictions

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(eg, informational or search) that render Arrow-Debreu allocations infeasible; this is the so-called 'mechanism design approach to monetary theory' — see Wallace (2010) for an overview. However, the analysis in such models typically restricts attention to the case of a uniform currency, ie, to models where there is only one form of currency.[1] We demonstrate (in Theorem 1) that such a restriction to uniform currencies restricts the set of attainable outcomes.

More precisely, abstract revelation mechanisms provide us with an upper bound on what is achievable, and it is a straightforward observation that currency reform can (weakly) improve upon a monetary mechanism. We provide an example of a dynamic environment with private information in which currency reform can actually achieve this upper bound, ie, currency reform can implement the central authority's chosen allocation. Our environment is the one described by Atkeson and Lucas (1992) (henceforth, AL), but it is clear that currency reform can often provide a *strict* improvement over a monetary mechanism. In particular, it follows immediately that currency reform can implement mechansisms in all environments that have the *one-dimensional summary statistic* property, ie, environments where past public and private histories can be summarised through a one-dimensional statistic.[2]

Our monetary mechanism with currency reform has the feature that it is *predictable* in the sense that it only depends on information available to the central authority at the start of the period, and it is *anonymous* in that agents' private histories remain private and are not known to the central authority. It also features *non-linear* pricing of consumption goods and future assets, as observed in practice (see Section 5.2 for some examples).[3]

Even though the central authority does not know any individual agent's history, we assume that the central authority knows the *distribution* of money and asset holdings in the economy. Theorem 1 shows that as long as the central authority can issue (and trade) currency and one-period option contracts, it can implement any allocation that is incentive compatible, even ones that rely on observable histories.

To see how currency reform can improve on allocations achieved with a uniform currency, suppose that histories are unobservable, and so the central authority cannot distinguish agents, and that the central authority uses a uniform currency to implement

(1) Typically, given a uniform currency, questions about taxation and fiscal policy are then posed.

(2) There is a large class of environments that satisfy the one-dimensional summary statistic property, as demonstrated by Kocherlakota (2002).

(3) Non-linear pricing also plays an essential role in other works like Kocherlakota (2003) and Andolfatto (2010) that we review below.

allocations. Notice that the central authority would like to achieve two things at any instant. It would like agents to truthfully reveal their current private information, and it would also like for them to reveal their past history. The first can be achieved by non-linear pricing (or non-linear taxation). However, the second is much harder to achieve if agents can save currency over time and if these savings are not observable. (Indeed, principal-agent problems where the agent has private savings are notoriously difficult. We provide below a discussion of how the literature addresses this problem.)

Currency reform solves these problems by allowing for a non-linear rate of exchange between currency at one date and the next. This is akin to non-linear pricing and works in exactly the same fashion. But crucially, currency reform also kills any incentive to save currency for future use. This is because with currency reform, the introduction of a new currency means that a currency that is saved will never be used again, and so becomes worthless. Now that savings are no longer an issue, the central authority can keep track of histories by summarising them in money holdings and having non-linear pricing for the consumption good.

Throughout we refer to a central authority rather than a planner, because we want to emphasise that our central authority need not be benevolent, and need not be maximising social welfare. All that is needed in our scheme is that the central authority be like a Central Banker who exchanges one currency for another at a certain rate. This Central Banker is more like a price discriminating monopolist, in that he sets non-linear exchange prices between currencies, than a traditional planner or a (Myersonian) mediator in the sense of mechanism design.

Our results lead naturally to the question, Why is currency reform so rare in practice? Most monetary models presuppose that there is a uniform currency, but this assumes away the question. Our results suggest that currency reform is a powerful tool, so powerful, in fact, that none are trusted with it. Indeed, we note, that currency reform seems to occur mainly in countries that are closer to the 'totalitarian' rather than 'democratic' end of the spectrum. (See Section 5.2 for more some instances.)

The remainder of the paper is organised as follows. In Section 1.1, we discuss related literature. Section 2 introduces the environment and recursive revelation mechanisms, while Section 3 describes a monetary mechanism featuring currency reform, ie, a monetary mechanism with a new currency in each period, that implements the recursive revelation mechanism in question. In Section 5.2, we describe some events in the last century that have featured currency reform. This is not an exhaustive list, but is intended to provide a flavour of what currency reform entails in practice. We emphasise that the environment in Section 2 has private information and full commitment.

1.1. Related Literature

We study a typical dynamic environment with private information, as described in AL. AL provide a description of the second best allocation in this economy. They (and others) have tried to implement it with uniform currency and simple assets, but don't reach the second best. Indeed, with only a uniform currency, Lucas (1978) shows that the unique equilibrium allocation is necessarily far away from the second best.[4] We show that if the central authority is endowed with the tools of currency reform, then the second best allocation can be implemented.

Our use of money is inspired by the literature that takes the mechanism design approach to monetary theory; see, for instance, the survey by Wallace (2010). However, most of this literature seeks to use the theory of mechanism design to, as Wallace (2010, p. 21) puts it, ' … explain as an optimum three features of most actual economies: currency is a uniform object; currency is (usually) dominated in rate of return; some transactions are accomplished using currency and others are accomplished in other ways'. In contrast, we directly use money and the mechanism design approach to implement optimal mechanisms, while emphasizing that we explicitly relax the assumption of a uniform currency. Our finding that relaxing the assumption of uniform currency attains a much richer set of allocations poses a challenge for this literature which aims to rationalize the aformentioned facts (eg, uniform currency) via the optimal design perspective.

Our findings are broadly in line with the findings in papers that accomplish improving the equilibrium allocation by endowing the central authority with additional tools. For instance, Kocherlakota (2003) shows how nonlinear pricing allows both the existence of money and an asset that dominates it, while also providing the central authority an additional instrument to screen agents with different taste shocks. Also of note is Andolfatto (2010), who demonstrates that nonlinear pricing can lead to Pareto improvements in the model of Lagos and Wright (2005).

Green (1987) considers an economy with private taste shocks, which also results in uninsurable risk, and then computes the efficient allocation from risk sharing with

(4) Indeed, the unique equilibrium allocation with a uniform currency is stationary (ie, constant across agents and over time), as is the distribution of money holdings. See Lucas (1992) for a fuller discussion and comparison of Lucas (1978) and AL.

an outside lender for a specific class of preferences. His environment is a precursor to the one considered by AL. Lucas (1992) provides an exhaustive literature review of earlier work on risk sharing in the large with private information.

Even though we work with the environment studied in AL, our results extend to all environments with the one-dimensional summary statistic property. These are environments where past signals and/or reports can be summarised by a one-dimensional variable. Kocherlakota (2002) shows that there is a large class of environments with this property. The main difference between his environment and ours is that we allow for instantaneous private information that affects social surplus, while he doesn't.

Our results should also extend to environments where agents can privately save money holdings. For instance, the ability to store privately[5] means that preferences over continuation problems are no longer common knowledge and are not known to the central authority. Private savings in an economy with money is a harder problem to handle, because the value of stored money is determined in equilibrium.[6] It is precisely this hurdle that the creation of new money overcomes, by ensuring that the value of saved currency is exactly zero, thereby forcing agents to exchange all their money holdings in each period. (See below in Section 5.2, the plight of the poor North Koreans whose savings came to nought after the North Korean government reformed the currency.)

2. Environment

Let us first describe the environment of Atkeson and Lucas (1992). Time is discrete. There is a continuum $\mathcal{H}$ of agents with a typical agent being denoted by h, and at each date $t = 0, 1, \ldots$, there is an amount y_t of resources, that we shall call *cake*, that is to be divided among the agents. Each agent's utility from cake is $\theta u(c)$, where c is the agent's consumption of cake, $u : \mathbb{R}_+ \to \mathbb{R} \cup \{-\infty\}$ is an increasing, smooth, and strictly concave function, and $\theta \in \{\theta_1, \theta_2\}$ is a *taste shock* where $0 < \theta_1 < \theta_2$. The probability of θ_i occurring is μ_i, and taste shocks are iid across agents and over time. We assume, without loss of generality, that $\theta_1\mu_1 + \theta_2\mu_2 = 1$. All agents discount the future at the common rate $\beta \in (0, 1)$.

(5) For example, Cole and Kocherlakota (2001) consider a setting where agents have endowments that are iid over time and can also be stored, both publicly as well as privately, and both at the same rate of return.

(6) For a more complete discussion of dynamic moral hazard with and without saving, see Sannikov (2008).

Let $D := u(\mathbb{R}_+) \subset \mathbb{R} \cup \{\pm\infty\}$, where we allow $u(0) = -\infty$. Then, the utility of a (possibly random) consumption sequence (c_t) is $(1-\beta)\,\mathbf{E}\sum_{t=0}^{\infty} \beta^t u(c_t)$.[7] Therefore, each agent's lifetime utility must lie in D. Let $C : D \to [0, \infty)$ be defined as $C(x) = u^{-1}(x)$, so $C(x)$ is the amount of cake consumed by an agent who gets x utiles of instantaneous consumption, modulo taste shocks.

There are two (equivalent) versions of the central authority's problem. First, given a fixed amount of cake per period (say, unit cake per capita), the central authority's problem is to maximise ex ante expected social welfare. A dual characterisation of the problem is to consider an initial level of utility to be promised to each agent, and then to find the least amount of cake required to make good on the promises.

We first consider the case where central authority can observe past reports.

2.1. Allocation Mechanisms in Atkeson and Lucas (1992)

In this section, we assume that the central authority can identify individuals via their history of reports. Of course, the central authority cannot actually observe an agent's taste shocks.

An agent in this economy only cares about his expected utility. Thus, we may identify an agent with the utility promised to him; an agent's promised lifetime utility is $w \in D$. Because taste shocks are iid, promised utility completely summarises an agent's past history of reports. Let $\mathbf{M}$ denote the space of probability of measures on D. A probability measure $\psi \in \mathbf{M}$ denotes the distribution of promised utilities to agents in the economy.

A ***recursive revelation mechanism*** is a triple $\sigma = (f, g, \psi_0)$ where $f, g : \{\theta_1, \theta_2\} \times D \times \mathbf{M} \to D$ are functions that respectively denote the instantaneous and continuation utilities of an agent who has taste shock θ, promised utility w, and where $\psi_0 \in \mathbf{M}$ is an initial distribution of promised utilities.[8] As mentioned above, each agent with a promised utility level of w is clearly identifiable as such, ie, each agent is identified with the utility promised him. In each period, he makes a report $\hat{\theta} \in \Theta$ to the planner and then gets an allocation of cake which yields instantaneous utility $f(\hat{\theta}, w, \psi)$, and some continuation utility $g(\hat{\theta}, w, \psi)$ that will identify him tomorrow.

(7) The term $(1-\beta)$ ensures that expected lifetime utility is measured in the same units as instantaneous consumption.

(8) For simplicity, we take ψ_0 to be given. In particular, the socially welfare maximising amount has ψ_0 as a Dirac point measure.

Given the function g and the distribution ψ, the following period's distribution of promises is denoted by $\mathsf{S}_g\psi$, so $\mathsf{S}_g : \mathbf{M} \to \mathbf{M}$ can be regarded as a Markov transition operator.[9] Finally, ψ_0 denotes the initial distribution of promised utility. Therefore, given w and ψ, an agent's (ex ante) lifetime expected utility under the policy σ is $\sum_i \mu_i\big[(1-\beta)\theta_i f(\theta_i, w, \psi) + \beta g(\theta_i, w, \psi)\big]$.

A recursive revelation mechanism σ

- *attains ψ with resources y* if the total amount of cake that is disbursed is feasible, ie, if

$$\sum_i \mu_i \int C\big(f(\theta_i, w, \psi)\big)\, \mathrm{d}\psi(w) \leq y$$

- is *incentive compatible* if for all $\theta, \theta' \in \{\theta_1, \theta_2\}$

$$(1-\beta)\theta f(\theta, w, \psi) + \beta g(\theta, w, \psi) \geq (1-\beta)\theta f(\theta', w, \psi) + \beta g(\theta', w, \psi)$$

- and satisfies ***promise keeping***[10] if

$$\sum_i \mu_i\big[(1-\beta)\theta_i f(\theta_i, w, \psi) + \beta g(\theta_i, w, \psi)\big] = w$$

We shall restrict attention to mechanisms with the following boundedness property. Given the mechanism σ and an initial level of utility w_0, we can inductively define the agent's continuation utility in period $t+1$ as a function of all the past reports as follows: $w_{t+1} := g(\hat{\theta}_t, w_t, \psi_t)$, where $w_t : D \times \Theta^{t-1} \to D$. Intuitively, this expression reflects the fact that the mechanism is Markovian in promised utility. We require that the mechanism satisfies the following version of the transversality condition: for all initial $w_0 \in D$ and $(\hat{\theta}_t) \in \Theta^\infty$,

$$\lim_{t\to\infty} \inf_{(\hat{\theta}_t)\in\Theta^\infty} \beta^t w_t(w_0, \hat{\theta}^{t-1}) = 0$$

where $\hat{\theta}^{t-1} \in \Theta^{t-1}$ for all t.

AL consider the dual version of the central authority's problem, wherein it tries to make good on the promises ψ_0 with the least amount of resources. AL show that at

(9) Formally, $(\mathsf{S}_g\psi)D_0 := \int_{B_g(D_0)} \mathrm{d}\mu\, \mathrm{d}\psi$, where $B_g(D_0) := \{(\theta, w) \in \Theta \times D : g(\theta, w, \psi) \in D_0\}$ for all Borel $D_0 \subset D$.

(10) Because there is a continuum of agents, it suffices to consider the promise keeping condition in expectation

the (second best) optimum, income distribution eventually becomes extremely skewed, with the fraction of agents who become immiserated (ie, whose utility goes off to minus infinity) eventually becoming 1. AL also try and decentralise this optimal allocation, but standard instruments like money are insufficient in that they cannot achieve the second best outcome. This is because standard instruments like money or additional assets are unable to screen agents across all histories. We address this issue next.

In trying to implement the optimal allocation, AL consider money or assets, and assume that there is a central authority who can issue these instruments. Following AL, we too consider a central authority that can issue currency and certain assets, but cannot identify agents because he (or it, in the case of a central authority) cannot observe the currency and asset holdings of any individual agent (though he does know the distribution of both). The central authority is also a clearinghouse where assets are exchanged for other assets at some exchange rate that he sets.

3. Monetary Mechanisms with Currency Reform

We shall now assume that at each point in time, the central authority (or the Central Banker) can costlessly print paper currency of different amounts. In particular, we shall assume that the central authority can print (perfectly divisible) paper currency. We shall also allow the central authority to print paper currency in different ***colours***. Instead of enumerating the colours as *red, blue, green,* ..., and so on, we shall, for simplicity, let the set of colours available be $\mathbb{N} = \{0, 1, 2, \dots\}$. Let ξ_t denote a typical distribution of money holdings of colour t, and let $\mathbf{M}_t$ denote the space of all distributions of money of colour t. We assume that the Central Banker

- Can observe the distribution of money holdings in each period (but cannot observe individual money holdings),
- Can create money of requisite amounts in any colour, and
- Is the only entity in the economy that can print money, so there is no counterfeiting and nor is there the threat of counterfeiting.

A ***monetary mechanism*** is a mechanism where agents trade money with the central authority in return for cake and some more money. A monetary mechanism of the kind described in Lucas (1978) (but also see Lucas 1992) features a uniform currency. A monetary mechanism features *currency reform* if the currency is transformed into another currency at some point in time. (This is also referred to as changing the monetary base.) Note that the transformation need not be 1-to-1. A monetary mechanism features *radical* currency reform if the currency base is changed in every period.

It is useful to define our notion of implementation.

Definition 3.1. Let $\sigma = (f, g, \psi_0)$ be a recursive revelation mechanism. It is implementable by a monetary mechanism if the outcome induced by the monetary mechanism corresponds to the outcome of the recursive revelation mechanism.

We can now state our main theorem.

Theorem 1. *Let σ be a recursive revelation mechanism. Then, there is a monetary mechanism featuring radical currency reform that implements it. In particular, second best (Pareto efficient) allocations are implementable by monetary mechanisms with radical currency reform.*

A typical problem with trying implement an allocation with a monetary mechanism is that agents can burn money or hide it for future use. As a result, the observed money holdings do not effectively reveal past histories. The monetary mechanism that we propose effectively eliminates the agents' incentives to burn or save money.

Radical currency reform, which changes the currency base in each period by withdrawing currency of a particular colour from distribution after one period of use, ensures that an agent does not have an incentive to save money from one period to another. (This is a fact well recognised by the North Korean regime, for instance; see Section 5.2 below.) By using an additional instrument that we introduce in the next section, the central authority can ensure that an agent also does not have an incentive to burn money. Put together, these features ensure that any incentive compatible recursive revelation mechanism can be realised as the outcome of a monetary mechanism with radical currency reform.

We shall now describe a monetary mechanism that can implement any recursive revelation mechanism σ, including the one that implements the second best allocation.

4. A Monetary Mechanism with Radical Currency Reform

We begin with some notation. A ***period-t option contract*** $A_t = \{(c_i, m_{i,t}) : c_i \geqslant 0 \text{ and } m_{i,t} \in \mathbb{R} \text{ for } i = 1, 2\}$, where c_i is an amount of cake for consumption and $m_{i,t}$ is an amount of currency of colour t. (Intuitively, we provide one pair $(c_i, m_{i,t})$ for each type of an agent.) The set of all period-t option contracts is denoted by $\mathscr{A}_t$. Before describing the mechanism, we shall sketch the timing of the interactions.

Consider period t. Every agent enters the period with an option contract, that is, a menu of choices. Each choice in this menu will give him some consumption in period t and some amount of money holdings m_t.

Each period has four stages, and the timing is as follows:

Time $t.0$**:** Agent $h \in \mathscr{H}$ enters the period with the option contract $A_t^h \in \mathscr{A}_t$.

Time $t.1$**:** Agent h realises taste shock θ_i, and makes a choice, ie, makes a choice from the set A_t^h.

Time $t.2$**:** The central authority executes the options chosen by each agent, so each agent gets some instantaneous consumption c_i^h and some amount of currency $m_{i,t}^h$.

Time $t.3$**:** Agent h takes his money holdings $m_{i,t}^h$ and goes to a market to buy an option contract for the next period, $A_{t+1}^h \in \mathscr{A}_{t+1}$, taking prices as given.

We are now ready to describe our monetary mechanism.

Definition 4.1. A ***radical monetary mechanism*** consists of currencies with colours $t \in \mathbb{N}$ (and amounts in $\mathbb{R}$), option contracts $A_t \in \mathscr{A}_t$, a distribution of period t money holdings $\xi_t \in \mathbf{M}_t$, a period-t pricing function $\mathbf{p}_t : \mathscr{A}_{t+1} \times \mathbf{M}_t \to \mathbb{R}$ for period $t+1$-option contracts, in terms of currency of colour t, and an initial, period 0 allocation of option contracts $A_1^h \in \mathscr{A}_1$ for every agent $h \in \mathscr{H}$. The mechanism proceeds as follows:

Date 0 At date $t = 0$, agent h is given the option contract (ie, the menu) $A_1^h \in \mathscr{A}_1$.

`Enter period` $t = 1$.

Date 1.1 After agent h observes his private taste shock (at time 1.1), let him exercise his option, ie, let agent h choose $(c_i^h, m_{i,1}^h)$ from the menu A_1^h.

Date 1.2 Execute options (at time 1.2) throughout the economy, so agent h gets consumption c_i^h and money holdings $m_{i,1}^h \in \mathbb{R}$. Record resulting distribution of money holdings ξ_1.[11]

Date 1.3 Fix a pricing function $\mathbf{p}_1 : \mathscr{A}_2 \times \mathbf{M}_1 \to \mathbb{R}$ for period-

2 option contracts, where the price is in terms of currency of colour 1. Let agents exchange (at time 1.3) their money holdings of first period money for an option contract in $\mathscr{A}_2$, with the understanding that there is no credit, ie, agent h can purchase $A_2 \in \mathscr{A}_2$ if, and only if, his money holdings m_1^h exceed $\mathbf{p}_1(A_2, \xi_1)$, the price of option contract A_2.

End period $t = 1$.
Enter period $t = 2$

Date 2.1

Repeat as in period 1 ...

We are now in a position to prove Theorem 1.

Proof of Theorem 1. The proof consists of constructing the appropriate monetary mechanism. Fix a recursive revelation mechanism $\sigma = (f, g, \psi_0)$. As we will see below, all money holdings $m_{i,t}$ will be in the set D, and will correspond to promised utiles in an appropriate way.

At time 0, consider agent h who will receive expected utility w from the mechanism. Give agent h the option contract $A_1^h \in \mathscr{A}_1$, where

$$A_1^h := \{(c_i^h, m_{i,1}^h) : c_i^h := C\big(f(\theta_i, w, \psi_0)\big),\; m_{i,1}^h := g(\theta_i, w, \psi_0),\; i = 1, 2\}$$

where ψ_0 be the original distribution of promised utilities. More generally, consider period t, and in particular, time $t.3$, after the central authority has executed the options. Suppose the distribution of money holdings of colour t is given by ξ_t. Construct option contracts $A_{t+1}(m_t, \xi_t) \in \mathscr{A}_{t+1}$ as follows:

$$A_{t+1}(m_t, \xi_t) := \{(c_i, m_{i,t+1}) : c_i := C\big(f(\theta_i, m_t, \xi_t)\big),\; m_{i,t+1} := g(\theta_i, m_i, \xi_t),\; i = 1, 2\}$$

and let the price of such an option contract at time $t.3$ be $\mathbf{p}_t\big(A(m_t, \xi_t), \xi_t\big) = m_t$.

(11) Thus, it is because the central authority disburses money that it knows the distribution of money holdings at any point in time.

In words, under the revelation mechanism, agents enter a period with a promised lifetime utility of w. After their taste shock is realised, they choose (by virtue of their reported shock) one of the two bundle choices, where each bundle contains instantaneous consumption and continuation promised utility. Under the proposed monetary mechanism, agents enter a period with an option menu which corresponds to the two bundle choices under σ. The price for this contract at the end of the previous period corresponds to the promised utility w.

Consider, now, agent h with menu A_1^h entering period $t = 1$. If this agent has the taste shock θ_i, then his optimal (expected utility maximising) choice will be $(c_i, m_{i,1})$, for $i = 1, 2$. This follows immediately from the fact that σ is incentive compatible. Moreover, the consumption from the monetary mechanism in period 1 is exactly the same as under σ. This leads to a distribution ξ_1 of money holdings of color 1. Notice that by construction, $\xi_1 := \mathsf{S}\psi_0 =: \psi_1$. Thus, the set of money holdings is D and the amount of issued currency is the sum of elements in D according to the distribution of money holding ξ.

In the monetary mechanism, consider the following strategy for agent h: After any history, when presented with the option contract A_t^h, choose the option $(c_i, m_{i,t})$ if the taste shock is θ_i, for $i = 1, 2$. Notice that this corresponds – in terms of outcomes – to reporting his type truthfully in the recursive revelation mechanism σ. Moreover, if there is any strategy in the monetary mechanism that can give agent h strictly greater utility than that afforded by truth-telling, such a strategy has a corresponding sequence of reports in σ. But this is not possible, because σ is incentive compatible. Therefore, in each period t, it is optimal for agent h (regardless of his choices in the past), to choose 'truthfully' (in the sense that it is incentive compatible for agent h with taste shock θ_i to choose $(c_i, m_{i,t})$ from his option contract), just as he would in the mechanism σ. Thus, the monetary mechanism presented implements σ. □

5. Discussion

5.1. Some Aspects of our Monetary Mechanism

Some comments on the monetary mechanism are in order.

- The central authority need not observe past trades made and option contracts held. It only observes the current distribution of money holdings, but not individual money holdings.

- This implies that the monetary mechanism is ***predictable*** in the sense that conditional on the information available to the Principal at time t, namely the observed distribution ξ_t of money holdings after options have been exercised, the price of the option contract A_t is deterministic. In contrast, the recursive revelation mechanism σ is not predictable, because the allocations and continuation utilities are random functions that depend on reported types. It is easy to see that this is just a version of the *taxation principle* from static mechanism design; see, for instance, Salanié (2005, p. 17).[12]

- The monetary mechanism described above is ***anonymous*** in the sense that all that matters are money holdings. This is because the monetary mechanism maps promised utilities in the recursive mechanism σ to money holdings, and because agents are identical up to promised utilities in the recursive mechanism.

- The pricing functional $\mathbf{p}_t$ is not required to be linear, and may well be non-linear. Indeed, at the optimum, it is *necessarily* non-linear.

- The choices from the option contract A_t^h determine new money holdings in the currency m_t.

- The central authority cannot observe individual holdings of m_t but knows the distribution ξ_t of m_t.

- Each colour of currency is used at exactly one date. In particular, money of colour t is used exactly at date t, and is used to convert wealth in period t into wealth in period $t + 1$. This conversion is typically non-linear. In that sense, this represents a generalisation of an Arrow security, as it allows agents to transfer wealth from one date to the next, but in such a way so as to respect incentive compatibility.

5.2. Currency Reform in Practice

Currency reforms characterized by non-linear conversion rates are not uncommon. The replacement of the East German MARK (M) by the West German DEUTSCHE MARK

(12) Intuitively, instead of asking the agent for his type, the taxation principle says you can give the agent a set of options, and ask him to choose his desired option. If this set is chosen so as to correspond to what the agent would receive in a direct revelation mechanism, then the final allocations will be the same.

(DM) implemented during the process of economic reunification of the East and West Germany in 1990 is one example. Savings accounts of the East Germans were converted at a 1M:1DM rate up to a limit of 4,000[13] for 15–59 year olds, a limit of 2,000 for the younger citizens and 6,000 for the older citizens. All other assets and liabilities were converted at the rate of 2M-1DM; see Bofinger (1990) for more details.

In most socialist countries, currency reforms were carried out for the purpose of undermining the wealthy and evening out the wealth distribution.[14] In the Soviet Union, for example, the 1947 reform converted currency in circulation for the new currency at the rate of 10:1. Savings were converted at the rate of 1:1 on the first 3,000 RUBLES, the rate of 3:2 on the amounts between 3,000 and 10,000, and the rate of 2:1 on higher amounts; see Atlas and Drozdov (1978). Similar post-war currency reforms took place in Poland, Czechoslovakia, Romania, Bulgaria, North Korea and East Germany, all of which entailed relatively low ceilings on the amount that could be exchanged for the newly issued currency. Savings in excess of the established ceilings effectively disappeared.

More recently, in 2009, revaluation of the North Korean WON effectively wiped out the savings of many people. Only savings in the amount up to 150,000 WON in cash and 300,000 WON in bank accounts could be converted for the new currency. Excess savings could not be converted.[15] Of course, this being North Korea, precise details of the reform are not known. More to the point, the reform achieved its objective, namely, that of wiping out savings. This had the happy[16] consequence of bringing to nought the endeavours of a nascent entrepreneurial class. It goes without saying that there is a welfare loss with the North Korean reform, but there is no reason to think of the North Korean central authority as maximising social welfare.

5.3. Digital Money

In a stimulating new work, Rogoff (2016) notes that there are many problems with cash, some of which include the fact that people can make illicit transactions so cash fosters an underground economy, it helps agents avoid taxes, and it makes monetary policy difficult because it becomes harder to have negative interest rates (as agents can

(13) Approximately $3,000 in U.S. dollars from the year 2000.
(14) As Keynes (1919, 1971) notes, 'There is no subtler, no surer means of overturning the existing basis of society than to debauch the currency.'
(15) See, for instance, http://news.bbc.co.uk/2/hi/asia-pacific/8394987.stm.
(16) But happy only from the point of view of the rulers of North Korea.

simply hold their cash holdings under the proverbial mattress).

He notes that if all cash were digital, then none of these problems would arise. This is exactly the point made by Kocherlakota (1998), that money serves as social memory when such memory is not readily available. Digital money would be a superior version of such social memory as many more transactions and histories would now be observable.[17]

By contrast, radical currency reform obviates the need for such contortions, and instead delivers perfect recall for the central authority. In other words, radical currency reform achieves all the desiderata laid out in Rogoff (2016).

5.4. Why a Uniform Currency?

Monetary policy is a powerful tool and, at least in the United States, monetary policy is conducted by a body — the Federal Reserve — that is independent of the government and hence, from everyday political pressures. There is a sense in which the Federal Reserve, for instance, derives its authority from the people; indeed, the Federal Reserve was established by an Act of Congress (in response to the financial panic of 1907).

So why doesn't the typical Central Bank upend the monetary base every so often, if only to repatriate unaccounted for moneys held offshore and in other places underground? Our analysis suggests the following answer. First, it isn't clear that most Central Banks can even reform the currency base. Because this power is somewhat nebulous, a Central Bank that reforms the currency base indicates that it indeed has this power and, more importantly, is willing to use it. The question then becomes, Will a democratic society be willing to give this much power to anyone?

This is a question central to all societies – how much power should a society delegate to its agents (eg, its politicians) and institutions? What checks and balances should there be on these institutions? Our result suggests that if a society were to allow its Central Bank to reform the currency base, then the Central Bank can achieve just about any outcome (thereby rendering fiscal policy irrelevant), and the society that gives so much power to its Central Bank better be sure that its Central Bankers are benevolent.

The question of how much power to delegate to a representative is an old one. For instance, in a collection of the decrees made by the French National Convention in

(17) Of course, there exist digital currencies such as Bitcoin, that does not rely on observable histories of transactions and so still protects privacy.

1793,[18] it is declared that

> They [the people's representatives] must consider that great responsibility follows inseparably from great power.

Luminaries such as Winston Churchill, Teddy Roosevelt, and Franklin D. Roosevelt have all made similar statements in later years. A precursor to this idea can also be found in the Biblical verse Luke 12:48 (King James version) '…and to whom men have committed much, of him they will ask the more'.

It seems that most modern societies have understood this tradeoff and do not want to give their Central Banks more power than they already have.

In other words, if currency reform must be performed by a Central Bank, it must be recognised that the Central Bank is an agent of the people. This raises standard issues in Industrial Organisation, where the agent must be paid some rents in order to incentivise behaviour. For instance, if the Central Bank does not share Society's objectives, then the Central Bank cannot be given the freedom to reform the currency base at will. Even if the Central Bank shares Society's preferences, there is always the concern that citizens could bribe the Central Bankers, which may be hard to detect. One way to avoid paying the information rents that arise from these agency problems is to simply disallow currency reform. Put differently, it is precisely because a central authority cannot *commit* to using currency reform for the greater good that it is not given this ability at all.[19]

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(18) See *Collection Générale des Décrets Rendus par la Convention Nationale* (1793, p. 72). The original French being '*Ils doivent envisager qu'une grande responsabilité est la suite inséparable d'un grand pouvoir.*'

(19) Athey, Atkeson and Kehoe (2005) also consider an environment where the Central Bank has information (and preferences) different from Society at large. They note that putting restrictions on how the Central Bank can react to (publcly available) information is one way to provide the Central Bank with the appropriate incentives.

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