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ABSTRACT

Money is an Experience Good: Competition and Trust in the Private Provision of Money

We study the interplay between competition and trust as efficiency-enhancing mechanims in the private provision of money. With commitment, trust is automatically achieved and competition ensures efficiency. Without commitment, competition plays no role. Trust does play a role but requires a lower bound on efficiency. Stationary inflation must be positive and, therefore, the Friedman rule cannot be achieved.

The quality of money can only be observed after its purchasing capacity is realized. In that sense money is an experience good. We show that the two problems, the time-inconsistency in the private provision of money and moral-hazard in the provision of experience goods, are isomorphic, and therefore the same results are attained in both settings.

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1　Introduction

Can currency be efficiently provided by competitive markets? A traditional *laissez-faire* view – as, for example, has been expressed by Hayek – based on a "Bertrand competition" argues that competition drives the price of money to its marginal cost. Therefore, if the marginal cost of producing currency is zero, competition drives nominal interest rates to zero and private provision of currency is efficient.

We show that there is a major flaw in this "Bertrand competition" argument, when applied to fiat money. When suppliers of currency cannot commit to their future actions, then competition loses its bite. The reason for this is that, while currencies compete on their promised rates of return, once agents hold a particular currency there may be an incentive for the issuer to inflate the price of goods in terms of this currency, reducing, in this way, the outstanding liabilities. Current currency portfolios have been pre-specified, while there is full flexibility to choose tomorrow's portfolios. Currencies compete for tomorrow's portfolios. When choices are sequential, currencies are no longer perfect substitutes; in a sense, they are not substitutes at all. Does "Bertrand competition" still drive promised rates of return to the efficient level? Not if those promises are not credible, if issuers of currencies are not trusted.

Private provision of currencies is by no means the only case where producers compete for promises and the standard "Bertrand competition" argument does not apply. Competition in experience goods - those whose quality can only be revealed by consuming the good - has similar properties. "Bertrand competition" can only affect market prices, but not the qualities which are observed *ex-post*. Firms have an incentive to be "fly-by-night" providing low quality products. So in a monopolistic competition context, even if goods are close substitutes, competition may not discipline firms.

Many services provided by specialists (plumbers, surgeons, financial intermediaries, etc.) are experience goods: the effort of the specialist affects the quality of the service (in fixing the plumbing, performing a surgical operation, managing a hedge fund, or rating securities), while such quality can only be *ex-post* imperfectly observed by the non-specialist consumer. For most of these services, warranties designed to mitigate the moral hazard problem are difficult to enforce and usually do not exist.

In this paper we show that while the provision of money and the provision

of experience goods seem a priori very different problems (the former being a moral hazard problem and the latter a time inconsistency problem) they are indeed isomorphic regarding the interplay between competition and trust.

In a dynamic economy, firms are concerned for their future market position, and the need to build up reputation may be enough to discipline firms to effectively provide high quality goods. Similarly, the "trust mechanism" may resolve the time inconsistency problem in the supply of money: concern for the future circulation of money may deter currency issuers from creating inflation. Nevertheless, reputation concerns exist as long as quality-goods suppliers (or currency suppliers) expect sufficiently high future profits to refrain from capturing the short-term profits. Does competition, by driving down profits, enhance efficiency but also destroy the disciplinary properties of the "trust mechanism"? The analysis of this trade-off is the central contribution of this paper.

The paper is organized as follows: we start with the simplest case of consumption goods in a model with monopolistic competition, as in Dixit and Stiglitz. In that model, one parameter controls the degree of competition between differentiated goods, so it is a very useful starting point for an analysis of the interaction between competition and trust. In studying dynamic monopolistic competition in the quality-goods markets (Section 2), we first consider the case of perfect observability, where the equilibrium is uniquely determined, and indexed by the degree of substitutability. As goods become closer substitutes, the equilibrium becomes more efficient, achieving Pareto efficiency in the limiting case of perfect substitution. However, when quality is only observed with a lag, the mark-up must be bounded away from zero so as to guarantee enough future profits to make it worthwhile for firms to be trustworthy. The rate of time preferences defines the lower bound on mark-ups. More precisely, we first show that any price covering such a mark-up can be the outcome of a symmetric stationary *sustainable equilibrium.* Increasing the degree of substitutability does not affect the set of equilibria, therefore competition plays no role.

We then analyze, in Section 3, the model of currency competition where goods are supplied in perfectly competitive markets, and consumers can buy these goods by using any of a continuum of differentiated currencies. Each currency is supplied by a profit maximizing firm. Even though the currencies are imperfect substitutes, by making the degree of substitutability arbitrarily large we can characterize the limiting economy of perfect substitution among currencies. The parallel with the case of perfect observability is the

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case with full commitment. In this case, currency competition achieves the efficient (Friedman rule) monetary equilibrium, as Hayek had envisioned. The analysis of equilibria without full commitment is isomorphic to the case of imperfect observability in the experience goods model. The equivalent of the lower bound on mark-ups is a non-negativity condition on inflation, which must be guaranteed for issuers of currency to be trustworthy. The analysis in this section makes it clear that the essence of the relationship between competition and trust is the same as in the case of experience goods. It is in this sense that we state that money is an experience good.

Our two main results extend to other goods and services that can be made isomorphic to our experience goods model. That is, *i)* the existence of a lower bound on efficiency defined by the need to 'sustain trust', and *ii)* an indeterminacy of expectations sustaining trust that may result in competition playing no role.

Our work is related to different strands of literature. In the industrial organization literature on experience goods, our work is closely related to Shapiro (1983).[1] He considers a similar model of monopolistic competition in which consumers' expectations regarding quality follow an ad-hoc exogenous process. He does not study the trade-offs between competition and reputation. In contrast, we consider rational expectations of quality and, as we have said, our central theme is the study of those trade-offs.

The issue of currency competition has been the subject of an extensive academic debate. This debate has seen many supporters of free competition making an exception when it comes to money (Friedman, 1960), while advocates of free currency competition (notably, Hayek 1974 and 1978, and Rockoff, 1975) have been somewhat isolated. In spite of this, the relatively recent reappraisal of the self-regulating properties of free banking[2] has raised new interest in the study of currency competition.

The problem of time-inconsistency of monetary policies has been exten-

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[1] In our terminology we follow Cabral, who in his monograph *The Economics of Reputation and Trust* (in progress), uses the term 'reputation' in referring to adverse selection problems (reputation regarding an unobservable type) and 'trust' in referring to moral hazard problems (trust regarding a hidden action). See also Tirole (1988) for an introductory account of the IO literature.

[2] See, for example, Calomiris and Kahn (1996), Dowd (1992), King (1983), Rolnick and Weber (1983), Selgin (1987), Selgin & White (1987), Vaubel (1985), and, more generally, White (1993) . See also Schuler (1992), for an account of historical episodes of free banking, and Hayek (1974,1978), Dowd (1992) and White (1993) for a broad perspective on the literature on free banking.

sively studied since Calvo (1978)[3], but with the partial exceptions of Klein (1974) and Taub (1985 and 1986), the currency competition argument has not been considered. Klein understood that the problem of currency competition could not be studied independently of the time inconsistency problem. Like Shapiro (1983), he postulated ad-hoc beliefs, so the way competition and reputation interplay in determining equilibrium outcomes is not analyzed. He raised some of the questions we address in this paper but without a full characterization as we do here. Taub (1985) studies two distinct regimes: one with full commitment with non-stationary ("time-inconsistent") policies, and another in which polices are constrained to be "time-consistent" (stationary). He shows that in the commitment case, the Friedman rule emerges as the competitive outcome, while in the "time-consistent" case the outcome is inefficient and, as a result, he argues in favor of the "natural monopoly" argument. While we have the same result when there is full commitment, our analysis of the "non-commitment case" differs substantially. Taub (1986) considers the problem of currency competition in a model in which the government can commit for a given number of periods. He obtains results that are similar to ours, although in our model what prevents firms from choosing fly-by-night strategies is endogenous reputation, rather than exogenous commitment. Finally, Marimon, Nicolini and Teles (2003) analyze the effects of electronic money, and other currency substitutes, competition on monetary policy but abstracting from reputational issues, which is the central topic of this paper.

2 A model of monopolistic competition with experience goods

Our model is a version of the model of monopolistic competition of Dixit and Stiglitz (1977), with experience goods. Consider an economy with a large number of identical households that gain utility from services and leisure. The utility function of the representative household is

$$\sum_{t=0}^{\infty} \beta^t \left[U(y_t) - \alpha n_t \right], \tag{1}$$

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[3]See, for example, Chang (1998), Chari & Kehoe (1990), Ireland (1994) and Stokey (1991).

where U is increasing and concave and, without loss of generality, $U(0) = 0$, α is a positive constant, n_t is work effort and y_t is an index of services

$$y_t = \left[\int_0^1 (y(i)_t q(i)_t)^{1/\mu} \, di \right]^\mu ,$$

with $\mu > 1$. $y(i)_t$ denotes the services derived from the consumption of good $i \in [0, 1]$. Each of the goods can be provided with variable quality, $q(i)_t = 0$ or 1.

Time must be devoted to production, according to the linear technology

$$y(i)_t q(i)_t = n(i)_t,$$

Total effort per capita is

$$n_t = \int_0^1 n(i)_t di.$$

We assume that there is a single monopolist that produces each good.

Producers have, at any time, the option of producing "fake" units of the consumption good that are costless to produce. A key assumption for the characterization of the equilibria is whether consumers can distinguish the high quality goods from the low quality ones before they buy them. We proceed to characterize the equilibrium when the quality of consumption goods are observed before they are purchased.

2.1 Monopolistic competition with perfect observability

If the quality of the good is public information, there exists a unique equilibrium in this model economy with monopolistic competitive firms. Each firm sets the price equal to a constant mark up over the unitary marginal cost.

In each period t, the representative household chooses the number of units of each good i to purchase, $y(i)_t$, as well as work effort, n_t, in order to maximize utility, (1), subject to

$$\sum_{t=0}^{\infty} Q_t \left[\int_0^1 (p(i)_t y(i)_t - \Pi(i)_t) \, di - n_t \right] \le 0,$$

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where $\Pi(i)_t$ are the per-capita profits of firm i, $p(i)_t$ is the price of goods in units of labor time, and Q_t is the price of labor at time t, in units of labor at time zero. The demand functions for goods will be given by

$$U'(y_t)y_t^{\frac{\mu-1}{\mu}}\left(y(i)_t q(i)_t\right)^{-\frac{\mu-1}{\mu}} q(i)_t = \alpha p(i)_t, \tag{2}$$

for all i and t. When $q(i)_t = 0$, then $y(i)_t = 0$.

When instead $q(i)_t = 1$, all i, the price of the composite good y_t is

$$p_t \equiv \left[\int_0^1 p(i)_t^{1/1-\mu} di\right]^{1-\mu} = \frac{U'(y_t)}{\alpha}$$

The demand functions for services of each of the goods, (2), can then be written as

$$y(i)_t = y_t \left[\frac{p(i)_t}{p_t}\right]^{\frac{\mu}{1-\mu}} \tag{3}$$

The monopolist of product i chooses the quality and the price to maximize profits

$$\sum_{t=0}^{\infty} \beta^t \left(p(i)_t y(i)_t - q(i)_t y(i)_t\right). \tag{4}$$

Since with $q(i)_t = 0$, $y(i)_t = 0$, and profits will be zero, then the firms will choose to provide high quality goods, $q(i)_t = 1$. They choose the prices to maximize profits (4) subject to the demand functions (3). This is a static problem. As the demand function has constant price elasticity, the optimal price per unit of service of each good will be

$$p(i)_t = \mu. \tag{5}$$

The market clearing condition

$$\int_0^1 q(i)_t y(i)_t di = n_t$$

must hold in equilibrium. The unique equilibrium will be characterized by a price which will be constant over time and across goods

$$\bar{p} = \mu, \tag{6}$$

as equation (5) shows. Therefore, the quantity of services of the goods, $y_t = \overline{y}$, will be constant and will satisfy the following condition

$$U'(\overline{y}) = \alpha\mu \tag{7}$$

The value of the parameter μ determines the substitutability of the goods. The closer is μ to one, the higher is the degree of substitutability. Note that as μ approaches one, the mark-up goes to zero and the equilibrium is a perfectly competitive one. On the other hand, as μ gets larger, so do the mark-ups. Note that we are not allowing for free entry, so profits will indeed be positive except in the limiting case in which $\mu \longrightarrow 1$.

Thus, there exists a unique equilibrium that is closer to the efficient outcome, the closer is the parameter μ to one. Indeed only in the limit, the marginal rate of substitution equals the marginal rate of transformation. The increased substitutability between goods increases competition and increased competition implies an outcome closer to the efficient one.[4]

2.2 Monopolistic competition with unobservable quality

We now assume that, as with many durable goods, consumers can observe the quality of the good -or service- only after purchasing it. This feature modifies the model above in very important ways. In particular, note that each firm now faces a "time inconsistency problem". As is clear from the expression for profits, (4) in each period t, once the consumers have paid the price of the good, $p(i)_t$, under the expectation that the good is of high quality, $q(i)_t = 1$, it is optimal to provide no services, $q(i)_t = 0$, and save the costs of production, as long as this does not affect future expectations. Of course, the firms may refrain from doing so, if this action can affect future demand, since after observing low quality the consumers might choose $y(i)_{t+j} = 0$, $j \geq 1$. In this section, we develop a model of trust to analyze this problem.

Let $p(i)_t \in \Re^+$ denote the price set by firm i in period t for a unit of good i, in units of time. Then, if the firm produces with quality $q(i)_t$, the price per

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[4]An alternative way to model imperfect competition is to assume that goods are perfect substitutes but production requires fixed entry costs, as in Salop(1979) circular-city-model. The lower the fixed costs, the stronger is competition and the lower the equilibrium mark-ups. Thus, there is a clear connection between lower values of μ in Dixit-Stiglitz and lower fixed costs in Salop. In fact, the same results go through in both models.

unit of service is $p^q(i)_t = p(i)_t/q(i)_t$. Since $q(i)_t$ can take the values zero or one, the price per unit of service is in the extended reals, $p^q(i)_t \in \Re^+ \cup \{\infty\}$. Let $\lambda_{i,t}(p(i)_t) = \Pr\{p^q(i)_t = p(i)_t\}$, i.e., the probability that firm i sets the price per unit of quality $p^q(i)_t$ equal to $p(i)_t$. Since $p(i)_t < \infty$, $\lambda_{i,t}(p(i)_t)$ is the probability that quality is high. Let h_t be the information available to a firm at the moment of making period t decisions. That is, $h_0 = \{\emptyset\}$ and, for $t > 0$, $h_t = \{h_{t-1}, p(i)_{t-1}, p^q(i)_{t-1}$ for all $i\}$. A strategy for firm i, is a $\sigma_i^f = \left\{\sigma_{i,t}^f\right\}$, where, $\sigma_{i,t}^f(h_t) = (p(i)_t, \lambda_{i,t}(p(i)_t))$.

The representative household simply decides how much to work and to purchase of every service, i.e., $(n_t, y(i)_t,$ for all $i)$, given the available information, which in period t is $\{h_t, p(i)_t,$ for all $i\}$, and the expectations on the quality of the service. An allocation rule is a $\sigma = \{\sigma_t\}$, where, $\sigma_t(h_t, p(i)_t,$ all $i) = (n_t, y(i)_t,$ all $i)$. Let $v_t^i(h_t, p(i)_t)$ denote the belief that, given history h_t and price $p(i)_t$, the price of good i per unit of quality, $p^q(i)_t$, is equal to the observed price, $p(i)_t$. That is, $v_t^i(h_t, p(i)_t)$ is the assessed probability that quality is high, $q(i)_t = 1$. Notice that we implicitly assume that beliefs about firm i do not depend on other firms' prices. Consumers' beliefs are *consistent* with firms' actions if for every (t, h_t), and price $p(i)_t$ in $\sigma_{i,t}^f(h_t)$, $v_t^i(h_t, p(i)_t) = \lambda_{i,t}(p(i)_t)$.[5]

A *Sustainable Monopolistic Competitive Equilibrium* (SMCE) consists of $\left((\sigma, v), (\sigma_i^f)\right)$ such that, for every (t, h_t)

1. $\sigma_{i,t}^f(h_t)$ solves the problem of firm i,

    and, given $p(i)_t$ in $\sigma_{i,t}^f(h_t)$,

2. $v_t^i(h_t, p(i)_t) = \lambda_{i,t}(p(i)_t)$, and

3. $(n_t, y(i)_t,$ all $i) = \sigma_t(h_t, p(i)_t,$ all $i)$ solves the problem of the household, given beliefs $v_t^i(h_t, p(i)_t)$, all i, and satisfies the market clearing condition $\int_0^1 y(i)_t q(i)_t di = n_t$.

A *Sustainable Monopolistic Competitive Equilibrium* (SMCE) provides a natural framework to study the interactions between competition and trust.

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[5] As in Kreps and Wilson (1982)' *Sequential Equilibrium* and as in *Perfect (Extended) Bayesian Equilibrium* we impose consistency conditions. However, in our imperfect information environment, a simple form of consistency on relative beliefs suffices (see, for example, Fudenberg and Tirole, 1991, Ch. 8 and Battigalli, 1996).

On the one hand, as long as μ is strictly larger than one, the economy exhibits monopolistic power, and as μ gets close to one, the competition between firms is increased. On the other hand, in making quality decisions, firms care about their reputation since quality provision has strategic implications.

Notice that the (3) requirement is simply that consumers's allocations satisfy their demands. In particular, given $(h_t, p(i)_t)$, and $\upsilon = \upsilon^i_t(h_t, p(i)_t)$, consumers' demands are given by

$$y(i)_t = y_t \left[\frac{U'(y_t)/\alpha}{p(i)_t/\upsilon} \right]^{\frac{\mu}{\mu-1}}$$

In what follows, we restrict attention to *symmetric equilibria* in the sense that all firms behave the same way, so expectations about quality are the same for every good.

In order to stress the pervasive effects of assuming that the quality is only observed after purchasing the good, let us consider an equilibrium where strategies do not depend on histories. If current actions of the firms do not affect the consumers' expectations about future quality, then, no matter what the price is, it is a dominant strategy for the firms to choose to provide the low quality, $q(i)_t = 0$, to save on production costs. If the firm produces low quality, then for any price $p(i)_t$, if $\upsilon^i_t(h_t, p(i)_t) = 0$, consumer's expectations are fulfilled. The resulting payoffs are zero. The firms can guarantee themselves this payoff, independently of the beliefs, so that this is *the worst SMCE*. More formally,

Proposition 1 *There exist* low quality SMCE, *supported by strategies* $\sigma^f_{i,t}(h_t) = (p(i)_t, 0)$, *and beliefs* $\upsilon^i_t(h_t, p(i)_t) = 0$, *with their corresponding allocations* $(n_t, y(i)_t) = (0,0)$, *for all i and (t, h_t). Furthermore, there is no SMCE with lower payoffs for the firms.*

Incidentally, note that this is the unique SMCE (payoff) in which strategies do not depend on histories. In this case no firm is ever trusted to provide high quality. This would be the unique outcome if firms where anonymous players not accountable for their past quality decisions.

The next step is to determine under what conditions the equilibrium outcome with perfect observability, described in the previous section, is the outcome of a SMCE. In order to check this, we consider the standard trigger strategies of reversion to the worst SMCE strategies.

Consider the stationary path

$$p(i)_t = \overline{p}, \lambda_{i,t}(\overline{p}) = 1, \ y(i)_t = y_{\overline{p}}, n_{\overline{p}} = y_{\overline{p}}$$

where $U'(y_{\overline{p}}) = \alpha\overline{p}$. We want to find conditions under which this outcome is supported by the following "revert to low quality" strategies and beliefs and allocation rules:

$$
\begin{aligned}
\sigma_{i,0}^f &= (\overline{p}, 1), \\
\sigma_{i,t}^f(h_t) &= (\overline{p}, 1), \text{ if } p^q(i)_n = p(i)_n = \overline{p} \text{ for } 0 \leq n < t, \\
&= (\overline{p}, 0), \text{ otherwise.}
\end{aligned}
$$

$$
\begin{aligned}
v_0^i(h_0, \ p(i)_0) &= 1 \text{ if } p(i)_0 = \overline{p} \text{ and } v_0^i(h_0, \ p(i)_0) = 0, \text{ otherwise} \\
v_t^i(h_t, p(i)_t) &= 1, \text{ if } p^q(i)_n = p(i)_n = \overline{p}, 0 \leq n < t \text{ and } p(i)_t = \overline{p} \\
v_t^i(h_t^c, p(i)_t) &= 0 \text{ otherwise.}
\end{aligned}
$$

$$
\begin{aligned}
\sigma_0(h_0, p(i)_0) &= (n_{\overline{p}}, y_{\overline{p}}) \text{ if } p(i)_0 = \overline{p}, \\
\sigma_0(h_0, p(i)_0) &= (0,0) \text{ if } p(i)_0 \neq \overline{p} \\
\sigma_t(h_t, p(i)_t) &= (n_{\overline{p}}, y_{\overline{p}}) \text{ if } p^q(i)_n = p(i)_n = \overline{p}, 0 \leq n < t \text{ and } p(i)_t = \overline{p} \\
\sigma_t(h_t, p(i)_t) &= (0,0) \text{ otherwise.}
\end{aligned}
$$

Consider first the monopolistic competition outcome with perfect observability; that is, $\overline{p} = \mu$ and $y_\mu = \overline{y}$. Notice that, if it is sequentially rational for firms to produce high quality with probability one, then the above strategies for the consumers will be sequentially rational, since they were optimal choices with perfect observability.

If the firm does indeed deliver the high quality good, then the profits, each period, will be given by $\Pi(i) = (\mu - 1)\overline{y}$ and, therefore, the present value of profits, after high quality is observed in all previous periods and the current price is μ, are given by $(\mu-1)\overline{y}/(1-\beta)$. On the other hand, if the firm deviates -say, in period t- and delivers the low quality good, while setting the price $p(i)_t = \mu$, the current profits will be $\mu\overline{y}$ and the present value of profits, after $p^q(i)_t = \infty$ is observed the last period (or any previous period), are zero. Thus, the firm chooses not to deviate and produce high quality if

$$(\mu - 1)\overline{y} + \beta\frac{(\mu - 1)\overline{y}}{1 - \beta} \geq \mu\overline{y} \tag{8}$$

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Let $\beta = 1/(1 + \rho)$, then the firm will choose not to deviate when

$$\mu \geq 1 + \rho.$$

Thus, we have shown the following proposition

Proposition 2 *If the market power is high enough, so that the mark-up is greater than or equal to the discount rate, then the perfect information equilibrium is the outcome of a SMCE.*

The intuition of the last proposition is clear. Given that the firm has the option of making a short run profit by selling low quality goods, the equilibrium mark-up must be high enough for the firm not to choose to do it. As the equilibrium profits are accrued over time, the discount rate -as an indicator of the observability lag- matters.

This is the intuition of the Industrial Organization literature on unobservable quality, and the first quotations go back to Adam Smith. If by reducing the quality the firm can make short run profits, a trust argument can explain why firms decide not to do so. As we have just seen, reputation is valuable when firms make positive profits in equilibrium. But, as competition gets tighter, i.e., in our model μ gets arbitrarily close to 1, monopolistic rents disappear and the equilibrium with perfect observability may not be sustainable through reputation if the discount rate is high enough. Notice that the time period can be seen as the time that it takes for consumers to observe the quality of the goods. The shorter is the information lag, the smaller is the discount rate, and the easier to sustain the equilibrium with perfect observability. Nevertheless, as long as $\rho > 0$, the Pareto efficient solution is never attained.

So far, we have only shown under which conditions is the perfect information equilibrium a SMCE. However, it should be clear that the above argument applies to any outcome defined by $\overline{p}$ and $y_{\overline{p}}$, as long as $\overline{p} \geq 1 + \rho$. In this case, the choices are sequentially rational since consumers satisfy their demands at $p(i)_t = p^q(i)_t = \overline{p}$, firms make non-negative profits and any deviation is punished. In particular, a price deviation is instantaneously punished by triggering the beliefs that the firm is producing low quality. It follows that a price deviation is dominated by choosing to announce $p(i)_t = \overline{p}$ and delivering high quality. In summary,

Proposition 3 *There exists a stationary SMCE outcome where the price per unit of service is $\overline{p}$ and firms always produce high quality iff $\overline{p} \geq 1 + \rho$.*

This analysis shows how high quality can be maintained through reputation, but there is no role for competition. In fact, if consumer expectations depend on price and quality history, there are no dimensions along which the firms can actually compete. In fact, the particular value the elasticity of substitution takes, a key parameter when the quality is observable, becomes irrelevant once this standard trust mechanism is in place. Consumers expectations alone determine the whole set of restrictions that the firms face.

3 A model of currency competition

In this section we present a model to study competition between profit maximizing currency issuers. As before, we focus on the interaction between competition and trust in the private provision of money and, in particular, whether it can be an efficient monetary arrangement. Although the model itself is somewhat different from the experience goods model and the existence of money introduces non-trivial dynamics which were not present in that model, the ways in which competition and trust interact are strikingly similar.

3.1 Currency competition with commitment

3.1.1 The model

In the monetary economy, there is a single consumption good and consumers' preferences are given by $\sum_{t=0}^{\infty} \beta^t \left[U(c_t) - \alpha n_t \right]$, where U satisfies the same monotonicity and concavity assumptions of the previous section. As before, the technology is linear in labor, with a unitary coefficient. We allow for free entry into the production of the good, so that firms will make zero profits in equilibrium and the price of consumption in terms of labor will be one.

We assume that consumers must buy the consumption good with a composite of the continuum of all possible differentiated currencies. This composite money aggregate is defined as

$$m_t = \left[\int_0^1 m(i)_t^{1/\mu} di \right]^{\mu}, \mu > 1$$

where $m(i)_t$ is the real value of type i money, used for transactions at time t. The monies are imperfect substitutes but we consider imperfect substitutability only as a methodological device to study the limiting economy

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where substitutability is arbitrarily large. In the limit each of the monies is general purchasing power. This model is a natural framework to analyze Hayek's conjecture that money can be supplied efficiently by the market, and, as such, it contains interesting implications for monetary theory.

We analyze the limiting economy as the degree of substitutability is arbitrarily large instead of the case of perfect substitutability because it is a natural way of dealing with the indeterminacy of money demands that arises when the monies are perfect substitutes.[6] When that is the case, in equilibrium all currencies must have the same return and only the total value of the currencies will be determined. The share of each currency in the portfolio, and hence the real demand for each currency, is indeterminate. For given supplies of the different monies the price levels are indeterminate. Thus, whether a given policy is time consistent depends on the arbitrary rule to pin down an equilibrium. For this reason we conduct our analysis when the degree of substitutability is finite, so that the real money demands are well defined and no indeterminacy arises.

The representative consumer maximizes utility subject to the following budget constraint

$$b_{t+1} + \int_0^1 \frac{M(i)_{t+1}}{P(i)_t} di + c_t \le n_t + b_t(1 + r_t) + \int_0^1 \frac{M(i)_t}{P(i)_t} di + \Pi_t, \ t \ge 0$$

where $P(i)_t$ is the price of the consumption good in units of money i and $M(i)_t$ is the quantity of money i, held from time $t-1$ to time t, and used for transactions at time t, so that $m(i)_t = \frac{M(i)_t}{P(i)_t}$. $\Pi(i)_t$ are the current profits of the provider of currency i in units of the consumption good, $\Pi_t = \int_0^1 \Pi(i)_t di$. Every period t, the consumer purchases $M(i)_{t+1}$ of currency i and real bonds b_{t+1} that pay the real interest rate r_{t+1} in period $t+1$. This budget constraint can be written as

$$b_{t+1} + \int_0^1 m(i)_{t+1}(1 + \pi(i)_{t+1}) di + c_t \le n_t + b_t(1 + r_t) + \int_0^1 m(i)_t di + \Pi_t, \ t \ge 0 \tag{9}$$

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[6]In Marimon, Nicolini and Teles (2003), we analyze the case of competition between inside money and outside money, when both are perfect substitutes. In that model we assume that when the returns are the same the households opt for currency. We also assume that the suppliers of inside money are small and not distinguishable, which removes the time inconsistency on their part.

where $\pi(i)_{t+1} = \frac{P(i)_{t+1}}{P(i)_t} - 1$.

The cash-in-advance constraint is

$$c_t \le m_t = \left[\int_0^1 m(i)_t^{1/\mu} di \right]^\mu \tag{10}$$

for all t.

Let $R(i)_{t+1}$ be the gross nominal interest rate from time t to $t+1$ on money i, so that $R(i)_{t+1} = (1 + r_{t+1})(1 + \pi(i)_{t+1})$, and let

$$R_{t+1} - 1 \equiv \left[\int_0^1 (R(i)_{t+1} - 1)^{\frac{1}{(1-\mu)}} di \right]^{1-\mu}$$

Then, the first order conditions of the consumer's problem imply:

$$U'(c_{t+1}) = \alpha R_{t+1}, \ t \ge 0$$

$$m(i)_{t+1} = \left(\frac{R(i)_{t+1} - 1}{R_{t+1} - 1} \right)^{\frac{\mu}{1-\mu}} m_{t+1}, \ t \ge 0 \tag{11}$$

$$r_{t+1} = \frac{1}{\beta} - 1 \equiv \rho, \ t \ge 0$$

The issuer of currency i faces an intertemporal budget constraint given by

$$\frac{M(i)_{t+1}}{P(i)_t} + d(i)_{t+1} = \frac{M(i)_t}{P(i)_t} + d(i)_t(1 + \rho) + \Pi(i)_t$$

where $d(i)_t$ is the debt issued by the i-currency issuer at time t, in units of the consumption good, and $\Pi(i)_t$ are the profits of the money issuer in units of the consumption good. It also faces the corresponding non-Ponzi constraints guaranteeing that the present value budget constraint is well defined. The present value of profits are

$$\sum_{t=0}^\infty \beta^t \Pi(i)_t = \sum_{t=1}^\infty \beta^t \left((R(i)_t - 1) m(i)_t \right) - \frac{M(i)_0}{P(i)_0} - \frac{d(i)_0}{\beta}. \tag{12}$$

In order to maximize the present value of profits, firms must choose $\pi(i)_t$ to maximize

$$(R(i)_t - 1) m(i)_t$$

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taking the demands for currency (11) as given. They must also minimize $\frac{M(i)_0}{P(i)_0}$. Notice that, as in standard (single currency) monetary models, a monetary policy for the i-currency issuer consists of a current price level and a sequence of future nominal interest rates: $(P(i)_0, \{R(i)_t\}_{t=1}^{\infty})$.

3.1.2 Equilibria with commitment

Regarding monetary policies, optimality requires the initial price level to be arbitrarily high such that the real value of initial outstanding money holdings (liabilities) $\frac{M(i)_0}{P(i)_0}$ becomes zero. This is achieved through a big open market operation in which the currency is sold back to the consumers. Each currency issuer takes a negative position in bond holdings, in an amount equal to the real quantity of money. In subsequent periods, the currency issuer collects the real rate of interest on those loans, as well as the inflation rate on real money holdings, corresponding to future money issuing.

To characterize the problem of maximizing time t profits, notice that to maximize

$$(R(i)_t - 1) \, m(i)_t$$

subject to (11), results in the choice

$$R(i)_t = \mu$$

This is not surprising, since this maximization problem is the same, in the quality-goods model, as that of maximizing (4) subject to (3). We only need to identify the gross nominal interest rate, in the currency competition model, $R(i)_t$ with the price $p(i)_t$ in the quality-goods model, and $m(i)_t$ with $y(i)_t$. As in the previous model, with these prices, the consumption of the goods, $\overline{y} = \overline{m}$, is constant and satisfies $U'(\overline{y}) = \alpha\mu$.

It follows that, as currency substitution increases, i.e., $\mu \searrow 1$, nominal interest rates tend to zero, i.e., $(R(i)_t - 1) \searrow 0$, which is supported by a deflationary monetary policy, i.e., $\pi(i)_t \searrow (\beta - 1)$. In other words, with perfect substitution of private currencies the monetary equilibrium is efficient and the Friedman rule is implemented. Thus, with full commitment, Hayek's conjecture, that efficient monetary equilibria can be achieved through currency competition, is verified.

Nevertheless, as in standard (single currency) monetary models, the full commitment monetary policy is time inconsistent. This can easily be seen

by considering how the budget constraints of a currency issuer evolves over time. At time t, the budget constraint is

$$\sum_{j=t}^{\infty} \beta^{j-t} \Pi(i)_j = \sum_{j=t+1}^{\infty} \beta^{j-t} \left((R(i)_j - 1)m(i)_j \right) - \frac{M(i)_t}{P(i)_t} - \frac{d(i)_t}{\beta} \qquad (13)$$

Thus, if given the option to change plans at time t,which we rule out when assuming full commitment, the currency issuer will find it optimal to expand the money supply and let $P(i)_t$ increase without bound. The reason is that the real money demand is decreasing in the nominal interest rates, i.e., in expected future prices. However, once consumers have made their currency decisions, the nominal money demand is rigid with respect to the realized price. We turn now to analyze the case without commitment.

3.2 Currency competition without commitment

As there is a parallel between quality-goods competition with perfect observability and currency competition with full commitment, there is a parallel between quality-goods competition with unobservable quality and currency competition without commitment. More specifically, in both models firms compete in prices that are not observable or that they cannot commit to: In the quality-goods model, this is the price of the good per unit of quality; in the currency competition model it is the nominal interest rate, or the inflation rate. With perfect observability in the first model and with full commitment in the second, there is no distinction between set and realized prices. With unobservable quality in the first model and lack of commitment in the second, we have to consider off-equilibrium paths where the *ex-post* realized prices may differ from the *ex-ante* prices. In fact, in such a case, firms maximize short run profits by setting an arbitrarily large realized price, which in the quality model corresponds to choosing low quality and in the currency model to inflate away current money holdings (i.e., in making "the quality of outstanding money" arbitrarily low). In both models, the timing is very important:[7] Consumers purchase services before they observe the quality they yield, in one, and they purchase monies before they observe

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[7]In a paper that also addresses the issue of competition in a time inconsistency setting, Kehoe(1989), used a different timing, and obtained the result that competition could solve the time consistency problem.

the real return they yield, in the other; in both models, consumers must form their expectations on realized prices, based on past information and current prices, and, in both models, reputation is what may prevent firms from "flying-by-night."

More formally, while monopolistic firms in the quality-goods model sequentially choose $(p(i)_t, p^q(i)_t)$, currency issuers choose $\left(R\left(i\right)_{t+1}, P(i)_t\right)$, where $R\left(i\right)_{t+1} \in \Re^+$ is an ex-ante gross nominal interest rate, between period t and $t + 1$. Since bonds are real, this interest rate is not a return on bonds. It works as an announcement of the price of holding money. Note that given a history, picking the price level at time t, is equivalent to picking the ex-post nominal interest rate $R^q(i)_t = (1+\rho)(1 + \frac{P(i)_t}{P(i)_{t-1}})$, except for the first period, since $P(i)_{-1}$ is not defined. Because the price level can be made arbitrarily large, $R^q(i)_t \in \Re^+ \cup \{\infty\}$. This notation helps keeping the parallel with the monopolistic competition model.

We can now define a *"Sustainable Currency Competition Equilibrium"* (SCCE) in a similar fashion as we have defined SMCE in the quality-goods model. Histories are given by $h_{-1} = \{\emptyset\}$, $h_0 = \{h_{-1}, P(i)_0, R(i)_1\}$ and $h_t = \left\{h_{t-1}, R\left(i\right)_{t+1}, R^q(i)_t, \text{ all } i\right\}$, for $t \geq 1$. The i-currency issuer strategy is given by

$$
\begin{aligned}
\sigma_{i,0}^b(h_{-1}) &= (R(i)_1, P(i)_0), \text{ and} \\
\sigma_{i,t}^b(h_{t-1}) &= (R(i)_{t+1}, \lambda_{i,t}), \text{ for } t \geq 1
\end{aligned}
$$

where $\lambda_{i,t}$ is a density function on R^+, such that $\lambda_{i,t}(h_{t-1}; R^q(i)_t)$ is the density of $R^q(i)_t$, conditional on h_{t-1}.[8]

Consumers behave competitively, deciding $\sigma_t^c(h_t) = \{c_t, n_t, b_{t+1}, M(i)_{t+1}, \text{all } i\}$, for $t \geq 0$, based on v_t^i - their beliefs about future decisions of the currency issuers - and corresponding equilibrium prices. $v_t^i(h_t; R^q(i)_{t+1})$ denotes the assessed density of the ex-post interest rate $R^q(i)_{t+1}$. Rational expectations requires that beliefs are consistent with currency issuers strategies,[9]

$$
v_t^i(h_t; R^q(i)_{t+1}) = \lambda_{i,t+1}(h_t; R^q(i)_{t+1})
$$

A SCCE consists of $\left((\sigma^c, v^i), (\sigma_i^b)\right)$, such that, for every (t, h_t), $\sigma_{i,t}^b(h_{t-1})$ solves the maximization problem of the i-currency issuer; $\sigma_t^c(h_t)$ solves the

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[8] Since issuers decide on $P(i)_0$ before consumers make any decision, there is no need to introduce mixed strategies on that decision.

[9] Note that at time t, consumer's care about future monetary policy, that is why time t beliefs ought to be the same as firm's strategies at $t + 1$.

consumer's problem given consistent beliefs $v_t^i(h_t; R^q(i)_{t+1})$, and all markets clear.

As with SMCE, there is a worst SCCE in which currencies are not held, since agents expect realized nominal interest rates to be arbitrarily large.

We check now whether a stationary gross nominal interest rate, $R = R(i)$, is sustainable as a SCCE. Suppose that the i-currency issuer considers a deviation in period $t > 0$, letting $R^q(i)_t \to \infty$, by printing arbitrarily large amounts of money. Suppose that agents' expectations are such that, after observing that the *ex-post* rate differs from the *ex-ante* rate, they become $v_{t+s}^{c,i}(h_{t+s}; R^q(i)_{t+1+s} = \infty) = 1$, for any h_{t+s}, $s \geq 0$. Given such beliefs, real money demand for that currency is zero from time t on, i.e., $m(i)_{t+s} = 0$, $s \geq 0$, which means that the newly issued pieces of paper are worthless.

The value of the outcome after the deviation is zero, except for the value of the outstanding real debt. The reason is that the deviation triggers a currency collapse for that currency, starting tomorrow. But, contrary to the quality-goods model with unobserved quality, the demand for money, being an asset, depends on future prices. Thus, the expectations of the currency collapse make the newly injected money be worthless today. Therefore, the present value of the benefits following a deviation is obtained by replacing the real value of money from time t on by zeroes in the expression for profits (13)

$$V^D(i)_t = -\frac{d(i)_t}{\beta}$$

On the other hand, if the issuer does not deviate, the present value of the profits are

$$
\begin{aligned}
V^C(i)_t &= \beta \frac{(R(i) - 1)m(i)}{1 - \beta} - \frac{M(i)_t}{P(i)_t} - \frac{d(i)_t}{\beta} \\
&= \rho^{-1}(R(i) - 1)m(i) - m(i) - d(i)_t \beta^{-1}
\end{aligned}
$$

The last equality follows from the fact that, in equilibrium, $m(i) = \frac{M(i)_t}{P(i)_t}$. It follows that the i-currency issuer will choose not to deviate from the stated policy when

$$\left[\rho^{-1}(R(i) - 1) - 1\right] \geq 0,$$
$$\text{i.e., } R(i) \geq 1 + \rho$$

or, equivalently, whenever $\pi(i) \geq 0$.

As in the previous model, the set of stationary SCCE is large. More formally, the following proposition parallels Proposition 3.

Proposition 4 *A policy* $(\pi(i) = \pi)$ *is an outcome of a stationary symmetric SCCE iff* $\pi \geq 0$.

An equilibrium path with symmetric stationary policies is sustainable if and only if the corresponding inflation rates are positive. The reason why inflation must be positive is because of the timing of collection of revenues for the issuers. Remember that along the commitment solution, the issuers make initial money holdings be valueless and, by an open market operation they sell back the new money balances to the consumers. Thus, at the first period the issuers hold positive assets in an amount equal to the real balances. From those assets they collect the real rate of interest, ρ. Thereafter, they also collect the inflation rate times the real money balances every period. If they deviate, they will keep the real asset holdings only.[10] Thus, as long as the returns they make with the inflation tax are non-negative, they have no incentives to deviate. In other words, future profits must be sufficiently high, and, in this monetary environment, future profits are the gains from future issuance of money. The gains corresponding to the initial issuance of money, the real rate on the real money stock, are sunk.

In summary, without full commitment, Hayek's conjecture, that efficient monetary equilibria can be achieved through currency competition, is not verified, as long as optimality requires deflation in equilibrium, as in Friedman´s rule.

4   Conclusions

In this paper, in order to answer an old question in monetary theory – can currency be efficiently provided by competitive markets? – we have addressed the more general issue of how two mechanisms, trust and competition – which supposedly discipline the actions of suppliers of goods, services, and currencies – interact. We first show a flaw in the standard "Bertrand competition"

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[10]Note that if the issuer were forced to hold their own currency denominated assets, then the efficient outcome could be supported as a SCCE.

argument when suppliers compete on promises rather than on tangible deliveries; we also show how seemingly different markets – such as experience goods and currencies – share the same basic properties and, therefore, results. The key issue is whether promises can be 'automatically trusted', and expectations based on them always fulfilled. In the provision of currencies (and other financial assets) promised returns fulfill consumers' expectations when currency suppliers are fully committed to their promises. Similarly, with experience goods promised and realized qualities are the same when quality is observable. In these contexts, trust is automatically achieved and the competition mechanism results in an efficient allocation provided suppliers do not have monopolistic power.

However, expectations based on promises may not be automatically fulfilled: either because suppliers cannot commit to future actions (in the case of currencies, the policy of maintaining future prices to achieve the promised returns), or because their actions are hidden (in the case of experience goods, the effort of implementing the promised quality). In these contexts, it must be in the interest of suppliers to be trustworthy: future rewards must compensate the temptation to renege on their promises. The need for such future rewards determines a lower bound on the degree of efficiency that can be achieved in these markets. In the experience goods market the lower bound requires that the mark up be as least as high as the rate of time preferences; in the currencies market the lower bound requires non-negative inflation and, therefore, positive nominal interest rates, away from the Friedman's rule of zero nominal interest rates. A first corollary of this result is that Hayek's conjecture, that efficient monetary equilibria can be achieved through currency competition is not verified if currency suppliers make sequential decisions.

There is a second, somewhat disturbing, corollary to the previous result. Once the "trust mechanism" works it fully determines which equilibrium is achieved and, since beliefs sustaining trust are fairly arbitrary, there is an indeterminacy of such equilibria. That is, any effective mark-up above the discount rate, or any positive inflation, can be part of a stationary equilibrium outcome. In other words, the competition mechanism plays no role. Placing restrictions on beliefs can change this last result. In particular, the indeterminacy problem arises because consumers use announced promises to coordinate their beliefs (on price per unit of quality, or on future nominal interest rates) and, therefore, any announcement satisfying the lower bound condition can be sustained as an equilibrium with a belief that trusts the announcement and mistrusts any deviation, even deviations which enhance

efficiency. Restrictions on beliefs that allow the latter deviations may restore a role for competition. We have not pursued this issue here.

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