LOCAL CURRENCY AS A DEVELOPMENT STRATEGY*

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Abstract

The introduction of a local currency may serve as a signal of demand for local goods. Where demand uncertainty deters firms from investing in more productive technologies, such a signal improves the chances that technology choice will be optimal. The introduction of a local currency therefore always improves ex-ante efficiency and may lead to ex-post efficiency, with strictly higher levels of productivity and welfare.

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I. Introduction

Less developed areas are typically characterized by low levels of productivity. In the development economics literature, firms' reluctance to invest in more productive technologies is commonly attributed to the small size of the domestic market. In some of the earliest works on the subject, Rosenstein-Rodan [1943] and Nurkse [1953] attribute the persistence of a "low-level equilibrium" – with low levels of income and productivity – to a lack of coordination in inter-sectoral investment, precipitated by limitations in market size.[1]

In this paper, we follow in the tradition of Rosenstein-Rodan and Nurkse in recognizing that insufficient demand may indeed deter local producers from selecting more productive technologies. However, we propose an alternative reason for firms' choice of less productive technologies – demand uncertainty. That efficient outcomes may be stymied by informational barriers has long been recognized by industrial organization theorists. It is also widely recognized that informational imperfections tend to be particularly severe in developing areas (see Stiglitz [1989] and Hoff and Stiglitz [1999] for an overview).

The effect of informational barriers on product markets in developing countries to date has, however, been largely restricted to analysis of imperfect consumer information regarding product quality. Mayer [1984] and Grossman and Horn [1988], for example, note that in industries with imperfect consumer information regarding product quality, late potential entrants may be dissuaded from entering because they lack the reputational advantage that established competitors possess. Since the former are typically situated in less developed countries, this deters the growth of local industry, even when such growth would be efficient.

Here, rather than focus on imperfect consumer information and its implications for entry, we consider how incomplete firm information regarding consumers' demand for their product affects technology choice. The idea is simple. A firm, when faced with a choice of technologies, may be unwilling to invest in “better” – lower marginal cost – technologies for fear that demand is insufficient to cover the investment necessary to acquire such technologies. If the firm does not expect that demand will be high enough to make such an investment worthwhile, then it will choose the less productive technology.

Whether such an investment decision is optimal ex-post obviously depends on demand realizations. The ex-post efficient outcome is one in which the firm chooses the more productive technology when actual demand is high, and the less productive technology when actual demand is low. The potential for inefficiency would therefore be attenuated if there existed some mechanism whereby demand uncertainty could be alleviated. Indeed, even a partial resolution of demand uncertainty would lead to an enhancement of ex-ante efficiency. We submit that one way of accomplishing this is through the introduction of a local currency.

There is, of course, a vast literature on multiple currencies dating back to Mundell’s [1961] seminal contribution. Traditionally, this literature has been concerned with such issues as goods and factor mobility and the effects of macroeconomic shocks. This emphasis is not surprising given that countries’ decisions regarding whether or not to introduce domestic currencies tend to be dominated by concerns about the potential benefits (in terms of say, employment or growth) of having independent exchange rates or monetary policies (see Abrams [1993] and Kalyuzhnova and Tridimas [1998]).

Although we too are interested in the role of multiple currencies in promoting efficiency, our focus is on a much more local, subnational level. It stems from the growing popularity of the use of local scrip in communities across the world to allegedly “promote local business” or “help the local economy”. In the last decade or so, over 1,500 such communities have burgeoned. One is Ithaca, New York (where these authors happen to reside).[2]

Local currency institutions themselves are subject to strict national guidelines which largely rule out any independence local authorities have regarding monetary policy or exchange rate regimes. What these local currency institutions basically do is to offer consumers in the local economies the option of holding a portion of their wealth in the national currency (say, dollars) and the remainder in the local currency (called "Hours" in Ithaca). As such, we are not concerned with such issues as optimal currency areas or the relative merits of fixed versus floating exchange rates. Our objective is much more basic and may be captured in the following thought experiment. Suppose all individuals initially held money in blue notes. Then how (if at all) might productivity and welfare be enhanced by allowing each individual to dye as much of their (blue) money as they wanted, red.

The Ithaca Hours system and most other local currency systems presently in use have two particularly salient features. First, dollars can be traded for Hours at a fixed exchange rate, but wealth held in Hours cannot be converted by consumers into dollars.[3] Once held, the only way for consumers to get rid of Hours is to spend them. Second, whereas dollars are a universally accepted means of payment, Hours are accepted only at locally owned and operated businesses. These features pose something of a puzzle in understanding why consumers are willing to hold Hours at all. What they can purchase using Hours, they can purchase using dollars, and much more besides. So, one thing we will be interested in is whether holding Hours is, as intuition suggests, a "weakly dominated strategy".

Given that consumers are willing to hold the local currency (and in 1,500 communities they actually are), we argue that it is precisely these features which account for its role in promoting efficient outcomes. Since they can only be spent on local goods, local currency holdings serve as a signal of demand for local products.[4] This reduces demand uncertainty and, as we argued earlier, any such attenuation enhances ex-ante efficiency and, in the case of full-revelation, ex-post efficiency.

Section II presents the basic model. Section III considers the equilibrium of a game in which firms face a technology choice with demand uncertainty in the absence of a local currency. In section IV, we analyze the equilibrium of the game with local currency. Section V is devoted to seeing, through an example, how the introduction of a local currency compares to other, more traditional, policies directed at demand revelation. Finally, section VI concludes.

II. The Model

Consider an economy consisting of N consumers and one local firm. Each consumer's utility depends on his consumption of a local good (l) and a national good (n). Utility, $u(l, n; \theta) = \phi(l; \theta) + n$, is quasi-linear in the local good, continuous, strictly quasi-concave, and increasing in both goods. There are two types of individuals: those who are very fond of the local good – θ_H, or "High" types – and those who are not quite as fond of it – θ_L, or "Low" types. Let $d(p, \theta)$ denote a θ-type consumer's utility maximizing level of local goods consumption subject to their budget constraint $pl + n \leq w$, where p denotes the price of the local good, and w is wealth (and is the same across all individuals). Then, what distinguishes a high type from a low type is that at any price $p > 0$, a high type will demand more of the local good than a low type; that is, $d(p, \theta_H) > d(p, \theta_L)$. Types are distributed i.i.d., and are private information with the probability of observing a high type being $\overline{q}$ where $\overline{q} \in (0, 1)$. If q is the expected proportion of high types, therefore, aggregate expected demand may be denoted by $ED(p; q) = N[qd(p, \theta_H) + (1 - q)d(p, \theta_L)]$.[5]

Before local currency enters the picture, wealth, w, is initially held entirely in the national currency, say dollars (D). With the introduction of a local currency, individuals will have the option of holding their currency in any combination of dollars or local money (m), so that $w = m + D$. However, local money can be used towards the purchase of local goods but *not* towards the purchase of national goods, whereas dollars can be spent on either good. Holding positive amounts of a local currency which is not readily convertible into dollars therefore commits an individual to the purchase of the local good.

On the firm's side, there is a single local firm operating in a perfectly contestable market (p.c.m.) for local goods. The local firm is risk neutral and acts as an expected profit maximizer. There is nothing special about this market structure except that, as we will see in the following section, it guarantees a downward sloping price expansion path.[6] There are two technology choices available to the local firm: $t \in \{t_1, t_2\}$. Under t_1, the firm can produce any amount of the good at a constant marginal cost of $c_1 > 0$. Under t_2, the firm faces a marginal cost of $c_2 < c_1$, but must incur a per capita fixed cost of $F > 0$. Although the assumption of a *per capita* fixed cost is unusual, we employ it in order to capture the idea that fixed costs to industrial production tend to increase as one moves from smaller to larger communities. For example, building a factory or buying a plot of land is likely to be considerably more expensive in a large city than it is in a rural town. Later on, we will be interested in seeing what happens as N gets large, so we will want to think about fixed costs rising in proportion to the size of the community. So, if $EC(t,p)$ denotes the firm's expected total costs under technology t and price p, then $EC(t_1,p) = c_1 ED(p;q)$ and $EC(t_2,p) = c_2 ED(p;q) + NF$.

Let $\eta(p,q) = \frac{\partial d(p,\theta)}{\partial p} \cdot \frac{p}{d(p,\theta)}$, $\theta-$type's price elasticity of demand, be elastic for all prices between c_1 and c_2. That is, for all $p \in [c_2, c_1]$, $|\eta(p,q)| \geq 1$. This implies that in this price range, an individual will spend more on the local good as the price of this good decreases. So for every $p \in [c_2, c_1]$, $c_1 d(c_1,\theta) \leq pd(p,\theta)$.

Given q, let $p(q) = \min\{p : (p - c_2)ED(p,q) - NF = 0\}$ denote the minimum price such that profits are equal to zero under the second technology. Then, $p(q)$ satisfies the condition: $p(q) = c_2 + \frac{NF}{ED(p(q),q)}$. Since $ED(p;q)$ is increasing in q, clearly $p(q)$ is decreasing in q, that is, $p' < 0$.

The crux of this paper lies in the idea that demand uncertainty may breed inefficiency, and this has two parts. First, in the absence of information firms are unwilling to invest in the more productive technology t_2, due to insufficient expected demand. Second, we need to allow for the possibility that this decision is inefficient, that is, if expected demand were sufficiently (and feasibly) high, the firm would have optimally chosen t_2. These two ideas are, respectively, captured in the following two assumptions: (i) $p(\overline{q}) > c_1$

and (ii) there exists a $\widetilde{q} \in (\overline{q}, 1)$ $s.t.$ $p(\widetilde{q}) = c_1$.[7] The first assumption simply says that when the expected proportion of high types is $\overline{q}$ (the unconditional expectation), a firm pricing at average cost must charge a price above c_1 if it chooses t_2. We saw earlier that $p' < 0$. The second assumption therefore says that there exists a feasible proportion of high-types ($\widetilde{q}$) above which a firm pricing at average cost can charge a lower price under the second technology than it can under the first.

III. Game without local currency

The game without local currency goes as follows. At the beginning of the period, nature reveals to each individual his type. This is private information; only the distribution of player types is common knowledge. The local firm then chooses a technology (t) and price (p). Consumers observe prices and decide how much of the local good to buy ($d(p, \theta)$). Finally, production and consumption take place.

An equilibrium of the game without local currency is a strategy for each consumer and a strategy (t, p) for the local firm. The consumer's strategy in this game is simple: they simply demand $d(p, \theta)$ of the local good (and spend the remainder of their income on the national good). The firm's strategy follows from the three features of perfect contestability: (i) an entrant incurs no sunk costs of entry, (ii) an entrant is able to begin serving before an incumbent can change its price and (iii) entrants and incumbents have identical access to extant technologies. These three conditions effectively impose a zero-profit condition on the firm's side, hence inducing a downward sloping price expansion path. This, coupled with consumers' strategies gives rise to Lemmas 1 and 2.

Lemma 1 Under p.c.m., a firm which chooses $t = t_1$ must charge $p = c_1$.

Proof of Lemma 1. Suppose $p > c_1$. Then, another firm could enter the market, under cut the price, and drive this producer out of business; $p < c_1$ implies $E\pi(p) < 0$, which is strictly dominated by $E\pi(c_1) = 0$. □

Lemma 2 Under p.c.m., a firm which chooses $t = t_2$ must charge $p = p(q)$

Proof of Lemma 2. Analogous to Lemma 1 □

A. *Equilibrium of the game without local currency*

Lemmas 1 and 2 give rise to the following equilibrium strategies for the firm and the consumers in the absence of a local currency.

Proposition 1 In the game without local currency, $(p^*, t^*) = (c_1, t_1)$,

$$l(\theta_H) = d(p^*, \theta_H), \text{and} l(\theta_L) = d(p^*, \theta_L)$$

Proof of Proposition 1. Suppose not; suppose the firm chose t_2. Then, from lemma 2, and given that $q = \overline{q}$, we know that $p = p(\overline{q}) > c_1$. So, from lemma 1, an entrant could choose t_1 and profitably under cut the firm, leaving it with a loss of NF. □

This proposition says that when a firm's only information regarding types is that the $Prob(\theta = \theta_H) = \overline{q}$, it will choose the less productive technology t_1 and charge the high price c_1. This equilibrium may be regarded as a "low-level equilibrium" in the sense that productivity and demand are lower, and prices, higher than they would be under technology 2.

However, the equilibrium may or may not be efficient in the ex-post sense. If the realized number of high-types in the economy is $K < \widetilde{q}N$, then the choice of technology (t_1) *is* ex-post efficient. If, however, $K \geq \widetilde{q}N$, t_2 would Pareto dominate t_1, with the firm at least as well off and consumers strictly better off. The potential ex-post inefficiency arises on account of the firm's uncertainty regarding the distribution of consumer types, which in turn determines aggregate demand for their product. As we argue in the following section, the introduction of a local currency may actually allow consumers to signal their type costlessly, thereby allowing firms and consumers to coordinate on an equilibrium which is efficient both in the expected and ex-post sense.

IV. Game with Local Currency

Now suppose that individuals have the option of holding a local currency, expendable only on local goods, and hence, serving as a signal of demand to local firms. The game with local currency runs as follows. First, nature reveals types. Each individual privately observes his type and then decides what portion of his (initially dollar) wealth to hold in local currency (m).They then go to the monetary authority and convert this portion into m at a fixed exchange rate. For simplicity, and without loss of generality, we assume this rate to be 1:1. Once converted, their local currency holdings cannot be reconverted into dollars and can only be spent on the purchase of local goods. The local firm observes the aggregate amount of local currency holdings (M). It then updates its beliefs regarding the aggregate number of θ_H-types in the economy and decides on a (p, t) combination. Individuals observe prices and decide how much of the local good to buy. Market transactions then take place. At the end of the period, firms (but not consumers) can go to the monetary authority and redeem their local currency holdings for dollars.

A perfect Bayesian equilibrium of the game with local currency consists of a strategy for each consumer and a strategy and beliefs for the firm which satisfy the following properties. First, each consumer's strategy is optimal given other consumers' strategies and the firm's beliefs and strategy. Second, the firm's strategy is optimal given beliefs and consumers' strategies. Finally, beliefs are consistent.

As with most Bayesian games, this one has multiple equilibria, some of which are more reasonable than others. For example, there exists an equilibrium in which the firm believes that $\#\theta_H = 0$ when $M \leq Nw$, no one holds local currency, and the firm employs the high marginal cost technology. Given that individuals can only spend local currency on local goods, beliefs such as these seem somewhat unreasonable.

To capture the idea that firms recognize that local currency must be spent on local products, therefore, we restrict our attention to beliefs which satisfy the following simple monotonicity property.[8] Let $\alpha(M)$ denote the firm's posterior regarding the number of θ_H-types in the economy. Then, monotonicity implies that $\alpha(M') \geq \alpha(M)$ for all $M' > M$, with $\alpha(M') > \alpha(M)$ for some $M' > M$ where $M, M' \in [0, wN]$. In other words, observing a larger aggregate local currency holding cannot induce the firm to think that at any given price $p > 0$, it will face a lower expected demand; furthermore, over some range of local currency holdings, the firm's beliefs regarding the proportion of high types in the economy is strictly increasing in M. The monotonicity assumption yields a unique equilibrium to the game with local currency, which has particularly intuitive properties, a couple of which coincide nicely with the characteristics of extant local currency systems.

A. *Equilibrium of the Game with Local Currency*

Consider the problem of a consumer i of type θ_j. She must decide how much of her wealth to hold in local currency ($m_i(\theta_j)$), and how much of the local good to consume ($x_i(p, m)$). When the firm has monotone beliefs, the consumer knows that holding more local currency may convince the firm that there are enough high types to choose t_2 and charge a lower price. However, the danger in holding local currency is that at any given price p, she may be stuck with more of the local currency than she would optimally like to spend on the local good. This problem would be overcome if the consumer held the minimum amount she would spend on the local good irregardless of the firm's technology choice and other consumers' strategies or, more precisely, an amount:

$$m_i(\theta_j) = \min_{p \in [c_1, c_2]} pd(p, \theta_j) \tag{1}$$

Since $|\eta(p, q)| \geq 1$ for all $p \in [c_2, c_1]$, we know that $m_i(\theta_j) = c_1 d(c_1, \theta_j)$. That is, the consumer's strategy is to hold that amount which she would spend on the local good if the firm were to stick to the less productive technology; notice that $m(\theta_H) > m(\theta_L)$ since $d(p, \theta_H) > d(p, \theta_L)$. If a consumer follows this money holding strategy, then her local goods consumption will be:

$$x_i(p, m_i) = \max\{d(p, \theta_j), \frac{m_i}{p}\} \tag{2}$$

Given that individuals are following this strategy, aggregate money holdings in the economy are $M = \sum_{i=1}^{N} m_i(\theta_j) = Km(\theta_H) + (N - K)m(\theta_L)$, where K is the number of high-types in the economy. The firm knows the aggregate local money holdings in the economy and, in equilibrium, beliefs must be consistent with consumers' strategies.[9] Therefore, re-arranging this equation and solving for K, the firm's (equilibrium) beliefs regarding the number of high-types in the economy naturally take the following form:

$$\alpha(M) = \frac{M - Nm(\theta_L)}{m(\theta_H) - m(\theta_L)} \tag{3}$$

Hence, if $m(\theta_L)$ and $m(\theta_H)$ denote low- and high-type consumers' equilibrium money-holding strategies, in observing the aggregate money holdings in the community the firm will be able to perfectly intuit the aggregate number of high-types in the economy. It is in this manner, therefore, that holding local currency signals demand. Let $\widetilde{K} = \widetilde{q}N$ be the critical number of high-types above which a firm will be induced to choose t_2 and let $\widetilde{M} = m(\theta_H)\widetilde{K} + m(\theta_L)(N - \widetilde{K})$. Then, the firm's equilibrium price-technology strategy is then very straight forward given its beliefs and consumers' strategies. It is given by:

$$(p, t) = \begin{cases} (c_1, t_1) & \text{if } M < \widetilde{M} \\ (c_2 + \frac{NF}{ED(p; \frac{\alpha(M)}{N})}, t_2) & \text{if } M \geq \widetilde{M} \end{cases} \tag{4}$$

In other words, if a firm sees "enough" local money in the community $(M \geq \widetilde{M})$, it will choose the more productive technology and charge a lower price. Otherwise, it will resort to the less productive technology. Proposition 2 describes equilibrium strategies and beliefs formally.

Proposition 2 If N is sufficiently large, in a game with local currency the following is a Perfect Bayesian Equilibrium with monotonic beliefs:

(i) Consumer i's money-holding and local goods consumption strategies are described by (1) and (2) respectively, where $i \in \{1, ...N\}$ and $j \in \{L, H\}$.

(ii) The firm's price-technology strategy is given by (4)

(iii) The firm's beliefs are of the form described in (3)

Proof of Proposition 2. Given consumers' strategies and the beliefs outlined in (i) and (iii), the firm's equilibrium strategy follows from Lemmas 1 and 2 and Proposition 1. Furthermore, given a money-holding strategy, consumer's local goods consumption follows naturally. Consider consumer i's money-holding strategy.

First consider a deviation to the left: $m' \in [0, m(\theta))$. Let $M' = M - (m(\theta) - m')$. For an individual of type-θ, there exist three possibilities.

(1) $\alpha(M') \geq \widetilde{K}$.

In this case, the firm chooses t_2 regardless of the individual's deviation. Average cost pricing and the monotonic beliefs property (m.b.p.) mean, however, that the individual stands to face a higher price, leaving him strictly worse off holding m' rather than $m(\theta)$.

(2) $\alpha(M) < \widetilde{K} \Rightarrow \alpha(M') < \widetilde{K}$ under m.b.p.

Here, the firm always chooses t_1 and charge c_1, so the individual is indifferent between holding $m(\theta)$ and m'.

(3) $\alpha(M) \geq \widetilde{K}$ and $\alpha(M') < \widetilde{K}$.

That the individual will induce a switch from t_2 to t_1 and hence face a higher price is a positive probability event for any $m' < m(\theta)$. Such an action would therefore make the deviator strictly worse off. Given that the individual is indifferent in case 2, but strictly worse off under cases 1 and 3, under m.b.p., the individual will never have an incentive to deviate to a lower $m(\theta)$.

Now, consider a deviation to the right: $m' \in (m(\theta), w]$. Without loss of generality, normalize $m(\theta_L) = 0$ and $m(\theta_H) = 1$. We first introduce some notation. Let $v_j(p) = u(d(p, \theta_j), w - pd(p, \theta_j))$ be a type-θ_j consumer's indirect utility at his optimal consumption bundle at price p. Let $\mathrm{v}_j(p, m) = u(x_j(p, m), w - px_j(p, m))$, be a type-$\theta_j$ consumer's maximum possible utility at price p when he holds m units of the local currency, where as before, $x_j(p, m) = \max\{d(p, \theta_j), \frac{m}{p}\}$. Notice that $v_j(p) \geq \mathrm{v}_j(p, m) \; \forall \; m, p$. Finally, let $\delta_j(p, m) = \mathrm{v}_j(p, m) - v_j(p)$. Clearly, $\delta_j(p, m) \leq 0$.

Consider a θ_H-type's incentive to deviate to $m' \in (m(\theta), w]$. (An analogous argument works for a θ_L-type, so we omit it here.) Let $[\widetilde{K} - m']$ be the biggest integer smaller than $(\widetilde{K} - m')$, and let $s = \#\theta_H$. Then with i.i.d. types, there are three possible states. In the first, the firm always chooses technology 1 and charges $p = p(\alpha(M)) = p(\alpha(M')) = c_1$. In the second, holding $m' \in (m(\theta), w]$ may induce the firm to switch from technology 1 to technology 2 and charge

$$p = p(\alpha(M')) = c_2 + \frac{NF}{\alpha(M')d(p(\alpha(M')), \theta_H) + (N - \alpha(M'))(d(p(\alpha(M')), \theta_L))}$$

In the third, the firm always chooses technology 2 and charges

$$p = p(\alpha(M')) = c_2 + \frac{NF}{\alpha(M')d(p(\alpha(M')), \theta_H) + (N - \alpha(M'))(d(p(\alpha(M')), \theta_L))}$$

State 1: $\#\theta_H \leq \widetilde{K} - m'$ with probability
$\rho_1 = \sum_{s=0}^{[\widetilde{K}-m']-1} \begin{pmatrix} N-1 \\ s \end{pmatrix} \overline{q}^s (1 - \overline{q})^{N-1-s}$

State 2: $\widetilde{K} - m' < \#\theta_H \leq \widetilde{K} - 1$ with probability

$\rho_2 = \sum_{s=[\widetilde{K}-m']-1}^{\widetilde{K}-2} \begin{pmatrix} N-1 \\ s \end{pmatrix} \overline{q}^s (1-\overline{q})^{N-1-s}$

State 3: $\#\theta_H \geq \widetilde{K}$ with probability
$\rho_3 = \sum_{s=\widetilde{K}-1}^{N-1} \begin{pmatrix} N-1 \\ s \end{pmatrix} \overline{q}^s (1-\overline{q})^{N-1-s}$

Let $\widetilde{K} = aN$ where $a \in (0,1)$ and let $B(r)$ be the benefits to the deviator when the state of the world is r. Then, $B(1) = \delta_H(c_1, m') < 0$ since $m' > m(\theta_H) = c_1 d(c_1, \theta)$, and $B(3) = (\mathrm{v}_H(p(\alpha(M'), m') - v_H(p(\alpha(M'))) \lesseqqgtr 0$. In State 2, holding $m' \in (m(\theta), w]$ induces the firm to switch from technology 1 to technology 2. The benefit to the deviator in this state is $B(2) = (\mathrm{v}_H(p(\alpha(M'), m') - v_H(c_1)) \lesseqqgtr 0$.The total expected net benefit from deviating is therefore:

$$EB(r) = \rho_1 B(1) + \rho_2 B(2) + \rho_3 B(3)$$

The first expression is always negative, and the last two have ambiguous sign. At worst, $B(2), B(3) > 0$. However, as N gets large, $\rho_3, \rho_2 \to 0$ and $\rho_1 \to 1$. So, $EB(r) \to EB(1) < 0$. Therefore, for large N, the individual has no incentive to deviate to $m' \in (m(\theta), w]$.

Finally, check that beliefs are correct in equilibrium (they are). □

Remark The equilibrium with monotonic beliefs described in proposition 2 is unique.

This proposition and the remark above together say that in the unique equilibrium of the game with local currency, each individual holds the minimum amount they will spend on the local good– regardless of what technology is eventually chosen – in the local currency. Firms, having observed the aggregate level of local currency holdings, perfectly infer the number of θ_H-types in the economy.

Consumers' equilibrium strategies are driven by the monotonicity of beliefs, which captures the idea that firms recognize the signaling potential of local money holdings. On one end, monotonic beliefs ensure that holding less than the minimum is a weakly dominated strategy. However, this becomes problematic at the other end. Although the individual never has an incentive to hold this amount in state 1, by this very property, individuals may be induced to hold more than their minimum in order to either lower prices in state 3 or induce a technology switch with lower prices in state 2. However, if N is big, the probability of being in the first state (in which you make a certain loss by over-holding) is big compared to the probability of being in states 2 or 3.[10] Therefore, the net benefit of deviations to the right is negative. It is precisely this logic which gives rise to the uniqueness of this equilibrium. For each consumer i, monotonicity rules out money holdings to the left of the minimum, and as we just saw, for sufficiently large N, money holdings larger than the minimum are ruled out as well.[11]

The equilibrium described in proposition 2 has several appealing properties. First, a symmetric equilibrium arises naturally from the consumers' strategies, considerably simplifying the construction of the firm's beliefs. Second, as mentioned in the introduction, casual intuition suggested that holding local currency is a weakly dominated strategy – dollars can be used to buy both national and local goods whereas local currency can only be used towards the purchase of the local good. However, a local currency has a supplementary attribute over and above being a unit of exchange: it serves a signal of demand for local products. Monotonicity coupled with the min-strategy therefore turns conventional intuition on its head, making the holding local currency a weakly dominant strategy over a certain range.

Third, efficiency arises even when individuals are following a particularly pessimistic strategy. In many coordination games, efficiency arises when players shoot for the moon at a potential cost, and this optimistic strategy becomes self-fulfilling. Here, people are acting in such a manner that even if the firm does not charge the lower price, they will not be hurt by their chosen strategies.

Fourth, individuals who are more keen about local goods hold larger amounts of the local currency; this is widely observed in practice. Finally, the equilibrium captures the fact that the actual amount of local currency in circulation tends to be small.[12] In this model, this could be explained by a combination of low demand for the local good at current prices as well as consumers' min-strategies.

V. Alternative Policies

The introduction of a local currency provides individuals with an instrument to signal their demand for local goods; it essentially acts as a demand revelation mechanism. In the equilibrium we have constructed, such a signal is perfectly revealing and can have one of two consequences. When the local firm's posteriors are sufficiently high, it switches to a more productive technology, charging a lower price. When they are sufficiently low, the firm stays with the less productive technology – the one they would have chosen in the absence of any signal. In equilibrium, firms earn zero expected profits, so, since they are risk neutral, firms are certainly no worse off under a local currency regime. By holding what they would spend on the local good anyway, consumers are never worse off when demand is revealed to be low. Furthermore, they are strictly better off when demand is revealed to be high. In the equilibrium we have constructed, therefore, the introduction of a local currency therefore always leads to a Pareto improvement: efficiency is enhanced in both an ex-ante and an ex-post sense.[13]

Ex-post optimality arises because in this equilibrium, the introduction of a local currency effectively induces truth-telling. Needless to say, the introduction of a local currency is not the only demand revelation mechanism available to policy makers. It would be instructive, therefore, to see how this policy compares to other demand revelation mechanisms a government may resort to.

Here, we consider two alternative mechanisms. The first is an especially obvious candidate: the government could simply go out and ask each individual what their type is. In such a survey, high types would clearly not have an incentive to lie – they stand to suffer a higher price if they do. However, for exactly the opposite reason, low types certainly do have an incentive to lie. Consequently, a simple survey is not going to induce individuals to reveal their types truthfully. Since all low types will claim to be high types, any survey must therefore be accompanied by an incentive for truth-telling.

This brings us to the second alternative. Suppose that rather than introduce a local currency, local goods production is organized in the public sector and the government pursues the following policy. First, it asks individuals to reveal their type. On the presumption that announcements are true, the government then chooses the appropriate technology in precisely the same manner as the firm did previously. In particular, it selects t_1 and charges a price $p = c_1$ if the proportion of self-declared θ_H-types ($r = \frac{R}{N}$) is less than $\widetilde{q}$; it chooses t_2, setting $p = \min(AC(t_2; r))$, otherwise. Trade then takes place at this price. If demand realizations are at variance with the anticipated demand, any profits or losses incurred by the government-producer are passed on to consumers in the form of lump-sum transfers or taxes, τ.

This policy, in effect, imposes a balanced budget constraint on the government. The restriction serves a dual purpose. First, it guarantees that the firm will earn zero-profits, thereby facilitating Pareto comparisons in equilibrium under this policy. Second, it enforces a discipline on punishment which may otherwise be taken to extremes in order to induce the desired (efficient) outcome in equilibrium. For example, the government could ask individuals to reveal their types and then kill everyone if observed demand were not in accordance with announcements. In equilibrium, then, all individuals would tell the truth, but such a policy is simply not reasonable. In analyzing this policy, closed form solutions are intractable, so we consider a simple example instead.

A. *An Example*

Consider an economy comprising 100 individuals ($N = 100$) with linear demand functions of the form $d(p, \theta) = \theta - p$, where $(\theta_{H,}\theta_L) = (12, 8)$.[14] Let each individual's wealth be $w = 60$ and let the probability of an individual being of type θ_H be $\overline{q} = 0.45$. Then, if $F = 0.8$, $c_1 = 0.62$ and $c_2 = 0.6$, $\widetilde{q} = 0.5$. Let a_i denote person i's announcement of his type, where $a_i = 1$ if he announces that he is a high type, and $a_i = 0$ if he announces that he is a low type. Then, $R = \sum_i a_i$ is the total number of individuals announcing high types and let $r = \frac{R}{N}$. Let $ED(p;R) = Rd(p,\theta_H) + (N-R)d(p,\theta_l)$ denote the expected demand for the local product following individuals' announcements of types, under the presumption that individuals are telling the truth. We know that when $r < 0.5$, the government will choose technology 1 and set a price $p(R) = 0.62$; and when $r \geq 0.5$ it will choose technology 2 and set a price $p(R) = 0.6 + \frac{NF}{ED(p;R)}$. Let $\pi(R,K)$ denote the government's (realized) profits when R individuals announce that they are θ_H-types and K individuals act like θ_H-types. Then, under the policy outlined above, the government's total tax/transfer bill will be: $\tau(R,K) = \pi(R,K)$, where $\pi(R,K) = N[(\frac{K}{N}d(p(R),\theta_H) + (1-\frac{K}{N})d(p(R),\theta_L))(p(R)-0.6) - 0.8]$ when $R > 50$ and $\pi(R,K) = 0$ otherwise. Clearly, whenever $R > K$, $\pi(R,K) \leq 0$ and when $R < K, \pi(R,K) \geq 0$.

What we are really interested in is whether a given tax schedule will induce truth-telling ($K = R$). In order to answer this question, we need to determine whether there exist profitable deviations from truth-telling. This means that we can restrict our attention to two cases: (i) $R = K+1$ and (ii) $R = K-1$. The first case pertains to a θ_L-type pretending to be a θ_H-type. The second case pertains to a θ_H-type pretending to be a θ_L-type. Let $v_i(p(R),\theta_{-j}|\theta_j) = u(d(p(R),\theta_j), w - p(R)d(p(R),\theta_j)) + \tau_i(R,K)$ denote the net benefit of lying for an individual i of type θ_j. Then, if $Ev_i(p(R),\theta_{-j}|\theta_j) > Ev_i(p(R),\theta_j|\theta_j)$, a type θ_j will be better off lying when others are telling the truth.

First consider the case in which the government targets any taxes or transfers directly to the deviator. That is, if i deviates whilst everyone else tells the truth, $\tau_i(R,K) = \pi(R,K)$ and $\tau_{-i}(R,K) = 0$.

Net Benefit to a High-type deviating under targeted transfers. As we can see in Figure I, a high type has no incentive to deviate in any state of the world (i.e. for any K). For $K \leq 50$, the deviation does not cause any change in price and the government earns zero profits. Hence, in this range, there is no tax or transfer. For $K > 50$, the net benefit (positive transfer from government's profits, less the utility loss from a higher price) is negative. Thus, the expected benefit from lying is negative.

Net Benefit to a Low-type deviating under targeted transfers. Similarly, as Figure II indicates, a low type has no incentive to deviate from truth-telling either.

The targeted tax/transfer policy therefore induces truth-telling. However, in order to carry out this policy, the government must be able to track both announcements and individual demands, and this is a rather extravagant requirement. In its absence, the government would need to resort to an aggregate rather than individual-level indicator in formulating its tax/transfer scheme. One such policy is a simple head-tax/transfer of the form $\tau_i(R, K) = \frac{\pi(R,K)}{N}$ for all i. Figures III and IV depict the incentives for deviation under this policy.

Net Benefit to a High-type deviating under a head-tax. The costs incurred by high-type deviating from truth-telling are magnified when the government institutes a per-capita rather than a targeted transfer. Consequently, as seen in Figure III, the expected benefit from lying continues to be negative.

Net Benefit to a Low-type deviating under a head-tax. As Figure IV shows, a low-type has no incentive to deviate when $K \leq 50$. However, unlike the case of a targeted tax, a low type actually does have an incentive to deviate under a head-tax when $K > 50$. Thus, the expected benefit from lying is positive.

How do the two policies outlined above compare to equilibrium of the currency policy discussed in the previous section? Pursuing a "min" strategy in the equilibrium outlined in Proposition 2 leads to full revelation. In this sense, it is analogous to truth-telling under the two policies considered above. As we saw earlier, it is never profitable for an individual to hold less than his minimum money holdings. Figures V and VI describe net benefits of deviating to the right. In particular, we consider what incentive the individual might have to deviate from holding $m = c_1 d(c_1, \theta)$ to $m' = m + \varepsilon$, where $\varepsilon = 0.01$.

Net Benefit of High-type deviating under Local Currency. As Figure V indicates, a high-type individual has a positive incentive to deviate from a min-strategy for $K > 50$. However, when $K \leq 50$, deviation entails a loss.[15] Therefore, when $N = 100$ and $\overline{q} = 0.45$, under the binomial distribution, the net benefit from deviating is negative.[16]

Net Benefit of Low-type deviating under Local Currency. Figure VI paints much the same picture as Figure V. Analogously, net expected benefits are negative and the low-type individual has no incentive to deviate from his min-strategy.[17]

B. *Discussion*

In the model we considered in Section IV, local currency holdings resulted in full revelation of demand and consequently, a Pareto optimal outcome. As this example demonstrates, it is possible to obtain the same result from a targeted transfer. Under such a policy, any given individual contemplating a unilateral deviation from truth-telling faces a trade off between a price difference on the one hand and transfers or tax on the other. In this example, for high (low) types, the former (latter) effect dominates. Although this sounds promising, it is important to recognise that a targeted policy has lavish book-keeping requirements. In order to enforce such a policy, the government must keep a record of names on both announcements and transactions. This promises to be an extremely complex, not to mention expensive, undertaking – arguably more so than printing local money.

Once you move to a less exacting system of taxation based on aggregate indicators, however, you lose the truth-telling equilibrium. In particular, when a targeted tax is substituted with a head tax, low-types now have an incentive to announce that they are high-types because they continue to reap the benefit of the resultant price reduction, while bearing only a fraction of the tax costs. In the equilibrium described in Proposition 2, however, a local currency policy essentially succeeds where the head-tax fails; firms are able to divine the number of high-types in the economy simply by observing aggregate money-holdings in the economy (M).

Besides being relatively inexpensive to administer and having minimal book-keeping requirements, local currency has the additional appeal of being decentralized and self-enforcing. The government's only function is to play the role of the monetary authority, printing and exchanging local currency. It need not worry about implementing punitive measures on consumers since, in deviating from their "min" strategy (which is analogous to truth-telling), players impose a potential cost upon themselves in terms of sub-optimal consumption.

VI. Conclusion

In addition to the standard attributes of currency, local money serves as a signal of demand for local goods, thereby attenuating demand uncertainty and enhancing efficiency. In the equilibrium we constructed money holdings are fully revealing, leading to ex-post optimality. Indeed, for any finite number of local firms producing a finite number of goods, this will be the case as long as firms know $d(p, \theta)$, the vector of demands for each firm's good.

Once we allow for more than two consumer types, however, the particular signal we considered no longer induces an information structure without noise. This is because a firm, in observing only M, has one equation in more than one unknown ($J - 1$ unknowns if there are J consumer types). Although residual uncertainty would mean that ex-post efficiency is no longer assured in this case, such a signal would nonetheless be informative. The important thing to notice is that the introduction of a local currency voluntarily held by optimising agents never increases firms' demand uncertainty and although ex-post efficiency is by no means guaranteed, ex-ante efficiency is always (weakly) improved. At worst, posteriors and priors are identical and at best, as in the equilibrium of the game we considered earlier, demand is perfectly revealed.

The use of a local currency to resolve demand uncertainty is particularly attractive in light of how little institutional involvement it entails. Indeed, most extant currency systems have been initiated by non-governmental agencies or, more commonly, by individuals. The institution's sole role is to print money and act as a currency exchange agency. Granted, this task involves both the cost of printing money and a certain degree of credibility. Neither individuals nor firms would be willing to trade in the local currency if they did not trust the monetary authority to play the role of facilitator in an honest manner. However, the same would be true of standard tax/transfer policies designed to elicit truth-telling. Indeed, policies such as those discussed in the previous section involve not only the assurance that the government will not simply pocket any gains, but also that it will set policy in order to enhance efficiency, assuming that it has taxation authority at all. These are, if anything, a more stringent set of requirements, particularly in the context of developing countries.

In this paper, we have focused on the signaling value of local currency. Local money enhances efficiency by serving as a signal to local producers of the demand for their products. However, the signaling opportunities for local currencies need not operate in this particular manner in order to promote efficiency. For example, members of local currency communities often claim that the use of a local currency cultivates a sense of community. It is not difficult to formalize this idea in a model in which national and local goods are substitutes and consumers' utility of local goods consumption increases in the number of agents consuming locally.

Such a model would essentially be a coordination game with two equilibria. In the "good equilibrium", everyone consumes locally and in the "bad equilibrium", nobody consumes locally. Here, holding positive amounts of local currency would actually be a weakly dominated strategy, but in sodoing agents may actually be able to coordinate on the "good" equilibrium by signaling their intent to consume locally.[18]

The idea that the mere introduction of a local currency may give rise greater efficiency and, potentially, higher productivity is disarmingly simple, especially when compared to the types of solutions which traditionally accompany developing areas' escape from low-level equilibria. For instance, the traditional prescription for escape from a low-level equilibria stemming from intersectoral coordination failures of the Rosenstein-Rodan type is large-scale government investment in shared infrastructure (see Murphy, Shleifer and Vishny [1989]). Similarly, the infant industry argument is an oft-cited resolution to inefficiently low entry (see Mayer [1984]).

However, there are a number of limitations to this policy. First, once uncertainty on the part of consumers regarding their own demand for the local good is introduced, local currency once more becomes a dominated asset. To some extent, this explains why individuals who hold local currency tend to be those who are well settled in the local community. More generally, however, it does suggests that the analysis would not go through in a climate of individual uncertainty in the absence further structure.

Second, as monetary theorists well recognize, the introduction of a new currency is no easy matter. In focusing on the introduction of a local currency to supplement a national one, we have skirted at least three important issues. The first is the level of credibility with which we have exogenously endowed the monetary authority. Clearly, if firms did not trust the monetary authority to redeem their local currency for dollars, this policy would never get off the ground. The second is the wealth-creation aspect of money. Evidence among extant local currency systems suggests that this may, in fact, be an important motivation for the introduction of local currency. Any explanation for why a national currency will not suffice would probably have to tell a story of a non-information-based market failure which leads to a (dollar) cash constraint among a subset of the population who would otherwise like to trade with one another. Finally, there looms the issue of why people are willing to hold money at all. At the very least, a dynamic framework would be required to answer this broader question.

References

Abrams, Richard, "Introduction of a New National Currency: Policy, Institutional and Technical Issues," IMF Working Paper WP/93/49, (1993).

Coate, Stephen and Stephen Morris, "On the Form of Transfers to Special Interests," *Journal of Political Economy*, CIII (1995), 1210-1235.

Eswaran, Mukesh and Ashok Kotwal, "Demand Externality and Industrial Productivity Growth in LDCs," *Journal of International Trade and Economic Development*, V (1996), 1-22.

Glover, Paul, Hometown Money: How to Enrich Your Community with Local Currency, Mimeo, (1995).

Grossman, Gene and Henrik Horn, "Infant-Industry Protection Reconsidered: The Case of Informational Barriers to Entry," *Quarterly Journal of Economics*, CIII (1988), 767-787.

Hoff, Karla and Joseph Stiglitz, "Modern Economic Theory and Development," G. Meier and J. Stiglitz (eds.), *Pioneers in Development*, Oxford University Press, Forthcoming.

Kalyuzhnova, Yelena and George Tridimas, "Dilemmas of Financial Development in Kazakstan," *Journal of International Development*, X (1998), 681-693.

Kiyotaki, Nobuhiro and Randall Wright, "A Search-Theoretic Approach to Monetary Economics," *American Economic Review*, LXXXIII (1993), 63-77.

Kocherlakota, Narayana and Thomas Krueger, "A Signaling Model of Multiple Currencies," *Review of Economic Dynamics*, II (1999), 231-244.

Matsuyama, Kiminori, "The Market Size, Entrepreneurship and the Big Push," *Journal of Japanese and International Economics* , VI (1992), 347-364.

Mayer, Wolfgang, "The Infant-Export Industry Argument," Canadian Journal of Economics, XVII (1984), 249-269.

Mundell, Robert, "A Theory of Optimal Currency Areas," *American Economic Review*, LI (1961), 509-517.

Murphy, Kevin, Andrei Shleifer and Robert Vishny, "Industrialization and the Big Push," *Journal of Political Economy* , XCVII (1989), 1003-1026.

Nurkse, Ragnar, *Problems of Capital Formation in Underdeveloped Countries* (New York: Oxford University Press, 1953).

Rosenstein-Rodan, Paul, "Problems of Industrialization in Eastern and South-eastern Europe," *Economic Journal*, LIII (1943) 202-211.

Stiglitz, Joseph, "Markets, Market Failures and Development," *American Economic Review*, LXXIX (1989), 197-203.

1. They argue that limitations in market size make it unprofitable for any one sector to industrialise, but if all sectors were to industrialize simultaneously, the subsequent increase in income, and hence demand, would make such investment worthwhile. Although this has been a notoriously difficult concept to formalize, Murphy, Shleifer and Vishny [1989]; Matsuyama [1992] and Eswaran and Kotwal [1996] each offer intriguing takes.

2. See `http://ccdev.lets.net/index2.html` or `http://www.ithacahours.org.`

3. In the United States, fixed exchange rates are mandated by federal law for tax purposes.

4. To our knowledge, the only other paper which exploits this signaling aspect of multiple currencies is Kocherlakota and Krueger [1999]. However, their principal concern is why different countries may opt for different currencies even if they abdicate independent control of their money supplies.

5. We allow q to be conditional upon some information; when there is no information, $q = \overline{q}$.

6. The analysis would be the same with Bertrand competion. However, Bertrand competition would entail carrying around an extra player without any added insight into the problem. We could also have had monopolistic or oligopolistic competition, with some added restrictions on the demand structure.

7. These assumptions would have to be modified under alternative market structures. For example, under Bertrand competition, the first assumption would have to be $p(\frac{\overline{q}}{2}) > c_1$. The actual structure of the assumptions is, however, only important insofar as it captures the idea of potential inefficiency arising from uncertainty.

8. This refinement is used in a different context in Coate and Morris [1995].

9. In Ithaca, information regarding the aggregate local money holdings is explicitly provided in a bi-monthly newspaper called "Hour Town".

10. This is akin to the voting literature in that with large N, the proba-

bility of being pivotal in affecting the outcome is small.

11. We believe the demand elasticity assumption to be an accurate representation of reality, since the goods typically sold in these markets are low-priced luxuries such as candles, honey and pottery. However, it is technically non-trivial since it ensures that the minimum holding is attained at expenditures under technology 1. If this were not the case – if the minimum is hit at expenditure under technology 2 instead – then the following problem would arise. We know that the benefits from holding more than the minimum in this case are strictly negative in state 3. As N becomes large, the probability of being in state 3 goes to zero faster than the probability of being in state 2 (and earning a potentially positive benefit). Although being in states 2 or 3 becomes a zero measure event as N goes to infinity, one can no longer rule out the possibility that there exist profitable deviations greater than the minimum at technology 2 expenditure.

12. In Ithaca, the total amount of local money in circulation amounts to a mere 64,000 USD. However, this amount is not an insignificant part of the local economy; on any given day at the farmer's market, 5 to 20 per cent of trade takes place in Ithaca Hours.

13. Note that by imposing a zero-profit condition, the market structure we adopt allows us to talk unambiguously about Pareto improvements. With other market structures we would have to consider more conventional measures such as surplus maximization.

14. A utility function of the form $u(l,\ n;\ \theta) = \frac{1-(\theta-l)^2}{2} + n$ would, for example, produce such a demand function.

15. A cursory look at figure 5 provides the basic intuition. Suppose the net benefit is 4×10^{-6} for all $K > 50$ and the loss, -1×10^{-6} for $K \leq 50$. Then, in order for the expected benefit to be positive, it must be the case that $\Pr(K > 50) \geq 0.2$. However, under the binomial distribution with $N = 100$ and $\overline{q} = 0.45$, $\Pr(K > 50) = 0.135 < 0.20$.

16. These results are for an epsilon-deviation. When a high-type individual holds enough extra money to convince the firm that there is one

additional high type in the economy (i.e. $K+1$ high-types), net benefits are lower than -8 for all $0 \leq K \leq 100$.

17. When a low-type individual holds enough extra money to convince the firm that there is one additional high type in the economy (i.e. $K+1$ high-types), net benefits are lower than -7 for all $0 \leq K \leq 100$.

18. This is closely related to the literature on forward induction.

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