Localised complementary currencies: the new tool for policymakers?
The Sardex exchange system

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Abstract

Sardex was created in 2010 in Sardinia, Italy. Today, it has 2500 users and it is growing exponentially. It is one of the three pilot projects of the European Union's Digipay4Growth, which tests three complementary currencies' capacity to provide business and access to credit to SMEs and foster growth: in Sardinia, Bristol, and Catalunya.

This paper analyses the microeconomic benefits for Sardex users, building the macroeconomic framework necessary to model the Sardex network. It evaluates the advantages to consumers, firms, and policymakers, adapting the models of investment (Tobin's q) and consumption (permanent income hypothesis) underlying the traditional IS curve, to the dual currency framework. It shows that Sardex increases consumption and investment, enabling firms to obtain higher profits, and enabling consumers to smoothen consumption by relaxing credit constraints, while supporting the local economy. Hence, it shows that Sardex produces a permanent real output gain, a countercyclical, stabilising effect on the economy, and that it provides additional sources of income for the government - besides an extraordinary economic insight into the economy.

Having refuted the claims for which it harms the primary currency, or that it constitutes a financial threat, the conclusion that this type of system should be implemented by policymakers is reached.

Introduction

This essay argues that governments should use a regional complementary exchange system with interest free loans to aid achieving sustainable local growth.

Firstly, the paper introduces the complementary exchange system that will be examined throughout the paper: the "Sardex" exchange network.

Secondly, it analyses the microeconomic benefits for Sardex users, hence modelling their macroeconomic behaviour. Firms face lower marginal cost of capital and higher demand. Tobin's q is consequently adapted to the new framework. Consumers face reduced credit constraints, and support local communities with regional-focused spending. The effect of relaxed credit constraints is shown on the permanent income hypothesis.

Thirdly, the paper discusses Sardex's benefits for policymakers, namely: a permanent real output gain, a stabilising, countercyclical effect on real output, an additional source of income, and an extraordinary insight into regional economic dynamics.

Ultimately, the paper discusses the claims for which Sardex may harm Euros' circulation, or constitute a financial threat. Having shown that risks are managed and contained, the paper concludes that policymakers should implement complementary currencies to achieve their goals of sustainable local growth. 67

The Sardex model

Agents pay a small fee to access the Sardex network; there, firms buy goods by creating interest-free debits. Debits have to respect a debt-ceiling, proportional to each firm's productive capacity, and have to be cleared within a set time frame. Buyers' debits correspond to sellers' credits; the latter can be spent immediately. Debits are cleared when debit-holders sell goods and services, hence gaining credits. Therefore, goods are paid through past or future provision of goods to other agents (Sardex srl 2015).

Hence, the supply of money is self-adjusting, and is equal to the economy's aggregate credits (or debits). If n is the number of indebted users i, and N-n is the number of non-indebted users j, $M^{SRD}_s = \Sigma debit^n_{i} = \Sigma credit^{N-n}_j$ (1)

Given the Fisher relation and zero nominal interest, the real interest rate is: $r^{SRD} = 0 - \pi^{SRD}$ (2) Where π^{SRD} is Sardex-inflation. Companies are obliged by the terms of the contract to sell at the same price at which they would sell in Euros. (Sardex srl 2015) Since most companies in the network sell in both currencies, enforcement of this rule is effective: SRD1 (the unit of account) buys what €1 would buy: $\pi^{€} = \pi^{SRD}$ (3) and $r^{SRD} = -\pi^{€}$ (2.1) Because SRD credits/debits only arise from exchanging of goods within the network, one cannot buy and sell SRD on Forex markets. The result is a separate economy where large volumes of liquidity can circulate, despite stagnation and lack of "ordinary" money.

The next section analyses formally why optimising agents use Sardex, and what the macroeconomic implications of their behaviour are.

Microeconomic benefits, and macroeconomic implications

We will consider two types of agents: firms, and consumers, maximising profits and utility respectively. We assume that Sardex's access fee is negligible, and that one can readily enter the network if they want to.

Firms

Microeconomic behaviour

Profit maximising firms always choose the cost-minimising inputs vector. (Cowell, 26). We assume no qualitative difference between capital purchased in Sardex, and in Euros. Assuming that marginal cost of capital, MC_k, is given by r, the real interest rate, plus the depreciation rate δ and given $r^{€} > r^{SRD}$, we will have that $r^{€} + \delta > r^{SRD} + \delta$ (4) $\Leftrightarrow MC^{SRD}_k > MC^{€}_k$ (4.1)

By 4.1, capital will be cheaper in Sardex. We infer: 68

Lemma 1. Cost-minimising firms always obtain capital from SRD, rather than Euros, until the borrowing limit (DSRD) is reached.

Hence, if dSRD is Sardex-debt, $MC_k = \{MC_k^{SRD} \text{ if } dSRD < DSRD \quad MC_k^{\euro} \text{ if } dSRD = DSRD$ (5)
i.e. $MC_k = \{\delta - \pi^{\euro} \text{ if } dSRD < DSRD \quad \delta + i - \pi^{\euro} \text{ if } dSRD = DSRD$ (5.1)
Notice that here i is the interest rate that firms would obtain from commercial banks (Carlin, 160), which is a mark-up on the Central Bank's rate, so that $r^{\euro} > r^{SRD}$ even in times of low Central Bank rates.

Macroeconomic behaviour: investment and "Tobin's q".
Consider a representative firm. Define q as the ratio between the marginal benefit of capital, and the marginal cost of capital. (Carlin, 29) $q = \frac{MB_k}{MC_k}$ (6)
MB_k is the effect of capital on total revenues. $MB_k = \frac{\partial TR}{\partial k} = \frac{\partial TR}{\partial Q} \frac{\partial Q}{\partial k} = \frac{\partial (p*Q)}{\partial Q} MP_k = (\frac{\partial p}{\partial Q} Q + p) MP_k = p(\frac{\partial p}{\partial Q} \frac{Q}{p} + 1) MP_k = p(1 + \frac{1}{\eta}) MP_k$ (7)
Where p is price, Q is output, η is elasticity of demand, and MP_k is marginal product of capital (we assume $\frac{\partial MP_k}{\partial k} < 0$ to capture diminishing marginal returns). Plugging (5.1) and (7) into (6), $q = \{\frac{MB_k}{MC_k^{SRD}} \text{ if } dSRD < DSRD \quad \frac{MB_k}{MC_k^{\euro}} \text{ if } dSRD = DSRD$ (8) i.e. $q = \{\frac{p(1 + \frac{1}{\eta}) MP_k}{\delta - \pi^{\euro}} \text{ if } dSRD < DSRD \quad \frac{p(1 + \frac{1}{\eta}) MP_k}{\delta + i - \pi^{\euro}} \text{ if } dSRD = DSRD$ (8.1)
Investment will increase if q>1, and will decrease if q<1. If q>1 implied a level of capital associated with a Sardex debt greater than $DSRD$, companies would invest in Euros until q=1. 69

If we did not have the Sardex system, we would have $q=p(1+1\eta)MPk\delta+i-\pi€$. Eliminating i lowers the denominator, so q should increase. As we assumed $\partial MPk\partial k<0$, agents will invest, lowering MPk, until q=1. Lemma 2 follows.

Lemma 2. Investment always increases if the Sardex exchange network is introduced.
We now follow a similar procedure for consumers.

Consumers
Microeconomic behaviour
Let us consider the utility-maximising quantity of a good x, supplied in both Euros ($x€$) and Sardex ($xSRD$), so that $xSRD+x€=x$ (9) Agents choose $xSRD$ and $x€$ maximising U($xSRD$, $x€$), subject to $xSRD+x€=x$. Because agents may potentially purchase only from one system and prices are equal, $xSRD$ and $x€$ will be perfect substitutes: U($xSRD,x€$)=a$x€$+b$xSRD$ (10)
If Sardex products were more time-consuming to source than euro-products, it may be that b<a. Then, individuals would only consume $x€$. They would only consume $xSRD$ if they wanted to sustain the local economy: b>a. Consumers would be indifferent if a=b. This is shown in the diagram below. Solutions are at P, Q, and on the constraint.

Studies have shown that households tend to prefer consuming in local complementary currencies, because money remains within the local network to support the economy. (Hoffman, 4-5) This means that for a considerable amount of Sardex users, we should expect b>a. This is consistent with Littera, Panadyotis, Dini, and Sartori's analysis of Sardex. (Littera, 12)
Lemma 3: consumers can sustain the local economy using Sardex. 70

To understand consumer-benefits further, we use Friedman's Permanent Income Hypothesis (henceforth: PIH). To simplify the algebra, let us assume that individuals live over an infinite lifespan. Supposing individuals are not credit constrained, and that they maximise the present value of the utilities $U(c_t)=\log(c_t)$ (which display diminishing marginal returns), PIH holds that

$$c_t = \frac{r}{1+r}\Psi_t^e \quad (11)$$

where $\Psi_t^e = (1+r)A_{t-1} + \sum_{i=0}^{\infty}\frac{1}{(1+r)^i}y_{t+i}^e \quad (12)$

which is the present value of expected lifetime wealth at time t: A_t is assets at time t, and y_{t+i}^e is expected after-tax income in period t+i (Carlin, 37). Optimal consumption is then smooth across the lifecycle, and predictable swings of the business cycle. When individuals earn less than they want to consume, they borrow. When they earn more, they repay the debts, and/or save money. (Ibid)

Thus, access to credit is essential for smooth consumption. The next section analyses the effect of introducing Sardex in a scenario where individuals are credit constrained, i.e. they cannot borrow as much as wish to.

Macroeconomic effect of relaxing credit constraints
Let us suppose, to simplify the algebra, that individuals' income was made up of an infinite stream of equal payments. Then, $c_t = \frac{r}{1+r}[(1+r)*0 + \sum_{i=0}^{\infty}\frac{1}{(1+r)^i}\bar{y}] = \bar{y} \quad (11.1)$
Suppose that at t=2, consumers were announced an increase in income at t=3. Agents would borrow at t=2, so that they could partially anticipate future earnings and consume more at t=2, where marginal utility is higher because of lower consumption (blue dotted line below). However, if agents were completely credit constrained, consumption would keep tracking income, jumping at t=3 (red line).

We could think of agents who are partially credit constrained as lying between the blue and the red line. By relaxing credit constraints, Sardex enables individuals to get closer to the blue optimal line, anticipating *some* of the increase in income (green dotted line), in periods with higher marginal utility because of lower consumption. The more constraints are relaxed, the more consumers redistribute future changes, the smoother consumption will be.
Lemmas 4 and 5 follow.

Lemma 4: Sardex enables credit constrained agents to get closer to their optimal consumption.
Lemma 5: Sardex stabilises consumption: the increase is smaller, and more gradual.

The next section analyses the policymaking implications of Lemmas 1-5.

Advantages for the policymaker
Advantage 1. Permanent output gain
An IS curve represents the demand-side of the economy. It displays the inverse relationship between interest rates and real output. Underlying the IS curve, there are microeconomic models of optimal

consumption (PIH) and investment (Tobin's q) (Carlin, 16). Let us consider the IS curve for the total economy. Let us temporarily assume that agents in Sardex operate in the same framework as agents in Euros. The total IS curve will be the horizontal addition of ISSRD and IS€. Suppose rmin is the lowest rate the Euro-economy can get to, given banking markups on central bank rate. Once we introduce the zero nominal SRD rate, we move along the ISSRD curve, leading to higher output $y2SRD$. As agents can now borrow in Sardex, consumption and investment will increase for any given r (relaxation of quantity credit-constrain). This leads to $y3SRD$.

Proposition 1. The Sardex system produces a permanent real output gain. 73

Advantage 2. Stabilising effects
The quantity theory of money asserts that in a given time period, if M is the amount of money in the economy, V is the velocity of circulation (how many times M is used), P is the price level, and T is the volume of transactions, MV=PT must hold. (Naqvi, 3) Substituting T with real output as is common in economic literature,
$$MSRDVSRD=PYSRD \text{ (12)}$$

Where $PYSRD$ is nominal Sardex-GDP. Because the complementary currency is small relatively to the Euro-region and prices are equal, we assume P to be exogenously determined by the Euro-Economy.

In a recession, we expect credit constraints to rise: individuals have lower income, and risk premia rise. (Iacoviello, 764) By lemma 5, PIH agents who were not credit constrained before, will move to Sardex to smoothen consumption. Then, as demand for goods rises, sellers should join the Sardex network to seize additional profit opportunities.

Two different effects should then take place. As more agents engage in the economy taking more debt, $MSRD$ rises, hence increasing output, given constant $VSRD$. As more consumers crowd the marketplace without actively creating debt themselves, $VSRD$ will increase, because output circulation will increase. Given $MSRDVSRD=PYSRD$, the latter enhances the effect of the former. The final effect can be represented as a rightward shift of the $ISSRD$ curve.

Lemma 6: the Sardex economy mitigates the fall in total income in a recession.
On the other hand, when the Euro-economy grows, credit constraints should fall: individuals have higher income, and risk premia decrease. Agents who are still credit constrained would keep using

Sardex debits. But agents that now attain their smooth consumption level, would stop borrowing, and would pay back debts. Hence, *MSRD* falls, and the Sardex economy shrinks.

The overall effect can be represented as a leftward shift of the *ISSRD* curve.

Lemma 7: the Sardex economy mitigates the fall in total income in a boom.
Authors have pointed out that complementary currencies' countercyclical benefits are do not significantly impact the bigger nation. (Krohn, 2008). Yet, this does not imply that they may not make a significant difference *locally*, in the weaker parts of the economy. Stodder has shown that Swiss Wir turnover (a bigger equivalente of Sardex, established in 1934) is directly correlated with unemployment.

(Stodder, 15). His empirical conclusions may be criticised because his paper does not account for endogeneity issues: turnover may be determined by interest rate policies, rather than unemployment.

However, it could be argued that his findings seem to fit our theoretical framework and to corroborate Sardex's counter-cyclicality.

From lemmas 6 and 7, we infer:

Proposition 2: Sardex has a countercyclical, stabilising effect on the local economy

Advantage 3. Additional sources of income

We analyse two ways to finance government spending through Sardex: cheaper debt, and monetisation of productive capacity.

Cheaper debt

Let us suppose that the Government could borrow money from the Sardex system, paying it back through goods and services. This is currently not the case in Sardinia, where the government does not have access to Sardex borrowing. We could model debt dynamics with $\Delta b = d + (r - \gamma)b$ where Δb is the change in debt-to-GDP ratio, b is debt-to-GDP ratio, d is existing debt, r is the interest rate, and γ is the growth rate of the economy (all in real terms). If $r - \gamma \geq 0$, Δb increases, and future debt rises. If $r - \gamma < 0$, future debt-to-GDP ratios will fall (Carlin, 520).

In a recession, $\gamma \in < 0$, while we expect the Sardex economy to grow: $\gamma SRD > 0$. Given $rSRD = -\pi$, we would have that $-\pi - \gamma SRD < (i - \pi) - \gamma \in$
i.e. $rSRD - \gamma SRD < r\in - \gamma \in$

From which we infer:
Proposition 3. Sardex-debt is cheaper than Euro-debt in recessions
Proposition 3 arises from lower real Sardex interest rates, and higher Sardex growth. Notice that if the economy were not deflating significantly, Sardex debt-to-GDP should also fall:
$-\pi - \gamma SRD < 0$

Monetisation of unused productive capacity

Lower interest rates, higher Tobin's q, and lower credit constraints enable the Government to benefit from additional aggregate demand in Sardex, just like any other seller. If demand for goods sold by the government is $\chi(q, \xi, r)$, where q is tobin's q, ξ is the level of credit constraints, and α is some positive constant, we have that $\chi(q, \xi, i - \pi) - \chi(q, \xi - \alpha, -\pi) = \Delta \chi$

Where $\Delta \chi$ is the amount of goods that the Government can sell in Sardex, but not in Euros. Selling $\Delta \chi$ in Sardex provides the government with extra revenue, without creating additional government debt. Policymakers could use these Sardex credits to pay public employees, or for *Helicopter money* stimuli – which Sardinian institutions already considered (Regione Sardegna, 2015).

When governments sell $\Delta \chi$ and receive credits, they receive an amount of credits corresponding to an increase in $MSRD$. These can be reassigned to agents for purposes of output targeting. Given MV=PT, 76

if Sardex velocity is higher than Euro velocity, then it will be more efficient to use helicopter stimuli in Sardex, rather than Euros. Current measurements by the Sardex company give $VSRD$=12.28 and $V€$=1.5 (Sardex srl, 2015). Thus, we infer:

Proposition 4: If VSRD>V€, and Δχ>0, the government can stimulate the Sardex economy without expanding its debt.

The following section outlines the "informational" benefits provided by the Sardex system, explaining how they can be used to optimise government stimuli's efficiency.

Advantage 4. Knowledge of economic structure

The economy can be seen as a "directed network" of nodes, in which "directed links" between nodes (non-symmentric connections) represent economic transactions. The money stock would follow the directed links, and GDP would then be the sum of the "walks" of the money stock in the network (Jackson, 511-520).

This implies that given different structures, the money stock will flow differently, and GDP dynamics will be different. Below, the liquidity in subnetwork N keeps circulating from A to E in a cycle, while in N' it leaves the subnetwork. If velocities were different, given the same money stock, GDP would be different.

Thus, a policymaker who planned to inject liquidity in the system should account for the structure of the economic network to maximise the stimulus' efficiency. The same reasoning applies to government spending.

In the Euro Economy, it is extremely complex for policymakers to account for these dynamics. How to best spread the effect of an helicopter money stimulus? Which taxes have the strongest impact on money circulation? The Sardex company, has perfect knowledge of the entire spending network. Hence, it is in a better position to to answer these questions. Governments could share data with the company and use it to monitor the economy, tailor their policies to the network structure, and readily measure their efficacy.

Proposition 5: Governments policies can be optimised and tailored to the network structure, in the Sardex system.

Given propositions 1-5, this paper concludes that there are compelling arguments for policymakers to use Sardex to aid achieving goals of local sustainable growth. 77

The next section answers two claims against this conclusion.

Assessing concerns
Someone could argue that Sardex may harm Euros' local circulation, and that $VSRD>V\mathcal{E}$ is a result of "Gresham's law", for which "bad money" (less useful Sardex-credits) drives out of circulation "good money" (more useful Euros) (Mundell, 1998). Hence, it may be argued that policymakers should limit Sardex's expansion.

However, Sardex requires users to pay sums above a certain threshold (which depends on the user's characteristics) in both Euros, and Sardex (Sardex, 2015). That already ensures that Sardex is a complement, and not a substitute, of the Euro. Moreover, even if such requirement were not in place, the efficiency gains from trade would provide incentives to Sardex-users to engage in transactions with non-Sardex users – locally, Nationally, and internationally. And because Sardex cannot be exchanged on foreign markets, agents would have to hold euros.

Someone may reply that Sardex exposes the economy to financial instability threats: it enables credit constrained agents with high default risks to take on new loans. Such view, however, would disregard the fact that Sardex assesses default risk (lower because of the lower rate), by evaluating the productive capacity of new users and the demand for their products. The company assigns the maximum debit level so that the default risk is contained. Therefore, risk is managed by Sardex, and the argument is rejected.

It has to be emphasised, however, that if policymakers thought that Sardex were a threat, the network's size could readily be manipulated. A cap on its number of members would limit growth. The average individual debit ceiling could be legally reduced, limiting risk and turnover. Taxes could be enforced, so that the marginal cost of capital in Sardex rises, and cost-minimising firms don't find it optimal anymore to invest through SRD. Thus, risks could be managed by the Government, too.

Conclusions
This paper has introduced the dynamics of the Sardex system. It has shown that firms maximise profits through the lower marginal cost of capital (Lemma 1), and that investment will be increased if Sardex is introduced (Lemma 2). It has also shown that credit constrained consumers can support the local economy (Lemma 3) while smoothening their consumption and getting closer to their optimum (Lemmas 4 and 5). Hence, it has shown that Sardex produces a permanent output gain, and a countercyclical, stabilising effect on real output (propositions 1 and 2). It has also shown that Sardex provides cheaper ways to finance government spending, and a vehicle of more effective demand-side stimuli, as we all as an extraordinary economic insight into the economy (propositions 3-5). It has concluded that these are compelling arguments for the system's implementation, and it has rejected the arguments for which Sardex harms the primary currency, or constitutes a financial threat.

"*Unconventional times call for unconventional remedies.*" This essay has argued that the Sardex model may be one of them.

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