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"As one dies, so dies the other"? On Local Complementary Currencies as two-sided platforms

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Abstract

Are Local Complementary Currencies doomed? We analyze the conditions of existence of these alternative monetary arrangements from the point of view of the theory of two-sided platforms. Considering their benefits to depend on the cross-externality generated by the presence of buyers and sellers using the alternative means of payment, we show that the possibility of such arrangements to be sustainable is weak. The result is established in a very general setting and with few restrictions on the parameters. Except in the presence of subsidies, the odds are low for Local Complementary Currencies to survive.

Keywords: *Community currency; Complementary currency; Local exchange systems; Two-sided platforms; Means of payment*
JEL Classification: D42, E41, E42, E59, L11

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1 Introduction

Local complementary currencies (LCCs) have gained popularity in many countries. The Global Financial Crisis may have been a catalyst, triggering some citizens to create an LCC in an pursuit to shield their community from the resented negative side-effects of globalization. This is because, for their supporters, LCCs are "alternative organizational forms and tools for social change" (North, 2014, p. 182), able to create new commons (Meyer and Hudon, 2017, 2019) or to pave a way towards a more sustainable development (Michel and Hudon, 2015). The movement has taken roots, as there would be more than 5 million users of the main platform currently used by the "communities" that develop and use local complementary currencies.[1] More than 400 LCCs, in more than 40 countries (as diverse as Austria and Venezuela) exist today. The issue is thus capturing attention, and local deciders and politicians are tempted to consider the creation of such a system to "revitalize" communities or local economic systems. This has at least forced many countries to regulate their creation and functioning. France, for instance, has made LCCs legal in 2014.[2]

However, many of the LCCs do not fulfill their promises: many projects do not emerge, and the mortality rate of LCCs is as probably superior to 25%. Moreover, although initially designed to create new commons beyond (sometimes, against) the State, most of the LCCs that survive rely on (local) government subsidies.

This raises the question of knowing if LCCs are doomed from the start, or if there are conditions to fill that could allow them to meet their supporters' expectations and wishes. So far, however, very few analytically grounded papers discuss LCCs, as most of the literature is based on case studies, or on programmatic arguments (which too often omit to mention economic constraints, if only the value of time necessary to create and manage an LCC). Of the few analytical studies, Mailath et al. (2016) figure prominently. The authors develop a formal model to explain how reciprocity in trades may trigger "buy local relationships". They mention that LCCs can fit into their analysis, as a form of "buy local" arrangement, and that this may bring social benefits (building community spirit, environmental gains through lower transportation costs, or better monitoring of producers), and show that such arrangements can survive if participants are selfish agents, simply because interactions create surplus, and hence a group can gain by diverting interactions from outside to inside the group. This is reminiscient of the Kocherlakota's (1998) argument of money as memory, if transactions keep track of their origin, but also of Bramoullé and Goyal's (2016) argument based on favoritism inside groups. However, there is an intrinsic limit to the existence of LCCs arrangements, as the larger their stock in an individual's wallet, the higher the probability that she has to buy a lower-quality good, thus reducing the icnetnive to stay in the "buy locally" system. Another perspective is brought by Jayaraman and Oak (2005), who argue that LCCs may "serve as a signal of demand to local firms" and develop a Bayesian game to analyze how they can enhance efficiency in the local economy. However, they signal that LCCs will stay a dominated instrument if consumers are not certain to favor locally-produced goods.

In this paper, we intend to delve deeper in the functioning of LCCs, and look at the inside of the their mechanics. Building on Evans and Schmalensee (2010), our contribution is to consider LCCs as two-sided

[1] According to https://www.complementarycurrency.org/what-we-do.html. (Last consultation: April, 2021).
[2] Most countries that regulate them do not consider LCCs as monies, but simply as payment instruments.

platforms, in which consumers and producers alike have to meet if they want to use the local currency. We also build on Weyl (2010), to analyze the conditions of existence from the supply side. The framework we use is general enough to embed all forms of LCC arrangements, from tokens to labels to currency units. Yet, it allows us to pinpoint the conditions under which such arrangements can exist, and prosper. We focus on the relationship between the cost structure of the system and the incentives for subsets of individuals to participate in an LCC arrangement.

This permits us to deliver a better understanding of the difficulties LCCs meet in their development. We show that such systems face well known problems of critical masses, on the buyer and seller demand sides, as well as of economies of scale on the supply side. The model we develop reveals that the main determinants of the success or failure of an LCC lie in (i) the number of potential users of both the buyer type (typically, households and individuals) and the seller type (businesses and suppliers of goods and services), (ii) the structure of user preferences (which includes the intensity of direct - or same-side - network externalities, the intensity of indirect - or cross side - network externalities, and their maximum willingness to pay to join the LCC-supporting community), and (iii) the cost structure of the LCC-supporting institution (be it an association, a fully private firm, or a subsidized one).

In particular, we detail the dynamics of buyer and seller participations, and show that the critical condition for success is to attract, from the very beginning of the project, a sufficient number of both buyers and sellers. A critical aspect of the system is that too high a participation fee dissuades potential users from participating in the LCC and that this is enough, given network externalities, to make the LCC less attractive to all. This reduces the odds that an LCC can survive and thrive. Symetrically, too low participation fees would not cover the supporting institution costs, killing the project in its infancy. Our model thus brings predictions that are largely consistent with the empirical evidence of the difficulty their supporters have in starting LCCs and, then, maintaining them alive.

The remainder of the paper is the following. First, we present the demand side of LCCs as two-sided platforms, presenting the double critical mass problem they face. We then turn to the incentives sellers have in joining such arrangements, focusing on the participation fees issue. The last section concludes.

2 A model of the demand for LCCs

2.1 Basic assumptions

In what follows, we consider a "local complementary currency" (LCC) as a two-sided payment platform. As defined by, e.g., Evans and Schmalensee (2007), platforms "serve distinct groups of customers who need each other in some way", they "provide a common meeting place", and "facilitate interactions between members of the two distinct customer groups". This definition thus fits the arrangements of real-life LCCs. The two customer groups (or sides) served by an LCC are the local consumers of goods or services, and the local producers or businesses (or buyers and sellers, respectively).

The first challenge faced by the promoters of an LCC is to attract sufficiently high numbers of both buyers

and sellers. As Evans and Schmalensee (2010) show, two-sided platforms may fail to launch if they do not overcome this fundamental double critical mass problem. The usual analyses of payment systems that build on the theory of two-sided platforms insist on (i) indirect externalities, assuming away direct externalities, and (ii) participation fees as an alternative or complement to usage fees.

With regard to the first point, network externalities, we build on Evans and Schmalensee (2010). Whereas they consider explicitly direct externalities only as a first case, and indirect externalities only as a second case, we consider a situation where both types of externalities coexist: the preferences of users depend on both the number of users of the same type and on the number of users of the other type (either buyers or sellers). We assume therefore that buyers and sellers value both types of participants to the LCC arrangement. It is a reasonable assumption, given the usual practice in LCCs. Sellers naturally value buyer participation, as buyers value seller participation, since the primary objective of a payment system is to facilitate market transactions. Sellers also value the participation of other sellers, since they usually cannot get rid of the LCC they earned from sales unless they dispense with it by purchasing some goods or services from other local businesses. And buyers also value the participation of other buyers, either because they need an interpersonal payment scheme, or because they appreciate that there are many people sharing the community values supposedly conveyed by LCCs.

Concerning participation, we assume away usage fees. Two reasons can be put forward to ground this assumption. First, we want to emphasize that, in any LCC arrangement, *mainly participation matters*, i.e., user utility is derived mainly from participation, because once users decide to participate, they will also use the LCC in payments.[3] Second, we have in mind LCC arrangements in which the managing institution does not observe transactions between buyers and sellers, and thus cannot collect usage fees. Therefore, fees can be collected on participation only.[4]

2.2 The demand for participation

We assume that some people want to launch an LCC in an area inhabited by $\bar{N}_B$ potential buyers and $\bar{N}_S$ potential sellers. We denote $N_B(t)$ the number of participating buyers and $N_S(t)$ the number of participating sellers at time t (we will further drop the time index to simplify notations). Users are endowed with an indirect utility function, represented by their net willingness to pay to participate in the payment scheme and use the payment instrument:

$$U_{B,i} = b_i V_B \left(N_B, N_S\right) - P_B \tag{1}$$

[3]In fact, some LCCs are "melting", in order to induce participants to use the currency: they loose face value when *not* used, or have notes expiring according to a pre-announced schedule. Theses LCCs can be considered as having a negative usage fee. In order to model both participation and usage fees (which is a two-part tariff), we would have to introduce some heterogeneity among users, and assume that buyers and sellers enter in variable numbers of transactions. Our simplification is usual in the theoretical literature on payment systems, where users are assumed to enter in one transaction only. Considering an heterogeneity of this type would complexify matter, without brinign substantial new results.

[4]The ability to collect usage fees probably depends on the underlying payment technology. If the LCC circulates as printed notes, like banknotes, our assumption is clearly valid. If the LCC circulates through electronic cards, transactions could be observed, recorded and charged for. However, in the latter, another monitoring cost would have ot be considered, reinforcing the difficulties we uncover.

$$U_{S,j} = s_j V_S (N_S, N_B) - P_S \tag{2}$$

We detail the analysis of buyers behaviour. All notations and interpretations are symmetric for the sellers (inverting indices S and B, i and j, and having s_j instead of b_i). $U_{B,i}$ is the net utility that buyers derive from participating in the LCC arrangement.[5] P_B is the (time invariant) membership fee charged to buyers who join the association that manages the LCC. $V_B (N_B, N_S)$ is the willingness to pay of the most enthusiastic potential buyer when N_B buyers and N_S sellers participate. We assume it is an increasing and quasi-concave function of both N_B (as there are same-side, or direct, external effects) and N_S (as there are also, and in practice most probably, cross-side, or indirect, external effects). In this respect, we depart form the simple assumption usually made, that willingness to pay only depends on the number of other side participants, most often in a linear way. In our context, given the community-based preference shown by supporters of LCCs, this assumption is the most adequate. Parameter b_i ($b_i \in [0, 1]$) characterizes each buyer i. and measures each buyer i's degree of sympathy towards the LCC: the higher b_i, the higher the utility derived from participation, all else equal. We assume that b_i is distributed among the $\bar{N}_B$ potential buyers according to a cumulative distribution function $F_B (b)$, so that $F_B (b)$ denotes the proportion of buyers who are willing to pay at most $bV_B (N_B, N_S)$ in order to participate, while $1 - F_B (b)$ denotes the proportion of buyers who are willing to pay more than $bV_B (N_B, N_S)$ to participate. We denote the associated density function by $f_B (b)$. Full details of the computations for the special case of CES-type utility functions are given in Appendix 1.

Given $\{P_B, N_B, N_S\}$, consumer i will participate in the LCC if and only if $U_{B,i} \geq 0$, that is $b_i \geq \frac{P_B}{V_B(N_B,N_S)}$, and the number of buyers willing to participate is then $\bar{N}_B \left[1 - F_B \left(\frac{P_B}{V_B(N_B,N_S)}\right)\right]$.

In equilibrium, $N_B = \bar{N}_B \left[1 - F_B \left(\frac{P_B}{V_B(N_B,N_S)}\right)\right]$: the share of the population of buyers that choose to participate, $\frac{N_B}{\bar{N}_B}$, is equal to the share of the population willing to pay, $1 - F_B \left(\frac{P_B}{V_B(N_B,N_S)}\right)$. The symmetric equilibrium condition applies to sellers.

The equilibrium demands for participation are then simultaneously given by:

$$\frac{N_B}{\bar{N}_B} = 1 - F_B \left(\frac{P_B}{V_B (N_B, N_S)}\right) \tag{3}$$

$$\frac{N_S}{\bar{N}_S} = 1 - F_S \left(\frac{P_S}{V_S (N_S, N_B)}\right) \tag{4}$$

or,

$$\Phi_B (N_B, N_S) \equiv \frac{\bar{N}_B - N_B}{\bar{N}_B} - F_B \left(\frac{P_B}{V_B (N_B, N_S)}\right) = 0 \tag{5}$$

$$\Phi_S (N_S, N_B) \equiv \frac{\bar{N}_S - N_S}{\bar{N}_S} - F_S \left(\frac{P_S}{V_S (N_S, N_B)}\right) = 0 \tag{6}$$

[5] It is probably easier to think of utility as measured in terms of the national currency (for instance, dollars or euros), although this does not matter for the arguments we develop in this article. Practically, the exchange rate of an LCC is generally fixed in terms of the national money. It is equal to 1 by law in the French case, for example.

$\Phi_B(N_B, N_S)$ is written as the difference between the percentage of non participating buyers and the percentage of buyers unwilling to pay P_B. The $\Phi_B(N_B, N_S) = 0$ condition is the condition for "constant buyer participation". As regards the dynamics of adjustment, assume that the number of participants on both sides of the market varies gradually other time, t, as in Evans and Schmalensee (2010). By construction, $N_B(t)$ is constant alongside the $\Phi_B(N_B, N_S) = 0$ curve. Assume that, from an initial position on this curve, N_S increases, all else equal. Then $V_B(N_B, N_S)$ increases, i.e., the value of buyer participation increases, so that $1 - F_B\left(\frac{P_B}{V_B(N_B,N_S)}\right)$ also increases, i.e., the proportion of buyers willing to pay and participate increases. It follows that $\Phi_B(N_B, N_S)$ increases and becomes positive. As a result, the number of participating buyers increases ($dN_B(t)/dt > 0$), above the $\Phi_B(N_B, N_S) = 0$ curve, where $\Phi_B(N_B, N_S) > 0$. Otherwise, if it decreases, $dN_B(t)/dt < 0$, below the curve, where $\Phi_B(N_B, N_S) < 0$. Hence, similarly to Evans and Schmalensee (2010), we can write:

$$sign\left\{\frac{dN_B(t)}{dt}\right\} = sign\left\{\Phi_B(N_B(t), N_S(t))\right\}$$

$$sign\left\{\frac{dN_S(t)}{dt}\right\} = sign\left\{\Phi_S(N_S(t), N_B(t))\right\}$$

The number of participants tends to increase (resp., decrease) if it is below (resp., above) its equilibrium level. For example, regarding buyers, the equilibrium number is $\overline{N}_B\left[1 - F_B\left(\frac{P_B}{V_B(N_B,N_S)}\right)\right]$, so that $\Phi_B(N_B(t), N_S(t)) > 0$ if and only if $N_B < \overline{N}_B\left[1 - F_B\left(\frac{P_B}{V_B(N_B,N_S)}\right)\right]$.

2.3 The equilibrium condition for buyer participation

We now detail the equilibrium condition for buyers, under a set of very general technical assumptions. The same analysis applies to the equilibrium condition for sellers.

Conjecture 1: Given P_B, the relationship between N_B and N_S involved by the condition for constant buyer participation, $\Phi_B(N_B(t), N_S(t)) = 0$, is U-shaped in the (N_B, N_S) map, for $0 \leq N_B \leq \bar{N}_B$.

(i) Whenever N_B and N_S are such that the LCC is deemed too expensive for all potential buyers, i.e., when $V_B(N_B, N_S) \leq P_B$, then no buyer participates, i.e., $F_B\left(\frac{P_B}{V_B(N_B,N_S)}\right) = 1$. It follows that $\Phi_B(N_B, N_S) < 0$, since $\left(\bar{N}_B - N_B\right)/\bar{N}_B \leq 1$. The equilibrium is thus degenerate, with $N_B = 0$.

(ii) Whenever N_B and N_S are such that $V_B(N_B, N_S) \geq P_B$, the LCC attracts some buyers, and a non-degenerate equilibrium exists. It should be noted that $V_B(N_B, N_S) \geq P_B$ implies that the $\Phi_B(N_B, N_S) = 0$ curve is above the $V(N_B, N_S) = P_B$ curve in the (N_B, N_S) map. Under this condition, when $N_B \to 0$, then there is a negative relationship between N_B and N_S along the $\Phi_B(N_B, N_S) = 0$ curve. The intuition is that when $N_B \to 0$, then $\left(\bar{N}_B - N_B\right)/\bar{N}_B \to 1$ and, in order for $\Phi_B(N_B, N_S)$ to stay equal to 0, $F_B\left(\frac{P_B}{V_B(N_B,N_S)}\right)$ must be equal to 1. This will be the case if $\frac{P_B}{V_B(N_B,N_S)}$ is equal to 1, that is, if $V(N_B, N_S) = P_B$. It follows that, when $N_B \to 0$, the $\Phi_B(N_B, N_S) = 0$ curve converges to the $V(N_B, N_S) = P_B$ curve, which is a decreasing indifference curve in the (N_B, N_S) map.

(iii) When $N_B \to \bar{N}_B$, there is a positive relationship between N_B and N_S along the $\Phi_B(N_B, N_S) = 0$ curve. The intuition is that when $N_B \to \bar{N}_B$, then $\left(\bar{N}_B - N_B\right)/\bar{N}_B \to 0$ and, in order for $\Phi_B(N_B, N_S)$ to

stay equal to 0, $F_B\left(\frac{P_B}{V_B(N_B,N_S)}\right)$ must be equal to 0. This will be the case if $\frac{P_B}{V_B(N_B,N_S)}$ is equal to 0, i.e., if $V(N_B,N_S)\to+\infty$. Given N_B, this implies that N_S should become very large, so that the relationship between N_B and N_S along the $\Phi_B(N_B,N_S)=0$ curve must be positive (almost vertical).

For $0\leq N_B\leq \bar{N_B}$, we can compute the slope of the $\Phi_B(N_B,N_S)=0$ curve for $0<N_B<\bar{N_B}$. It is given by:

$$\frac{dN_S}{dN_B}\mid_{d\Phi_B=0}=\frac{V_B^2}{\bar{N_B}P_Bf_BV_{BS}}-\frac{V_{BB}}{V_{BS}} \tag{7}$$

where V_B stands for $V_B(N_B,N_S)$, f_B stands for$f_B\left(\frac{P_B}{V_B(N_B,N_S)}\right)$, V_{BB} stands for $\frac{\partial V_B(N_B,N_S)}{\partial N_B}$, and V_{BS} for $\frac{\partial V_B(N_B,N_S)}{\partial N_S}$.

The first term is non-negative, and tends towards 0 when N_B does. The second term is the slope of the $V_B(N_B,N_S)=P_B$ curve, which is negative, from the assumption that $V_B(N_B,N_S)$ is quasi-concave. Then, the two curves have equal slopes as $N_B\to 0$. The slope of the $\Phi_B(N_B,N_S)=0$ curve is greater than that of the $V_B(N_B,N_S)=P_B$ curve when $N_B>0$.

Computing the variation of the slope of the $\Phi_B(N_B,N_S)=0$ curve, we obtain:

$$\frac{d^2N_S}{dN_B^2}\mid_{d\Phi_B=0}=\frac{V_B^2}{\bar{N_B}P_Bf_BV_{BS}}\left(\frac{2V_{BB}}{V_B}-\frac{V_{BSB}}{V_S}+\frac{f_B'}{f_B}\frac{P_BV_{BB}}{V_B^2}\right)+\frac{\partial}{\partial N_B}\left(\frac{-V_{BB}}{V_{BS}}\right) \tag{8}$$

where V_{BSB} stands for $\frac{\partial V_{BS}(N_B,N_S)}{\partial N_B}$, f_B' stands for$f_B'\left(\frac{P_B}{V_B(N_B,N_S)}\right)$ and $f_B'(x)=\frac{df_B(b)}{db}$. The second term is positive, due to the quasi-concavity of $V_B(N_B,N_S)$. The first term may be positive or negative, because the sign of the second factor is indeterminate, as it depends on the characteristics of $V_B(N_B,N_S)$ and $F_B(b)$. So, without more specific assumptions, we cannot prove that the slope of the $\Phi_B(N_B,N_S)=0$ curve is increasing with N_B, which would be necessary and sufficient to obtain the U-shape. However, the above reasoning shows that the left branch is downward sloping and that the right branch is upward sloping.[6] (Appendix 2 considers a case where Assumption 1 does not stand, revealing that the consequences are more complex to derive, but without changing the argument.) Hence, we can reasonably assume that the relationship between N_B and N_S is U-shaped. In particular, it can be shown that, using a constant elasticity of substitution function for $V_B(N_B,N_S)$ and a beta distribution for $F_B(b)$ yields, the conditions are verified for a wide range of parameters.

Conjecture 2: Ceteris paribus, an increase in P_B induces an upward shift of the $\Phi_B(N_B(t),N_S(t))=0$ curve in the (N_B,N_S) map. In other words, an LCC is an ordinary good.

Proof: All else equal, an increase in P_B induces an increase in $F_B\left(\frac{P_B}{V_B(N_B,N_S)}\right)$, the share of the population of potential buyers who do not participate. Then, $\Phi_B(N_B,N_S)$ decreases, from 0 at the initial level of P_B, to a negative value at the new level of P_B. It follows that the $\Phi_B(N_B(t),N_S(t))=0$ curve shifts upwards in the (N_B,N_S) map, since we have $\Phi_B<0$ below the curve. QED.

The intuition is easy to grasp: a given number of buyers still participate if an increase in the number of sellers N_S compensates for the higher membership fee.

[6]Nevertheless, the implicit function $\Phi_B(N_B(t),N_S(t))=0$ may have several local extrema. See the appendix.

Conjecture 3: If the distribution of b_i across the population of buyers changes, so that the new distribution first-order stochastically dominates the initial one, then the new $\Phi_B(N_B, N_S) = 0$ curve lies below the initial one in the (N_B, N_S) map.

Proof: If $G_B(b)$ denotes the new cumulative distribution function of b_i. $G_B(b)$ first order stochastically dominates the initial function $F_B(b)$ if and only if $G_B(b) \leq F_B(b)$ for all b, with strict inequality for some b. Then, given $\{P_B, N_B, N_S\}$, we have $\frac{(\bar{N}_B - N_B)}{\bar{N}_B} - G_B\left(\frac{P_B}{V_B(N_B,N_S)}\right) \geq \frac{(\bar{N}_B - N_B)}{\bar{N}_B} - F_B\left(\frac{P_B}{V_B(N_B,N_S)}\right)$, and for any $\{P_B, N_B, N_S\}$ such that $\Phi_B(N_B, N_S) \equiv \frac{(\bar{N}_B - N_B)}{\bar{N}_B} - F_B\left(\frac{P_B}{V_B(N_B,N_S)}\right) = 0$, the inequality $\frac{(\bar{N}_B - N_B)}{\bar{N}_B} - G_B\left(\frac{P_B}{V_B(N_B,N_S)}\right) \geq 0$ holds. The $\{N_B, N_S\}$ point lies on the initial equilibrium curve, and above the new one, which therefore lies below. QED.

The intuition here is that, under the new distribution, there are more potential buyers willing to pay a higher price to participate to the LCC, i.e., more potential buyers being "enthusiastic" about the LCC. Therefore, it requires less sellers to attract the same number of buyers at any given value of the membership fee.

Conjecture 4: If the distribution of b_i across the population of buyers changes, so that the skewness of the new distribution is greater than the skewness of the initial distribution, then the new $\Phi_B(N_B, N_S) = 0$ curve lies below the initial one in the (N_B, N_S) map.

Proof: Along the same line as for the previous assumption, and more intuitive. A greater skewness means that there are relatively more "enthusiastic" buyers, endowed with higher b_i who are willing to pay more to participate to the LCC, given the number of participating sellers. QED

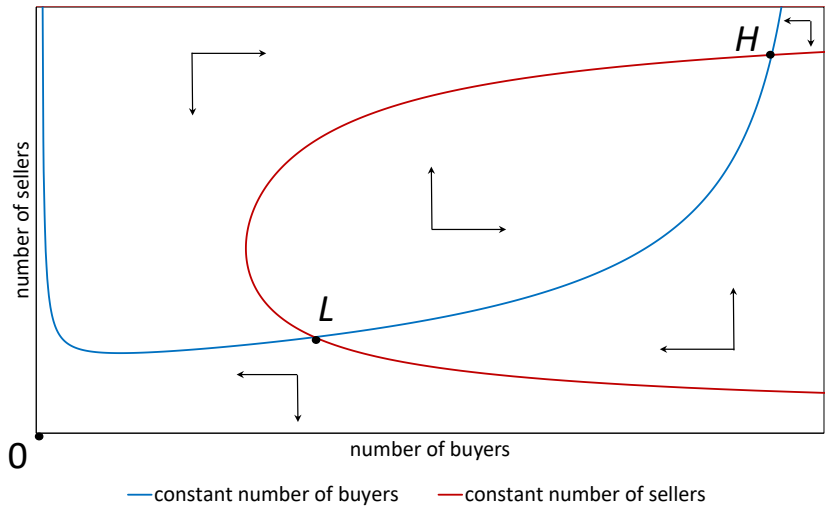
2.4 The double critical mass problem

To be a viable arrangement, any LCC arrangement faces a double critical mass problem: it has to attract a high enough number of buyers, as well as a high enough number of sellers. Otherwise, either the currency units will not be able to circulate enough, or the currency units will chase a small number of products in a small numer of shops, reducing the inccntives for the sellers to participate.

Figure 1 displays a benchmark case, in which the demand model can have three stationary equilibria, as shown by the phase diagram. The first equilibrium is a stable "no participation" equilibrium, with $N_B = N_S = 0$. The other two are such that the membership fees are low enough for some buyers and sellers to participate. One equilibrium is an unstable "low participation" equilibrium (L) with $N_{B,L}$ buyers and $N_{S,L}$ sellers, while the other is a "high participation stable equilibrium" (H). This benchmark case illustrates the double critical mass problem. If the LCC association fails to attract at least $N_{B,L}$ buyers and $N_{S,L}$ sellers, the number of users initially participating will gradually revert to 0. Moreover, both numbers of participants must be exceeded at the same time, in order to trigger a dynamics leading to the high equilibrium, otherwise the no participation case will be reached.

In figure 2, we show a case in which membership fees are too high. Then, there is no participation in equilibrium. The membership fee of each side is not too high *per se*, since the two "constant participation" curves do fit in the $\left[0, \bar{N}_B\right] \times \left[0, \bar{N}_S\right]$ quadrant. But the two conditions for "constant participation" cannot

Figure 1: The double critical mass problem (benchmark case)



Note: the figure is drawn assuming that:

- $V_B(N_B, N_S)$ is a CES function with $\xi_B = 1$, $\delta = 0.2$ and $\rho = 0.7$,$\bar{N}_B = 1000$, $P_B = 50$, b_i follows a $\mathrm{B}(2,2)$ distribution.
- $V_S(N_S, N_B)$ is a CES function with $\xi_S = 1$, $\delta = 0.5$ and $\rho = 0.2$,$\bar{N}_S = 300$, $P_S = 100$, s_j follows a $\mathrm{B}(2,2)$ distribution.

simultaneously hold for any positive (N_B, N_S) pair. This shows that the pricing strategy of the institution that manages the LCC is of upmost importance for the success of the arrangement.

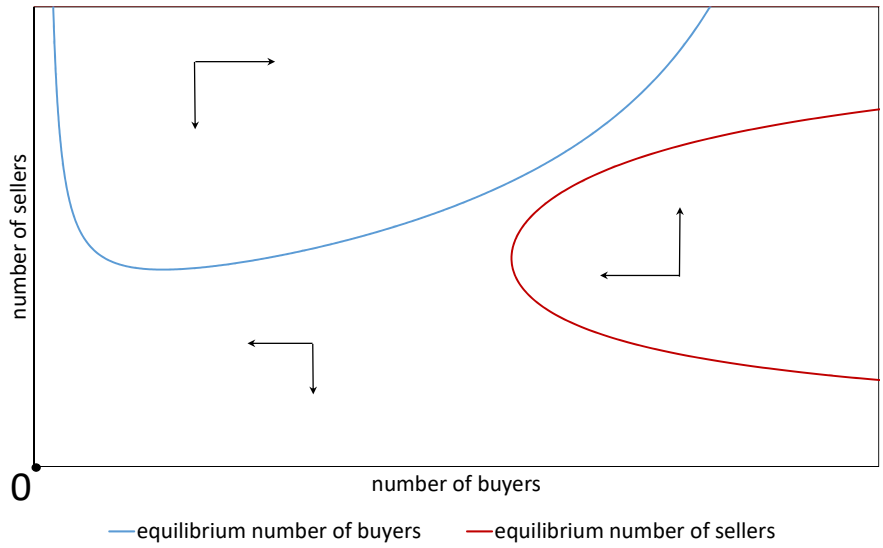
In figure 3, we show the influence of another parameter, the degree of enthusiasm (aka the degree of sympathy towards the LCC). If potential users on either side are characterized by too low a degree of enthusiasm, then there is no participation in equilibrium. This is the case when the distributions of b_i and s_j are positively skewed, so that the buyers with low b_i and sellers with low s_j are relatively more frequently met in the population.

In such a situation, the institution managing the LCC could try to compensate the lack of enthusiasm by lowering the participation fee. However, as we will see now, this may either not be enough, or meet other issues, as supply side considerations also prevail.

3 The supply side of LCC

As our framework makes clear, for LCCs, the key success factor is participation on both sides. This feature is generally overlooked in the literature on local complementary currencies, as these kind of projects tend to be promoted by supporters, who tend to consider that firms and citizens will benefit, unambiguously, from the implementation of such parallel currencies, if only for the feeling of "belonging-to-a-community" the LCC will create. They also insist on the fact that firms will gain from acting in a short-circuit economy. However, this is assumed, not proven, and disregards the fact that potential LCC users, whether buyers or sellers, optimally trade off the costs and benefits of the LCC in their decision-making process. And an important parameter in the decision to participate, and thus, as shown above, a critical condition of existence for LCCs, is the price requested to participants to belong to the arrangement.

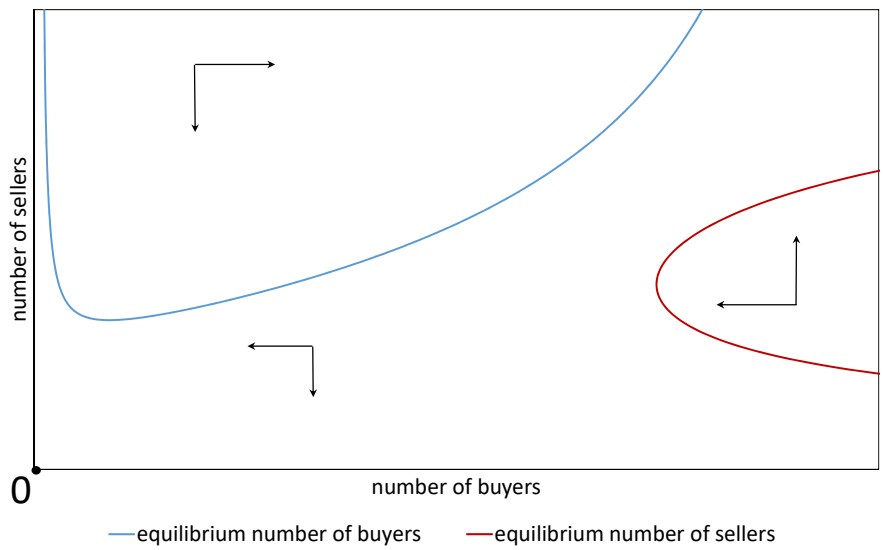
Figure 2: No participation when membership is too expensive



Note: the figure is drawn assuming that:

- $V_B(N_B, N_S)$ is a CES function with $\xi_B = 1$, $\delta = 0.2$ and $\rho = 0.7$,$\bar{N}_B = 1000$, $P_B = 100$, b_i follows a $\mathrm{B}(2,2)$ distribution.
- $V_S(N_S, N_B)$ is a CES function with $\xi_S = 1$, $\delta = 0.5$ and $\rho = 0.2$,$\bar{N}_S = 300$, $P_S = 140$, s_j follows a $\mathrm{B}(2,2)$ distribution.

Figure 3: No participation when enthusiasm is low



Note: the figure is drawn assuming that:

- $V_B(N_B, N_S)$ is a CES function with $\xi_B = 1$, $\delta = 0.2$ and $\rho = 0.7$,$\bar{N}_B = 1000$, $P_B = 50$, b_i follows a $\mathrm{B}(2,5)$ distribution.
- $V_S(N_S, N_B)$ is a CES function with $\xi_S = 1$, $\delta = 0.5$ and $\rho = 0.2$,$\bar{N}_S = 300$, $P_S = 100$, s_j follows a $\mathrm{B}(2,4)$ distribution.

LCC advocates generally ignore the pricing mechanisms, because (1) they tend to consider LCCs as monies, not as payment platforms, and neglect emission costs, and (2) they most often adopt a social or so-called citizen-based point of view and tend to equate not-for-profit organizations with not-costly organizations. If one wants to know under which conditions LCCs could really thrive and prosper, then pricing mechanisms have to be considered.

Optimal pricing theory in multi-sided monopoly platforms has been analyzed by Weyl (2010), who presents a model encompassing the ones of, e.g., Rochet and Tirole (2006), or Armstrong (2006). Weyl (2010) applies the model to payments platforms, considers the different types of price distortions that can affect multi-sided markets, and analyzes cases in which tariffs set by platforms can have several components, since membership and interaction are assumed to be costly to and priced by the platform. The author discusses several conditions for optimal pricing, depending on the sources of heterogeneity among users, and on the objective function of the platform (maximizing the total social value - without or with achieving a minimum absolute profit -, or maximizing private profit).

3.1 The problem of setting participation fees

As for other platforms, the two critical masses that any LCC faces are endogenously formed and, as shown above, they depend crucially on the level of membership fees. The difficulty here is that, in order to determine the optimal level of fees, the institution promoting the currency would have to explicitly state its objective function, and know its own cost structure. Both conditions are often not met, as objective of the institutions or communities supporting LCCs are often loosely written and vaguely described, while the cost structure is often considered as nil, due to its reliance on voluntary work from the community members.

From an economist point of view, this can nevertheless be translated as the following assumptions:

(i) the institution promoting the LCC is a nonprofit organization (this is the case for most real world LCCs),

(ii) it sets participation fees so as to maximize a given objective function,

(iii) the association determines the optimal participations, N_B and N_S, following Weyl (2010), from which optimal prices (or, as Weyl calls them, "insulating tariffs") can be computed.

Regarding the cost structure, the managing institution incurs variable as well as fixed costs. Costs reported in financial statements include staff costs, selling and marketing costs, premises costs, and general administrative costs[7]. It should noted that the functioning of the institution generally relies on volunteer activity, which is not a monetary cost to the association, but should nevertheless be valued, in accordance with Financial Accounting Standards. Moreover, even from a purely social perspective, it is important to take volunteer time into account and to value volunteer contributions, in order to evaluate as precisely as possible the properties of the LCC. On an annual basis, most costs are independent of the number of users. Variable costs would include, e.g., the cost of processing membership applications. Issuing the LCC paper notes and/or organizing the digital emission and electronic payment system, disseminating and updating information, including marketing spending and maintaining a website, can also be considered as expenses mostly independent of the number of users.

[7]See, for example, the financial statement of the Bristol Pound Community Interest Company, https://beta.companieshouse.gov.uk/company/07346360/filing-history (lastly accessed: 30 July 2021).

We therefore consider that the supply of an LCC exhibits increasing returns to scale. The cost function of the LCC managing institution is thus characterized by constant marginal costs (with respect to the number of users), plus a fixed cost:

$$C\left(N_B, N_S\right) \equiv c_B N_B + c_S N_S + K \tag{9}$$

where c_B and c_S are the costs attached to each type of participant, and K,standardly, is the institution's capital.

The association's gross surplus is then defined in the following way:

$$\pi \equiv \left(P_B - c_B\right) N_B + \left(P_S - c_S\right) N_S \tag{10}$$

and its profit, or net income is equal to: $\pi - K$.

Regarding the objective function, denoted $W\left(N_B, N_S\right)$, we will consider that, as a non profit organization, the institution that runs the LCC does not aim to maximize its profit. To embed more empirical cases, we rely on a more general form than profit, considering that the objective function is increasing in the number of buyers and of sellers, with a specific trade-off between the two types of users. Assuming that the LCC association maximizes the welfare of users, measured as the total surplus of participating buyers and sellers, is a special case of the assumption we make, since the total surplus is the sum of individual net willingnesses to pay, which all depend an the number of participants.

The choice problem of the LCC association can thus be formulated as follows:

$$Max\ W\left(N_B, N_S\right) \tag{11}$$

s.t.:

$\pi \geq K$, where $\pi \equiv \left(P_B - c_B\right) N_B + \left(P_S - c_S\right) N_S$,

$\Phi_B\left(N_B, N_S\right) = 0$,

$\Phi_S\left(N_S, N_B\right) = 0$.

Note that the two conditions for equilibrium participation, $\Phi_B\left(N_B, N_S\right) = 0$ and $\Phi_S\left(N_S, N_B\right) = 0$, determine each respective inverse demand function[8]:

$$P_B = F_B^{-1}\left(\frac{\bar{N_B} - N_B}{\bar{N_B}}\right) V_B\left(N_B, N_S\right) \equiv P_B\left(N_B, N_S\right) \tag{12}$$

$$P_S = F_S^{-1}\left(\frac{\bar{N_S} - N_S}{\bar{N_S}}\right) V_S\left(N_S, N_B\right) \equiv P_S\left(N_S, N_B\right) \tag{13}$$

.

Technically, then, the maximization problem is a standard Ramsey pricing problem (see, e.g., Baumol, 2008), which can be expressed in terms of the numbers of participants. As can be seen, the prices on both sides of the platform increase with the number of participants, with the (only apparently paradoxical) consequence that

[8]The elasticities of prices with respect to same-side participation may be positive or negative, since prices are computed as the product of two factors, the first increasing with, and the second decreasing with, same-side participation. The cross elasticities are positive: on the buyer side, since $V_B\left(N_B, N_S\right)$ is increasing in N_S, so is $P_B\left(N_B, N_S\right)$; and the same applies on the seller side.

this reduce the incentives to particpate in the arrangement. This thus raises the question of the very possibility of LCCs in the first place.

In other words, to be an efficient alternative, an LCC relies on the fact that an individual's utility is contingent on the actions of others. The buyers benefit from the presence of sellers accepting the currency, and sellers benefit from the presence of buyers in the area. This externality is precisely the foundation of the promoters' enthusiasm for these alternative arrangements. However, the above equations reveal that the externality cannot be "priced" (i.e., internalized).[9]

3.2 Are LCCs doomed?

Our model thus defines the situations in which the LCC succeeds. The implicit assumption of our model is that buyers and sellers can always use the official currency that the LCC complements locally.[10] In a crisis that virtually wipes out the official currency, or in a small area where inhabitants have a very strong attachment or sense of belonging to their region, or a very strong regional culture, the willingness to pay to join the LCC scheme may be very high, which then makes cost-covering pricing easily acceptable to users, and participation large. In our model, the would be represented with high $V_B(N_B, N_S)$ and $V_S(N_B, N_S)$, as well as with cumulative distribution functions $F_B(b)$ and $F_S(s)$ that would be concentrated towards the high values of b and s. These are however special cases, and one could even ask if they would be desirable.[11] In other words, LCCs may succeed in areas where people are strongly convinced beforehand, but this sheer feature may reduce their appeal to promote another economic system in a convincing, broad, way.

The LCC may be doomed, however, and this may happen even before considering optimal pricing. This is notably the case if the *cost structure* is very unfavourable given the potential participations. This case occurs typically when participation is deemed "too expensive" by potential buyers or sellers, as discussed above, even if membership fees are set as low as the level of marginal costs, $P_B = c_B$ and $P_S = c_S$. Such a pricing structure does not cover the fixed costs, and does not trigger a high enough participation. In such a situation, the project is still-born.[12]

Another reason for failure is *mispricing*: participation fees are often set by rule of thumb, without careful "market" survey. However, even an optimal pricing policy may yield optimal participations and membership fees such that costs are not covered by receipts, if the market is too narrow as is well known from the economics of natural monopolies (in such as case, there are no levels of N_B, N_S allowing that $\pi \geq K$).

Moreover, increasing prices in order to cover fixed costs can even worsen the situation, by reducing potential

[9] Jain and Townsend (2021) show that, in a Walrasian world of competing, for-profit, platforms, the sum of fees paid has to cover platform costs to reach an efficient equilibrium. And allowing different fees to be charged would only increase the complexity of the system, its management costs, and reduce its attractiveness for many potential users. For an example of complex tarification, see Anderson and Bedre-Defolie (2021).

[10] This assumption is made in all models on payment systems (for instance, payment card users can always use cash as an alternative).

[11] If, for example, the strong local culture induces inhabitants to reject not only the official currency, but all the other institutions, up to the point where secession from the main territory is considered as a viable alternative. In this case, multiple costs would have to be considered, in a discussion that goes well beyond the scope of this article.

[12] Obviously, the number of unborn projects is unknown, and many projects can live, borne out by their supporters, until the point where their enthusiasm wanes. In the case of France, in which many projects are discussed and many LCCs circulate, we have counted 65 projects which have been or are still active. Among these, 11 (17%) have been stopped, with an average age at death inferior to 3 years.

members' participation. Cross-subsidizing participation could be explored, in the case where participation is too expensive at marginal cost pricing on one side only, but this may not suffice to offset the first effect, as seen above. The LCC is also doomed when prices that maximize gross surplus do not generate a maximum surplus that is high enough to cover fixed costs.

One can also view the failure of LCC associations as rooted in *cost underestimation*: running an association is time consuming, even for volunteers, and this (social) cost is often underestimated ex ante. LCCs may fail for sheer lack of managing volunteers[13].

Of course, it can be argued that the institution managing the LCC renders collective services and that it does not have to break even. This is exactly the situation analyzed by Weil (2010), when he considers the *interior* optimal price structure under Ramsey pricing, where "social welfare is maximized subject to achieving a minimum absolute profit". He introduces the case for Ramsey pricing by stating that "achieving first-best prices may be infeasible in practice as it would require subsidies whose granting, given the cost of raising public funds, political economy constraints, and imperfect information, would be more costly than the monopoly distortions they seek to address". This argument implies in our case that the institution that runs the LCC would have to be supported by public subsidies, e.g., subsidies from local authorities. This would obviously solve the issue, but at the cost of introducing another problem: notwithstanding their own cost of funds, local authorities are typically confronted with competing demands by communities, associations, etc. They should then carefully check the relative efficiency of alternative ways of achieving the same goals as the LCC. For example, if an LCC is supported as a way of promoting local activity (typically, local organic food production), it should be compared to other means, like specific labeling and advertising. Or, if an LCC is promoted as a way to create of "feeling-of-living-together", the question becomes: are there other policy measures that would reach the same goal? Is it better to support sports or an LCC?

4 Conclusion

We have analyzed Local Complementary Currencies (LCCs), drawing on the economics of two sided platforms. Our results points to reasonable explanations for why LCCs generally fail, viz. either the demand side or the supply side of the LCC sector, or both. Proponents of these schemes often fail to acknowledge the pricing mechanisms matter, because they either consider LCCs as monies, while they de facto are payment platforms, or because they equate not-for-profit organizations with not-costly organizations. If one wants to know under which conditions LCCs could really thrive and prosper, then pricing mechanisms have to be considered.

However, as we have shown, even this may not be enough, and the cost structure of the institutions whose activity is dedicated to an LCC makes it hard to defined conditions under which the scheme could operate in a sustainable way. As a consequence, given the potential benefits of LCCs, one may argue that local authorities should step in and foot the bill. Since public funding is at stake, such a prescription should then be based on a clear economic analysis, comparing the costs and benefits of the different, competing, claims made on the

[13]The slow implementation process may even discourage volunteers, which could result in the LCC never to be launched (see the previous note).

public purse. Another possibility is that LCCs could be a bad instrument to an otherwise socially valuable goal (namely, favoring local producers and reducing transportation needs and costs). If this is the case, an alternative public policy instrument, such as local labeling, should be considered.

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Appendix 1: CES gross value and beta CDF

Assume $V_B(N_B, N_S)$ is a constant elasticity of substitution function, written as:

$$V_B(N_B, N_S) = \xi \left(\delta N_B^{-\rho} + (1-\delta) N_S^{-\rho}\right)^{-1/\rho}.$$

As is well known, the first parameter, ξ, is a scale parameter. In our framework, where $V_B(N_B, N_S)$ is the willingness to pay of the most enthusiastic potential buyer when N_B buyers and N_S sellers participate, ξ allows to arbitrarily fix the level of this willingness to pay for any participation, in particular when *all* potential buyers and sellers participate, i.e., $V_B\left(\bar{N}_B, \bar{N}_S\right)$. The second parameter, δ, is the distribution parameter. In our context, the closer δ is to 1, the more users put value on same side participation, and the closer to 0, the more users tend to value opposite side participation. The literature on payment systems usually considers indirect externalities only, with would coincide in our framework with $\delta = 0$. The third parameter, ρ, is the substitution parameter : if it is equal to -1, both types of participants are perfect substitutes to buyers, if it increases to infinity, they become perfect complements. With $\rho = 0$, the CES function is a simple Cobb-Douglas function: $V_B(N_B, N_S) = \xi_B N_B^{\delta} N_S^{1-\delta}$.

When $V_B(N_B, N_S)$ is a constant elasticity of substitution function, with scale, distribution and substitution parameters ξ, δ and ρ, the equilibrium condition $\Phi_B(N_B, N_S) \equiv \frac{\bar{N}_B - N_B}{\bar{N}_B} - F_B\left(\frac{P_B}{V_B(N_B, N_S)}\right) = 0$ can be written as:

$$N_S = \frac{P_B(1-\delta)^{1/\rho} N_B}{\left(N_B^{\rho}\left[\xi F_B^{-1}\left(\frac{\bar{N}_B - N_B}{\bar{N}_B}\right)\right]^{\rho} - P_B^{\rho}\delta\right)^{1/\rho}} \tag{14}$$

.

Assume also that the degree of sympathy towards the LCC, b_i, follows a beta distribution, with probability density function $f_B(b) = \frac{b^{p-1}(1-b)^{q-1}}{\mathrm{B}(p,q)}$ if $b \in [0,1]$, $f_B(b) = 0$ if $b \notin [0,1]$, where $B(p,q) = \int_0^1 x^{p-1}(1-x)^{q-1}\,dx$ is the beta function, and $p, q > 0$. The distribution is symmetric for $p = q$, and uniform for $p = q = 1$. In our framework, the higher p relative to q, the higher the proportion of potential buyers who are more sympathetic to the LCC (the skewness of the beta distribution has the sign of $p - q$).

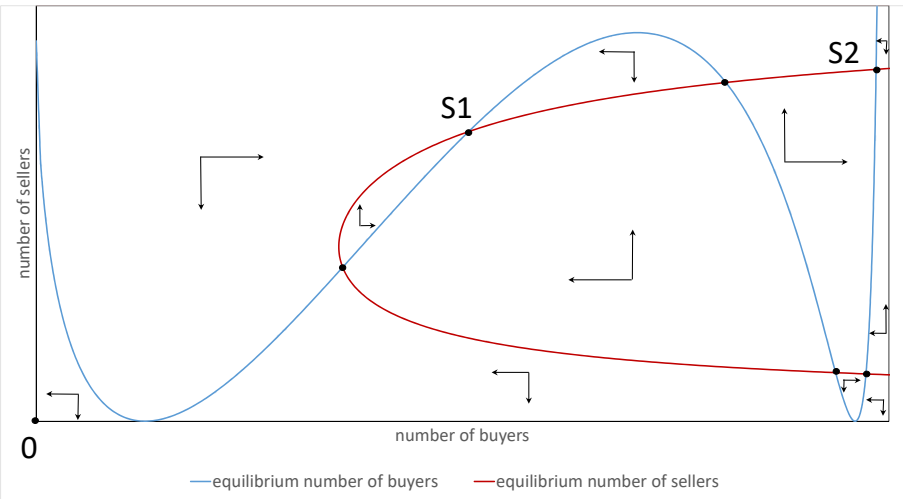
Appendix 2 : W-shaped condition for constant buyer participation

For some functional forms and parameter values, Assumption 1 does not hold, and, given P_B, the relationship between N_B and N_S involved by the condition for constant buyer participation, $\Phi_B(N_B(t), N_S(t)) = 0$, is not U-shaped in the (N_B, N_S) map, for $0 \leq N_B \leq \bar{N}_B$, but can be W-shaped (see figure 4). Then, there may be more than just two equilibria with positive participation.

Figure 4 shows a case with six such equilibria, among which two are stable, one with lower participation (S1) than the other (S2). The "benchmark" scenario detailed in the text still holds, namely that a double critical mass problem has to be overcome in order to reach a stable equilibrium (S1).

However, the scenario is now is a bit more complex than the benchmark. The LCC can still be stuck in the low participation equilibrium, unless it reaches a higher joint participation threshold.

Figure 4: W-shaped condition for constant buyer participation



Note: the figure is drawn assuming that:

- $V_B(N_B, N_S)$ is a CES function with $\delta = 0.65$ and $\rho = -0.5$,$\bar{N}_B = 1000$, $P_B = 35$, b_i follows a $\mathrm{B}(2,3)$ distribution.
- $V_S(N_S, N_B)$ is a CES function with $\delta = 0.5$ and $\rho = 0.2$,$\bar{N}_S = 300$, $P_S = 100$, s_j follows a $\mathrm{B}(2,2.5)$ distribution.