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

Jean-Baptiste Desquilbet* Etienne Farvaque†

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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, inducing groups of citizens in various areas around the world to create an LCC, hoping to shield their community from the resented negative side-effects of globalization. Indeed, 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 the 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 decision makers 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 probably higher than 25%. Moreover, although initially designed to create new commons beyond or even sometimes, against the State, most of the LCCs that survive nowadays rely on (local) government subsidies.

This raises the question whether LCCs are doomed from the start, i.e., under what conditions they could meet their supporters' expectations and wishes. So far, most of the literature[3] is based on case studies, or on programmatic arguments, which too often overlook economic constraints, if only the value of time necessary to create and manage an LCC. Only few analytically grounded papers discuss LCCs. Colacelli and Blackburn (2009) base their analysis on the search theory of money developed by Kyotaki and Wright (1989, 1993) and derive conditions for both a local currency and a national currency to circulate in equilibrium: scarcity of the national currency, relative transaction costs, and diversification of the local economy. They test these conditions on Argentinian data from the early 2000s, at a time when Argentina was in deep crisis. More recently, Rietz (2019) conducts lab experiments to test the predictions of currency competition models, which depend on assumptions about the bargaining process and the trade restrictions.

Another perspective is brought by Jayaraman and Oak (2005), who develop a Bayesian game to analyze how LCCs can enhance efficiency in the local economy in equilibrium. They argue that LCCs may "serve as a signal of demand to local firms" (p. 598). In their model, a high enough holding of the LCC is interpreted by producers as a high demand for local products, which helps resolve uncertainty and induces producers to invest in a more productive technology, which leads to a lower equilibrium price. In equilibrium, "money holdings are fully revealing, leading to ex post optimality" (p. 608).

Along a completely different line, Mailath *et al.* (2016) develop a formal model of a network of firms and consumers, without money, to explain how reciprocity in trades may trigger "buy local relationships". They

[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.
[3] See the on-line "bibliography of community currency research" at https://www.cc-literature.org/.

mention that LCCs can fit into their analysis, as a form of "buy local" arrangement. They show that such arrangements can be beneficial even if participants are selfish agents, i.e., without resorting to arguments such as building community spirit, improving environmental conditions through lower transportation costs, or influencing the conditions of production: "buy local" arrangements create surplus for a group by diverting trades from outside to inside the group, and by providing an enforcement mechanism through monitoring and reciprocity.

In the present paper, we take yet another approach to delve deeper in the functioning of LCCs. Our contribution is to consider LCCs as payment schemes that are well known to work like two-sided platforms. 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 and services, or buyers, and the local producers or businesses, or sellers. We build on Evans and Schmalensee (2010) to explicit the dynamics of the demand for participation in the payment scheme from both the consumer side and the seller side. We also build on Weyl (2010), to analyze the supply side of payment schemes, i.e., their cost structure. 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, focusing on the relationship between the cost structure of the system and the incentives for subsets of individuals to participate. We thus provide 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:

1. the number of potential users of both the buyer type, households and individuals, and the seller type, businesses and suppliers of goods and services;

2. 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 the users' maximum willingness to pay to join the LCC-supporting community;

3. the cost structure of the LCC-supporting institution, be it an association or a fully private firm, whether subsidized or not.

Contrary to models that focus on equilibrium conditions, and following Evans and Schmalensee (2010), we detail the dynamics of buyer and seller participation and show that success depends on the ability to attract, from the very beginning of the project, a sufficient number of both buyers and sellers. We also show that pricing is a critical success factor, in that too high a participation fee deters potential users from participating in the LCC, which is enough to make the LCC less attractive to all, given network externalities. Symmetrically, too low participation fees would not cover the costs of the supporting institution, nipping the project in the bud. The

predictions of our model are thus largely consistent with the empirical evidence on the difficulty in launching LCCs and keeping them afloat.

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 LCCs as two-sided payment platforms

In what follows, we consider an LCC as a two-sided payment platform. 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 analyses of payment systems that build on the theory of two-sided platforms usually insist on (i) indirect externalities, assuming away direct externalities, and (ii) participation fees as either an alternative or a complement to usage fees.

As regards network externalities, we build on Evans and Schmalensee (2010). Their model applies to various industries, and they provide social networking sites, content sharing platforms, business to business exchanges, and payment card systems as examples. Whereas they assume either direct externalities only or indirect externalities only, we consider a situation where both types of externalities coexist: we assume that 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, i.e., 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 many people share the community values supposedly conveyed by LCCs.

As regards fees, we assume away usage fees, for two reasons. First, we want to emphasize that, in any LCC arrangement, *mainly participation matters*, and that user utility is derived mainly from participation, because once users decide to participate, they will also use the LCC in payments.[4] 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.[5]

[4] 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. Clearly, usage fees are not different from participation fees in models of payment systems where users trade only once, which is a commonly made simplifying assumption, see, e.g., Verdier (2011). Considering an heterogeneity of this type would unnecessarily complicate the model.

[5] Usage fees can be collected in payment card systems. So, the ability to collect usage fees in an LCC arrangement certainly 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.

2.2 The demands for participation

We assume that some people set up an association to launch and manage 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 omit the time index to simplify notations when it can be done without ambiguity). 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:

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

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

We detail the analysis for buyer behavior. 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.[6] P_B is the (time invariant) membership fee charged to buyers who join the managing association. $V_B\left(N_B, N_S\right)$ is a time-invariant function that measures the willingness to pay of the most enthusiastic potential buyer when N_B buyers and N_S sellers participate. We assume $V_B\left(N_B, N_S\right)$ 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), and that for any $n \geq 0$,$V_B\left(0, n\right) = V_B\left(0, n\right) = 0$, i.e., the most enthusiastic buyer is not willing to pay a strictly positive amount to participate if there is either no buyer or no seller. Parameter b_i, $b_i \in [0, 1]$, characterizes each buyer i and measures 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 $F_B\left(b\right)$, so that $F_B\left(b\right)$ denotes the proportion of buyers who are willing to pay at most $bV_B\left(N_B, N_S\right)$ to participate, while $1 - F_B\left(b\right)$ denotes the proportion of buyers who are willing to pay more than $bV_B\left(N_B, N_S\right)$ to participate. We denote the associated density function by $f_B\left(b\right)$.

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 (or "willing participants") is then $\bar{N}_B\left[1 - F_B\left(\frac{P_B}{V_B(N_B, N_S)}\right)\right]$.

Denote by $\Phi_B\left(N_B\left(t\right), N_S\left(t\right)\right)$ the difference between the number of willing participants and the number of actual participants.

$$\Phi_B\left(N_B\left(t\right), N_S\left(t\right)\right) \equiv \bar{N_B}\left(1 - F_B\left(\frac{P_B}{V_B\left(N_B\left(t\right), N_S\left(t\right)\right)}\right)\right) - N_B\left(t\right) \tag{3}$$

We assume a simple dynamics of adjustment in the number of actual participants[7]. If the number of

[6] 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. In practice, 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.

[7] Evans and Schmalensee (2010) do not detail the dynamics of their model, but it follows the same lines. As in their paper, we have :

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

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

actual participants is smaller than the number of willing participants, then it increases by some fraction of the difference, viz. :

$$\frac{dN_B(t)}{dt} = \theta_B \left[\Phi_B\left(N_B(t), N_S(t)\right) - N_B(t)\right] \tag{4}$$

where θ_B, $0 < \theta_B \leq 1$ is the speed of adjustment (with $\theta_B = 1$, all willing participants who are not already participating would join, and all participants who are no longer willing to participate would quit).

The participation dynamics is the same for sellers, with the appropriate changes in notations :

$$\frac{dN_S(t)}{dt} = \theta_S \left[\Phi_S\left(N_S(t), N_B(t)\right) - N_S(t)\right] \tag{5}$$

where :

$$\Phi_S\left(N_S(t), N_B(t)\right) = \bar{N_S}\left(1 - F_S\left(\frac{P_S}{V_S\left(N_S(t), N_B(t)\right)}\right)\right) - N_S(t) \tag{6}$$

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:

$$\Phi_B\left(N_B(t), N_S(t)\right) = 0 \tag{7}$$

$$\Phi_S\left(N_S(t), N_B(t)\right) = 0 \tag{8}$$

Equations (7) and (8) are, respectively, the condition for "constant buyer participation" and the condition for "constant seller participation".

2.3 The equilibrium condition for buyer participation

We now detail the equilibrium condition for buyers, equation (7), under a set of very general technical assumptions[8]. We show that it relates N_S to N_B as an implicit function that is globally U-shaped on the $\left[0; \bar{N_B}\right]$ interval, in the loose sense that it is strictly decreasing for low values of N_B and strictly increasing for high values of N_B, but may be increasing or decreasing for intermediate values of N_B. We then show how this equilibrium relationship is affected by changes in P_B and changes in the distribution function $F_B(b)$.

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 $\Phi_B(N_B, N_S) > 0$, and it decreases, $dN_B(t)/dt < 0$, below the curve, where $\Phi_B(N_B, N_S) < 0$.

[8]The same analysis applies to the equilibrium condition for sellers, equation (8), with appropriate changes in notation.

Proposition 1: (a) For $0 \leq N_B \leq \bar{N_B}$, the relationship between N_B and N_S along the $\Phi_B(N_B, N_S) = 0$ curve may be either positive or negative. (b) When N_B is low (approaches 0), there is a negative relationship between N_B and N_S along the $\Phi_B(N_B, N_S) = 0$ curve. (c) When N_B is high (approaches $\bar{N_B}$), there is a positive relationship between N_B and N_S along the $\Phi_B(N_B, N_S) = 0$ curve.

Proof: Assume numbers N_B and N_S exist in their respective admissible intervals, such that the condition for constant buyer participation is satisfied : $\Phi_B(N_B, N_S) = 0$. The slope of the $\Phi_B(N_B, N_S) = 0$ curve is given by:

$$\frac{dN_S}{dN_B} \mid_{\Phi_B=0} = \frac{V_B^2}{\bar{N_B} P_B f_B V_{BS}} - \frac{V_{BB}}{V_{BS}} \tag{9}$$

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 $\frac{\partial V_B}{\partial N_B}(N_B, N_S)$, and V_{BS} for $\frac{\partial V_B}{\partial N_S}(N_B, N_S)$.

(a) The first term in (9) is non-negative since all factors involved are non-negative. The second term is negative, from the assumption that $V_B(N_B, N_S)$is increasing in both arguments and quasi-concave. Therefore, for $0 \leq N_B \leq \bar{N_B}$, the slope may be either positive or negative, depending on the properties of $V_B(N_B, N_S)$ and $F_B(b)$.

(b) When $N_B \to 0$, the first term in (9) tends towards 0. The second term is the slope of the $V_B(N_B, N_S) = P_B$ curve, which is negative. Then, as $N_B \to 0$, the slope of the $\Phi_B(N_B, N_S) = 0$ curve tends towards the slope of the $V_B(N_B, N_S) = P_B$ curve, and it is therefore negative[9].

(c) 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 tend to 0. This will be the case if $\frac{P_B}{V_B(N_B,N_S)}$ tends 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). QED.

As a consequence of proposition (1), we cannot, without imposing some restrictions on $V(N_B, N_S)$ and $F_B(b)$, ascertain that the $\Phi_B(N_B, N_S) = 0$ curve is convex, and that its slope is increasing with N_B, which would be necessary and sufficient to obtain a strict U-shape[10]. However, the double critical mass problem argument we want to make does not depend on the strict convexity of the equilibrium condition for buyers (or sellers).

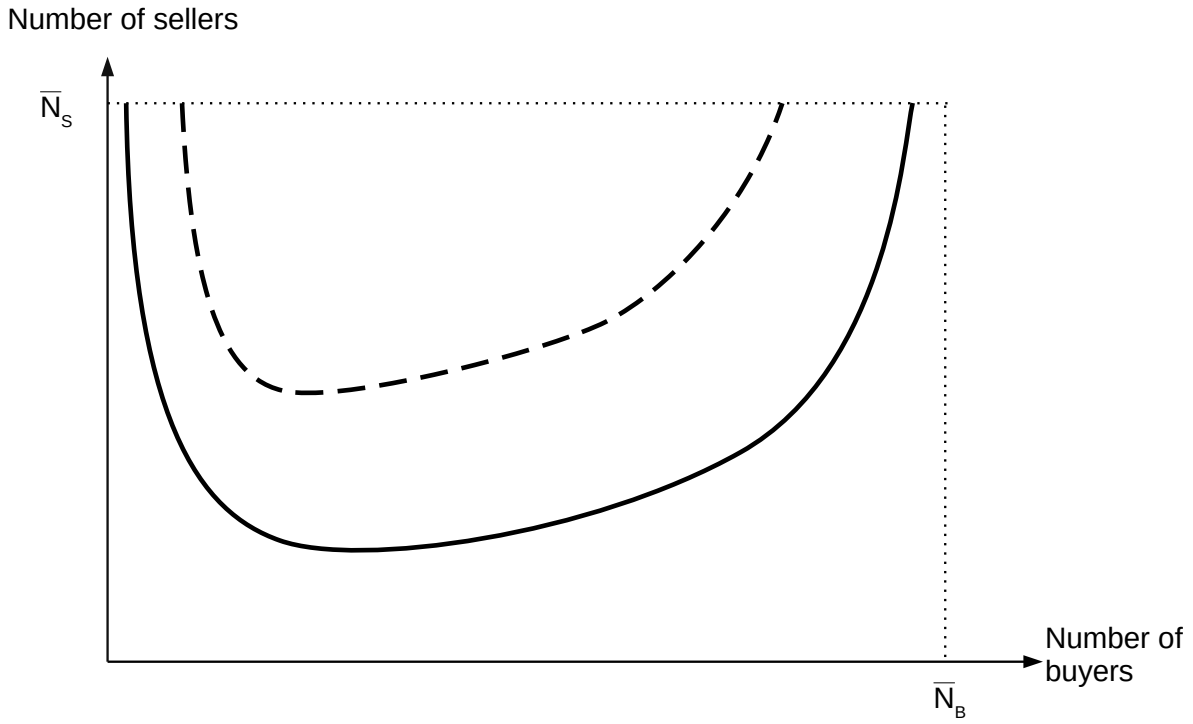
Proposition 2: Ceteris paribus, an increase in P_B induces an upward shift of the $\Phi_B(N_B(t), N_S(t)) = 0$ curve in the (N_B, N_S) map.

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

[9]Notice that 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 $N_B > 0$. 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 tend to 1. This will be the case if $\frac{P_B}{V_B(N_B,N_S)}$tends 1, that is, if $V(N_B, N_S)$ tends to 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.

[10]Using a constant elasticity of substitution function for $V_B(N_B, N_S)$ and a beta distribution for $F_B(b)$ yields, the convexity the equilibrium condition for buyers is verified for a wide range of parameters.

Figure 1: Constant buyer participation



Note: the continuous line represents the condition for constant buyer participation, assuming its convexity, for a given participation fee and a given distribution of the willingess to pay of buyers; the dashed line represents the same condition for a higher participation fee (proposition 2) and/or a first-order stochastically dominated or more right-skewed distribution of the willingess to pay of buyers (propositions 3 and 4).

(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. This is illustrated in figure 1.

Proposition 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 arrangement, 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. Figure 1 also illustrates this proposition.

Proposition 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: Again, denote $G_B(b)$ the new cumulative distribution function of b_i. There are several ways to compare the skewness of distributions (see, e.g., Chiu (2010)). We use here the definition by Van Zwet (1964) as given by Chiu (2010): $G_B(b)$ is more skewed to the right in the sense of Van Zwet (1964) if $G_B^{-1}(F_B(b)) \equiv H_B(b)$ is convex. Since $H_B(b)$ maps $[0;1]$ into $[0;1]$, with $H_B(0) = 0$ and $H_B(1) = 1$, assuming $H_B(b)$ is convex implies that $H_B(b) \leq b$. Given $\{P_B, N_B, N_S\}$, if $H_B(b)$ is convex then $G_B^{-1}\left(F_B\left(\frac{P_B}{V_B(N_B,N_S)}\right)\right) \leq \frac{P_B}{V_B(N_B,N_S)}$, therefore $G_B\left(\frac{P_B}{V_B(N_B,N_S)}\right) \geq F_B\left(\frac{P_B}{V_B(N_B,N_S)}\right)$. If $\frac{(\bar{N}_B - N_B)}{\bar{N}_B} - F_B\left(\frac{P_B}{V_B(N_B,N_S)}\right) = 0$, then $\frac{(\bar{N}_B - N_B)}{\bar{N}_B} - G_B\left(\frac{P_B}{V_B(N_B,N_S)}\right) \leq 0$. The $\{N_B, N_S\}$ point lies on the initial equilibrium curve, and below the new one; therefore, the new equilibrium curve lies above the initial one. QED.

Figure 1 also illustrates this proposition. The intuition is as follows. Positive skewness of the distribution of b_i on the $[0;1]$ interval means that the distribution is relatively more concentrated on lower values of b_i. A greater skewness means that the concentration of potential buyers on the lower values of b_i increases, and that there are relatively less "enthusiastic" buyers, who are endowed with a higher b_i and willing to pay the given participation fee to the LCC, given the number of participating sellers. The number of participating buyers would be unchanged if either the number of sellers increases, or the participation fees decreases.

2.4 The double critical mass problem

To be a viable arrangement, as shown by Evans and Schmalensee (2010) for other two-sided platforms, any LCC arrangement faces a double critical mass problem, because of the direct and indirect network externalities: it has to attract a high enough number of buyers, as well as a high enough number of sellers.

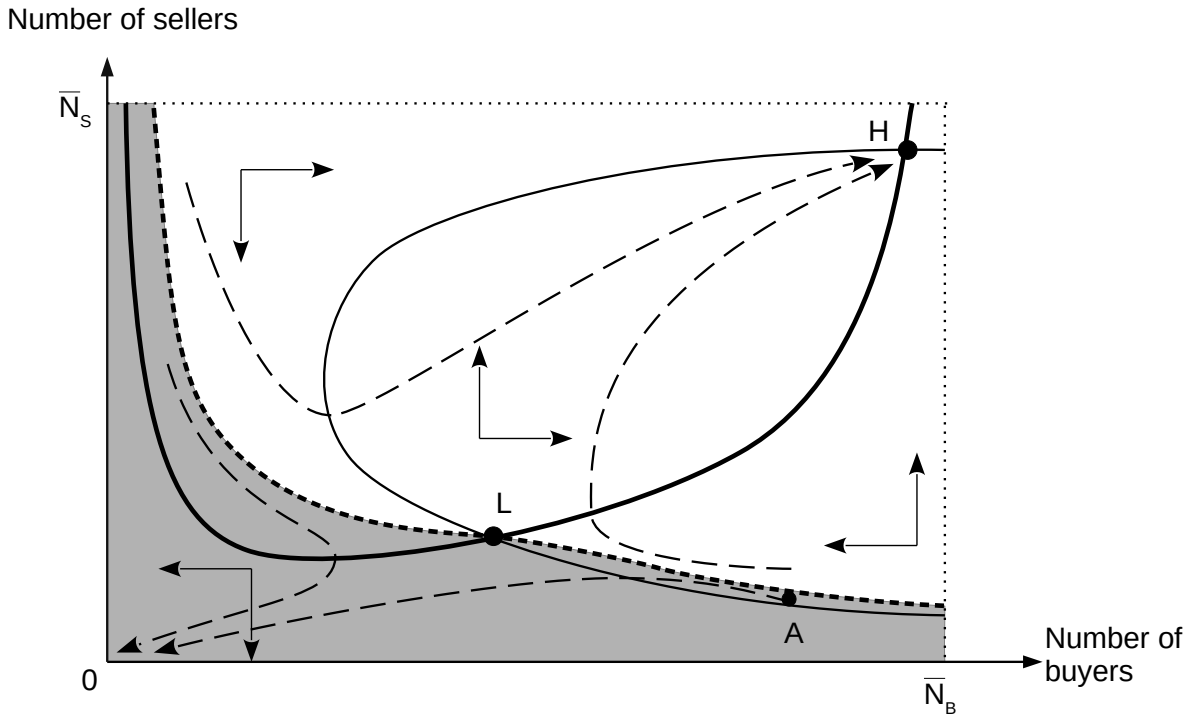
Figure 2 displays a benchmark case, in which the demand model has three stationary equilibria, as shown by the phase diagram. The first equilibrium is the origin, a stable "no participation" equilibrium, with $N_B = N_S = 0$. The other two are such that the membership fees are low enough for some buyers and sellers to participate. One equilibrium (L) is a "low participation" saddle-point equilibrium, while the other (H) is a "high participation" stable equilibrium[11].

This benchmark case illustrates the double critical mass problem. If the LCC association fails to attract combined numbers of buyers above the separatrix, the number of users initially participating will gradually revert to 0. For example, if the LCC initially attracts a high number of buyers, but a small number of sellers (point A), more sellers are attracted by the popularity of the LCC among buyers and join, while some buyers quit, as they may be disappointed by the smaller number of places where they can use the LCC. After some time, that depends on the adjustment speeds of buyer and seller participations, the adjustment path crosses the line of constant seller participation, then both types gradually quit, and the LCC ends with no participants at all.

It is clear, from the mathematics of phase diagrams, that the position and shape of the separatrix depends on the characteristics of both equilibrium conditions, (7) and (8) and that of the functions on which they are

[11] These properties are inferred from the direction indicators.

Figure 2: The double critical mass problem (benchmark case)



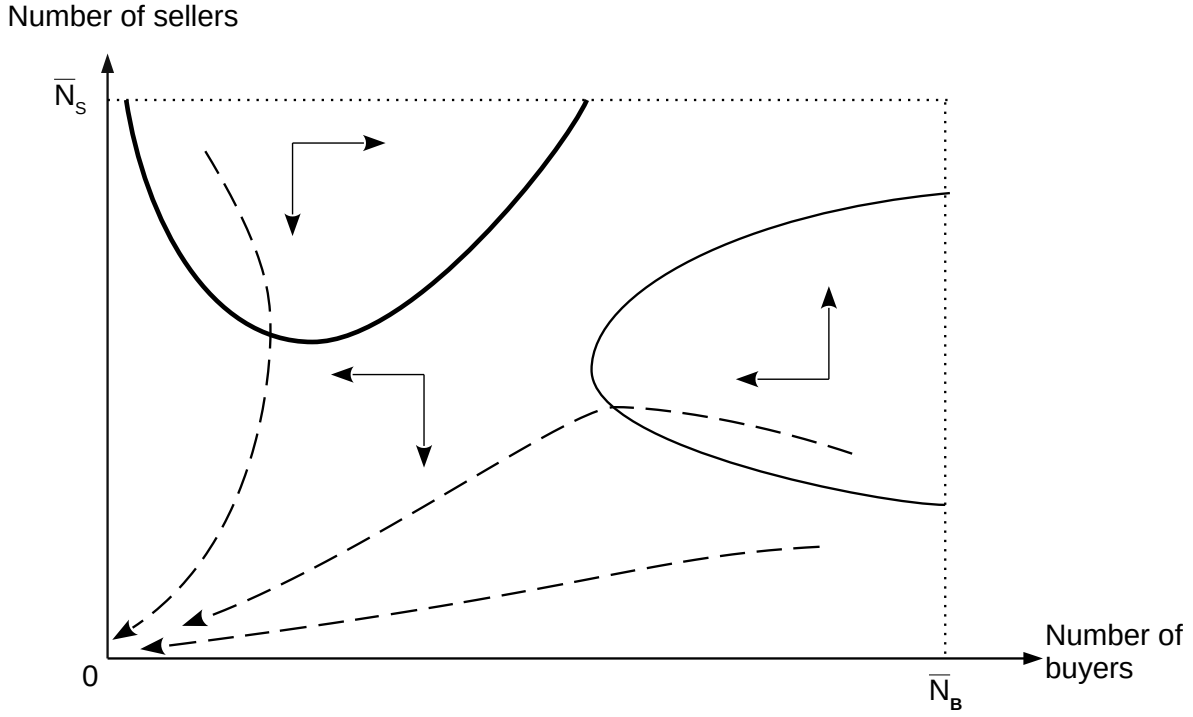
Note: the heavy continuous line through points L and H represents the condition for "constant buyer participation" (7) and the thin continuous line represents the condition for "constant seller participation" (8); the dotted line through L is the separatrix that converges to L; the combined thin straight arrows are the direction indicators; the curved dashed arrows show examples of trajectories.

based, $V_B(N_B, N_S)$, $V_S(N_S, N_B)$, $F_B(b)$, $F_S(s)$,as well as on the assumed speeds of adjustment, θ_B and θ_S. The important point is that, both numbers of participants N_B and N_S must be high enough at the same time, above the shaded area of figure 2, in order to trigger a dynamics leading to the high equilibrium, otherwise the no participation equilibrium will be reached.

In figure 3, we show a case in which membership fees are too high, so that 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 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.

Figure 2 also illustrates the influence of another parameter, the degree of enthusiasm (a.k.a. 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 association managing the LCC could attempt to compensate for the lack of enthusiasm by lowering the participation fee. However, as we explain next, this may meet other issues, as supply side considerations also prevail.

Figure 3: No participation when membership is too expensive or when enthusiasm is low



Note: the heavy continuous line represents the condition for "constant buyer participation" (7) and the thin continuous line represents the condition for "constant seller participation" (8); the combined thin straight arrows are the direction indicators; the curved dashed arrows show examples of trajectories.

3 The supply side of LCC

As our framework makes clear, the key success factor for LCCs is participation on both sides. This feature is generally overlooked in the literature on local complementary currencies. This because these projects are promoted by activists, who consider that local 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.

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 thoroughly analyzed by Weyl (2010), who presents a general model which encompasses that of Rochet and Tirole (2006), Armstrong (2006), among others, and applies to payments platforms, among others. In this model, tariffs set by platforms can have several components, since membership and interaction are assumed to be costly to, and priced by, the platform.

Weyl (2010) discusses several conditions for optimal pricing, depending on the objective function of the platform, maximizing total social value without or with achieving a minimum absolute profit, or maximizing private profit, and on the sources of heterogeneity among users. He also underlines the different types of price distortions that affect multi-sided markets, and some technicalities have been commented on by Tan and Wright (2018).

Weyl (2010) demonstrates the *interior* optimal price structure under Ramsey pricing, where "social welfare is maximized subject to achieving a minimum absolute profit" (p. 1653). 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" (p. 1653). This is the closest he comes to the question we address here. However, he does not consider the maximum level of profit the platform can obtain.

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 be aware of its own cost structure. Both conditions are often not met in real-life LCCs, as the 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.

In order to analyze the economics of local currencies in a consistent way, we assume that:

1. the association promoting the LCC is a nonprofit organization, as is the case for most real world LCCs;
2. the LCC services are produced with increasing returns to scale;
3. it sets participation fees so as to maximize a given objective function, denoted $W(N_B, N_S)$;
4. the association determines optimal memberships, N_B and N_S, as in Weyl (2010), from which optimal prices 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[12]. It should be noted that, even before permanent staff are hired, 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 social benefits 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

[12]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).

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.

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:

$$C\left(N_B, N_S\right) \equiv c_B N_B + c_S N_S + K \tag{10}$$

where c_B and c_S are the marginal costs attached to each type of participant, and K, the institution's fixed cost.

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

$$\pi \equiv \left(P_B - c_B\right) N_B + \left(P_S - c_S\right) N_S \tag{11}$$

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 association that runs the LCC does not aim to maximize its profit. To embed more real-life cases, we rely on a more general form than profit, and we consider 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 on the number of participants.

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

$$Max\ W\left(N_B, N_S\right) \tag{12}$$

s.t.:

$\pi \geq K$, where π is defined in (11),

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

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

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[13]:

$$P_B = F_B^{-1}\left(\frac{\bar{N_B} - N_B}{\bar{N_B}}\right) V_B\left(N_B, N_S\right) \equiv P_B\left(N_B, N_S\right) \tag{13}$$

$$P_S = F_S^{-1}\left(\frac{\bar{N_S} - N_S}{\bar{N_S}}\right) V_S\left(N_S, N_B\right) \equiv P_S\left(N_S, N_B\right) \tag{14}$$

.

[13]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.

Technically, then, the maximization problem looks like a standard Ramsey pricing problem (see, e.g., Baumol, 2008), which can be solved in terms of the numbers of participants. However, we do not need to compute optimal prices to discuss the viability of the LLC.[14]

3.2 Are LCCs doomed?

Our model helps to frame 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.[15] The LCC could typically succeed if a crisis virtually wipes out the official currency[16], or in a local area where inhabitants have a very strong attachment or sense of belonging to their region, or a very strong regional culture[17], 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, this 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. Although they appear as special cases of our model, such situation probably deserve a more thorough analysis[18]. 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 unfavorable given the potential participations on both buyer and seller sides. 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 may not even trigger a high enough participation. In such a situation, the project is still-born.[19]

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 participation 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, i.e., when prices that maximize gross surplus do not generate a maximum surplus that is high enough to compensate for fixed costs (in such as case, there are no levels of N_B, N_S allowing that $\pi \geq K$).

[14] 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 pricing, see Anderson and Bedre-Defolie (2021).

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

[16] The Argentinian experience with the *Credito* in the early 2000s is such an example. The Swiss *WIR* was launched in such a crisis context, in 1934, and rapidly reached a high number of active members (Stodder, 2009).

[17] For example, people in the French Basque Country have developed the *Eusko* that seems to expand, albeit with strong financial support of local, national and even European public authorities, as advertised on their website (https://www.euskalmoneta.org/ - last accessed April 2021). The successful development of the *Sardex* in Italian Sardigna is another example. In this specific case, the "critical mass" problem was recognized early on, and the system took-off after three years thanks to a 150k€ private investment in the network infrastructure (Litera et al., 2017).

[18] 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 refers to the macroeconomic analysis of Optimal Currency Areas, multiple currency monetary regimes, dollarization, and goes well beyond the scope of this article.

[19] 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, at the time of writing. Among these, 11 (17%) have been stopped, with an average age at death inferior to 3 years.

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.

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 volunteers for the managing association[20].

Of course, it can be argued that the LCC provides community services and that the managing association does not have to break even. This argument implies that the LCC association 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 enhance the sense of togetherness, the question becomes whether other policy measures could more efficiently reach the same goal. To which recipient subsidiaries are best allocated, a sports club, a musical society, a cultural organization, among others, or a local complementary currency ?

4 Conclusion

We analyze Local Complementary Currencies (LCCs), drawing on the economics of payment systems considered as two sided platforms. Our results explanain why LCCs generally fail, viz. either the demand side, where two critical masses must be reached simultaneously both in buyer participation and in seller participation, or the supply side of the LCC sector, where the cost structure and pricing decision matter, or both. Proponents of these schemes often fail to acknowledge that 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 discussed, the cost structure of the LCC-managing institution gives rise to economies of scale and make it hard to meet the conditions under which the scheme could operate in a sustainable way. As a consequence, 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 public purse. Another possibility is that LCCs could be an inefficient 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 at least be considered.

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

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