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BUYING LOCALLY

By

George J. Mailath, Andrew Postlewaite, and Larry Samuelson

March 2015

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Buying Locally*

George J. Mailath† Andrew Postlewaite‡ Larry Samuelson§

March 4, 2015

Abstract

"Buy local" arrangements encourage members of a community or group to patronize one another rather than the external economy. They range from formal mechanisms such as local currencies to informal "I'll buy from you if you buy from me" arrangements, and are often championed on social or environmental grounds. We show that in a monopolistically competitive economy, buy local arrangements can have salutary effects even for selfish agents immune to social or environmental considerations. Buy local arrangements effectively allow firms to exploit the equilibrium price-cost gap to profitably expand their sales at the going price.

Keywords: Buy local, local currency, trading favors, reciprocity, monopolistic competition.

JEL Classification Numbers: D43, D85, L14, R12.

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1 Introduction

People often perceive gains from having members of a community "buy local." At one end of the scale are formal schemes such as local currencies (such as Ithaca hours, Good, 1998). In the middle are organizations (such as the Business Alliance for Local Living Economics, `http://www.livingeconomies.org`) or norms (such as a custom of "keeping the money at home" or a prescription that "you do business with those who do business with you") encouraging reciprocal buying habits. For example:[1]

> "I make my money here, and people naturally expect me to spend it here. ... I'd be just as glad if you dealt with Jenson or Ludelmeyer as much as you can, instead of Howland & Gould, who go to Dr. Gould every last time ... I don't see why I should be paying out my good money for groceries and having them pass it on to Terry Gould!"
>
> "I've gone to Howland & Gould because they're better, and cleaner."
>
> "I know. ... Course Jenson is tricky—give you short weight—and Ludelmeyer is a shiftless old Dutch hog. But same time, I mean let's keep the trade in the family whenever it is convenient, see how I mean?"

At the other end are reciprocal relationships, of the form described in Ellickson (1991), in which people informally provide goods and services to one another.

Why do people buy locally? The reciprocity built into buy local arrangements may bring social benefits—supporters often refer to local buying arrangements as playing an important role in building community spirit. Buy local arrangements are often championed for their environmental benefits, typically in the form of lower transportation costs. Buying locally may make it easier for consumers to influence conditions of production, from ensuring

[1] Sinclair Lewis, *Main Street*, International Collector's Library, Garden City, NY, 1948; 95.

that products are "natural" to seeing that workers are treated fairly. Buying locally may be a way of providing public goods, perhaps in the form of a diverse or picturesque local business district.

We argue that it is not necessary to introduce social factors, environmental considerations, influence, or externalities to account for buy local relationships. Buying locally can be beneficial even when agents are motivated strictly by selfish concerns.

A buy local arrangement is clearly in an agent's best interest if the goods and services provided by the partners in the arrangement are routinely better than any other on offer. But how do we account for the behavior in the preceding excerpt, where this is not the case? The essence of a buy local arrangement is its reciprocity—agent i buys from another agent j within the arrangement even when j's price-quality package isn't the best on offer because j will similarly buy from within the arrangement in similar circumstances. This reciprocity may be valuable in a world of monopolistic competition. Each seller, facing a downward sloping demand function, sets price above marginal cost and so receives a strictly positive profit from an additional sale. Agent j may not have the optimal price-quality package, but if the utility i foregoes from purchasing from j is less than j's gain from the transaction, and i similarly makes sales within the arrangement that would not otherwise occur, the members of the arrangement are made better off by the buy local arrangement.

Buy local arrangements involve tradeoffs between agents-as-firms making additional profitable sales and agents-as-consumers making suboptimal purchases. In order for a buy local arrangement to be beneficial, the costs of making suboptimal purchases cannot be too large. Equivalently, the goods available inside the buy local arrangement should be at least plausible substitutes for the consumers' most preferred choices. This is more likely if the members of the buy local arrangement are "close" in some appropriate sense. This suggests that communities connected by common interests, culture, or physical proximity are ideal candidates for successful buy local arrangements.

Our model of monopolistic competition is a special case of Hart (1985), in which we take the number and composition of firms in the market as fixed. Agents act as both consumers and firms. Firms post prices and consumers, acting as price takers, then choose which firms to patronize. Because the firms are monopolistically competitive and hence sell at prices higher than marginal cost, each firm would like to sell more at its current price. We allow a subset of agents to engage in a buy local relationship. This reciprocal patronage will often call for consumers to settle for something

less than their most-preferred good. The return for doing so is that the buy local arrangement allows the agents' firms to increase the quantity they sell without reducing their price.

Because its participants sometimes forgo their most-preferred product, a buy local arrangement requires monitoring and enforcement. We return to these considerations in Section 4, noting here that the various types of buy local arrangements mentioned in our opening paragraph solve these problems in different ways. Local currencies can serve as a monitoring device, ensuring that one can reap the benefits of additional sales only if one accepts the local currency, in much the same way that money can serve as memory (Kocherlakota, 1998). The doctor in the *Main Street* example may pay the same for his groceries as does the rest of the public, just as the shopkeeper may pay for his office visits, each incurring costs (the purchaser will sometimes prefer to buy elsewhere) to boost the demand of the other, with networks of gossip providing the required monitoring and enforcement. The transactions in reciprocal conventions may take place without transfers—Alice the plumber may fix Bob's sink whenever needed, while Bob the roofer takes care of Alice's roof—with the monitoring and enforcement arising out of the bilateral and repeated nature of the interaction.

2 An Example: The Benefits of Buying Locally

We begin with an economy with a numeraire good, produced by a perfectly competitive industry employing a constant-returns-to-scale technology, as well as goods 1 and 2. There are four firms in the economy, denoted by $\{f_{ij} : i = 1, 2, j = 1, 2\}$. Firm f_{ij} produces good j, so that there are two firms producing each good. Firms costlessly produce output, though this simplifying assumption is not essential.

The owners of the firms constitute the consumers in the economy. For simplicity, we assume each firm f_{ij} is owned by one consumer a_{ij}. Consumers behave competitively, in the sense that the price and profit of firm f_{ij} are taken to be exogenous in consumer a_{ij}'s utility maximization problem. This is equivalent to assuming each firm is owned by a continuum of identical consumers (as assumed by Hart, 1985).

Consumers receive utility from consumption of the numeraire and the two goods. The utilities a consumer obtains from purchasing good j from firm f_{1j} and from firm f_{2j} are stochastic. It is sometimes preferable to buy good j from firm f_{1j} and sometimes preferable to buy from firm f_{2j}. Firm f_{ij}'s product may be distinguished by a flavor, color, size, function, or other

characteristics that the consumer sometimes prefers to others. We model these random preferences by assuming that each consumer a_{ij} takes four independent uniform draws from the unit interval, with the realization $\lambda_{\ell k}$ determining for good k the distance between the consumer's ideal good and the good produced by firm $f_{\ell k}$. This distance arises in a space of product characteristics that may or may not have geographic distance as one of its dimensions. In particular, consumer a_{ij} may find the good produced by its own firm less attractive than the same good produced by the other firm (i.e., $\lambda_{ij} > \lambda_{\ell j}$, $\ell \neq i$).

For each consumer, a_{ij}, let $\mathbf{1}_{\ell k}$ denote the indicator equaling 1 if the consumer purchases good k from firm $f_{\ell k}$ (possibly the firm the consumer owns), and 0 otherwise. Consumer a_{ij} buys either zero or one unit of goods 1 and 2, receiving utility

$$z + \sum_{\ell,k=1}^{2} (\Lambda_k - \lambda_{\ell k})\mathbf{1}_{\ell k},$$

where z is the consumption of the numeraire, $\mathbf{1}_{1k}\mathbf{1}_{2k} = 0$, and Λ_1 and Λ_2 are constants larger than 2. Consumer a_{ij}'s budget constraint is

$$\sum\nolimits_{\ell,k} p_{\ell k}\mathbf{1}_{\ell k} + z = \pi_{ij} + Z,$$

where $p_{\ell k}$ is the price of firm $f_{\ell k}$'s good, π_{ij} is the profit earned by a_{ij}'s firm, and Z is an endowment of the numeraire larger than $\Lambda_1 + \Lambda_2$. This endowment ensures that we need not be concerned with corner solutions.

2.1 The Market Outcome

We first calculate the market outcome. Each of the four firms simultaneously sets a price. Simultaneously, consumers receive their distance draws. After observing their distance draws and the firms' prices, each of the four consumers chooses a firm from whom to purchase each good (or does not purchase at all).

Consider good j and suppose consumers face prices p_{1j} and p_{2j} from firms f_{1j} and f_{2j}. A consumer, having drawn distances λ_{1j} and λ_{2j}, purchases from firm f_{1j} if $\Lambda_j - \lambda_{1j} - p_{1j} > \max\{0,\ \Lambda_j - \lambda_{2j} - p_{2j}\}$. It is straightforward to verify that there is a symmetric monopolistic equilibrium with prices $p_{1j} = p_{2j} = \frac{1}{2}$, and that this is the unique equilibrium.[2] Given these common

[2]The calculations are in Appendix A.1. This example is a special case of the model in Section 3.2, and the equilibrium prices can also be deduced from that analysis.

prices, each consumer purchases from the firm closest to the consumer. Each firm receives an expected payoff of $\pi = 1$ (a price of $1/2$, and probability $1/2$ that each of the four consumers are closest to the firm and hence purchase from it, for an expectation of two purchases).[3] Each consumer has expected income 1 (received from its firm). Consumers can borrow and lend costlessly on a competitive capital market, so that their budget constraint need only hold in expectation. Because Λ_1 and Λ_2 each exceed 2, each consumer purchases both goods, regardless of her distance draws, and (in expectation) purchases none of the numeraire. The ex ante expected utility produced by good j is

$$\int_0^1 (\Lambda_j - \lambda) 2(1-\lambda) d\lambda = \Lambda_j - \frac{1}{3}, \tag{1}$$

where $2(1-\lambda)$ is the density of the minimum of two independent draws from uniform distributions on $[0,1]$. Summing the utility from the two goods, each consumer receives ex ante expected utility $\Lambda_1 + \Lambda_2 - \frac{2}{3}$, and so the total market surplus is $4\Lambda_1 + 4\Lambda_2 - \frac{8}{3}$.

2.2 Buying Locally

Now suppose that consumers a_{11} and a_{12} agree that they will patronize only each others' firms (firms f_{11} and f_{12}), regardless of the consumer draws they happen to receive. They agree to hold their prices constant at $1/2$ (we come back to this assumption in Section 3.3; this will be the equilibrium price in the presence of the buy local arrangement, see Proposition 2). We refer to this as a *buy local* arrangement and these two agents as *inside agents* (and agents not in the arrangement as *outside agents*). Under this arrangement, there will be circumstances in which an inside consumer is buying from an inside firm even though she would prefer to buy from an outside firm.

Consider agent a_{11}. The expected profit of this agent's firm f_{11} is

$$1 + \frac{1}{2} = \frac{3}{2},$$

since consumers a_{11} and a_{12} always purchase from this firm, and consumers a_{21} and a_{22} each find that firm f_{11} has the lowest distance draw, and hence purchase from f_{11} (at price $1/2$), with probability $1/2$. Consumer a_{11} receives expected utility

$$\frac{3}{2} + \Lambda_1 - \frac{1}{2} - \frac{1}{2} + \Lambda_2 - \frac{1}{2} - \frac{1}{2} = \Lambda_1 + \Lambda_2 - \frac{1}{2},$$

[3] Under the interpretation that each consumer is a representative of a continuum of consumers, there is no aggregate uncertainty and firm payoffs are not random.

since this consumer receives profit 3/2 from her firm, always buys from firms f_{11} and f_{12} at price 1/2, and the expected distance when buying the good from firm f_{1k} is 1/2.

Thus, each inside agent has higher payoff under the buy local arrangement than in the competitive equilibrium. The loss of utility from sometimes buying from an inside firm when the outside firm has a lower distance draw is more than compensated for by the increased profits.

The outside agent a_{2k} receives 1/2 from his firm, since only consumers a_{21} and a_{22} purchase from f_{2k} and then only when that firm has the lower distance draw. Agent a_{2k} receives expected utility (recall (1))

$$\frac{1}{2} + \Lambda_1 - \frac{1}{3} - \frac{1}{2} + \Lambda_2 - \frac{1}{3} - \frac{1}{2} = \Lambda_1 + \Lambda_2 - \frac{7}{6},$$

smaller than without the buy local arrangement. Total surplus is $4\Lambda_1 + 4\Lambda_2 - 10/3$, less than the total (of $4\Lambda_1 + 4\Lambda_2 - \frac{8}{3}$) in the absence of the buying locally arrangement.

Insiders gain in the buy local equilibrium because their consumer loss from patronizing one another is less than their firms' gain. The basic forces behind this result, which we expect to be robust to variations in the model, are that marginal consumers who patronize an inside rather than an outside firm are close to indifferent between the two firms, and hence will sacrifice little. The imperfectly competitive firms are setting prices above marginal cost and hence gain relatively more, leading to an aggregate gain for inside agents. These gains reflect the fact that monopolistically competitive firms price above marginal cost, and hence are always anxious to sell more at their going price.

2.3 Exploiting Outsiders?

The buy local arrangement in our example reallocates some surplus from outsiders to insiders, sacrificing some in the process. This gives the buy local arrangement a similarity to a prisoners' dilemma. The agents in location 2 have an incentive to also form a buy local arrangement, regardless of whether the agents in location 1 do so. But the worst outcome is for both locations to form (separate) buy local arrangements, so that no firm reaps the benefits of increased sales while consumers find their choices restricted.

A buy local arrangement need not always involve a reallocation of surplus from outsiders to insiders. Consider again the previous example, but suppose that firms f_{21} and f_{22} are replaced by a perfectly competitive market. In particular, each of these producers has constant marginal and average cost

given by 1/2. As a result, they will supply an arbitrarily large amount of good 1 or good 2 at any price at least 1/2, and will supply nothing at lower prices. Firms f_{11} and f_{12} remain as before, as do consumers. Then:

- There are no gains to a_{21} and a_{22} from forming a buy local arrangement. The payoffs to such an arrangement come from directing strictly profitable purchases that formerly went outside to the insiders of the arrangement. There are now no strictly profitable purchases for firms f_{21} and f_{22}, and hence no such gains to be had. Similarly, consumers a_{21} and a_{22} lose nothing when location-1 agents form a buy local arrangement.
- The calculation of the benefits to consumers a_{11} and a_{12} from forming a buy local arrangement remain just as before.

In this case the buy local arrangement is surplus enhancing. Independent of the effect on outsiders, there is an efficiency gain associated with a buy local arrangement because it allows us to partially overcome the inefficiency of imperfect competition, and in this case doing so imposes no costs.

The essence of the buy local arrangement is that monopolistic competition leads to prices that exceed marginal cost. We have worked with a particularly simple monopolistically competitive market, but the fine details of the model are not important as long as prices exceed marginal cost. Some potentially profitable trades will then go unexploited. The buy local arrangement allows some such trades to be made, enhancing total surplus.

3 Buying Locally

3.1 The Model

We next set out a general model that extends the example of Section 2. We use this model to determine what kinds of buy local agreements will be profitable for the participants and to identify conditions under which buy local agreements cannot be struck.

There are M goods, each of which is produced by N firms. For many of our examples we take $M = 2$. Each firm f_{ij} produces good j and is owned by the competitive consumer a_{ij}.[4] As before, for each consumer, a_{ij}, let $\mathbf{1}_{\ell k}$

[4] While a continuum population of consumers provides a foundation for the assumption that consumers are competitive, it is not necessary. The important point is that consumers are competitive. We assume each firm is owned by a finite number of consumers to emphasize that our analysis does not require a large population of consumers.

denote the indicator equaling 1 if the consumer purchases good k from firm $f_{\ell k}$ (possibly the firm the consumer owns), and 0 otherwise. Consumer a_{ij} buys either zero or one unit of each good k, receiving utility

$$Z + \pi_{ij} + \sum\nolimits_{\ell,k} (\Lambda_k - \lambda_{\ell k} - p_{\ell k}) \mathbf{1}_{\ell k},$$

where $Z > \sum_k \Lambda_k$ is the endowment of numeraire, $\mathbf{1}_{\ell k}\mathbf{1}_{\ell' k} = 0$ if $\ell \neq \ell'$, $p_{\ell k}$ is the price at firm $f_{\ell k}$, and π_{ij} is the profit earned by a_{ij}'s firm. We will often interpret the indices i and ℓ as identifying locations, with f_{ij} and a_{ij} for a fixed value of i identifying the various firms and at location i and the consumers who own them.

For each good, each consumer takes n distance draws from n firms that produce that good, capturing the relative attractiveness of those goods. Distance draws are independent across consumers and goods, taken from a uniform distribution on the unit interval. We necessarily have $n \leq N$, and we assume $n \geq 2$, so that there is competition between firms.

If $n = N$, every agent a_{ij} takes (for every good) a distance draw from every location. If $n < N$, then the consumer takes a draw from some, but not all, locations. The firms for which consumer a_{ij} takes distance draws, for each good, are determined (possibly randomly) as part of the specification of the model. For example, consumer a_{ij} may take a distance draw from firm f_{7k}, with probability one, but from firm f_{28k} with probability zero. There might be some randomness in determining the identity of the firms from whom distance draws are taken: if $n = 3$, consumer a_{2j} may draw from firms f_{1k} and f_{3k} with probability one, and from another firm equally likely to be any one of firms $f_{4k}, \ldots, f_{Nk}$. Together, the ability to choose the magnitude of n and the specification of which consumers take distance draws from which firms gives us a great deal of flexibility, allowing us to model interesting heterogeneity with which to explore structures of buy local arrangements that might be profitable. We will be more specific about our assumptions on the distance draws when we introduce buy local arrangements.

The timing is as follows: First, firms post prices and consumers take distance draws, and then consumers (having observed prices and distance draws) purchase from their preferred firm. Consumers can purchase only from firms from whom they have taken a distance draw.

The distance draws generate a network in which consumers and firms are the nodes. We say there is a link between consumer a_{ij} and firm $f_{\ell k}$ if consumer a_{ij} takes a distance draw from firm $f_{\ell k}$. The network is random if there is randomness in the identity of the firms from whom consumers take

distance draws. If not, the network is deterministic.

Two characteristics of the network will be important. First, every consumer in the network has *deterministic* degree n, where n is the number of distance draws the consumer takes. At one extreme, we have the case in which $n = N$, so that every consumer takes a distance draw from every firm (that is, the network is *complete bipartite*: agents are divided into two groups, firms and consumers, and every consumer is connected to every firm). At the other extreme, corresponding to the case $n = 1$, is the monopolistic network, which we exclude with our assumption that $n \geq 2$.

Second, it need not be the case that every firm has the same degree, even if the network is deterministic. In the case of a random network, the firm realized degrees will obviously vary. The firms' expected degrees may also vary. We say that the network is uniform if each consumer is equally likely to take a distance draw from each firm. Notice that for each $n \geq 2$, there is a uniform network with that value of n.

3.2 Equilibrium Prices

The competitive equilibrium in the absence of a buy local arrangement is easily characterized.

Proposition 1. *There exists a unique symmetric equilibrium, and in this equilibrium, every firm prices at* $1/n$.

The proof, given in Appendix A.2, is a straightforward calculation. The key to uniqueness is that optimal prices depend on the number of distance draws each customer takes, but not on the number of customers who go to a firm. Hence, we can identify the equilibrium price once we know n, the number of distance draws each agent takes, without knowing anything about the firms from whom these draws are taken. In equilibrium, every firm will choose the same price.

3.3 Buy Local Arrangements

For simplicity, we analyze a particularly elementary form of buy local arrangement, a *simple buy local arrangement*: The set of agents in a simple buy local arrangement is a set of agents $\mathcal{A}_L := \{a_{ij} : i \in L, j = 1, \ldots, M\}$, where $L \subset \{1, \ldots, N\}$. Hence, if one consumer or firm at some location i is involved in the buy local arrangement, then everyone at the location is involved. In an abuse of notation, we denote the number of locations in set L also by L. In a simple buy local arrangement, if a consumer a_{ij} in the

arrangement receives at least one distance draw for good k from a firm $f_{\ell k}$ who is in the arrangement, then a_{ij} purchases good k within the arrangement. A consumer who receives no distance draws for good k from within the arrangement cannot buy inside, and is free to purchase outside.

A buy local arrangement is a social arrangement, and the membership of stable (or equilibrium) buy local arrangements will presumably reflect the network structure of the network draws (such as clustering). We interpret agents with a common index i as being grouped together by the network draws in such a way as to make them a natural candidate for membership in a buy local arrangement. They may occupy a particular geographic neighborhood. They may be members of a church, fraternal organization, or ethnic minority. They may simply be a group of people who have strong social ties. One characteristic making a group a "natural candidate" for a buy local arrangement is the ability of members to monitor one another.

We consider simple symmetric patterns of clustering in network draws.[5] The restrictions constrain the pattern and nature of clustering of the distance draws, and we are interested in clusters of consumers and firms that have value as simple buy local arrangements. We say the distance draw network is $\mathcal{A}_L$-*symmetric* if:

1. the probability distribution over the number of distance draws from firms within L is the same for all consumers in L and all goods; and

2. if consumer a_{ij} in L takes m good k draws from firms in L, each firm in L is drawn with probability m/L.[6]

The complete bipartite network (in which $n = N$) is $\mathcal{A}_L$-symmetric for all $L \subset \{1, \ldots, N\}$, as is any uniform network. Many other distance draw networks will be $\mathcal{A}_L$-symmetric for some choices of L. For example, each agent may take L draws from inside L and $n - L$ outside draws (perhaps from randomly determined firms). We would interpret this as a case in which consumers can always purchase from any firm within their community, as well as sometimes encountering opportunities to purchase outside.

When the distance draw network is $\mathcal{A}_L$-symmetric, the costs and benefits from the simple buy local arrangement for $\mathcal{A}_L$ are uniformly distributed among $\mathcal{A}_L$, allowing us to rely on arguments that focus on a representative member of the arrangement. Notice that $\mathcal{A}_L$-symmetry allows the distribution of consumer distance draws to treat firms inside and outside $\mathcal{A}_L$

[5] We discuss asymmetries in Section 3.6.

[6] Equivalently, any m firms producing good k within L are equally likely to be drawn (from).

quite differently, and we shall see that this difference is important to the profitability of buy-local arrangements.

We assume that in the presence of a buy local arrangement, firms continue to set prices to maximize profits. This assumption is innocuous. This pricing rule allows the firms inside the buy local arrangement to optimally extract surplus from outsiders, with no adverse effects on insiders since, given our symmetry assumptions, the prices paid by inside consumers to inside firms are pure transfers that wash out in expectation, and hence have no economic impact.[7] In some buy-local arrangements, it may well be most convenient for insiders to pay the market price, so that (for example) some customers of a butcher shop do not wonder why they are paying while others are not. The impact of the agreement would be unchanged if insiders paid a different (common) price, perhaps (for example) because a pair of people in a reciprocal arrangement find it more convenient not to collect payments.

There is always a profitable simple buy local arrangement.

Proposition 2.

(2.1) The equilibrium prices in the presence of a simple buy local arrangement equal $1/n$*, the equilibrium prices without such an arrangement.*

(2.2) Suppose the network is $\mathcal{A}_L$*-symmetric for a set* $\mathcal{A}_L$ *satisfying* $L = N - 1$*. If there is positive probability that consumers in* $\mathcal{A}_L$ *draw from firm outside* $\mathcal{A}_L$*, then the simple buy local arrangement for* $\mathcal{A}_L$ *is strictly profitable for its members.*

The proof is a straightforward generalization of the calculations behind the introductory example and is given in Appendix A.3. However, the simple buy local arrangement we use in the proof to demonstrate existence of a profitable arrangement is crude, since it uses little of the structural features of the network relating consumers to firms. In particular, the arrangement consists of all but one of the firms.

Proposition 2 is silent about the optimal buy local arrangement. In general, the optimal buy local arrangement need not be simple. In expectation, the consumer losses in a simple buy local arrangement are smaller than the gains enjoyed by firms. However, there will be instances in which a consumer is forced to purchase inside the arrangement even though the reduction in distance draw they could achieve by purchasing outside exceeds the price.

[7] There might yet be some impact from altering prices if these affect the purchase decisions of inside consumers, but the buy local arrangement is successful precisely because inside consumers sometimes ignore their price signals, and the most effective arrangement will set the price so as to maximize the payoff from selling to outsiders, while making separate arrangements governing the purchases of insiders.

The buy local arrangement would be even more valuable if the arrangement called for consumers to purchase inside only when the price exceeds the resulting difference in distance draws, so that every diverted transaction enhances the welfare of those in the arrangement. However, the monitoring required to sustain such an arrangement would likely be difficult.[8] We restrict attention to simple arrangements, viewing this as reflecting limits on the feasibility for such arrangements.

3.4 Uniform Networks

The structure of the network induced by the consumers' distance draws plays a central role in the feasibility and optimality of buy local arrangements. We first consider uniform networks—networks in which every firm is equally likely to be the target of a distance draw for each consumer. There are many uniform networks, differing in the number of distance draws each consumer takes. Notice that our symmetry assumptions on consumers' distance draws are necessarily satisfied in this case.

We next show that uniform networks require buy local arrangements of implausibly large sizes in order to be profitable, and hence that plausible buy local arrangements are closely linked to nontrivial network structures.

We begin with the case of $n = 2$, so that for each good each consumer takes two distance draws, and with each pair of firms in the economy equally likely to be the targets of those draws. In the absence of a buy local arrangement, the equilibrium price is, from Proposition 1,

$$p = \frac{1}{2}$$

and the expected distance produced by a pair of distance draws is the expected value of the first-order statistic of two uniform draws, which is $\frac{1}{3}$.

Now consider a simple buy local arrangement consisting of LM consumers, which (as usual) we can interpret as consisting of the M consumers residing at each of L locations. From Proposition 2, the price remains $1/2$. The outcome under the buy local arrangement only differs from the monopolistic equilibrium for an agent when there is a good for which the agent takes one inside draw, one outside draw, and the inside distance draw is larger than the outside distance draw. Denote this event by G. Conditional on this event, the expected value of the outside draw is the expected value of the first-order statistic of a uniform distribution, $1/3$, while the expected value of the inside draw is the expected value of the second-order statistic,

[8] We return to the issue of enforcement in Section 4.1.

2/3. Hence, the net gain of the arrangement, per agent and per good, is given by

$$\left[\frac{1}{2}-\frac{1}{3}\right]\Pr(G)=\frac{1}{6}\,\frac{\frac{1}{2}\binom{L}{1}\binom{N-L}{1}}{\binom{N}{2}}=\frac{1}{6}\,\frac{L(N-L)}{N(N-1)}.$$

This expression is positive, for all $L<N$. The costs and benefits of any such transaction will typically accrue to different people, but our symmetry assumptions ensure that the new benefits are uniformly distributed among the members of the arrangement, and hence that the arrangement is profitable for each of its members, for any $L<N$. The per capita profitability of the arrangement is maximized by choosing the size L of the buy local arrangement to maximize $\Pr(G)$, which is done by setting L equal equal to one of the integers closest to $N/2$ (which may be $N/2$). Hence all simple buy local arrangements are profitable, while the optimal such arrangement includes half of the agents in the economy.

Now consider the other extreme of the complete bipartite network, that is, $n=N$, so that for every good every consumer takes a distance draw from every firm. ¿From Proposition 1, the equilibrium price is $1/N$. The gain per agent and per good of a buy local arrangement of size L is given by

$$\frac{N-L}{N}\frac{1}{N},$$

since this gain comes from the prospect that a member of the buy local arrangement may bring a purchase at price $1/N$ inside the arrangement instead of going outside, and each such consumer formerly purchased outside with probability $(N-L)/N$. The cost per agent and per good is

$$\left[\frac{1}{L+1}-\frac{1}{N+1}\right],$$

since the consumer expects a minimum distance of $1/(N+1)$ from being able to purchase anywhere in the market, and only expects a minimum from buying inside the arrangement of $1/(L+1)$. The buy local arrangement with K agents thus has a per capita and per good gain of

$$\frac{N-L}{N^2}-\left[\frac{1}{L+1}-\frac{1}{N+1}\right]. \tag{2}$$

Once again our symmetry assumptions ensure that the costs and benefits of the buy local agreement are uniformly distributed among the participants,

and hence that if (2) is positive, then every agent in the buy local agreement gains from the agreement.

The expression in (2) is concave in L, equals zero at $L = N$, and is negative at $L = 0$. Simple buy local arrangements will then be profitable for all values of L between some minimum size $\underline{L}$ and $N - 1$. Setting (2) equal to zero and rearranging yields

$$(N - L)[(L + 1)(N + 1) - N^2] = 0.$$

The minimum profitable buy local size $\underline{L}$ is the smallest integer larger than $N^2/(N - 1) - 1$, giving $\underline{L} = N - 1$. A simple buy local arrangement in a complete bipartite network is only profitable if it includes all but the consumers at one location.

What explains the difference between these two results? In the complete network there are many substitutes for each good. As a result, the equilibrium price is low ($1/N$), while a small buy local arrangement has a large likelihood that a group member's best outside consumer draw is significantly lower than the best inside draw. The benefits of small arrangements (many sales transferred from outside to inside) are thus relatively small compared to the costs (foregone consumer draws), and to be profitable, groups of participants must be large. In contrast, when $n = 2$, there are few substitutes, the equilibrium price is high ($1/2$), and there is a little likelihood that a group member's outside consumer draw is significantly lower than the inside draw. In this case, redirecting sales inside is always profitable, and any size arrangement is profitable.

How large must uniform networks be in order to be profitable, when they are less extreme than the case in which each agent takes 2 draws or the case of the complete bipartite network? The large buy local arrangements that are required for profitability of the complete bipartite network are more representative than the smaller profitable buy local arrangements of $n = 2$. For example, for any $n \geq 3$, in order to be profitable, a simple buy local arrangement must include at least one third of the agents in the economy:

Proposition 3. *Suppose $n \geq 3$. A simple buy local arrangement of size L is profitable in a uniform network only if*

$$L - 1 > \frac{n^2 - 3n + 1}{n^2 - 2n}(N - 2). \tag{3}$$

We prove this result in Appendix A.4 as a corollary of Proposition 4.

As the number n of distance draws taken by an agent grows, the fraction in (3) approaches unity, implying that a profitable buy local arrangement

will include virtually all of the agents in the economy. We regard such arrangements as implausible, noting that actual buy local arrangements, reflecting their name, typically do not include almost everyone in the world.

3.5 Structured Networks

The counterintuitive prospect of buy local arrangements comprising almost the entire economy leads us to investigate networks that are not uniform. In particular, we believe that buy local networks are likely to involve groups of people who are relatively isolated, in the sense that their distance draws are relatively likely to come from inside the group.

Rather than impose a specific structure on the buy local arrangement and the network, we instead ask for an arbitrary set of agents $\mathcal{A}_L$ and $\mathcal{A}_L$-symmetric network, what is required for each member of $\mathcal{A}_L$ to find the simple buy local arrangement for $\mathcal{A}_L$ beneficial.

A buy local arrangement has an effect only if a purchase that would ordinarily be made outside the arrangement is diverted to an inside producer. The profitability of the arrangement hinges on comparing the gain from such a diversion, namely the price paid to the firm, to the cost, in the form of a less desired good for the consumer. To get an idea of the latter, we note that such a diversion occurs only if the consumer's lowest distance draw comes from outside the arrangement. The diversion will be least costly when the consumer's second-lowest distance draw comes from inside the arrangement. The following proposition shows that the buy local arrangement will be profitable only if diverted purchases are sufficiently likely to fall into this least-cost category.

Proposition 4. *Fix a set of agents $\mathcal{A}_L$, an $\mathcal{A}_L$-symmetric network, a consumer a_{ij}, and a good. Let E_1 denote the event that agent a_{ij}'s lowest distance draw for the good is from outside $\mathcal{A}_L$ and there exists at least one draw for the good from within $\mathcal{A}_L$. Let $E_2 \subset E_1$ denote the subevent of E_1 where additionally agent a_{ij}'s second lowest draw is from inside $\mathcal{A}_L$. Then, the buy local arrangement for $\mathcal{A}_L$ is profitable for agent a_{ij} only if*

$$\Pr(E_2 \mid E_1) > \frac{n-1}{n}. \tag{4}$$

Proof. The buy local arrangement has an effect only if there is some agent a_{ij} who draws his minimum distance draw for some good from outside the buy local arrangement, and takes at least one draw from inside, i.e., only on E_1. Our symmetry assumptions ensure that the buy local arrangement

is beneficial for (all of) its members if and only if the net benefit generated by such an event is positive. An upper bound on the net benefit is

$$\frac{1}{n} - \left[\frac{2}{n+1}\Pr(E_2 \mid \ E_1) + \frac{3}{n+1}(1 - \Pr(E_2 \mid \ E_1)) - \frac{1}{n+1}\right], \qquad (5)$$

where $1/n$ is the price of the trade that is diverted inside, $1/(n+1)$ (the expected value of the first-order statistic) is the expected value of the minimum distance draw, which by assumption comes from outside $\mathcal{A}_L$, $2/(n+1)$ (the expected value of the second-order statistic) is the expected value of the best inside distance draw if the second largest draw comes from inside $\mathcal{A}_L$, $3/(n+1)$ (the expected value of the third-order statistic) is a lower bound on the expected value of the best inside draw if the second-smallest draw does not come from inside, and $\Pr(E_2 \mid E_1)$ is the probability that the second-smallest draw comes from inside $\mathcal{A}_L$ (given that the smallest draw is outside and there is at least one inside draw). This is an upper bound because $3/(n+1)$ in general underestimates the distance draw taken from inside $\mathcal{A}_L$. Notice that the expected value of the buy local arrangement is profitable on the event E_2 that the second lowest draw come from inside $\mathcal{A}_L$, but not otherwise.

The result now follows from noting that the upper bound on profits (5) is nonnegative if and only if $\Pr(E_2 \mid E_1) > (n-1)/n$. ■

The implication of this result is that buy local arrangements will be profitable only if, whenever a consumer's first choice is to purchase outside, it is sufficiently likely that her second choice comes from inside the arrangement. This is in turn likely if the consumer takes many distance draws from within the arrangement. Consumers who take most of their draws from outside will not find buy local arrangements profitable. The following example illustrates.

Example. As a simple example of a structured network, suppose there is a group $\mathcal{A}_L$ in which each member receives one distance draw from within the group and two other distance draws uniformly drawn from all firms. Consumers outside $\mathcal{A}_L$ receive three distance draws uniformly drawn from all firms. The equilibrium price, with or without a buy local arrangement, is

$$p = \frac{1}{3}$$

and the expected distance is $1/4$.

Given the symmetry in this group, the condition in Proposition 4 is necessary for a buy local arrangement for $\mathcal{A}_L$ to be profitable. Since there are only three draws, the condition is also sufficient. It remains to evaluate the inequality $\Pr(E_2 \mid E_1) > 2/3$.

Let F_b be the event that there are b inside draws and $3-b$ outside draws, for $b = 1, 2$. Let $G_b \subset F_b$ be the event that there are b inside draws, $3-b$ outside draws, and that (the minimum of) the inside draw is greater than (the minimum of) the outside draw, for $b = 1, 2$. Note that $E_1 = G_1 \cup G_2$, $G_2 \subset E_2 \subset G_1 \cup G_2$, and $\Pr(E_2 \mid G_1) = 1/2$. [To verify the last assertion, let λ_i be the draw from the consumer's firm, λ_o be the draw from the outside firm that is the lowest draw overall, and λ the remaining draw that may be inside or outside. On E_2, either λ is drawn from an inside firm (corresponding to G_2) or λ is drawn from an outside firm and $\lambda_i < \lambda$ (which occurs with probability $1/2$ on G_1).]

Moreover, $\Pr(G_1) = \Pr(G_1 \mid F_1)\Pr(F_1) = (2/3)\Pr(F_1)$ and $\Pr(G_2) = \Pr(G_2 \mid F_2)\Pr(F_2) = (1/3)\Pr(F_2)$.

Substituting,

$$\frac{2}{3} < \Pr(E_2 \mid E_1) = \frac{\Pr(E_2)}{\Pr(E_1)} = \frac{\Pr(E_2 \mid G_1)\Pr(G_1) + \Pr(E_2 \mid G_2)\Pr(G_2)}{\Pr(G_1) + \Pr(G_2)} = \frac{\Pr(F_1) + \Pr(F_2)}{2\Pr(F_1) + \Pr(F_2)}$$

is equivalent to $\Pr(F_2) > \Pr(F_1)$.

Thus, we have the condition that a simple buy local arrangement in this structured network is profitable if and only if the probability of sampling more inside firms is *higher* than the probability of sampling more outside firms. A profitable simple buy local arrangement requires a group of agents who are sufficiently likely to take distance draws from one another. ★

The case of deterministically structured networks provides another illustration.

Proposition 5. *Suppose there is a group of L agents, each of whom takes n distance draws, with $1 \leq m \leq \min\{n, L\}$ draws from inside the group and $n-m$ from outside the group. A simple buy local arrangement by this group is profitable if and only if*

$$m = n - 1. \tag{6}$$

Proof. The equilibrium price is $1/n$. Hence, the per capita and per good gain from the arrangement is $(n-m)/n^2$, since $(n-m)/n$ is the probability

that an insider would have purchased outside, and has her purchase pushed inside, bringing a price of $1/n$ inside the arrangement. The per capita and per good cost of the arrangement is

$$\frac{1}{m+1} - \frac{1}{n+1},$$

since the expected minimum distance draw is now $1/(m+1)$ rather than $1/(n+1)$. The net gain of the arrangement is

$$\frac{n-m}{n}\frac{1}{n} - \frac{1}{m+1} - \frac{1}{n+1} = \frac{(n-m)}{n^2} - \frac{(n-m)}{(m+1)(n+1)}.$$

This expression is positive (which, given our symmetry assumptions, suffices for each member to gain from the arrangement) if and only if

$$(m+1)(n+1) > n^2,$$

which requires $m = n-1$. ■

Note that the result of Proposition 5 is quite different from the observation that buy local arrangements for complete bipartite network are profitable only if $L = N-1$ (from Section 3.4). In Section 3.4, the network is complete (and so there is no sense of distinct communities within the network), while in Proposition 5, we are examining a community of agents, and in order for the arrangement to be profitable, the community must be close-knit, in that all but one of the members' distance draws must come from within the community.

Who then will form buy local arrangements? Communities that are already tightly knit, in the sense that they already do most of their business with one another. This includes isolated communities, such as Ithaca, whose geography ensures that they do most of their business with one another, and close communities, such as south Philadelphia, whose customs have the same effect.

3.6 Product Asymmetries

We have assumed that buy local arrangements included sets of agents of the form $\{a_{ij} : i \in L, j = 1, \ldots, M\}$, where $L \subset \{1, \ldots, N\}$. Our symmetry assumptions on distance draws ensure that this is without loss of generality. If it is profitable to include one good in the arrangement, it is profitable to include all. Equivalently, if one consumer at location i is involved, then

all consumers at this location will benefit from being included. This had the advantage of allowing us to conduct our analysis on a per agent and per good basis, isolating the forces behind the buy local arrangement with a minimum of clutter.

It requires only more tedious calculations to drop the symmetry assumptions and consider buy local arrangements for arbitrary subsets of $\{1,\ldots,N\}\times\{1,\ldots,M\}$. The most obvious extension is to allow the firms from whom distance draws are taken to differ across goods. Buy local arrangements would then in general include some goods and exclude others, in some cases including only one good j. The inherent separability across commodities implies that our analysis also covers the case of multiple disjoint buy local arrangements, perhaps involving the same agents but different goods.

We consider here a different source of asymmetry across products, involving the distributions from which the distance draws at a particular firm are taken, and how this can present a barrier to buy local arrangements. If one consumer is almost indifferent over the source of the good purchased but another is not, an arrangement involving the two may not be possible. To see this, return to our introductory example, with two modifications. First, suppose that consumer a_{i1} consumes only good 2, and consumer a_{i2} consumes only good 1. Second, suppose that the distance draws for goods 1 and 2, instead of being uniformly drawn on the unit interval, are uniformly drawn on $[0,\bar{\lambda}_1]$ and $[0,\bar{\lambda}_2]$. Smaller intervals will characterize more homogeneous goods and hence more competitive markets.

Consider the market for good j. Calculations analogous to those done for the symmetric model given an equilibrium price

$$p_1 = p_2 = \frac{\bar{\lambda}_j}{2}.$$

As expected, the price collapses to zero as z_j approaches zero and hence the output of the two firms become perfect substitutes.

We begin by calculating payoffs in the market in the absence of a buy local arrangement. Let $\Lambda_1 = \Lambda_2 \equiv \Lambda$. For owners of firms producing good 1, profits are $\bar{\lambda}_1/2$. The consumer payoff is (recall the owner consumes good 2, and that $\Lambda_2 - \bar{\lambda}_2/2 - \lambda_2$ is the utility garnered from purchasing good 2 at the going price, $\bar{\lambda}_2/2$, with distance draw λ_2, while $2(\bar{\lambda}_2 - \lambda_2)/\bar{\lambda}_2^2$ is the density of the minimum of two draws from a uniform distribution on $[0,\bar{\lambda}_2]$)

$$\int_0^{\bar{\lambda}_2}\left(\Lambda - \frac{\bar{\lambda}_2}{2} - \lambda_2\right)2\frac{(\bar{\lambda}_2-\lambda_2)}{\bar{\lambda}_2^2}d\lambda_2 = \Lambda - \frac{5}{6}\bar{\lambda}_2.$$

This matches our previous result when $\bar{\lambda}_1 = \bar{\lambda}_2 = 1$. We get analogous results for owners of firms producing good 2. Hence, under the market, the total (producer plus consumer) payoffs of agents earning firms producing goods 1 and 2 are, respectively

$$\Lambda - \frac{5}{6}\bar{\lambda}_2 + \frac{\bar{\lambda}_1}{2} \quad \text{and} \quad \Lambda - \frac{5}{6}\bar{\lambda}_1 + \frac{\bar{\lambda}_2}{2}.$$

Now consider a buy local arrangement between agents a_{i1} and a_{i2}. A firm producing good 1 earns $(\bar{\lambda}_1/2)(3/2)$ while the owner's utility from consumption is now $\Lambda - \bar{\lambda}_2/2 - \bar{\lambda}_2/2 = \Lambda - \bar{\lambda}_2$, where the first $\bar{\lambda}_2/2$ is the price paid for the good and the second is the expected distance from a single draw from a uniform distribution on $[0, \bar{\lambda}_2]$. The total payoffs to the agents producing goods 1 and 2, under the buy local arrangement, are now

$$\Lambda - \bar{\lambda}_2 + \frac{3}{4}\bar{\lambda}_1 \quad \text{and} \quad \Lambda - \bar{\lambda}_1 + \frac{3}{4}\bar{\lambda}_2.$$

Comparing these results we find that, no matter what the values of $\bar{\lambda}_1$ and $\bar{\lambda}_2$, the *total* surplus to the two agents in the buy local arrangement is higher than the sum of the surpluses they earn without the arrangement. However, this surplus may be asymmetrically distributed, to the point that one agent may be unwilling to participate in the arrangement. The conditions for both agents to benefit are

$$\frac{3}{4}\bar{\lambda}_1 - \bar{\lambda}_2 > \frac{\bar{\lambda}_1}{2} - \frac{5}{6}\bar{\lambda}_2 \quad \text{and} \quad \frac{3}{4}\bar{\lambda}_2 - \bar{\lambda}_1 > \frac{\bar{\lambda}_2}{2} - \frac{5}{6}\bar{\lambda}_1,$$

or

$$3\bar{\lambda}_1 > 2\bar{\lambda}_2 \quad \text{and} \quad 3\bar{\lambda}_2 > 2\bar{\lambda}_1,$$

and hence an arrangement is not possible when there is too much asymmetry across agents.

4 Discussion

4.1 Enforcement

The essence of a buy local arrangement is that consumers sometimes buy from within the arrangement, even though they would prefer to purchase outside. There must then be some enforcement mechanism to prevent an agent in a buy local arrangement from taking advantage of her partners by enjoying their purchases while never foregoing an outside purchase. We think in terms of three prototype enforcement mechanisms, corresponding to three types of buy local arrangements mentioned in Section 1: local currency (which we discuss in Section 4.2), monitoring, and reciprocal relationships.

4.1.1 Effective Monitoring

A buy local arrangement need not involve a formal institution like local currencies if the participants can monitor one another's activities and respond to failures to buy within the arrangement. For example, Alice may find that if she neglects opportunities to buy from others in the arrangement, then they do not purchase from her. It is a familiar idea that variations in continuation play can prompt people to resist myopic incentives, provided that their current actions can be monitored sufficiently precisely. Her compatriots in the buy local arrangement must be sufficiently likely to observe that Alice neglected an opportunity to buy inside the agreement. This reinforces our belief, albeit for different reasons than those lying behind Proposition 4, that buy local arrangements are most likely to be successful among closely-knit groups of people. Within such groups, an active gossip network may amplify the power of monitoring. Ellickson's (1991) book highlights the important role of gossip in sustaining cooperation among the California ranchers he studies.

4.1.2 Reciprocal Relationships

Even if agents can never observe the buyer opportunities of other agents, buy local arrangements may be sustainable as reciprocal relationships. Suppose a pair of agents consider a buy local arrangement, knowing that both would be better off if each purchased from the other whenever taking a distance draw from the other, but that such distance draws do not always occur and distance draws cannot be observed. Each agent is then tempted to cheat on the arrangement, buying outside whenever she prefers, knowing that this will be interpreted as the absence of an inside distance draw.

However, there is an efficiency-increasing arrangement that is incentive compatible. Suppose that the agents agree to use the following rule of whether to buy or not buy:

- If in the last transaction in which one agent made a purchase and one did not, it was agent i who made the purchase, then agent i will buy from agent j whenever her distance draw from j is lower than all outside draws, and agent j will buy from i the next time j takes a distance draw from i that does not exceed j's minimum draw by a parameter Δ.

Whenever agent i buys from j but j does not buy from i, then i is subsequently free to purchase from her most preferred seller, until j next

purchases from i, at which point the roles are reversed. Agent i's continuation payoff is highest immediately after i has purchased from j, and i will thus be willing to do so even if j is not the lowest distance draw for i, as long as the difference in distance draws is not too large. We thus find a value of Δ for which this behavior constitutes an equilibrium.

The enforcement mechanism in the preceding subsection is reminiscent of the favor-trading arrangements studied by Abdulkadiroğlu and Bagwell (2013).[9] A key difference is that in their model it is clear when a favor has been done. In our case, only the purchase decision by agent i is observable, but j cannot observe whether this purchase is myopically optimal for i or whether i has conferred a "favor" on j by purchasing from j despite a lower distance draw elsewhere.

4.2 Local Currencies

There are estimated to be more than 4,000 local currencies throughout the world (Lietaer and Dunne, 2013), with one of the most visible being Ithaca Hours, circulating in Ithaca, New York. In 1998 there were about 1,300 users of Ithaca Hours who conduced about $2 million worth of trade in Hours (cf. Good, 1998).[10]

A local currency such as Ithaca Hours is accepted at a fixed exchange rate by participating local businesses, but not by other businesses. Consequently, the currency is dominated (at least weakly) by US currency, which can be used in any transaction. Therefore, holders of the currency prefer to spend the currency rather than US currency when possible. If the preference is strict, a consumer will prefer to patronize a participating business even if the price-quality package is a bit less than that offered by a nonparticipating business. Given this preference, firms benefit from participation because of the diversion of purchases from nonparticipating businesses, as in the case of a buy local arrangement.

As in the equilibria of the model analyzed in Section 3, the benefits to a seller accepting a local currency depend on two things: how many purchases are diverted from outside the participating group to inside, and the cost to the seller due to his own diversion of purchases outside the group to (less

[9] See Hauser and Hopenhayn (2008) for a related model, and Ellickson (1991) for a very nice discussion of informal favor trading.

[10] People can purchase Ithaca hours from the issuers (who use the proceeds to promote Ithaca hours via advertising and discount coupons) with U.S. currency at an exchange rate of $10 for one Hour. Businesses and individuals who agree to accept Ithaca Hours are paid two Hours for joining the arrangement.

desirable) purchases inside the group. If the amount of local currency is small, it will be a small percentage of a seller's revenue. A person who has a small amount of local currency may find it relatively easy to use the local currency for purchases within the group only when they are his first choice. In this case, no purchases are diverted from outside the group to inside.

When the amount of local currency is larger, a person will find that his stock of local currency grows unless he uses it for inside purchases that he would otherwise not make. The increase in the amount of local currency increases the wedge between the person's value of inside currency and US currency, and consequently of the proportion of trades that are made inside. When the amount of local currency is sufficiently large, all purchases will be inside when possible, endogenously mimicking the equilibrium behavior in the model above.

Local currencies will be relatively ineffective when the proportion of sellers who accept the local currency is too large. In that case, most draws are likely to come from participating sellers, and consumers will have little reason to choose an inside seller unless he is the unconstrained most attractive.

An attractive aspect of a buy local arrangement induced by a local currency is that agents will divert a purchase from an outside seller to an inside seller only when the difference in the values of the two to the buyer is not too large. The seller trades off the benefit of using some of the (dominated) local currency with the cost of purchasing a lesser valued good. This reduces the possible inefficiency that arises when all purchases must be inside (as in the simple buy local arrangement of Section 3) even when there is a loss to the trading pair.

Many local currencies have another interesting feature: local currencies may build into their currency demurrage, or the cost of holding the currency. Chiemgauer, a local currency in Bavaria linked to the euro, circulates as bills in denominations from 1 to 50 euros that must be validated every three months at a cost of two percent of the value of the bill (Tóth, 2011). This of course ensures that they are dominated by the euro, and gives holders an incentive not only to use them when possible, but to use them quickly. A consumer holding local currency that depreciates will have a higher threshold for purchasing from a producer who accepts the local currency than the threshold for purchasing from a nonparticipating producer. This reinforces the incentive for consumers to divert purchases from outside producers to insider producers, enhancing the benefit to the latter of accepting the local currency. Also, in a dynamic world, there can be an efficiency gain in "speeding up" consumption essentially for similar reasons as in our model

above. When the marginal gain to the seller is positive, there can be an aggregate efficiency gain when consumers purchase more frequently.

4.3 Related Ideas

4.3.1 Barter

The essence of a buy local arrangement is that participants can tie their transactions—agent 1 buys more frequently from agent 2 because 2 buys more frequently from 1. Barter shares the idea of tying transactions since it involves physically exchanging our products.

One possibility is that barter organizations are simply convenient ways of organizing buy local arrangements.[11] Alternatively, barter may relax liquidity constraints. Prendergast and Stole (2001) examine a model in which firms can offer optimal screening mechanisms rather than simply posting prices, so that the motivation for buying locally examined in this paper does not arise, and then show that barter can be useful in the presence of liquidity constraints.[12]

4.3.2 Strategic Trade Policy

There is a large literature addressing the possibility that countries can gain by setting tariffs that make it more attractive for domestic consumers to purchase from domestic rather than foreign producers. However, the forces captured by the standard such model differ from those studied here in that gains arise because the tariff effectively allows domestic agents to wield market power, decreasing the demand and hence the price of imported goods. (Johnson (1953–1954) is an early reference, and Syropoulos (2002) a more recent one.)

More recent attention has been devoted to strategic trade arrangements, under which participating countries agree not to employ tariffs when transacting with each other. One might view these as attempts to divert pur-

[11] See, for example, "The Cash-Strapped Turn to Barter," by Michey Meece, *New York Times*, November 12, 2008.

[12] Ellingsen (2000) similarly explores a link between liquidity constraints and barter. He shows that barter can serve as a screening device, revealing information to sellers about a buyer's financial position if there is both imperfect competition and liquidity constraints. Ellingsen hints that he could imagine barter in a world of imperfect competition devoid of liquidity constraints, but there sees no reason why we couldn't simply obviate the need for barter by appropriate price discrimination, which we assume not possible.

There is a literature beginning with Caves (1974) that also examines barter as a possible way to price discriminate.

chases from countries outside the strategic trade arrangement to those inside, much like our buy local arrangement. However, strategic trade arrangements are often studied in perfectly competitive models, precluding the type of gains that appear in our model and ensuring that the benefits of the arrangement must come through price effects. The obvious explanation for such arrangements is that it allows countries to avoid inefficient "prisoners' dilemma" outcomes of noncooperative attempts to improve the terms of trade by raising tariffs.[13]

"New trade" theory examines models of imperfectly competitive firms, often deliberately constructed so as to exclude the terms-of-trade effect that are the focus of the traditional literature. Consumers have a taste for variety that calls for them to consume a basket of all firms' goods. A strategic trade arrangement makes domestic goods cheaper and foreign goods more expensive, causing consumers to substitute into domestic goods, in the process reducing the variety of their consumption. This gives rise to a price index effect, highlighted (for example) by Venables (1987). However, as Ossa (2011) argues, firms will also relocate from the foreign to the domestic country. Since they are imperfectly competitive and earn positive profits, this relocation brings a welfare gain. The key difference here is that our buy local arrangements require no relocations to bring welfare gains.

A Proofs

A.1 Calculations, Section 2.

The probability that consumer a_{ij} purchases good k from firm $f_{\ell k}$ is, conditional on the draw $\lambda_{\ell k}$,

$$\Pr(\lambda_{\ell k} + p_{\ell k} < \lambda_{\ell' k} + p_{\ell' k} | \lambda_{\ell k}) = \begin{cases} 1 & \text{if } \lambda_{\ell k} + p_{\ell k} - p_{\ell' k} < 0 \\ 1 - (\lambda_{\ell k} + p_{\ell k} - p_{\ell' k}) & \text{if } \lambda_{\ell k} + p_{\ell k} - p_{\ell' k} \in (0,1) \\ 0 & \text{if } \lambda_{\ell k} + p_{\ell k} - p_{\ell' k} > 1. \end{cases}$$

Lemma 1. *Suppose* $|p_{\ell k} - p_{\ell' k}| \leq 1$. *Firm* $f_{\ell k}$*'s expected profit is*

$$\pi_{\ell k}(p_{\ell k}, p_{\ell' k}) = \begin{cases} 2p_{\ell k}[1 - p_{\ell k} + p_{\ell' k}]^2 & \text{if } p_{\ell k} \geq p_{\ell' k} \\ 2p_{\ell k}[2 - (1 - p_{\ell' k} + p_{\ell k})^2] & \text{if } p_{\ell k} < p_{\ell' k}. \end{cases}$$

[13] Bagwell and Staiger (2002) suggest this as the traditional economic and political economy approach to trade.

Proof. The expected profit is 4 times the expected profit per consumer, which is $p_{\ell k}$ times the unconditional probability of a consumer purchase.

Suppose $p_{\ell k} \geq p_{\ell' k}$. The unconditional probability that a consumer purchases from $f_{\ell k}$ is

$$\begin{aligned}\int_0^{1-p_{\ell k}+p_{\ell' k}} & 1-(\lambda+p_{\ell k}-p_{\ell' k})\ d\lambda \\ &= \left\{[1-(p_{\ell k}-p_{\ell' k})]\lambda-\frac{1}{2}\lambda^2\right\}\Big|_0^{1-p_{\ell k}+p_{\ell' k}} \\ &= \frac{1}{2}(1-p_{\ell k}+p_{\ell' k})^2.\end{aligned}$$

Suppose $p_{\ell k} < p_{\ell' k}$. The expected probability that a consumer purchases from $f_{\ell k}$ is

$$\begin{aligned}\int_0^{p_{\ell' k}-p_{\ell k}} & 1d\lambda+\int_{p_{\ell' k}-p_{\ell k}}^1 1-(\lambda+p_{\ell k}-p_{\ell' k})\ d\lambda \\ &= (p_{\ell' k}-p_{\ell k})+\left\{[1-(p_{\ell k}-p_{\ell' k})]\lambda-\frac{1}{2}\lambda^2\right\}\Big|_{p_{\ell' k}-p_{\ell k}}^1 \\ &= (p_{\ell' k}-p_{\ell k})-\frac{1}{2}[(p_{\ell' k}-p_{\ell k})^2-1] \\ &= \frac{1}{2}\left[2-(1-p_{\ell' k}+p_{\ell k})^2\right].\end{aligned}$$

■

It is immediate that in any monopolistic equilibrium, we have $|p_{\ell k} - p_{\ell' k}| < 1$ (otherwise, a firm is making zero sales and has a profitable deviation).

We now argue every monopolistic equilibrium is symmetric. Suppose not, and that $(p_{\ell k}, p_{\ell' k})$ is a monopolistic equilibrium with $p_{\ell k} < p_{\ell' k}$. Since prices are interior, each firm's first order condition must be satisfied. For firm $f_{\ell k}$, we have

$$\begin{aligned}0 &= [2-(1-p_{\ell' k}+p_{\ell k})^2]+p_{\ell k}[-2(1-p_{\ell' k}+p_{\ell k})] \\ &= 2-(1-p_{\ell' k}+p_{\ell k})(1-p_{\ell' k}+3p_{\ell k}).\end{aligned}$$

Since $1-p_{\ell' k}+p_{\ell k} \in (0,1)$, this implies

$$2 < 1-p_{\ell' k}+3p_{\ell k} \iff 1 < 3p_{\ell k}-p_{\ell' k}$$

and so $p_{\ell' k} > p_{\ell k} > 1/2$.

For firm $f_{\ell' k}$, we have

$$\begin{aligned} 0 &= [1 - p_{\ell' k} + p_{\ell k}]^2 - 2p_{\ell' k}[1 - p_{\ell' k} + p_{\ell k}] \\ &= (1 - p_{\ell' k} + p_{\ell k})(1 - 3p_{\ell' k} + p_{\ell k}). \end{aligned}$$

Since $1 - p_{\ell' k} + p_{\ell k} \neq 0$, we have

$$1 = 3p_{\ell' k} - p_{\ell k},$$

and so $p_{\ell' k} < 1/2$, a contradiction.

Given the piecewise description of the firm's payoff function, it is not obvious that first order conditions hold with equality in a symmetric equilibrium (we deal with this explicitly in the proof of Proposition 1 in Appendix A.2). However, it turns out that they do, which immediately yields pricing at 1/2.

A.2 Proof of Proposition 1

Let p^* be a candidate symmetric equilibrium price. Consider a particular firm, identified as firm 1, who sets price p_1. A consumer will purchase from this firm only if the sum of the consumer's distance draw and price is less than the corresponding term for each of the other $n-1$ firms from which the consumer draws, i.e., if and only if $\lambda_1 + p_1 - p^* < \min\{\lambda_2, \ldots, \lambda_n\}$, where $\lambda_2, \ldots, \lambda_n$ denote the other draws. The probability of this event, conditional on the draw λ_1, is

$$\begin{aligned} &\Pr(\lambda_1 + p_1 - p^* < \min\{\lambda_2, \ldots, \lambda_n\} | \lambda_1) \\ &\qquad = \begin{cases} 1 & \text{if } \lambda_1 + p_1 - p^* < 0 \\ (1 - (\lambda_1 + p_1 - p^*))^{n-1} & \text{if } \lambda_1 + p_1 - p^* \in (0, 1) \\ 0 & \text{if } \lambda_1 + p_1 - p^* > 1. \end{cases} \end{aligned}$$

Lemma 2. *Suppose $|p_1 - p^*| \leq 1$. The firm's expected profit (per consumer) is*

$$\pi(p_1, p^*) = \begin{cases} \frac{p_1}{n}[1 - p_1 + p^*]^n & \text{if } p_1 \geq p^* \\ p_1[p^* - p_1 + \frac{1}{n}(1 - (p^* - p_1)^n)] & \text{if } p_1 < p^*. \end{cases}$$

Proof. The expected profit per consumer is simply price times the unconditional probability of a consumer purchase.

Suppose $p_1 \geq p^*$. The unconditional probability is

$$\int_0^{1-p_1+p^*} [1 - (\lambda_1 + p_1 - p^*)]^{n-1} \, d\lambda_1$$

$$= \frac{-1}{n}[1-(\lambda_1+p_1-p^*)]^n\Big|_0^{1-p_1+p^*}$$
$$= \frac{1}{n}(1-p_1+p^*)^n.$$

Suppose $p_1 < p^*$. The expected probability is

$$\int_0^{p^*-p_1} 1 d\lambda_1 + \int_{p^*-p_1}^1 [1-(\lambda_1+p_1-p^*)]^{n-1}\, d\lambda_1$$
$$= (p^*-p_1) - \frac{1}{n}[1-(\lambda+p_1-p^*)]^n\Big|_{p^*-p_1}^1$$
$$= (p^*-p_1) + \frac{1}{n}[1-(p^*-p_1)^n].$$

■

If $p_1 = p^*$ is to be optimal, then the left derivative of $\pi(p_1, p^*)$ with respect to p_1 evaluated at $p_1 = p^*$ cannot be strictly positive and the right derivative of $\pi(p_1, p^*)$ with respect to p_1 evaluated at $p_1 = p^*$ cannot be strictly negative. The left derivative of $\pi(p_1, p^*)$ with respect to p_1 evaluated at $p_1 = p^*$ is

$$p^* - p_1 + \frac{1}{n}[1-(p^*-p_1)^n] - p_1 + (p^*-p_1)^{n-1}p_1,$$

and this is not strictly negative at $p_1 = p^*$ if

$$\frac{1}{n} - p^* \geq 0.$$

The right derivative of $\pi(p_1, p^*)$ with respect to p_1 evaluated at $p_1 = p^*$ is

$$-p_1[1-p_1+p^*]^{n-1} + \frac{1}{n}[1-p_1+p^*]^n,$$

and this is not strictly positive at $p_1 = p^*$ if

$$\frac{1}{n} - p^* \leq 0.$$

Combining these two inequalities, we conclude that in any symmetric monopolistic equilibrium, we have $p^* = 1/n$.

It remains to verify that given $p^* = 1/n$, firm 1 does not have an incentive to deviate. It is straightforward to verify that

$$\frac{\partial \pi}{\partial p_1} \geq 0 \quad \forall p_1 \leq p^* = \frac{1}{n}$$

and

$$\frac{\partial \pi}{\partial p_1} \leq 0 \quad \forall p_1 \geq p^* = \frac{1}{n},$$

so there is no incentive to deviate.

A.3 Proof of Proposition 2

(2.1) The advent of a buy local arrangement affects the number of expected customers for each firm, but not the expected profit per customer, and hence the equilibrium price remains $1/n$.

(2.2) The buy local arrangement for $\mathcal{A}_L$ affects the payoffs of its members only if a consumer in $\mathcal{A}_L$ takes one distance draw from outside $\mathcal{A}_L$, and $n-1$ distance draws from inside $\mathcal{A}_L$, and draws the minimum distance from outside. In this circumstance, the consumer diverts a purchase that would ordinarily have gone outside $\mathcal{A}_L$ to a firm inside $\mathcal{A}_L$. This purchase is made at price $1/n$, and so the gain (to some the agent in $\mathcal{A}_L$ from whom the good is purchased) in this event is $1/n$. The cost to the consumer is the difference between the expected value of the first-order statistic of n draws from uniform distributions on $[0, 1]$ (the expected distance if the consumer is free to purchase outside) and the expected value of the second order statistic (the expected distance if the consumer is required to purchase inside). The expected value of the kth order statistic is $k/(n+1)$, so the gain from the buy local arrangement exceeds the expected cost if

$$\frac{1}{n} > \frac{2}{n+1} - \frac{1}{n+1},$$

which is obvious.

This ensures that every diversion of a purchase from outside to inside the arrangement yields a positive net benefit to the members of the arrangement. Of course, the costs and benefits of any particular such diversion may accrue to different people. However, the symmetry properties of the arrangement ensure that the net benefits are uniformly distributed across the members of the buy local arrangement, and hence that each member benefits from the arrangement.

A.4 Proof of Proposition 3

Applying Proposition 4, the simple buy local arrangement is profitable under a uniform network if (4) holds. In the current case,

$$\Pr(E_2 \mid E_1) = \frac{1}{n-1} + \frac{n-2}{n-1}\frac{L-1}{N-2}.$$

In particular, we know from the definitions of E_1 and E_2 that the lowest draw is from outside the arrangement, and at least one draw is from inside. With probability $1/(n-1)$, the latter is the second lowest, accounting for the first term. With probability $(n-2)/(n-1)$, the latter is not the lowest, in which case the second lowest draw is equally likely to be any of the $N-2$ remaining firms, $L-1$ of which are inside the arrangement. Given this calculation, condition (4) holds if

$$\frac{1}{n-1} + \frac{n-2}{n-1}\frac{L-1}{N-2} > 1 - \frac{1}{n},$$

that is,

$$\begin{aligned} L-1 &> \left(1 - \frac{1}{n} - \frac{1}{n-1}\right)\frac{n-1}{n-2}(N-2) \\ &= \frac{n^2-3n+1}{n^2-2n}(N-2). \end{aligned}$$

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