PRICE DISCRIMINATION THROUGH BARTER: A THEORY AND EVIDENCE FROM RUSSIA*

Sergei Guriev† and Dmitry Kvasov‡

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Abstract

We build a model of imperfect competition where firms can sell for cash or in-kind payments. Barter is indivisible, and there is no double coincidence of wants. Despite these deficiencies, barter emerges in equilibrium as a means of price discrimination if market power is sufficiently concentrated. The model predicts negative correlation between number of sellers and share of barter in sales. We also show that barter disappears at certain level of concentration. Using survey data on Russian firms, we show that empirical evidence is consistent with predictions of the model.

JEL Codes: D43, L13, P23.

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†New Economic School, RECEP, CEPR and WDI. E-mail: sguriev@nes.cemi.rssi.ru

‡Pennsylvania State University. E-mail: dvk106@psu.edu

1 Introduction

Rapid growth of non-monetary transactions is one of the most striking features of Russia's transition to a market economy. Russian economy has become highly demonetized. Since the macroeconomic stabilization of 1995, the broad money base M2 has been only about 15 per cent of annual GDP which is far below levels observed in OECD countries and even in other transition economies (see Russian Economic Trends (1995-99)). The three primary non-monetary means of payment have been barter, interfirm arrears (or offsets) and promissory notes (vecksels). Interfirm arrears emerged during high-inflation in 1992-94. Since stabilization in 1995 they went down but did not entirely disappear. Barter and promissory notes have become major means of payment after stabilization in 1995. According to various sources, barter accounts for 30 to 80 per cent of interfirm transactions (Aukutzionek (1998), Karpov (1997), Hendley et al. (1998)). Data on promissory notes are scarce but some estimates indicate that they account for 10-20 per cent of interfirm transactions with total volume being as large as 10 per cent GDP (Voitkova (1999)).[1]

The demonetization of this depth is unprecedented in modern economic history. The mainstream economic theory of money has explained why barter is crowded out by fiat money in all developed economies. Kiyotaki and Wright (1989), Williamson and Wright (1994), Banerjee and Maskin (1996) build general equilibrium models with asymmetric information and/or random matching to show that introduction of a universal medium of exchange can increase welfare. Money is considered to be a superior mode of exchange. Russia's demonetization experience is therefore a challenge to modern economics. We have to answer precisely the opposite question: why has barter crowded out the monetary exchange?

There is a number of competing answers to this question. Most managers maintain the view that barter is explained by liquidity squeeze due to tight monetary policy. The second reason is often brought up by government officials who say that barter is used to avoid paying taxes in full. Third, outside investors often claim that managers use barter to divert profits, entrench and delay restructuring.

Ellingsen (1998) and Marin and Schnitzer (1999) have suggested that barter in Russia may emerge as a response to contractual imperfections.

[1] In our survey, 40 per cent of sales are paid in kind and 10 per cent are paid in vecksels.

Ellingsen (1998) builds a model in which liquidity-constrained agents signal their type via payments in kind. Marin and Schnitzer (1999) assume that barter helps to enforce debt contracts since barter can be used as a hostage.[2] Thus barter makes possible exchange between liquidity constrained firms in an environment with costly contracting.

Gaddy and Ickes (1999) suggest that barter is a natural substitute for restructuring. In their model, managers can invest their time either in 'relational' capital which facilitates barter within existing trading networks or into 'restructuring' which makes it possible to sell the firm's products in new markets. Therefore growth of barter should be negatively correlated with restructuring.

We believe that discussion of barter in Russia is incomplete without taking into account the role of market structure. Anecdotal evidence suggests that these are the natural monopolies that are most engaged in barter (Gaddy and Ickes (1998b)). Gazprom (the natural gas monopoly) and RAO UES (the electricity monopoly) have reported cash receipts low as 10 per cent of total revenue (after 1998 devaluation, the share of cash in RAO UES's revenues has gone up to 40 per cent). The rest has been paid in vecksels, coal, metal, machinery and even jet fighters.

In this paper, we build a model of barter as a means of price discrimination that predicts a positive correlation between concentration of market power and share of barter in sales. The argument that barter can be used as a means of price discrimination is certainly not new. Caves and Marin (1992) analyze the countertrade between Western and second and third world countries. They show that price discrimination may be responsible for wide use of countertrade transactions in the global economy.[3] Our model is different from Caves and Marin's in several respects. First, we provide a closed model of an imperfectly competitive industry and solve for the partial equilibrium taking into account responses of all sellers and buyers in the market. Second, there is an important distinction between international and domestic barter. In foreign trade, it is usually possible to separate markets. In domestic sales, there is a single market and only incentive-compatible discrimination is feasible.

[2] Though often criticized, such an assumption is not uncommon in modern financial economics. E.g. Myers and Rajan (1998) assume that the more liquid assets are, the greater the 'transformation' (i.e. diversion) risk is.

[3] See also Ellingsen and Stole (1996) who suggest that international barter may be a device to commit not to engage into unilateral imports.

The main result of our analysis is that barter can indeed emerge in equilibrium as a means of price discrimination even if there are no liquidity constraints. Our model predicts that barter is more likely to occur in concentrated industries and decreases with competition. Moreover, there is a threshold level of competition at which barter disappears altogether. These predictions are empirically testable. We use a survey of Russian firms in order to check whether our model is consistent with data.

Until recently, empirical work on barter in Russia and other transition economies has been scarce. In the last year or two, however, a number of independent surveys has been conducted. Based on the collected data, quite a few authors have tried to measure barter and to test various theories of barter. The work can be roughly classified into two large classes. The first approach is to ask managers how much they barter and why they barter and try to regress their answers on their perceptions of their firms' characteristics such as indebtedness, competitiveness, access to markets etc. This approach is used in Commander and Mumssen (1998), Carlin et al. (forthcoming), Brana and Maurel (1999), Marin and Schnitzer (1999). Commander and Mummsen (1998) and Carlin et al. find that barter is related to financial difficulties. Tax evasion and corporate governance problems are not reported by managers as primary causes of barter. Brana and Maurel (1999) use panel data to show that the explanation of barter is different for profitable and loss-making firms. Potentially viable firms use barter to relax liquidity constraints while highly indebted firms take advantage of barter to avoid restructuring. Marin and Schnitzer (1999) use data on barter prices and find support for their model that barter serves as a hostage to build trust among liquidity-constrained trading parties.

The other approach to empirical analysis of barter is to ask managers how much they barter and match their answers with official statistics on their firms. This approach allows to get rid of bias introduced by manager's imperfect information and lack of incentives to reveal sensitive information. In particular, Guriev and Ickes (forthcoming) use this approach to test the liquidity hypothesis. Indeed, if firm A says that firm B pays her in kind because B has no money, A may be mislead since she does not have complete information on B's financial standing. Guriev and Ickes test whether share of in-kind payments for inputs depends on firm's liquidity and find no significant relationship. It would also be very interesting to apply this approach to testing tax evasion and corporate governance theories. Unfortunately, unlike the financial accounts, data on unpaid taxes and conflicts between managers and owners are very hard to get.

In this paper, we have chosen the second approach. Unlike Carlin et al. (forthcoming) and Caves and Marin (1992) we measure competition directly through concentration ratios rather than via managers' perception of competition.[4] We find that barter is indeed correlated with concentration. We also test our hypotheses about structural break due to abrupt disappearance of barter when competition crosses certain threshold. We find the critical level of concentration and show that the structural change is indeed present in the data and consistent with our model.

The paper is organized as follows. In Section 2, we build a simple model of price-discriminating monopoly which is then extended to the case of oligopoly. Section 3 contains results of our empirical analysis. Section 4 concludes.

2 The model

In this Section we shall study a simple model of barter as a screening device for price discrimination. In Subsection 2.1 we start with a standard model of a monopoly selling to a continuum of buyers. We introduce notation and make technical assumptions. In the Subsection 2.2, we add barter. In Subsection 2.3 we extend the analysis for the case of oligopoly and solve for Cournot equilibria.

2.1 The setting

Consider a monopoly seller S that supplies an input to a continuum of buyers B (industrial firms). The marginal cost of the input is constant and equal to $c \in [0, 1]$. Each buyer has a linear technology which converts a unit of the input into one unit of output worth v to the buyer. The buyer's maximum capacity is one unit. The buyer's outside option is zero so that buyers add value whenever $v > c$ and destroy value if $v < c$.

We assume that v is distributed on $[0; 1]$ with c.d.f. $F(v)$. The buyer's type v is her private information, but the distribution function $F(\cdot)$ is com-

[4] Carlin et al. use two measures. First, they ask managers how many competitors they have. Second, they ask about price elasticity of demand for the firm's products. Their empirical analysis provide weak evidence for positive correlation between barter and concentration.

mon knowledge. The timing is as follows: S offers a menu of contracts, the buyer learns her type and chooses which contract to take.

Let us introduce the average value of output given it is below v :

$$G(v) = \int_0^v x dF(x) / \int_0^v dF(x) \tag{1}$$

Assumption A1. Density $f(v) = F'(v)$ is continuous and positive. $v - G(v)$ is an increasing function of v. The hazard ratio $f(v)/(1 - F(v))$ is a non-decreasing function of v.

This assumption is satisfied whenever distribution is sufficiently close to uniform. For the uniform distribution $F(v) = v$, $G(v) = v/2$, $v - G(v) = v/2$, $f(v)/(1 - F(v)) = 1/(1 - v)$.

First, let us describe the social optimum. The first best is to supply the input to the buyers with $v \geq c$ and shut down all the others. This outcome would be implemented if the input market were perfectly competitive. The price of the input would then be set equal to its marginal cost c. Only buyers with $v \geq c$ would buy the input and produce. Total social welfare would be $\int_c^1 (v - c) f(v) dv$.

In the second best, the seller offers a menu of contracts$\{(p, q)\}$: buy $q \in [0, 1]$ units of input and pay p in cash. If a buyer with quality v picks a contract (p, q) her utility is $vq - p$ while the seller gets $p - cq$. According to the Revelation Principle we can re-formulate the problem as follows: the monopoly offers a menu of contracts $\{p(v), q(v)\}$, $v \in [0, 1]$ such that each type v selects a contract $\{(p(v), q(v))\}$. The seller maximizes

$$\int_0^1 (p(v) - cq(v)) dF(v) \tag{2}$$

subject to incentive-compatibility and individual rationality constraints

$$vq(v) - p(v) \geq vq(v') - p(v'), \; vq(v) - p(v) \geq 0 \text{ for all } v, v' \in [0, 1]$$

A straightforward analysis of this adverse selection problem (see Salanie (1997)) gives

$$q(v) = \arg\max_{q \in [0,1]} q \left[v - c - \frac{1 - F(v)}{f(v)} \right]$$

The seller offers only two contracts $\{(p^m, 1), (0, 0)\}$.[5] The price p^m solves

$$p^m - c = (1 - F(p^m))/f(p^m). \tag{3}$$

All buyers with $v \geq p^m$ will buy and produce and the others will not.[6] The deadweight loss

$$\int_c^{p^m} (v - c)f(v)dv \tag{4}$$

arises due to the fact that buyers with $v \in (c, p^m)$ that could potentially add value, do not produce. This equilibrium is essentially a textbook case of a monopoly serving a market with demand curve $Q = 1 - F(p)$.

2.2 Barter as a means of price discrimination

Now we shall introduce in-kind payments. Suppose that the seller can offer the buyers a menu of triples $\{(p, b, q)\}$: buy $q \in [0, 1]$ units of input for cash payment p and in-kind payment $b \in \{0, 1\}$. If $b = 1$, the buyer's output is given to the seller. It is important to emphasize that unlike money, the barter is indivisible. In this model we follow the strategy of introducing all possible shortcomings of barter in order to show that in the presence of market power barter can emerge even if it is very inefficient.

Another drawback of barter is the need for double coincidence of wants. We assume that seller values the buyer's output less than the buyer. A unit of buyer v's product is worth only αv to S, where $0 < \alpha < 1$. This assumption implies that the seller has an inferior technology for re-selling or using the buyer's product relative to the buyer herself.[7] The cost of barter $1 - \alpha$ may be interpreted as a probability that there is no double coincidence of wants so that S has to throw the in-kind payments away.

If the buyer v chooses a contract (p, b, q), she gets the payoff $vq(1-b) - p$. The seller gets $(\alpha vb - c)q + p$. The optimal menu of contracts $\{(p, b, q)\}$ maximizes

[5] The intuition for the corner solution is simple: both B and S are risk-neutral and their valuations of the input are linear in quantity. In the equilibrium, there are no contracts with $q \in (0, 1)$.

[6] Hereinafter we assume that whenever indifferent, the buyers choose to buy the input and produce.

[7] A more general approach would be to assume that the value of buyer v's output to the seller is an arbitrary function $\alpha(v)$ where $\alpha(v) \leq v$. We have checked some alternative formulations and found that analysis becomes much more complex without adding more insights.

$$\int_0^1 (p(v) + \alpha v b(v) q(v) - c q(v)) f(v) dv \tag{5}$$

subject to incentive-compatibility and individual rationality constraints

$$0 \leq v(1 - b(v))q(v) - p(v) \geq v(1 - b(v'))q(v') - p(v') \text{ for all } v, v' \in [0, 1]$$

In order to characterize the solution, we shall introduce more notation. Denote p^{mb}, p^* that solve

$$p^{mb}(1 - \alpha) = (1 - F(p^{mb}))/f(p^{mb}), \quad \alpha G(p^*) = c, \tag{6}$$

respectively.

Proposition 1 *The optimal menu of contracts $\{(p, b, q)\}$ is as follows. There exists $\bar{c}$ such that if $c < \bar{c}$, S chooses to use barter and offers the following menu of contracts: $\{(p^{mb}, 0, 1), (0, 1, 1), (0, 0, 0)\}$.*[8] *If $c > \bar{c}$ S chooses not to use barter and offers the couple $\{(p^m, 0, 1), (0, 0, 0)\}$ where p^m solves (3).*

The intuition is again simple. Since both seller's and buyers' preferences are linear in the quantity, there are no contracts with q between zero and one.

Example. Consider a uniform distribution $f(p) = 1$. In this case $\bar{c} = (1 - \alpha/2)^{-1/2} - 1$, $p^{mb} = (2 - \alpha)^{-1}$, $p^m = (1 + c)/2$, $p^* = 2c/\alpha$.

Further on, we will only study the case where monopoly is better-off using barter.

Assumption A2. The monopoly is better-off using barter: $c < \bar{c}$.

This assumption is satisfied if marginal cost of production is not too high. We believe that it is quite appropriate for Russian economy in transition. Most Russian firms produce well under capacity. Neither capital nor labor are fully utilized.

A2 implies $p^{mb} > p^*$. Indeed, we have the following chain of inequalities: $(p^{mb} - c)(1 - F(p^{mb})) + (\alpha G(p^{mb}) - c)F(p^{mb}) > (p^m - c)(1 - F(p^m)) =$

[8] This menu is similar to a standard debt contract. The constract says: 'S supplies a unit of input to B; B must pay S p^{mb} in cash or S gets ownership of B's output'. The barter trade is therefore similar to (inefficient) liquidation. Unlike conventional models of debt (Hart (1995)), we assume that there is no possibility for ex post renegotiation (or that the renegotiation is very costly). The model with renegotiation where the buyer has at least some bargaining power has a very similar equilibrium, except of course elimination of deadweight loss due to the double coincidence of wants.

$\max_p \{(p-c)(1-F(p))\} \geq (p^{mb}-c)(1-F(p^{mb}))$. Therefore $(\alpha G(p^{mb}) - c)F(p^{mb}) > 0$. It is not surprising: the monopoly prefers to use barter only if the average value of payments in kind is better than the marginal cost. The other implication of A2 is that the monetary price is higher in the presence of barter: $p^{mb} > p^m$. Indeed, the seller's profit function $(p-c)(1-F(p)) + (\alpha G(p) - c)F(p)$ increases at $p = p^m$. The first term $(p-c)(1-F(p))$ is the profit collected in the cash market which is maximized at $p = p^m$ and the second term increases with p. The intuition is simple: if there were no barter, raising the cash price would result in losing customers, while in the presence of barter, these customers are not lost — they switch to paying in kind.

The welfare effect of barter is ambiguous.. The deadweight loss in the equilibrium with barter is $(1-\alpha)G(p^{mb})+ (c - G(c))F(c)$ which may be greater or less than the deadweight loss (4) would be if barter contracts were prohibited. There are two sources of inefficiency. First, the direct inefficiency of barter is due to the fact that the seller gets the good that she does not need as much as the buyer $\alpha < 1$. Second, some inefficient buyers with $v < c$ get the input and produce. These two effects may be either larger or smaller than the deadweight loss (4) without barter that is caused by underprovision of the input by the monopoly seller.

This simple model illustrates the relevant policy trade-offs. If barter were prohibited, a monopoly would produce too little, some efficient buyers would close down. However, if barter is allowed, the losses are not only due to the lack of double coincidence of wants (proportional to $1-\alpha$). There are also losses due to the asymmetric information about the quality of payments in kind. The value of the barter payments is greater than the cost of input they are made of: $\alpha G(p^{mb}) > c$ on average. Some of the buyers who get the input and produce are not efficient. Thus the model rather supports the claim that barter helps non-profitable firms survive and delay restructuring since they are pooled together with profitable ones in the barter market. This is an implication of indivisibility of barter. If barter payments were perfectly divisible, the seller would be able to discriminate against the most inefficient buyers.

2.3 Barter in oligopoly

Let us now extend our analysis to oligopoly. Suppose that there are N identical sellers with the same marginal cost c. We will look at the Cournot oligopoly assuming that sellers determine how much to sell for cash and for barter taking into account change in the monetary market price in response to change in their supply decision. Each firm sells q_i for cash at the market price p and r_i for the buyers' output. In equilibrium, total quantity supplied to the cash market $Q = \sum_{i=1}^{N} q_i$ equals quantity demanded $\int_p^1 f(v)dv = 1 - F(p)$. The rest of buyers $v < p$ buy in the barter market paying with their output so that each seller expects to get $r_i \alpha G(p)$. Since buyers in the barter market are indifferent between buying and not buying we assume that if total supply in the barter market $R = \sum_{i=1}^{N} r_i$ is below $F(p)$, the demand is stochastically rationed so that the average quality of payments in kind remains $\alpha G(p)$.

The seller i takes other seller's strategies q_j and r_j as given and maximizes

$$\pi(q_i, q_{-i}, r_i) = p(q_i + q_{-i})q_i + r_i \alpha G(p) - cq_i - cr_i \tag{7}$$

subject to

$$0 \leq r_i \leq 1 - (q_i + q_{-i}) - r_{-i}. \tag{8}$$

Here $q_{-i} = \sum_{j \neq i} q_j$, $r_{-i} = \sum_{j \neq i} r_j$. The inverse demand function $p(Q)$ is given by $Q = 1 - F(p)$.

Formally, we shall look for Nash equilibria in the game among N sellers whose strategies are couples (q_i, r_i) that satisfy (8) and $q_i \geq 0$. The payoffs are given by (7).[9]

We will classify equilibria by the presence of barter and then carry out comparative statics analysis with regard to N.[10] Notice that firm i has an incentive to sell for barter whenever $\partial \pi / \partial r_i = \alpha G(p) - c \geq 0$ or $p \geq p^*$.

1. *'Barter' equilibria*. This is the case where $p \geq p^*$. The objective function increases with r_i. Therefore the sellers want to barter as much as possible $r_i = 1 - (q_i + q_{-i}) - r_{-i}$. The first order condition for q_i implies $q_i = f(p)\left[p - \alpha G(p) - \alpha(p - G(p))(F(p) - r_{-i})/F(p)\right]$.[11] Adding up for $i = 1, .., N$ and dividing by $f(p)$ we obtain the equation for equilibrium price

$$(p - \alpha G(p))N - \alpha(p - G(p)) = \frac{1 - F(p)}{f(p)}. \tag{9}$$

[9] Strictly speaking, we have not defined a game in the normal form, since other players' strategies influence both payoff function and the set of possible strategies for each player. However, we can easily reformulate the problem setting payoff equal to (7) if (8) is satisfied and $-\infty$ otherwise.

[10] In this stylized model we take N to be a positive real number. However, at $N = 1$ the equilibria will indeed coincide with the ones in case of monopoly.

[11] We have used the identity $G'(p) = (p - G(p))f(p)/F(p)$.

We will denote $p^b(N)$ the price p that solves (9) for a given N. The necessary and sufficient condition for existence of a barter equilibrium is $p^b(N) \geq p^*$. The total amount of barter sales is $R = F(p^b(N))$. The barter sales of individual sellers r_i must satisfy $\sum_{i=1}^N r_i = R$. In the symmetric equilibrium $r_i = F(p^b)/N$ and $q_i = (1 - F(p^b))/N$. There is also a continuum of asymmetric equilibria. In all equilibria, however, p and R are the same.

2. *'No-barter' equilibria.* If $p \leq p^*$, the sellers do not barter $r_i = 0$ and the first order condition for q_i implies $q_i = (p - c)f(p)$. Adding up and dividing by $f(p)$ we get the conventional Cournot equilibrium

$$(p - c)N = \frac{1 - F(p)}{f(p)} \tag{10}$$

Let us introduce $p^{nb}(N)$ as a solution to (10). The necessary and sufficient condition for existence of a no-barter equilibrium is $p^{nb}(N) \leq p^*$. The total amount of barter sales is zero.

3. *'Rationed barter' equilibria.* If $p = p^*$, the sellers are indifferent about how much to offer for barter. The first order condition for q_i implies $q_i = (p^* - c)f(p^*) - r_i(p - G(p))f(p)/F(p)$. Adding up, we get

$$R/F(p^*) = \left[(p^* - c)N - (1 - F(p^*))/f(p^*)\right] / \left[\alpha(p^* - G(p^*))\right] \tag{11}$$

Barter sales of individual sellers r_i must satisfy $\sum_{i=1}^N r_i = R$. The necessary and sufficient condition for existence of a rationed-barter equilibrium is (8) i.e. $0 \leq R/F(p^*) \leq 1$. These inequalities hold if and only if both inequalities $p^b(N) \geq p^*$ and $p^{nb}(N) \leq p^*$ hold. Thus the rationed barter equilibrium exists if and only if both 'barter' and 'no-barter' equilibria exist.

Let us denote N^b a solution to $p^b(N) = p^*$ and N^{nb} a solution to $p^{nb}(N) = p^*$.

Proposition 2 *Assume A1-A2. Both N^b and N^{nb} exist and $N^b > N^{nb}$. The set of equilibria of the game above is as follows:*

1. *If $N < N^{nb}$ then there is a unique stable equilibrium which is a barter equilibrium*

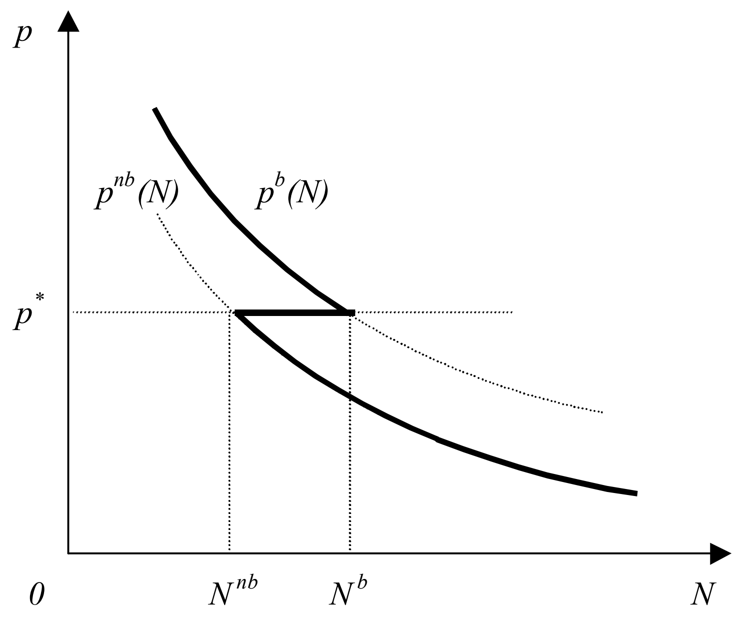

Figure 1: Oligopoly price p as function of number of sellers N.

2. *If $N > N^b$ then there is a unique stable equilibrium which is a no-barter equilibrium*

3. *If $N \in (N^{nb}, N^b)$ then there are three equilibria two of which (barter and no-barter) are stable and one (rationed barter) is unstable.*

4. *If $N = N^b$ then there are two equilibria: a stable one (no-barter) and an unstable one (barter).*

5. *If $N = N^{nb}$ then there are two equilibria: a stable one (barter) and an unstable one (no-barter).*

Figure 1 illustrates the structure of equilibria according to Proposition 2.

The intuition for multiplicity of equilibria at $N \in (N^{nb}, N^b)$ is as follows. Whenever one seller chooses to sell more for cash, she drives down the cash price of the input. The additional cash purchases are made by the buyers who

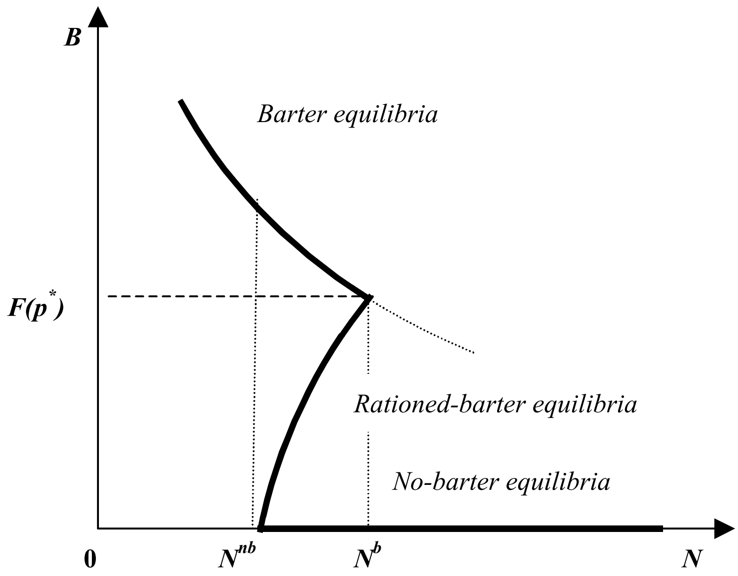

Figure 2: Share of barter sales in total sales $B = R/(R+Q)$ as a function of number of sellers N.

were initially the most efficient ones among those buying for barter. With these buyers leaving the barter market, the average quality of payments in kind goes down. Thus other sellers will have incentives to sell more for cash and less for barter.[12]

It it interesting to see how share of barter in sales in the industry $B = R/(R+Q)$ changes with number of sellers N. In the barter equilibria $B = R = F(p^b(N))$. Since $p^b(N)$ is a continuous decreasing function, y is a continuous decreasing function of N. In the no-barter equilibria $B = R = 0$. In the rationed barter equilibria $Q = 1 - F(p^*)$, R is a linear function of N given by (11). Therefore $B = [1 + (1 - F(p^*))/R]^{-1}$ is a continuous increasing hyperbolic function of N that connects points $(N^{nb}, 0)$ and $(N^b, F(p^*))$ in

[12]This externality is somewhat similar to aggregate demand externality in the new Keynesian macroeconomics.

the (N, B) space (see Figure 2).

Let us briefly discuss what properties of the model determine the structure of equilibria. First, both in barter and no-barter equilibria, prices go down if number of sellers increases. Second, for a given number of sellers, the cash price in barter equilibrium is greater than the price in no-barter equilibrium. This is also intuitive. In barter equilibria, sellers have more incentives to charge higher prices because the marginal buyers who would leave the market in case of no-barter equilibria, now simply switch to barter and therefore contribute to profits from barter sales. Third, in barter equilibria the cash price should be above certain level p^* otherwise the average quality of payments in kind is below marginal cost and barter is not profitable. Similarly, in no-barter equilibria price should be below p^*. Under these three conditions, the structure of equilibria should be exactly like in Figures 1 and 2.

In the no-barter equilibria, the deadweight loss occurs since the cash price is higher than the marginal cost. Therefore some efficient buyers do not buy and produce. In the barter equilibria, all buyers produce including the value-subtracting ones. Also, there are transactions costs of barter $(1 - \alpha)F(p^b(N))G(p^b(N))$. The social planner has to compare the deadweight loss of a no-barter equilibrium where too many firms are shut down but transaction costs are low with that of barter equilibrium where too few firms are shut down and transactions costs are high.

3 Empirical analysis

The model implies the following empirical predictions. First, the greater the market concentration $1/N$, the greater the level of barter in sales $B = R/(R+Q)$. Second, if the industry is sufficiently competitive $(1/N < 1/N^b)$ the barter disappears altogether. Third, there should be a structural break in the range $1/N \in [1/N^b, 1/N^{nb}]$ where the industry jumps from the no-barter equilibrium to the full-barter equilibrium.

3.1 The data

We use the dataset 'Barter in Russian industrial firms' built in the New Economic School Research Project 'Non-Monetary Transactions in Russian Economy'. This dataset was created by matching the surveys of managers of Russian industrial firms conducted in 1996-98 by Serguei Tsoukhlo (Institute of Economies in Transition, Moscow) with Goskomstat database of Russian firms (Federal Committee of Statistics of Russian Federation). Since Goskomstat data were most complete for 1996 and 1997 we ran regressions for 1996 and 1997 data.

The barter data included six to seven hundred firms each year. The barter data are answers of firms' managers to the following (eight) questions: 'how much of your firm's inputs (outputs) were paid in rubles, in dollars, in kind and in promissory notes?' The Goskomstat database includes compulsory statistical reports that all large and medium-size firms must submit to Russian Federal Statistics Committee. There are over 16 thousand firms in the database. After matching barter data with the Goskomstat data we ended up with 987 observations with 475 (48%) in 1996 and 512 in 1997. Among these, 264 firms appeared both in 1996 and 1997.

The concentration ratios CR4 (share of four biggest firms in total sales of an industry) were calculated for 5-digit OKONKh industries (more than three hundred industries) using the Goskomstat database.[13] In our sample, some industries are not represented so that we have on average 4 firms in each industry, with up to 30 firms in some industries. Given the average CR4 in these industries is almost 40 per cent, this is quite a few. An alternative approach would be to calculate CR4s for broader (e.g. 4-digit) industries. However, we believe that such concentration ratios are less informative. In Russia's OKONKh classification many 4-digit industries include 5-digit industries that use each other's outputs as inputs in their production. Therefore firms in such 4-digit industries do not compete with each other.

3.2 Empirical results

The main regression we have run was an OLS regression of B (share of barter in sales) on $CR4$ (concentration ratio in the firm's industry) and a proxy of size ls (logarithm of sales in thousands of non-denominated rubles). We have included the proxy for size into our regression because there should evidently be economies of scale in using barter. In terms of our model, the greater the firm is, the less the transaction costs of barter $1-\alpha$ are. We have also tried other measures of size such as employment and got similar results.

[13] We thank David Brown and Annette Brown for providing us with the concentration ratios they have calculated. The CR4s they have obtained coincide with ones that Federal Antimonopoly Committee has included in its Annual Report.

Since our model applies to interfirm transactions we need to control for sales to foreign and retail customers. The former is easy to measure: we shall use share of exports in sales *export* (we have also tried share of non-CIS exports in sales and results were similar). It is less clear how to control for retail sales. As a proxy for sales to consumers we have used a consumer good industry dummy (CGI). We set $CGI = 1$ for consumer good industries and $CGI = 0$ otherwise. In our sample, 28% firms are in consumer good industries. Unfortunately, CGI is a very crude estimate of a firm's exposure to consumer market and is in fact industry-specific rather than firm-specific.[14] Also, even producers of consumer goods are not necessarily selling directly to consumers or even to retail trade. This is why one should be careful with interpretation of regressions with CGI. However, we shall include CGI into regression since it can help us control for an alternative explanation of positive correlation between concentration and barter. In consumer good industries there are many small firms, and all firms receive cash from individual consumers (or retail trade). In the intermediate good industries, the minimum efficiency scale is high, there are fewer firms and they supply to other firms (or wholesale trade) who are willing to pay in kind. Thus, if we assume that the farther from the retail market the less cash is paid, there should be a positive correlation between distance from the consumer market and barter. Since there is also a positive correlation between the distance to market and concentration, barter and concentration should be correlated.

We have not included other industry dummies into regressions. The main idea of our theory is that all industries are alike and the only thing that matters is the market structure. We have introduced the following regional dummies: $rgmsk = 1$ if the firm is based in Moscow, $rgural = 1$ if the firm is based in Urals, $rgasia = 1$ if the firm is based in Siberia or Far East. The base category is European Russia except Moscow. The variable $year97$ equals 0 if the observation belongs to 1996 survey and 1 if it is from 1997 survey.

The summary statistics and the correlation matrix are shown in the Appendix A. There is no multi-collinearity.. The signs of pair-wise correlations are intuitive. There is more barter in larger firms, in concentrated industries and in those who sell less to foreign customers and consumers. There is

[14]The latest data we have for production of consumer goods by each firm date back to 1993. In 1993, share of consumers goods in output were indeed correlated with CGI. In consumer good industries $CGI = 1$, the share of consumer goods was 48 per cent while in the other industries it was only 13 per cent.

B				
$CR4$	0.08***(0.03)	0.06**(0.03)	0.05*(0.03)	0.03(0.03)
ls		0.016***(0.004)		0.014***(0.004)
$export$		-0.13***(0.05)	-0.13***(0.05)	-0.17***(0.05)
CGI			-0.09***(0.02)	-0.09***(0.02)
$yr97$	0.04**(0.01)	0.03**(0.01)	0.03**(0.01)	0.03**(0.01)
$rgmsk$	-0.20***(0.02)	-0.20***(0.02)	-0.19***(0.02)	-0.19***(0.02)
$rgural$	0.15***(0.03)	0.14***(0.03)	0.17*** (0.03)	0.15***(0.03)
$rgasia$	0.08***(0.03)	0.07***(0.03)	0.09***(0.03)	0.08***(0.03)
$const$	0.35***(0.02)	0.10(0.07)	0.39***(0.02)	0.16**(0.07)
N	987	987	987	987
R^2	0.12	0.14	0.15	0.16

Table 1: OLS regression results. *** significant at 1% level, ** 5% level, * 10% level.

slightly more barter in 1997 than in 1996 (see Guriev and Ickes (1999) for the analysis of dynamic economies of scale in barter). Consumer good industries are less concentrated. Average CR4 for consumer good industries is 25 per cent which is significantly lower than in the other industries (42 per cent). There is more barter in Siberia and Urals and less barter in Moscow.

The results of the basic OLS regressions are shown in Table 1.

In most specifications, share of barter positively and significantly depends on concentration. When we include CGI into regression, the effect of concentration decreases and may even become insignificant. Therefore, the evidence corroborates the theory that there is less barter in consumer markets.[15]

In order to test for the structural break we have introduced a dummy D that takes the value of 1 if $CR4 < CR4_*$ and $D = 0$ otherwise. Then we added a term $D * CR4$ to our regression. The coefficient on $CR4$ would then show the effect of concentration for industries with $CR4 > CR4_*$. The effect of concentration for competitive industries $CR4 < CR4_*$ would be equal to the sum of coefficients on $CR4$ and $D * CR4$.

To find the cutoff point $CR4_*$ we have calculated the Andrews statistic (Andrews, 1993) for every $CR4^* \in [0.03, 0.75]$. Figure 3 shows that the

[15] On the other hand, the impact of CGI and $export$ variables can also be interpreted as the effect of foreign competition (there has been a huge import penetration in Russian consumer markets).

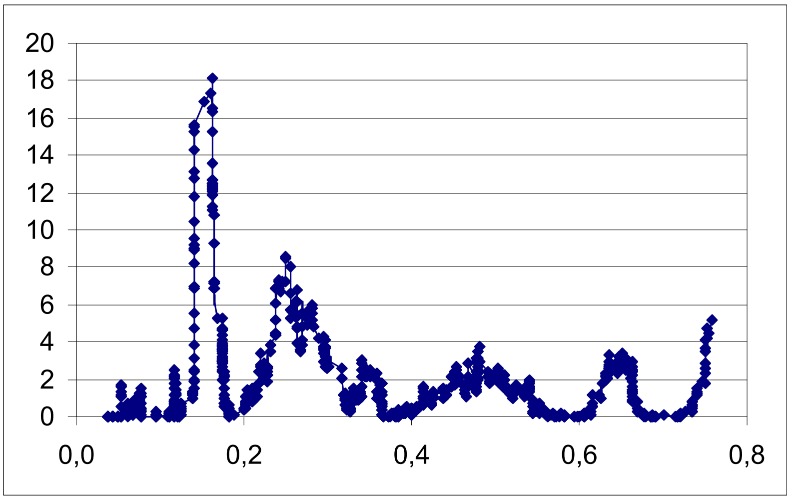

Figure 3: Andrews' statistic as a function of the suspected structural change point $CR4^*$. The maximum is reached at $CR4^* = 0.1616$.

statistic reaches maximum at $CR4^* = 0.1616$. At this point the statistic equals 18.11 which is well above the asymptotic critical value 6.8 calculated in Andrews (1993). There is another local maximum at $CR4^* = 0.2504$ but there the statistic equals or only marginally exceeds the critical value. Therefore the structural change is most likely to occur at $CR4^* = 0.1616$. In our sample, 27% observations are in the industries with $CR4 < 0.1616$.

The results of the regressions with the structural change are presented in the Table 2.

The results are fully consistent with our model. If concentration is greater than the cutoff level, the coefficient on $CR4$ is positive and significant but small (0.10). However if concentration is below the cutoff level, the coefficient on concentration is positive, significant and much greater (0.93=0.83+0.10). In terms of Fig.4 (which is essentially Fig.2 redrawn in $(1/N, B)$ coordinates), the coefficient 0.10 is the slope of the barter equilibria curve, while 0.93 represents the abrupt jump from barter equilibria curve down to no-barter equilibria curve.

Another way to test the prediction that barter disappears with an increase in competition is to run probit regressions. We have generated a binary variable b_0 that takes the value of 1 whenever $B = 0$ and zero if $B = 0$. In

B				
$CR4$	0.12***(0.03)	0.10***(0.03)	0.11***(0.03)	0.10***(0.03)
$D * CR4$	0.50**(0.12)	0.54**(0.21)	0.54**(0.21)	0.83***(0.21)
ls		0.014***(0.004)	0.017***(0.004)	0.015***(0.004)
CGI				-0.10***(0.02)
$export$			-0.13***(0.05)	-0.17***(0.05)
$yr97$	0.04**(0.01)	0.03**(0.01)	0.03**(0.01)	0.03**(0.01)
$rgmsk$	-0.20***(0.02)	-0.20***(0.03)	-0.20***(0.02)	-0.18***(0.02)
$rgural$	0.15***(0.03)	0.14***(0.03)	0.14***(0.03)	0.15***(0.03)
$rgasia$	0.08***(0.03)	0.07***(0.03)	0.07***(0.02)	0.08***(0.03)
$const$	0.32***(0.02)	0.10(0.07)	0.06(0.08)	0.11(0.07)
N	987	987	987	987
R^2	0.13	0.14	0.14	0.17

Table 2: OLS regressions with structural change. *** denotes significance at 1% level, ** 5% level, * 10% level.

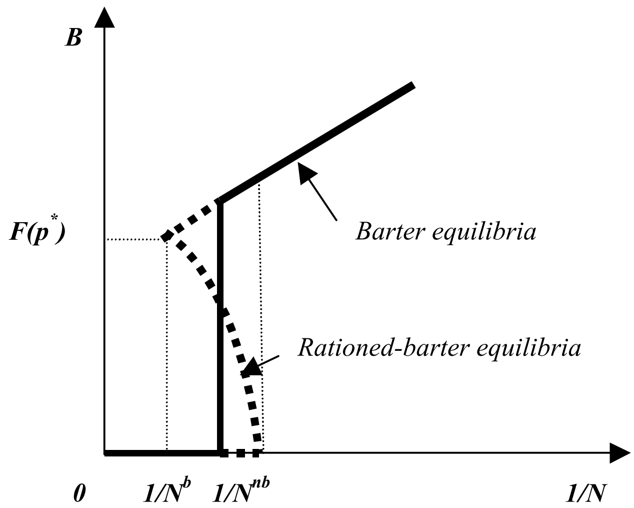

Figure 4: Share of barter in sales B as function of concentration $1/N$. At certain concentration below $1/N^b$ there occurs an abrupt jump from barter to no-barter equilibrium. At concentrations above $1/N^b$, industries are in the barter equilibrium.

	b_0	b_0	b_1	b_2
$CR4$	0.41*(0.22)	0.25(0.23)	0.38*(0.21)	0.29*(0.17)
ls		0.07***(0.03)	0.08***(0.03)	0.08***(0.03)
$rgmsk$		-0.85***(0.15)	-0.94***(0.14)	-1.00***(0.14)
$const$	1.16***(0.09)	0.14(0.55)	-0.21(0.51)	-0.71(0.44)
N	987	987	987	987
Ps. R^2	0.01	0.06	0.08	0.07

Table 3: Probit estimates.

our sample, only 10% firms have zero barter. The results are reported in Table 3. The probability to have barter increases with concentration. The coefficient is marginally significant and becomes insignificant whenever we control for other factors. Our theory predicts that probability to have barter increases with size for size is a proxy for the parameter α. Year dummies and regional dummies except Moscow are not significant.

It is also of interest to check whether concentration has any impact on probability to have very low barter share rather than zero barter share. Indeed, occasional barter deals occur in OECD economies as well. We have looked at two cutoff points 0.1 and 0.2. In our sample, 13% firms have share of barter in sales below 10% and 27% of the firms have the barter share below 0.2. We have introduced two binary variables $b1$ and b_2. The binary variable b_1 is 1 whenever $B < 0.1$ and 0 otherwise. Similarly, $b_2 = 1$ when $B < 0.2$ and $b_2 = 0$ otherwise. The results of probit estimates with cutoff levels are also shown in Table 3. The probability to have very low barter decreases with concentration as well as the probability to have no barter at all. The effect of concentration is more significant for probability to have very low barter rather than probability of zero barter.

The pairwise correlation between concentration and b_i is also stronger for b_1 and b_2 than for b_0. We have run t-tests and found that concentration is on average 5-6% lower for firms with $b_i = 1$, but the difference is significant at 1% level for b_1 and b_2 but not for b_0.

4 Conclusions and policy implications

Let us summarize our results. We have developed a simple model of barter as a means of price discrimination. In our model, buyers are not liquidity constrained and are able to pay cash for their inputs. Also, there is no double coincidence of wants so that the barter transactions are less efficient than the monetary ones. The buyers do need the sellers' product but the sellers do not need the buyers'. The value of the buyer's output to the seller is only $\alpha < 1$ of its value to the buyer. Second, we assume that barter is indivisible. In the asymmetric information framework this assumption leads to inefficient pooling in the barter market. Since the quality of payments in kind is not observable, inefficient buyers will be engaged in barter along with the efficient ones.

Our main result is that even with all these deficiencies, barter can emerge in equilibrium if the markets are sufficiently concentrated. The amount of barter increases with concentration. The intuition is straightforward. Since equilibria under imperfect competition are usually characterized by underproduction relative to the social optimum, sellers may be interested in an additional channel of sales even if this channel is costly.

In order to test predictions of the model, we have built a unique dataset. We matched a survey of managers' on the degree of barter in their firms with official statistical firm-level data. The empirical analysis supports our model. Barter positively and significantly depends on the concentration especially in a model with a structural break that our theory predicts.

Our result raises a legitimate question. If barter is explained by high concentration of market power, why is it observed in Russia and is virtually non-existent in other economies? One answer to this question would be that in Russia markets are more concentrated than in other economies. This claim is well-accepted by general public and policymakers but is not supported by data (see Brown et al. (1994), Brown and Brown, (1998)). Our model may offer another explanation. For the same level of concentration there may be two stable equilibria: one with barter and one without barter. Therefore there may be path-dependence. In 1995, a liquidity shock has thrown the economy into a high barter state. Since that time, price flexibility should have restored equilibrium level of real money stock. The real money supply, however, is now 2 to 3 times as low as it used to be. In terms of Polterovitch (1998), Russian economy is in the institutional trap of barter.

The multiple equilibria argument is rather common in modern literature on transition and development. It is basically the essence of so-called 'post-Washington consensus' that is gradually replacing the Washington consensus on economic transition. The post-Washington consensus states that institutions matter a great deal for economic transition and may fail to emerge spontaneously. Government should intervene to promote good institutions, otherwise the economy will find itself in a low-level equilibrium. However, what our model suggests is not simply a restatement that Russia may be in a low-level equilibrium. We have shown that at some level of competition the barter equilibrium disappears and industry jumps to the no-barter equilibrium. This argument suggests non-trivial policy implications. In order to reduce barter, government should promote competition. Moreover, even if competition policy may have had a little effect on barter so far, government should not give up. Our model (along with empirical analysis) suggests that barter may fall dramatically when certain threshold level of competition is achieved.

The other question is whether policymakers should fight barter. We show that from the social planner's point of view the trade-off is as follows. Under imperfect competition, the no-barter equilibrium is characterized by underproduction: many efficient firms close down. The barter equilibrium is too soft, all efficient firms produce but so do the inefficient ones. Also, the barter equilibrium is characterized by high transaction costs. Our model provides no unambiguous answer which equilibrium is more efficient. On the other hand, the model clearly predicts that policymakers who are more concerned with excess employment would rather choose the barter equilibrium as one with less firm closures and mass redundancies. This may explain why local politicians encourage barter relatively more often than the federal government. Certainly, our model is not a general equilibrium model and it does not take it into some important negative consequences of barter. Widespread barter reduces transparency in the economy which in turns leads to worse corporate governance, lower tax collection and greater corruption.

Appendix A: Tables

Table A1. Summary statistics.

Variable	Explanation	Mean	Std.Dev	Min	Max
B	Share of barter in sales	0.39	0.24	0	0.83
ls	Log sales	17.13	1.76	9.10	22.27
$CR4$	5-digit concentration	0.38	0.26	0.04	1
$export$	Share of export in sales	0.07	0.16	0	0.97
CGI	Consumer good industry	0.28	0.45	0	1
$rgmsk$	Moscow	0.10	0.31	0	1
$rgural$	Urals	0.06	0.23	0	1
$rgasia$	Siberia and Far East	0.09	0.29	0	1

Table A2. The correlation matrix (*** denotes significance at 1% level).

	B	ls	$CR4$	$export$	CGI	$year97$
B	1					
ls	0.14***	1				
$CR4$	0.11***	0.25***	1			
$export$	-0.02	0.28***	0.20***	1		
CGI	-0.18***	-0.16***	-0.28***	-0.20***	1	
$year97$	0.10***	0.00	0.02	-0.07	0.02	1

Appendix B: Proofs

Proof of Proposition 1. The buyer's rent in equilibrium

$U(v) = v(1 - b(v))q(v) - p(v)$ is a monotonic function of v. Indeed, let us take arbitrary v',$v'' \in [0, 1]$ such that $v' < v''$ and write down incentive compatibility (IC) constraints:

$$\begin{aligned} v''(1 - b(v''))q(v'') - p(v'') &\geq v''(1 - b(v'))q(v') - p(v') \\ v'(1 - b(v'))q(v') - p(v') &\geq v'(1 - b(v''))q(v'') - p(v'') \end{aligned} \tag{12}$$

These inequalities imply

$$(1 - b(v'))q(v') \leq \frac{U(v'') - U(v')}{v'' - v'} \leq (1 - b(v''))q(v'') \tag{13}$$

Since $(1 - b(v'))q(v') \geq 0$, we obtain $U(v'') \geq U(v')$.

The next step is to prove that the quantity of the output that the buyer keeps $(1 - b(v))q(v)$ is also a non-decreasing function of v. Adding up (12), we get $(v'' - v')\{(1 - b(v''))q(v'') - (1 - b(v'))q(v')\} \geq 0$. Therefore $v' < v''$ implies $(1 - b(v''))q(v'') \geq (1 - b(v'))q(v')$. Therefore,

$$U(v) = U(0) + \int_0^v (1 - b(x))q(x)dx. \tag{14}$$

Substituting $p(v) = v(1 - b(v))q(v) - U(v)$ into (5) we obtain that the seller chooses $U(0) \geq 0, q(v) \in [0, 1]$ and $b(v) \in \{0, 1\}$ to maximize

$$\int_0^1 \left\{ v - c - \frac{1 - F(v)}{f(v)} + b(v) \left[\frac{1 - F(v)}{f(v)} - v(1 - \alpha) \right] \right\} q(v)f(v)dv - U(0) \tag{15}$$

Apparently, $U(0) = 0$. Choosing optimal q and b is more complicated. If barter were perfectly divisible, the solution would be straightforward. There could be two cases. If $p^{mb} < p^m$ then $b = 0$ and $q = 1$ whenever $v > p^m$. If $p^{mb} > p^m$ then $q = 1$ whenever $v > c/\alpha$ and $b = 1$ for $v < p^{mb}$. The former case coincides with the monopoly equilibrium without barter. In the latter case, buyers are split into three groups. The most efficient buyers pay cash price p^{mb}, the buyers with intermediate productivity $v \in (c/\alpha, p^{mb})$ pay in kind and the least productive buyers do not produce. Notice that in this equilibrium both all buyers with $v \leq p^{mb}$ receive zero rent and are indifferent between producing and paying in kind or not producing at all. Above, we assumed that whenever indifferent, buyers choose to produce. Therefore, to make buyers with $v < c/\alpha$ shut down and buyers with $v > c/\alpha$ produce, the seller must offer some infinitesimal reward to the latter. This can be done through making$1 - b(v)$ being strictly positive although very small. Thus, although, in equilibrium $b(v)$ is either 0 or very close to 1, perfect divisibility of in-kind is crucial for separating buyers with $v \in (0, c/\alpha)$ and $v \in (c/\alpha, p^{mb})$.

Formally, indivisibility of barter imposes the following constraint on the choice of q and b : there can be either contracts without barter $b = 0$ with various q or one contract with barter $b = 1$. The matter is that whenever barter is present, buyers receive zero rent and are indifferent. Therefore they choose to produce maximum amount. Let maximize (15) subject to this constraint. Since buyers' rent increases with v, there is certain $\bar{v}$ such that all buyers with $v > \bar{v}$ will choose cash contracts $b(v) = 0$, $q(v) \in [0, 1]$ and all buyers with $v < \bar{v}$ will choose the barter contract $b(v) = 1$, $q(v) = \tilde{q} \in [0, 1]$. The seller gets

$\int_{\bar{v}}^{1} \left\{ v - c - \frac{1-F(v)}{f(v)} \right\} q(v) f(v) dv + \tilde{q} \int_{0}^{\bar{v}} \{\alpha v - c\} f(v) dv = (\bar{v} - c)(1 - F(\bar{v})) + \tilde{q} F(\bar{v})(\alpha G(\bar{v}) - c)$.

There can potentially be three cases. First, it could be that $\bar{v} > p^*$, then f.o.c. requires $\bar{v} = p^{mb}$. Second, it could be $\bar{v} < p^*$, then f.o.c. implies $\bar{v} = p^m$. Third it could be $\bar{v} = p^*$. However, in order $\bar{v} = p^*$ to be a maximum, the right-hand side derivative should be negative and the left-hand side derivative should positive. Since $\tilde{q} = 0$ for all $\bar{v} < p^*$ and $\tilde{q} = 1$ for $\bar{v} > p^*$, this requires $1 - F(p^*) - p^*(1 - \alpha) f(p^*) < 0 < 1 - F(p^*) - (p^* - c) f(p^*)$. Since $\alpha p^* \geq \alpha G(p^*) = c$, this is not possible. Thus the optimal menu of contracts is either $\{(p^{mb}, 0, 1), (0, 1, 1), (0, 0, 0)\}$ or $\{(p^m, 0, 1), (0, 0, 0)\}$ whichever provides the seller with a higher payoff. Let us denote $\bar{c}$ the value of c that solves

$$\max_{p \in [0,1]} \{p(1 - F(p)) + \alpha G(p) F(p)\} - c = \max_{p \in [0,1]} \{(p - c)(1 - F(p))\}$$

The seller chooses to use barter whenever the left-hand side is greater than the right-hand side, i.e. $c < \bar{c}$. Apparently, $\bar{c}$ increases with α $d\bar{c}/d\alpha = G(p^{mb}) F(p^{mb}) / F(p^m)$; $\bar{c} \to 0$ at $\alpha \to 0$. ■

Proof of Proposition 2. We will organize the proof in several steps.

Step 1. Prove that $p^b(N)$ and $p^{nb}(N)$ are decreasing functions of N and $p^b(N) > p^{nb}(N)$ for all $N < N^b$.

Solving (9) for N we obtain

$$N = 1 + [(1 - F(p))/f(p) - (1-\alpha)p] \,/\, [p - \alpha G(p)] \tag{16}$$

which is a decreasing function of p. Consequently, the inverse function $p^b(N)$ is also decreasing. Since $p^b(1) = p^{mb} > p^*$ and $p^b(\infty) = 0$ there exists a unique solution to $p^b(N) = p^*$. Similarly, (10) implies $N = (1 - F(p))/\,[(p-c)f(p)]$ which is a decreasing function. Since $p^{nb}(0) = 1 > p^*$ and $p^b(\infty) = c < p^*$ there exists a unique solution to $p^{nb}(N) = p^*$.

For all $N < N^b$, we have $p^b(N) > p^*$ and therefore $\alpha G(p^{nb}(N)) > c$. Using (9) and (10) we get

$$\frac{(p^{nb}-c)f(p^{nb})N}{1-F(p^{nb})} = \frac{(p^b-c)f(p^b)N}{1-F(p^b)} - f(p^b)\frac{(\alpha G(p^b)-c)N + \alpha(p^b - G(p^b))}{1-F(p^b)}$$

which implies $p^{nb}(N) > p^b(N)$.

Step 2. Prove that $N^b > N^{nb}$.

This follows from Step 1. Indeed, both $p^{nb}(N)$ and $p^b(N)$ are continuous decreasing functions, $p^{nb}(N) < p^b(N)$ for all $N < N^b$ and $p^{nb}(N^{nb}) = p^b(N^b) = p^*$.

Step 3. Existence of equilibria.

The barter equilibrium exists if and only if $p^b(N^b) \geq p^*$ i.e. $N \leq N^b$. The no-barter equilibrium exists if and only if $p^{nb}(N^{nb}) \leq p^*$ i.e. $N \geq N^{nb}$. The rationed barter equilibrium exists if and only if both barter and no-barter equilibria exist.

Step 4. Stability of equilibria.

Barter equilibrium at $N < N^b$ and no-barter equilibrium at $N > N^{nb}$ are stable. Indeed if there is no barter and one seller deviates by offering a positive amount of barter sales, other sellers have no incentives to deviate. If, in a barter equilibrium, one seller deviates by offering less barter then other sellers's best response is to capture the unattended customer and therefore restore total barter sales equal to $F(p)$.

The rationed barter equilibrium is unstable. Indeed, if one seller chooses to sell a little more for barter and a little less for cash, the price in the cash market will increase which would make average quality of payments in kind $\alpha G(p)$ greater than marginal cost of production c. Then all other sellers will want to sell for barter and the barter equilibrium will be reached. Similarly, if one seller decides to deviate from rationed barter equilibrium selling more for cash and less for barter, $\alpha G(p)$ will fall below c and everyone will give up selling for barter so that no barter equilibrium will be reached. ■

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