Payments in Kind

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Abstract

Payments in kind pose an enduring and empirically important puzzle. The paper provides a formalization of the popular view that payments in kind are due to financial constraints. The key assumption is that buyers' liquidity is private information. Buyers who are financially constrained may prove their hardship by making part of the payment in kind. The paper models explicitly the credit market imperfections which lead to payments in kind and yields predictions which are consistent with a number of empirical observations. In particular, it offers a coherent explanation for the recent explosion of barter in Russia and other former Soviet republics.

Keywords: In–kind payments, barter, countertrade, financial constraints, price discrimination.
JEL Codes: G20, D82, F10.

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1 Introduction

The use of commodities rather than cash as a means of payment has long puzzled economists. Unless traders fear that cash is subject to counterfeit, or to rapid inflation, it would seem that commodities should never be used as payment.[1] After all, as Jevons (1875) famously argued, the main function of money is to eliminate the need for a double coincidence of wants between any pair of traders. Nonetheless, various forms of domestic and international barter continue to flourish even in the age of liberalized financial markets and stable money.[2]

Recently, we have witnessed massive domestic barter at the firm level in Russia (and in several of the other former Soviet republics). In Russia, barter constituted almost fifty per cent of industrial sales in 1997, up from around five per cent in 1992 (Aukutsionek (1997,1998)). In the same five year period, Russian firms started to pay their workers in kind on a grand scale, sometimes under tragi–comic circumstances. Hungry workers were paid everything from porcelain and kitchen utensils to sex toys and fertilizer, in the form of piles of manure, instead of their ordinary money wage. Likewise, a large fraction of taxes were being paid in kind rather than cash (OECD, 1997). This scale of barter obviously signifies an inefficient allocation of resources. Possibly, there may be other harmful effects too: Woodruff (1999) asserts that the collapse of monetary transactions is the single greatest challenge to political cohesion in Russia.

Since the current barter experience in the former Soviet republics is so dramatic, it is easy to forget that domestic barter is not a new phenomenon. In the period from 1925 to 1965 barter was quite common even in the United States. The practice was known under the name of reciprocal dealing. During the Great Depression, the volume of reciprocal dealing increased substantially, and in the thirties the practice was widespread (see Lewis (1938) and in particular Stocking and Mueller (1957)). As late as the mid–sixties, a majority of large American firms at had their own trade relations departments (McCreary

[1] Occasionally, buyers have no choice but to barter, due to explicit government regulation of cash trade. Such government mandated countertrade has been analyzed, inter alia, in Ellingsen and Stole (1996). In the current paper, however, I focus exclusively on voluntary barter agreements.

[2] I will use the terms barter and countertrade interchangeably, as the model will allow all transactions to be denominated in cash. In the period 1985–1992, the amount of barter was often quoted to be around 10–15 % of world trade. It has probably declined in the last few years. For references to the considerable literature on international barter, see for example Marin and Schnitzer (1995) and Ellingsen and Stole (1996). For discussions of domestic barter in recent times, see Neale and Sercu (1993) and Prendergast and Stole (1996).

and Guzzardi (1965)), whose main task was to engage in reciprocal dealing (Finney (1969)).

Both the American and the Russian experiences show that inflation is no prerequisite for barter. During the depression there were deflation, and the Russian barter boom coincided with a steady fall in inflation from four digit to two digit levels. Neither is is likely that barter booms are due to sudden increases in double coincidences of wants. A typical case of international barter is when a firm located in a developed country makes a sale to a firm in a less developed country or a country in the former eastern block, agreeing to accept goods produced by the buyer as part of the payment.[3] The goods used as payment are often completely unrelated to the purchased goods; indeed a considerable international trading house industry exists due to firms' desire to dispose of goods which they have received as payment.[4] Western firms hardly ever make use of goods that they receive as payment from their LDC customers. Domestic barter shares this characteristic. For example, 40% of the goods that Russian firms obtain through domestic barter they would never consider buying (Aukutsionek (1997)), and around 25% is resold or rebartered.

Practitioners often claim that payments in kind are due to financial constraints. A buyer who is short of cash may pay out of current or future inventories instead. The purpose of this paper is to develop a formal theory based on this simple idea. This task may look laughably simple, but it is not. In fact, academic economists have long expressed serious doubts about whether financial constraints can explain barter at all. The profession's disbelief is succinctly summarized by the two rhetorical questions: "If a buyer can pay in kind, why would he not first sell his own goods to a third party and then pay in cash? And, if the buyer has not yet produced his goods; why not borrow from the financial market rather than from the seller?" This point is well taken, but it does not prove that cash trade dominates barter. Rather, it forces us to think seriously about why access to credit is limited and how credit constraints might generate barter. Actually, a key finding of this paper is that credit constraints by themselves will not give rise to barter; they do so only if the seller has market power and is incompletely informed about the buyer's financial position.

[3] Blodgett (1994) reports that firm–level barter is the single most important form of international barter. Forms of countertrade which occur at national or industry level rather than at firm level include *offset*, *bilateral clearing* and *switch trading*. As for the geographical pattern, Blodgett finds that in 1990/91 only about 3% of barter is intra–OECD trade, whereas OECD–EBC trade accounts for almost 30% and EBC–LDC for 27% of all barter.

[4] Palia (1990) is a detailed description of the countertrade services industry the way it looked in the late 1980's.

The model presented below builds on a notion of credit constraints which is by now quite conventional, the central assumption being that a borrower is unable to credibly pledge all future benefits as security for a loan.[5] The paper goes on to show that when the seller is uncertain about the buyer's financial position, barter can serve as a screening device. In equilibrium, liquid buyers are induced to pay entirely in cash, whereas illiquid buyers pay partly in kind. Thus, barter is a form of second–degree price discrimination.

Although the model is quite stylized, it generates a number of empirical predictions. Payments in kind are associated with poor credit conditions, low financial transparency, market power, large transactions and excess capacity. The fraction of the total payment which is made in kind rather than in cash is decreasing in the buyer's financial resources and in the collateral value of the traded goods. All these predictions match the available evidence.

Earlier academic literature on payment in kind has touched on several of the ideas of this paper. The notion of barter as price discrimination is quite old; however, early formal modelling such as Caves (1974) does not explain why barter is a better way to price discriminate than simply quoting different prices to different buyers. Hence, the theory could really only explain barter as a way to circumvent regulated or collusive prices. The idea that asymmetric information might be crucial, and that barter constitutes second–degree rather than third–degree price discrimination, was hinted at by Caves and Marin (1992) and has been analyzed in more detail by Prendergast and Stole (1996). However, in their model price discrimination is made possible by differences in *willingness* to pay rather than *ability* to pay; they do not explore the role of credit constraints, which I consider to be crucial. Prendergast and Stole (1997) is more closely related, as it analyses the role of liquidity, and I shall have more to say about this paper below. A series of papers by Marin and Schnitzer (1995,1997,1999) all build on the idea that some firms are financially constrained. Marin and Schnitzer argue that sellers agree to make a counterpurchase because this secures their claim on the buyer; the arrangement creates what the authors call a "deal–specific collateral." A major gap in this argument is that it fails to explain why the buyer cannot borrow against the value of future production from a financial intermediary. If goods can serve as collateral for the debt incurred through a purchase, the goods might as well collateralize bank debts. One may worry that Marin and Schnitzer artificially create a role for collateralized trade credit by assuming away other forms of credit. In contrast, the current model allows the existence of specialized financial intermediaries with superior ability to enforce credit contracts.

[5]However, it is *not* assumed that payments in kind generate higher revenue for the seller than payments in cash.

The paper is organized as follows. Section 2 presents a model of inter–firm trade. Section 3 derives the menu of contracts which will be offered by the seller and shows under which conditions there will be barter in equilibrium. The theory is confronted with a number of empirical regularities. Section 4 modifies the modelling framework to study in–kind payments to workers. Section 5 concludes.

2 Model

We first consider the interaction between two firms, labelled B and S. Firm B, the buyer, wants to purchase one unit of the product which firm S, the seller, has for sale. The seller's product is referred to as product S, and has an opportunity cost of zero. The seller is a monopolist; imperfect competition in the market for product S is necessary for price discrimination to be an issue. Firm B produces $\bar{q}$ units of a different product, referred to as product B. Both firms maximize expected profits.

A key distinction in the model is that between pledgeable and unpledgeable returns. Any returns that a debtor can credibly promise to pay a creditor are called pledgeable; other returns are called unpledgeable.[6] In countries with poor legal protection of creditors, as e.g. Russia today, most future returns appear to be unpledgeable in this sense.

There are two dates in the model, dates 1 and 2. Firm B needs to purchase product S at date 1 (the product has no value to firm B if the purchase is delayed). Firm B's gross return from purchasing product S is denoted $s + \sigma$, where $s > 0$ is pledgeable and $\sigma > 0$ is unpledgeable. This return accrues at date 2. There is no discounting. Product B is in stock at date 1, but it is illiquid in the sense that firm B gets a higher price for it at date 2 than at date 1. Specifically, if firm B keeps control of product B until date 2, it earns a (per unit) pledgeable return $b > 0$ and an unpledgeable return $\beta > 0$. If product B is sold at date 1 it generates $l > 0$ per unit; if product B is used in a barter deal and hence sold on by firm S, firm S earns $v > 0$ per unit.[7] These payoffs

[6]The assumption that a debtor can divert some cash in the future is in the spirit of e.g. Bolton and Scharfstein (1990) and Hart and Moore (1998). This is the simplest way to formalize a notion of credit constraints. An alternative way to introduce credit constraints, applied by Holmström and Tirole (1998) among others, is debtor moral hazard at the production stage. I see no reason why the main conclusions regarding payments in kind would not hold in the latter framework, but the analysis would undoubtedly become considerably more cumbersome.

[7]A special case of illiquidity of product B is if the date 1 price is very sensitive to the sales volume, in which case l should be seen as the *marginal revenue* of a sale at date 1.

are summarized in Table 1.

TABLE 1: Feasible returns

	Date 1	Date 2
Product S	0	$s+\sigma$
Product B	v or l	$b+\beta$

These returns are ranked as follows.

Assumption 1 $v \leq l \leq b$.

This first inequality captures an important ingredient of the model. Since $v \leq l$, firm S is no better at marketing product B at date 1 than firm B is. In other words, the model does *not* make the assumption that firm S has access to a superior marketing technology compared to firm B.[8]

The second inequality means that product B is so illiquid that firm B prefers to borrow against future revenues to selling at date 1. While there could be payments in kind even if product B were more liquid, with $b < l < b+\beta$, the assumption $l < b$ simplifies the exposition. It is not important why product B is illiquid. Indeed most products are illiquid in the sense that the seller needs to lower the price if he needs to sell large quantities quickly. Under financial distress, other factors than downward sloping demand also begin to matter. Even in a perfectly competitive market products are illiquid until they reach the final buyer as long as the producer has a cost advantage in production, storage and marketing.

Firm B's cash holdings at date 1 are denoted c.[9]

To begin with, we assume that S has all the bargaining power and makes a take–it–or–leave–it offer to B.[10] An offer consists of a menu $p(q)$ describing for

[8]If we were to assume that $v > l$, not only would it be a rather trivial theory of barter—it would almost certainly be wrong. In international barter, the firms which accept payments in kind usually unload the goods to specialist intermediaries, called trading houses.

[9]These cash holdings need not be positive; a negative c is simply a measure of firm B's debt overhang problem.

[10]The results are robust to letting firm B can make some contract proposals, as will be discussed below.

each amount of counterpurchase q the cash price that firm B has to pay.[11] The buyer accepts the item on the menu which yields the highest utility, conditional on utility being non–negative.[12] Otherwise, firm B rejects the offer.

To summarize: The seller's payoff from trade is $p(q) + qv$ and the buyer's payoff from trade is $s + \sigma - p(q) - q(b + \beta)$.

If the credit market were perfect, in the sense that all returns were pledgeable (and that debt overhang did not constitute a problem), it is easily seen that cash trade would be the unique outcome. The gain from trade in product S would be s, and firm B would have been able to raise any amount up to $s+b\bar{q}$ from the credit market. Since the terms of trade are negotiated under perfect information of this fact, there is nothing to be gained by involving product B in the trade. Firm S can simply ask for s to be paid in cash.

When some returns are unpledgeable, so that the value of product S is $s+\sigma$, creditors are still only willing to lend $b\bar{q} + s$ against the date 2 revenues, and if $b\bar{q} + c + s < s + \sigma$, B is unable to pay his full valuation of product S at date 1. Financial constraints alone do not generate payments in kind, however. To see this, suppose for a moment that information is complete and symmetric. Firm S then knows that the most firm B can credibly commit to pay in cash for product S is $b\bar{q} + c + s$. Alternatively, Firm S can ask for part of the payment in kind. The maximum value of the payment to S is then $v\bar{q} + c + s$. However, since $v \leq b$ (by assumption), there is no reason to ask for any payment in kind. There is always a cash price offer that is at least as profitable from the seller's point of view as is any offer involving a positive amount of barter. Thus, we have established the following benchmark.

Proposition 1 *If all future returns are pledgeable($\beta = \sigma = 0$), or if the buyer's cash holding is known by the seller, then there is no rationale for payment in kind.*

In what follows, we shall assume that c is private information. The seller knows only that c belongs to some set $C = [\underline{c}, \bar{c}]$, to which he assigns a probability distribution, $F(c)$. The problem is only interesting if there is a positive probability that the buyer cannot raise sufficient cash to pay for the unpledgeable returns associated with the product he wants to purchase. Hence, we assume that $F(\sigma - b\bar{q}) > 0$. The probability distribution is assumed to be differentiable, and we denote the associated density function $f(c)$. If there is a mass

[11] To avoid misunderstanding, let me emphasize that both transactions may be denominated in cash, and that it does not matter who deliver their goods first. This will become clear below.

[12] If the buyer rejects offers which gives zero utility, the analysis below goes through with the tiny difference that the seller sets prices which are epsilon lower.

point, it is thus located at $\underline{c}$. Indeed, one might argue that there is a positive probability that a financially distressed buyer has no ready money whatsoever. Our results only rely on the assumption that this probability is not too large.

Assumption 2 $F(\underline{c}) < \beta/(b + \beta - v)$.

This completes the description of the model.

3 Analysis

We first show that offering only the all–cash price is strictly dominated under quite weak assumptions. To see this, suppose the seller offered an all–cash price $\hat{p}$ exclusively. Moreover, suppose there is a positive probability that the buyer has too little cash to pay this price, i.e., $F(\hat{p} - s - b\bar{q}) > 0$. Then, the seller is strictly better off by offering a menu $p(q)$ of cash and kind, for example

$$p(q) = \begin{cases} \hat{p} - xq & \text{if } q \leq q^m; \\ \hat{p} - xq^m & \text{if } q > q^m. \end{cases} \tag{1}$$

The interpretation is that the seller offers a reduction in the cash price of x per unit of in–kind payment q, up to some limit q^m. For the offer to be meaningful, we restrict attention to $x \in (b, b + \beta]$. (If $x < b$ nobody would pay in kind; if $x > b + \beta$, everyone would avoid paying cash as much as possible.) The limit q^m is imposed because $x > v$. Very large payments in kind would make the transaction unprofitable for the seller. Observe that the seller may, without loss of generality, insist on always being paid $\hat{p}$ in cash, as long as the buyer is paid xq in cash first (or can borrow in full against this promise). Thus, the model admits the most common form of counterpurchase contract, i.e., the bilateral cash deal.

The seller's menu allows a liquid buyer to avoid barter. He can choose the all–cash price $\hat{p}$ as before. In addition, any buyer who has a cash holding of more than $\hat{p} - s - x\bar{q}$ can now finance the purchase. Notice that no liquid buyer will want to pay in kind, because $\hat{p} \leq \hat{p} - xq + (b + \beta)q$. It remains to check that the illiquid buyer is willing to pay, and that the seller is better off. An illiquid buyer accepts the offer as long as the value of product S is greater than its price,

$$s + \sigma \geq \hat{p} - xq + (b + \beta)q.$$

Note that, since $\hat{p} \leq s + \sigma$, this constraint necessarily holds if $x = b + \beta$. The seller is willing to make the offer as long as he values the payment positively, i.e., as long as

$$\hat{p} - xq + vq > 0.$$

Thus, while the seller might want to limit the amount of payment in kind, he is always willing to accept some. The probability that there is barter given this alternative contract is hence $F(\hat{p} - s - b\bar{q}) - F(\hat{p} - s - x\bar{q})$ if $\bar{q} \leq q^m$ and $F(\hat{p} - s - b\bar{q}) - F(\hat{p} - s - b\bar{q} - (x - b)q^m)$ otherwise. In either case the probability is positive.

Proposition 2 *Any all–cash price $\hat{p}$ which the buyer does not accept for sure is strictly dominated by an offer which entails payment in kind with positive probability.*

The intuition behind the result is straightforward. In essence the seller offers to pay $x \in (b, b + \beta]$ for product B. This offer will only be accepted by a buyer who cannot afford to wait for a better deal (without losing the purchase of product S); in other words, a buyer who takes this offer thereby proves that he is financially constrained. Thus, the cash and kind offer creates new trade without diverting any all–cash trade. Notice in particular that v, the seller's valuation of the buyer's product, is quite unimportant. Even if the seller were to have a cost of taking product B (so that $v < 0$), the seller would be willing to engage in the barter deal as long as the cash payment $\hat{p}$ exceeds this cost. This fact serves as a stark illustration of the paper's key message: *The primary function of the barter deal is to extract as much cash as possible from the buyer, not to top up the cash payment with goods.*

In order to say more about the likelihood of barter, we need to characterize the optimal menu. In the Appendix we show that an optimal menu is indeed linear, just as in equation (1). Hence, it remains to identify the optimal discount x and the optimal all–cash price $\hat{p}$. As a first step, let us characterize the payments of a financially constrained buyer, given that there is trade. Since the buyer prefers to pay cash rather than kind, we know that he pays all his cash, so

$$c + b(\bar{q} - q) + s = p(q). \tag{2}$$

For simplicity, let us from now on focus on the case in which $\bar{q} < q^m$. Using (1), we can then solve for the in–kind payment,

$$q(c) = \frac{\hat{p} - c - b\bar{q} - s}{x - b}. \tag{3}$$

Let

$$c_1 = \max\{\underline{c}, \hat{p} - x\bar{q} - s\}$$

denote the cash holding of the marginal buyer, and let

$$c_2 = \min\{\sigma - b\bar{q}, \hat{p} - b\bar{q} - s\}$$

denote the cash holding of the marginal all–cash buyer. The seller's expected profit can then be written as

$$\begin{aligned} \pi &= (1-F(c_2))\hat{p} + \int_{c_1}^{c_2} [c + b(\bar{q} - q(c)) + s + vq(c)] f(c)\, dc \\ &= (1-F(c_2))\hat{p} + \int_{c_1}^{c_2} [c + b\bar{q} + s - (b-v)q(c))] f(c)\, dc. \end{aligned} \tag{4}$$

The seller sets x and $\hat{p}$ to maximize profit. Since x only enters π through c_1 and $q(c)$, and both are decreasing in x, it follows that there is a corner solution at $x = b + \beta$. Thus, if there is any barter at all, the quantity is

$$q(c) = \frac{\hat{p} - c - b\bar{q} - s}{\beta}. \tag{5}$$

Intuitively, there are two forces which both push up x. First, the probability of trade is increasing in x: The more the seller pays for the buyer's goods, the larger is the probability that the buyer accepts the deal. Secondly, for given c, the seller prefers that the buyer's goods are turned into cash, yielding b per unit, rather than being transferred in kind, which yields the seller v per unit.

We are now ready to move beyond Proposition 2. There is no barter if the seller finds it optimal to offer an all–cash price which is accepted with certainty. And of course, a cash only contract is an optimal offer whenever the seller is certain that buyer has enough cash to pay his reservation value $s + \sigma$. The more surprising result, and the key insight of the paper, is that there will be payments in kind with positive probability otherwise, i.e., whenever $s + \sigma > \underline{c} + b\bar{q} + s$.

Proposition 3 *There is a positive probability of payments in kind if and only if $\sigma > \underline{c} + b\bar{q}$.*

To prove the if part, we simply need to show that it is never optimal to offer the highest all–cash price that is accepted for sure and induces no barter, i.e., $\hat{p} = \underline{c} + b\bar{q} + s$, if this price is below $s + \sigma$. To do this, consider the profit the seller gets when setting $\hat{p}$ in such a way that the buyer is able to transact for sure,

$$\pi = (1-F(c_2))\hat{p} + \int_{\underline{c}}^{c_2} [c + b\bar{q} + s - (b-v)q(c))] f(c)\, dc. \tag{6}$$

Differentiate with respect to $\hat{p}$ and rearrange to get

$$\frac{\partial \pi}{\partial \hat{p}} = 1 - \left(1 + \frac{b-v}{\beta}\right) F(c_2). \tag{7}$$

This expression is positive at $\hat{p} = \underline{c} + b\bar{q} + s$ if

$$F(\underline{c}) < \frac{\beta}{b + \beta - v},$$

which is true by Assumption 2. This proves that it is profitable to raise the price above $\underline{c} + b\bar{q} + s$, and hence that there will be some payment in kind.

To interpret Proposition 3, it is useful to define the following variables:

- $s + \sigma$ - transaction size;
- $s/(s + \sigma)$ - pledgeability of returns from product S;
- $(b + \beta)\bar{q}$ - value of the buyer's illiquid assets;
- $b/(b + \beta)$ - pledgeability of returns from product B.

The critical inequality says that there is barter with positive probability if and only if

$$\frac{\sigma}{s + \sigma}(s + \sigma) > \frac{b}{b + \beta}(b + \beta)\bar{q} + \underline{c}. \tag{8}$$

Hence, barter is a consequence of (i) low pledgeability of future returns (both from product S and product B), (ii) large transactions, (iii) poor buyers (low value of both liquid and illiquid assets).

What is the welfare effect of barter arrangements? Supposing that we are interested in the sum of seller profits and buyer profits, the analysis is in principle very simple. On the one hand, barter generates a gain of $s + \sigma$ for every trade that would otherwise have been foregone. On the other hand, there is an allocative loss of $(b + \beta - v)q(c)$. Since the seller will reject any trade for which $\hat{p} < (b + \beta - v)q(c)$, it follows that he will never accept a deal which generates a net welfare loss. Hence, whenever the availability of barter does not affect the price $\hat{p}$, barter is surely beneficial.[13]

This is not to say that the conditions which gives rise to barter are beneficial. In the present model, aggregate welfare is always higher when the buyer is not financially constrained. However, the unconstrained regime does not necessarily Pareto–dominate the financially constrained regime. Buyers may be better off if they are financially constrained, because this may lower the all–cash price $\hat{p}$ below their valuation $s + \sigma$.

[13]The only case in which there could be a net loss is when the seller increases the price $\hat{p}$ above the level which would have prevailed without barter. Then, with some probability, there will be a distortion which would not exist if barter were forbidden. However, it would not be easy to construct an example in which this effect dominates the trade creation effect.

3.1 Digression: The interior solution p^*

Before proceeding to discuss the detailed properties of barter deals, we need to characterize the price $\hat{p}$ in case it is not located at a corner (the corner solutions are $s+\sigma$ and $\underline{c}+s+(b+\beta)\bar{q}$).

Consider first the case $c_1 > \underline{c}$. The first–order condition for p^* to constitute an interior maximum is

$$1 - F(c_2) - [p^* - (b+\beta-v)\bar{q}]f(c_1) - \frac{b-v}{\beta}[F(c_2) - F(c_1)] = 0.$$

This condition is obtained by differentiating (4) at a point where $c_1 = \hat{p} - (b+\beta)\bar{q} - s$ and $c_2 = \hat{p} - b\bar{q} - s$. To facilitate a meaningful comparative static analysis, it is useful to rewrite this first–order condition as

$$\begin{aligned} 1 - F(c_1) \quad &- \quad \left[p^* - \left(1 - \frac{v}{b+\beta}\right)(b+\beta)\bar{q}\right] f(c_1) \\ &- \quad \left(\frac{\beta}{b+\beta}\right)^{-1}\left(1 - \frac{v}{b+\beta}\right)[F(c_2) - F(c_1)] = 0. \end{aligned} \tag{9}$$

Next, consider the case $c_1 = \underline{c}$ and $c_2 = \hat{p} - b\bar{q} - s$. Differentiation of (4) in this case yields

$$\frac{\partial \pi}{\partial \hat{p}} = 1 - \left(1 + \frac{b-v}{\beta}\right) F(c_2).$$

Since $c_2 \leq \underline{c} + \beta\bar{q}$, this expression is positive by Assumption 2. Hence, there is no interior solution with $c_1 = \underline{c}$.

3.2 The barter probability

We are now ready to characterize the barter probability in more detail. Given that the probability is positive, how does it vary with parameters?

Let the barter probability be denoted

$$k = \begin{cases} F(c_2) - F(c_1) & \text{if } c_1 > \underline{c}; \\ F(c_2) & \text{if } c_1 = \underline{c}. \end{cases}$$

Proposition 3 shows under what circumstances k is positive. A natural question is how k varies with the model's parameters. As it turns out, the barter probability can be written

$$k = \begin{cases} F(\sigma - b\bar{q}) & \text{if } \hat{p} = s + \sigma \text{ and } c_1 = \underline{c}; \\ F(\sigma - b\bar{q}) - F(\sigma - (b+\beta)\bar{q}) & \text{if } \hat{p} = s + \sigma \text{ and } c_1 > \underline{c}; \\ F(p^* - s - b\bar{q}) - F(p^* - s - (b+\beta)\bar{q}) & \text{if } \hat{p} \in (s + \underline{c} + (b+\beta)\bar{q}, s+\sigma); \\ F(\underline{c} + \beta\bar{q}) & \text{if } \hat{p} = s + \underline{c} + (b+\beta)\bar{q}, \end{cases} \tag{10}$$

where p^* is the optimal value of $\hat{p}$ in case the solution is interior. The first three cases in (10) are immediate from the definitions of c_1 and c_2. The last line says that whenever there is trade with probability one at a price $\hat{p} < s+\sigma$, then the price solves the equation $c_1 = \hat{p} - (b+\beta)\bar{q} - s = \underline{c}$. (As we have just seen, there cannot be an interior solution for $\hat{p}$ unless $c_1 > \underline{c}$.)

Of the four cases described in equation (10), the first will occur for a set of relatively small transaction sizes, and the last will occur for all sufficiently large transaction sizes.

Proposition 4 *(i) There is an interval of "small" transaction sizes such that for any transaction in this interval the barter probability is given by $k = F(\sigma - b\bar{q})$. (ii) For any sufficiently large transaction, the barter probability is $k = F(\underline{c} + \beta\bar{q})$.*

To prove (i), recall that the seller's profit is increasing in $\hat{p}$ at the point where a marginal increase in $\hat{p}$ induces the buyer to pay part of the price in kind with positive probability (see the proof of Proposition 3). Hence, as the transaction size increases slightly from the critical level given by the equation $\sigma = \underline{c} + b\bar{q}$, so that the transaction becomes larger than

$$s + \sigma = \frac{\underline{c} + b\bar{q}}{1 - s/(s+\sigma)}$$

(below which the buyer always pays $s+\sigma$ in cash), the optimal price remains at $\hat{p} = s + \sigma$. To prove (ii), note first that if the transaction is very large, then no buyer is able to transact at a price $s+\sigma$. Thus, we just need to show that, for large enough transactions, any price different from $\hat{p} = \underline{c} + s + (b+\beta)\bar{q}$ is suboptimal. (This is the highest price which is never rejected by the buyer.) Differentiation of (4) for $c_1 > \underline{c}$ yields

$$\frac{\partial \pi}{\partial \hat{p}} = 1 - F(c_2) - (\hat{p} - (b + \beta - v)\bar{q})f(c_1) - \frac{b - v}{\beta}[F(c_2) - F(c_1)]. \tag{11}$$

Evaluating at $\hat{p} = \underline{c} + s + (b+\beta)\bar{q}$, we have

$$\frac{\partial \pi}{\partial \hat{p}} = 1 - F(c_2) - (\underline{c} + s + v\bar{q})f(c_1) - \frac{b - v}{\beta}[F(c_2) - F(c_1)],$$

which is negative for large enough $s + \sigma$ (again we use the fact that $s = [s/(s+\sigma)][s+\sigma]$). This proves that any price slightly above $\underline{c} + s + (b+\beta)\bar{q}$ is suboptimal for large transactions; the extension to any price above $\underline{c} + s + (b+\beta)\bar{q}$ is immediate. We have already shown that a lowering of the price below $\underline{c} + s + (b+\beta)\bar{q}$ never pays. Hence, for large enough transactions, the optimal price is $\underline{c} + s + (b+\beta)\bar{q}$, and the associated probability of barter is $k = F(\underline{c} + \beta\bar{q})$.

Proposition 4 allows a simple characterization of the barter probability for large transactions and for a subset of smaller transactions. For large transactions, the probability of barter is an increasing function of $\beta\bar{q}$, with other parameters being irrelevant. Hence the smaller is the pledgeability of returns from product B, and the more of the product the buyer has in stock, the larger is the probability of barter. For the smaller transactions covered by the proposition, the probability of barter remains decreasing in the pledgeability of product B, but is also decreasing in the amount of product B in stock. The reason for the difference is that in this case a larger stock $\bar{q}$ enables a larger set of buyer types to pay $s + \sigma$ in cash. For the smaller transactions, we also see that the barter probability is decreasing in the pledgeability of returns from product S and increasing in the transaction size.

The most problematic cases are given by the second and third line in (10), which describe transactions of an intermediate size.[14] In these parameter regions, the probability of barter may go in either direction as transaction size increases; both c_1 and c_2 are increasing with transaction size, and the change in the barter probability depends on the exact shape of $F(c)$. With a uniform distribution of cash holdings, the barter probability is constant over this range; with other distributions, the probability of barter may well be non–monotonic in every parameter.

If we restrict attention to the special case of a uniform distribution of cash holdings, three parameters have a monotonic impact.

Proposition 5 *If $F(c)$ is a uniform distribution, then the barter probability is decreasing in $b/(b+\beta)$, non–decreasing in $s+\sigma$, and non–increasing in $s/(s+\sigma)$.*

The proof is immediate from differentiation of (10) and therefore omitted. We could perform a similar comparative static analysis with respect to the average cash holding of the buyers, keeping the form of the distribution constant (i.e., a multiplicative shift of the distribution function). This exercise is essentially

[14] In some examples, these cases never arise, in others they do. In particular, they arise when the interval C is sufficiently large.

the mirror image of a change in transaction size, with richer buyers having the same effect as smaller transactions.

The nice property of Proposition 5 is that it echoes the necessary and sufficient condition for a positive barter probability given above; if an increase in a parameter makes a positive probability of barter more likely, then it also makes a large probability more likely. Hence, Proposition 5 delivers unambiguously the key prediction that the volume of barter should be related to financial constraints. Large transactions, poor buyers, and ill–functioning credit markets lead to high probabilities of barter.

Many features of the Russian barter explosion fit the theory. From 1992 to 1997, barter increased tenfold, from five percent of industrial sales to fifty percent of industrial sales. In the same period, bank credit to the non–financial sector fell from 34 percent of GDP to ten percent of GDP. Since output was falling too, the credit contraction was in fact even worse than these numbers suggest.[15] Thus, there is a strong correlation between the collapse of domestic commercial credit and the emergence of barter. At the same time the circulation of cash in the economy was sound; there was a steady fall in the inflation rate, but no sign of a deflation, and people were happy to trade in roubles as well as in dollars. The monetary drama was all in credit rather than cash. Another piece of evidence can be had from the survey of barter motives by Aukutsionek (1997,1998). Firms report that their dominant motives for bartering is either lack of current capital or desire to sell quicker. These are precisely the motives that describe the concerns of the buyers and sellers respectively in the current model. A survey of barter motives in Ukraina, reported by Kaufman and Marin (1998), comes to a similar conclusion.[16] Seen in this way, the Russian experience is an extreme example of how a recession crushes credit, which in turn leads to barter. This general mechanism may also explain why barter is almost always associated with recessions.[17]

The theory might also explain why plants and machinery are relatively often paid in kind. For example, the share of plants and machinery in countertrade exports to LDC's is much higher than the corresponding share in ordinary exports.[18] This may simply be due to the fact that these transactions are generally very large compared to purchases of final goods and intermediate

[15] All numbers can be found in OECD (1997).

[16] At the same time, the surveys give very little support to the notion that firms barter to avoid taxes or because it is easier to enforce barter payments than conventional cash or trade credit payments. Thus, the survey data provides evidence against the key assumption of Marin and Schnitzer's models, namely, that barter provides better legal enforcement.

[17] See Stocking and Mueller (1957), Caves (1974) and the references therein.

[18] This regularity is documented by Bussard (1987). See also Marin and Schnitzer (1995).

goods, which can normally be bought in smaller batches. Also, the return comes later. It is for large long–term investments that financial constraints are most important.

3.3 The compensation ratio

The above analysis has considered the probability of barter. Another challenge is to explain observed differences across barter contracts. One feature that has attracted attention in the literature is *the compensation ratio*, defined as the value of barter imports (the value of product B deliveries) divided by the value of barter exports,

$$r = \frac{(b+\beta)q}{\hat{p}}.$$

Using (5), the compensation ratio can be written

$$r = \frac{b+\beta}{\beta}\left(1 - \frac{c+s+b\bar{q}}{\hat{p}}\right). \tag{12}$$

To fully characterize the compensation ratio, note that there are three different candidate prices $\hat{p}$ to be considered: the two possible corner solutions $s+\sigma$ and $\underline{c}+s+(b+\beta)\bar{q}$ and the possible interior solution $\hat{p}=p^*$. We are then ready to prove the next result.

Proposition 6 *The compensation ratio is decreasing in the pledgeability of returns $b/(b+\beta)$ and $s/(s+\sigma)$.*

This result, which is proved in the Appendix, is due to the fact that pledgeable returns can be borrowed against: Greater pledgeability of returns from product S means that if $\hat{p}$ remains constant the buyer is able to pay a larger fraction of the price in cash. If $\hat{p}$ is not kept constant, i.e., the seller increases the price, that of course also serves to decrease the compensation ratio.

The only econometric study of compensation ratios that I am aware of is Marin and Schnitzer (1995). They find that the compensation ratio is higher when the buyer's goods are homogeneous (undifferentiated), lower when the seller's goods are machinery or manufacturing plants. It is not entirely clear whether Proposition 6 is consistent with these findings or not. Consistency requires (i) that returns from differentiated outputs are easier to pledge than returns from homogeneous outputs and (ii) that returns from machines and manufacturing equipment are easier to pledge than returns from other inputs. Let us consider these in turn.

A possible story why it is easier to finance differentiated outputs is that creditors are better able to monitor the sale of differentiated goods than the sale of homogeneous goods. The former goods typically bear the seller's mark, the latter do not. Also, differentiated goods are on average priced at a larger mark–up than homogeneous goods. Hence, producers of differentiated goods have more to lose from bankruptcy or bad reputation and will thus resist defaulting on their debts.[19] However, it is not difficult to come up with stories which yield the opposite prediction, so I will not claim that this finding is unambiguously supportive of the model.

The low compensation ratios for machines and manufacturing are easier to explain in terms of the model. Machines and plants are widely recognized by bankers as being better collateral than raw materials and intermediate inputs.

Marin and Schnitzer also find that buyers located in highly indebted countries have higher compensation ratios. To compare firms with different indebtedness, let $F_H(c)$ denote the distribution of cash for a firm in a high liquidity environment and let $F_L(c)$ be the corresponding distribution for a firm in a low liquidity environment. The difference in liquidity is expressed through the monotone likelihood ratio property (MLRP).

Assumption 3 *For any $c \in C$, let*

$$\frac{d}{dc}\frac{f_H(c)}{f_L(c)} > 0.$$

As is well known, the MLRP implies that F_H first order stochastically dominates F_L, but MLRP is somewhat stronger. Let

$$\bar{r}_i = \frac{1}{[F_i(c_2) - F_i(c_1)]}\int_{c_1}^{c_2} r(c) f_i(c)\, dc,$$

express the expected compensation ratio given environment $i \in \{L, H\}$. In general, $r(c)$ may depend on expected liquidity through $\hat{p}$. To avoid this complication, let us here confine attention to cases in which the price $\hat{p}$ is independent of expected liquidity.[20]

Proposition 7 *Suppose $\hat{p} \in \{s + \sigma, \underline{c} + s + (b + \beta)\bar{q}\}$ for both environments. Then the expected compensation ratio is a decreasing function of expected liquidity, i.e., $\bar{r}_H < \bar{r}_L$.*

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[19]For example, when the source of differentiation is research and development, large costs are often sunk at an early stage and are only recouped through fat margins.

[20]The result extends straightforwardly to the case of an interior price $\hat{p} = p^*$ under the condition that p^* is higher for F_H than for F_L. But although it is very natural that the price should increase as the buyers get richer, I have been unable to find an appealing condition under which it is generally true.

The proof is in the Appendix. The intuition is quite obvious: Large compensation ratios $r(c)$ correspond to low levels of c, and low levels of c are relatively more likely when liquidity is low.

3.4 Contract proposals by the buyer

So far, we have assumed that contracts are proposed by the seller, and that the buyer can only accept or reject. A realistic alternative assumption would be that the seller can commit to some general market price, p, but that buyers are free to propose cash and kind contracts. Given that the buyer cannot credibly commit not to buy at the all–cash price, it is quite easy to show that this alternative set–up generates exactly the same outcome as above.

The argument is briefly as follows. The seller would only accept a cash and kind offer if he thought that the buyer was not prepared to pay the cash price. Hence, the cash and kind offer would have to satisfy the same form of incentive constraint as before. Supposing that the seller offers the cash price $\hat{p}$, the buyer could credibly signal his inability to pay $\hat{p}$ in cash, by offering to pay $\hat{p} - (b + \beta)q$ in cash and q in kind, just as above.

Essentially, the liquidity constrained buyer says to the seller: "I will not buy from you unless you buy from me." The credibility of such statements has sometimes been an issue. Here, the statement is believable, because a poor buyer proposes terms of trade which would not be proposed by a rich buyer.

4 Goods for Wages

In the last couple of years, paying wages in kind have become increasingly common in Russia and in many other republics of the former Soviet Union. The purpose of this section is to show how in–kind wages can be explained as a result of firms' financial constraints. In analogy with our discussion of inter–firm barter, the argument is that payment in kind is the only credible way for employers to prove to the workers that the firm has run out of cash and that credit constraints are binding.

Consider for simplicity a firm with one worker. The firm has previously promised a certain wage w^*. (For our purposes we can abstract from the issue of the worker's contribution to firm value.) Faced with tight liquidity, the firm must decide whether it should attempt to renegotiate the labor contract. If the worker is not satisfied with the firm's renegotiation offer, he can reject it. If the firm is sufficiently liquid, it then has to pay w^*. If the firm is not sufficiently liquid, it goes bankrupt, in which case assets are liquidated and the firm has to pay a bankruptcy cost y. In bankruptcy, the worker receives the minimum of w^* and whatever cash is left after liquidation.

As before, this cash holding $c \in C$ is private information. The firm has inventories which are worth $l \leq b$ per unit if the firm liquidates them immediately at date 1 and $b+\beta$ per unit if they are sold by the firm at date 2. Assume that bankruptcy costs are large enough that the workers would not want to bankrupt the firm in order to obtain the liquidation value of inventories instead of being paid the inventories in kind, i.e., $y \geq (l-v)\bar{q}$. In this section, we also assume that the firm can pledge at most half of future revenues to creditors, i.e., $\beta \geq b$. Finally, we assume that with positive probability $c + b\bar{q} < w^*$.

The interaction between the firm and the worker is a three–stage game. At the first stage, Nature chooses the firm's type, i.e., some $c \in C$ is learnt privately by the firm. At the second stage, the firm chooses some wage offer w and whether to offer some of its output as a payment in kind. The firm's strategy can be written as a mapping $(q, w) : C \to \mathbb{R}^2_+$. If $w = w^*$ the game ends, as the worker has no right to oppose the prior contract. Otherwise, the game continues to the third stage, where the worker decides whether to accept or reject the new offer. Hence the worker's strategy is a mapping $L : \mathbb{R}^2_+ \to \{Accept, Reject\}$.

Since the informed party moves first, we will look for Perfect Bayesian Equilibria of this game. In particular we are interested in separating equilibria such that payments in kind are used as a self–selection device. One plausible equilibrium which entails payments in kind with positive probability is the following: The firm uses the strategy

$$w(c) = \begin{cases} w^* & \text{if } c + b\bar{q} \geq w^*; \\ c + b(\bar{q} - q(c)) & \text{otherwise,} \end{cases} \tag{13}$$

$$q(c) = \begin{cases} 0 & \text{if } c + b\bar{q} \geq w^*; \\ \dfrac{w^* - c - b\bar{q}}{\beta}, & \text{otherwise,} \end{cases} \tag{14}$$

and the worker uses the strategy

$$L(q, w) = \begin{cases} Accept & \text{if } (q, w) \in E'; \\ Reject & \text{otherwise,} \end{cases} \tag{15}$$

where $E = \{(q(c), w(c)) | c \in C\}$ are the pairs of q and w that may be offered in equilibrium, and $E' = \{(w, q) | w + (b + \beta)\bar{q} \geq w^*\}$ are offers which are at least as costly to the firm as are the equilibrium offers. (Note that E' includes E.) It remains to specify the worker's beliefs. For offers in the set E' the worker believes with probability 1 that the firm's cash holding is given by $c = w - b(\bar{q} - q)$ if $w < w^*$, if $(q, w) \notin E'$, then the worker believes that $c + l\bar{q} > w^* - y$. (As usual there is a variety of out–of–equilibrium beliefs which support the equilibrium outcome, and this is just one example)

It is straightforward to check that we have described a Perfect Bayesian Equilibrium; for details see the Appendix. While there are other equilibria of the game, the one we have studied is the best separating equilibrium of the model, and thus has considerable merit.[21] The interesting feature of the equilibrium is that a financially constrained firm pays as much cash as it possibly can and adds just enough payment in kind to convince the worker that it plays honestly. I.e., the worker understands that the firm cannot pay any more cash, because the firm would rather have paid more in cash and less in kind.

5 Final Remarks

We have seen that payments in kind may arise because they represent a credible way for buyers to prove that they are financially constrained. By also identifying the source of financial constraints, the presence of returns which cannot be pledged as collateral for loans, the theory provides a number of predictions regarding the causes and nature of payments in kind. The theory suggests that the only way in which to remonetize transactions is to rescue commercial credit markets, either by improving creditor protection, increasing transparency, or by reinflating equity values.

Given the prominence that is given to financial constraints in the vast applied literature on countertrade, the theoretical literature's neglect of financial constraints is quite striking. The work of Marin and Schnitzer (1995,1997,1999) is a rare exception, but as argued in the introduction their theory is incomplete in that it assumes away the credit market.[22]

Contemporaneous work by Prendergast and Stole (1997) articulates the same fundamental insight as this paper; barter may serve as a way of segmenting the market on the basis of buyers' ability to pay. However, their analysis is different in several respects; for example they consider a symmetric situation with two–sided incomplete information, and, like Marin and Schnitzer, they abstract from financial intermediation. Thus, the two papers are complemen-

[21]The best separating equilibrium always satisfies some standard refinement criteria such as D1. In order to apply other criteria, which sometimes pick pooling equilibria even when separating equilibria exist, we would need to add distributional assumptions regarding c.

[22]Moreover, Marin and Schnitzer (1995) rely on moral hazard problems on each side of the market; both producers have the opportunity to shirk on quality. An objection to this reliance on moral hazard problems is that LDC firms sometimes pay using quite generic products, and hence have little opportunity to shirk on quality, whereas DC firms are frequently large multinationals who have a valuable reputation at stake and choose not to shirk on quality for this reason. Other models of barter which emphasize moral hazard problems are those of Chan and Hoy (1991) and Choi and Maldoom (1992).

tary. Prendergast and Stole's model provides insight into what goes on at an American barter exchange, where there is a great degree of symmetry between the agents. The current paper is geared towards asymmetric situations, where there is not necessarily a double coincidence of wants. It explains why goods are used as a means of payment even in situations where the seller (the recipient of the in–kind payment) values these goods less than the buyer does. The current paper also covers a range of topics which are not addressed by Prendergast and Stole. For example, it determines the mix between cash and kind payments and analyses the question of in–kind wages.

Trade credit is related to barter in that it links two transactions which need need not be. Interestingly, trade credit has also been analyzed as a consequence of private information about liquidity; see Smith (1987) and Brennan, Maximovic and Zechner (1988). In the trade credit literature too the main idea is that buyers self–select, with financially constrained buyers accepting to pay a high price for the trade credit and unconstrained buyers paying cash. Nonetheless, the mechanism is quite different. Trade credit at high interest rates only works when the buyer can credibly pledge to pay out a large fraction of future revenues. Barter works well under the opposite assumption.

The present theory of payment in kind is also related to models of public in–kind transfers. As Blackorby and Donaldson (1988) showed, transfers in kind rather than cash are useful in screening recipients according to their privately observed wealth. An important difference between the two problems is that payments in kind arise even if the principal (here, the seller) is not altruistic.

Ultimately, any theory of barter is a contribution to the theory of money. Recent models of money, such as Kiyotaki and Wright (1989) and Banerjee and Maskin (1996), typically abstract from the issue of financial contracts in order to focus sharply on the role of money as a medium of exchange. These theories explain the emergence of money in one form or another. In doing so, they are almost too successful, because they shed little light on the historical episodes in which massive amounts of inefficient barter transactions have occurred alongside cash trade. The current paper provides a perspective on this issue. With imperfect competition in the goods markets, money will eliminate barter only if agents are well informed about each others' financial situation or if creditors' claims are well protected.

6 Appendix

6.1 Linearity

In the main text, we studied linear contracts of the form $p = \hat{p} - xq$, and showed that within this class it is optimal to have $x = b + \beta$. We will now briefly indicate why the optimal contract is linear.

We restrict attention to selling mechanisms which have the property that the buyer only pays if the seller delivers. Appealing to the Revelation Principle, and abusing notation, we can state the seller's problem as finding a pair of functions $(p(c), q(c))$ which solves

$$\max_{p(\cdot),q(\cdot)} \int_{\underline{c}}^{\overline{c}} [p(c) + q(c)v] f(c)\, dc$$

subject to the participation constraint

$$s + \sigma - p(c) - q(c)(b + \beta) \geq 0,$$

the incentive compatibility constraint

$$p(c) + q(c)(b + \beta) \leq p(\hat{c}) + q(\hat{c}) \text{ forall } c \text{ and } \hat{c},$$

the financial constraint

$$p(c) \leq c + s + b(\bar{q} - q(c)),$$

and the feasibility constraint

$$q(c) \in [0, \bar{q}].$$

As usual, we think of $\hat{c}$ as as a "message" that the buyer can send about his true type c.

Note that if the participation constraint is satisfied for some type $\tilde{c}$, then (because of the incentive constraint) it must also be satisfied for all $c > \tilde{c}$. The same reasoning holds for the financial constraint.

Let the buyer's maximum utility be denoted

$$u(c) = \max_{\hat{c}} [s + \sigma - p(\hat{c}) - q(\hat{c})(b + \beta)].$$

Using the incentive constraint, we know that (for any participating buyer)

$$u(c) = s + \sigma - p(c) - q(c)(b + \beta).$$

How does u vary with c? Since $p(c)$ and $q(c)$ are optimally chosen by the buyer's report $\hat{c}$ it follows by the envelope theorem that

$$\frac{du}{dc} = \frac{\partial u}{\partial c} = 0$$

for all c such that the incentive compatibility constraint binds. Thus, for any c in such an interval, we must have

$$p'(c) = -q'(c)(b+\beta).$$

Hence, whenever q moves, p indeed moves linearly.

6.2 Proof of Proposition 6

Let us prove the result for changes in $s/(s+\sigma)$. Consider first the case $\hat{p} = s+\sigma$. Then

$$r = \frac{b+\beta}{\beta}\left[1 - \frac{c + \dfrac{s}{s+\sigma} + b\bar{q}}{s+\sigma}\right],$$

which is clearly decreasing in $s/(s+\sigma)$. The case $\hat{p} = \underline{c}+s+(b+\beta)\bar{q}$ is similar. Finally, consider the case of an interior price, $\hat{p} = p^*$. Differentiation of (12) yields

$$\frac{dr}{d\dfrac{s}{s+\sigma}} = -\frac{b+\beta}{\beta}\frac{(s+\sigma)p^* - \dfrac{dp^*}{d\dfrac{s}{s+\sigma}}(c+s+b\bar{q})}{(p^*)^2}.$$

Since r is non–negative, $c+s+b\bar{q} \leq p^*$. Hence, our conclusion follows if we can show that $dp^*/d(s/(s+\sigma)) < s+\sigma$. To do this, differentiate the first–order condition (9) to get

$$\frac{dp^*}{d\dfrac{s}{s+\sigma}} = (s+\sigma)\frac{-f(c_1)+x}{-2f(c_1)+x},$$

where

$$x = -f'(c_1)\left[p^* - \left(1 - \frac{v}{b+\beta}\right)(b+\beta)\bar{q}\right] - \left(\frac{\beta}{b+\beta}\right)^{-1}\left(1 - \frac{v}{b+\beta}\right)[f(c_2)-f(c_1)].$$

Hence

$$\frac{dp^*}{d\dfrac{s}{s+\sigma}} < (s+\sigma).$$

The proof for $b/(b+\beta)$ is similar.

6.3 Proof of Proposition 7

The argument goes as follows.[23] By assumption $\hat{p}$ is independent of expected liquidity, i.e., $\hat{p} = s + \sigma$ or $\hat{p} = \underline{c} + s + (b + \beta)\bar{q}$ for both $i = H$ and $i = L$. Let

$$\tilde{f}_i(c) = \frac{f_i(c)}{F_i(c_2) - F_i(c_1)}$$

denote the conditional density given liquidity level i. Our claim, that $\bar{r}_L > \bar{r}_H$, can then be written

$$\int_{c_1}^{c_2} r(c)\tilde{f}_L(c)\, dc > \int_{c_1}^{c_2} r(c) f_H(c)\, dc,$$

or equivalently

$$\int_{c_1}^{c_2} r(c)\tilde{f}_L(c) \left[1 - \frac{\tilde{f}_H(c)}{\tilde{f}_L(c)}\right] dc > 0. \tag{16}$$

Since, by assumption, the unconditional likelihood ratio is monotonically increasing, so is the conditional likelihood ratio. Hence the term in brackets is monotonically decreasing. Let $g(c)$ be any function which is restricted to be positive and non–increasing.

Replacing $r(c)$ by $g(c)$ in (16) and minimizing with respect to the function $g(\cdot)$, we see that the minimum is reached for $g(c)$ being constant. The reasoning goes as follows. Let c^* be the solution to $\tilde{f}_H(c^*) = \tilde{f}_L(c^*)$. We want the negative part of (16) to be as large as possible, hence $g(c)$ should be constant for all $c > c^*$. Similarly, we want the positive part of (16) to be as small as possible, hence $g(c)$ should be constant for $c < c^*$. But if $g(c)$ is constant, (16) holds with equality. Thus, the inequality is strict for the decreasing function $r(c)$.

6.4 Goods for Wages

Here is a brief proof that the proposed strategies and beliefs described in Section 4 form a Perfect Bayesian Equilibrium. Notice that the set of equilibrium offers E is described by the function

$$\hat{q}(w) = \begin{cases} 0 & \text{if } w \geq w^*; \\ \dfrac{w^* - w}{b + \beta} & \text{otherwise.} \end{cases}$$

The steps of the proof are the following. *Step 1.* Clearly, the worker's beliefs are consistent with Bayes' rule along the equilibrium path; each offer

[23] I am grateful to Tomas Björk for suggesting this proof.

is made only by one type of firm (type c) and the worker upon seeing an offer $(q(c), w(c))$ assigns probability 1 to the event that the firm's type is c. In order to confirm that the strategies form a perfect equilibrium given the worker's beliefs, we first check that the worker's strategy constitutes a best response. *Step 2.* Consider deviations by the worker. Rejecting any offer in the set E', with $w < w^*$ yields a payoff $c + l\bar{q} - y$. Hence the no–deviation constraint is

$$w + qv \geq c + l\bar{q} - y.$$

Using (13)

$$y \geq (l - b)\bar{q} - (v - b)q,$$

which is implied by our assumption that $y \geq (l - v)\bar{q}$. Hence, it is indeed best for the worker to accept offers in E'. Accepting offers $(q, w) \notin E'$ on the other hand is irrational, since the worker believes he will get paid w^* if he rejects. It remains to show that the firm's strategy is a best response. *Step 3.* Suppose first that $c + b\bar{q} < w^*$ so the the firm is credit constrained. We must confirm that it is not optimal to offer a pair (q', w') with $w' < w = c < w^*$ and $q' = \hat{q}(w')$. The original offer yields the firm a payoff $(\bar{q} - q)\beta$, whereas the deviation would yield $(\bar{q} - q')\beta + w - w'$. Hence the incentive constraint can be written

$$(\bar{q} - q)\beta \geq (\bar{q} - q')\beta + w - w'.$$

Using (13) the condition becomes

$$\beta(q' - q) \geq b(q' - q),$$

which is satisfied due to the assumption that $\beta > b$. If the firm is not credit constrained, the no–deviation constraint becomes instead

$$c + (b + \beta)\bar{q} - w^* \geq c + (b + \beta)(\bar{q} - q) - w.$$

Using (13), the condition becomes

$$q \geq \frac{w^* - c - b\bar{q}}{\beta}$$

which, by equation (14), is true for our proposed $q(c)$.

Inserting $q = \hat{q}(w)$ and $q' = \hat{q}(w')$, we see that the condition holds with equality.

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